Drain and Dry Your Walls Fast

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Study after study has shown that water is the most significant factor in the premature deterioration of buildings and that rain is the leading cause of water problems in walls. Yet water problems can be eliminated through proper design and construction.

This paper outlines how to prevent moisture problems in walls by successfully using the "**6-D**" strategies of wall design:

Deflection: using features of the building to limit exposure of the walls to rain, such as overhangs and drips.

Drainage: using design features that provide a means to direct water that does penetrate the wall back to the outside.

Drying: using features that facilitate the drying of materials that get wet.

Durability: using materials that are tolerant of moisture.

and

DELTA®-**D**RY: an innovative water resistive barrier and drainage membrane from Cosella-Dörken intended to replace the building paper or house wrap in conventional wall construction.

The First 4-Ds of Wall Design: Deflection, Drainage, Drying and Durability

Deflection

Keeping rain off a wall (*Deflection*) is the most obvious way to prevent water penetration – no water, no problem. Unfortunately, methods to accomplish that are not so obvious. While the use of overhangs and the protection afforded by adjacent buildings will help deflect some rain from the wall, there is no way to keep it all away. Walls must be designed to get wet.

The face-seal approach to wall design assumes that the exterior surface will be completely watertight for the life of the building, and could be considered a deflection strategy. However, this design approach has not proven reliable, as exterior seals must receive vigilant maintenance to assure performance.

Drainage

The control of exterior moisture requires an effective **water shedding surface** *and* an effective **water resistive barrier**. The term, “water shedding surface”, refers to the surface of assemblies, interfaces and details that deflect and/or shed the vast majority of water impacting on the wall. In the case of a vinyl-clad wall, for example, the *water shedding surface* would be the vinyl siding. The “water resistive barrier” is the surface furthest into the wall from the exterior that can accommodate some exterior water without causing damage to interior finishes or materials within the assemblies. In most conventional residential walls, this would be the building paper or house wrap. In a DELTA®-DRY wall, the *water resistive barrier* is the DELTA®-DRY, which is intended to replace the building paper or house wrap.

A wall designed with a separate *water shedding surface* and *water resistive barrier* accepts the reality that water will get into the wall past the *water shedding surface*. These walls, referred to as “Drained Cavity Walls”, incorporate an air space or free-draining material, such as DELTA®-DRY, in the wall assembly between the *water shedding surface* and the *water resistive barrier*. Water that penetrates the *water shedding surface* is prevented from going deeper into the wall horizontally by the *water resistive barrier* and gravity is relied upon to cause *Drainage* of the rainwater before it can cause deterioration of the more sensitive inner wall materials. Internal flashings at the bottom of the cavity direct the water out of the wall assembly through weep holes.

Drying

To prevent damage, any moisture that gets into the wall assembly that cannot be drained quickly, must be able to *Dry* before it causes deterioration to the materials in the wall assembly. Material deterioration and mold growth are related to the type of material, how wet the material is allowed to get, and to how long it remains wet. Therefore, walls should be designed in such a way that they incorporate materials that resist deterioration and are able to dry as quickly as possible.

Moisture within the wall assembly can be removed from either the inside or outside surfaces through evaporation, diffusion (the movement of vapor due to a difference in relative humidity or vapor pressure) and air movement. Air movement is recognized as a much more powerful moisture transport mechanism than diffusion through a surface. This is the key advantage of DELTA®-DRY over traditional building paper or housewrap. While the DELTA®-DRY material itself is both air and vapor impermeable, its contoured surfaces and the manner in which it is properly installed provide air channels on both sides, providing improved drying capability.

Durability

Durability can be achieved by designing and constructing walls according the principals discussed above, and by using materials more resistant to moisture and mold. Some materials are inherently more durable than others. For example, aluminum or other properly painted metals are generally more durable than wood-based products or materials such as sealants or gypsum board. In design, consideration should be given to the placement of less durable materials that will require repair or maintenance such that these materials are more readily accessible.

Durability by design also involves the use of assemblies and details that incorporate some redundancy. DELTA®-DRY, while inherently more durable than many other products, also provides redundancy of design by providing *two* drainage layers.

So what is DELTA®-DRY?

DELTA®-DRY is a water resistive barrier and drainage membrane with unique properties. Formed from silver-colored 0.55 mm thick High Density Polyethylene (HDPE) into a studded sheet, DELTA®-DRY has an overall thickness of about 7.5 mm. The "studs" are located 41 mm on center, in rows half that distance apart. Each stud is approximately 6 mm high on its convex side and is connected in four directions to adjacent studs by channels approximately 3 mm high. DELTA®-DRY comes in rolls 39 in. wide and 50 ft. in length. Unlike many typical drainage sheets, the stud and channel profile (patent pending) of DELTA®-DRY provides independent drainage spaces on *both* sides of the sheet, interior and exterior.

How Does DELTA®-DRY Work?

DELTA®-DRY is intended to replace the building paper or house wrap in a conventional wall design to provide a unique approach to managing both moisture from outside and moisture from inside in order to protect the wall cavity against moisture damage.

DELTA®-DRY is impermeable to water; its water penetration resistance is 118 psi, which is the equivalent of a column of water over 80 m high, and in a water ponding test, no water seepage was observed (based on testing performed by Bodycote Materials Testing Canada Inc., Mississauga, Ontario). Therefore, any water getting past the exterior cladding is prevented from penetrating any further into the wall assembly to the materials more susceptible to moisture deterioration. The contoured design provides drainage channels for any such water to be directed by gravity to the bottom of the wall and out of the assembly. In the case of walls with absorptive exterior claddings, such as masonry or stucco, the channels in the DELTA®-DRY also provide improved drying capability compared to traditional house wrap.

Building paper and house wraps are generally required to be permeable to water vapor to allow moisture from within the wall assembly to dry to the outside of the wall. Drying to the inside of the wall is not possible in walls designed for cold or mixed climates due to the presence of a vapor barrier on the warm side of the insulation. Unlike typical house wraps, DELTA®-DRY is designed to be impermeable to water vapor to prevent the problem of solar-driven moisture entering the wall cavity; its water vapor transmission is only 1.2 ng/Pa.s.m^2 as measured by Bodycote Materials Testing Canada. Yet, it still allows drying of interior moisture to the exterior through the air gap on the studded side of the membrane. In fact, this drying mechanism has been proven, through laboratory testing at the University of Waterloo (U of W) in Waterloo, Ontario, Canada and through computer simulations at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, U.S.A., to be superior to that of traditional building paper.

Performance Characteristics of DELTA®-DRY

Improved Drainage Capacity

The drainage capacity of a wall using DELTA®-DRY as the Water Resistive Barrier (WRB) was compared to the drainage capacity of a conventional wall using #15 felt sheathing paper as the WRB. Mock-up vinyl-clad walls were constructed at U of W and a known quantity of water was applied to the top of each wall between the sheathing board and the WRB. The amount of water that drained out of the walls was measured.

Both walls drained very well. Even at the relatively high rate of application (one liter per minute), water exited within seconds of entering the top of both walls. But overall, the DELTA®-DRY wall performed better, retaining less water than the conventional wall due to the small amount of absorption into the #15 felt. The drainage from the DELTA®-DRY wall was so high that professional engineers that evaluated the product expect it to perform at least as well as a conventional strapped cavity system.

Superior Wall Drying Capability

After each drainage test, the walls were gravimetrically monitored to see how quickly the water stored in the drainage gap and adjoining materials could dry. In the first set of tests, a fan was used to simulate the ventilation effect of a light, 5 km/hr wind. In the second test, a heat lamp was used eight hours a day for several days to simulate the cycle of daily solar radiation. In both situations, the DELTA®-DRY wall dried faster than the wall with #15 felt sheathing paper.

Under the simulated ventilation, the DELTA®-DRY wall dried to an equilibrium moisture content of approximately 100 g in just over one day, whereas the #15 felt wall took six days to reach an equilibrium moisture content of 150 g.

Under simulated solar heating, the DELTA®-DRY wall dried four times *slower* than with the wind-driven ventilation, taking just over four days to reach an equilibrium moisture content of 100 g. The #15 felt wall showed a similar increase in drying time under solar heating compared to the ventilation drying. These results clearly indicate that the ventilation from even a small wind pressure can result in more drying than a moderate amount of solar heating.

Wall Drying Capability with Absorbent Claddings

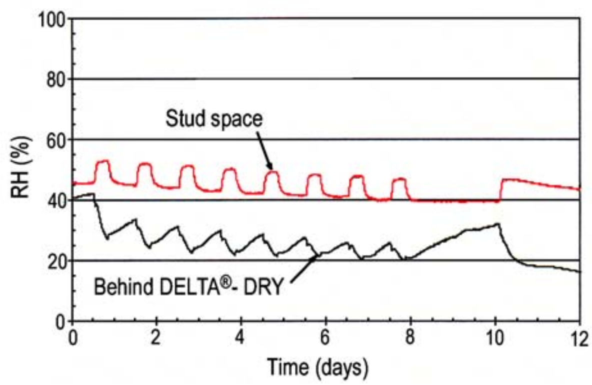
Walls with absorbent claddings, such as brick, stucco, and wood, can store significant quantities of rainwater. To assess the performance of DELTA®-DRY with a more absorbent cladding, two additional drainage and drying tests were conducted using walls clad with Hardipanel® (a fiber-cement board). Both the wall with DELTA®-DRY and the wall with #15 sheathing felt initially stored a significant amount of water in the cladding. However, the drying rate of the DELTA®-DRY wall was again faster than the wall using the sheathing paper (117 g/day vs. 109 g/day).

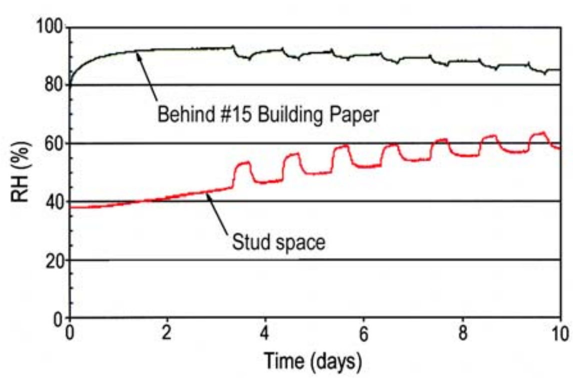
To quote the research report from U of W, "it is clear from even these results that the DELTA®-DRY membrane is both well drained and well ventilated. When tested with both vinyl siding and a monolithic absorbent cladding (like stucco) the walls with DELTA®-DRY drained just as quickly, retained slightly less water, and dried more quickly under both wind driven and solar drying than walls with #15 felt."

Prevention of Summertime Condensation

During warm weather, especially when the sun heats the surfaces of the wall, the vapor pressure can be higher on the exterior side of the wall, driving moisture to the inside of the wall and causing dangerous summertime condensation within framed walls. As present-day construction methods do not allow walls to easily dry inwards, water can become trapped within the wall system making drying slow or impossible and creating conditions conducive to mold growth.

To evaluate the ability of DELTA®-DRY to prevent the inward flow of sun-driven moisture, the relative humidity in the stud space and behind both the DELTA®-DRY and the sheathing membrane was measured during the solar drying tests conducted at the University of Waterloo. The results of these tests are shown in the graphs below.





As can be seen, the moisture conditions of the two walls are very different even though the laboratory conditions are equivalent. Behind the DELTA®-DRY, the relative humidity drops over the test period as the solar heating dries the sheathing board (OSB). Each time the heating lamp is on, the relative humidity in the stud space increases, but over the duration of the test, the relative humidity in the stud space is dropping. This indicates that drying is occurring.

On the other hand, the relative humidity in the stud space of the wall with the #15 felt sheathing paper climbs to very high levels and the relative humidity behind the sheathing paper rises steadily as moisture transfers from the cladding, through the sheathing paper, into the wood studs.

As stated in the U of W test report, “it is clear that DELTA®-DRY essentially eliminates inward vapor diffusion from wetted cladding heated by the sun. As experienced in other field and lab experiments, #15 felt will allow diffusion to flow inward and increase the moisture content of the sheathing and studs.”

Removal of Construction Moisture

Construction moisture is that which is given off by new construction materials, such as wood or concrete. Since there is little that can be done to totally eliminate construction moisture, it is important that consideration be given in the design to allowing the construction moisture to escape from the wall to the exterior before it can cause deterioration of other wall materials. For example, wood studs should not be enclosed in a double vapor barrier, such as polyethylene film on one side and EPS insulation on the other. The polyethylene and EPS would limit the opportunity for the wood to dry, and if it can’t dry, deterioration will occur. With conventional sheathing membranes, the very property that resists inward diffusion, also resists outward diffusion, the primary drying mechanism through the sheathing membrane. Fortunately, DELTA®-DRY offers a perfect solution to construction moisture. The drainage and drying layer adjacent to the sheathing board provides a ventilation space for the removal of construction moisture from within the wall space.

Removal of Condensation Caused by Exfiltration of Interior Moisture

Interior moisture is generated by the people living in the building – from perspiration, respiration, and activities, such as bathing, clothes washing, or cooking. Interior moisture is normally prevented from entering the wall assembly through the use of an air barrier and a vapor retarder. The functions of the air barrier and the vapor retarder are sometimes confused, especially as a single material is often used to provide both functions. The function of the air barrier is to stop air flowing into or across the building envelope. Preventing this air flow is crucial in controlling interior moisture because of the moisture that is carried within the air. The function of the vapor retarder is to resist the movement of moisture through vapor diffusion – the movement of water molecules due to a difference in vapor pressure. Moisture migration via vapor diffusion is much less significant than that via air movement.

If either the air barrier or the vapor retarder is not properly installed or performing its function, interior moisture can enter the wall system. When this happens in cold climates during the winter season, the moisture will condense inside the wall assembly. Unless the wall is designed so that it dries quickly, deterioration of the wall materials may occur.

The contoured interior surface of DELTA®-DRY provides a second drainage layer. Any water vapor that condenses on the inside surface of the DELTA®-DRY will be carried by gravity to the bottom of the cavity and directed out of the wall by flashings. This second drainage layer also acts as a ventilation channel to help promote drying of the wall.

Resistance to Changes in Properties Under Environmental Loads

The HDPE sheet from which DELTA®-DRY is fabricated is stabilized against oxidation in a similar way to DELTA®-MS, a product used for drainage of foundation walls that has been sold for over 30 years in Europe and over 10 years in North America. DELTA®-DRY is also stabilized against UV degradation. There is a long history of the durable use of HDPE material in building construction. Therefore, DELTA®-DRY is expected to remain very durable in wall construction.

Cosella-Dörken provides a 20-year product warranty that states, "DELTA®-DRY will not decompose or degrade when installed according to Cosella-Dörken's installation guide. Cosella-Dörken will replace any defective DELTA®-DRY for a period of 20 years from the date of installation".

Resistance to Fire

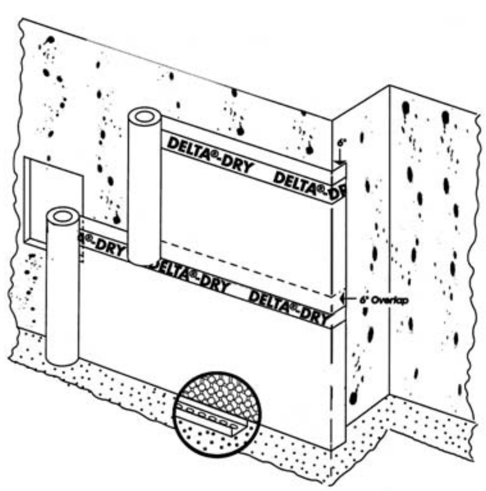
The flame spread and smoke development characteristic of DELTA-DRY were evaluated at Underwriters' Laboratories of Canada (ULC) in Toronto, Ontario, to both Canadian and U.S. test standards. The results are shown below:

CAN/ULC-S102.2		ASTM E-84	
Flame Spread	Smoke Development	Flame Spread	Smoke Development
210	105-190	275-334	400-450

These values are relatively low values for plastic materials and DELTA-DRY could be considered a minor combustible component.

Simple and Easy Installation

DELTA®-DRY is installed after the installation of the exterior sheathing board but before the installation of the windows and doors. In the case of a wall with vinyl or other siding material, a drainage track with weep holes is installed along the entire bottom perimeter of the wall. In the case of a masonry wall, the DELTA®-DRY is wrapped over the brick-ledge to provide drainage and ventilation. Flashing with a drip edge is installed above window and doors openings.



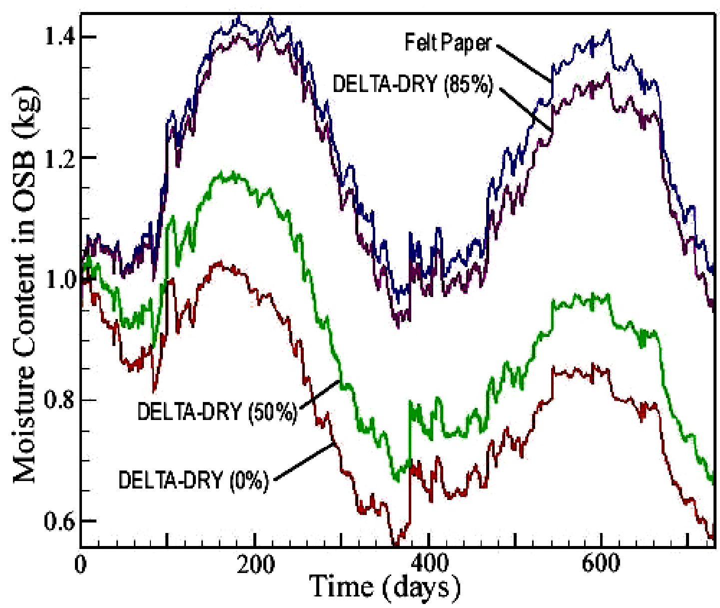
After the simple wall preparations are complete, the DELTA®-DRY is unrolled and fastened to the sheathing using ½ in. corrosion resistant, large head (roofing) nails or ½ in. by ½ in. staples spaced every 12 in. to 16 in. apart. It is installed with the convex side of the studs to the wall interior. The DELTA®-DRY should be unrolled directly over window and door openings. It is then easily cut with a utility knife along the perimeter of the window and door openings. Because the material itself is stabilized against UV degradation, there are no durability concerns for the limited time it will be exposed to UV during construction.

The DELTA®-DRY must be continuous around all wall corners with an overlap of at least 6 in. beyond any corner. To maintain the installation plane and tightness of the overlap, the studs of the overlapping sheets must be interlocked. Vertical joints between sheets must be overlapped at least 6 in. (about 5 studs in a row or 7 off-set studs) and horizontal joints must be overlapped at least 3 in. (about 3 studs in a row or 5 off-set studs). The bottom sheet should be shingled over the vertical leg of the drainage track, and upper sheets should be shingled over the bottom sheet so that any water draining down the surface will be properly directed to the exterior.

Ensuring the Drying Capabilities

The top and bottom edges of the DELTA®-DRY must be kept open so that both the interior and exterior spaces are drained and ventilated. However, in anticipation that some blockage may occur in actual construction, hygrothermal computer simulations were run at Oak Ridge National Laboratory (ORNL) to determine the effect of such blockages. Hygrothermal simulations consider the combined heat, air and moisture performance of the wall system.

Using MOISTURE-EXPERT, a state-of-the-art hygrothermal model, yearly simulations were performed using hourly weather data for a range of climates, including Toronto, Seattle, Atlanta, Baton Rouge and Norfolk. The hourly weather data used in the simulations is what is known as a *Moisture Design Year* (MDY). From thirty years of hourly data, two weather years were developed, one that coincides with the 10^{th} percentile coldest year and one that coincides with the 10^{th} percentile hottest year; the influence of rain load was included in the analysis to determine the hygric loads and to establish the MDY.



First, the computer model results were compared to the laboratory test results obtained at the University of Waterloo; good agreement was found between the lab and model predictions. As can be seen in the adjacent graph of the Toronto results for a brick wall, the moisture content in the sheathing board (OSB) of the DELTA®-DRY wall with 0% blockage was up to 40% lower than the moisture content in the building paper wall. The model was also run assuming a 50% blockage and an 85% blockage of the second cavity (between the DELTA®-DRY and sheathing board). Even with 85% blockage, the DELTA®-DRY performed as well as the wall with #15 felt paper. Similar results were obtained for the other climate centres, although the disparity between the performance of the DELTA®-DRY wall and the sheathing paper wall was naturally not as great in warm and hot climates as in cold to mixed climates.

To quote the research report from ORNL, “an extensive improvement in moisture management has been proven when employing DELTA®-DRY as a weather resistive barrier in the wall for most climates. DELTA®-DRY is able to outperform conventional building paper by far in regards to drying performance of the wall cavity”.

Installed Performance

Effect of Fastening on Water Intrusion Resistance

The concern often arises that the use of fasteners that penetrate a *water resistive barrier* may compromise its water intrusion resistance compared to a system that uses strapping or cladding loosely fastened to the backup. In the case of DELTA®-DRY, the nature of the pattern of studs and channels results in a drainage space, either on the interior or exterior of the DELTA®-DRY sheet, at all fastener locations. The combination of this feature and the impermeable nature of the plastic sheet leads to the expectation that fasteners would have much less impact than with more conventional sheathing membranes in both strapped and unstrapped applications.

Compressive Strength

Compressive strength tests conducted at Bodycote Materials Testing Canada demonstrated that a load of 5 kPa (100 psf) compressed the material by about 10%. It took a load of 30 kPa (600 psf) to compress the material by 25%. The drainage capabilities of the product will not be affected by compressive loads normally expected on site. Further, there is extensive empirical evidence from years of experience that drainage materials with less compressive strength than DELTA®-DRY, when used as a shingle and siding underlay, can resist nailing forces and retain fastener effectiveness against wind and gravity loads on steeply pitched roofs.

Effect on Structural Loads

The DELTA®-DRY membrane itself will not support shear forces, so fasteners for the cladding will be cantilevered out by the thickness of the DELTA®-DRY and subject to some bending load. This is not an unusual situation. There is a long history of successful fastening of cladding though non-structural sheathings, such as fibreglass, semi-rigid fibreglass, and foam, all of which are far thicker then DELTA®-DRY. Therefore, fastening the cladding through the DELTA®-DRY material is not expected to negatively affect how structural loads (gravity, wind and seismic) are carried by the fasteners and substrate.

In Summary

The DELTA®-DRY weather resistive barrier and drainage membrane has been proven through laboratory testing and hygrothermal computer simulations to outperform a conventional sheathing membrane with respect to:

- Drainage
- Drying
- Prevention of inward moisture transfer, and
- Removal of interstitial moisture.

The unique stud and channel design is the key to the success of the product’s performance. The University of Waterloo test results showed that the ventilation from even a small wind pressure can result in more wall drying than a moderate amount of solar heating, and as stated by ORNL, “the ventilation on both sides of this weather resistive barrier has shown enhanced drying performance.”

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