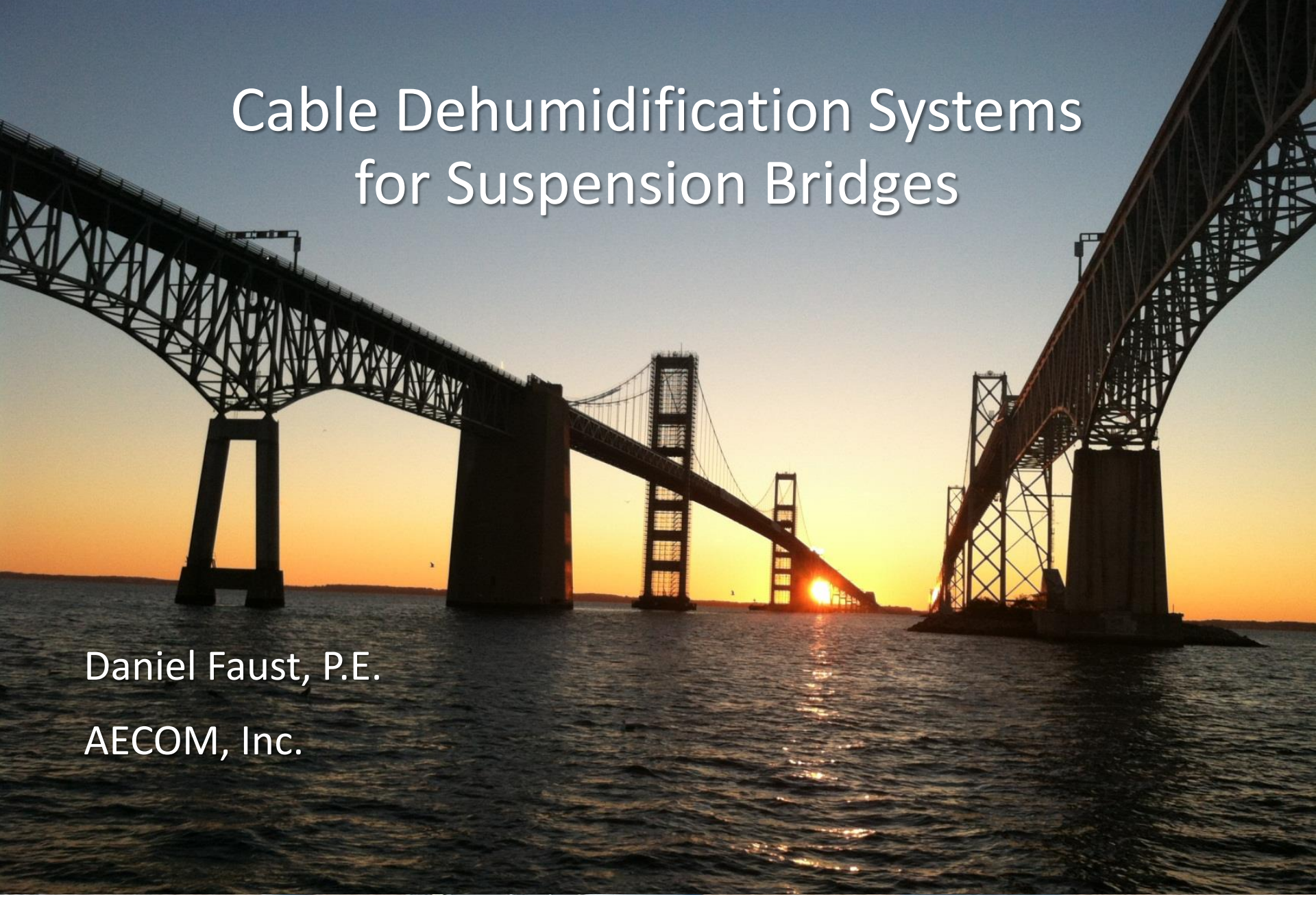
Cable Dehumidification Systems for Suspension Bridges



Daniel Faust, P.E.

AECOM, Inc.

TSP2 Western Bridge Preservation Partnership Meeting

May 8-10, 2013

UK Bridge Locations

Severn Bridge

Forth Road Bridge

Tamar Bridge

Humber Bridge

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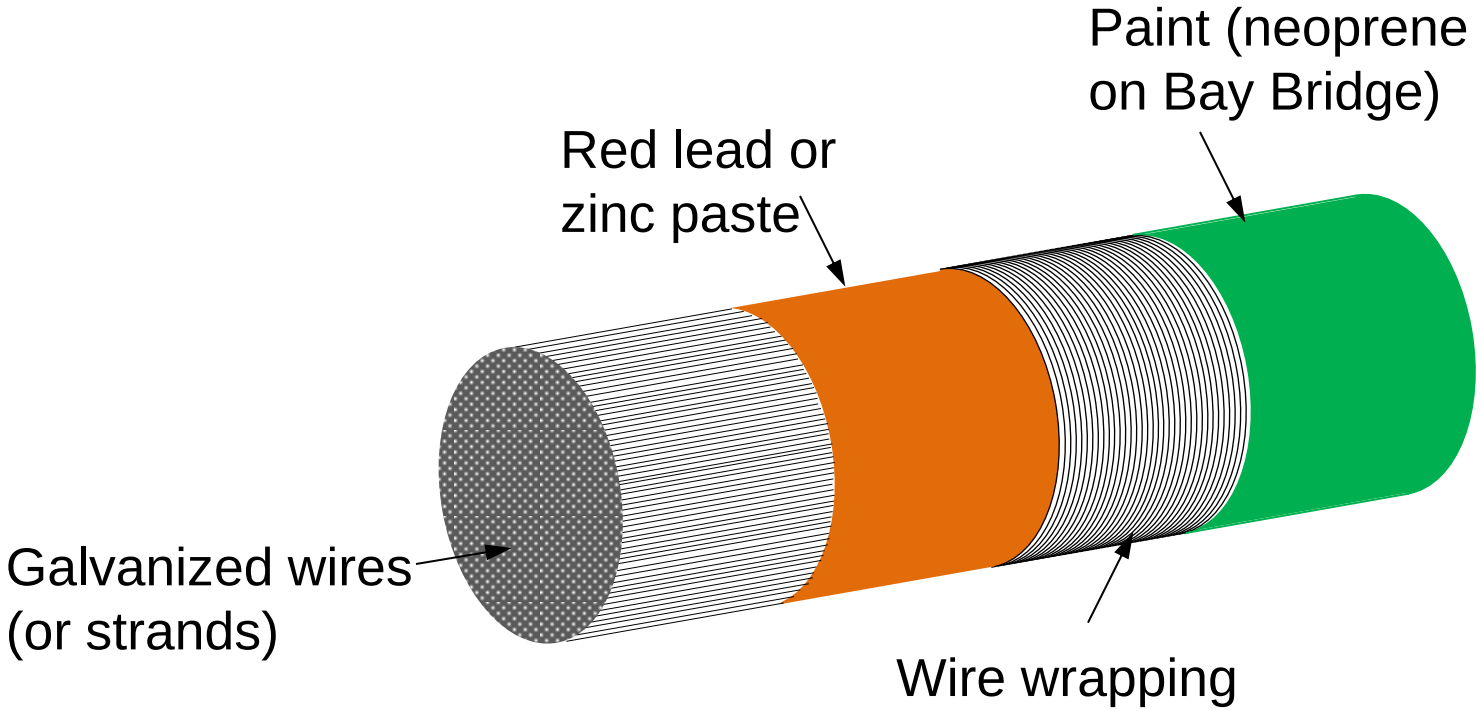
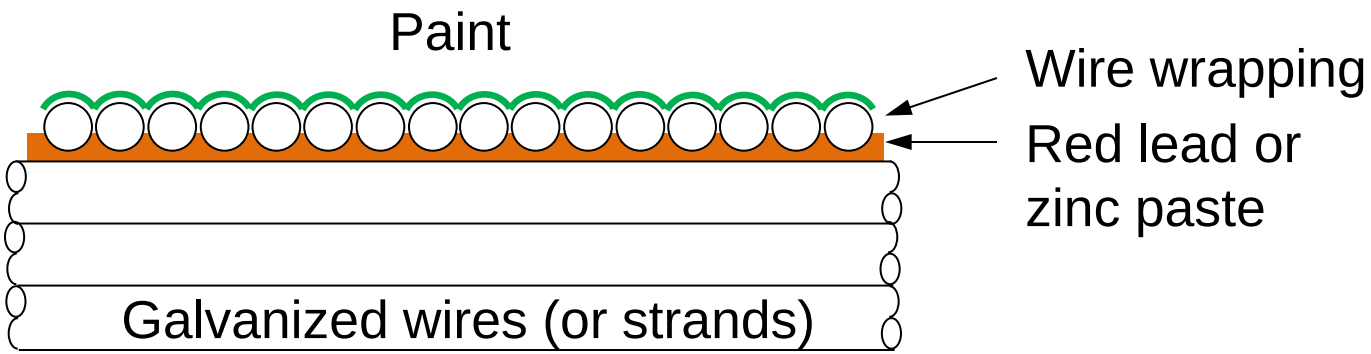
US Bridge Locations

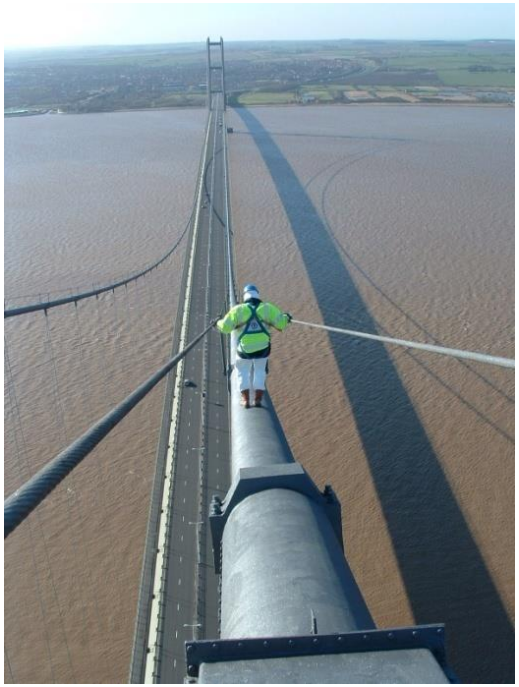
Chesapeake Bay Bridges

Conventional Cable Protection





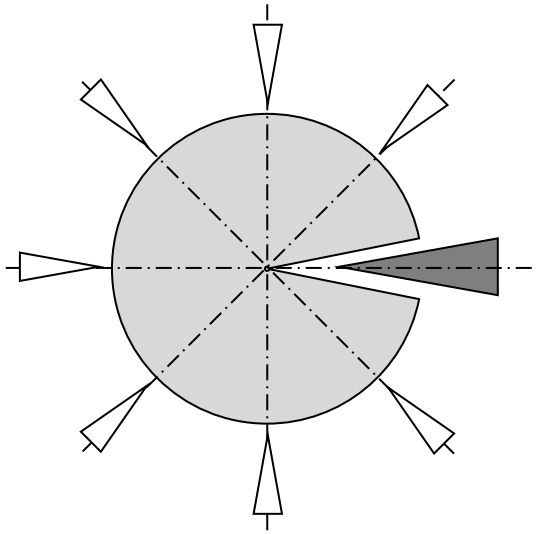
Conventional Cable Management



Conclusions - cables were well maintained but in spite of this there was evidence of water inside....

Recommendations - carry out an internal cable inspection

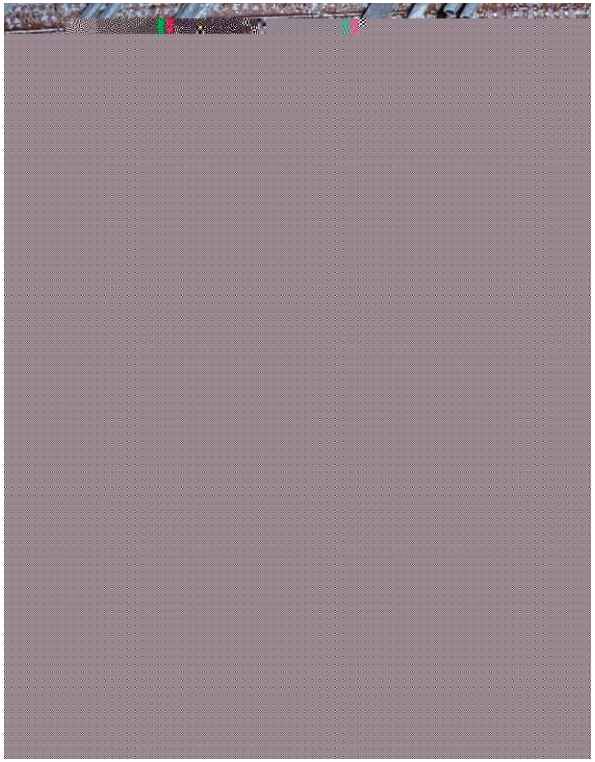
Internal Cable Inspections - Summary



- NCHRP 534 Guidelines – Guidelines for Inspection and Strength Evaluation of Suspension Bridge Parallel Wire Cables
- Internal Visual Inspection of Cable (Stage 1 – 4)
- Testing of Sample Wires (Strength of Stage 1, 2, 3, 4)
- Statistical Assessment to Determine Strength of Cable

Forth Road Bridge Internal Cable Inspection (2004, 2008 & 2012)

External corrosion



Broken wires

Internal corrosion

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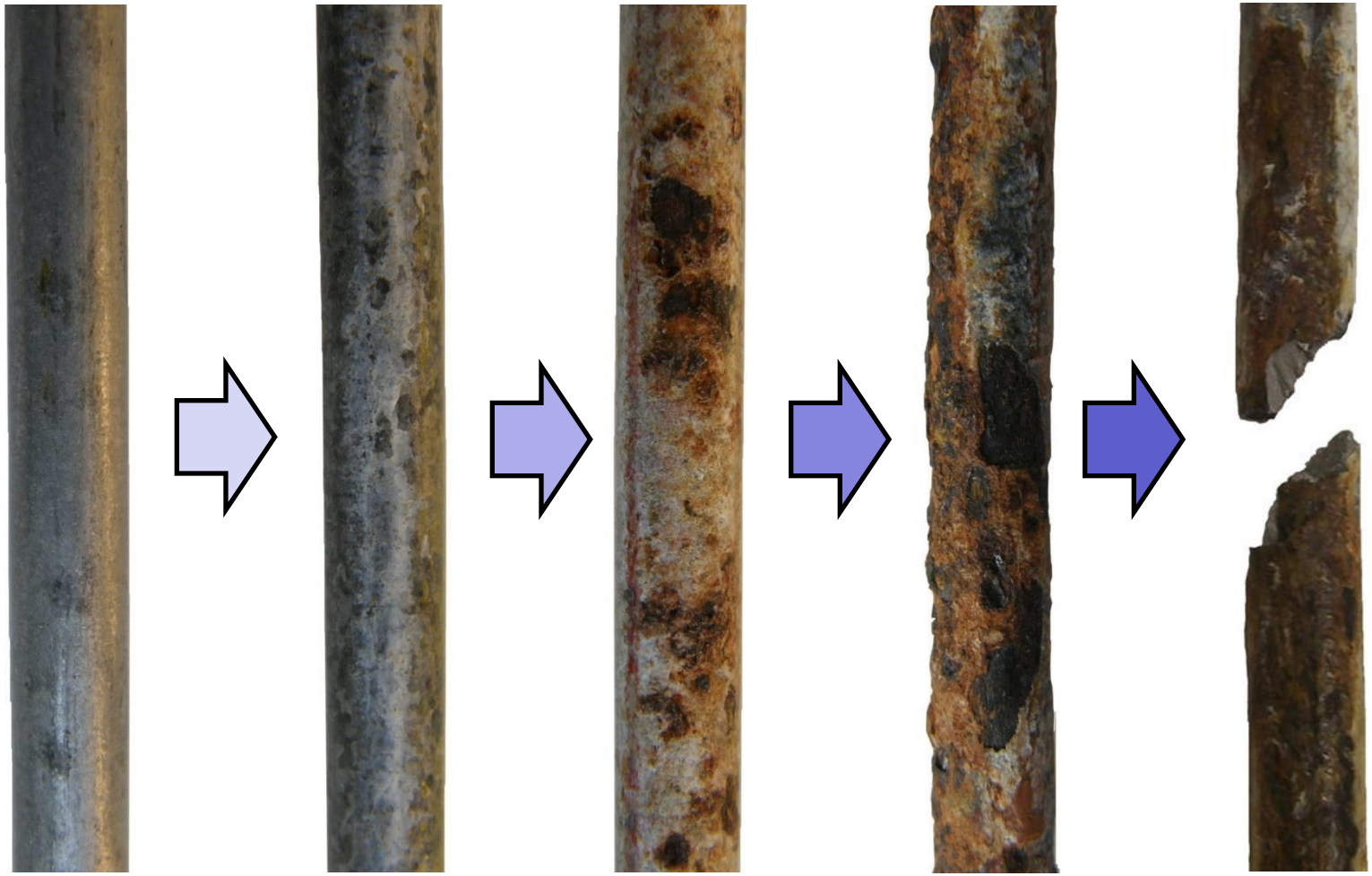
Strategy for Cable Preservation:
Understanding the deterioration process



Stage 1 2 3 4 Broken

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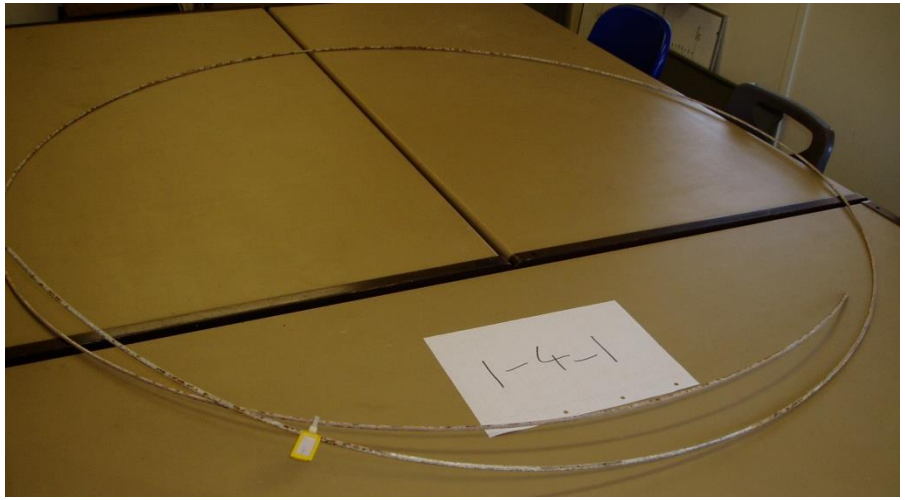
Strategy for Cable Preservation: Understanding the deterioration process

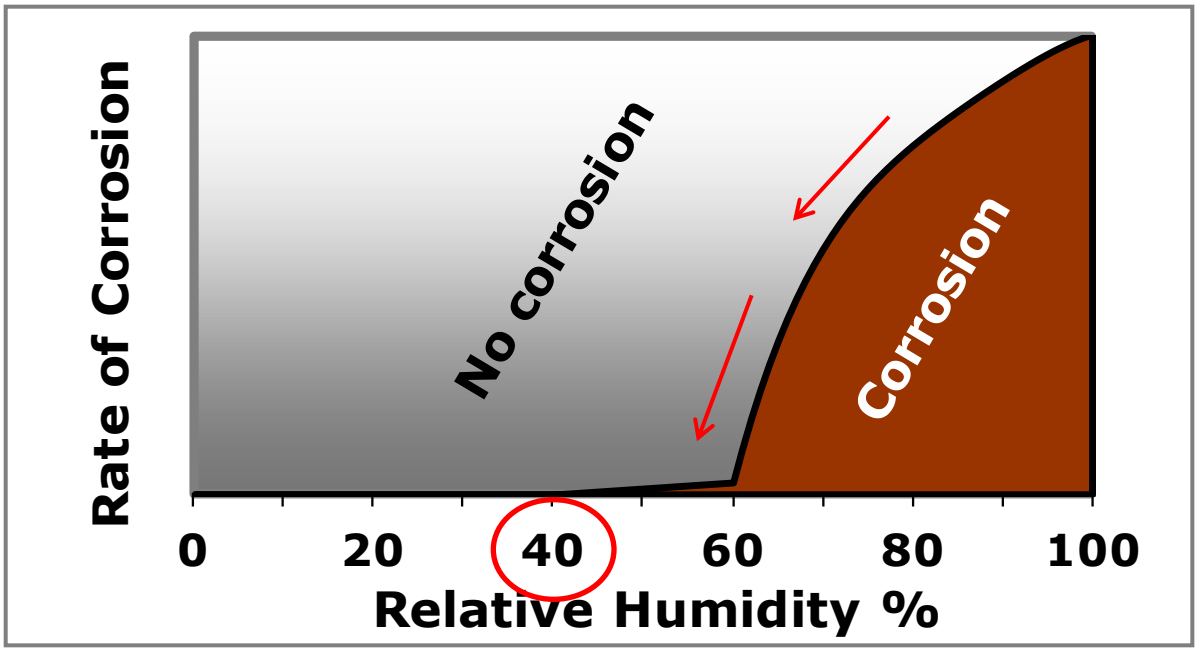
- Wire “cast diameter” causes tensile stress when wire is straightened under dead load
- Wires susceptible to brittle failure due to the fabrication process – formulation of alloys and “cold working” into final diameter



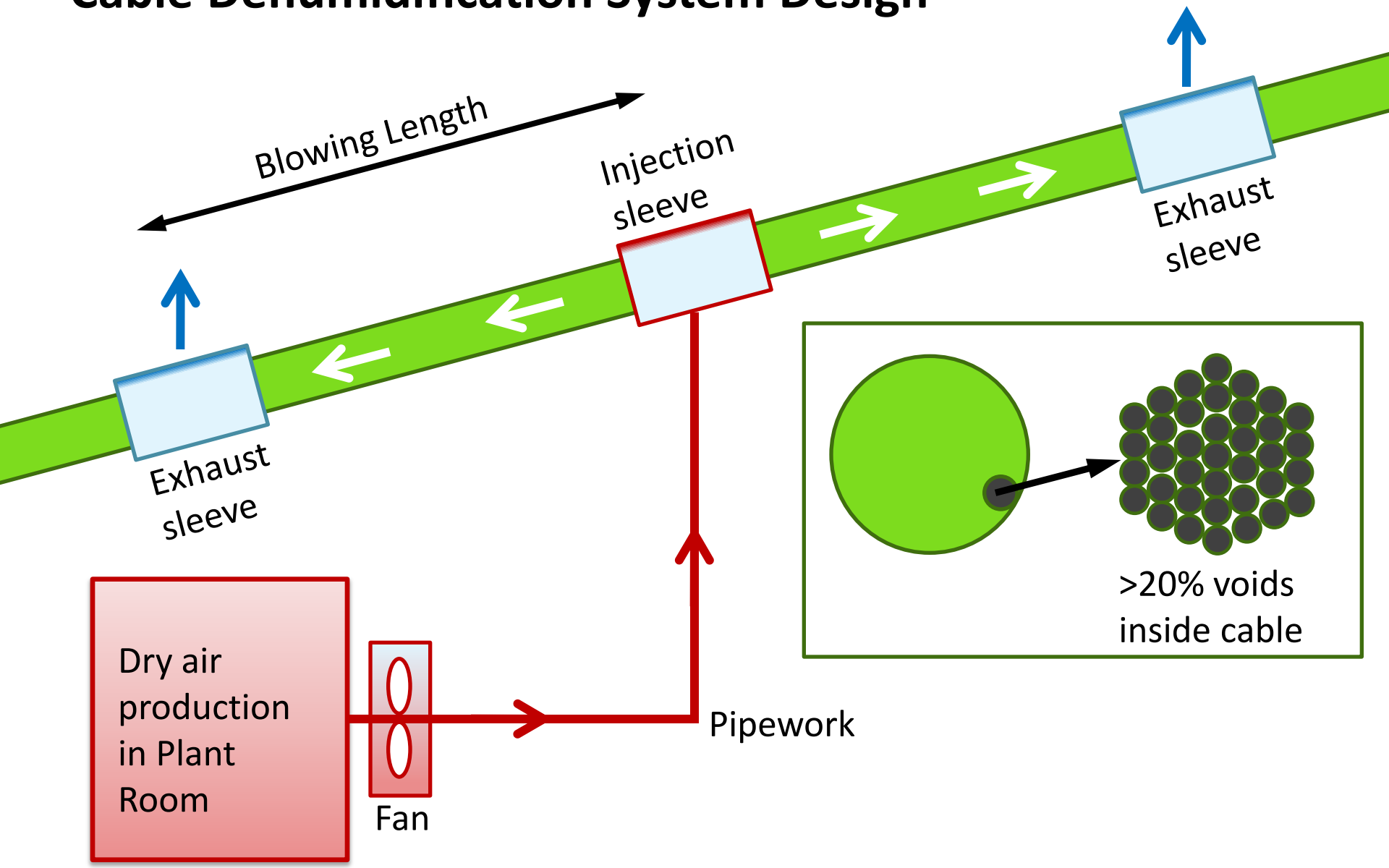
- Cable microenvironment (water, contaminants, zinc, iron) produces hydrogen molecules that drive the growth of cracks
- crack propagation and breakage is aided by the tensile stress in the wire
- Cracks can and do initially form in wires that are in good condition
- The key to long term preservation – **permanently alter the cable microenvironment** before cracks

Strategy for Cable Preservation: Cable Dehumidification

- Developed for Akashi Kaikyo Bridge in Japan
- Advantages:
  - Tackles cause of corrosion by removing water
  - No adverse effect on cables
  - Can see results through monitoring system



Cable Dehumidification System Design



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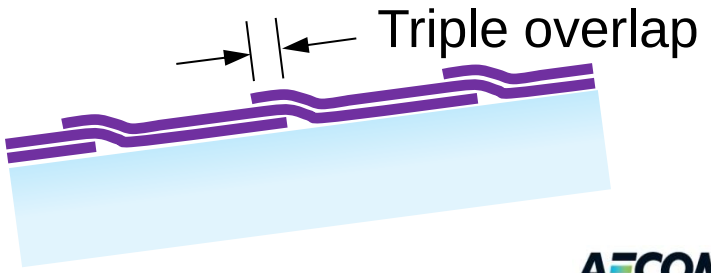
Making the cables airtight – wrapping

Cable has to be over-wrapped to make airtight

Long service life expected with virtually no maintenance

And the two layers heat bonded together to seal



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Making the cables airtight – cable band sealing

Wrap & seal

Install wedge & seal

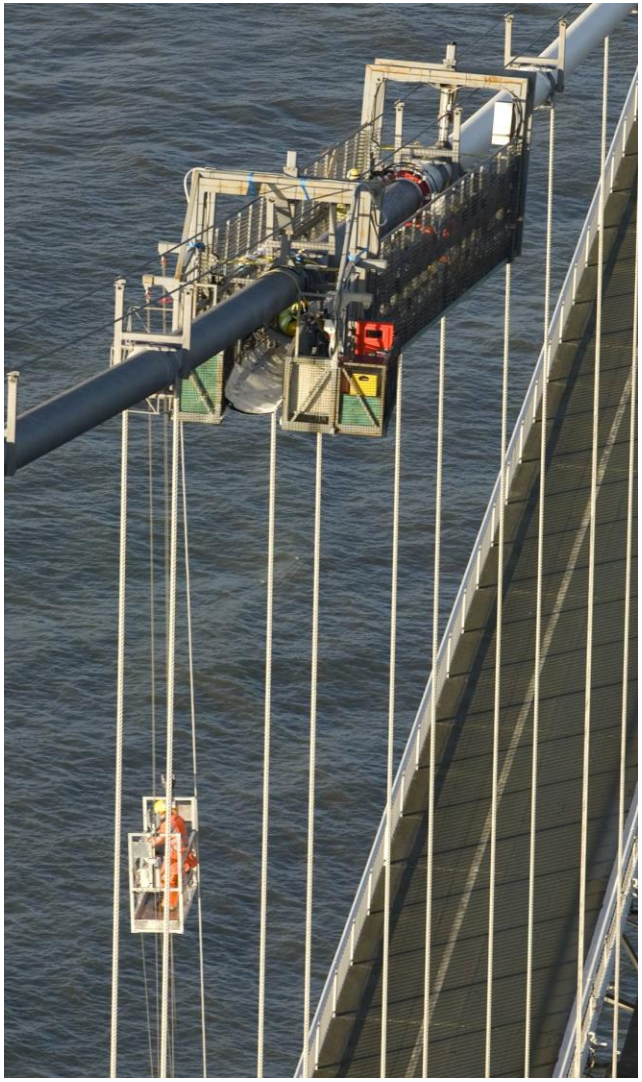
Finish

Injection and Exhaust Sleeves

Injection sleeve

Exhaust sleeve

Main Cable Access – Gantries



Worker/Material Hoist

Gantry at tower top

Severn Gantry

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Main Cable Access - Catwalks

- Full length catwalks installed to allow access by multiple trades at different times to different parts of the cables

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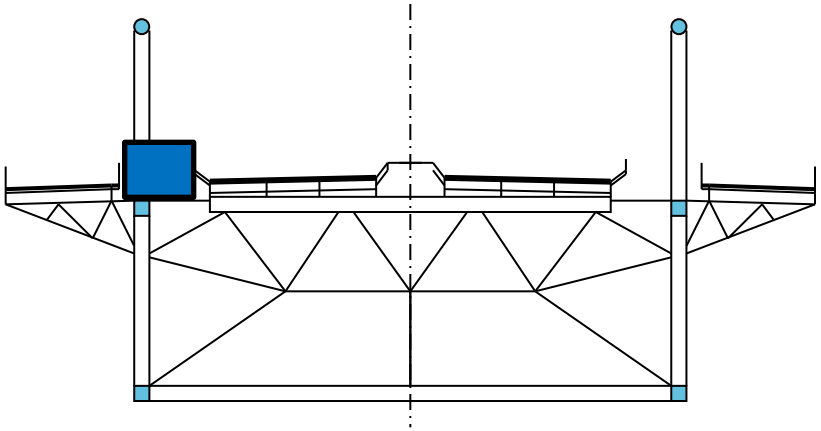
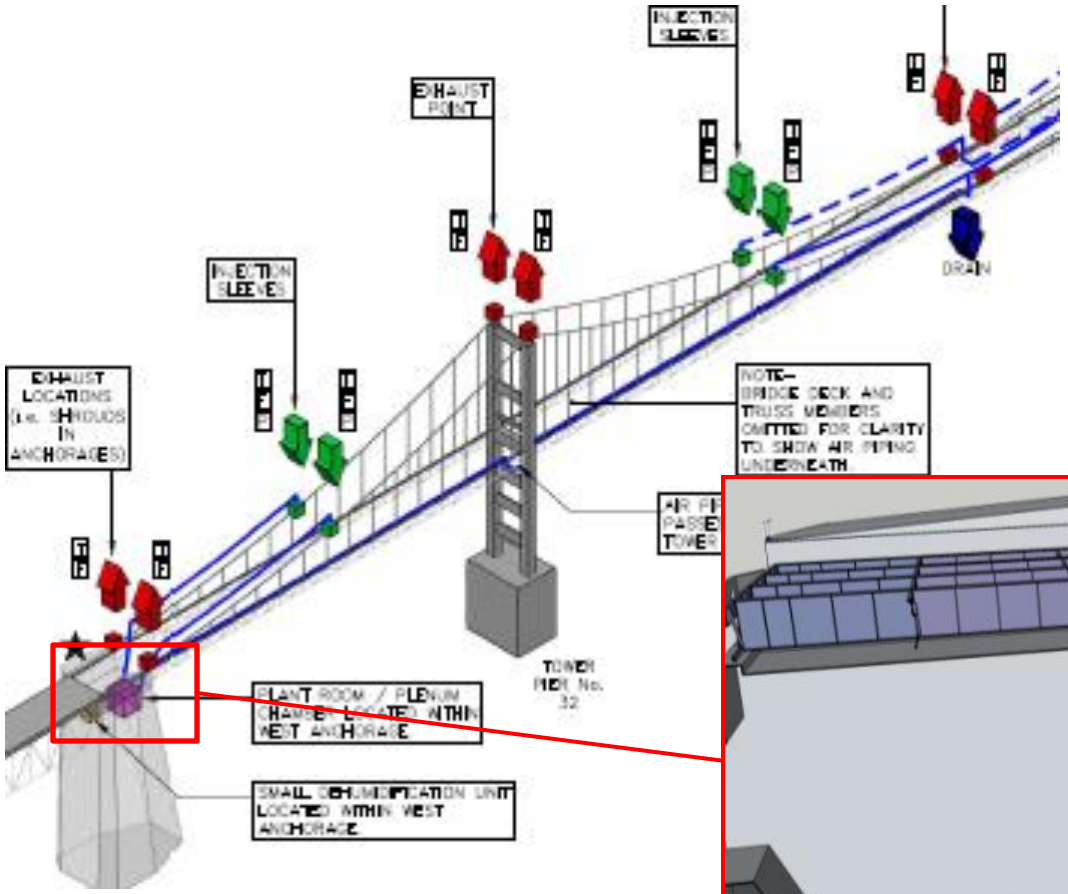
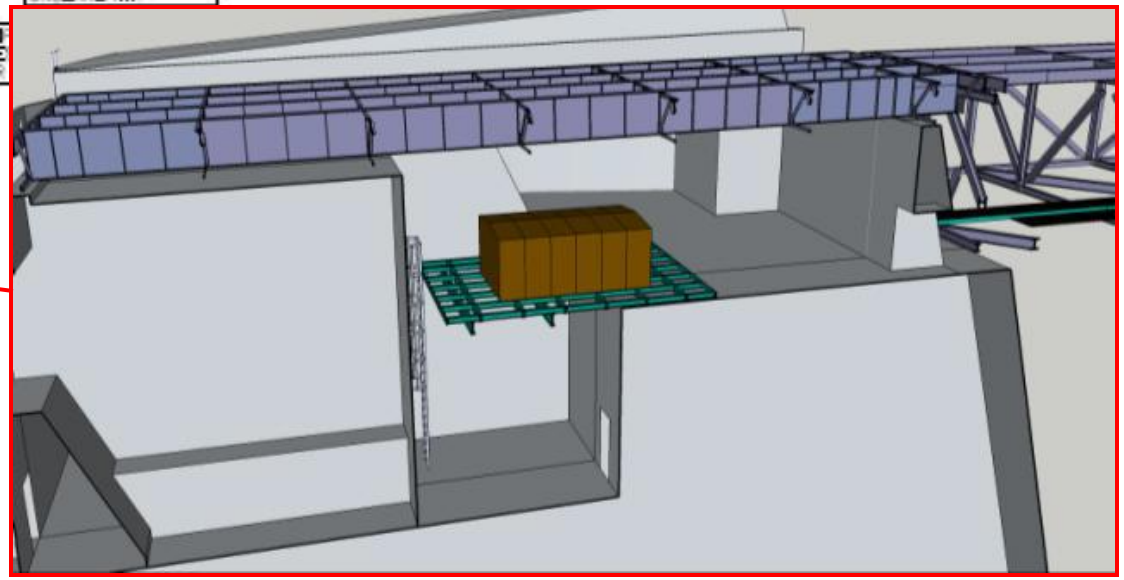
Access – Boat and Stair Tower Access

Plant Rooms – Roadway Level (Forth Bridge)

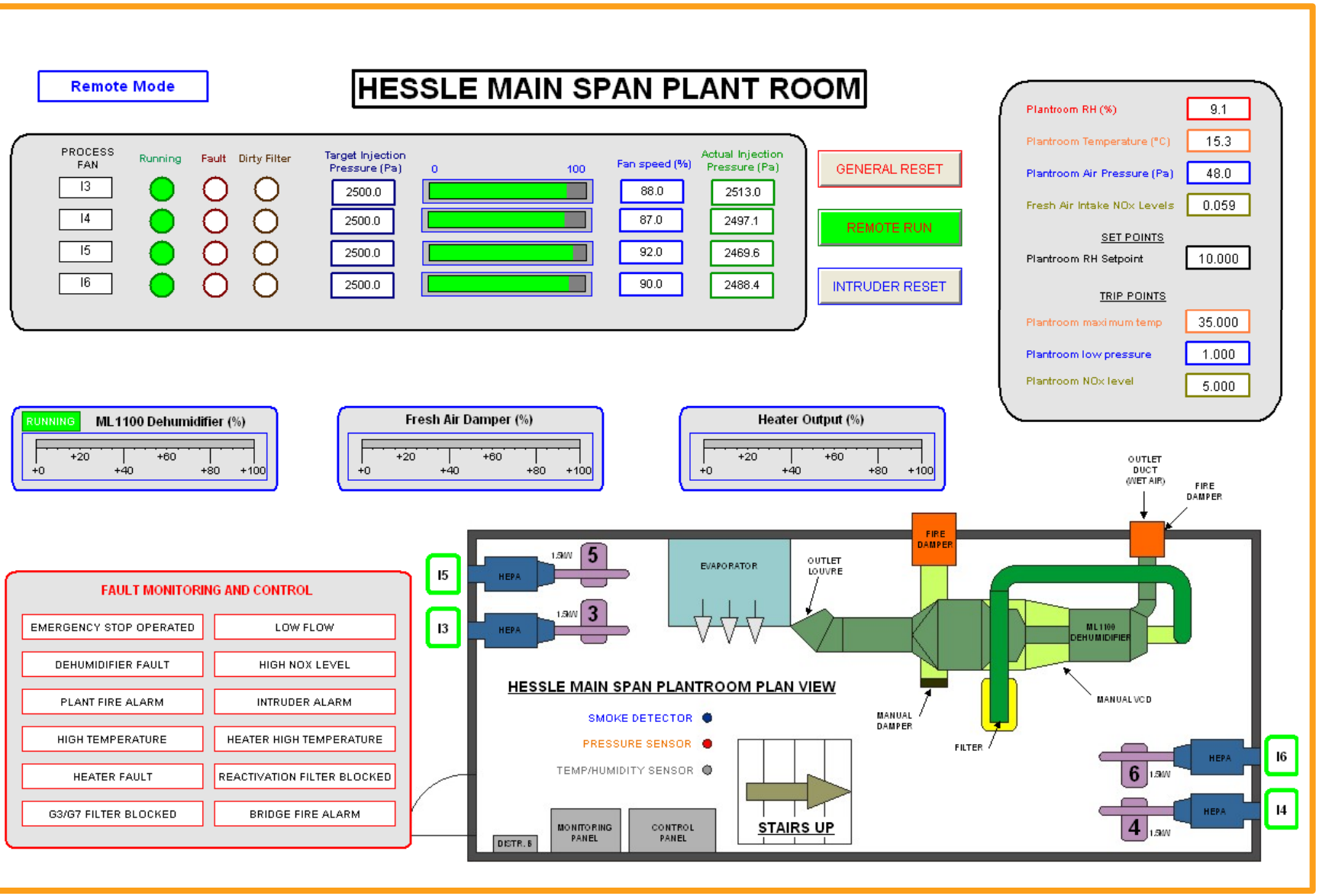


Plant Room – Anchorage (Bay Bridge)

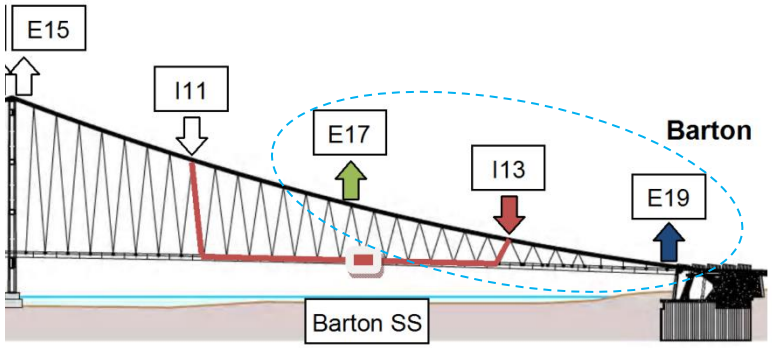


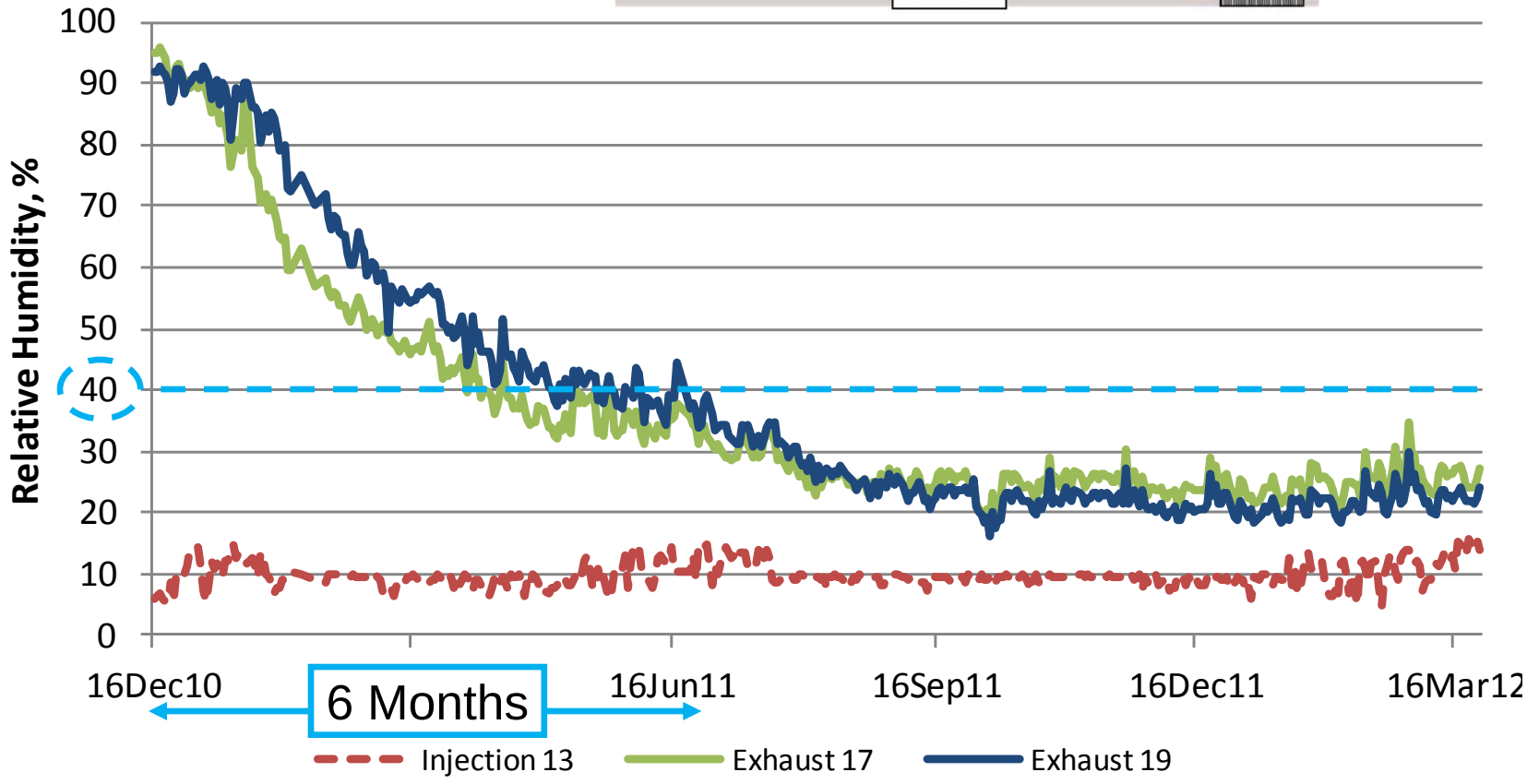


Monitoring & Control System – web interface



Drying Progress





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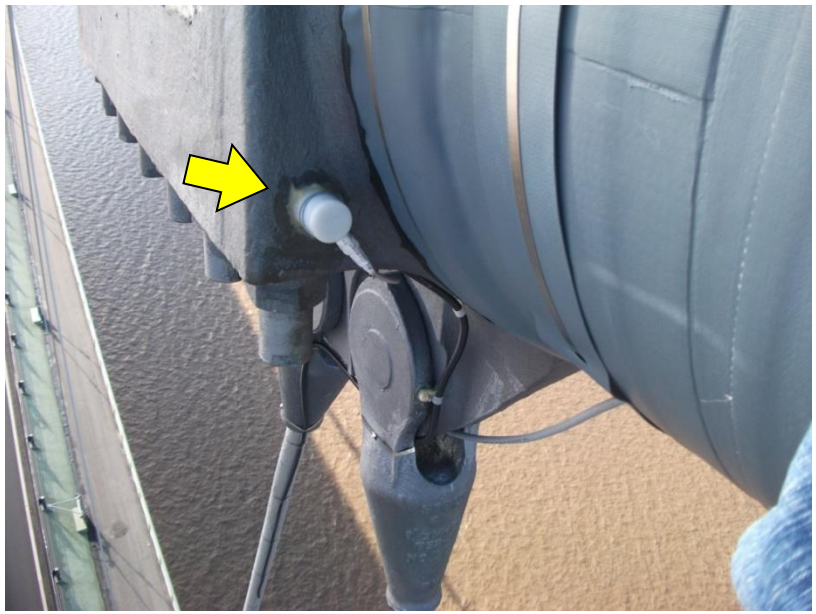
Operation and Maintenance

Draining water from mid span exhaust sleeve during initial drying

Opening sensor boxes facilitate inspection or replacement

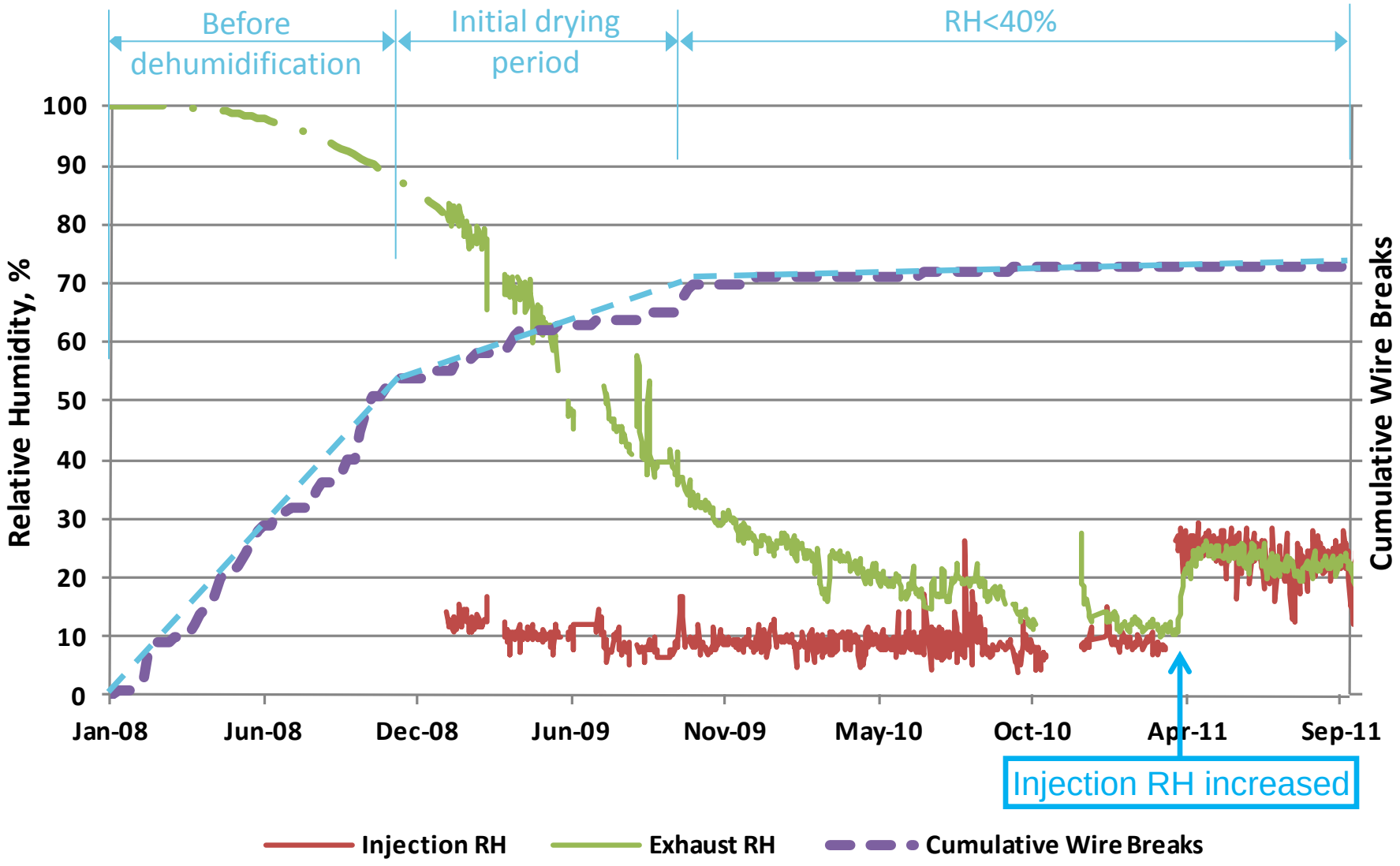
Cable Management - Acoustic Monitoring



Sensor mounted on cable band

Installation of signal cables down suspenders

Beneficial Effect of Main Cable Dehumidification on Reducing Wire Breaks



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Media attention

The projects have attracted considerable media attention, in national press, international engineering press and local tv

Dehumidifiers slow Forth Road Bridge cable corrosion

28 February 2013 | By Declan Lynch

Corrosion of the Forth Road Bridge's main suspension cables has significantly slowed down following the installation of a dehumidification system, according to an official report published this week.

Friends of the Earth Scotland
Policy Briefing Paper

Forth Road Bridge:
Can we fix it? Yes we can!

15 January 2008

Friends of the Earth Scotland

BBC NEWS

Study into Forth bridge dry-out

A study into the possibility of installing a drying-out system for suspension cables on the Forth Road Bridge is expected to get the go ahead.

It follows a report which warned the bridge could be shut to all traffic in under 14 years unless action was taken. Consultants are to look into fitting £12m de-humidification equipment, which would pump dry air onto the wet cables. The Forth Estuary Transport Association (Feta) is set to appoint engineers Faber Maunsell later this month.

Excellent track record

"The team Faber Maunsell has put together to carry out this study brings together the very best in experience across the world in dealing with similar situations.

"They have an excellent track record in understanding the complex issues involved in tackling corrosion in suspension bridges and, most importantly, providing the right solutions."

From The Sunday Times
January 29, 2006

Giant hair dryers to save Forth bridge

Jason Allardyce

ANTI-CORROSION devices which operate like giant hair dryers could be fitted to the suspension cables of the Forth Road Bridge to extend its life.

Conclusions

- The main cables of existing suspension bridges have been found to have heavily corroded and broken wires, in spite of good maintenance
- Traditional cable protection systems alone (paste, wrapping wire and paint) have not provided adequate corrosion protection
- Water is clearly driving the deterioration process
- Cable dehumidification has been successfully applied to reduce the RH within cables and suppress the rate of wire deterioration
- Dehumidification system maintenance and operation is undemanding if appropriately considered at the design stage and in the longer term, effective performance and energy use are key considerations.
- Acoustic monitoring systems and internal cable inspections used to monitor future (reduced) rate of deterioration.


Thank You
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