Performance Issues with Vinyl Windows

Gerson Bers, LEED AP

Allana Buick & Bers, Inc.

January 27 & 28, 2014

14th Annual Hawaii Winter Workshop
Roofing, Waterproofing, and Exterior Walls
Marriott Waikiki Beach, Honolulu, HI

Objectives

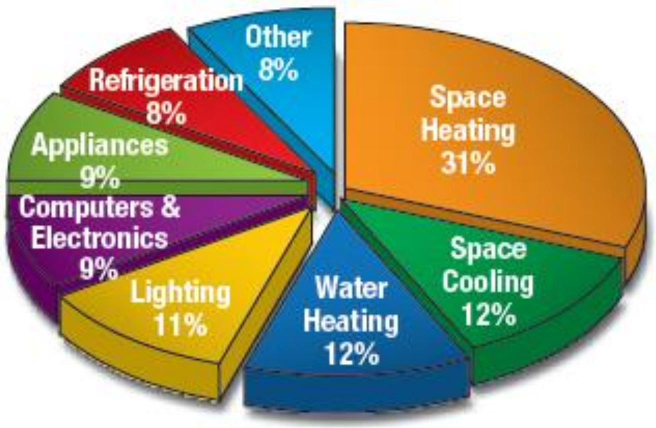
- **Window Basics**
- **History of Vinyl Windows**
- **Pros of Vinyl**
- **Cons of Vinyl**
- **Are Vinyl Windows "Green"?**
- **Technical Aspects of Vinyl Windows**
  - External Glazed vs. Internal Glazed
  - How do Drainage Paths Work on Vinyl Windows?
  - How do You Flash Vinyl Windows into Various Exterior Cladding Systems?
- **Understanding Why Vinyl Windows Fail**
  - How are they Performing?
  - What is Working?
  - What is Failing?
- **Case Study**

SoCal Chapter

Window / Energy Statistics

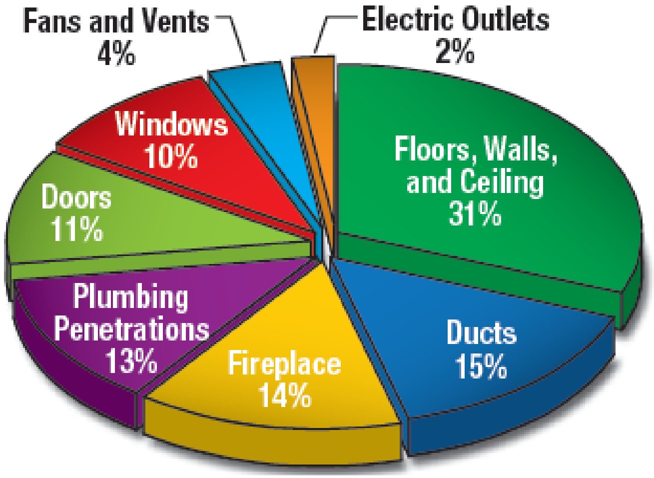
- Heating and Cooling Account for the Largest Part of a Typical Utility Bill
- Windows Account for 10% of the Air Infiltration

How We Use Energy



Heating and Cooling accounts for the biggest part of a typical utility bill.

How Does the Air Escape



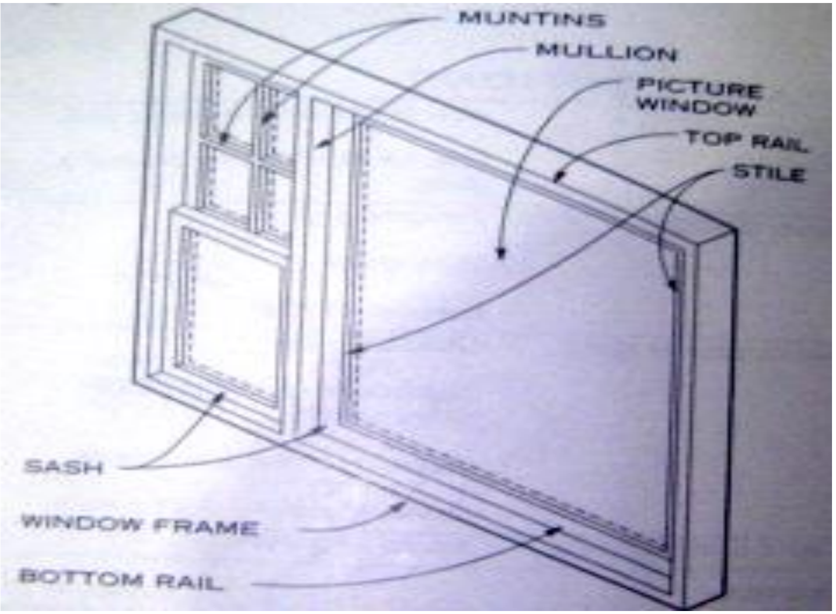
Air infiltrates through every crack and crevasse. As you can see over 20% is lost through your windows and doors.

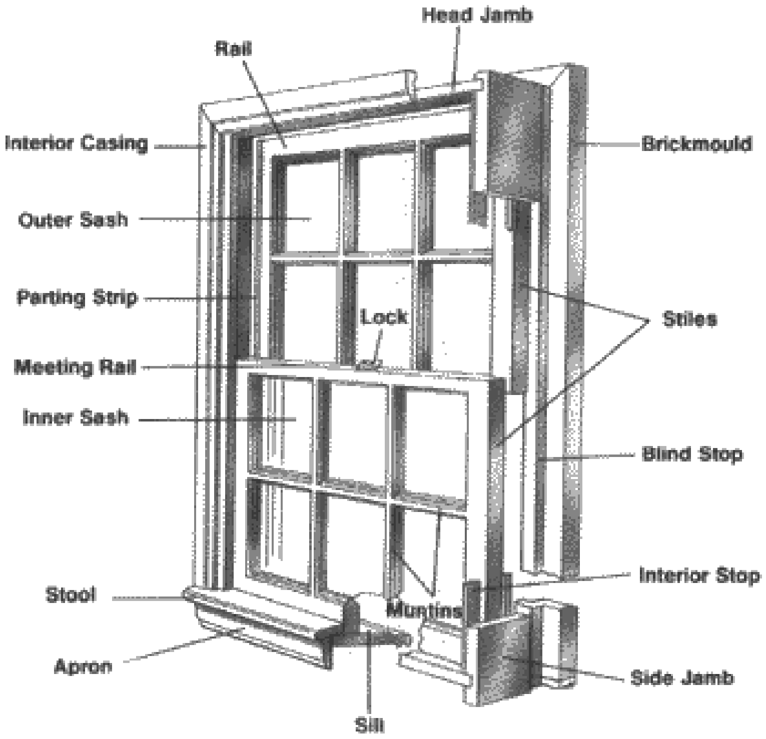
Source: U.S. Department of Energy

SoCal Chapter

Window Basics

- Windows originate from the Old English "eagbryl" meaning eye-hole, and eagduru meaning eye-door.





Windows Are Important

- Windows are among the most complex building components in a building.
- At several hundred dollars to thousands of dollars apiece, windows are also among the most expensive.
- In addition to the important architectural and aesthetic contribution they make, windows have very far-reaching energy consequences.
- The number of windows, total area, and orientation to the sun can make or break the energy efficiency of a high-performance building.

SoCal Chapter

A Ridiculous Amount to Know About Windows

- **A list of ASTM Standard Test Methods Relevant to Building Envelope Windows**

ASTM C 162 Standard Terminology of Glass and Glass Products
ASTM C 509 Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM C 510 Standard Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants
ASTM C 542 Standard Specification for Lock-Strip Gaskets
ASTM C 716 Standard Specification for Installing Lock-Strip Gaskets and Infill Glazing Materials
ASTM C 717 Standard Terminology of Building Seals and Sealants
ASTM C 793 Standard Test Method for the Effects of Accelerated Weathering on Elastomeric Joint Sealants
ASTM C 794 Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
ASTM C 864 Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
ASTM C 920 Standard Specification for Elastomeric Joint Sealants
ASTM C 964 Standard Guide for Lock-Strip Gasket Glazing
ASTM C 1036 Standard Specification for Flat Glass
ASTM C 1048 Standard Specification for Heat-Treated Flat Glassâ€"Kind HS, Kind FT Coated and Uncoated
ASTM C 1087 Standard Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems
ASTM C 1115 Standard Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories
ASTM C 1135 Standard Test Method for Determining Tensile Adhesion Properties of Structural Sealants
ASTM C 1172 Standard Specification for Laminated Architectural Flat Glass
ASTM C 1184 Standard Specification for Structural Silicone Sealants
ASTM C 1193 Standard Guide for Use of Joint Sealants
ASTM C 1249 Standard Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications
ASTM C 1256 Standard Practice for Interpreting Glass Fracture Features
ASTM C 1265 Standard Test Method for Determining the Tensile Properties of an Insulating Glass Edge Seal for Structural Glazing Applications
ASTM C 1279 Standard Test Method for Non-Destructive Photoelastic Measurement of Edge and Surface Stresses in Annealed, Heat-Strengthened, and Fully Tempered Flat Glass
ASTM C 1281 Standard Specification for Preformed Tape Sealants for Glazing Applications
ASTM C 1294 Standard Test Method for Compatibility of Insulating Glass Edge Sealants with Liquid-Applied Glazing Materials
ASTM C 1349 Standard Specification for Architectural Flat Glass Clad Polycarbonate
ASTM C 1369 Standard Specification for Secondary Edge Sealants for Structurally Glazed Insulating Glass Units
ASTM C 1375 Standard Guide for Substrates Used in Testing Building Seals and Sealants
ASTM C 1376 Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass
ASTM C 1377 Standard Test Method for Calibration of Surface/Stress Measuring Devices
ASTM C 1392 Standard Guide for Evaluating Failure of Structural Sealant Glazing
ASTM C 1394 Standard Guide for In-Situ Structural Silicone Glazing Evaluation
ASTM C 1399 Standard Test Method for Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems
ASTM C 1401 Standard Guide for Structural Sealant Glazing
ASTM C 1422 Standard Specification for Chemically Strengthened Flat Glass
ASTM C 1464 Standard Specification for Bent Glass
ASTM C 1472 Standard Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width
ASTM C 1487 Standard Guide for Remedying Structural Silicone Glazing
ASTM C 1503 Standard Specification for Silvered Flat Glass Mirror
ASTM C 1564 Standard Guide for Use of Silicone Sealants for Protective Glazing Systems
ASTM C 1678-07 Standard Practice for Fractographic Analysis
ASTM E 90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
ASTM E 119 Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E 283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E 330 Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E 331 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E 336 Standard Test Method for Measurement of Airborne Sound Insulation in Buildings
ASTM E 413 Classification for Rating Sound Insulation
ASTM E 488 Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM E 514 Standard Test Method for Water Penetration and Leakage Through Masonry
ASTM E 546 Standard Test Method for Frost Point of Sealed Insulating Glass Units
ASTM E 547 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls by Cyclic Static Air Pressure Differential
ASTM E 576 Standard Test Method for Frost Point of Sealed Insulating Glass Units in the Vertical Position
ASTM E 631 Standard Terminology of Building Constructions
ASTM E 754 Standard Test Method for Pullout Resistance of Ties and Anchors Embedded in Masonry Mortar Joints
ASTM E 773 Standard Test Method for Accelerated Weathering of Sealed Insulating Glass Units
ASTM E 774 Standard Specification for Classification of the Durability of Sealed Insulating Glass Units
ASTM E 783 Standard Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
ASTM E 894 Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings
ASTM E 966 Standard Guide for Field Measurement of Airborne Sound Insulation of Building Facades and Facade Elements
ASTM E 987 Standard Test Methods for Deglazing Force of Fenestration Products
ASTM E 997 Standard Test Method for Structural Performance of Glass in Exterior Windows, Curtain Walls, and Doors Under the Influence of Uniform Static Loads by Destructive Methods
ASTM E 998 Standard Test Method for Structural Performance of Glass in Windows, Curtain Walls, and Doors Under the Influence of Uniform Static Loads by Nondestructive Method
ASTM E 1105 Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference
ASTM E 1233 Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential
ASTM E 1300 Standard Practice for Determining Load Resistance of Glass in Buildings
ASTM E 1332 Standard Classification for Determination of Outdoor-Indoor Transmission Class
ASTM E 1423 Standard Practice for Determining the Steady State Thermal Transmittance of Fenestration Systems
ASTM E 1424 Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure and Temperature Differences Across the Specimen
ASTM E 1425 Standard Practice for Determining the Acoustical Performance of Exterior Windows and Doors
ASTM E 1825 Standard Guide for Evaluation of Exterior Building Wall Materials, Products, and Systems
ASTM E 1886 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missiles and Exposed to Cyclic Pressure Differentials
ASTM E 1996 Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricanes
ASTM E 2010 Standard Test Method for Positive Pressure Fire Tests of Window Assemblies
ASTM E 2074 Standard Test Method for Fire Tests of Door Assemblies, Including Positive Pressure Testing of Side- Hinged and Pivoted Swinging Door Assemblies
ASTM E 2094 Standard Practice for Evaluating the Service Life of Chromogenic Glazings
ASTM E 2099 Standard Practice for the Specification and Evaluation of Pre-Construction Laboratory Mockups of Exterior Wall Systems
ASTM E 2112 Standard Practice for Installation of Exterior Windows, Doors and Skylights
ASTM E 2128 Standard Guide for Evaluating Water Leakage of Building Walls
ASTM E 2141 Standard Test Methods for Assessing the Durability of Absorptive Electrochromic Coatings on Sealed Insulating Glass Units
ASTM E 2188 Standard Test Method for Insulating Glass Unit Performance
ASTM E 2189 Standard Test Method for Testing Resistance to Fogging in Insulating Glass Units
ASTM E 2190 Standard Specification for Insulating Glass Unit Performance and Evaluation
ASTM E 2268 Standard Test Method for Water Penetration of Exterior Windows, Skylights, and Doors by Rapid Pulsed Air Pressure Difference
ASTM E 2269 Standard Test Method for Determining Argon Concentration in Sealed Insulating Glass Units using Gas Chromatography
ASTM E 2270 Standard Practice for Periodic Inspection of Building Facades for Unsafe Conditions
ASTM E 2319 Standard Test Method for Determining Air Flow Through the Face and Sides of Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E 2353 Standard Test Methods for the Performance of Glass in Permanent Glass Railing Systems, Guards and Balusters
ASTM E 2395 Standard Specification for Voluntary Security Performance of Windows and Door Assemblies with and without Glazing Impact
ASTM F 1233 Standard Test Method for Security Glazing Materials and Systems
ASTM F 1641 Standard Test Method for Measuring Penetration Resistance of Security Glazing Using a Pendulum Impactor
ASTM F 1642 Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
ASTM F 1915 Standard Test Methods for Glazing for Detention Facilities
ASTM F 2248 Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass
ASTM STP 1054 Technology of Glazing Systems
ASTM STP 552 C. J. Parise, "Window and Wall Testing," 1974.
ASTM STP 606 J. A. Dallen & P. Paulus, "Lock-Strip Glazing Gaskets," 1976

SoCal Chapter

Tip of The Iceberg in Window Knowledge

- A list of AAMA Standards Pertaining to Windows

AAMA Aluminum Curtain Wall Design Guide Manual
AAMA/NWWDA 101/I.S.2 Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors
AAMA 501 Methods of Test for Exterior Walls
AAMA 501.1 Methods of Tests for Exterior Walls – Dynamic Test (laboratory)
AAMA 501.2 Methods of Tests for Exterior Walls – Hose Test (field)
AAMA 501.4 & 501.6 Recommended Static Test Method for Evaluating Curtain Wall and Storefront Systems Subjected to Seismic and Wind Induced Interstory Drifts and Recommended Dynamic Test Method For Determining the Seismic Drift Causing Glass Fallout from a Wall System
AAMA 501.5 Test Method for Thermal Cycling of Exterior Walls
AAMA 503 Voluntary Specification for Field Testing of Metal Storefronts, Curtain Walls and Sloped Glazing Systems
AAMA 507 Standard Practice for Determining the Thermal Performance Characteristics of Fenestration Systems Installed in Commercial Buildings
AAMA 510 Voluntary Guide Specification for Blast Hazard Mitigation for Fenestration Systems
AAMA 609 Cleaning and Maintenance Guide
AAMA 610 Cleaning and Maintenance Guide
AAMA 611 Voluntary Specification for Anodized Architectural Aluminum
AAMA 800 Series Series of publications on sealant specifications
AAMA 850 Fenestration Sealants Guide Manual
AAMA 1503 Voluntary Standards for Thermal Transmittance and Performance
AAMA 1503.1 Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections
AAMA 1504 Voluntary Standard for Thermal Performance of Windows, Doors and Glazed Walls
AAMA 1600 Voluntary Specification for Skylights
AAMA 2604 Voluntary Specification for High Performance Organic Coatings on Aluminum Extrusions and Panels
AAMA AFPA Anodic Finishes/Painted Aluminum
AAMA CW-DG-1 Aluminum Curtain Wall Design Guide Manual
AAMA CW-RS-1 Rain Screen Principle and Pressure Equalization
AAMA CW-11 Design Wind Loads and Boundary Layer Wind Tunnel Testing
AAMA CW-12 Structural Properties of Glass
AAMA CW-13 Structural Sealant Glazing Systems
AAMA CWG-1 Installation of Aluminum Curtain Walls
AAMA FSCOM-1 Fire Safety in High Rise Curtain Walls
AAMA GAG-1 Glass and Glazing
AAMA GDSG-1 Glass Design for Sloped Glazing
AAMA JS-1 Joint Sealants
AAMA MCWM-1 Metal Curtain Wall Manual
AAMA SDGS-1 Structural Design Guidelines for Aluminum Framed Skylights
AAMA SFM-1 Aluminum Store Front and Entrance Manual
AAMA SHDG-2 The Skylight Handbook Design Guidelines
AAMA TIR-A7 Sloped Glazing Guidelines
AAMA TIR-A9 Metal Curtain Wall Fasteners
AAMA TIR-A11 Maximum Allowable Deflection of Framing Systems for Building Cladding Components at Design Wind Loads
AAMA TSGG Two-Sided Structural Glazing Guidelines for Aluminum Framed Skylights
AAMA WSG.1 Window Selection Guide

- And lets not forget NFRC, ANSI, ASCE, CPSC, NFPA, UL, and GANA Standards

SoCal Chapter

Window Frame Considerations

- The window frames do more than hold the glass in place and allow the window to open and close.
- They are an important part of a window's overall thermal performance.
- The type of frame helps dictate how much maintenance the window will need over its lifetime.
- Equally important to the thermal performance of the frame is the water resistance performance.
- Frame materials include:
  - Wood
  - Aluminum
  - Vinyl
  - Fiberglass
  - Both vinyl- and aluminum-clad substrates

SoCal Chapter

Window Frame Types

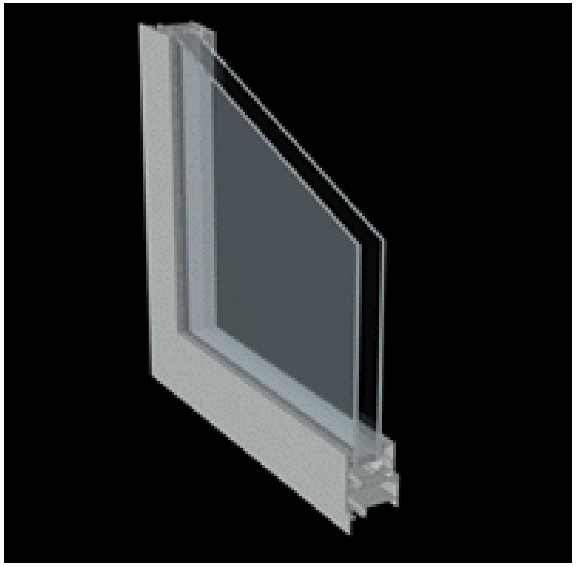
- **Wood**
  - The traditional window frame material
  - Wood frames are high maintenance, they require sanding and staining, and the outer frame may require re-finishing every few years.

- **Clad Wood**
  - Clad the exterior face of the frame with either vinyl or aluminum, creating a permanent weather-resistant surface.

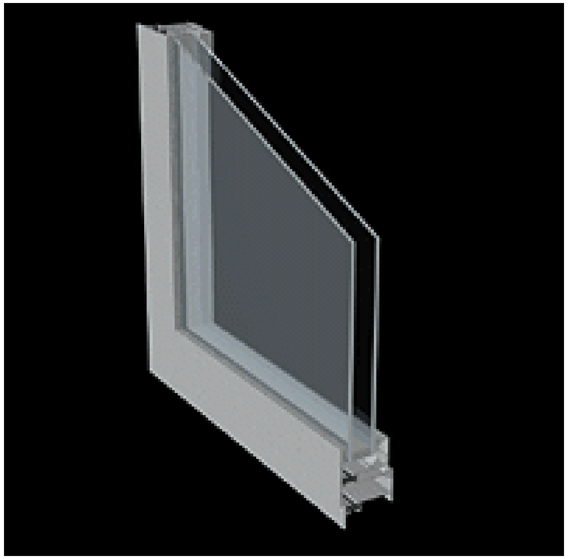
SoCal Chapter

Window Frame Types

- **Aluminum**
  - Aluminum window frames are light, strong, durable but with high thermal conductance. They readily conduct heat, greatly raising the overall U-factor of a window unit.



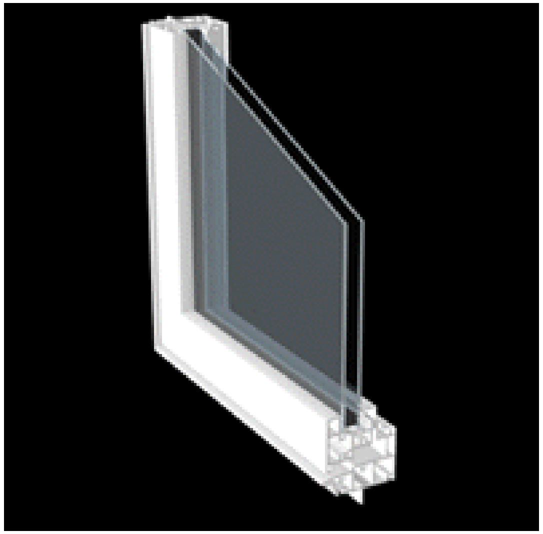
- **Aluminum with Thermal Break**
  - The most common solution to the heat conduction problem of aluminum frames is to provide a thermal break by splitting the frame components into interior and exterior pieces and use a less conductive material to join them.



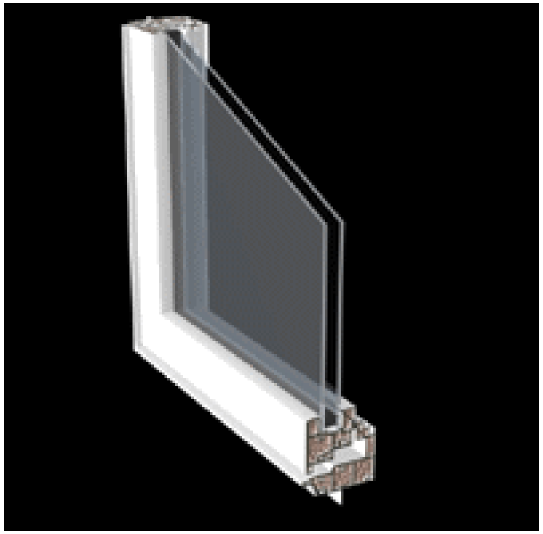
SoCal Chapter

Window Frame Types

- **Vinyl**
  – Vinyl does not conduct heat very well and is therefore considered a good thermal insulator.
  – Vinyl comes in different wood grain finishes and does not require painting or finishing.

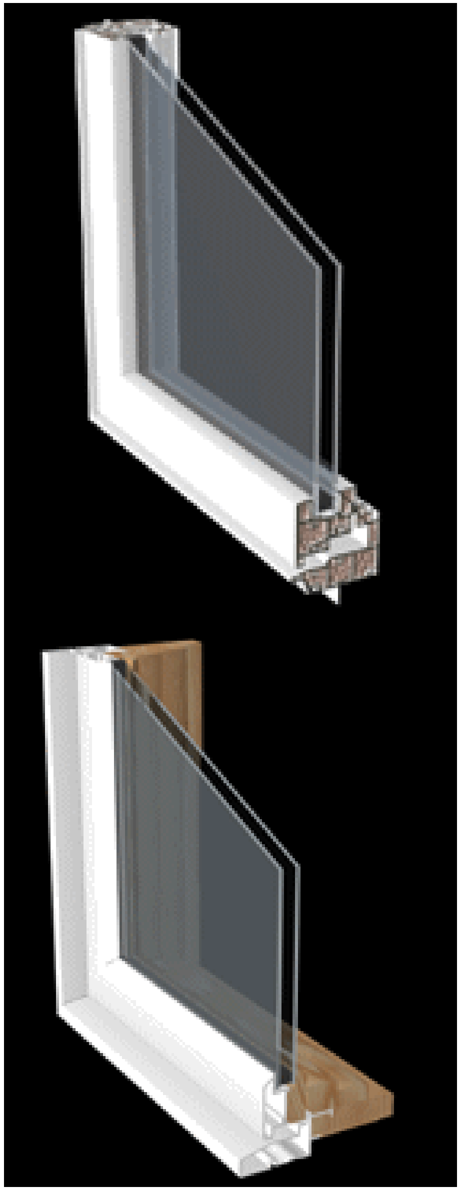


- **Insulated Vinyl**
  – In insulated vinyl frames, the non-draining hollow cavities of the frame are filled with insulation making them thermally superior to standard vinyl and wood frames. Usually these high performance frames are used with high performance glazings.



Window Frame Types

- **Fiberglass**
  - Generally the more expensive option. They don't need to be painted or caulked often, and they have high insulation values.
  - Fiberglass expands and contracts almost the same as window glass in extreme temperature changes, which contributes to the longevity of the seals around the glass.
- **Hybrid**
  - Use of two or more frame materials
- **Composite**
  - Very stable, and have the same or better structural and thermal properties as conventional wood, with better moisture resistance and more decay resistance.



SoCal Chapter

History of Vinyl Windows

- **In the late 1800's, European researchers used an earlier discovered gas called vinyl chloride in a mixture, creating what they considered to be a useless rigid material. Although this material was examined by other scientists, at this time, no one could come up with a commercial use for it.**

- **In the 1920's, BF Goodrich scientists started experimenting and created what we now know as PVC or vinyl. Throughout the late 1920s, the experiments continued while BF Goodrich struggled to market the material.**

- **In the 1930's, vinyl usage was starting to become commercial. Shock absorbing seals were the initial eye opener to reducing our country's dependence on rubber and oil. Vinyl was used to develop the first American synthetic tires.**

- **In the 1940's, Vinyl was used as a nonflammable electrical wire coating and took the place of rubber during World War II.**

SoCal Chapter

History - Continued

- In the 1950's, Vinyl continued to diversify. The most important innovation came when irrigation pipe made from rigid vinyl was introduced and PVC pipe was born.

- Vinyl sales grew in the mid 1990's for both new construction and remodeling by 125%!

- Today: More than 30 Billion pounds of vinyl is produced worldwide today, about 60 percent is used in the construction industry.

- According to the AAMA/WDMA 2011/2012 Statistical Review and Forecast - vinyl windows accounted for 67% of all conventional residential windows sold in the US.

SoCal Chapter

Facts About Vinyl Windows

- **Pros:**
  - Vinyl windows and doors are energy efficient during both the manufacturing and use phases of their lifecycle.
  - Vinyl products have low embodied energy – meaning the amount of energy required to convert the raw material into an end product is lower than most alternatives.
  - A lifecycle study report by Franklin Associates showed that vinyl windows required up to 3 times less energy to manufacture than aluminum windows.
  - The use of vinyl over other window frame alternatives can save the US nearly 2 trillion BTU's of energy per year – enough to meet the yearly electrical needs of up to 20,000 single-family homes.
  - Vinyl is considered a relatively green product.. Or is it?

SoCal Chapter

Facts About Vinyl Windows - Cons

- **Cons:**
  - Unreliable and defective mass-produced and imported product due to different manufacturing techniques and levels of quality standards.
  - Many mass produced vinyl windows are made with lower grade materials.
  - PVC in not as rigid as wood or aluminum and thus is only effective for relatively small windows. (They can be fitted with internal metal stiffners.)
  - PVC is a little tricky for sealant adhesion – sometimes caulking materials doesn't stick to it. When working with any substrate, and especially PVC, you must do adhesion tests before applying sealants.

Facts About Vinyl Windows - Cons

- **Cons:**
  - PVC is a thermoplastic with a relatively low melting point, about 212°F. It can begin to soften 149°F and if it heats up too much, it can bend and “take a set”.
  - Dark-colored vinyl if installed in a location where it receives reflected light from a window, can reach 219°F.
  - PVC has a greater coefficient of thermal expansion than wood, aluminum, or glass. This means it shrinks and grows more with temperature changes. Glazing sealants can shear because the PVC is moving against the more stable glass which can result in leaks around the glass.

SoCal Chapter

Is Vinyl "Green"?

- Modern design of vinyl window frames enhance their energy efficiency by creating chambers in the frame that provide additional resistance to heat transfer with insulating air pockets.

- Vinyl windows can last on average 20-30 years with little maintenance.

- In addition, the low maintenance requirements of vinyl windows can eliminate the need for paints, stains, strippers, etc. - which can negatively impact indoor air quality.

SoCal Chapter

Is Vinyl "Green"?

- Vinyl is a thermoplastic, so it can be reprocessed for recycling using heat with minimal loss of properties.
- Thermoplastic Vinyl frames can be heat welded which can make them water tight for the life of the window.
- Vinyl windows and doors are resilient to rot, rust, corrosion, blistering, flaking, and insect infestation
- Vinyl windows are manufactured with UV inhibitors for improved weathering and stabilizers to protect the frames from cracking, splitting, pitting, or chalking.

SoCal Chapter

Is Vinyl “Green”?

- **Vinyl production requires consuming in excess of 40% of the chlorine gas produced in this country.**
  - That is the largest use of the gas in the world. By comparison, 5% of the nation's chlorine gas is used to disinfect water – and that includes sewage treatment.

- **Among the most important by-products of the PVC life cycle are dioxin, ethylene dichloride (EDC), and vinyl chloride monomer (VCM). Dioxin is one of the most potent carcinogens known to science.**

SoCal Chapter

Vinyl Windows – Are They Reliable?

- **The Federal Trade Commission recently issued a publication that endorsed vinyl-frame windows because they "insulate well and don't need painting."**

- **While Vinyl Windows offer many energy efficiency and maintenance benefits… You must ask:**

  – As a construction professional am I opening myself to liability specifying Vinyl Windows?
  – Do the vinyl windows actually perform as advertised?
  – Do they provide the Owner with a product that has longevity and is adverse to defects?

SoCal Chapter

Technical Aspects of Vinyl Windows

- External Glazed vs. Internal Glazed
- How do Drainage Paths Work on Vinyl Windows?
- How do You Flash Vinyl Windows into Various Exterior Cladding Systems?

SoCal Chapter

What is a Mulled Window

- When 2 to 3 windows are joined together

What is a Mulled Window

- When 2 to 3 windows are joined together

SoCal Chapter

What is a Mulled Windows

- When 2 to 3 windows are joined together

What is a Mulled Windows

- Mulled joints have a beauty cap or cover

SoCal Chapter

Mulled Windows

- Mulled joint cap has been removed

Mulled Windows Issues

- **Individual windows are tested for various rating**
- **Mulled windows are often not tested as an assembled unit**
- **Various modes of failure can result from the untested assembly:**
  - Mulled joints can allow water infiltration leading to leaks both inside and behind the flexible flashing
  - Window's welded corners can fail due to stresses

SoCal Chapter

Horizontal and Vertical Mullion Failures

SoCal Chapter

Horizontal and Vertical Mullion Failures

SoCal Chapter

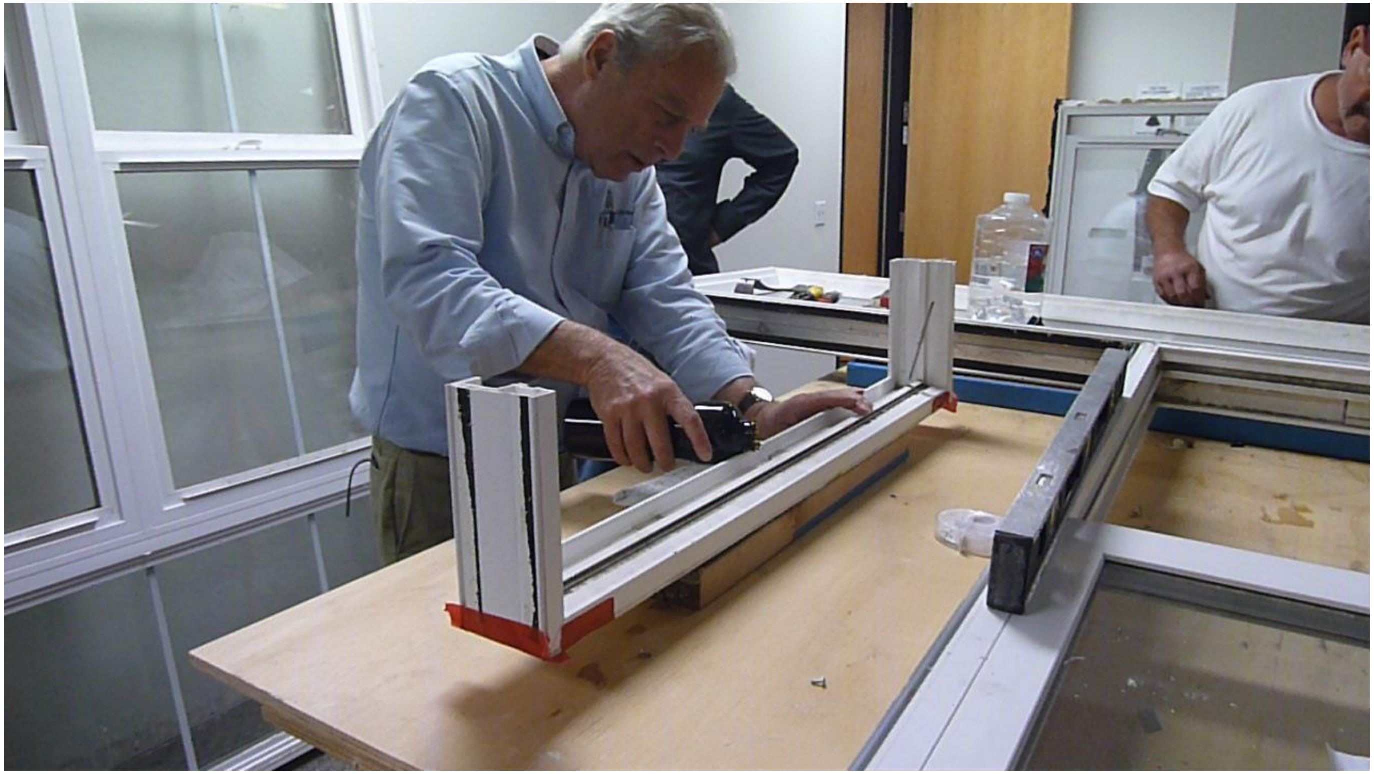
Horizontal and Vertical Mullion Failures

Horizontal and Vertical Mullion Failures

Vertical Mulled Failure

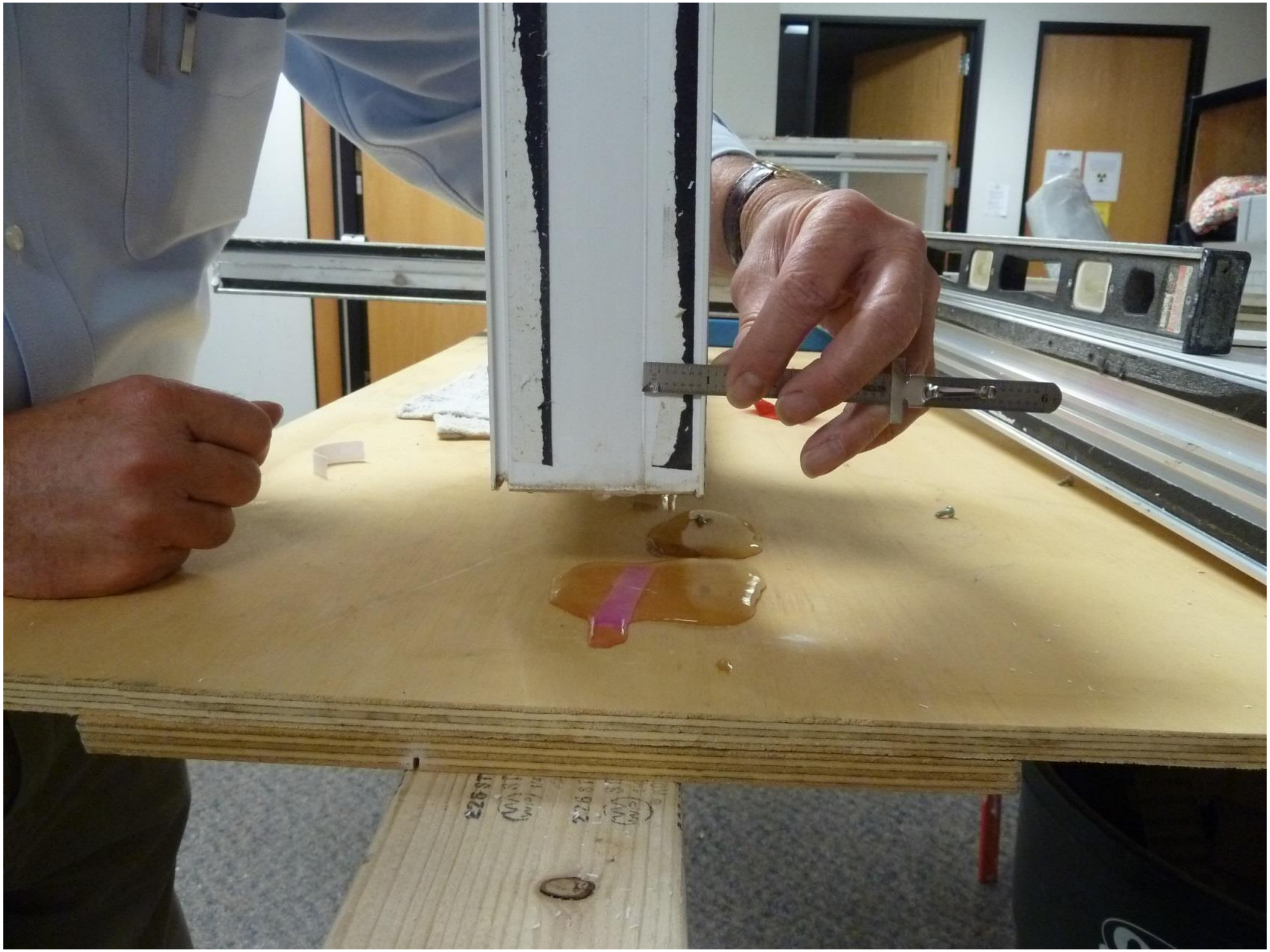
Vertical Mulled Failure

- **A fixed mullion is not flexible and can crack from movement during transport or due to thermal changes**



SoCal Chapter

Vertical Mulled Failure



Understanding Why Vinyl Windows Fail

- Poor design and manufacturing techniques
- Intermediate frame joints in window are usually not welded and often fail due to poor sealing techniques
- Vinyl frames can be wavy and are more difficult to seal against glass because glass is more flat than the frame
- Glazing seals used in vinyl windows is often a foam tape which can fail due to UV, long term exposure to water and waviness of vinyl frames
- Mulling or joining of several windows to form a larger window
- Internal glazing leaves glazing seals vulnerable to UV

What is Working and What is Not Working?

- Properly design and manufactured windows seem to work well and are performing
- Pre-mature failures are mostly due to poor manufacturing techniques, and poor design.
- Cheaper materials within a window system can cause premature failures
- Vinyl windows are limited to smaller size and mulling smaller windows together to form a large window has inherent issues and risks.

SoCal Chapter

Common Problems of Vinyl Windows

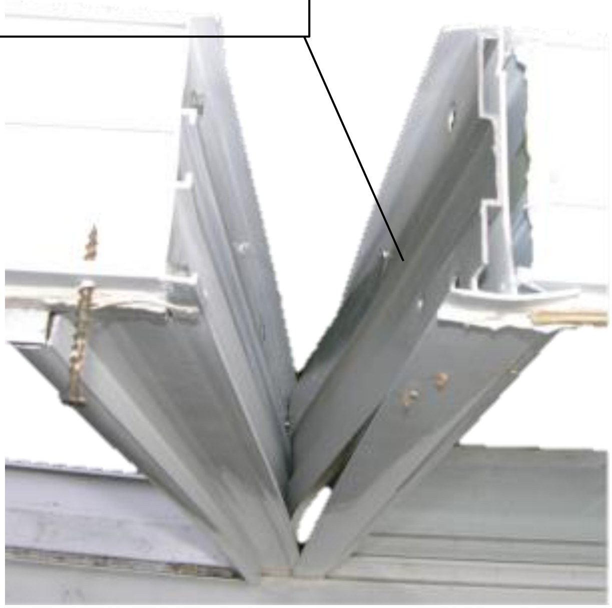
- Older vinyl windows without fused/welded corners are prone to water leaks (screw-spline joinery is prone to leak)
- Screw-spline joinery in some cases not conducive to effective sealing and sealant adhesion

Image Source: C. Window Expert

Water Leaks Through Mulled Joints

- **Mullions and capping trim attachments generally must be continuously sealed to the window on the exterior.**
- **If screws are driven into the window from the interior – this can produce leaks and should be avoided.**
- **If sealant between the aluminum mullion is not applied, leaks usually occur.**

Aluminum stiffner. Note an absence of sealant between the aluminum and the windows.

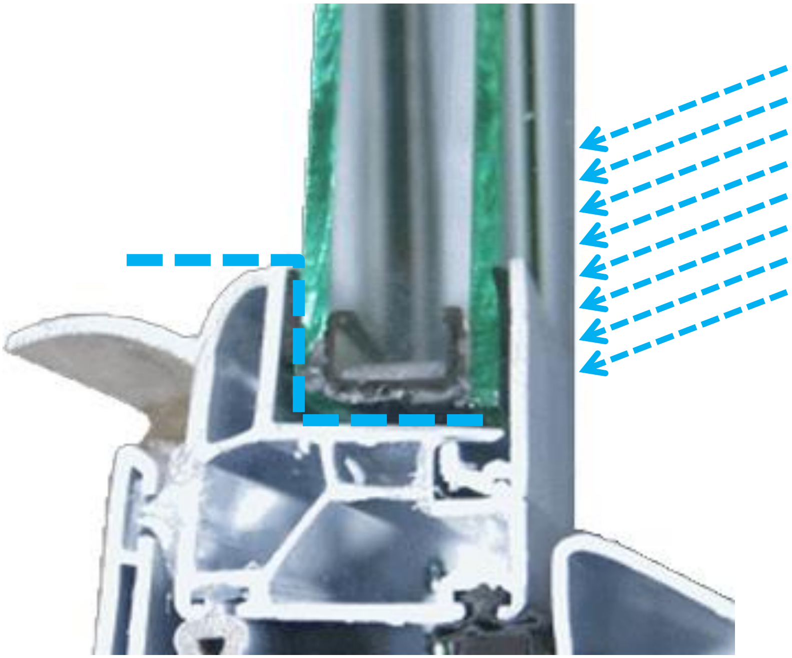


Mulled windows separated.

SoCal Chapter

Water Leaks Through Glazing??

- **Thermal movement of PVC is up to 7 times that of glass.**
- **As the temperature changes, the PVC can slide against the glass and puts stress and wear on the glazing sealant.**
- **The sealant might be only 1/16″ thick and eventually is sheared.**
- **In some cases a vinyl window sash can overflow with just a light spray.**



SoCal Chapter

Insulated Glass Seal Failure

- **When too much moisture moves through the seal and into the space the desiccant will eventually lose its ability to adsorb any more moisture.**
- **The result of the failure of the seal to keep out excess moisture is that condensation may occur causing the unit to have a fogged appearance.**
- **Premature failure of sealed units is usually caused by:**
  - Poor design of the unit so that it will not pass the standard ASTM tests recommended by the Sealed Insulated Glass Manufacturers Association (SIGMA)
  - Poor workmanship on an individual unit during fabrication
  - Poor frame design which will allow the unit to sit in a high moisture environment

RCI SoCal Chapter

Case Study 1

- Apartment project was built in 2007-08 and consists of 4-5 stories of wood frame construction over a post tensioned concrete podium containing a garage and retail shops.

- The project uses "fin" style vinyl windows and there are Juliette balcony railings with sliding windows and sliding glass doors at the courtyard entrances.

- The windows are vinyl casement windows with steel reinforced mullions

- ABB was retained to assist in analyzing window failures.

The Project, Case Study 1

SoCal Chapter

Testing, Case Study 1

- ABB performed several air and water infiltration tests, reviewed shop drawings, conducted visual observations of interiors, and reviewed previous reports.

- ABB also had ASTM E1105.01 and ASTM E783.02 window tests completed.

- Since the windows immediately failed the water and air tests due to glazing seal related failure, we isolated the glazing failures and performed tests for other failures.

Glazing Failures

- **Several windows tested leaked at glass-to-glazing bead junctures.**
- **The windows are interior glazed and have a poor quality acrylic adhesive closed-cell foam glazing tape. These seals have failed in all windows where the glazing was tested.**
- **Water Test Failure:**
  - Windows were tested at 3.5 psf, 2/3^{rds} of the Manufacturer's stated performance standards.
  - Of the three windows that were tested without isolating the glazing, all three failed to pass. This is a 100% failure rate.

Glazing Failures And Resultant Leak.

SoCal Chapter

Glazing Failure Analysis

- **The design of the windows caused premature failure of the glazing seals at the window-to-frame transition, and causes the windows to fail to perform. Design factors causing these failures are:**
  - Glazing is installed from the interior, which causes the glazing tape to be the primary line of defense against water intrusion. The tape is susceptible to UV and heat degradation, is of inferior quality, and is not a long-term solution to this condition.
  - The window frame is designed with a horizontal flat surface at the frame-to-glass joint, so water sits in contact with the glazing tape, causing premature Insulated Glass Unit (IGU) failure.
  - Current glazing tape is an acrylic adhesive closed-cell foam tape that is compressed with glazing stops at the interior. In our testing, we observed that the tape did not make uniform contact with the glass thereby allowing water to bypass the tape altogether.
  - When the glazing seal fails, water flows into the sill tracks of each piece of glass. This is sometimes the upper lites that have a drained horizontal mullion, and sometimes it is the lower sill track that has no method of managing water that enters the frame at that location.

SoCal Chapter

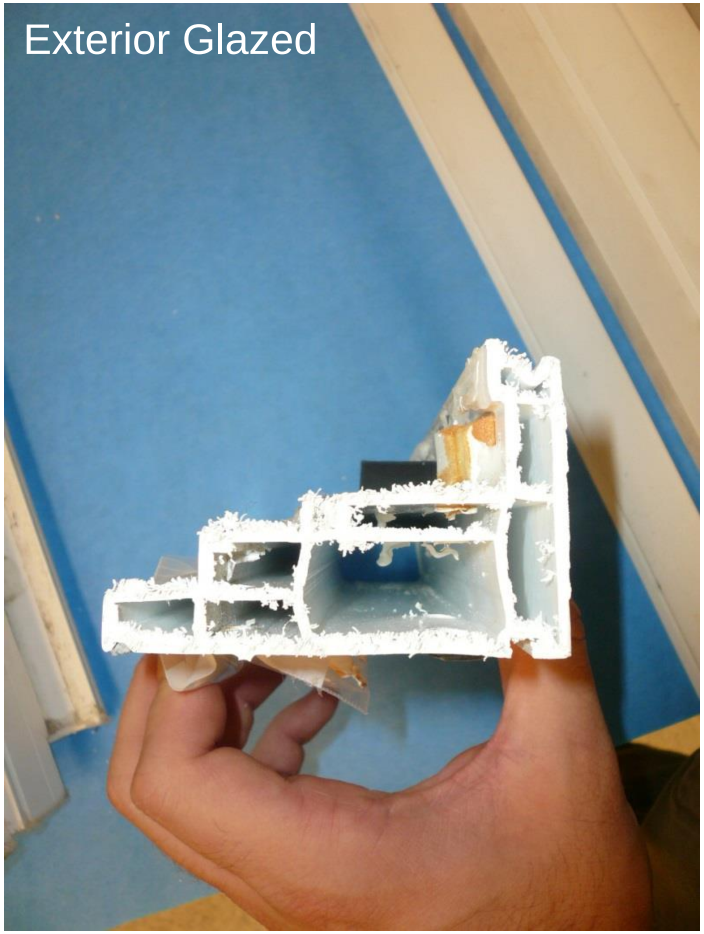
Glass Being Removed

SoCal Chapter

Glazing Tape Is Discolored And Stained From Dirt And Water

Glazing Gaskets

- Often the windows are internally glazed, exposing the foam gaskets to UV and water exposure



SoCal Chapter

Laboratory Testing For Air Tightness

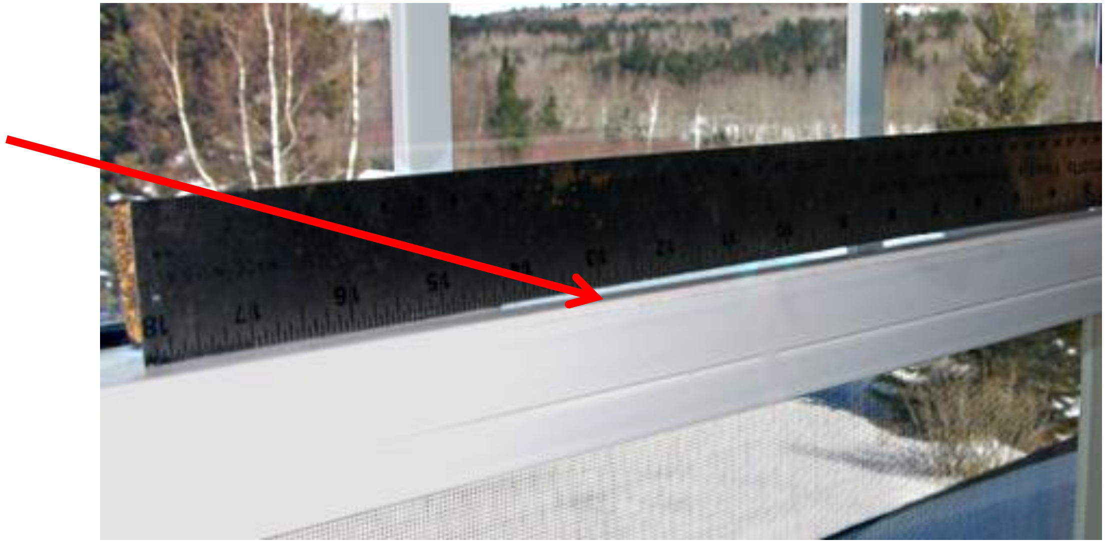
- **Glazing tape failure also causes Air-Leakage test failure:**
  - Due to failed glazing seals, windows tested (ASTM E 283-91) did not meet project specified air leakage performance standards.
  - Of the seven windows tested for air leakage all seven failed to meet the air leakage standards in Manufacturer's shop drawings. This is a 100% failure rate.

Business card fits between glazing tape and window frame illustrating glazing tape failure.

SoCal Chapter

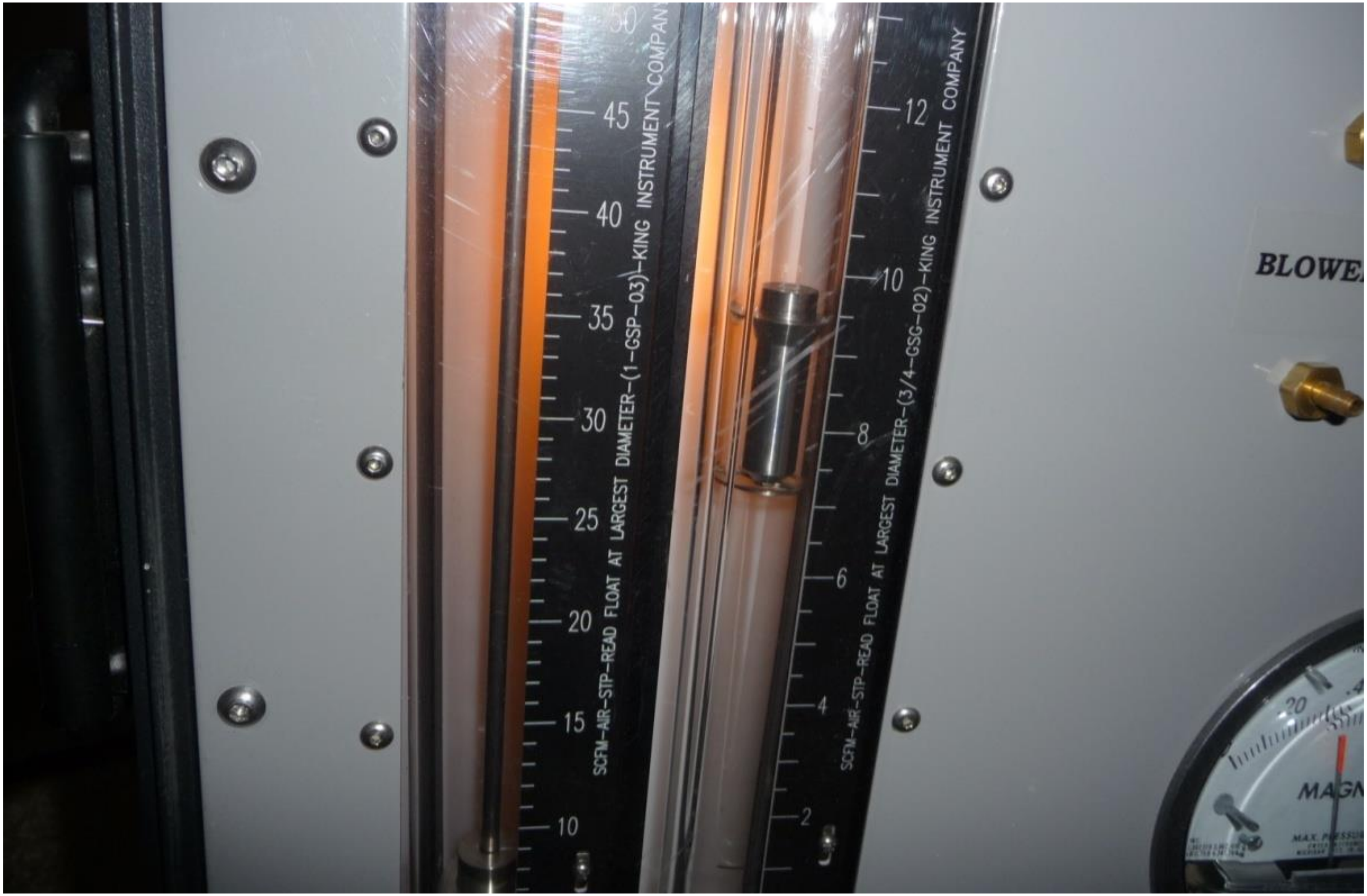
Bowing and Bending of Frame

- Due to the inherent flexibility of vinyl, framing members are often reinforced with steel.
- Framing members with long spans should be designed to limit excessive bending.
- Such bending will often result in reduced performance and the misalignment can make the weather-seals and glazing gaskets non-effective causing excessive condensation, air infiltration, and water infiltration.



SoCal Chapter

Air Pressure Gauge In Action During Air Leakage Testing

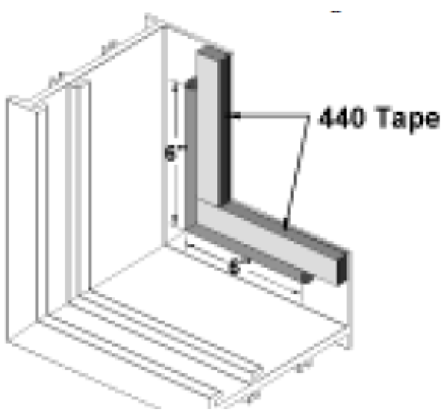


SoCal Chapter

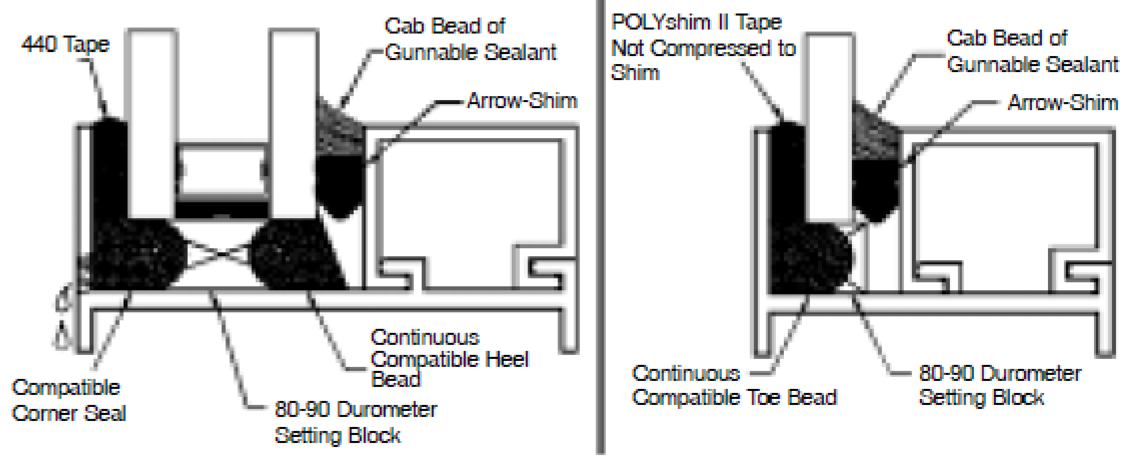
Case Study 1 In-Situ Air Leakage Test Chamber

Glazing Gaskets Enhanced

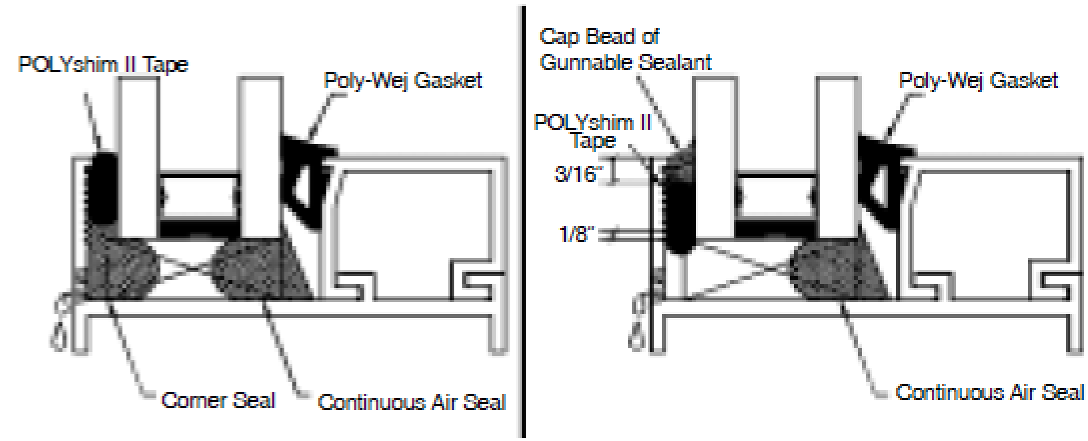
- **We recommend dual seals at glazing gaskets that include foam tape or butyl tape AND wet silicone sealant**



Non-Compression Glazing Systems

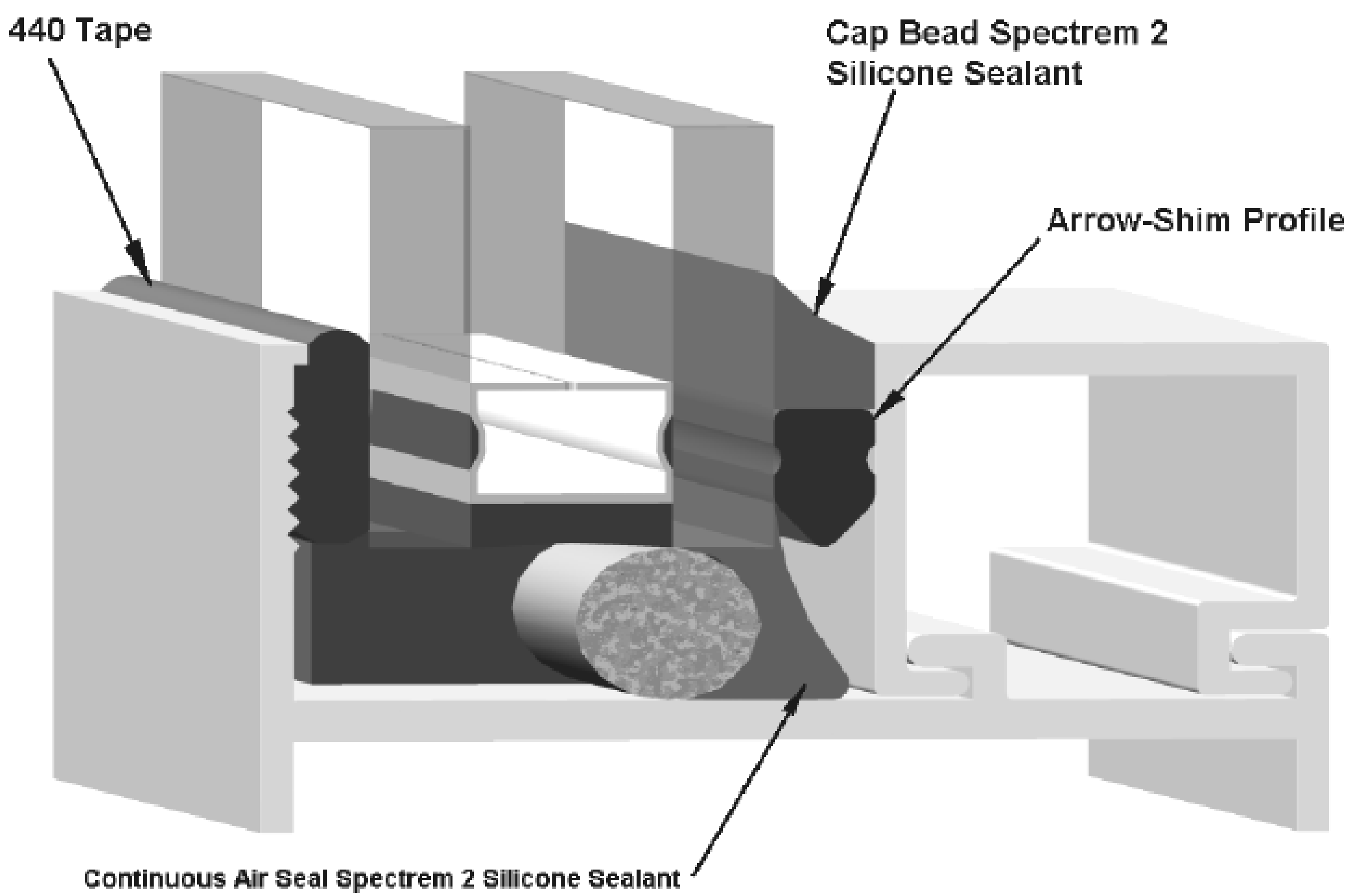


Compression Glazing Systems

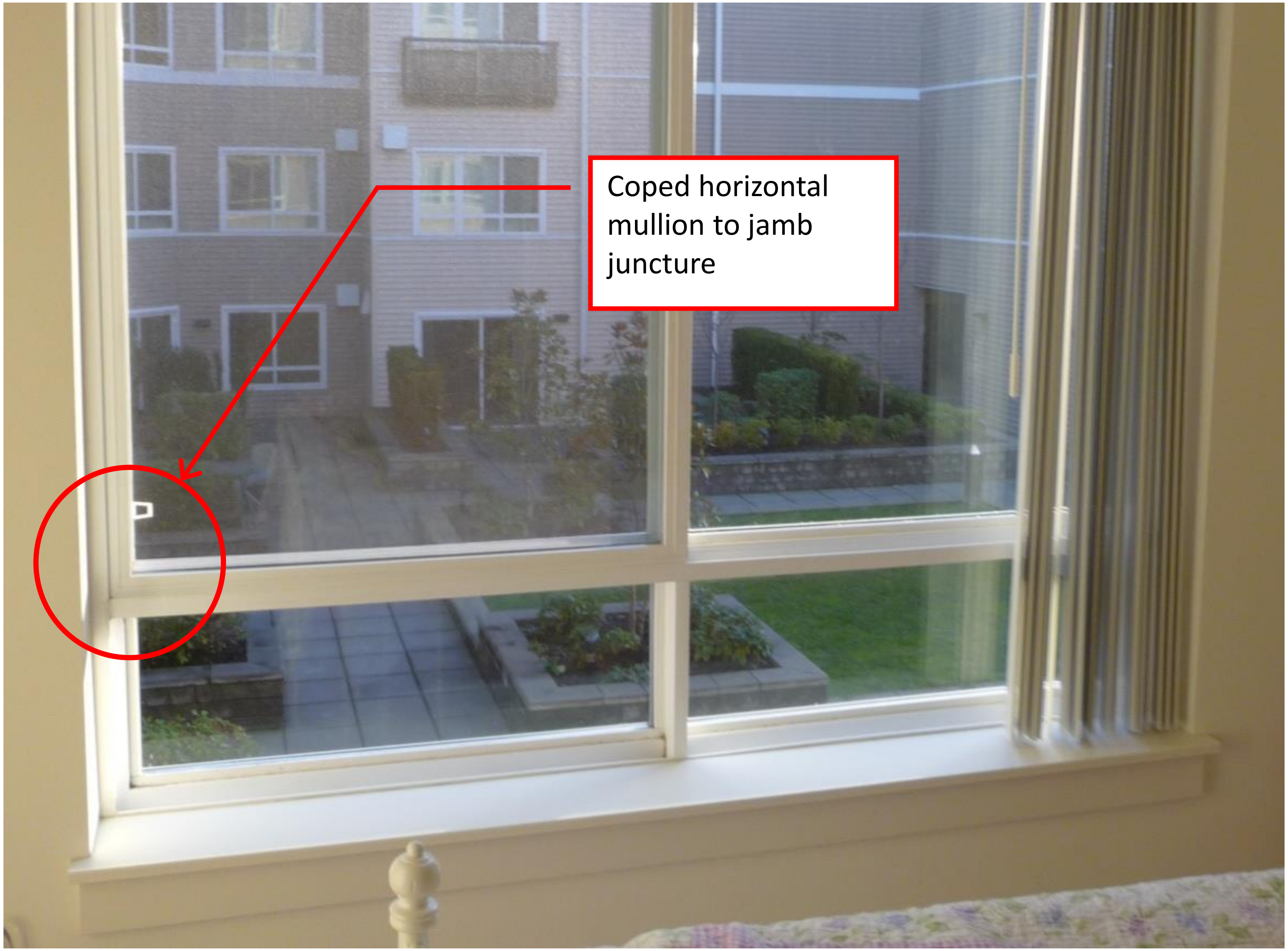


SoCal Chapter

Glazing Gaskets Enhanced

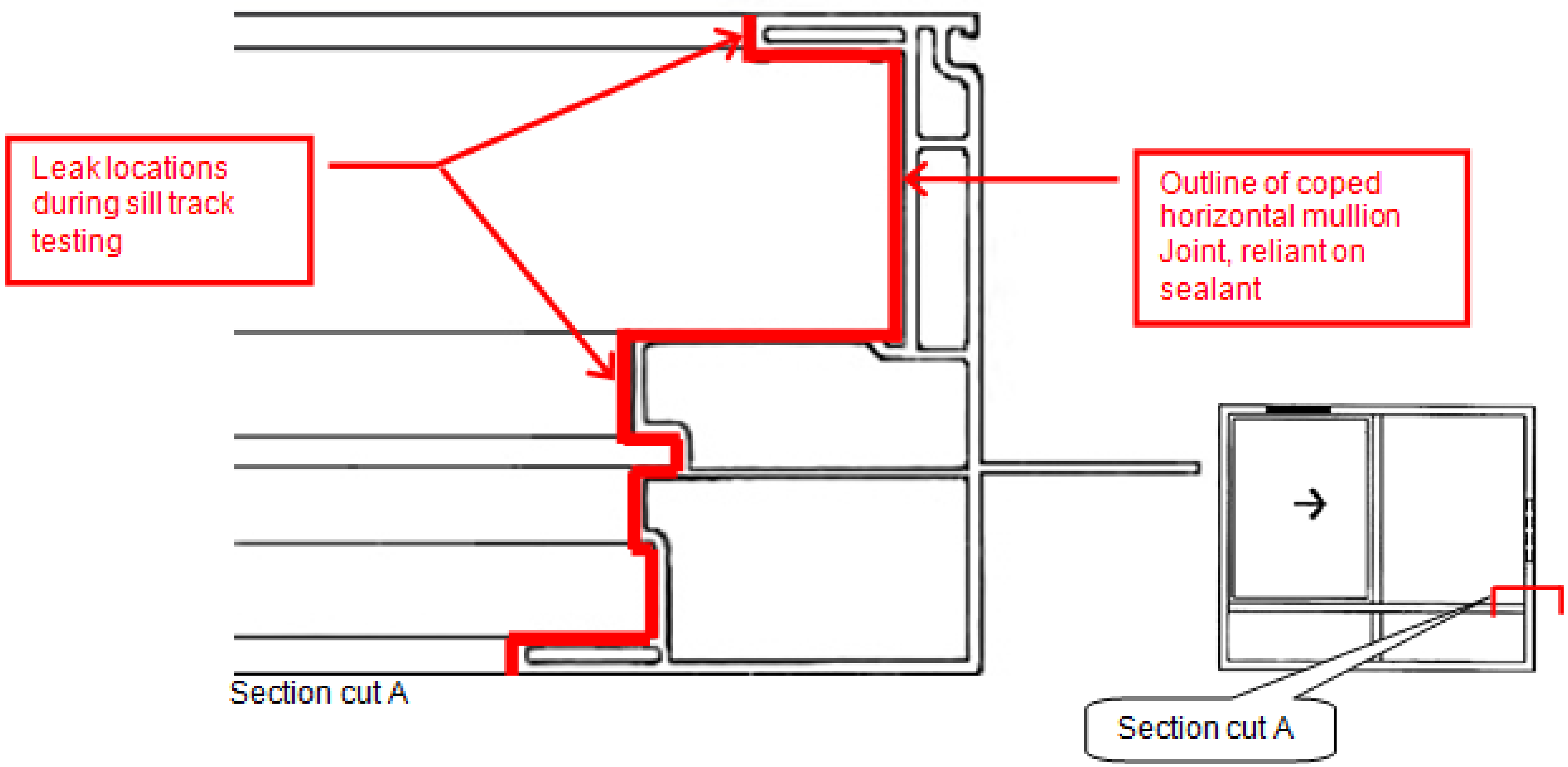


Case Study 1, Coped Horizontal Jamb Juncture



Leak Location During Sill Track Testing

- The sealant-dependent coped joint in the horizontal mullion has failed and allows water to leak through this junction and accumulate in the lower fixed "dry" sill track, which is not designed to manage water.



Findings Summary

- **Based on our testing and visual observations, it was our opinion that the windows failed due to poor fabrication and design.**
- **We observed the following defects within the window assembly:**
  - The coped intermediate horizontal mullion was improperly sealed in the factory. Attempts were made to rectify the failed seals by the manufacturer earlier and those repairs have since failed.
  - Improperly constructed weep holes and drainage pathway caused intermediate sill track to overflow and leak to the interior.
  - Failed glazing tape. Poor quality acrylic had prematurely failed throughout the project.
  - Fastener holes at coped horizontal juncture were leaking.

SoCal Chapter

The Coped Intermediate Horizontal Mullion Is Improperly Sealed

- The horizontal-to-vertical coped mullion-to-jamb extrusion joint was improperly sealed in the factory and the leaks at this juncture was not discovered until after all the windows had already been installed.

- The manufacturer responded to a warranty claim and attempted to repair this condition in the field by applying sealant and injecting foam at this juncture. The frame was sealed with silicone sealant from the exterior of the joint at the positive and negative side of the seam and a hole was drilled and expanding foam was injected blindly at this juncture.

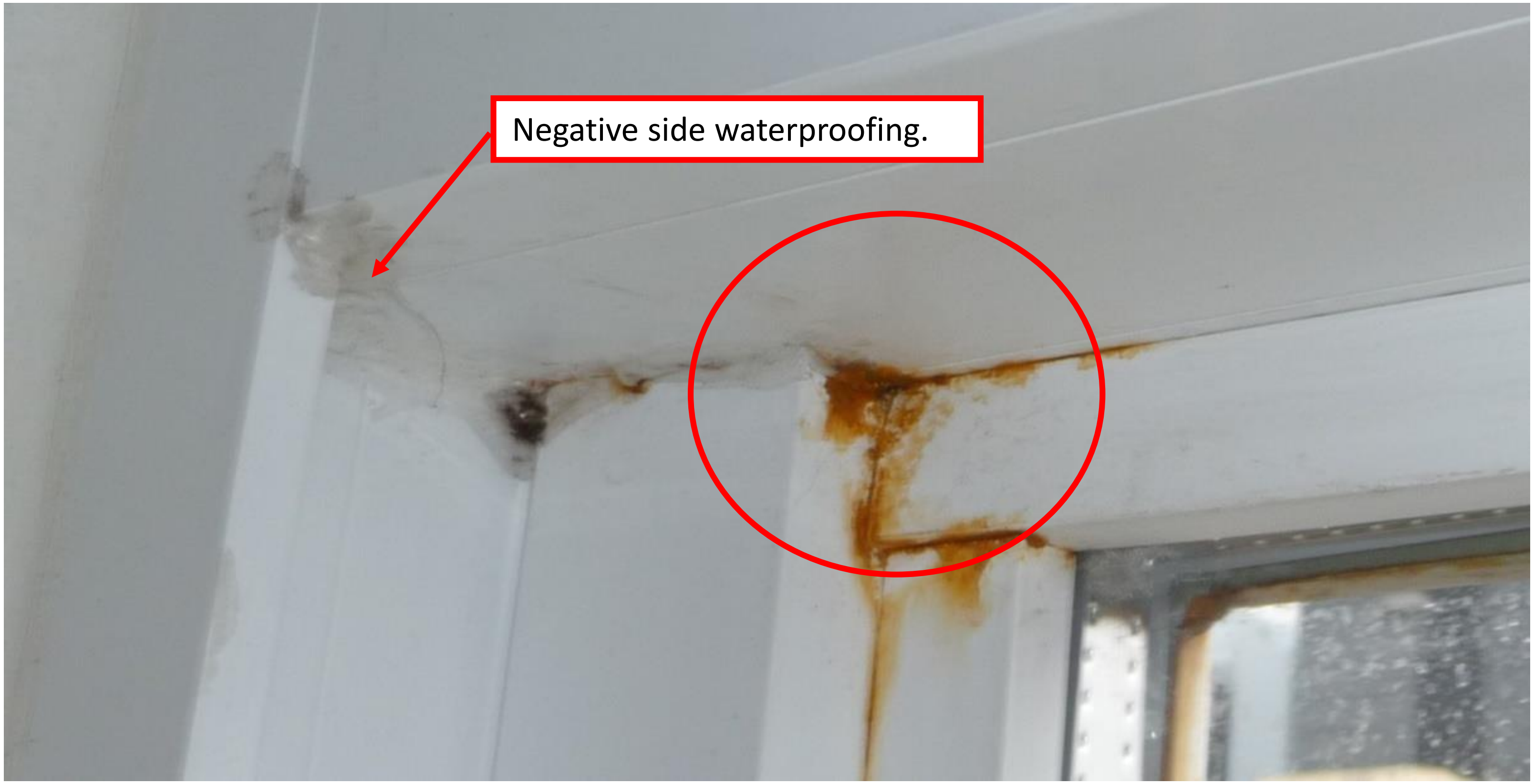
- This method of sealing the joint was inadequate for long-term performance, had failed again resulting in more water leakage and damage to interior finishes.

SoCal Chapter

Coped Joint Failure

A = Manufacturer attempted to seal leak by pumping foam at coped joing
B = Clear silicone sealant, failed attempt to seal coped joint.

Staining From The Water In Contact With The Structural Reinforcing Causing It To Rust



- **Sealant is installed at underside of coped horizontal-to-vertical mullion joint failed to stop leak. The leaks are rust staining from the structural steel reinforcement.**

Window Drainage and Weeping Issues

- Water travels at the jambs and can rust the steel bar

Typical Build-up Of Water in Lower Sill Track

- **This buildup is the result of water standing in this non-draining track.**

Water Intrusion-Damaged Wood Stool.

SoCal Chapter

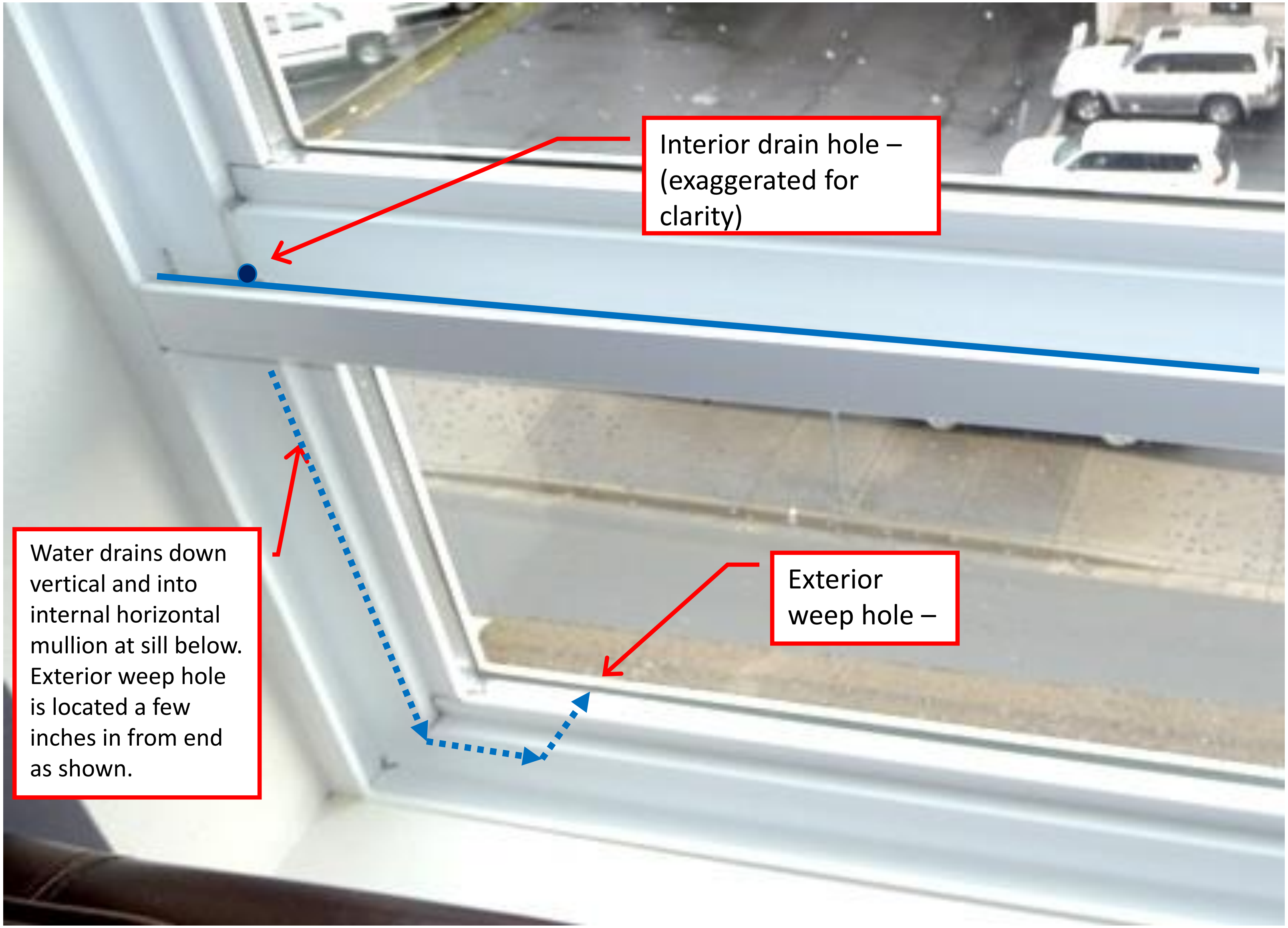
Improperly Constructed Weep Holes And Drainage Pathway

- **Windows were manufactured with improperly constructed weep holes and drainage pathway.**

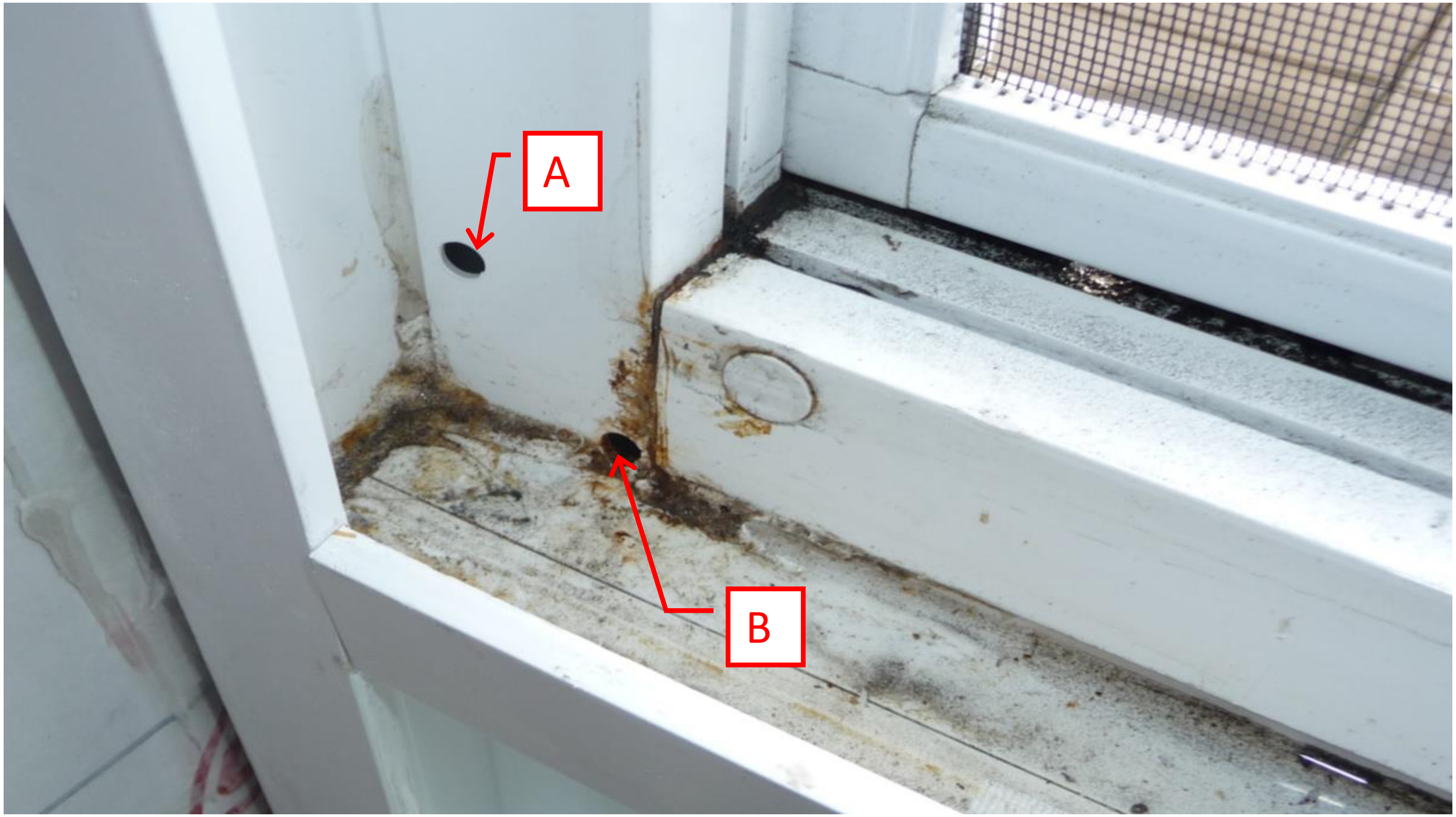
- **The weep holes were constructed with 5 mm diameter hole which encourages surface tension and prevents proper drainage down the pathway.**

- **According to the Glazing Association of North America, the minimum size of weep hole to prevent surface tension is 8 mm or 5/16th inch.**

Case Study 1, Drainage Pathway Analyzed



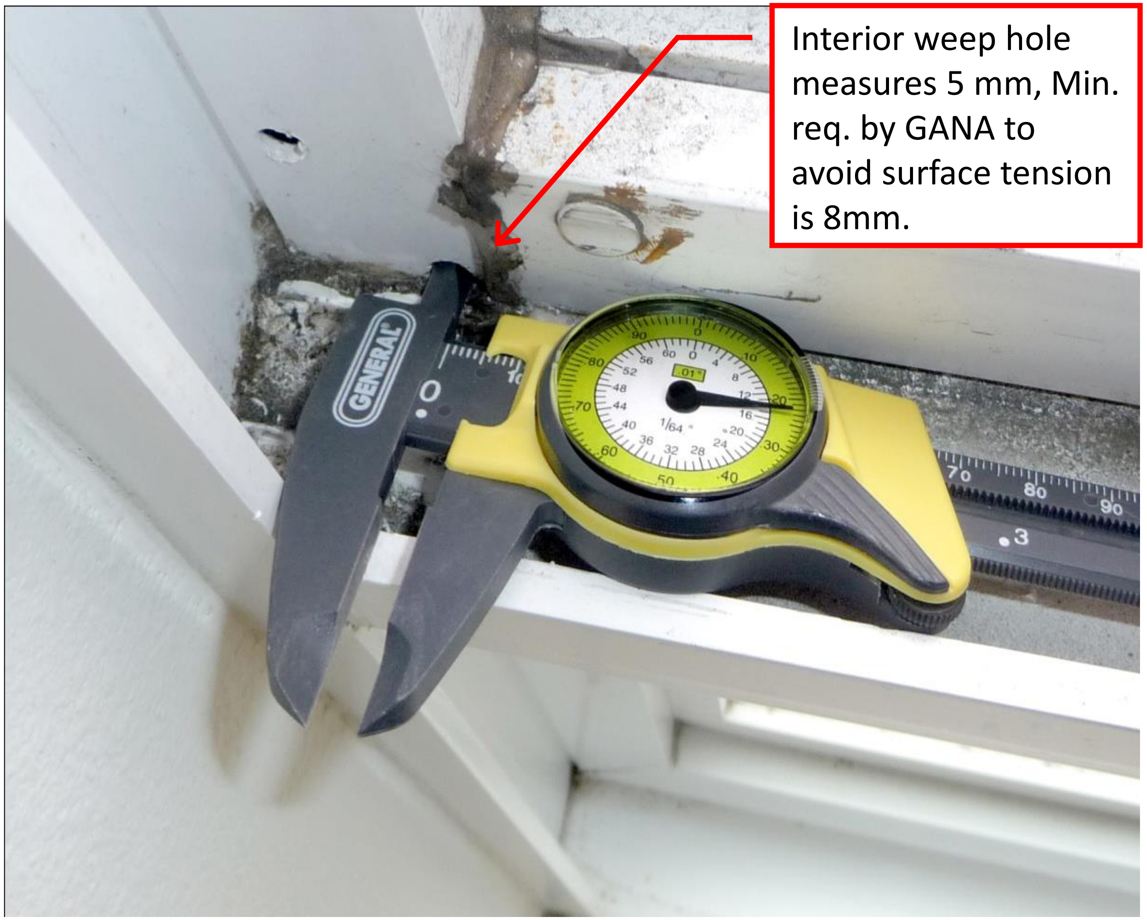
Weep Holes



A = Pressure relief/equalization hole (after the fact).

B = Upper Drain Hole; drain hole is undersized and does not meet GANA minimum weep hole size of 5/16" (8mm). Drain holes measured are 5 mm in diameter.

Interior and Exterior Weeps



Interior weep hole measures 5 mm, Min. req. by GANA to avoid surface tension is 8mm.

Exterior weeps are ¼” high by 3/8” wide.

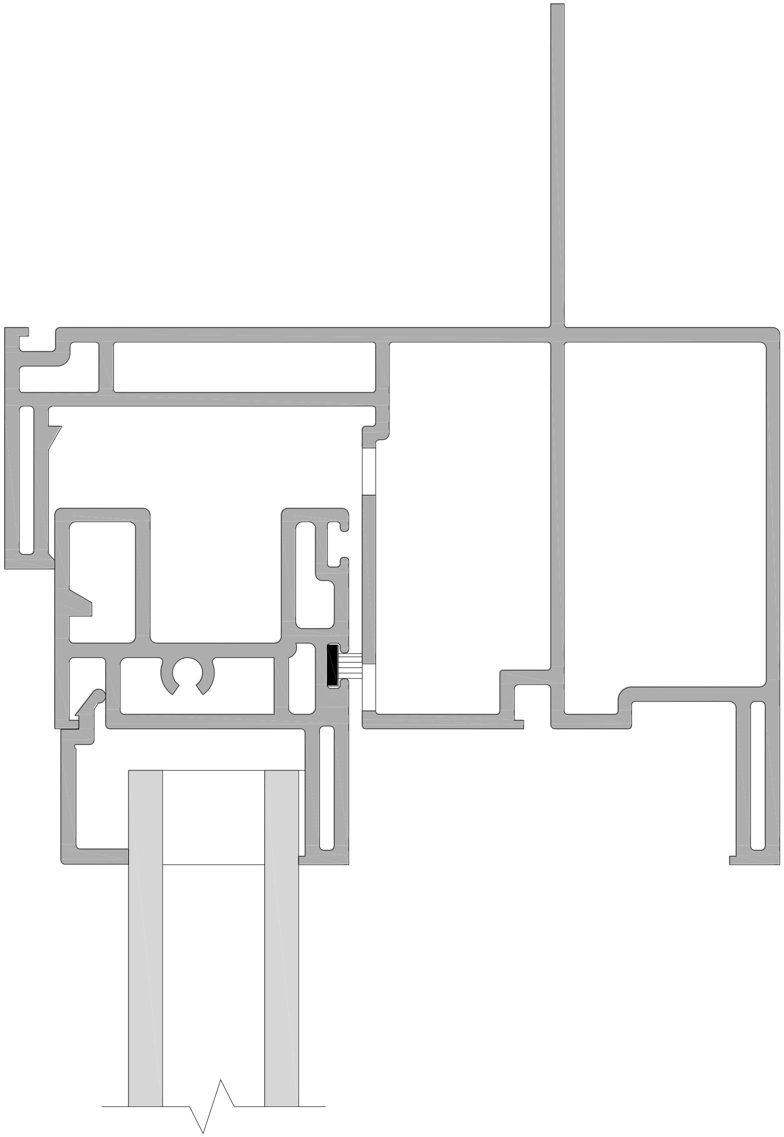
SoCal Chapter

Drainage Defect Condition

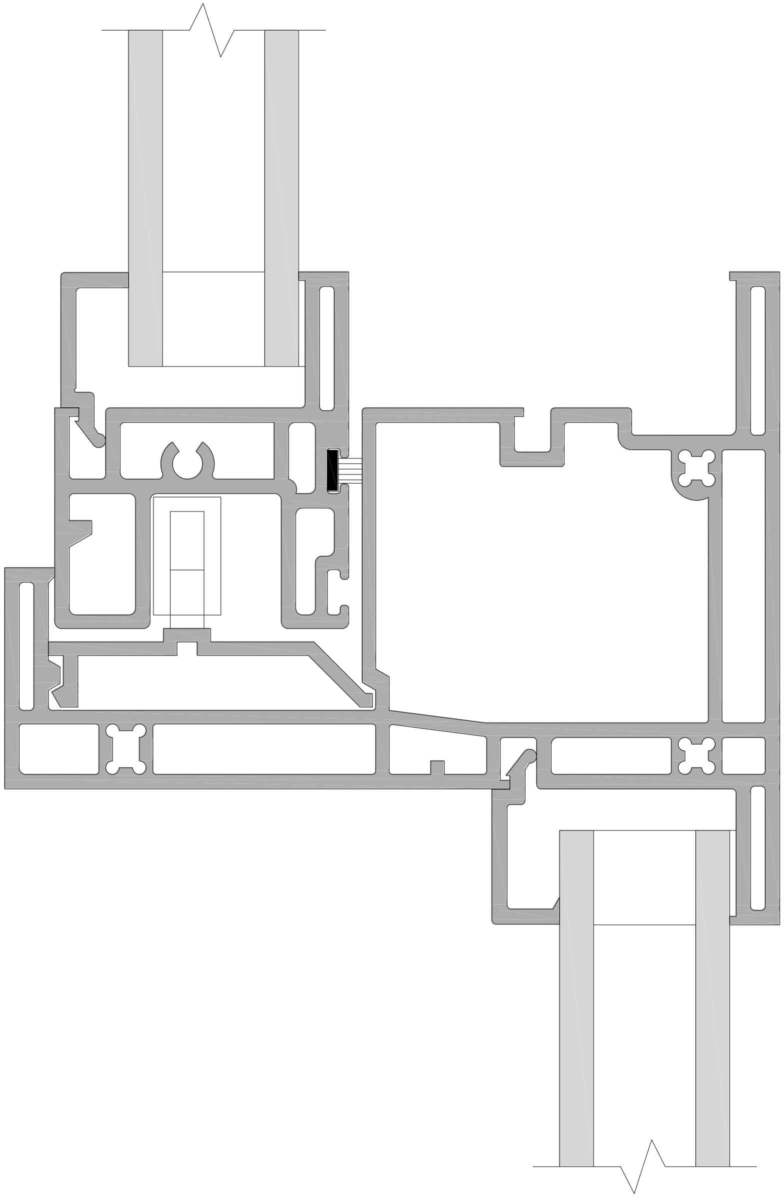
- **Due to the above weep hole and drainage pathway construction the windows failed to perform per the manufacturer's performance requirements.**
  - Windows were tested at 3.5 psf, 2/3^{rds} the Manufacturer stated performance standards at all windows where glazing was isolated from testing.
  - We isolated the glazing-to-frame connections to test only the frame conditions.
  - Water rushed into the frame from the operable sash-to-horizontal transom bar track.
  - Initially water was blown onto the stool through percolation, then water overwhelmed the intermediate transom and poured into the sill track and splashed onto the wood stool.
  - Once the sill track was overwhelmed the water flowed onto the wood stool.
  - Of the 13 ASTM E1105 water tests conducted at windows with the above described drain pathway construction, all 13 failed to pass the test.

SoCal Chapter

Head

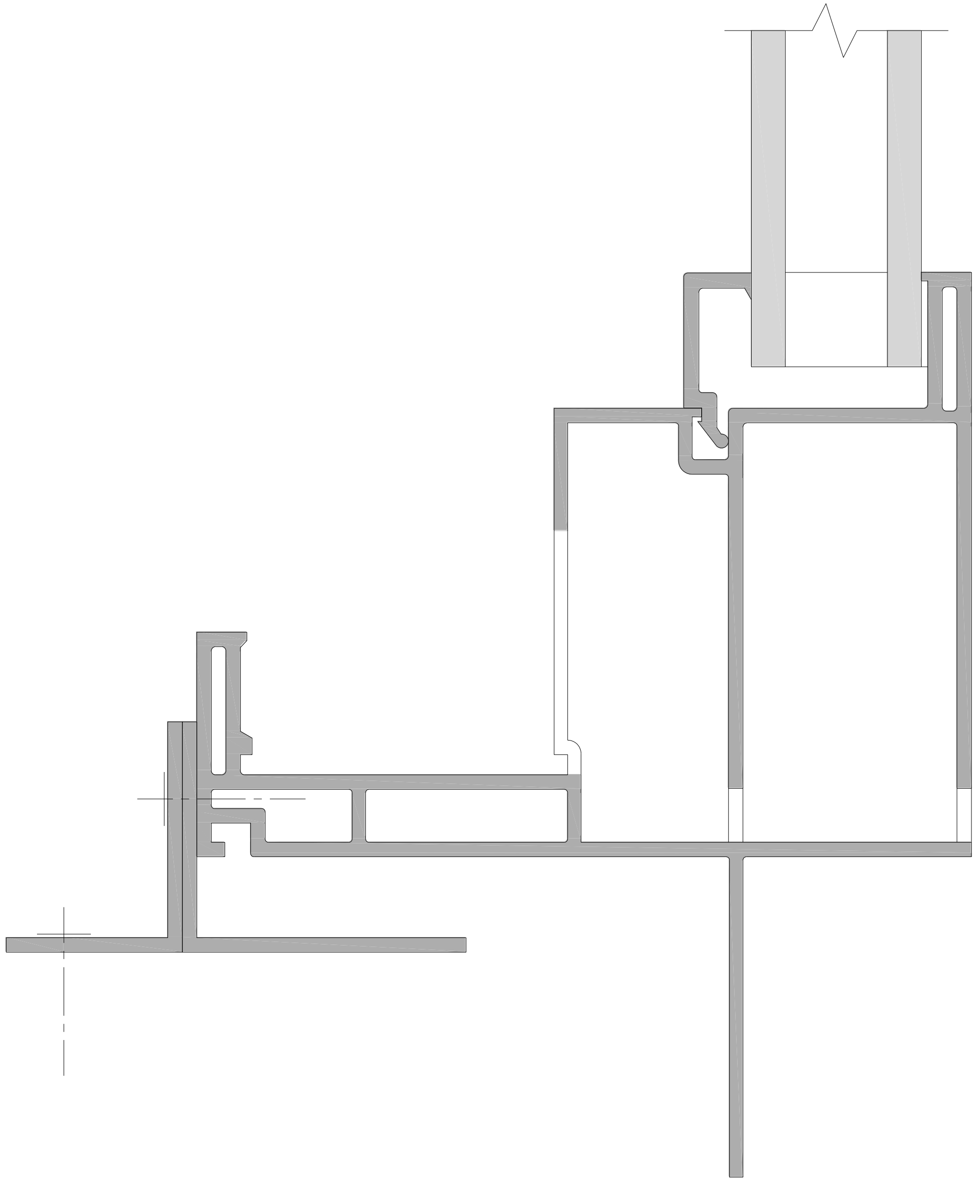


Horizontal Mullion



SoCal Chapter

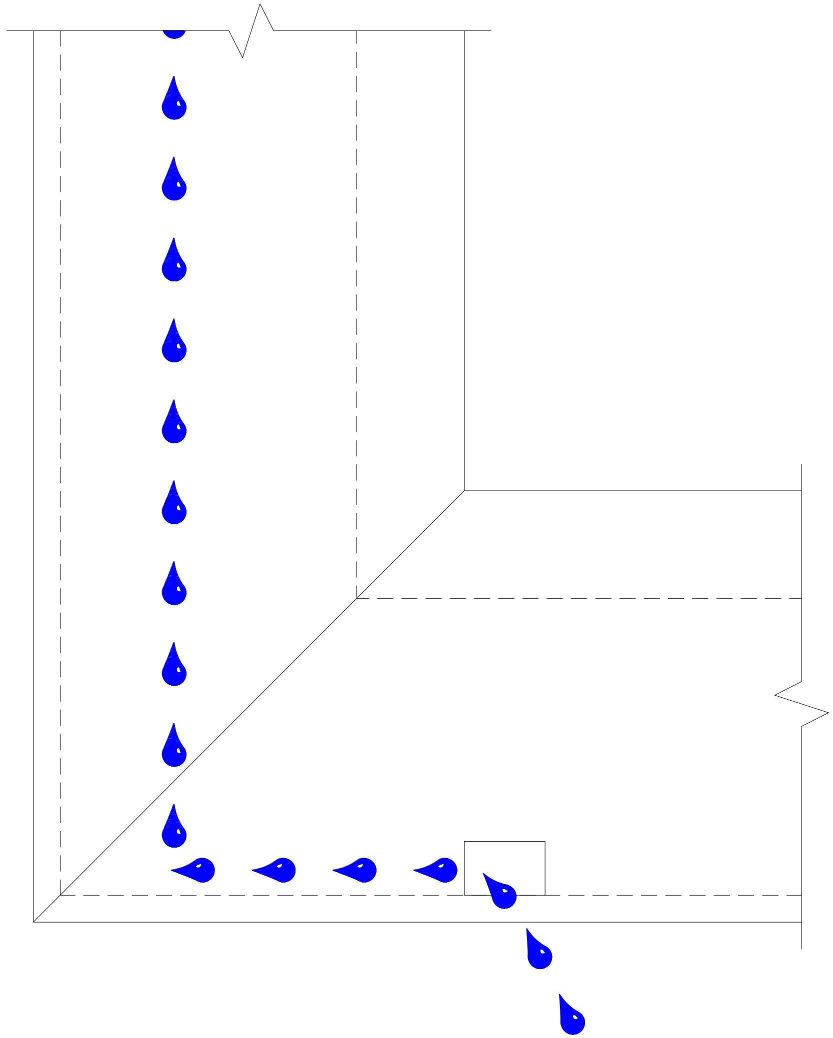
Sill



SoCal Chapter

Drainage Testing Results - Continued

Elevation



SoCal Chapter

Conclusion, Vinyl Windows

- **Coped horizontal to vertical joints can fail if they are not properly designed and manufactured.**
- **Glazing gaskets fail due to internal glazing, poor acrylic material, poor frame contact, lack of back-up sealant.**
- **Drainage weep holes need to be properly designed to drain water.**
- **Mulled window joints are susceptible to various failures. Most mulled windows are not tested in the mulled configuration.**

SoCal Chapter

Thank You!

Questions?

Gbers@abbae.com