Understanding Common Roofing Issues & Replacement Options

Presented by:

Karim Allana, PE, RWC, RRC

Founding Principal, Chief Executive Officer

Allana Buick & Bers, Inc.

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- **Education:** B.S., Civil Engineering, Santa Clara University
- **Registration:** P.E., Civil Engineering, California, Washington, Nevada, and Hawaii
- **Certification:** Registered Roof Consultant (RRC), Roof Consultants Institute, and Registered Waterproofing Consultant (RWC)
- **Overview:**
  - CEO and Senior Principal at Allana Buick & Bers.
  - Former Turner Construction Employee (Project Engineering and Superintendent)
  - Over 37 years experience providing superior technical standards in all aspects of building technology and energy efficiency.
  - Principal consultant in forensic investigations of building assemblies, failure analysis, evaluation and design of building infrastructure and building envelope evaluation and design.
  - Expert in all aspects of building envelope technology.
  - Completed numerous new construction, addition, rehabilitation, remodel and modernization projects for public and private sector clients.
  - Specialization in siding, roofing, cement plaster, wood, water intrusion damage, window assemblies, storefronts, below grade waterproofing, energy efficiency, solar engineering and complex building envelope and mechanical assemblies.

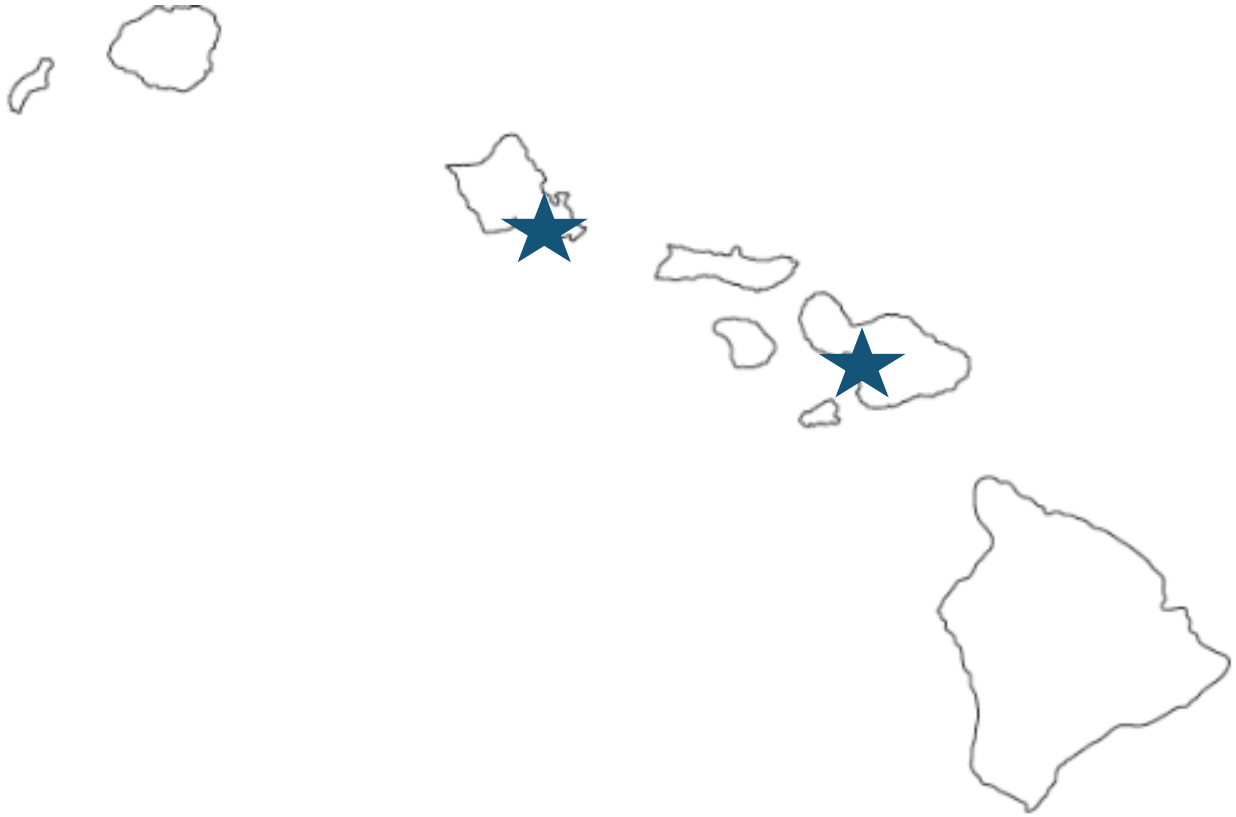
ABBAE Firm Overview

- Allana Buick & Bers (ABBAE) is an Architectural Engineering firm specializing in Construction Management of exterior enclosure repairs and mechanical upgrades
- ABBAE has over 32 years of experience with over 12,000 projects
- 55% of our work is building rehabilitation and repairs with over $5 Billion in rehab construction.
- ABBAE is a leading forensic firm with many expert witnesses.
- Office Locations – 16 offices across Hawaii, Oregon, Washington, California, Nevada, Texas, Virginia, Oklahoma, Michigan, and North Carolina

Staff & In-House Expertise

- Licensed Professional Engineers – Civil, Structural, and Mechanical
- Registered Architects
- Building Enclosure Commissioning Process Providers (BECxPs)
- Registered Roofing Consultants (RRCs)
- Registered Waterproofing Consultants (RWCs)
- Registered Building Envelope Consultant (RBEC)
- Registered Exterior Wall Consultant (REWCs)
- Registered Roof Observers (RROs)
- Certified Exterior Insulation and Finish System (EIFS) inspectors
- Curtain Wall Specialists
- ICC Certified Building Inspectors
- Water Testing Experts
- Leak Investigation and Diagnosis Experts
- Infrared Imaging and Nuclear Moisture Scanning Experts

Hawaii Office Locations



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Understanding Common Roofing Issues and Replacement Options

Presentation Agenda

- Lifespan and Longevity of Low and Steep Sloped Roofing Assemblies
- Case studies of PVC and TPO roofs
- Local Island Roofing Issues
  - Old Wood “Shake Roofs”
  - Composite Shingle Materials
- Common glazing issues in new and older buildings
  - Residential vinyl and aluminum windows
  - Commercial storefront style windows
  - Sliding doors
  - Curtain wall systems

Lifespan and Longevity of Roofing Assemblies

Life Expectancy of Buildings and Assemblies

- Life expectancy of building:
  - IRS's definition – 39.33 years
  - In reality, buildings can last from 50 to 1000 years

- Lifespans of historic buildings by type:
  - Wood framed low rise, 50 - 250 years
  - Mass masonry, 100 - 500 years
  - High-rise, > 100 to 250 years

What Makes a Long Lasting Building?

- The number 1 contributing factor for longer lasting assemblies is good construction, free from defects.
- The number 2 factor is superior design.
- The number 3 factor is system/material selection.
  - Roofs that can last over 40 years and are not dependent on “maintenance” or repairs to keep them water tight
  - Horizontal waterproofing assemblies like podiums, and roof decks are reliably waterproofed and constructed to last for the life of the building
  - Exposed horizontal waterproofing systems like balconies and lanais can last between 5 years and 20 years
  - Below grade waterproofing is built to last the life of the building
  - Exterior skin can last for the life of the building (50 to 500 years)
  - Sealant replacement cycle is limited to 20+ years and water intrusion is not entirely sealant dependent

Roof Life Expectancies

- Roofs are capable of lasting 40+ years but most do not
- Some single ply roofs are newer on the market and don’t have proven performance track record
- Roofs can get damage and fail due to excessive foot traffic
- Roofs can fail due to environmental conditions
- Roofs can fail due to improper installation of components
- Product defects can lead to premature failures
- Composite shake and synthetic roof material failure

Hot Applied
Built Up Roofing (BUR)

Implications on Defective Construction

- Attachment of Roofs
- Embedded Metal Flashings
- Base Flashings
- Parapet Wall Flashings
- Sleeper Detail
- Drainage and Slope
- Surfacing and UV Protection

Hot Applied Built Up Roof (BUR)

Built Up Roofing (BUR)

- BUR systems are field applied and quality control is essential for performance and longevity. Properly applied, BURs can last up to 50 years!

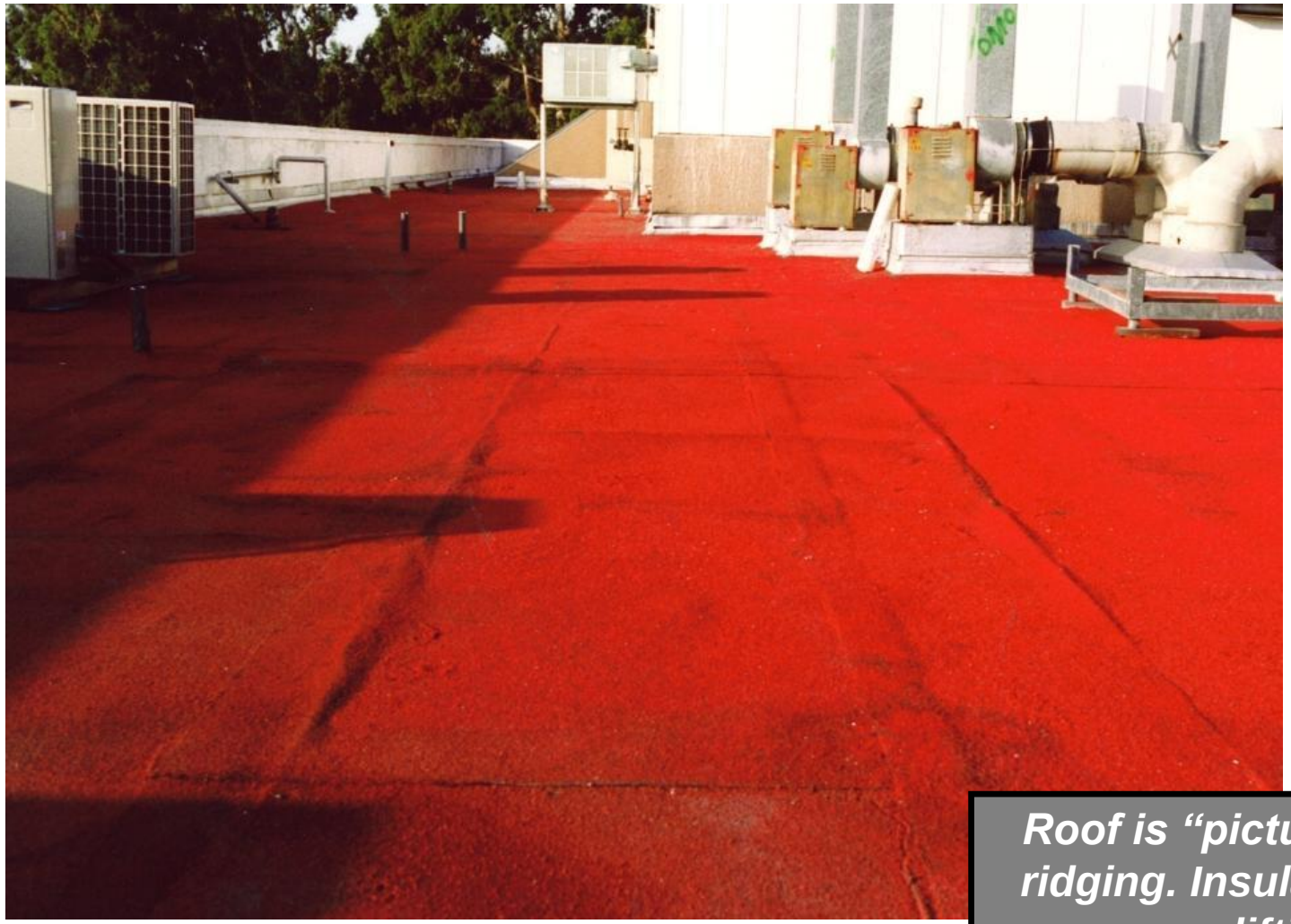
Lifespan Reduced By Defective Construction

DEFECT: Lack of brooming of felts and improper asphalt temperature causes voids and poor saturation of roof plies.

Attachment

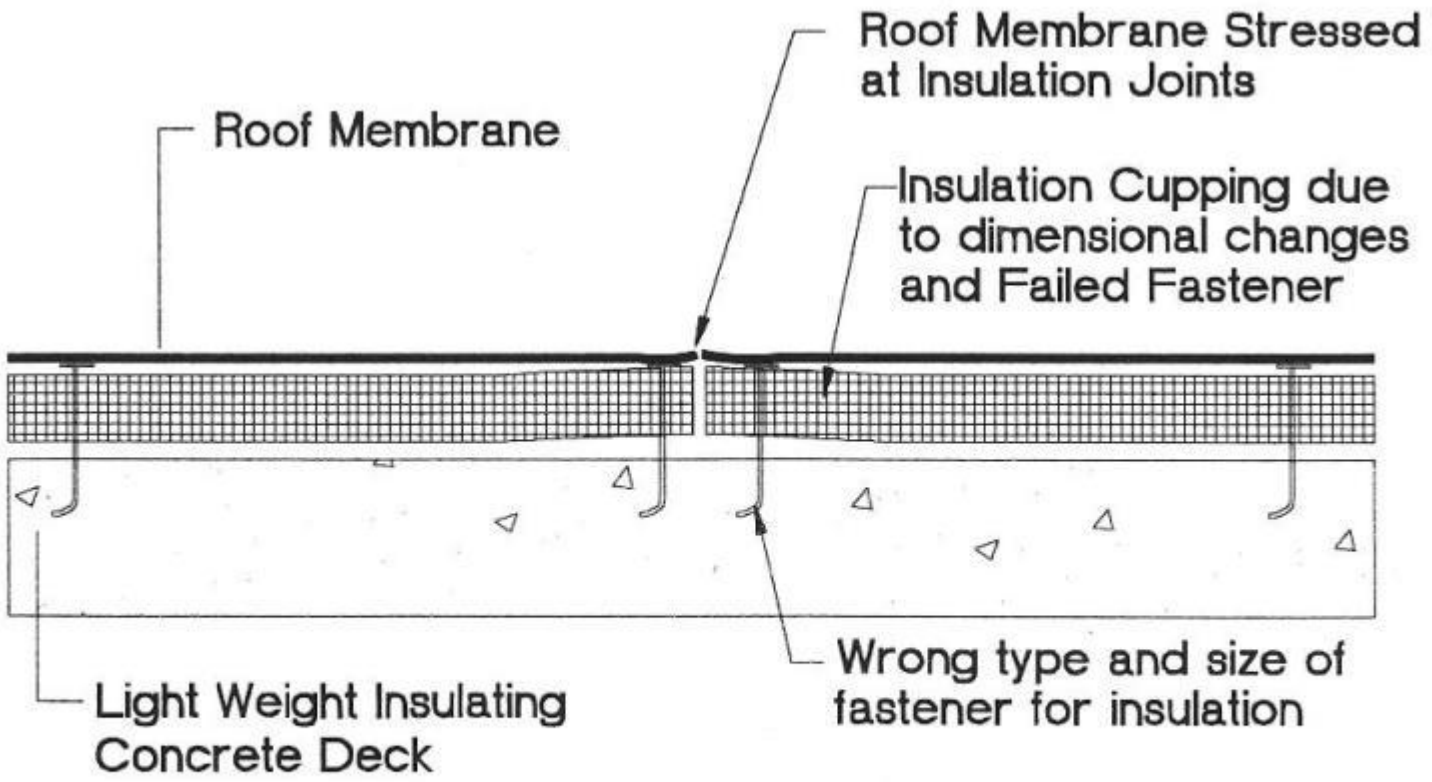
- Proper attachment of roofing system is essential.
- Membrane attachment with mechanical fasteners or with adhesion
- Insulation attachment with fasteners and discs or approved adhesive over substrate
- Proper attachment of substrate to structure
- Improperly attached roofs can…
  - Blow-off or detach
  - Cause splitting and ridging
  - Cause premature failure

Example Failure From Roof Attachment Issue



Roof is "picture framing" and ridging. Insulation boards are lifting up

Improperly Attached Roof Caused Failure



PICTURE FRAMING + ROOF SPLITTING CAUSED BY POOR FASTENING OF INSULATION BOARD TO SUBSTRATE

Wrong Type of Fastener Caused Failure

DEFECT: Improper securement of roof. causing cupping of insulation material.

Ponding Water Leads to Deterioration

Crickets are undersized in some locations, or not provided at all. Need to be deeper and redesigned. Note deterioration.

Modified Bitumen Roofing SBS or APP Modified

Modified Bituminous Roofs

- Modified bitumen roofs can either be SBS (Polystyrene-butadiene-styrene) based or APP (Atactic Polypropylene)
- A synthetic rubber/plastic polymer added to hot asphalt
- Thick, coated, polyester and or fiberglass reinforced sheets are factory made and applied in the field.
- Applied with torch applied, hot asphalt, or cold adhesive
- SBS Roof Characteristics
  - Synthetic rubber with poor resistance to UV. This type of membrane requires good surfacing
  - SBS sheets can be torch applied, adhered with cold adhesive or hot asphalt
  - Roofs are susceptible to solvent attic from hot asphalt
- APP Roof Characteristics
  - Synthetic plastic with great resistance to UV.
  - SBS sheets are generally torch applied or adhered with adhesive

New, Hot Applied SBS 1 ply Smooth Sheet

2nd ply SBS with Cap Sheet Surfacing

12 Year Old SBS Roof Crazing and UV Damage

Single Ply PVC and TPO Roofs

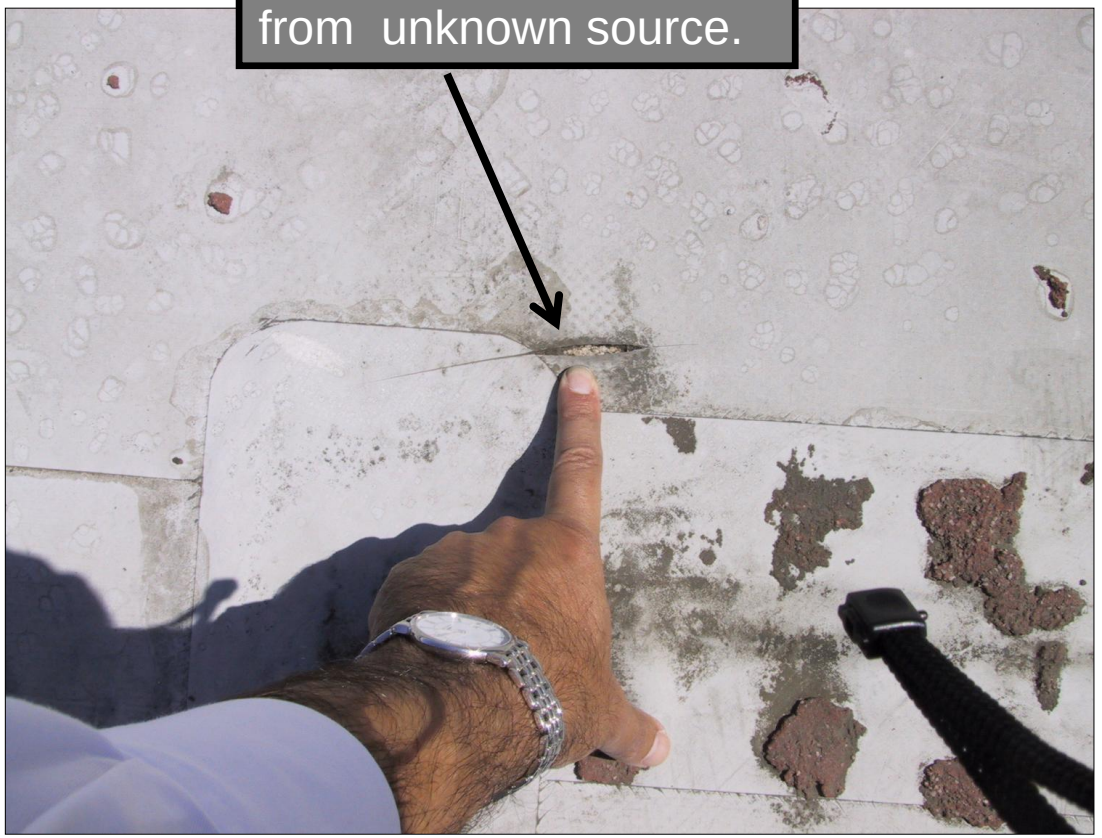
PVC Roof Chemistry

- Polyvinyl chloride (PVC) is a vinyl thermoplastic polymer constructed of repeating vinyl groups (ethanol's): through chemical reaction, hydrogen atoms are replaced with a chlorine in the form of chloride.
- Roughly half of the PVC compound is chlorine and half is vinyl and additives.
- Third most commonly used plastic (after polyethylene and polypropylene).
- Naturally stiff and light.
- Among the most widely used plastic in construction applications.

PVC Life Expectancy Study

18 year old single ply roof on a department store in Northern California.

Single Ply Membranes Susceptible To Damage



Single Ply Susceptible To Standing Water

PVC Roof Membrane Sustainability Score

- Membrane Material
  - Field areas of membrane performance good 20+ years for 40 mil membrane
  - 80 Mil membrane may last 30+ years
  - Easy to patch on back of sheet. Did not attempt to patch on front of sheet
- Traffic And Impact Damage
  - Susceptible from impact damage
  - Damage easy to identify and repair

TPO Roofs and Performance Study

5 Years Old Carlisle, Hospital Building, Vegas

5 Years Old Carlisle, Hospital Building, Vegas

Corner of parapet wall, membrane completely gone, Severe Damage

5 Years Old Carlisle, Hospital Building, Vegas

Membrane lost and glass has deteriorated

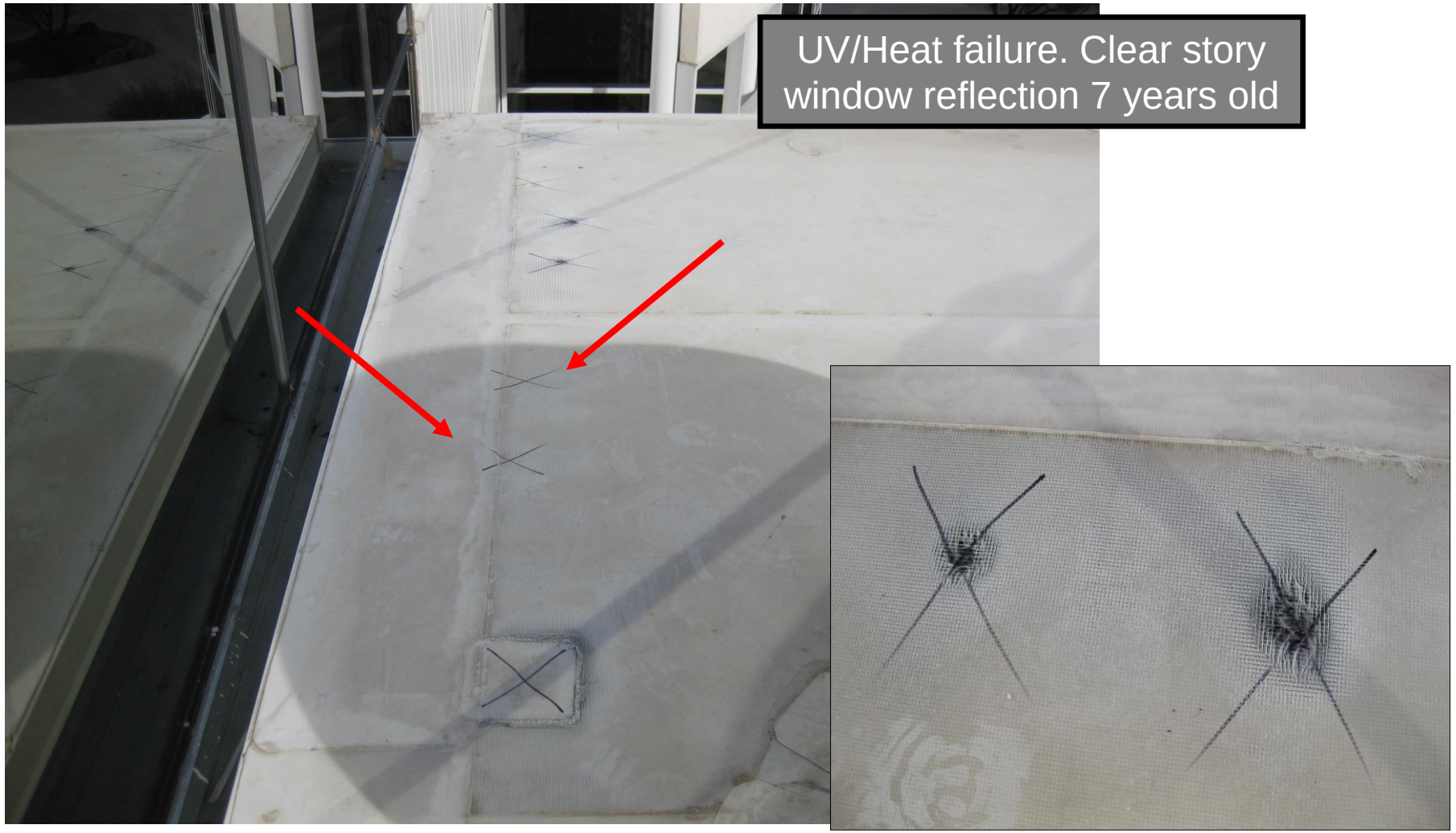
Despite UV Protection, Failed Under Black Mat

Severe failure under walk pad and upper membrane layer

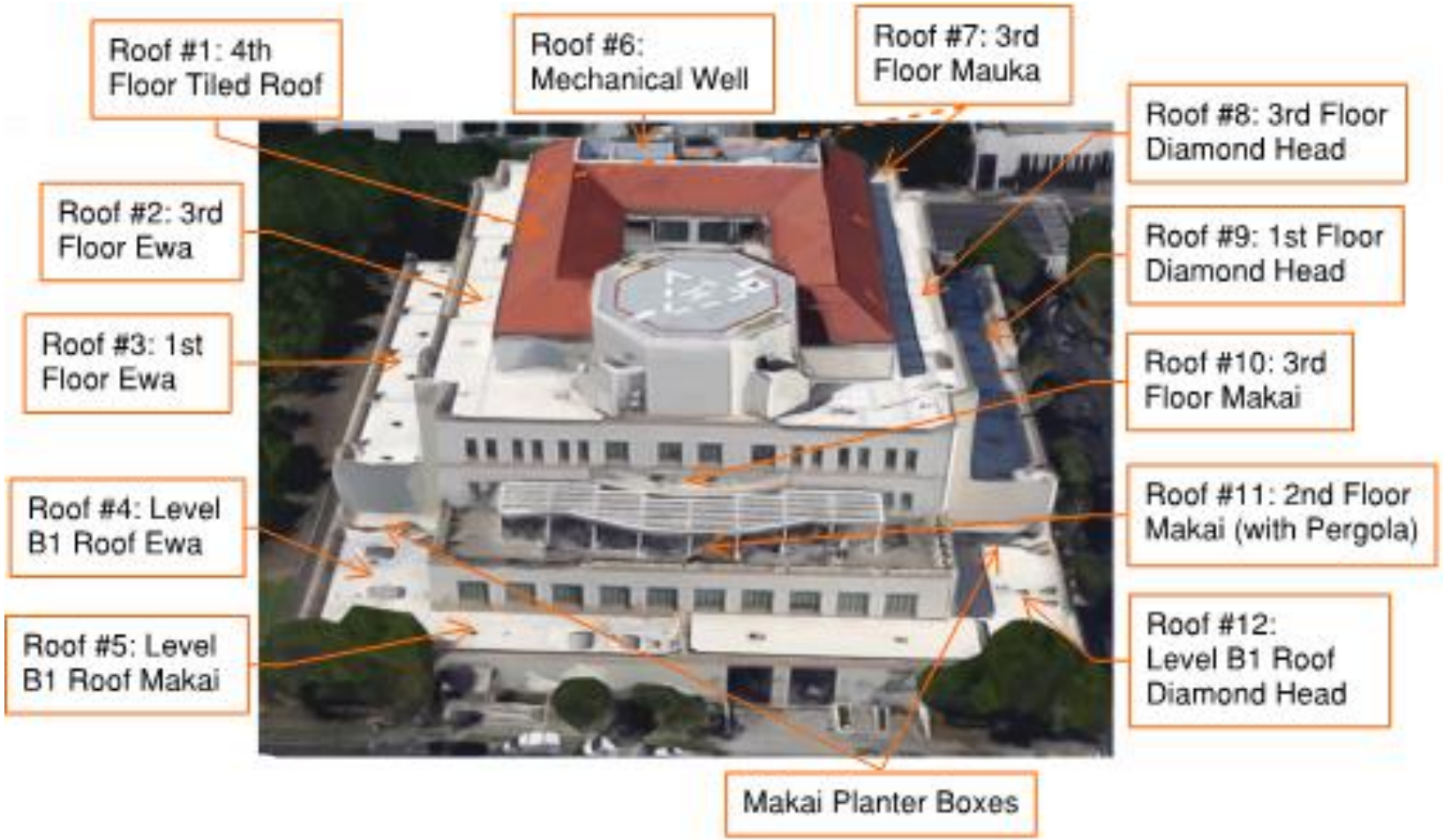
Sun Reflection, GAF TPO 2.5 Years Old

Original GAF roof failed in 3 years. GAF replaced it march 2008. New roof also failing

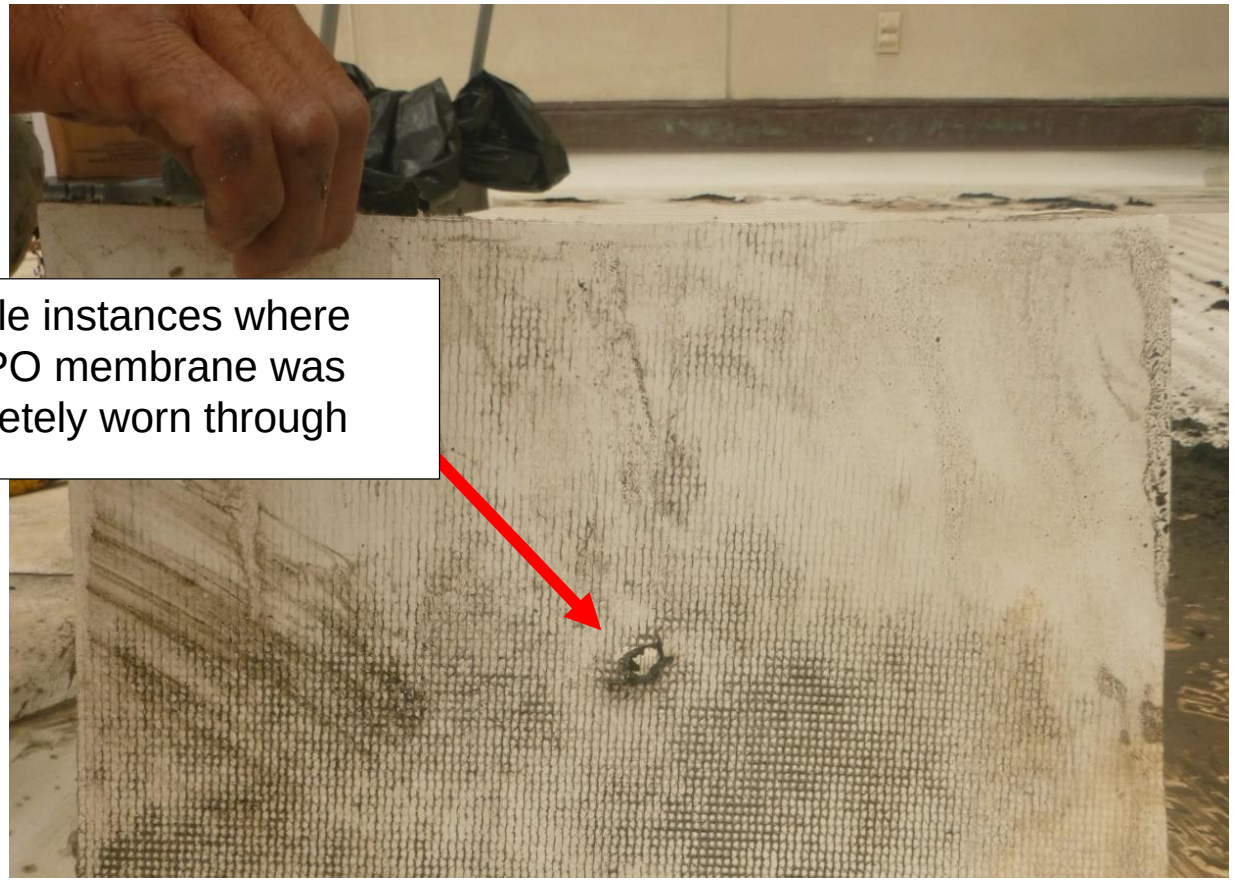
Sun Reflecting Off Clearstory Glass Increase Heat



Honolulu Police Headquarters, 2018



HPD Roof Performance After 12 Years



Multiple instances where the TPO membrane was completely worn through

TPO Sustainability Score

- UV – Heat Damage
  - All membrane manufacturers suffered some level of damage
  - GAF seemed to fare the worst.
  - Firestone seemed to fare the best
  - Failures appear to be mostly adjacent to parapet walls, reflection from clear story windows and metal panels create high “heat”
  - More failures in hot climate zones like Las Vegas
  - Hawaii TPO life expectancy is 12-15 years

Lessons Learned, Older TPO And PVC Roof

- Weldability of older TPO continues to be an issue
- Owners will need frequent inspections, timely repairs, and use of proper patching techniques.
- PVC appears to be performing better and not have an issue with heat
- Neither PVC or TPO lose appreciable membrane thickness.
- Membrane thickness loss is dependent on erosion due rain and water run-off. Less in Las Vegas due to lack of rain. More in Washington State due to higher rainfall and related erosion.

Keys To Sustainable Roofing Assemblies

- Roof longevity is dependent on:
  - Selection of roofing membranes that resist heat, sun, wind and water
  - Proper construction, to prevent “premature” leaks in flashings and drains that require repairs and maintenance
  - Roofs are “designed” with little or no need for maintenance
    - Blowing off leaves and annual inspection are recommended
  - Redundant assembly with belt and suspenders

Old Shake Roofs and Other Composite Material Failures

Typical “Heavy” Wood Shakes – 20+ Years Old

Wood Shake Shingles – Traditionally made of wood, popular in the 1960s-70s.

Wood Shake Substitute - Composite Material

- Widely discontinued use due to issues with fire rating, longevity, and wind resistance in high wind zones.
- Commonly replaced with synthetic “wood shingles”
- New “Shake-Style” Shingles – Replicates look of wood shake, made of composite materials (typically asphalt/concrete, clay or fiberglass).
- Composite Shake warranties are for 25+ years, but are known for pre-mature failure (there have been many lawsuits).

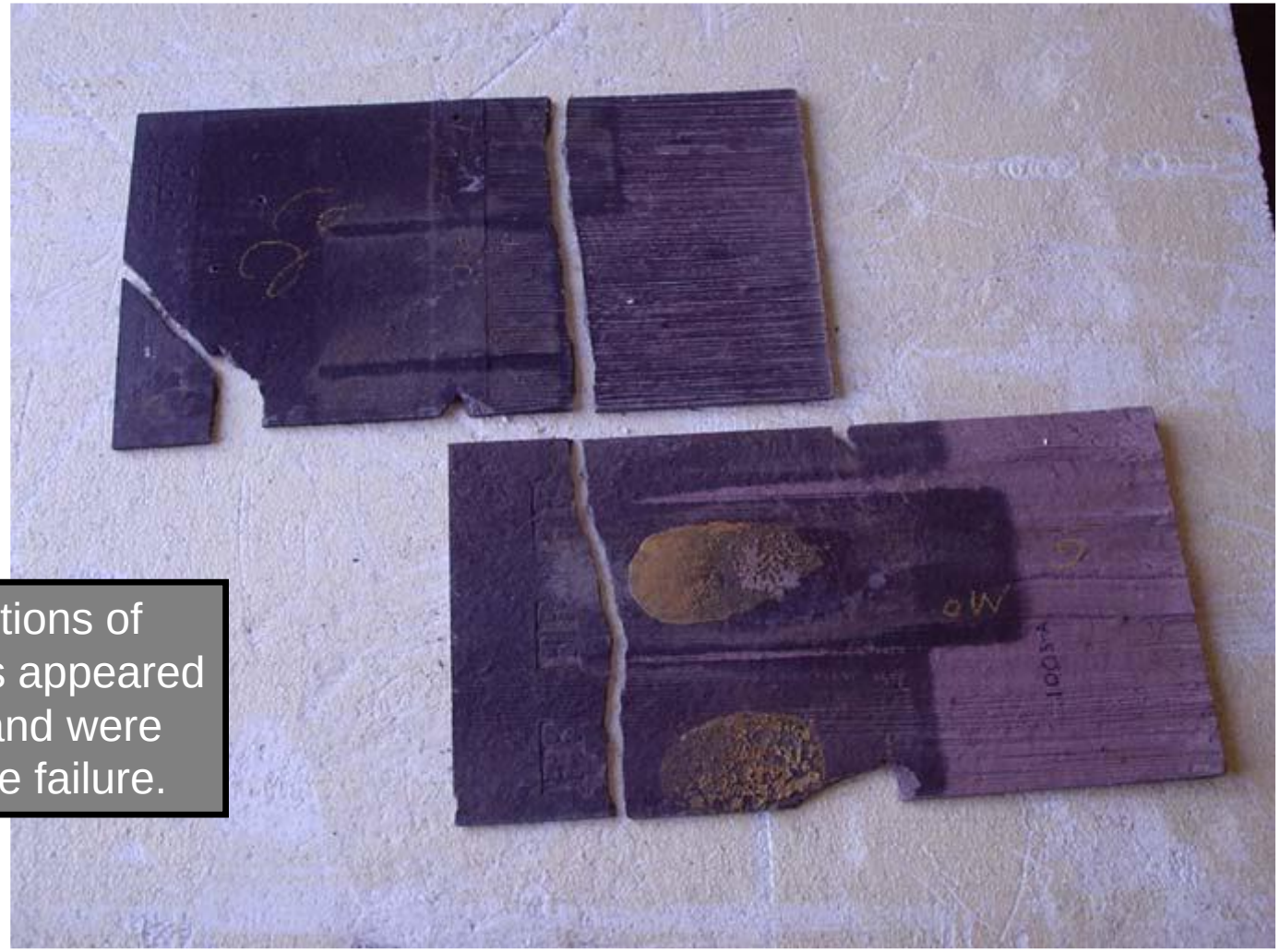
Testing “Fire Free” Composite Shake Failure

Testing occurred 3 – 5 years in service

Common Composite Material Failures

- 2 Common Types of Composite Shingles
- Cementitious Wood Fiber Composites
  - Fail via deterioration from high water absorption and “pulp sugars”
  - Absorbed water creates an alkaline solution that corrodes wood fiber
  - Sugars in wood pulp (used as fibers) cause cement to fall apart
- Polymer Composites
  - Fail via high temperature and UV exposure.
  - Causes degradation, warping, distortion, and fracturing.
  - Compositions vary but can be manufactured of post industrial plastics, used tires and other materials, or fiberglass.
  - They can also contain cedar wood shavings and other materials to help protect them from UV degradation.

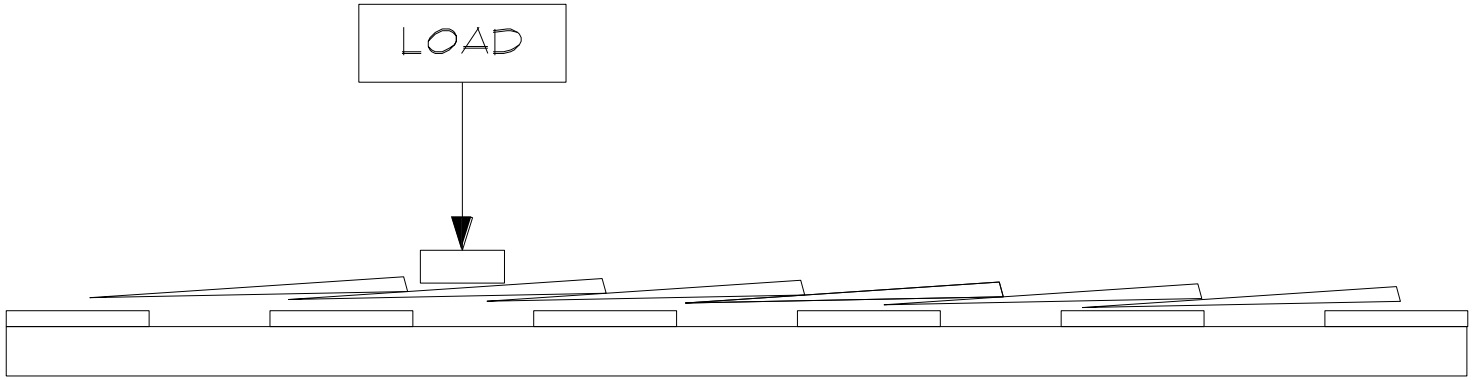
Back Side of Fire Free Roofing Shakes



Exposed portions of shingle samples appeared pink in color and were prone to brittle failure.

Testing occurred 3 – 5 years in service

ICBO AC 07 Flexure Test FireFree Shakes



Condition	Average Failure Load (lbs.)	Average Allowable Load (lbs.)	Minimum Failure Load (lbs.)	Minimum Allowable Load (lbs.)
Dry	304	300	207	250
Wet	242	250	194	225

Poor Quality Construction Issue

Roof Tiles Not Fastened And Are Slipping

Lack of Fasteners at Rake Tile (Lose Tiles)

Foam Adhesive Not Bonded to Underlayment

Tile Adhesive Adhesion Failure

Lack of Foam Paddy Under Hip Tile

Self Adhered Flashing Lap is Dis-bonded

Self Adhered Flashing Dis-bonded

Self Adhered Modified Bitumen is Melting

Understanding Common Glazing Issues & Replacement Options

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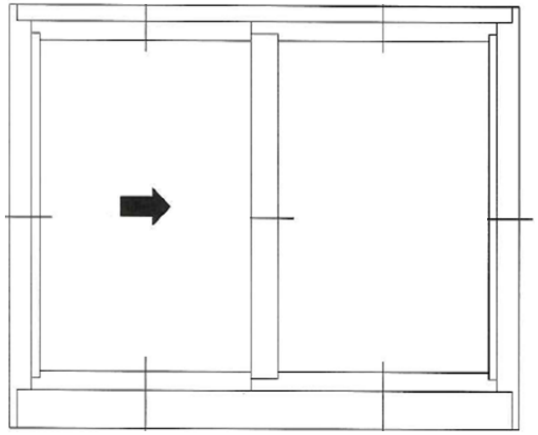
Presentation Agenda

- Performance Issues with Vinyl Windows
- Curtain Wall and Glazing Failures

Performance Issues with Vinyl Glazing

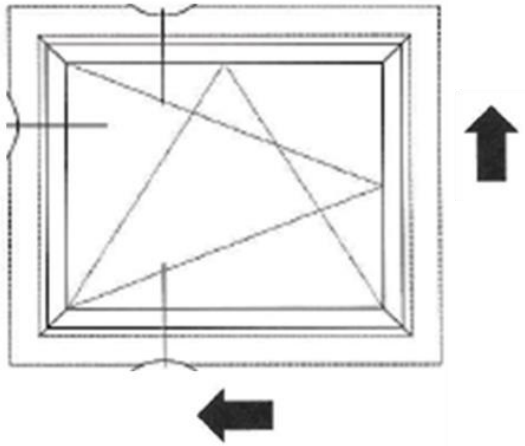
Examples of Different Window Configurations

Sliding Window

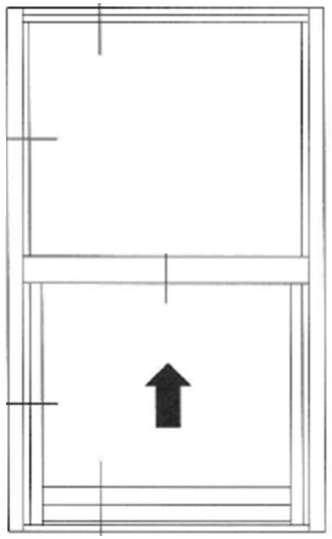


Casement / Awning Window

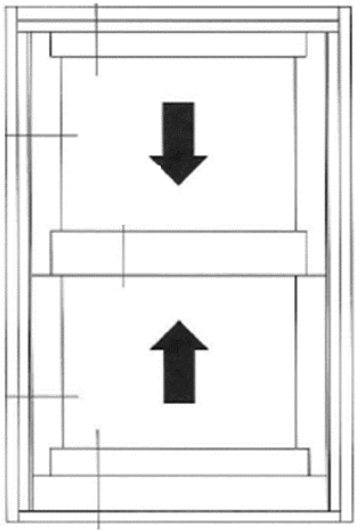
(hinge point on top verse side)



Single Hung Window



Double Hung Window



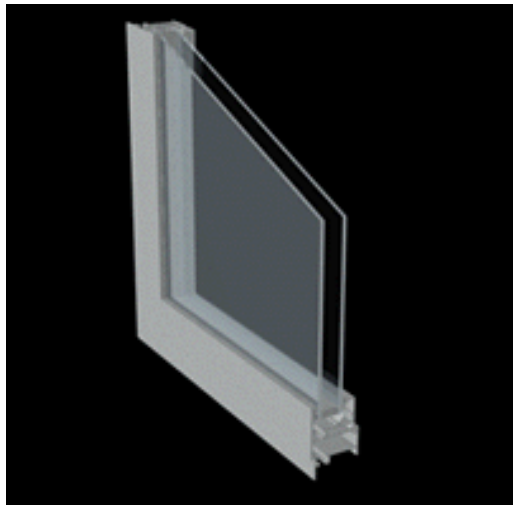
Window Frame Types

- 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

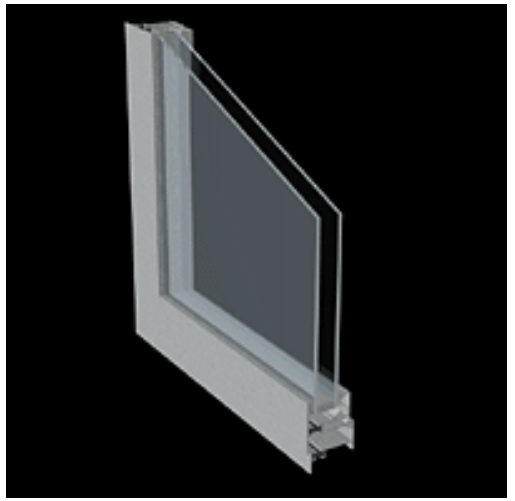
- Aluminum Clad Wood
  - Clad the exterior face of the frame with either vinyl or aluminum, creating a permanent weather-resistant surface

Window Frame Types

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

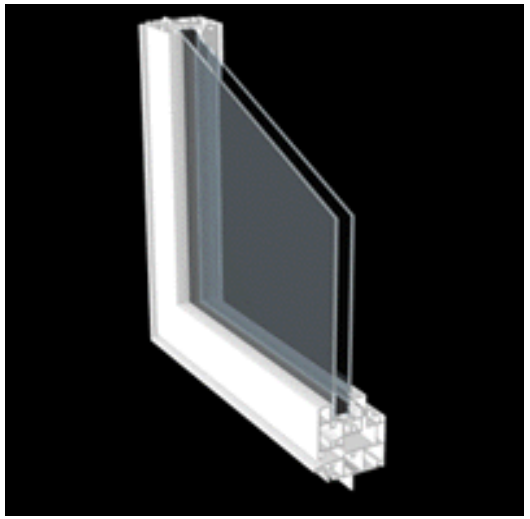


- Aluminum with Thermal Break
  - The most common solution to the heat conduction problem of aluminum frames is to provide a thermal break by splitting the frame components into interior and exterior pieces and use a less conductive material to join them

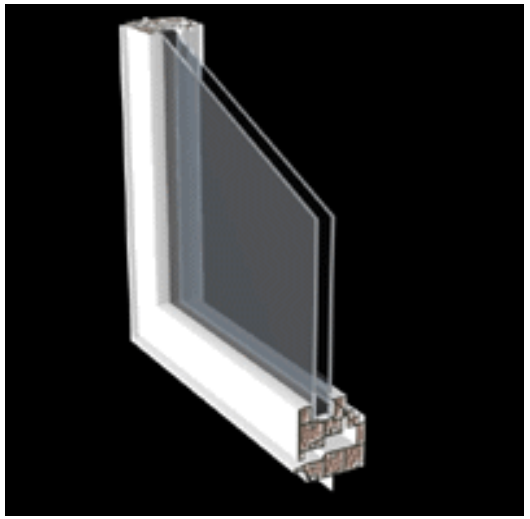


Window Frame Types

- 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



Facts About Vinyl Windows

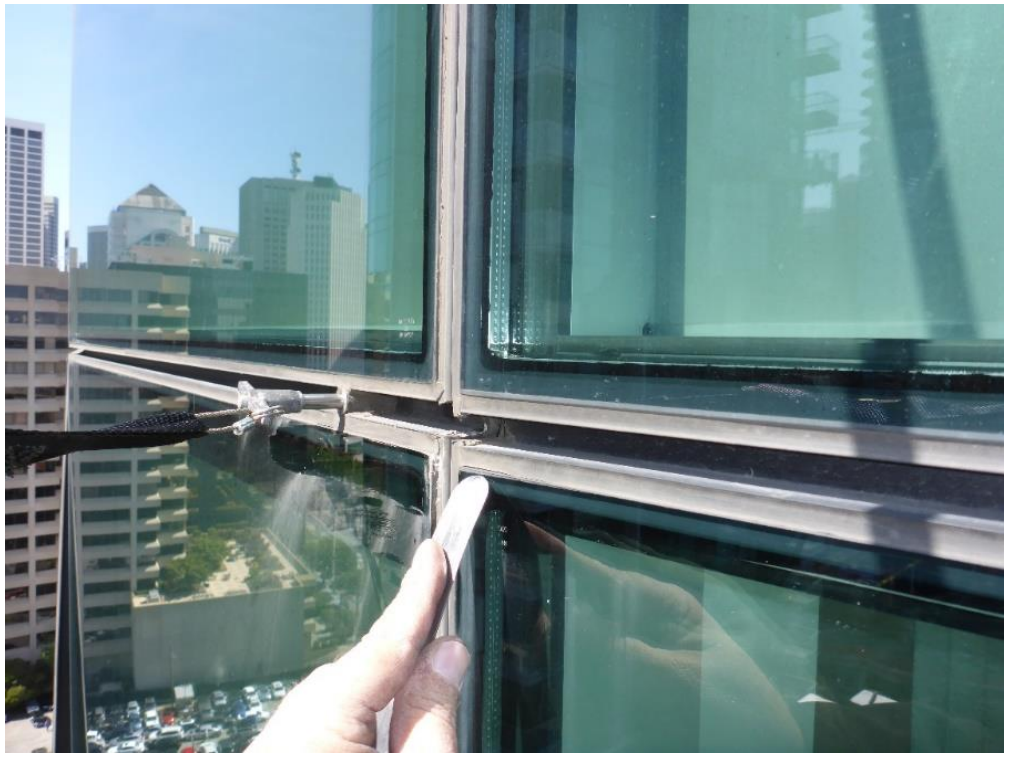
- PVC is a thermoplastic with a relatively low melting point, about 212°F. It can begin to soften at 149°F and if it heats up too much, it can bend and “take a set”

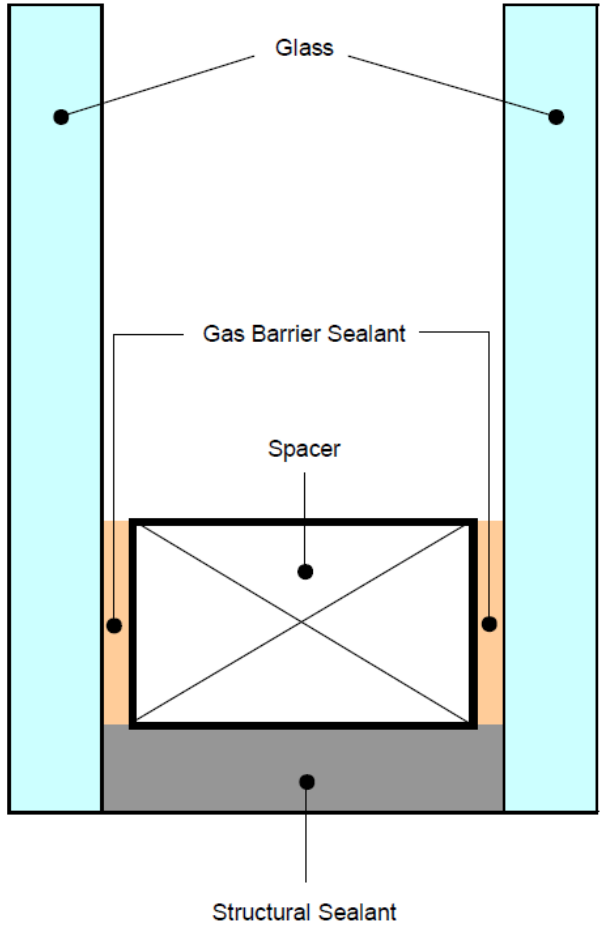
- Dark-colored vinyl if installed in a location where it receives reflected light from a window, can reach 219°F

- 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 can bend more, and has more movement against the stable glass which can result in leaks around the glazing seals

What is an Insulating Glass Unit?

- Insulating Glass Units are sealed with PIB and Silicone combinations of 2 or more liters of glass separated by a dry air space



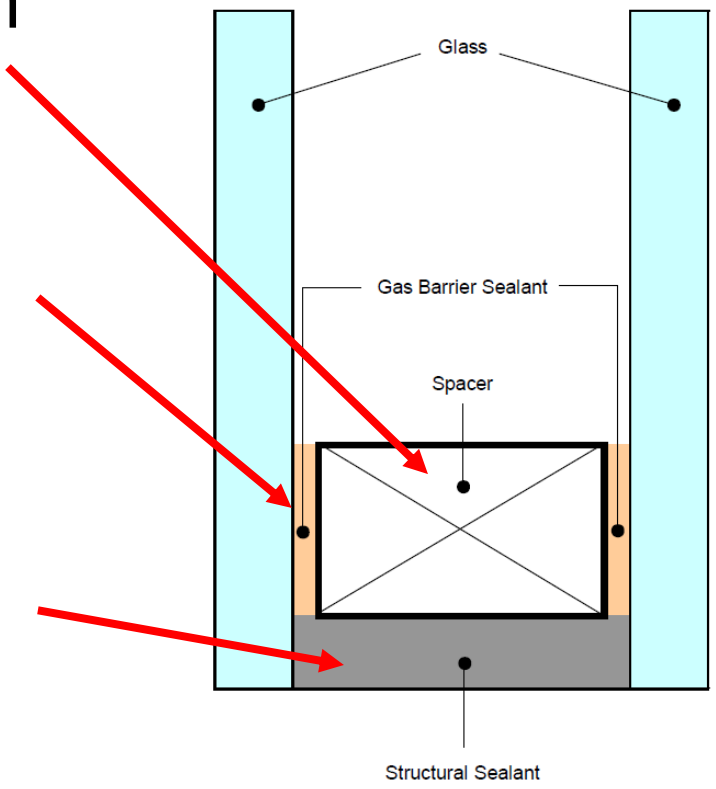


How Are Dual Glazing Units Sealed?

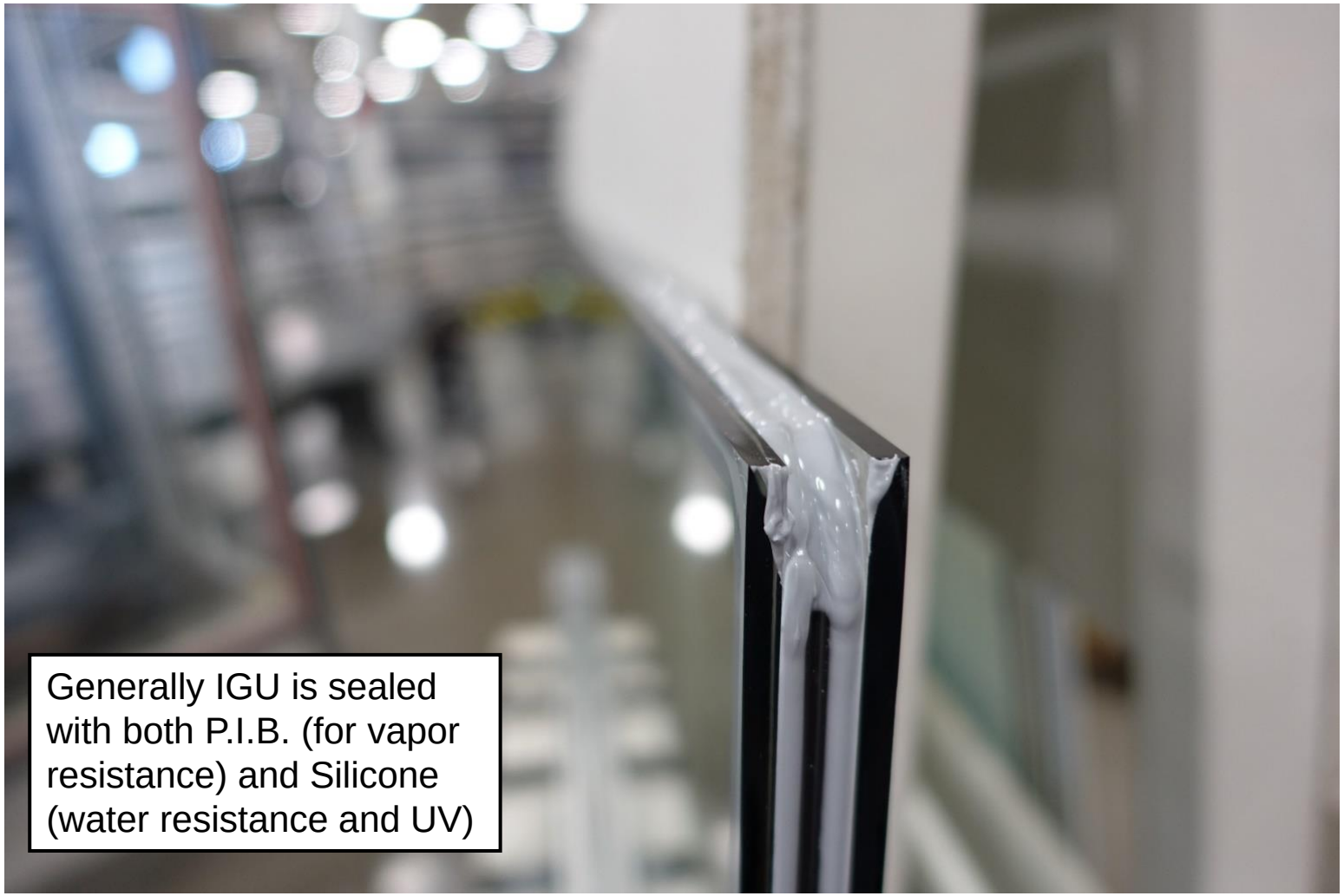
Spacer, usually aluminum or stainless steel

Primary Seal (PIB) impermeable to moisture diffusion.

Secondary Seal (structural) and selected to hold unit together through long-term weathering (UV) and prevent water infiltration



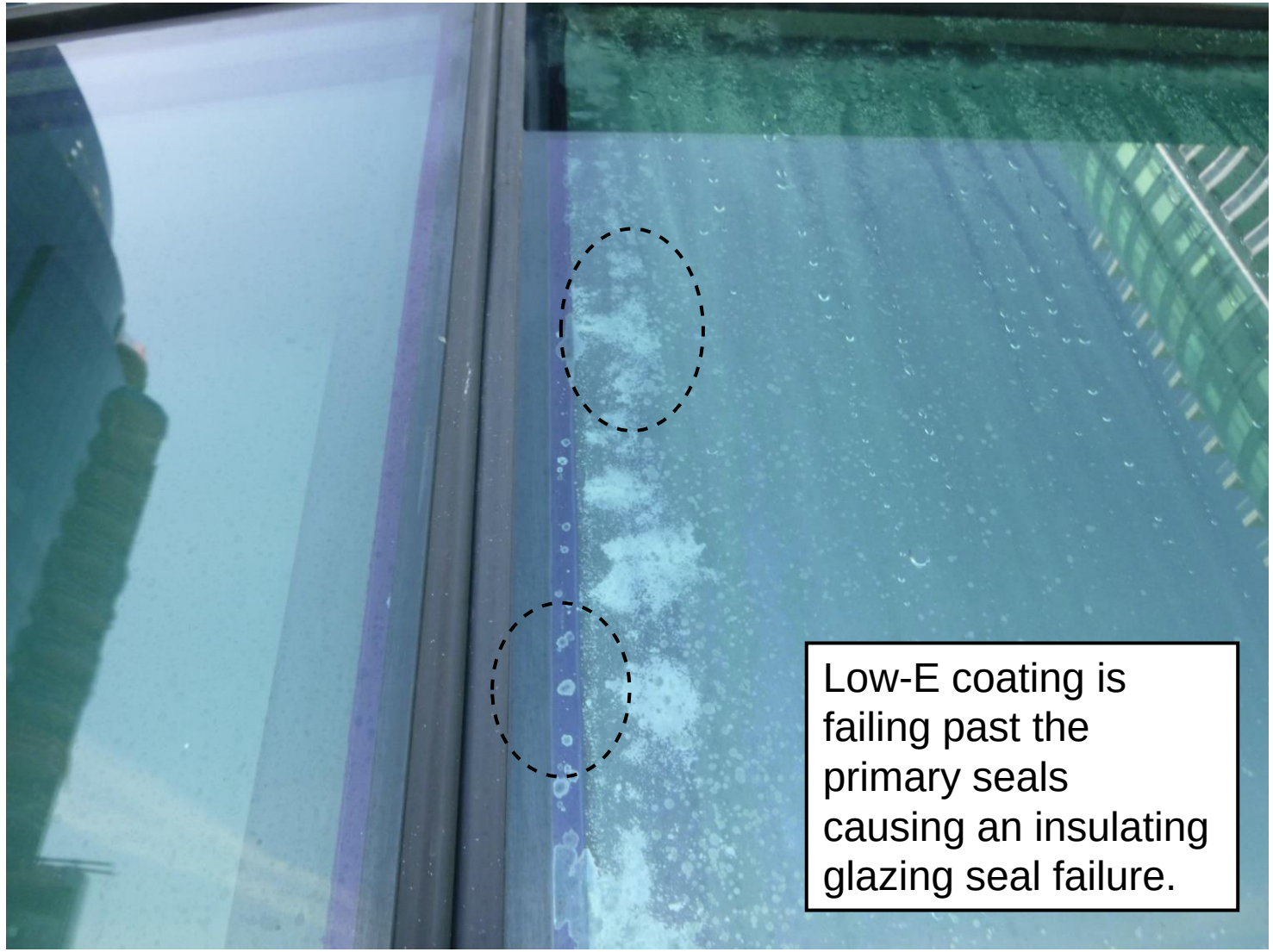
IGU Units Sealed With Dual Sealants



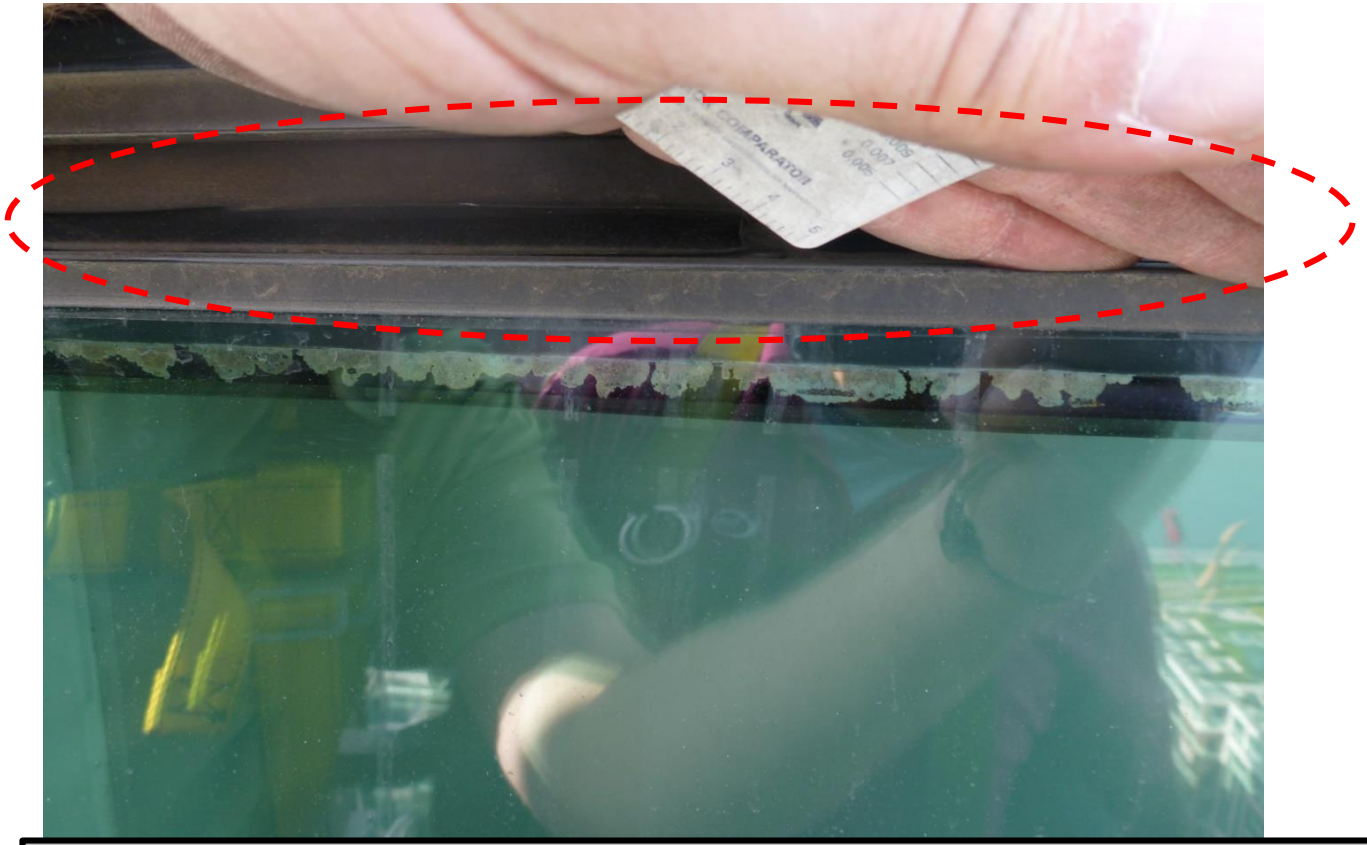
Insulating Glass Seal Failure

Building D, Unit 28F

Tarnishing of Low-E Silver Coatings



IGU Carry a Minimum 10 Year Warranty



Failure can occur if the Low-e silver coating is not “edge deleted”. Edge of the glass can start corroding and corrosion can spread to the inside, by-passing the seals

IGU carry a minimum of 10 year warranty by all manufacturers

What is a Mulled Windows

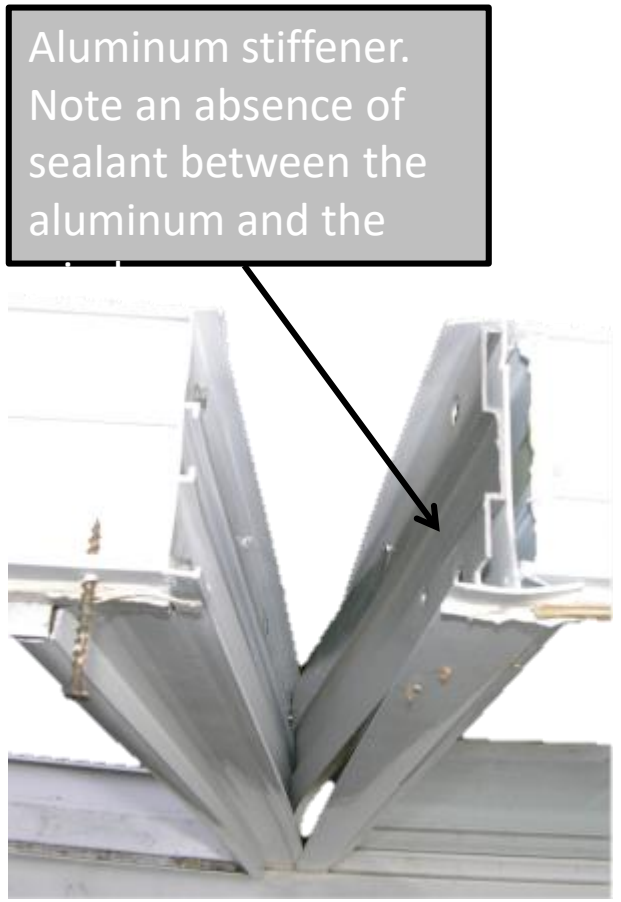
- When 2 to 3 windows are joined together

Mulled Windows

- Mulled joint cap has been removed

Water Leaks Through “Mulled” Joints

- Mullion is a stiffener used to join window frames together
- Mulled joints can inherently allow water intrusion due to a number of issues
- Often only single windows are tested under AAMA 501 protocol and not the “mulled” configuration
- If you have mulled windows, high likelihood of leaks



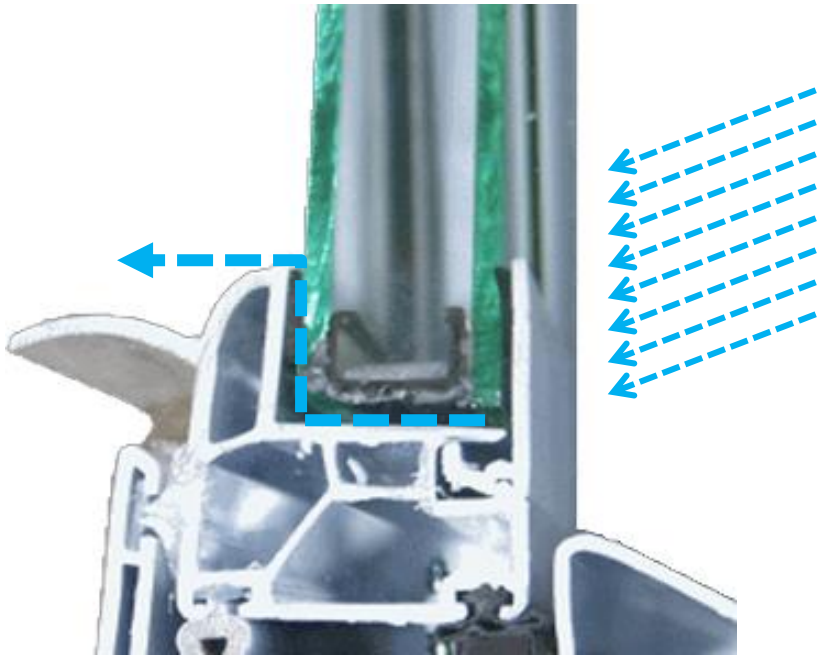
Mulled windows separated

Horizontal and Vertical Mullion Failures

Horizontal and Vertical Mullion Failures

Water Leaks Through Glazing Seals

- “Glazing seal” refers to the seal between the glass and window sash
- Commercial windows use tape with adhesive backing on two sides and silicone heel or cap beads for glazing seals
- Fin style windows often only use acrylic tape and no wet silicone
- Acrylic tape can break down from UV and water
- In some cases window sashes can overflow with just a light spray



Glazing Seal Failures And Resultant Leak

Glazing Seal Failures And Resultant Leak

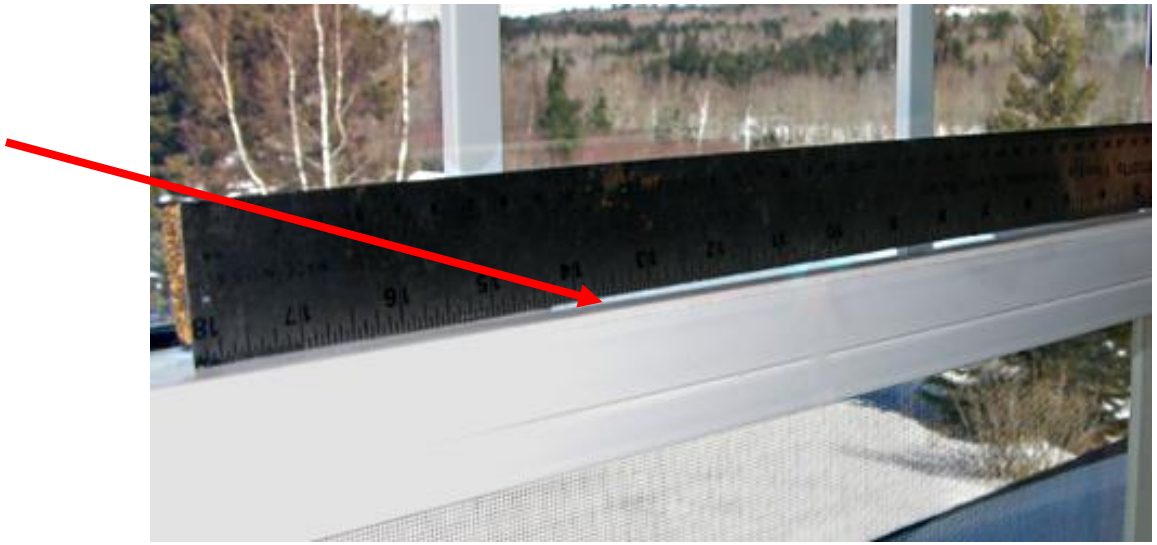
Glazing Tape Is Discolored And Stained

Glazing Seal Failure Analysis

- The window manufacturer used poor quality “foam” tape as glazing seals.
- Commercial windows use tape with adhesive backing on two sides and silicone heel or cap beads for glazing seal.
- Residential “fin style” windows are generally glazed with just acrylic foam tape. The tape is susceptible to UV and heat degradation, is of inferior quality, and is not a long-term solution to this condition

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



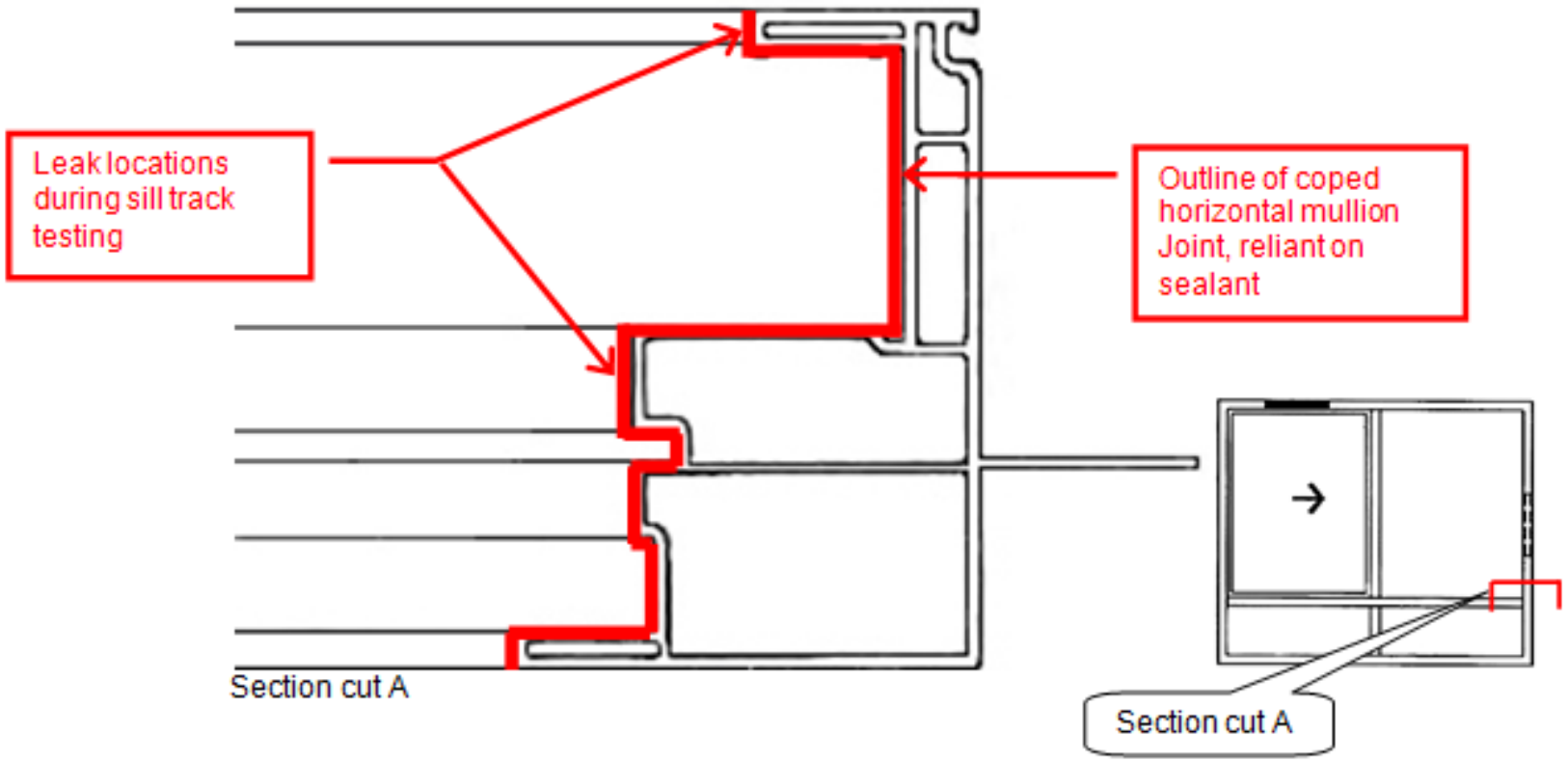
Window Frame Joint Failure

Coped Frame Are Hard To Seal

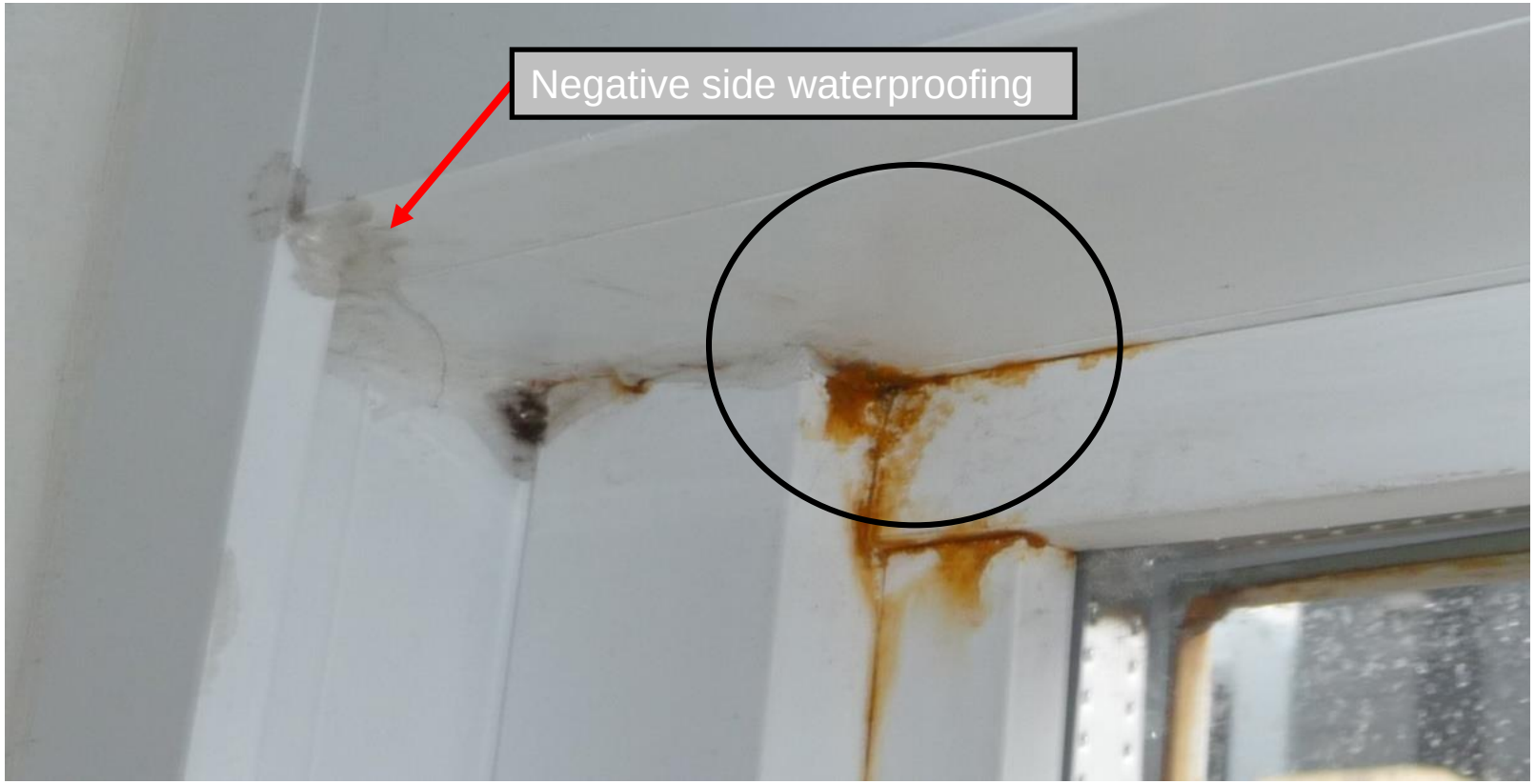
A = Manufacturer attempted to seal leak by pumping foam at coped joint
B = Clear silicone sealant, failed attempt to seal coped joint

Coped Joint Are Hard To Seal

- 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

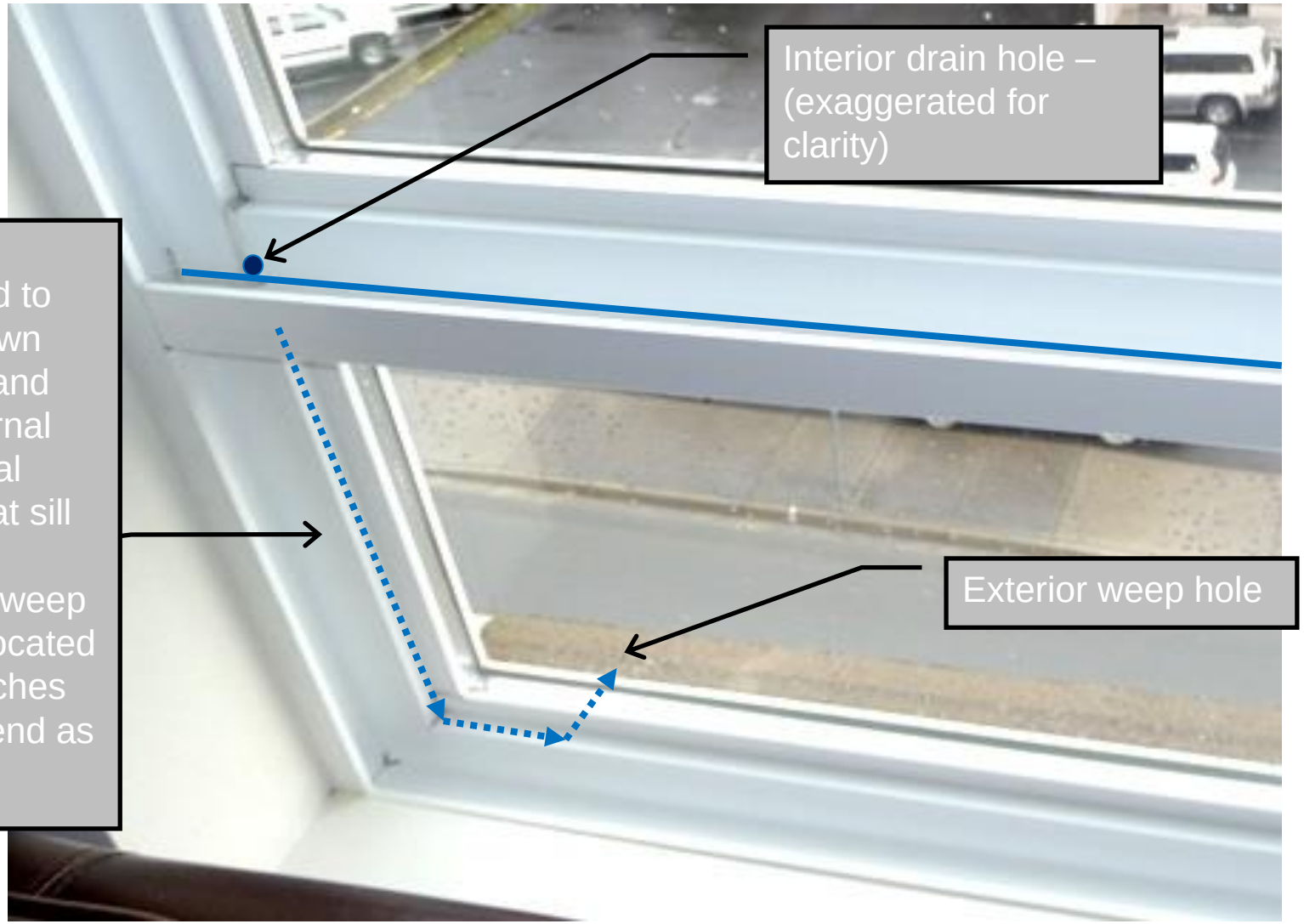


Rust Stain at Coped Joint From Reinforcing

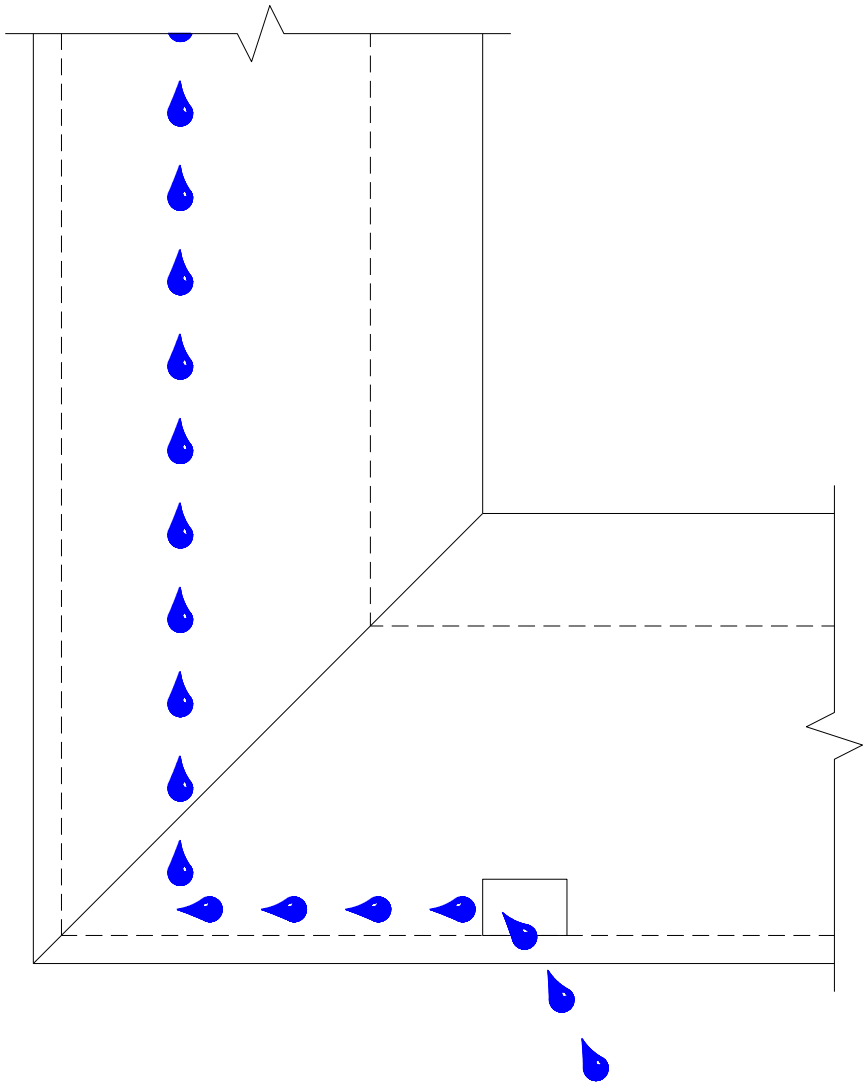


- Sealant installed at underside of coped horizontal-to-vertical mullion joint failed to stop the leak. The leaks are rust staining from the structural steel reinforcement

Window Drainage Pathway Analyzed



Elevation



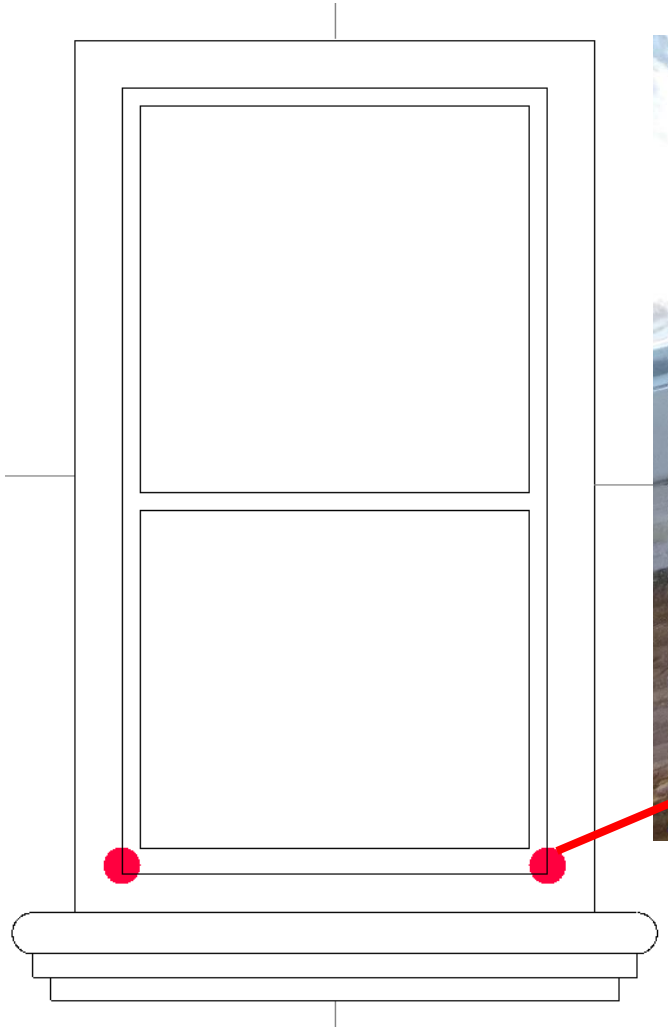
Improperly Constructed Weep And Drainage

- Windows were manufactured with improperly constructed weep holes and drainage pathway
- The weep holes were constructed with 5 mm (13/64”) 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 5/16”

Window Drainage To Internal Steel Reinforcement

- Water traveling down weep pathway can rust the steel bar

Aluminum Fin-Style Window Leaks at Corners



Window Frame Corner Seals and Leaks

Aluminum Frame Corners are sealed in the factory before being screwed together. Applying sealant in place from the top doesn't work because of lack of proper geometry and profile

Sealant is applied in the frame corner joint *before* the frames are screw splined together

Leak at Coped Corners Due To Failed Sealants

Failed Corner Acrylic Sealants, Exposed to UV

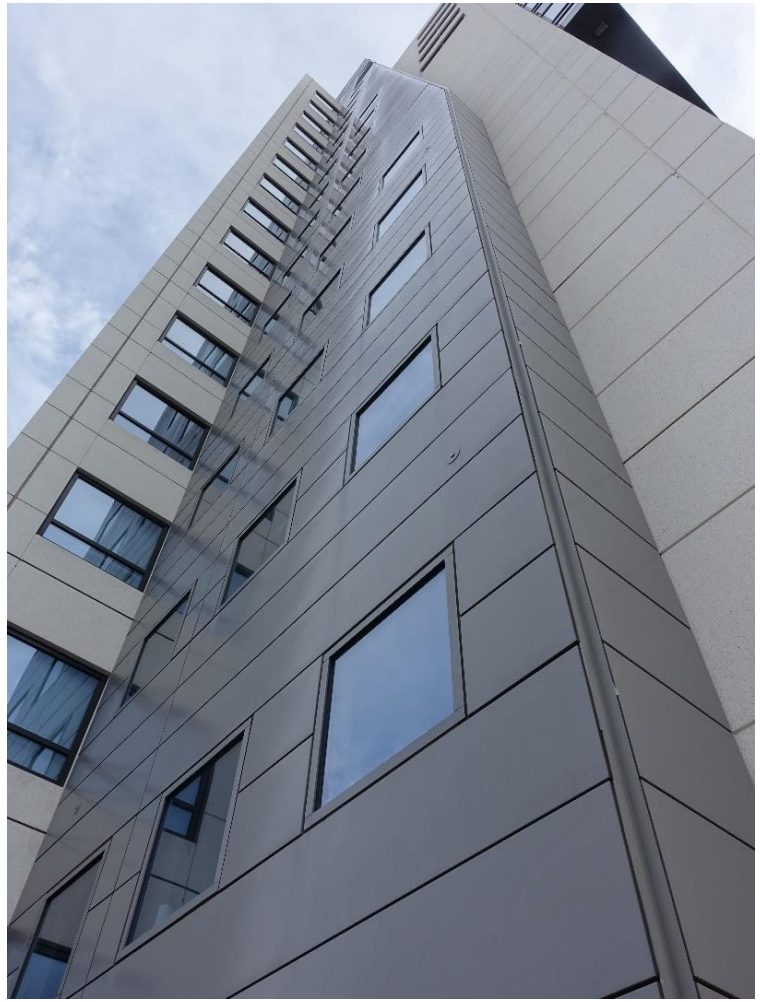
According to recent laboratory testing, the acrylic sealants are inherently not designed for the window frames and can revert to a tacky state due to chemical degradation. These sealants are not recommended where water immersion will occur

Conclusion, Fin (Flange) Style Windows

- Coped or mitered horizontal to vertical joints can fail if they are not properly designed and manufactured
- Glazing gaskets fail due to poor internal glazing, poor acrylic foam tape material, poor frame contact, lack of back-up sealant
- IGU Seals are susceptible to failure if coatings are not edge deleted and proper types of IGU sealants are not used
- 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

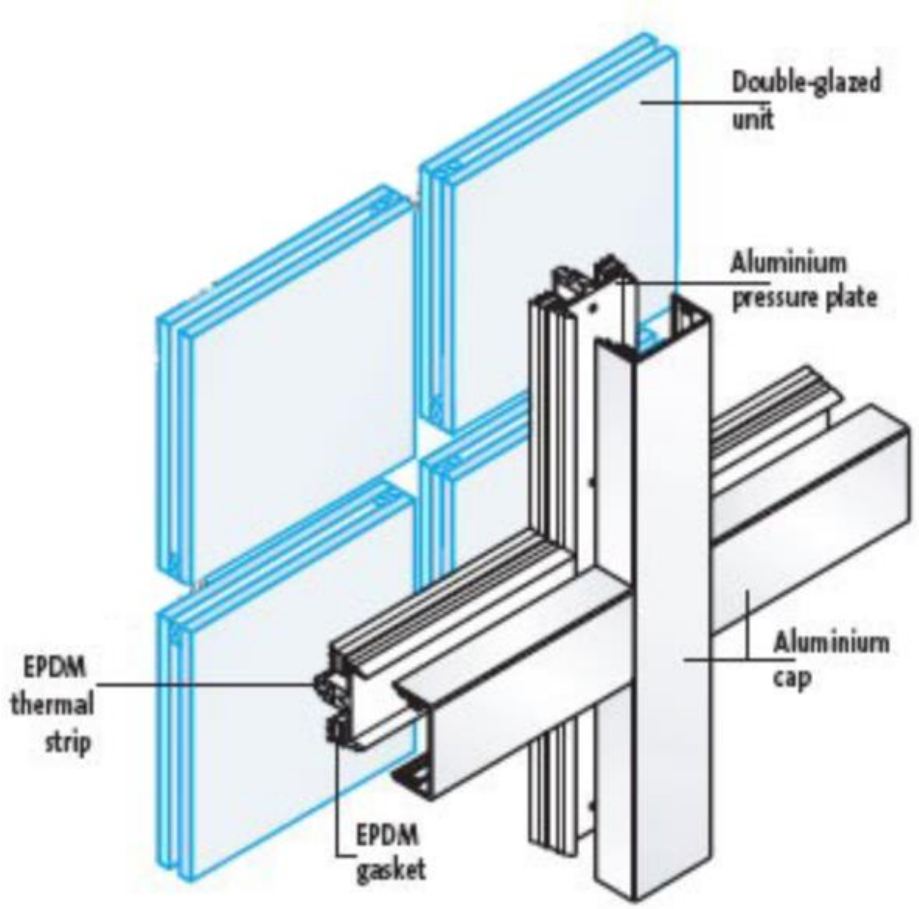
Commercial Window Common Failures

- Gasket Failure
  - Water Intrusion
  - Air infiltration
- Aluminum Coating Failure
  - New Wash issues
  - Coating thickness issue
  - Contaminants
- Corrosion of Glass
  - Edge deletion issue
  - Standing water on seals
- IGU Polyisobutylene (PIB) Failure
- Aluminum Thermal Break Failure



What is a Gasket?

- Gaskets - strips of synthetic rubber compressed between the glazing and frame or frame to frame
- Generally extruded EPDM
- Can be special ordered with silicone



Gasket Failures

- Drying out, shrinking and cracking
- Exposure to UV radiation
- Exposure to freeze-thaw cycles
- Improper maintenance

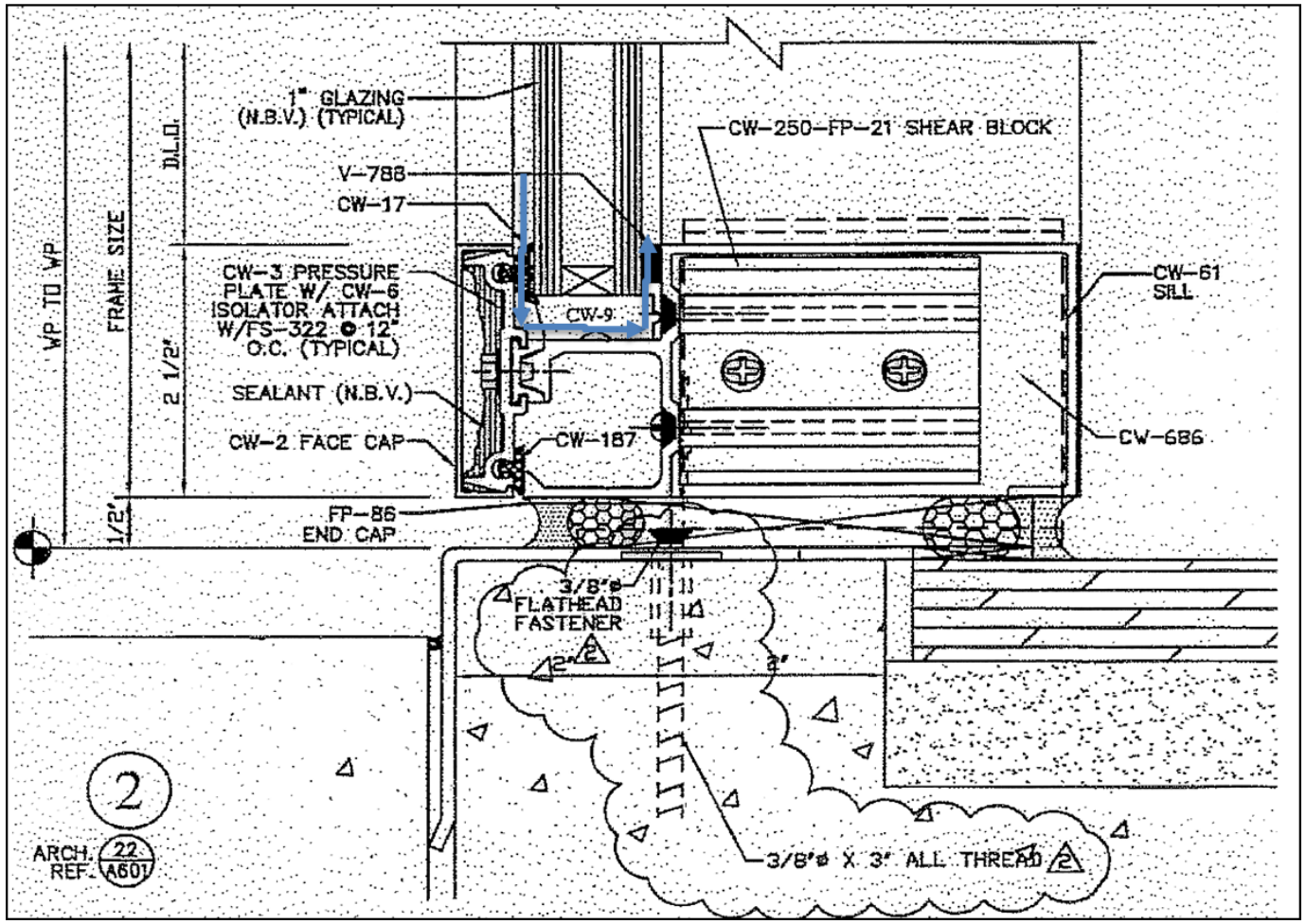
Gasket Shrinkage / Failure

Mondavi Gasket Shrinkage / Failure

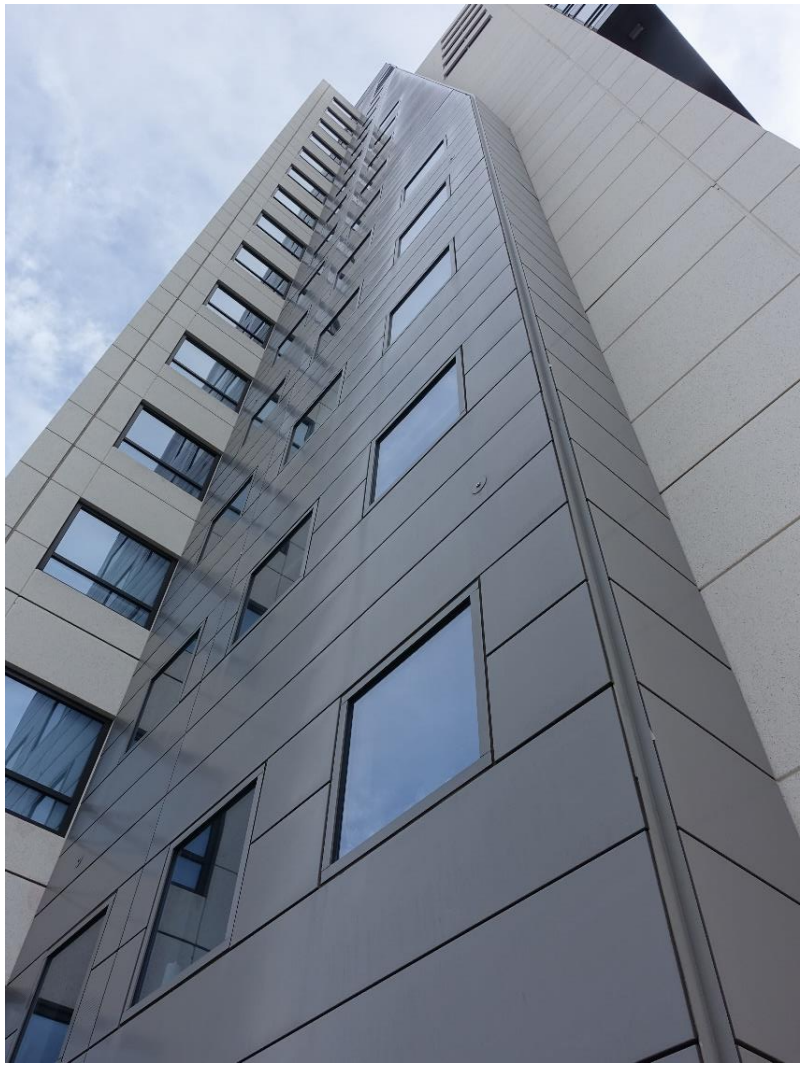
Gasket Shrinkage Can Cause Leaks

Exterior & Interior Gaskets Are Susceptible

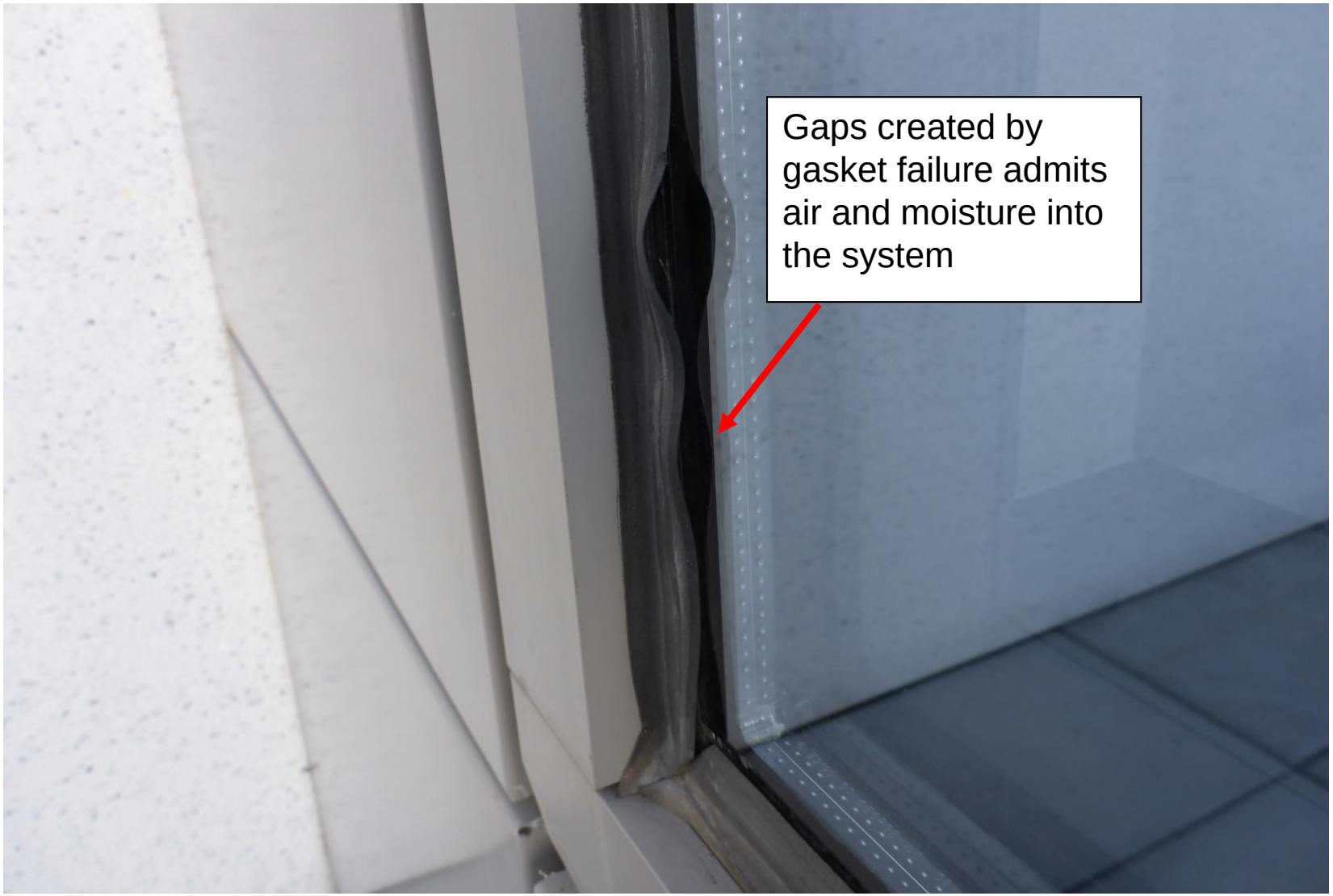
15/16” glazing installed produces a loose seal and leaks



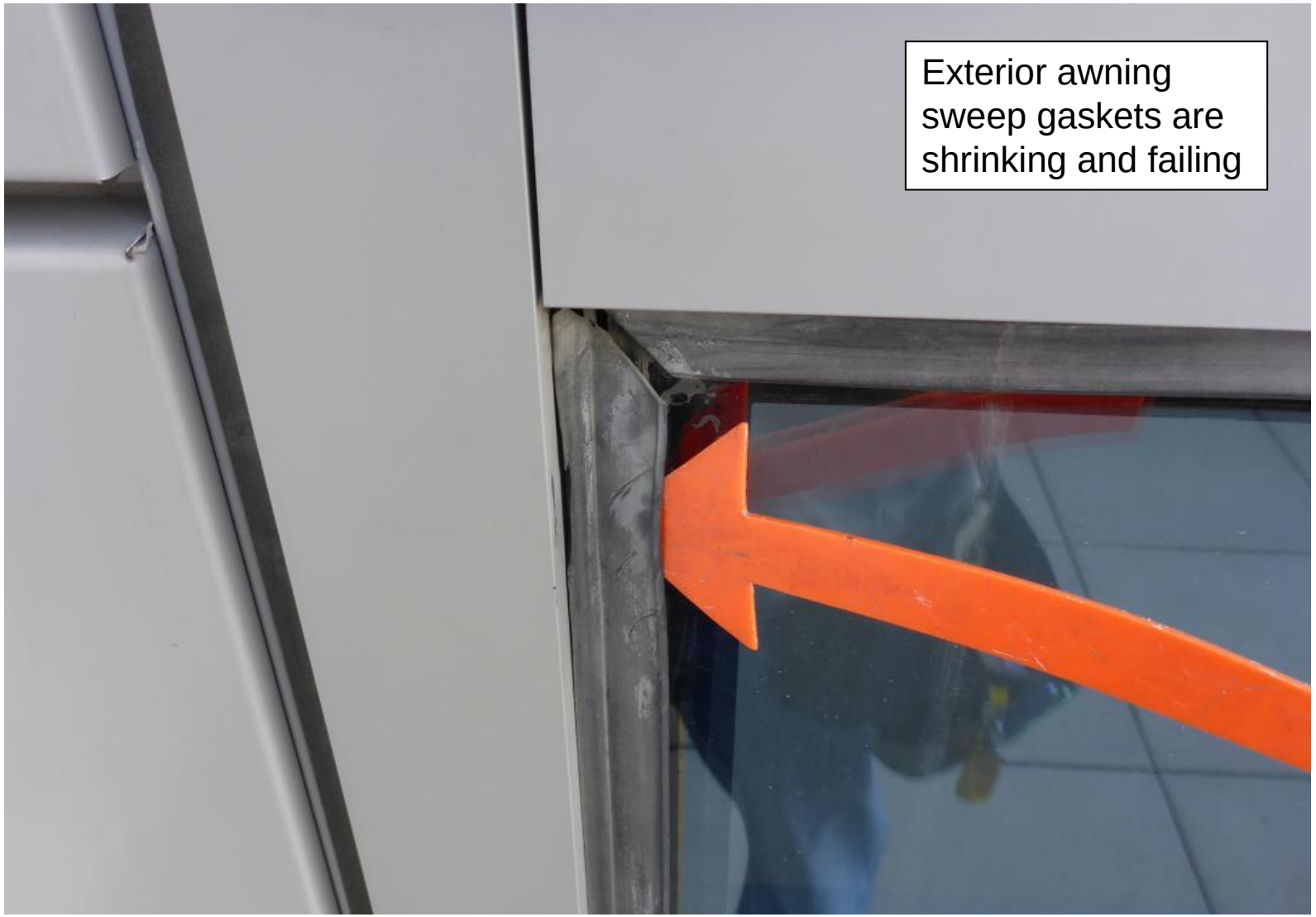
High Rise Condo



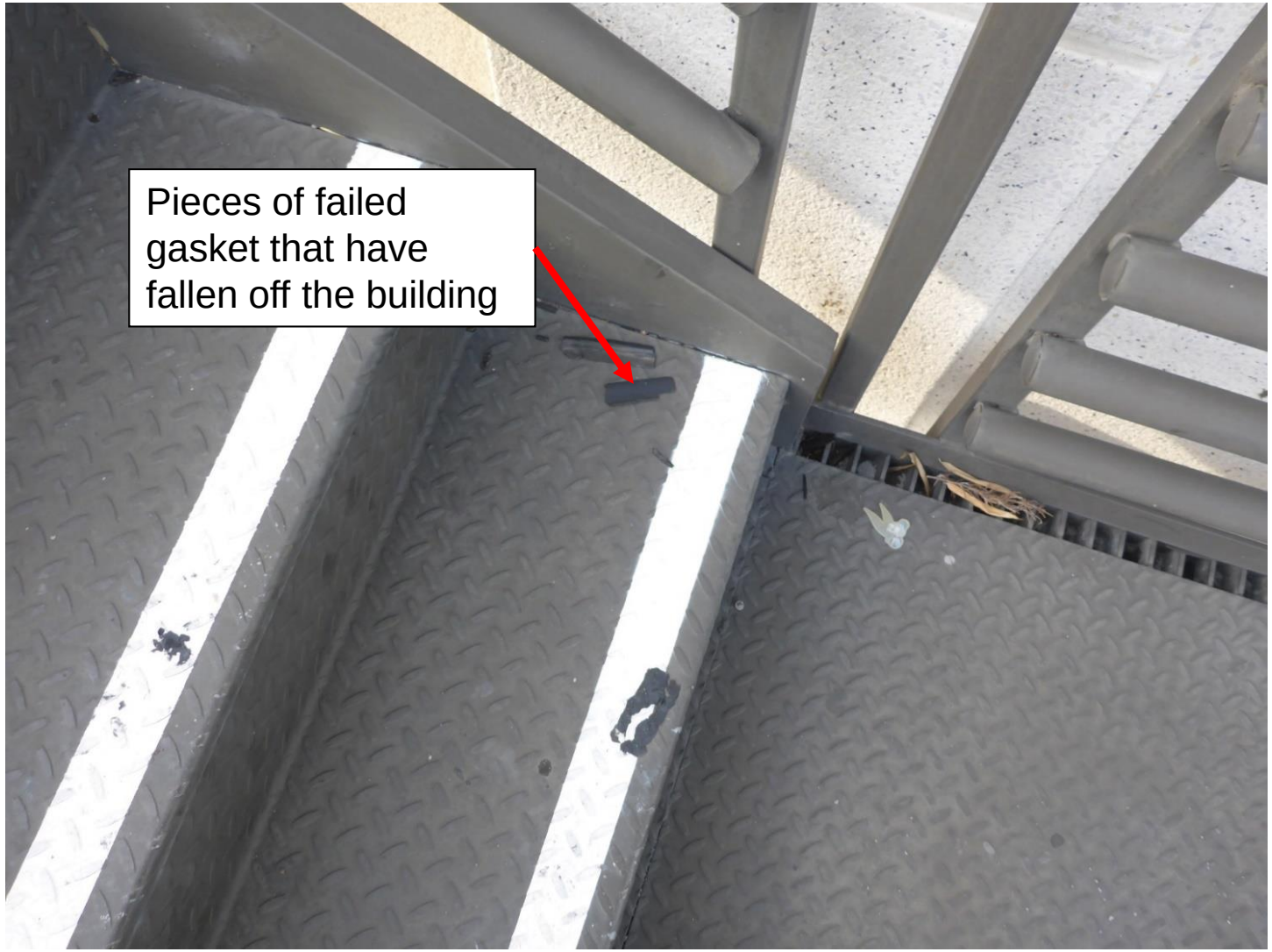
Gasket Failure



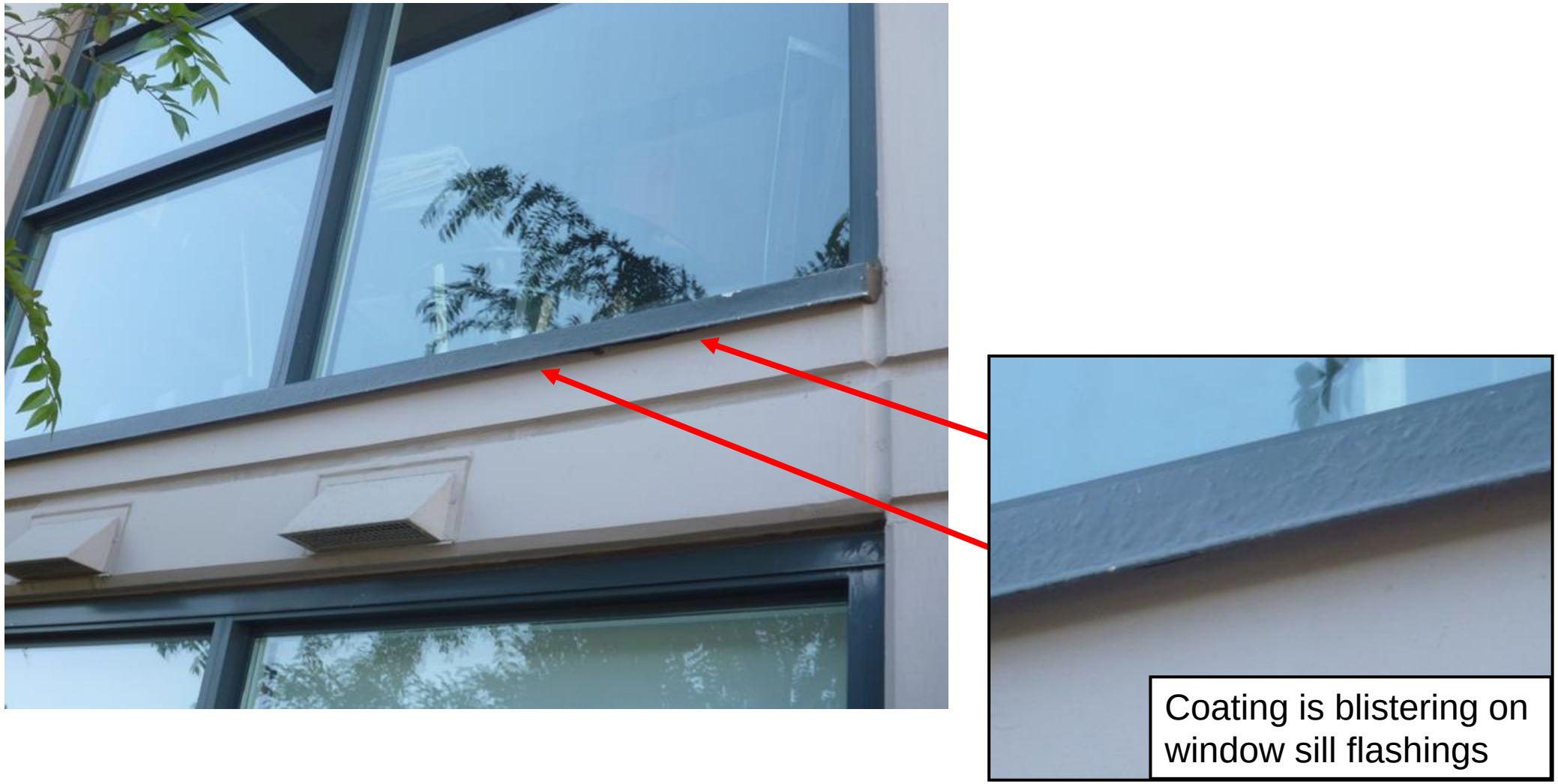
Gasket Failure Shrinking and Split Corner



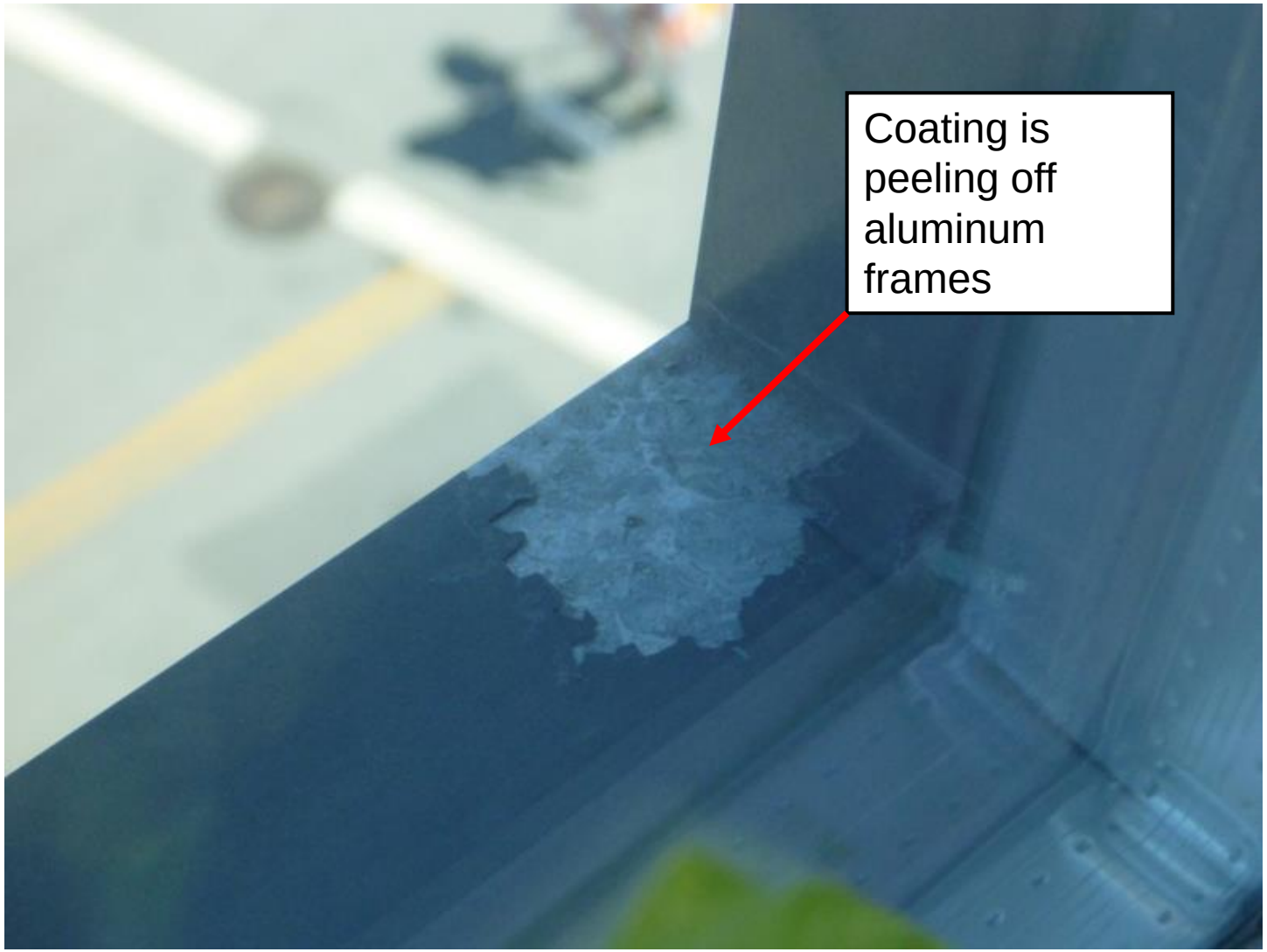
Gasket Failure- Fallen and Melted Into Stair



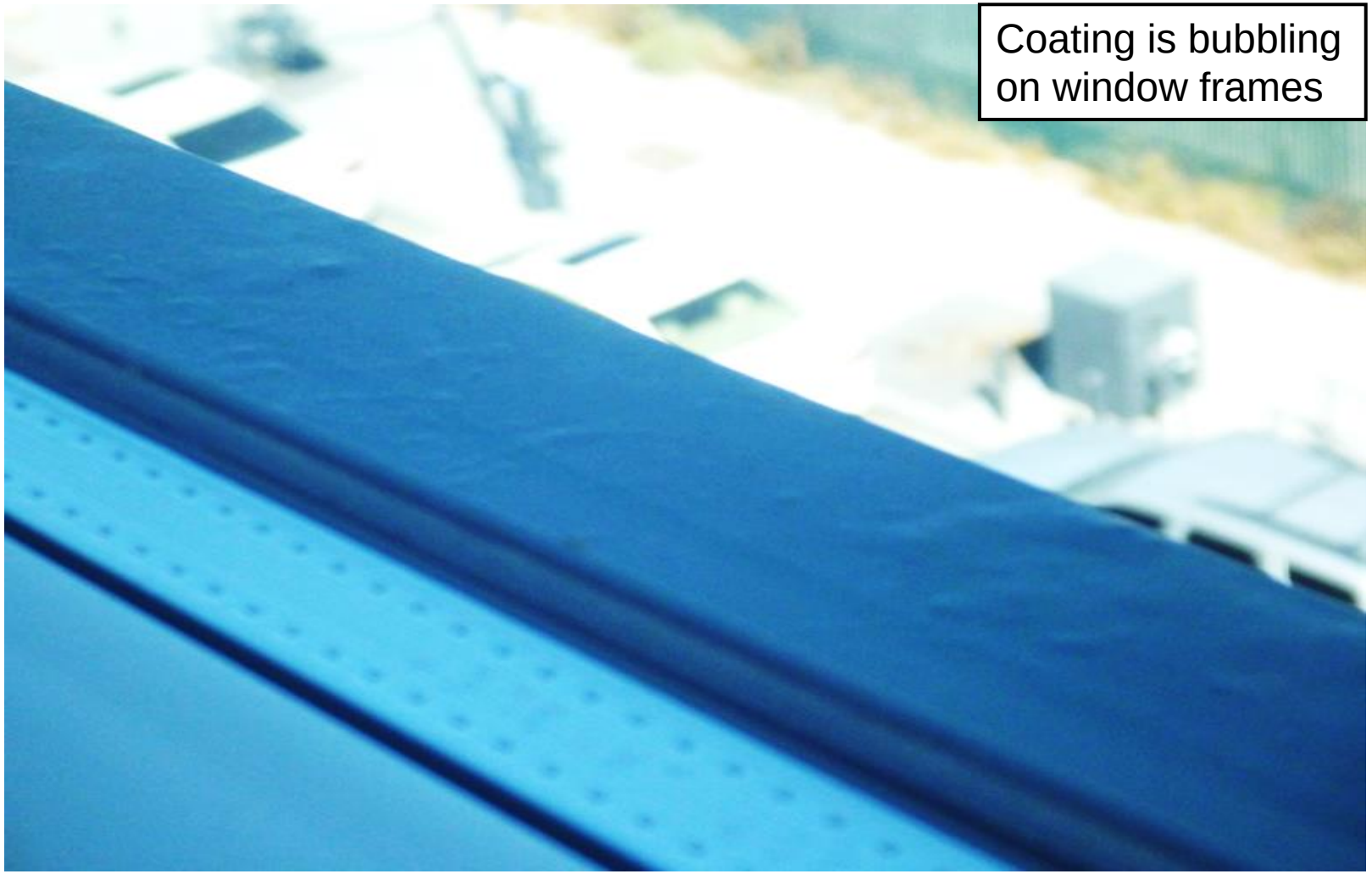
Aluminum Coating Failure



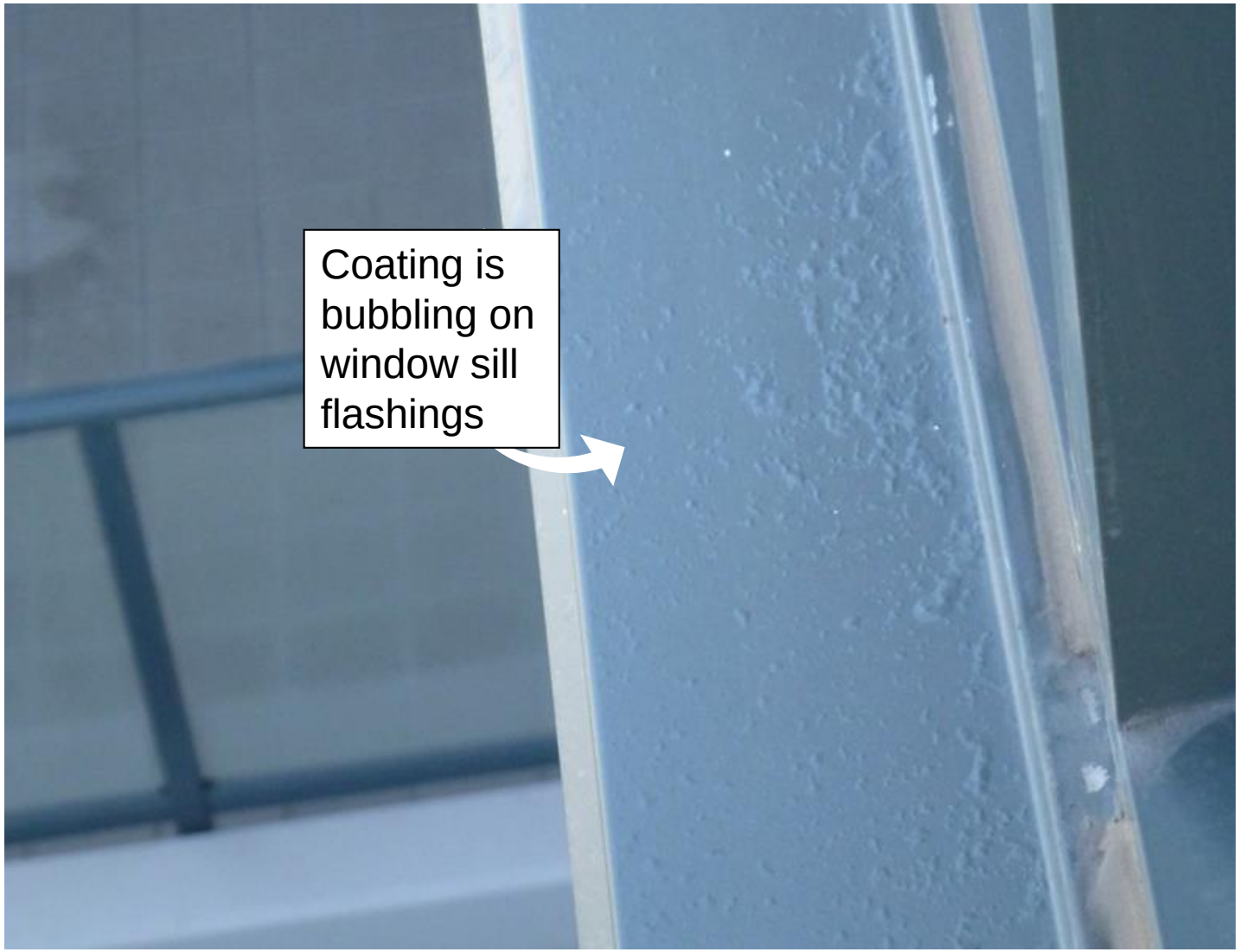
Aluminum Coating Failure



Kynar Coating Failure



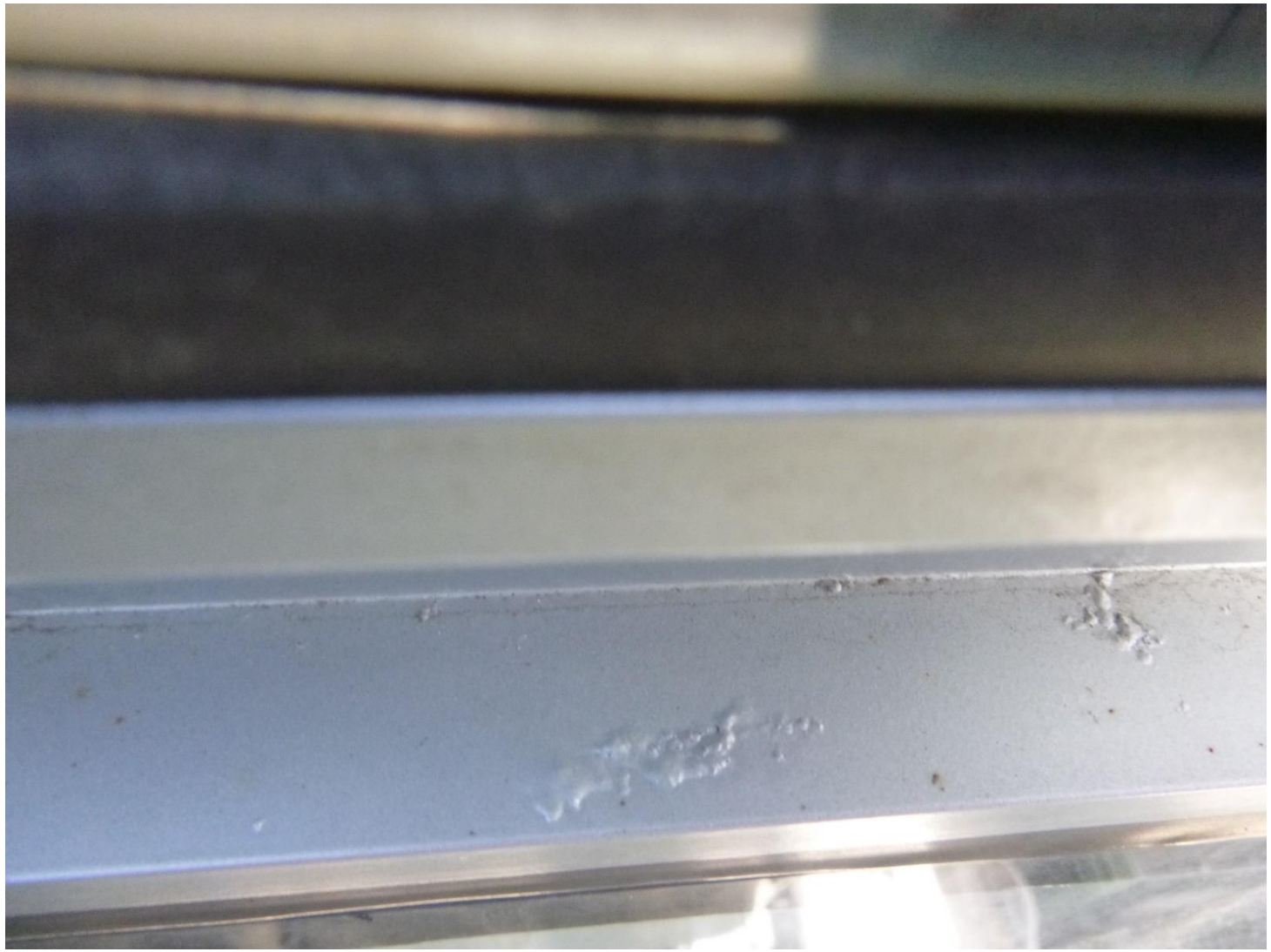
Coating is Erupting And Failing



High Rise Condominium Coating Failure

Coating Is Erupting in Little Bubbles

Coating Is Erupting in Little Bubbles



Coating Failure Advanced to Pitting

Aluminum Coating Failure Causes

- Proper surface preparation and pre-treatments are not followed
  - Missing primer
- Coating requirements are not followed
  - Improper thickness of coating
- Lack of surface prep – leading to trapped contaminants

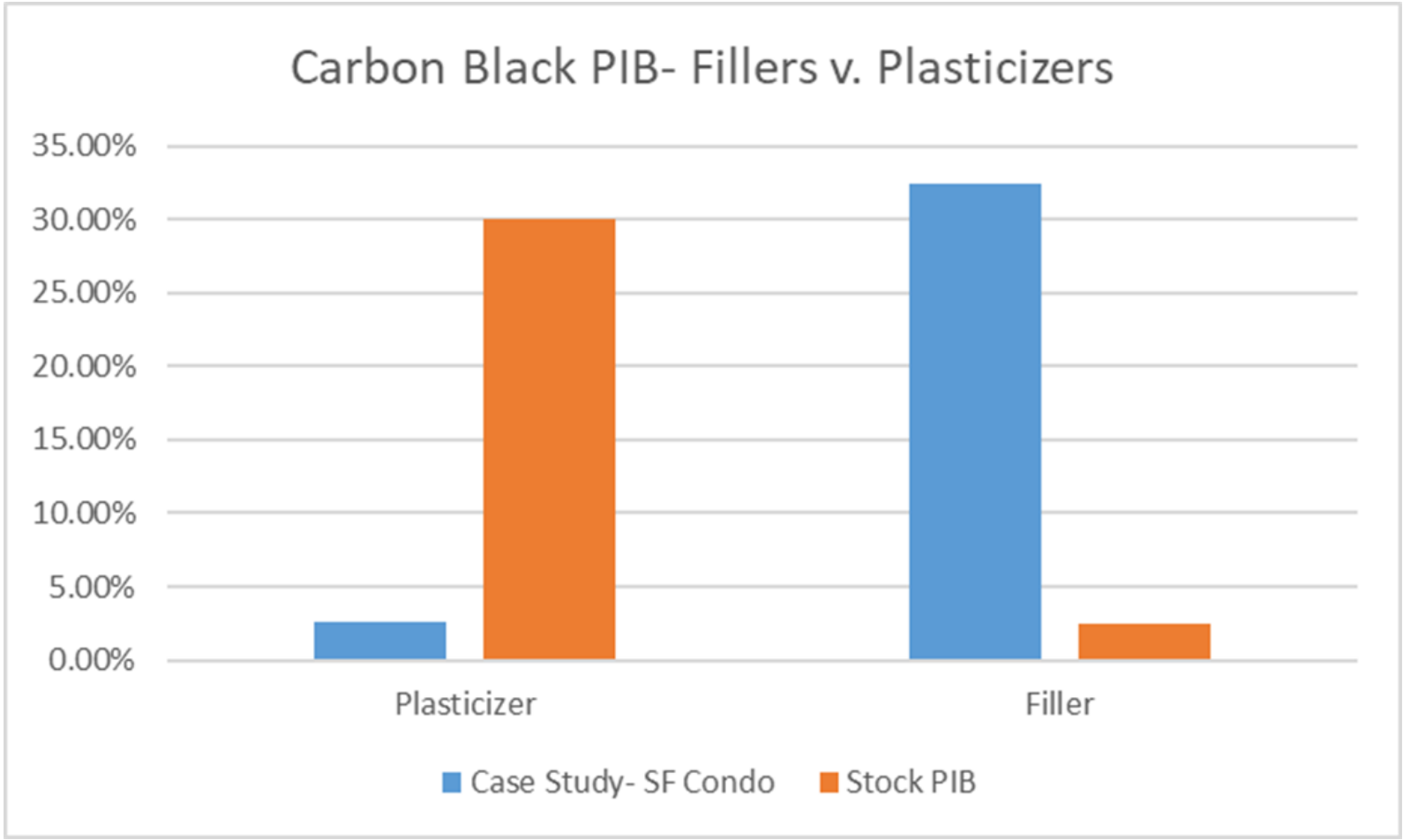
PIB Migration/Failure in IGU

PIB Migration, Moving/Walking Up

Example of PIB Migration

PIB Migration Issue

PIB Sealant Test Results



PIB Migration Mitigation

- Requires glazing replacement
- Limited to gray PIB
- Gray PIB contains 64.8% polymer with plasticizers as low as 2.6%
    - PIB control samples are 97.5% polymer

Replacing Glass is Very Expensive!

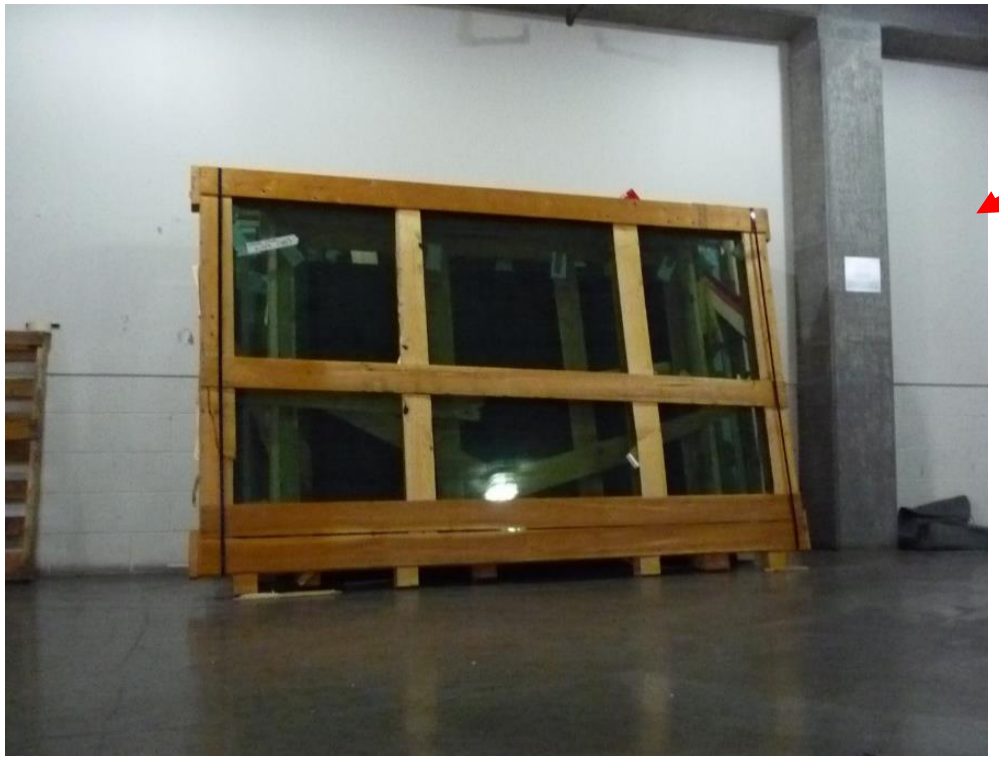
Replacing failed glazing on 650 unit high-rise building can cost over $100MM

Replacing Glass, Slow and Tedious

2 Consultants on window washing rigs

3 Consultants on the inside handling glass

Replacing Glass, Slow and Tedious



Removed glass from site

Labeled and crated, shipped to lab

Questions and Answers

Thank You!

Karim Allana, PE, RRC, RWC
CEO, Senior Principal
Allana Buick & Bers, Inc.