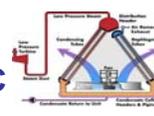




ACC Corrosion/FAC and Cycle Chemistry

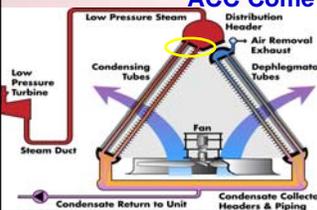
International ACC Conference
Xian, China
13th – 16th October 2015

Barry Dooley






ACC Come in Many Sizes





But the FAC / Corrosion damage is the same worldwide with all chemistries



Corrosion/FAC in ACC and The Consequences

- **High concentrations of iron around the cycle**
 - **Boiler/HRSG deposits** (expensive chemical cleaning)
 - **Boiler/HRSG Tube Failures** (overheating and TF)
 - **Steam Turbine Deposits** (including aluminum)
- **Need for Iron Removal Processes**
 - **Condensate Polishing and/or Filters**
- **Limitations around the cycle**
 - **Condensate polishing** (may have to change mode)
- **Overall an ACC “controls” the unit cycle chemistry**
 - **International Guidelines now available for ACC and two-phase flow** (IAPWS Volatile Guidance 2015)



There is an ACC Corrosion Index to Categorize Corrosion and Track Improvements

DHACI

(Dooley, Howell, Air-cooled Condenser, Corrosion Index)



DHACI for Tube Inlets

1. Tube entries in relatively good shape (maybe some dark deposited areas)
2. Various black/grey deposits on tube entries as well as flash rust areas, but no white bare metal areas
3. Few white bare metal areas on a number of tube entries. Some black areas of deposit
4. Serious white bare metal areas on/at numerous tube entries. Lots of black areas of deposition adjacent to white areas
5. Most serious. Holes in the tubing or welding. Obvious corrosion on many tube entries

Examples included on later slides

Dooley & Howell et al, PPChem 2009



DHACI for Lower Ducts

- A. Ducting shows no general signs of two-phase damage
- B. Minor white areas on generally grey ducting. Maybe some tiger striping with darker grey/black areas of two-phase damage
- C. Serious white bare metal areas in the hot box and at numerous changes of direction (eg. at intersections of exhaust ducting to vertical riser). White areas are obvious regions of lost metal.

Dooley & Howell et al, PPChem 2009



We know what the Corrosion Looks Like



and what Holes at Tube Entries Look Like



Inspections Worldwide show the same Features
 Combined Cycle with ACC after ~ 15,000 hrs.

DHACI 3

Concentration of Two-phase FAC beneath Supports

Structural Integrity Associates, Inc.

Inspections Worldwide show the same Features
 750 MW Supercritical on OT at pH 9, ~4,000 hrs.

DHACI 4

Concentration of Two-phase FAC beneath Supports

Source: Richardson and Joy, ACCUG 2011

Structural Integrity Associates, Inc.

Inspections in China
 650 MW Supercritical with Shuang Liang ACC. 15 Months.

DHACI 3

ACC Duct Work not Passivated

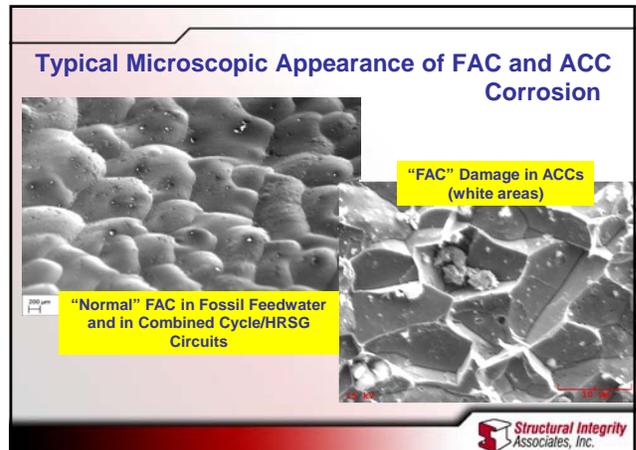
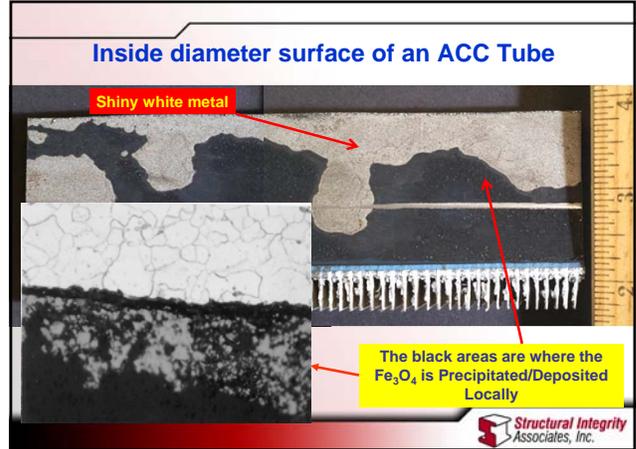
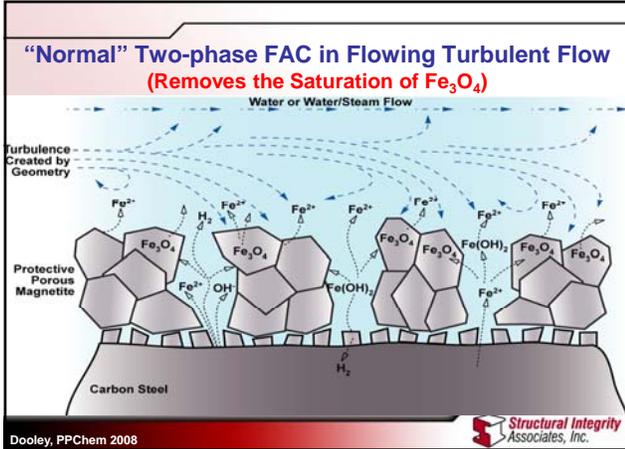
Concentration of Two-phase FAC beneath Supports

Structural Integrity Associates, Inc.

So is the ACC Corrosion Mechanism Low Temperature Two-Phase FAC?
 which is
 Dependent on Removing the Saturation of Fe_3O_4 at the Surface and Precipitating/Depositing it Adjacently

(Two ACC Tubes with damage (white areas) have been analyzed)

Structural Integrity Associates, Inc.



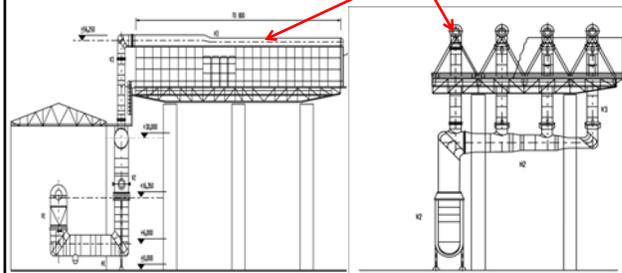
So do we Fully Understand the Environment and the Corrosion Mechanism?

Solutions are already being applied

- Increase bulk pH up to 9.8
- Increase local pH (amines including filming)
- Filters (average and absolute) and condensate polishers
- Coatings (epoxy), Sleeves, Inserts
- Alternate Materials to CS
- Designs



To Understand the Corrosion Here we need to Understand the Environment in the PTZ

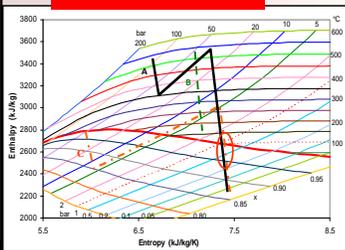


The PTZ Environment in the LP Steam Turbine is Completely Understood

Mollier Diagram
A. Fossil Reheat Turbine
B. Backpressure Turbine
C. Reheat Turbine in a nuclear LWR plant

Generation of the ACC Environment

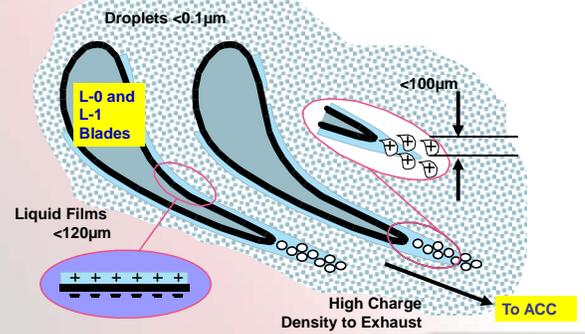
Heterogeneous droplet Nucleation and Liquid Films on ST Blades
 (Droplets and Liquid Films in the ACC vary from 0.1 – 50 microns and don't contain any oxygen until during shutdown)

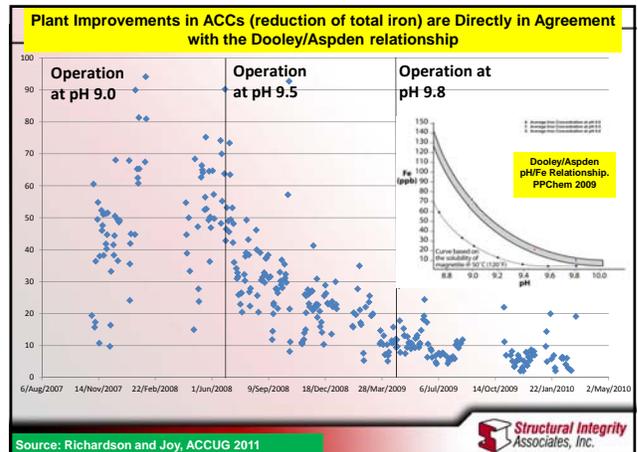
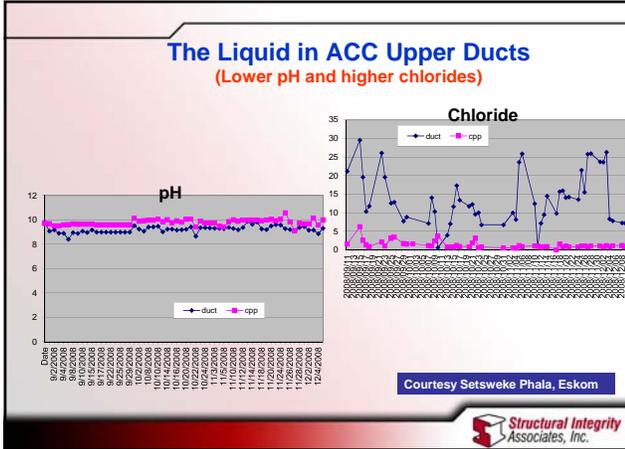


Source: IAPWS Technical Guidance Document 2013



Generation of the ACC Environment is in the PTZ





Thoughts on “corrosion” in air-cooled condensers

Based on work conducted in Australia, Chile, China, Dubai, India, Ireland, Mexico, Qatar, South Africa, UK and US

Increasing condensate pH to 9.8 will gradually eliminate the FAC damage at the tube entries and iron levels will reduce to IAPWS suggested levels (5 - 10 ppb). Documented by reducing the DHACI

Damage on cross members is not “repaired” as quickly by increasing pH. Is this LDI caused by the larger droplets leaving the PTZ of the LP Steam Turbine?

Copyright Structural Integrity Associates, Inc. 2015



Summary

- **Some aspects relate to (LT Two-phase) FAC**
 - Adjacent black and white areas in severe turbulent areas
 - Increasing local pH reduces damage
- **But some aspects don't** (normal FAC scalloped appearance and white areas on cross members is probably LDI)
- **Environment is known and has been measured**
 - Two-phase mixture formed in PTZ of the steam turbine
 - Concentrating liquids (Higher in chloride/sulphate, organics)
 - Lower in pH (0.5) and very low in dissolved oxygen (close to zero)
- **“Repaired” two-phase FAC areas turn red slowly**
 - Mechanism in ACC is thus not totally understood & what are amines doing?
- **Results from a number of plants indicate increased Al levels in turbine and drum deposits**
 - This may result from initial operation

