"Rainscreen" Description Manual

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HISTORY

Almost all residential and many commercial buildings constructed since the mid 1980's are suffering water intrusion problems, in many cases resulting in the complete rotting out of the exterior building envelope. In most cases this damage is not immediately visible since it is hidden by the siding or other cladding. The widespread nature of the problem has only become evident over the past few years as investigations have included the removal of cladding to check on the condition of the building envelope. In addition, moisture meters have been used to determine possible problem areas hidden behind siding, rather than relying on a purely visual inspection of the exterior.

Typical Balcony Corner and Railing Attachment Before Inspection

Balcony Damage Where Flashing and Railings Were Removed After Inspection

Most residential multi-family dwellings are constructed in such a way that the cladding is required to act as the waterproofing membrane for the building exterior. The cladding types often vary throughout the building and are invariably penetrated by windows, ducts, electrical fixtures, railings, etc. In most cases, there has been a heavy reliance on caulking to seal these penetrations and material transitions. In addition, there has been an increasing use of flexible membrane (peel & stick) to seal some components such as windows. Unfortunately, this additional sealing does nothing to prevent water entering behind these barriers via the internal structure of the window itself, e.g. screw holes, mitered corners of the frame, seals, etc.

Wood Rot Discovered Behind Siding beneath Windows

In many cases the sealants act to wick moisture into the fabric of the building or prevent water from draining out. This type of design, where the exterior cladding and associated caulking etc., is required to prevent water intrusion is known as a ***face sealed system*** and is the basis for most current housing designs**.**

The question is often asked about why much older buildings do not seem to exhibit the same degree of damage from water leakage as their modern counterparts. The answer appears to be that prior to 1985 there was so much air leakage through the building envelope that any leaks tended to dry out very quickly. In addition, because buildings tended to be not well sealed, it was rarely possible to generate the kind of partial vacuums or negative pressures which today play a large role in physically drawing water into the building. However, due to energy conservation requirements, we are obligated to continue designing these structures with a low air leakage rate.

RAINSCREEN CONSTRUCTION

The extensive nature of the leakage problems and the resulting structural damage during the 90's has caused a great deal of investigation and some major changes in the design approach taken for some new buildings. These new design techniques have a history in theory of over 50 years in North America and a practical application of approximately 10 years. The buildings constructed using these techniques for the past several years are performing extremely well and exhibit none of the problems associated with the previous generation of buildings. It must also be said that the concept behind this new design technique has been well known elsewhere in the world for decades.

The new design concept for the building envelope provides for a cavity between the exterior cladding and the main structure of the wall. This cavity allows for free drainage of any water which may penetrate the cladding, an air space to provide rapid drying, as well as a means of ensuring pressure equalization across the cavity to prevent water being drawn into the building itself. The accepted minimum width of this cavity is ½" to ¾". This cavity can be provided in many ways, the important feature being that it should allow for free drainage and air drying potential while limiting the overall size of cavity created.

In the case of these buildings, a cavity is formed by attaching the cladding to pressure treated 1x4 vertical wood strapping attached to the sheathing of the building. A cavity was not needed behind the cedar shingles, as cedar shingles breathe well naturally without the addition of an air gap between sheathing and shingle.

This new type of cavity construction is generally known as a ***Rainscreen***. The design concept accepts that leakage will occur but that it will be redirected to the exterior.

CLIMATE CONDITIONS

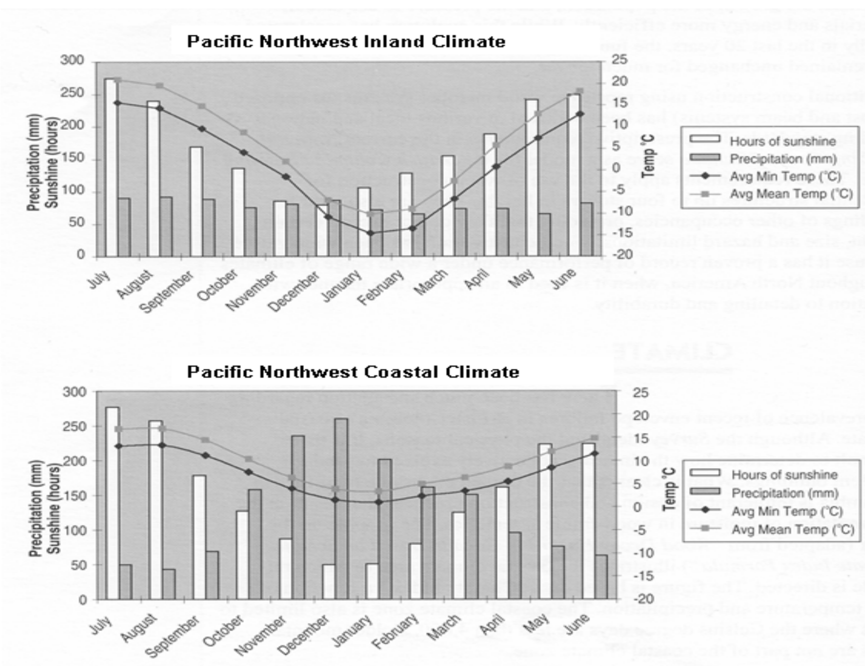
Our coastal climate in the Pacific Northwest has unique attributes and nuances that make it unique in North America from a building envelope design standpoint.

Clearly an end result of our climate type is that it is intolerant of design and construction practices that result in the accumulation of moisture in wood frame or steel frame assemblies.

The following attributes of climate have an impact on performance of building envelopes in our coastal regions.

- The frequency and intensity of wind driven rain is a determining factor in the amount of rain entering from outside.
- The difference between indoor and outdoor temperature helps determines if and where condensation can form on the interior of the structure.
- The drying potential and vapor transfer flow is determined by the amount of sunshine, humidity, and temperature.
- The outer temperature determines the temperature in the outer materials of the structure. Fungal decay of wood or proliferation of mold colonies will not progress unless the temperature and humidity are within certain ranges.

Our specific Pacific Northwest climate that is subject of this manual is our Coastal climate and not the Interior climate. **Table I** compares our coastal climate with our inland climate. One can notice immediately the differences in winter precipitation and temperature extremes.



The winter months in the coastal climate are characterized by most of the rainfall and very little sun. Wetting exposure of a building is high and the drying potential is low.

The moderate temperatures reduce the potential for condensation to occur but conversely allow fugal growth to occur even in winter.

Table 1

The occurrence of wind driven rain in coastal climates is much higher than that for inland climates. There is almost always a directional component to exposure to wind driven rain. It is generally not advisable to design certain elevations of a building differently for different exposure conditions. The exception to this rule would be the high exposure condition associated with an elevation directed toward an ocean or large body of water where additional protection from moisture may be warranted.

This combination of climate factors sets the priorities for building envelope design in the Pacific Northwest:

1. The most important wetting mechanism to address is rain penetration.
2. There is little ability to dry assemblies through vapor diffusion, (especially in winter), so the ability to drain water that gets past the outside cladding and allowance for airflow in a cavity is very important.
3. Condensation from interior sources is a less important factor than it is for colder inland climates.

Insulation levels should always be dictated based on specific building requirements. In general, the coastal climate will require lower insulation levels that the inland climate.

AIR & VAPOR BARRIERS & VENTILATION

In order to keep a building from structural decay and eventual failure, the building must be kept dry. To keep a building dry requires careful attention to the components used to construct the building, their properties, function, and installation. The major components of Rainscreen construction in keeping water out of a building structure are the air barrier, the vapor barrier, and the water resistant barrier. These elements are the key materials in the success of a Rainscreen assembly.

VAPOR RETARDERS AND AIR BARRIERS

Water vapor moves through building enclosures in two ways. 1) It diffuses through solid materials, and 2) It is carried by air currents through cracks and openings. Vapor retarders are designed to impede the flow of vapor by diffusion. Air barriers prevent the movement of air into the wall assemblies where it may condense**. If uncontrolled air movement has stopped, so has the large majority of water vapor movement.**

VENTILATION

Moisture levels inside buildings can be reduced by direct ventilation to the exterior of bathrooms, clothes dryers, and gas appliances such as stoves, and water heaters. During the winter, moisture levels can be diluted by the exchange of indoor moisture laden air with dry outdoor air. Dilution usually occurs in older buildings through natural air changes (uncontrolled infiltration and exfiltration), but in newer construction, it occurs through mechanical ventilation by fans or blowers. Dilution through air exchange is only possible when outside air is dryer than the inside air. The air moisture differences are greatest in the heating season. Air circulation at the inside surface of exterior walls can also help control surface condensation on walls and windows. When air movement is obstructed by draperies or other window treatments, condensation is more likely to occur. This can allow mildew to form in some circumstances. As the moisture in the interior air is reduced, the vapor drive is also similarly reduced thus decreasing the potential for condensation in the wall assemblies.

AIR BARRIERS

The purpose of an air barrier in any building assembly is to restrict the amount of airflow between the interior and exterior of a wall. If installed correctly, the air barrier will limit the potential for heat loss and condensation through and in the wall cavity. To achieve this restriction, the air barrier must be impermeable to air flow, must be adequately supported or rigid in itself to prohibit movement, must be structurally sufficient for the amount of air pressure forced upon it, and most importantly, an air barrier must be continuous. With regard to air barriers, the areas of general concern include any location where a break may occur, such as where the exterior walls meet floors and roofs, window openings, and any penetrations through walls for electric boxes and the like.

It is of note that up to 90% of vapor transmission through an assembly is through air flow and not by diffusion. Controlling air leakage therefore also has a large effect on vapor transmission and consequently condensation control.

Air barriers can be placed on the interior, exterior, or within the cavity of a wall assembly. As a general rule, providing an air barrier on the interior as well as the exterior is desirable. Placed on the interior, an air barrier prevents moisture filled air from moving into the wall cavity. A cavity air barrier is often dense insulation and is used for retrofit buildings. However, because of the difficulty of installation, qualified installers are hard to find for this type of barrier. Exterior air barriers, on the other hand, install relatively easily. The exterior placement of a continuous barrier not only limits the amount of moisture laden air from outside air to the interior wall cavity, but also controls wind-washing. Wind-washing on a wall can contribute to the growth of mold and mildew by creating cold spots in wall assemblies. It is therefore important to close of the cavity at building corners and other locations subject to high wind loads. In the case of cladding supported by clips, additional vertical battens are also required to the cavity size.

Air barriers can be made of several types of materials. The most common material used in the greater Pacific Northwest region is gypsum board. The use of this material is referred to as the Airtight Drywall Approach, or ADA. When sealed to the framing, this air barrier approach can also be referred to as the Airtight Sheathing Approach, or ASA. Polyethylene film can also be used in wall assemblies to create a continuous barrier where drywall is not sufficient. When this type of wall is constructed, it is called the poly-wrap approach. To seal the polyethylene air barrier at the interior to the top and bottom plates would create a Sealed Polyethylene Approach. Building paper can be installed as an air barrier over the exterior sheathing. This approach is referred to as the Exterior Sheathing Approach or Housewrap Approach.

No matter where the air barrier is placed or what material is used within the wall assembly, the barrier must be continuous to be effective. Careful installation must be employed to ensure that this occurs.

On this project, a modified airtight drywall approach is being taken. The air barrier is the drywall with openings around windows, etc. being sealed using expanding polyurethane foam acoustic caulk.

VAPOR BARRIERS

Just as the air barrier prevents condensation in a wall assembly, so does the vapor barrier. However, the vapor barrier limits the transmission of moisture through diffusion instead of strictly through air movement.

The purpose of a vapor barrier is to stop vapor from transferring from the interior to the wall cavity and condensing there, thereby encouraging mold growth and rot. In order to avoid this problem, the vapor permeability on the interior must be approximately three to five times that of the outside surface. A vapor barrier's effectiveness is a direct percentage of the surface area which it covers, 90% covered surface area means the barrier will be 90% effective. Continuity in a vapor barrier, therefore, has little bearing upon successfulness.

Placement of the vapor barrier is based on the climate of the building in which it is being installed. In a heating climate, the vapor barrier should be placed on the interior to prevent the warm, moist inside air from diffusing toward the cold outside air into the wall cavity to condense. In a cooling climate, exterior placement is most effective to create a barrier between the warm moist outside air and the cool air conditioning of the interior spaces. In the temperate climate of the greater Pacific Northwest, where the temperature and humidity difference is minimal between interior and exterior year-round, a vapor barrier has little function. However, a material with low vapor permeability should be placed on the interior of the wall assembly as a precaution to prevent any vapor movement to the wall cavity. Generally, a paint-on coating is sufficient as a vapor barrier for such a temperate region. Other materials used can include polyethylene films, aluminum foils, vinyl wall coverings, rigid insulation, sheet metal, damproofing, plywood, and waferboards.

WATER RESISTANT BARRIERS

Water or weather resistant barriers, also known as moisture barriers are, in contrast to the vapor barrier, very critical in wall assemblies of the Pacific Northwest. The water resistant barrier acts as the last line of defense against wind-driven rain penetrating the wall cavity.

The water resistant barrier is the furthest layer from the exterior that can accommodate moisture without incurring damage to the building and its structure. Ideally, a moisture barrier will have the ability to breathe as well as block water from passing through it. Because a vapor barrier is only as effective as the surface area that it covers, any moisture that does form in the wall cavity should have a way to evaporate to the exterior, thus moisture barrier breathability becomes important. One of the most effective breather membranes available is a Goretex® similar material called Roofshield/Vaproshield™ which can hold a head of water up to three feet and still allow air passage. The most common type, but not the most efficient, moisture barrier is building paper. Because building paper does not breathe freely and has a tendency to absorb moisture over an extended period of time, its effectiveness is severely limited in a wet region like the Pacific Northwest where materials have little time to dry out once wetted.

Roofshield/Vaproshield Water Resistant Barrier Application under pressure treated vertical strapping

However, practical experience has shown that when used in a cavity type Rainscreen assembly, even building paper has proved surprisingly satisfactory.

In this project, a layer of Roofshield/Vaproshield™ water resistant membrane was applied. The layer is installed in a minimum 6” vertical and horizontal lap configuration to create a shingled effect.

At a few locations, additional reinforcement is required for the paper and a flexible flashing material known as “Peel and Stick” or “Blueskin” may be used. As the terms suggest, it adheres to the paper and is normally blue in color.

FLASHINGS

Flashings are devices used to close off openings or to direct water away from vulnerable areas. They can be either metal (and therefore rigid), or they can be made from flexible materials which can easily conform to the surface to which they are applied. The most common type of flexible flashing is usually referred to as "peel and stick". Peel and stick is a rubberized asphalt sheet material which is self-adhesive on one side, although a primer is frequently needed, especially in damp or cold conditions.

Metal flashings are generally painted aluminum, painted steel, or galvanized steel sheet. 18 to 26 gauge sheet metal is preferred due to its rigidity although it is slightly harder to work than the most common 30 gauge materials used. 30 gauge material should only be used in non-visible locations or where long straight lines are not required, or where there is a possibility of their being damaged by incidental contact. Painted aluminum flashings can be used although their thickness should not be less than 20-22 gauge. In addition, aluminum should not be used in contact with materials such as concrete where corrosion is a possibility.

The principle types of flashings encountered in the building envelope are as follows:

THROUGH WALL FLASHING

- These flashings are usually placed at each floor level so as to break up the cavity behind the cladding into shorter sections so as to preclude a "stack effect" from occurring. The through wall flashing also provides a mechanism to effectively drain the Rainscreen cavity at frequent intervals.
- For the through wall flashings to be effective, it is necessary to ensure that the water resistant barrier placed on the sheathing of the wall assembly is properly lapped over the vertical leg of the through wall flashing. It is also generally required to place additional water resistant barrier between the metal flashing and the sheathing so as to minimize the possibility of condensation affecting the substrate below.
- Since the through wall flashing is an integral part of the Rainscreen, it is important to provide sufficient gap between the siding and the horizontal leg of the flashing so that water can drain freely out of the cavity. The minimum gap should be 1/8" and preferably ¼". Siding should not butt to the underside of the flashing and it is good practice to allow approximately 1/2" between the siding and the underside of the through wall flashing.
- The through wall flashing is usually placed at each floor level, providing the 1/2" gap beneath the flashing will allow for any frame shrinkage to occur without distortion of either the siding or the flashing itself. The lack of gap is the most common reason for flashings becoming back sloped and actually leading water into an assembly after the building has been completed.
- The through wall flashings act as a baffle and provide a mechanism to shed water away from the siding below, mitigating the possibility of staining. The

leading edge of the through wall flashings should be fitted with a vertical leg and a drip edge.

- The front vertical leg length should be at least 1/2” and this may or may not include a drip edge of 3/8”-1/2” in width. To provide adequate lap with the water resistant barrier, the back vertical leg should be a minimum of 4” in height.
- Because the through wall flashing is there primarily as a diverter rather than a water barrier, individual lengths of flashing may be simply lapped at joints, with the lap being caulked. However, a neater and stronger joint occurs when standing seams are used on the horizontal leg or when the two pieces are lapped with the front drip edge slotted into the adjacent seamed drip edge. Flashing lengths should be as long as possible and short add-on pieces are not acceptable either aesthetically or for practical purposes.
- While inside corners may be lapped, exterior corners should always be provided with a standing seam joint, preferably pre-manufactured. Lap joints are rarely satisfactory visually and tend to produce more staining than if a standing seam joint had been employed.
- The horizontal leg of the through wall flashing needs to have a slope of between 10 and 15 percent to allow for positive drainage and to guard against back slope occurring should untoward building shrinkage occur which would press the siding against the flashing.

HEAD FLASHINGS

Window head flashings are placed above windows and doors so as to protect the head of the window from direct driving rain as well as to enable drainage from the cavities above. These flashings are provided with end dams so as to prevent water from entering into the cavity on either side of the window. It is sometimes necessary to further seal this opening using caulking depending on the type of window surround chosen.

CLADDING TYPES & FURRING SYSTEMS

The first barrier to water intrusion in a Rainscreen system is the exterior cladding. The cladding is required to resist a number of physical stresses including wind seismic loading, temperature changes and moisture penetration as well as forces imposed on it by the building itself due to frame shortening, deflection etc.

By creating a cavity behind the cladding, the drying potential of the assembly is increased dramatically as well as greatly decreasing the pressure differential between the inside and outside of the building. The commonly accepted cavity width of ½”-3/4” is used as providing the minimum distance which water is unlikely to jump across due to pressure differentials.

The question is how to create this cavity? Many different ways have been tried and the only ones which have proved successful are those which provide either vertical strapping or individual clips to support the cladding.

There are a number of panel and board type cladding materials available which use aluminum or stainless steel clips to anchor the cladding to the building. These have the advantage that the contact area to the main wall is greatly reduced and usually they are hidden so that fasteners do not project through to the face of the cladding.

All fasteners used in the exterior cladding should be either stainless steel or hot dipped galvanized. In reality, only a small fraction of direct rainfall enters the cavity and the increased ventilation quickly dries it up. The potential for corrosion is therefore minimal, but because the consequences are severe if failure occurs, the difference in cost between plated and hot dipped or stainless steel is not being taken into account.

Attachment of all cladding to the battens should proceed as per a normal application onto a continuous sheathing. The difference is that all the fasteners are placed through the battens. If the attachments are designed to go into studs or solid blocking, then the battens also need to be placed at those locations. Normally most claddings are light enough to not require additional fasteners to take into account the additional load on the fastener due to it being longer.

WALL PENETRATIONS

Wall penetrations come in all shapes and sizes but in all cases they provide a means for water to enter the main wall assembly. Traditionally these penetrations, whether meter boxes or hose bibs, were simply caulked into the siding.

Because these caulking applications never provided a correct caulk joint format, the joints quickly failed, often without outward signs. Water would leak through these joints by capillary action and rot and mold issues would begin. The biggest problem was not that water entered the system; it was that water wasn't allowed to quickly evaporate.

As part of Rainscreen design these penetrations are required to prohibit water from staying in the assembly, draining out or drying out by exposure to air. Flashings also act as baffles to deflect rain from the wall penetrations.

Details generally include a through wall flashing above the penetration to deflect some water away as well as to drain the cavity above.
The penetrating box is either fitted with flanges which are placed onto the sheathing or is protected within a separate flanged box. The flanges allow the water resistant barrier to be properly shingled over the penetration.

The water resistant barrier is often further protected by a piece of flexible membrane placed over it behind the flanged unit, especially if there is a possibility of wind driven rain directly entering.

The exception to the flanged box, etc., is for hose bibs and small electrical outlets. These can be wrapped with peel and stick and flashed onto the water resistant barrier using more of the same. Plastic exterior type boxes should also be used. This is also one of those few occasions when it does help to caulk the penetration through the siding.