TECH SOLUTIONS 214.0
REDUCE WALL CONDENSATION POTENTIAL WITH INSULATED SHEATHING

SUMMARY

Insulated sheathing provides exceptional moisture protection performance in residential walls versus traditional spun-bonded polyolefin housewrap with oriented strand board (OSB) sheathing. Increasing stud cavity temperature is critical to managing the potential for condensation within conventional light framed wall designs. The high R-value* of exterior wall insulation increases stud cavity temperature, creating a distinct moisture protection advantage over other non-insulated sheathing materials, as shown in Figure 1.

The moisture content was analyzed in two types of wall assemblies – an assembly using STYROFOAM SIS™ Brand Structural Insulated Sheathing and one using housewrap and OSB. Testing was performed in both hot and cold climate scenarios. Neither of the wall assemblies experienced moisture content greater than 20 percent, which is the generally accepted threshold for potential mold growing conditions with wood-based products. The analyses contained in this document demonstrate that insulated sheathings result in drier stud cavities than non-insulated sheathing in both hot and cold climates.

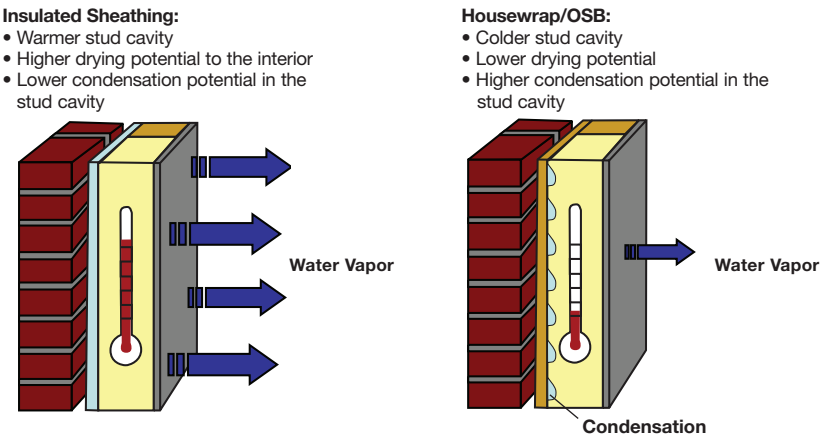
The Core of Moisture Protection

The substantial energy savings advantage of continuous insulated foam sheathing in residential walls is well known. However, does insulated sheathing offer greater moisture protection than housewrap and OSB? What impact does sheathing have on condensation potential inside the stud cavity? Further, is the perm of sheathing materials the most important factor to consider for condensation potential inside the wall cavity? Or, does the sheathing's R-value play a greater role?

Why is it important to ask these questions? Excessive moisture inside the wall can potentially lead to mold. Wood or wood-based products with a moisture content of 20 percent or more are considered to have favorable conditions for mold growth.[1] It is imperative to understand the impact that sheathing selection can have on the condensation potential inside the stud cavity.

The two wall system types shown in Figure 2 meet water-resistive barrier (WRB) requirements, and therefore effectively shed bulk water. However, not all WRB systems perform equally in managing condensation potential and moisture content inside the wall. The ability to shed bulk water should not be confused with the ability to manage condensation potential and moisture content inside the wall. Both abilities are vital to providing comprehensive moisture management in residential walls. The following analyses reveal how insulated sheathings provide a moisture protection advantage over housewrap and OSB sheathing materials.

Figure 1: Insulated sheathing results in higher temperatures in the stud cavity, which increases moisture evaporation and drying to the interior.



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*R means resistance to heat flow. The higher the R-value, the greater the insulating power.

Reduce Wall Condensation Potential with Insulated Sheathing

Not only does insulated foam sheathing have an obvious energy savings advantage, it also elevates the temperature of the stud cavity in cold weather. Elevating the temperature inside the wall decreases condensation potential and increases drying potential to the inside of the building.

Another cold climate comparison monitored moisture content inside the gypsum board during the same two-year period (Figure 4). Again, the wall systems with STYROFOAM SIS™ Brand Structural Insulated Sheathing outperformed the wall system featuring housewrap/OSB. Walls using STYROFOAM SIS™ Brand Sheathing had substantially lower moisture content in the gypsum board during the summer months, which allows wood studs behind STYROFOAM SIS™ Brand Sheathing to "live" in a drier wall environment, reducing the potential for mold and rotting.

WUFI Results: Hot Climate Comparison

From Figures 5 and 6, it is evident that STYROFOAM SIS™ Brand Structural Insulated Sheathing outperforms housewrap/OSB sheathing in hot southern climates, in this case Houston (ASHRAE Climate Zone 2). Again, the insulated foam sheathing kept the wall components drier during the two-year period.

Figure 5: STYROFOAM SIS™ Brand Structural Insulated Sheathing vs. Housewrap/OSB; % Moisture Content of Sheathing; Houston

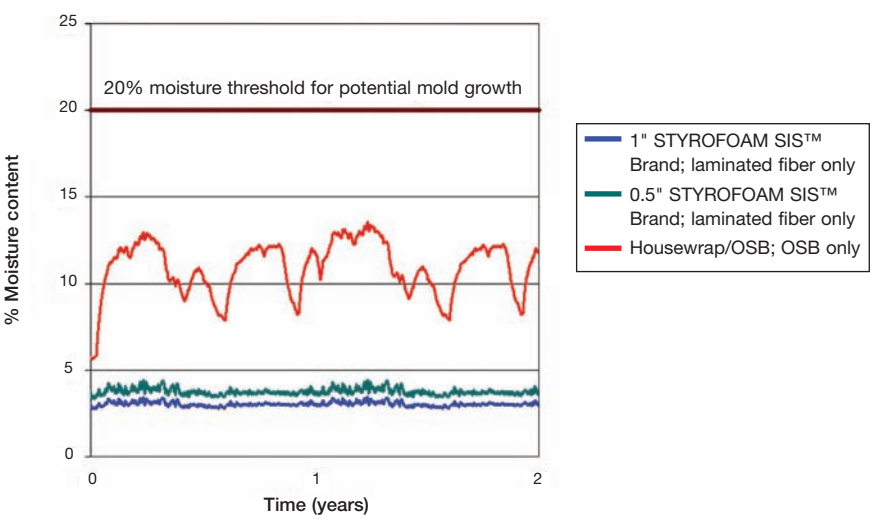


Figure 6: STYROFOAM SIS™ Brand Structural Insulated Sheathing vs. Housewrap/OSB; % Moisture Content of Gypsum Board; Houston

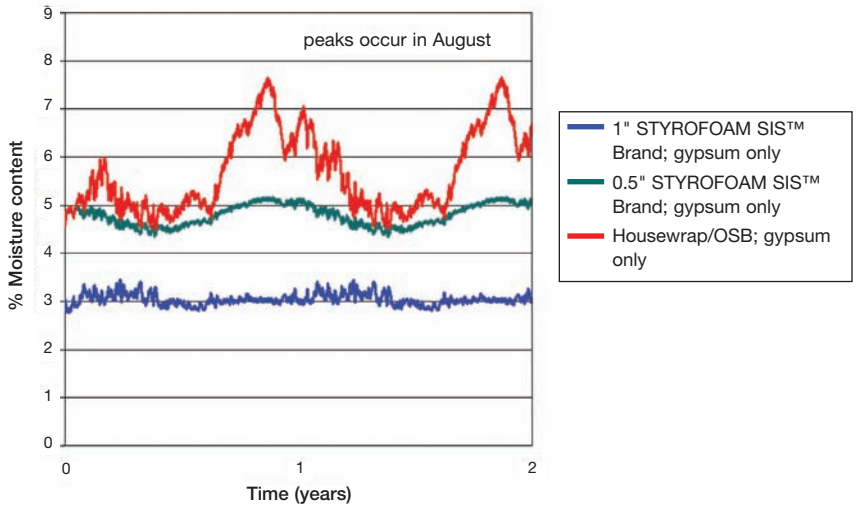


Figure 5 demonstrates that housewrap/OSB sheathing is much closer to the 20 percent threshold for potential mold growing conditions. So in hot climates, too, insulated foam sheathing demonstrates exceptional performance and is well under the 20 percent threshold.

Reduce Wall Condensation Potential with Insulated Sheathing

Figure 3 compares the moisture content within the actual sheathing material of each wall assembly. For STYROFOAM SIS™ Brand Sheathing, the moisture content is monitored inside the laminated fiber portion only. For the housewrap/OSB sheathing, the moisture content is monitored inside the OSB portion only. The laminated fiber and OSB are both wood-based materials that face the interior side of the stud cavity in their respective wall systems. This location is the most critical portion of the wall to compare because condensation is most likely to occur here, especially during winter months. The two peaks in the moisture content data shown in Figure 3 occurred during winter months when temperatures are coldest.

STYROFOAM SIS™ Brand Sheathing had exceptional performance not only in the winter months, but it exceeded the moisture protection performance of housewrap/OSB during the entire two-year period by a wide margin. Housewrap/OSB did not keep the wall components nearly as dry.

It is evident from Figure 3 that housewrap/OSB sheathing is much closer to the 20 percent threshold for potential mold growing conditions. Insulated foam sheathing demonstrates exceptional performance and is well under the 20 percent threshold.

Figure 3: STYROFOAM SIS™ Brand Structural Insulated Sheathing vs. Housewrap/OSB; % Moisture Content of Sheathing; Chicago

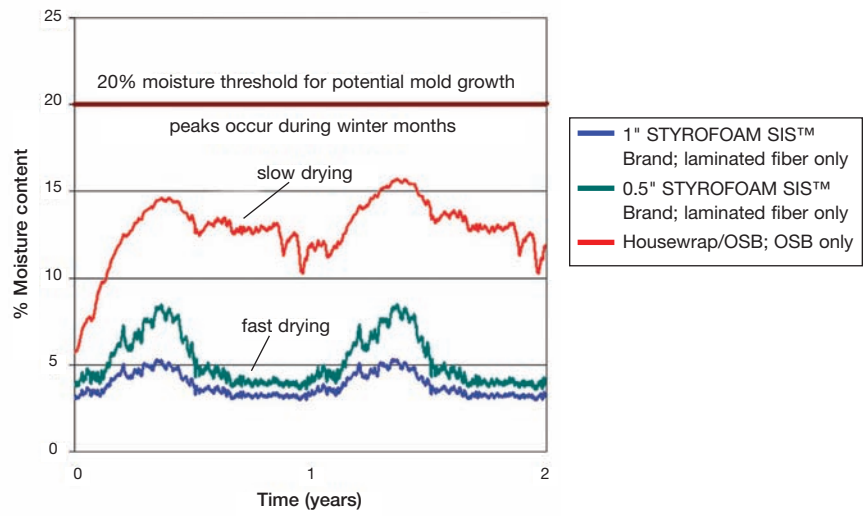
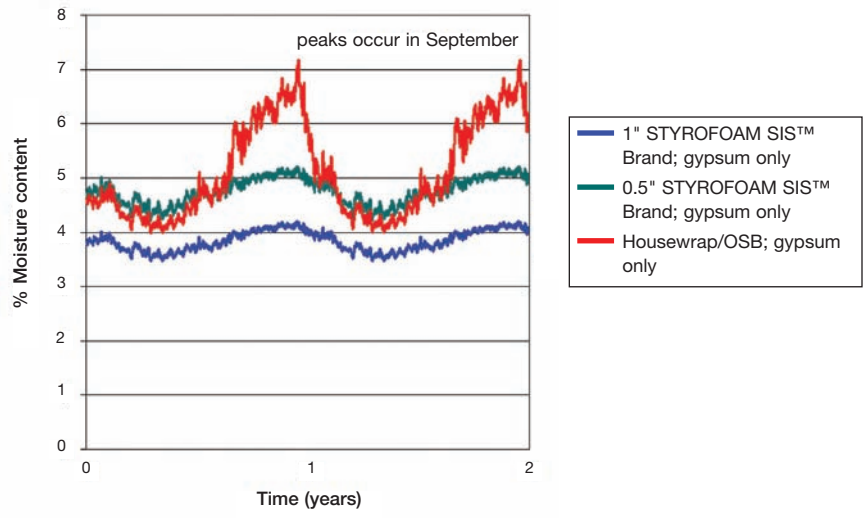


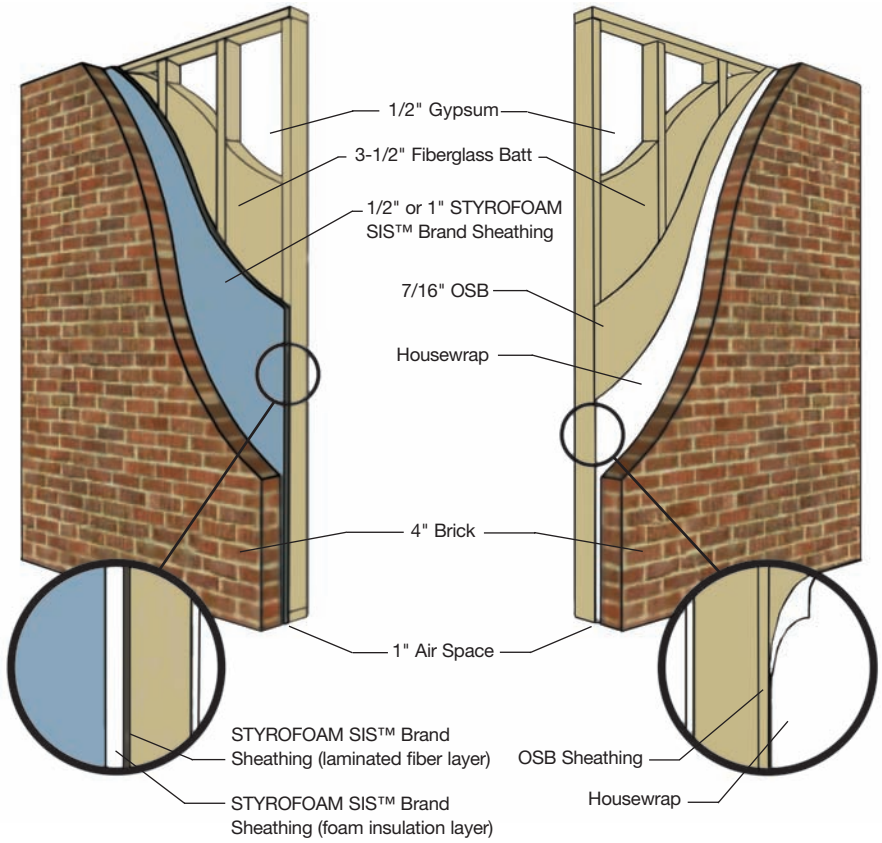
Figure 4: STYROFOAM SIS™ Brand Structural Insulated Sheathing vs. Housewrap/OSB; % Moisture Content of Gypsum Board; Chicago



The wall temperature of the sheathing's interior surface was also monitored during the two-year period. During the winter months, the interior surface of 1" STYROFOAM SIS™ Brand Sheathing was as much as 14°F warmer than the housewrap/OSB interior surface and the 1/2" STYROFOAM SIS™ Brand Sheathing was as much as 7°F warmer.

The higher wall temperatures within the wall assemblies featuring STYROFOAM SIS™ Brand Sheathing are principally due to the high R-value of the rigid foam layer. Higher stud cavity temperature is the primary reason the assemblies using STYROFOAM SIS™ Brand Sheathing had considerably lower moisture content.

Figure 2: STYROFOAM SIS™ Brand Structural Insulated Sheathing Wall Assembly vs. Housewrap/OSB Wall Assembly



Methodology

Two residential wall systems were compared using the WUFI ORNL[2] (PRO version 3.3) heat and moisture analysis tool for building envelope construction. WUFI is recognized as a highly advanced method of hygrothermal modeling by North American organizations such as ASHRAE (American Society for Heating, Refrigerating and Air-Conditioning Engineers) and BETEC (Building Environment and Thermal Envelope Council). WUFI PRO modeling is well documented and has been validated by many comparisons between calculated and field performance data.

The wall systems compared were identical except for the sheathing materials. See Figure 2 for a detailed comparison. One wall system featured STYROFOAM SIS™ Brand Structural Insulated Sheathing. The other wall system utilized housewrap with OSB sheathing. Two climate scenarios, cold and hot, were modeled for each wall system.

Key inputs for the model were:

- Mean interior relative humidity: 40 percent with an amplitude of 10 percent
- Mean interior temperature: 70°F with an amplitude of 1.8
- Two coats of latex paint on drywall, 3 perms
- No interior vapor retarder (e.g., polyethylene)
- R-13 fiberglass batts; unfaced
- Housewrap, 58 perms
- OSB, <1 perm
- STYROFOAM SIS™ Brand Structural Insulated Sheathing is a multilayer product: facer, foam and laminated fiber layer
- Exterior STYROFOAM SIS™ Brand Sheathing facer, ≤0.3 perm

WUFI Results: Cold Climate Comparison

A comparison of the two wall systems was made in the northern cold weather climate profile of Chicago (ASHRAE Climate Zone 5). Except for the sheathing materials, all other factors were the same for both wall systems. The time period modeled was two years, with a start date of October 1. Three sheathing materials were modeled: 1/2" and 1" thick STYROFOAM SIS™ Brand Structural Insulated Sheathing and housewrap/OSB. The results are shown in Figures 3 and 4.

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Other Insulated Foam Sheathing Products

These results demonstrate the effectiveness of STYROFOAM SIS™ Brand Structural Insulated Sheathing. However, similar results can also be achieved with other continuous insulated foam sheathing products from Dow Building Solutions, such as:

- STYROFOAM™ Brand Residential Sheathing (extruded polystyrene)
- THERMAX™ Sheathing (polyisocyanurate)
- Super TUFF-R™ Insulation (polyisocyanurate)

Similar to STYROFOAM SIS™ Brand Sheathing, these products all have low water vapor permeance of ≤0.3 perm, and can be installed as a WRB. Typically, insulated foam sheathings are non-structural, although STYROFOAM SIS™ Brand Sheathing combines the benefits of continuous insulation, WRB and structural bracing into one product. STYROFOAM SIS™ Brand Sheathing is the only insulation product from Dow that can be used for lateral bracing.

Significance of Perm

Housewrap, at 58 perms, is generally considered an adequate way to manage moisture in residential walls. A common perception in the residential building industry is that high-perm housewrap makes the walls more "breathable," leading to better performance than low-perm insulated sheathing. Yet the comparison data presented here clearly show otherwise.

Why didn't the high-perm housewrap perform as well as the low-perm insulated foam sheathing in the analyses? The housewrap's perm was not a significant factor since the OSB has such a low perm at <1 perm. The housewrap's high perm does not help the wall "breathe," since the OSB determines the rate of water vapor diffusion to the outside. Both the housewrap and the OSB have very low R-values and do not have the ability to raise the temperature of the wall cavity to the same level of performance as can be achieved with insulated sheathing.

The end result is clear: Insulated sheathing provides exceptional condensation protection in residential walls because it raises the temperature of the stud cavity in cold weather, causing decreased condensation potential and increased stud cavity drying potential to the inside of the building. The sheathing R-value has a greater effect on thermal and moisture performance than permeance rating in this application.

Third-party Agreement

The following building scientists and researchers recognize the moisture protection advantage of insulated sheathing in wall construction:

The insulated effect of the foam sheathing does have the effect of keeping the stud cavity at a higher temperature during the winter than a similar cavity using plywood or fiberboard sheathing.
– USDA Forest Products Laboratory, Research Paper FPL 433

Use exterior insulating sheathing in place of or in addition to plywood or fiberboard sheathing to greatly reduce the chance for high wall cavity moisture levels and the long-term potential for wood decay.
– Northwest Wall Moisture Study, George A. Tsongas, Ph.D., P.E.

... laboratory tests showed that the addition of an exterior low-permeability insulation retrofit system would result in a reduction in the moisture accumulation within the existing wood siding and sheathing. These findings are consistent with the results of a limited field survey. The model showed that the addition of the exterior retrofit insulation system raised the temperature at the interface between the cavity insulation and the wood-fiber sheathing.
– National Bureau of Standards, Report DE-79-3 No. 3

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References

1. Southern Pine Council, “Managing Moisture and Mold” Product Performance Facts, www.southernpine.com/pdf/MOLDsheet0903_907.pdf
2. WUFI is a trademark of the Fraunhofer Institute for Building Physics in Holzkirchen, Germany. WUFI ORNL is jointly developed with the Oak Ridge National Laboratory in Oak Ridge, Tenn., and funded by the U.S. Department of Energy. WUFI PRO version 3.3 is commercially available heat and moisture modeling software. Note: Models do not guarantee actual field performance.

For Technical Information: 1-866-583-BLUE (2583) . For Sales Information: 1-800-232-2436
THE DOW CHEMICAL COMPANY . Dow Building Solutions . 200 Larkin . Midland, MI 48674
www.dowbuildingsolutions.com

NOTICE: Changes to the International Residential Code require the installation of a water-resistive barrier (WRB) within most exterior wall assemblies in residential construction. The following Dow insulated sheathing products qualify as a WRB when installed according to the installation instructions developed for “installation of foam sheathing as a water-resistive barrier”: STYROFOAM™ DURAMATE™ Plus, STYROFOAM™ Residential Sheathing, STYROFOAM™ Tongue and Groove, STYROFOAM SIS™, STYROFOAM™ Square Edge, STYROFOAM™ Residing Board, STYROFOAM™ High Performance Underlayment, THERMAX™ Sheathing, TUFF-R™ and Super TUFF-R™ and therefore do not require the use of a building paper or a housewrap as a WRB. When a WRB is not needed, these Dow foam sheathings may be installed according to standard installation instructions for foam sheathing from Dow. Be sure products and installation instructions meet code requirements for your particular location. Note: WEATHERMATE™ and WEATHERMATE™ Plus Housewraps have already qualified as water-resistive alternatives to the prescribed felt (see Evaluation Reports NER-593 and NER-640 for approved alternative).

STYROFOAM™ Brand Extruded Polystyrene Insulation
CAUTION: This product is combustible. Protect from high heat sources. A protective barrier or thermal barrier may be required as specified in the appropriate building code. For more information, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400.

Dow 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, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400.

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

Building and/or construction practices unrelated to building materials could greatly affect moisture and the potential for mold formation. No material supplier including Dow can give assurance that mold will not develop in any specific system.

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