WHITE PAPER

Understanding Rainscreen Wall Systems

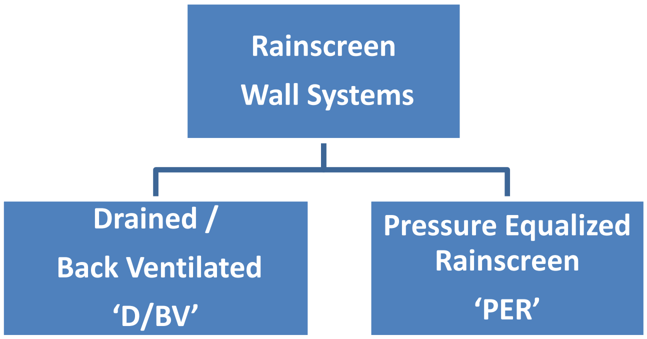
Introduction

Understanding Rainscreen Wall Systems was created to clarify the key principles and background information for **Drained/Back Ventilated** or **Pressure Equalized Rainscreen** wall systems. This should also act as a resource for the General Contractor, Code Official or Building Owner to explain how the design properties of these two systems accomplish water infiltration management and control. Both systems use some amount of open joinery and generally allow a limited amount of water into the rainscreen cavity area between the cladding and the air/water barrier. **Drained/Back Ventilated** (D/BV) systems rely on the rainscreen cavity to both drain and dry-out any residual water. **Pressure Equalized Rainscreen** systems (PER) also employ a rainscreen cavity, but add **compartmentalization** to minimize water penetration in areas such as building corners where wind pressures can increase significantly. In these areas, rainscreen compartmentalization facilitates rapid pressure equalization greatly minimizing, and in some designs eliminate, water penetration into the rainscreen cavity. Rainscreens may be designed as D/BV or PER systems using a variety of metal cladding materials such as Metal Composite Materials (MCM), Insulated Metal Panel (IMP) or single skin metal products.

This design method has become so extensively used in the last several years that an industry organization has been created. The Rainscreen Association in North America (RAiNA) has been created bringing together architects, component manufacturers, fabricators, and installation contractors to understand and facilitate development of this new style of cladding used on various construction project types around the world.

System designer concerns for moisture and the related consequences, such as mold and metal corrosion, have increased the demand for rainscreen wall systems which offer needed venting and drying potential while controlling rainwater. Since these wall systems are constructed from several components which must work as an assembly to obtain the desired performance, there is much confusion about how the components should be specified, contracted, and installed. This paper identifies some of the most common metal-faced rainscreen systems and the required performance features. Also reviewed are test protocols written by AAMA for testing both system types. The Metal Construction Association (MCA) is aware and concerned about the level of confusion and misinformation feeding the increased presence of Pressure Equalized Rainscreen metal-based cladding systems in the domestic commercial design and construction marketplace. If not corrected, this misunderstanding will result in structures with water and air leakage failures which will inevitably point back to the system suppliers. Only when the design and performance of rainscreen systems are understood as an acceptable standard of quality for the industry will the threat of failure, via an unexpected volume of water in the rainscreen cavity, be dramatically diminished. This requires proper design, detailing, fabrication, testing, and installation. As an extreme example, although too commonly seen, rainscreen systems should never be applied to horizontal or skyward sloping surfaces. The open joinery typical of rainscreen systems simply cannot control the buildup of water on non-vertical surfaces that is common with rain-producing weather events. An alternate means of water control must be used for these surfaces. (Soffit applications would generally be acceptable since there is no real wetting potential.)

It should be noted that the performance of all D/BV and PER systems rely upon a properly detailed and installed air/water barrier that is appropriate for the project climate zone. It must also be assumed that in all air/water barriers, a certain level of imperfection will exist resulting from typical rainscreen installation. Air/water barrier imperfections create a worst-case assembly that can reduce pressure equalization. This condition is recognized within both rainscreen testing standards: AAMA 508-14, 'Voluntary Test Method and Specification for Pressure Equalized Rainscreen Wall Cladding Systems' and AAMA 509-14 'Voluntary Test and Classification Method for Drained and Back Ventilated Rainscreen Wall Cladding Systems'.



Rainscreen Wall Systems

Rainscreen wall design consists of two distinct components: ***cladding assembly (panels and joints) and an air/water barrier with exterior sheathing support***. Additional elements such as a rainscreen cavity and the potential use of exterior insulation are also common, however the cladding and the air/water barrier are the critical installation components. The cladding sheds and controls most of the rain water and the joint design creates openings which allow the removal of water and the rainscreen cavity to equalize with the ambient pressure. This pressure equalization eliminates the force that pulls water into the rainscreen cavity. This force is a result of a pressure difference across the cladding. The more joint openings, the easier it is to achieve pressure equalization. However, more joint openings will also allow a greater chance of rainwater entry through means other than pressure difference across the cladding. The ***air/water barrier with exterior sheathing support*** performs multiple functions including:

- Acting as a water barrier
- Acting as a vapor barrier
- Acting as an air barrier
- (Potentially) contributing to thermal performance
- Acting as a structural element (in a PER system)

In a **PER system**, the allowable amount of water entering the rainscreen cavity and **contacting the air/water barrier** is strictly limited and defined in the AAMA 508 test standard. The level of performance is typically achieved through compartmentalization and the use of smaller, protected cladding joint openings.

In a **D/BV system**, joints are more open and the water entering the rainscreen cavity and contacting the air/water barrier may be relatively unlimited. The AAMA 509 test standard is a classification method and not a pass/fail test. Based on the design of D/BV systems, there will likely be more water in the rainscreen cavity than in a PER system. It is important for the designer and detailer to understand the volume of water that must be managed and drained from the D/BV systems as shown in the AAMA 509 test results.

Which type system to specify is often confusing. Since the cladding and air/water barrier are often by different suppliers, and controlled by different specification sections, the system performance criteria is often incorrectly applied to the cladding alone. Specified performance need to be for the **rainscreen system** and not the separate components.

It should be noted that a D/BV system with enough openings to pressure equalize the rainscreen cavity does not equal a pressure equalized system. Unless the system has the mandated compartmentalization and meets the criteria of AAMA 508 (limited wetting of the air/water barrier) the cladding system is not a PER system.

As JM Anderson and JR Gill stated in Rainscreen Cladding a Guide to Design Principles and Practices "The Rainscreen approach to weather protection developed into two distinct techniques. First there is the drained and back-ventilated rainscreen which involves draining off most of the rain water at the outermost surface of the wall and providing for rainscreen cavity drainage and evaporation of the remainder. Second there is the pressure-equalized rainscreen. Here the aim is to eliminate penetration through the rainscreen not by tightly sealing joints, but by leaving some or all of them open to the passage of air ***but not of water***. Both approaches can work successfully, but care must be taken that the two are not confused, since the adoption of hybrid versions can result in unsatisfactory performance."

Aside from Anderson and Gill's D/BV definition, it should be noted that in today's wall system market the definition of the D/BV rainscreen has been expanded to include cladding joints that are totally open with no back up channels to divert moisture to the exterior. This is recognized in the AAMA 509 standard which provides test results indicating the volume of water entering the rainscreen cavity and the amount of ventilation allowed by the joint design. This information should only be used to compare one system to another.

Let's take a look at the two fundamental wall systems using rainscreen design in more detail:

Drained/Back Ventilated (D/BV) Rainscreen

The D/BV system employs …

1) A series of sheets, panels, or planks (collectively called 'Cladding') fixed to vertical or horizontal support channels or rails. Cladding joints are open, but most are designed to obstruct water penetration by kinetic energy and wind force. It must be understood that the joinery is designed to minimize, not prevent, water penetration. Water penetration resulting from variable wind-induced air pressure differentials will occur. At times, relatively large amounts of water will penetrate the cladding through the open joinery. Wetting of the air/water barrier surface can occur and is permitted. AAMA 509 will help define the volume of water that may contact the air/water barrier that must be controlled and drained to the exterior.
2) Some designs may introduce vertical channels to collect and drain the penetrating water through gravity to the bottom and exterior of the cladding.
3) Fenestrations and system penetrations must be continuously flashed and detailed to collect and direct water to the exterior or re-direct the water into vertical drainage channels.

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4) A rainscreen cavity between the cladding and air/water barrier is necessary to facilitate positive back-ventilation and drainage. Ventilation promotes rapid evaporation of any rain water deposited on the surfaces of the air/water barrier or on the interior surface of the cladding and drainage provides for the immediate evacuation of any excessive water that may pass by the exterior cladding. However, research has demonstrated that this rainscreen cavity should be a minimum of 25mm (1") deep for brick or masonry veneer walls (in order to keep the cavity reasonably clear of mortar accumulation). For other cladding materials, a minimum of 10mm (3/8") is recommended in order to promote proper ventilation .[1] The rainscreen cavity depth should be in addition to the depth of exterior applied insulation material so the ventilation flow is not restricted.

5) D/BV walls ***require*** an air/water barrier on the interior side of the rainscreen cavity. This barrier is generally placed on the outer face of the exterior sheathing. This continuous barrier is, by design, allowed to be exposed to water and serves to control airflow through the wall, reduces static air pressure differences across the cladding and provide the rainscreen with a second line of defense against water penetration. The exterior sheathing, in addition to having an air/water barrier applied, must be completely flashed to eliminate water penetration into the building and direct run-off of any water infiltration to the exterior.

6) The exterior sheathing is generally the structural building enclosure wall and should be designed to envelop the building's interior environment.

7) Water resistant insulation may be applied to the exterior side of the air/water barrier to meet thermal design requirements. Use of insulation in this manner helps to maximize usable building space and minimize the chances of condensation and cold bridging to the exterior sheathing.

8) While there are many opinions on the level of design wind load for the cladding and exterior sheathing, there is currently no design support to reduce the wind load impact on either element. Each component and attachments should be designed to withstand 100% of the design wind load.

9) Ventilation can be achieved by either vertical or horizontal cladding joints. Multiple openings in the cladding joints are included to achieve air flow and enhance drying of wetted rainscreen cavity.

Anderson and Gill state that a main point is D/BV **claddings** are not designed to be watertight and no deliberate attempt is made to minimize the structural or water penetrating effects of wind by pressure-equalization. Instead, the rainscreen cavity behind the cladding is drained and positive back-ventilation is used to promote rapid evaporation of any rainwater deposited on the air/water barrier surface. Conventional air/water test criteria cannot be applied to the cladding alone (due to its open joinery design), but should more properly be applied to the complete wall system including the air/water barrier.

To document the amount of ventilation through the exterior cladding and the amount of water contacting the air/water barrier through a series of static and dynamic water tests, AAMA published AAMA 509 'Voluntary Test and Classification Method for Drained and Back Ventilated Rainscreen Wall Cladding Systems'. Since DB/V systems range from totally open cladding joints to a more controlled joint system, AAMA 509 created a classification system for the amount of air and water allowed through the cladding and contacting the air/water barrier. There is no pass/fail criteria for this standard. It is important for the designer to understand the requirements related to a specific project to properly use the information obtained from an AAMA 509 rainscreen test report

Refer to Figures 1 and 2 for representations of a D/BV rainscreen system with horizontal and vertical joints. The example uses the 'Hook & Pin' open joinery method which is recognized as a D/BV rainscreen system. Other joinery details can be employed under the D/BV theory of design such as spline joinery systems, so long as suitable venting is provided.

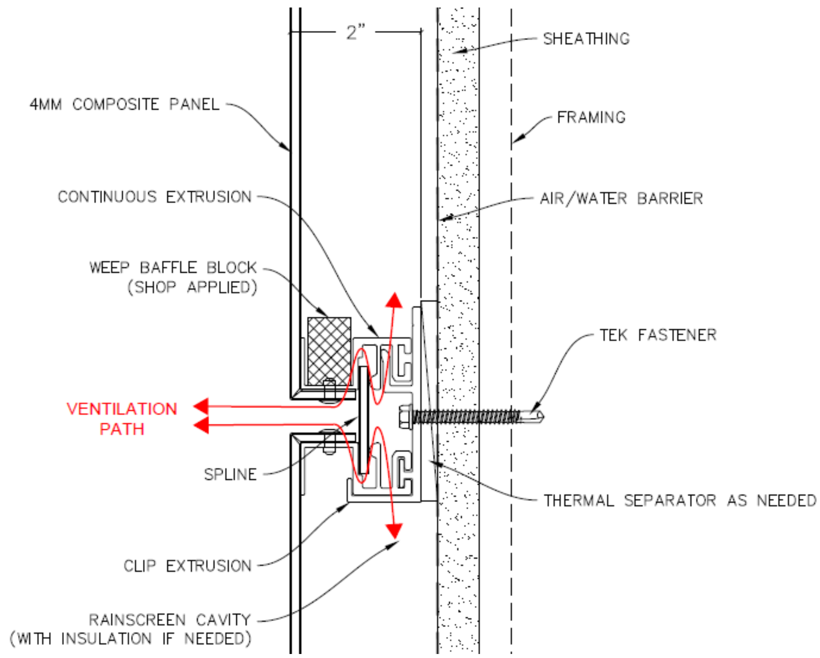

Figure 1: Typical horizontal joint detail for D/BV rainscreen panel system

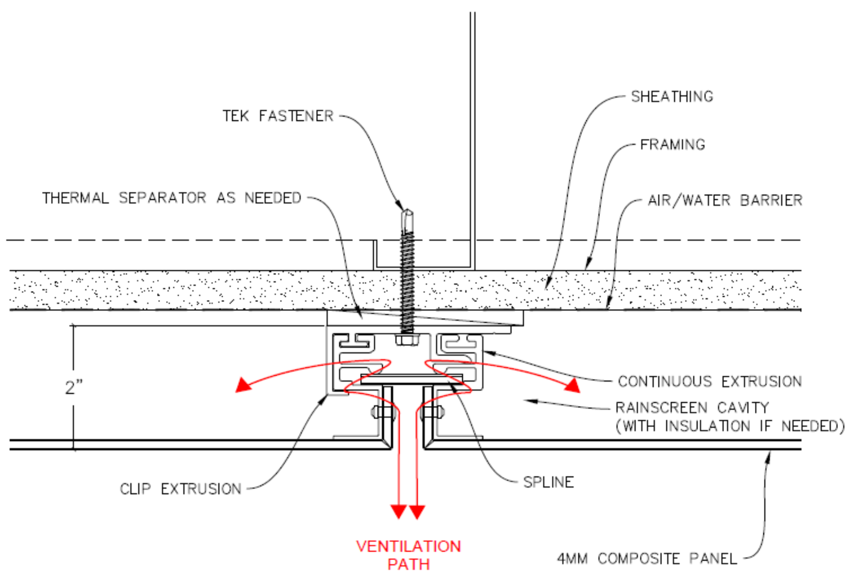

Figure 2: Typical vertical joint detail for D/BV rainscreen panel system

Pressure Equalized Rainscreen (PER) Wall System

Pressure equalized rainscreen (PER) walls are generally more design intensive and are sensitive to design variations and deviations from the PER design principles. The openings in the PER cladding joints must be specifically designed to allow both static and dynamic pressure equalization to take place across the rainscreen with very limited water passing into the rainscreen cavity. The essential defining attribute that differentiates PER from D/BV systems is the design and use of compartmentalization within the rainscreen cavity. The need for compartmentalization is that pressure equalization can only occur within very brief time periods (seconds) if the internal volume of the rainscreen cavity behind the rainscreen is known and controlled. This compartmentalization is essential because wind pressures across a building face are typically not uniform and are constantly changing. The number and geometry of the vent openings are calculated based upon the known rainscreen cavity volume to allow sufficient air flow in and out of the rainscreen cavity quickly enough to respond to ever-changing wind dynamics. This facilitates pressure differences across the cladding to be minimized when compared to the rainscreen cavity pressures. Equalizing the air-pressure on the external and internal sides of the cladding reduces, if not eliminates the rain-driving forces. The effective area of the venting depends upon:

1) the air tightness of the air/water barrier,
2) the stiffness of the cladding and exterior sheathing and
3) the volume of the individual compartments that make up the rainscreen cavity.

Rainscreen cavities are an essential element of proper pressure-equalized design by:

1) controlling vertical and lateral air flow,
2) defining the size of the vent openings that must be designed to facilitate pressure equalization, limit water infiltration, and control water drainage at times of air-pressure disequilibrium.

Non-compartmentalized rainscreen cavities cannot be classified as pressure-equalized since larger volumes of water may enter the rainscreen cavity as a result of varying rainscreen cavity pressures.

There are a number of the PER systems with construction elements that are similar to the D/BV rainscreen, but have several significant and important differences.

What is similar between the DB/V and PER systems? (Refer to D/BV outline and Figures 1 and 2).

Elements (1), (3), (4), (5), (6) and (7) are common construction elements of both D/BV and PER systems. However, the 'Rainscreen Cavity' (4) must be more specifically designed and controlled in both size and volume to facilitate pressure-equalization. The 'moisture barrier' (5) must be an air/water barrier which can significantly deter air leakage into the building interior thus cutting off air-pressure differentials that can bleed the rainscreen cavity and reduce pressure equalization. The design and installation of the air/water barrier is a prime consideration in any rainscreen system. The Air Barrier Association of America (ABAA) has developed a master specification section 01410 'The Air Barrier System' that details design considerations that must be addressed when specifying the air/water barrier. While a high-quality air barrier installation is desired, it must be recognized that there is a likelihood of minor installation flaws. To replicate field installation, AAMA 508 defines a minimum level of air leakage that the wall assembly must accommodate for testing.

As noted in AAMA 508, at this point in time there is insufficient evidence to substantiate any reduction in the structural design load for the connection system of the cladding for the PER systems.

What is the difference between the DB/V and PER systems? (Refer to Figures 3 and 4)

In a PER system, the cladding joinery (1) design is altered to create extensions back to the face of the air/water barrier or exterior sheathing (5) or insulation (7) creating 'pressure-controllable compartments' at both vertical and horizontal joints. The size of the cladding and the compartmentalization behind requires a series of special calculations that must be proven-out by testing*. Each building has unique wind dynamics which must be taken into consideration so a 'one-size-fits-all' approach is not recommended. Vertical drainage channels (2) are typically interrupted by the bottom horizontal joinery of each compartmented unit because the primary design intent for a PER system is to create isolated cladding units with rainscreen cavities that self-drain any incidental water penetration.

Anderson and Gill note that for **drained and back-ventilated rainscreens:**

> "The main point to note about the drained and back-ventilated approach is that claddings are allowed to leak, and no deliberate attempt is made to minimize the effects of wind by means of pressure equalization. Instead, the rainscreen cavity behind the cladding is drained and positive back-ventilation is used to promote the rapid evaporation of any rainwater deposited on the inner leaf (air/water barrier). The same process is used to evacuate the water vapour which permeates through the inner leaf (air/water barrier) and its insulating layer."

Anderson and Gill further offer the following main point for **pressure-equalized rainscreens**…

> "The main point to note about the pressure-equalized rainscreen approach is that without relying on the use of sealants or gaskets, every effort is made to minimize or eliminate leakage through the joints in the cladding assembly…There may, however, be some minor leakage into the rainscreen cavity and a precautionary drainage mechanism is therefore necessary. Positive back ventilation is also used to promote the rapid evaporation of residual rainwater and to evaporate the water vapour which permeated through the inner leaf (air/water barrier)."

Unlike AAMA 509, AAMA 508 a Voluntary Test Method and Specification for Pressure Equalized Rainscreen Wall Cladding Systems quantifies and limits the amount of water entering the rainscreen cavity and contacting the air/water barrier. *

<u>Key elements for Figures 3 and 4</u>:

(1) The cladding system (or the 'Rainscreen')
(2) Vertical drainage channel
(3) Penetration flashing
(4) Rainscreen cavity/compartment
(5) Air/water barrier
(6) Approved 'air/water barrier' compatible flashing membrane tape at all penetrations

(7) The air/water barrier or face of the exterior sheathing
(8) Moisture resistant insulation (optional, as required by thermal design requirements)
(9) Ventilation path for pressure equalization and drainage
(10) Horizontal air dam used to create compartmentalization
(11) The building structural wall

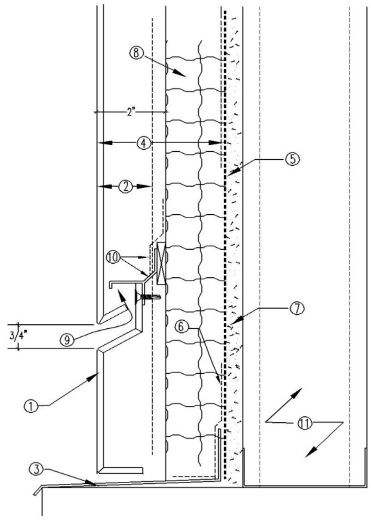

Figure 3: Typical horizontal joint detail for rainscreen PER panel system

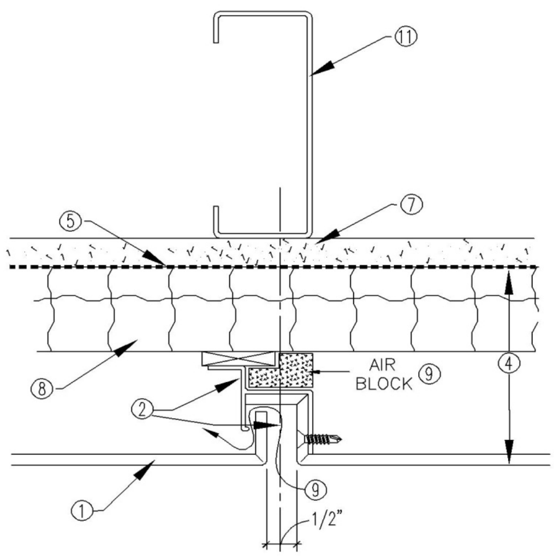

Figure 4: Typical vertical joint detail for rainscreen PER panel system.

* One of the key elements of substantiating the existence of pressure equalization within a system is testing. While critical design calculations are a must for proper design, testing will prove the validity of these calculations. Up until 2005, there was no industry recognized testing protocol for proving-out pressure

equalization. AAMA has released a test method which incorporates both cyclic and dynamic testing using air barriers with a defined level of imperfections. The AAMA 508 ‘Voluntary Method and Specification for Pressure Equalized Rainscreen Wall Cladding Systems’ © 2005, dated December 2005 is the first recognized domestic testing protocol to be adopted specifically addressing rainscreen performance. Subsequently the AAMA 509 protocol was written for the DB/V rainscreen wall systems. Copies of the testing procedures can be obtained (for a small fee) at www.fgiaonline.org (enter in search: ‘508’ or '509')

In Conclusion

There should be no confusion between rainscreen types, yet confusion appears widespread. Too often, system designers are faced with specifications that commingle the elements of both rainscreen system types and even introduce performance requirements of other non-rain-screen cladding designs.

JM Anderson and JR Gill stated in their highly recognized technical book Rainscreen Cladding a Guide to Design Principles and Practice … “Successful application in design, however, particularly as regards detailing, demands clear understanding of the scientific principles underlying the main approaches to rainscreen cladding …Successful rainscreen design depends on proper understanding of both of the design principles and of the way in which the technology originated and developed … confusion may lead to the development of hybrid versions, which may or may not achieve the design objectives.”

In summary, there are two basic types of rainscreen systems currently in use – The Drained/Back-Ventilated (D/BV) and the Pressure-Equalized Rainscreen (PER). Both systems employ open joinery and allow water into the rainscreen cavity between the cladding and air/water barrier. Drained/Back-Ventilated systems rely on the rainscreen cavity to both drain and dry-out residual water. The AAMA 509 test protocol documents the volume of water entering the rainscreen cavity and contacting the air barrier, as well as the amount of rainscreen cavity venting. Pressure-Equalized Rainscreen systems employ drainable compartmentalization to limit water penetration during periods of pressure disequilibrium and to facilitate rapid pressure equalization. AAMA 508 establishes the performance criteria for PER systems relative to the volume of water entering the rainscreen cavity contacting the air barrier as well as the ability of the wall system to quickly pressure equalize.

It should be well understood by the design and construction professionals that since the various rainscreen system elements (cladding, insulation, air/vapor barrier and exterior sheathing) can likely be supplied by different sources/subcontractors, specifications and contracting methods need to be closely coordinated and controlled to assure satisfactory performance of the complete rainscreen system. Contractually, the overall warranty and performance of a rainscreen wall must ultimately be designed and defined by the construction professionals. The open-ended and non-specific nature of many specifications lead to confusion and reliance upon one element, usually either the air/water barrier or cladding supplier, to solve all function and performance criteria without requiring responsibility within the specifications and/or contract. As much as inappropriate design and representation of a rainscreen system by its supplier/manufacturer, the inappropriate specification and contracting of a rainscreen system will ultimately lead to lower than desired performance levels relative to weather tightness.

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Footnotes:

1. NRC-CNRC Construction Technology Update No 9: Evolution of Wall Design for Controlling Rain Penetration© 1997, by G.A. Chown, W.C. Brown and D.F. Poirer. National research Council of Canada December 1997 ISSN 1206:1220

The design intent for the true 'rainscreen' panel/cladding system is more clearly defined and discussed in a variety of reputable publications available through the internet and industry sources. A short bibliography is:

Primary source: American Architectural Manufacturers Association (1540 East Dundee Road - Suite 310, Palatine, IL 60067 (847)202-1350)

The Rainscreen Principle and Pressure-equalized Wall Design (AAMA Aluminum Curtain Wall Series) (copyright© 1996) [Note: The original article can be found in the Architectural Aluminum Manufacturers Association (AAMA - 35 East Wacker Drive, Chicago, IL 60601): Aluminum Curtain Wall Design Guide Manual, Volume 2 (copyright© 1979)]

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Notes:

1) The illustrations in this document are conceptual in nature and are not intended to represent any manufacturers system. Any representation to the contrary is purely coincidental.
2) The information contained herein should not be used as a basis for reduction of the load-resisting characteristics of the outer leaf.
3) This document is meant to serve as a conceptual explanation and not a design guideline for rainscreen systems.

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