Lessons in Insulating Glazing Unit Failures
Failure Mechanisms and Re-Glazing of an all Glass Tower

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Outline

→ How do Building Enclosures and Insulating Glazing Units (IGUs) Fail?
→ Standard and Innovative In-Situ IGU Testing Methods
→ Selection of New IGUs and Replacement in an Occupied Building

Failed Building Enclosures – Rot and Corrosion

Failed Windows – Corrosion & Wind

Alright... So What Fails Here?

Failed Tempered Glazing – Nickel Sulphide Inclusions
Overheating in a Cold Climate

Background – Case Study

- Residential condo building constructed in 2002 – entirely structurally glazed curtainwall – R-5 proprietary triple IGUs
- First fogged IGUs reportedly observed in 2003
  - Contractor replaced all desiccant tubes
  - More fogging persisted
  - Corrosion of low-e noticed
  - More desiccant tubes replaced
- Retained by owners to first investigate in 2006
- Continued investigations through 2007-2008
- Acknowledgement of widespread and worsening problem
- Owners decide to proceed with re-glazing
- Design in 2011 - Re-glazing in 2012

Insulating Glazing Units

Quantifying IGU Failures in the Field

- Visual Review
  - Rating based on visual observation and level of fogging and low-e corrosion damage visible from 30 feet away
  - Dew/frost-point testing (ASTM E-576)
    - Measures how dry the IGU airspace is and estimate the saturation level of the desiccant
    - Can estimate remaining service life of IGUs
    - Can quantify failed units and units close to failure

Fogged and Corroded Glazing Units (Surface #5)

Visual Review of IGU Conditions, 2006 through 2009

- 3 suites, 3204, 3304, 3803 (all new suites)
- A total of 53 IGUs reviewed in 2009
- 85% of all units are showing considerable low-e corrosion
- Minor
  - 15%
- Moderate
  - 26%
- Severe
  - 59%
- Clear
  - 0%
 Mapping IGU Degradation with Time

But How and Why are They Failing So Fast?

Further testing procedures evolved:
- Desiccant saturation measurement
- Pressure testing
  - Measure leakage rate of IGUs
- Flow testing
  - Measure flow through the desiccant tube in service
- Eventual removal
  - For visual and laboratory testing
  - Delayed for several years to get safety variance to remove IGUs

Desiccant Saturation Testing

- Once desiccant reaches 80%, it no longer protects IGU from fogging – dewpoint above 0°C (32°F)
- Found saturated desiccant in all fogged units, and drier desiccant in clear IGUs

Desiccant Saturation Testing

In-situ IGU Pressure Testing

- Purpose to determine how “sealed” the IGUs actually are
- Built a specialized testing apparatus to measure pressure decay of IGUs in-situ
- Correlate condensation/low-e corrosion with “leakiness” of the IGUs

Desiccant Saturation Testing

Pressure Testing Apparatus

- A completely sealed IGU will retain applied pressure indefinitely (i.e. car tires, basketball etc).
- A leaky unit will exhibit a loss of pressure with time (pressure decay).
- Air is leaking out through perimeter glazing seal
- The pressure decay can be measured and an approximate leakage area calculated
- Correlate with corrosion and dewpoint measurement
- Units that cannot be pressurized are very leaky (i.e. like a flat tire)
- Can also use to test new units (originally the IGU company was going to replace all fogged units)

Pressure Testing Theory
Pressure Decay Testing

Pressure Test Data - Correlating Level of Leaks to Pressure Decay - Suite 3903

- Low flow sensors connected to open end of desiccant tubes
- Data recorded every second
- Temperature data also collected
- Wind speed and direction data taken from site

Flow Monitoring

Desiccant Tube

- Flow

Glazing Unit

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- Temperature data also collected
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Pressure and Flow through Desiccant Tube

Suit 4702 Glazing Unit Pressure and Flow Relationship

- Air flows from outside into the IGU through edge seal defects then into suite through desiccant tube – driven by wind pressure differences and thermal expansion/contraction
- Desiccant tube flow rate of <0.01 L/min resulting in exchange of 1-5 Liters of air per day just from wind
- Estimated service life of external desiccant tubes with these average flow rates is <5 years to saturation
- Not accounting for other leaks (as indicated by pressure decay testing)
- Could this replaceable desiccant tube design have worked in theory? 10x more desiccant by volume within IGU edge seal anyway

In-Situ Monitoring Results

Partial IGU Removal – Replace Broken IGU

- Eventual (2 year later) IGU removal of Intact IGU
IGU Perimeter Seal Discontinuity Testing

- Over 20 unique leakage locations observed in addition to the desiccant tube hole.

Investigation Summary

- Systemic failure of IGUs due to an inadequately sealed "thermally efficient" edge spacer
  - PVC, aluminum, stainless steel foil & hot-melt butyl differential expansion/contraction
  - No real durable structural edge seal
  - Removable desiccant tubes easily overwhelmed in service
  - IGU failure led to frequent fogging and corrosion of silver low-e coating on surface #2
  - All IGUs need to be replaced
  - Other units in building with stainless steel (not silver) low-e coating are also fogging but not corroding.
  - Remaining Life?

Selecting New Glazing Units

- Criteria: Match existing residential portion plus improve performance
  - Lower SHGC to reduce overheating and issues with undersized AC units
  - All-glass triple vs previous PET suspended film triple
  - Durable edge seal spacer (thin stainless, dual seal with proven track record)
  - Original low-e coating not available (old AFG) and hard to match
  - Narrowed down hundreds of new alternate options for Owners and City to choose from
  - Many plant and site mock-ups for color

Why Mockups are Performed

Trend towards "thermally broken" edge spacer bars with plastic thermal breaks (polyurethanes, PVC)

Selection of New IGU Spacers

- Trend towards "thermally broken" edge spacer bars with plastic thermal breaks (polyurethanes, PVC)
- Have investigated the fogging of several brand-new IGUs where VOCs (mainly ethanol and propanol & water) were present in all fogged units but not within any good un-fogged units.
- Some molecular sieve desiccants are better at absorbing VOCs than others
- Need to be careful with edge seal spacer selection

Structural Silicone Sealant Detailing in the Field

PLAN DETAIL AT VERTICAL FAUX STONE CONCEPT
Why More Mock-ups are Performed

In strive for more energy efficient products and buildings – inevitably some do fail.

Lessons learned from failures provide valuable lessons in durability.

Edge seal durability very important in thermally efficient IGUs.

In-situ pressure decay testing of IGUs a possible diagnostic tool to test seal integrity (in factory QC and in-situ).

Mock-ups during Restoration as useful as New Construction.

Replacing Floor-Ceiling IGUs in a Fully Occupied Condo

Conclusions

- In strive for more energy efficient products and buildings – inevitably some do fail
- Lessons learned from failures provide valuable lessons in durability.
- Edge seal durability very important in thermally efficient IGUs.
- In-situ pressure decay testing of IGUs a possible diagnostic tool to test seal integrity (in factory QC and in-situ).
- Mock-ups during Restoration as useful as New Construction.

Discussion

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