

Cost Effective Chemical Removal of Corrosion Inducing Surface Salts

A Special Presentation for:

2003 PDA Annual Conference

Uhlig and Revie's
Corrosion & Corrosion Control:

“The most important single factor influencing the life of a paint is the proper preparation of the metal surface”

Salts and Surface Preparation

Why?

- Salts are a leading cause of coating failure today.
- Visual standards for surface preparation do not take soluble salts into account.
- Visual standards were adequate for lead paint applications.

Why test for and remove surface salts?

- “Do it right the first time”
 - ◆ Prevent premature failure of coatings.
- Avoid costly rework.
 - ◆ Eliminate asset productivity loss.
- Long term savings – improved coatings performance.

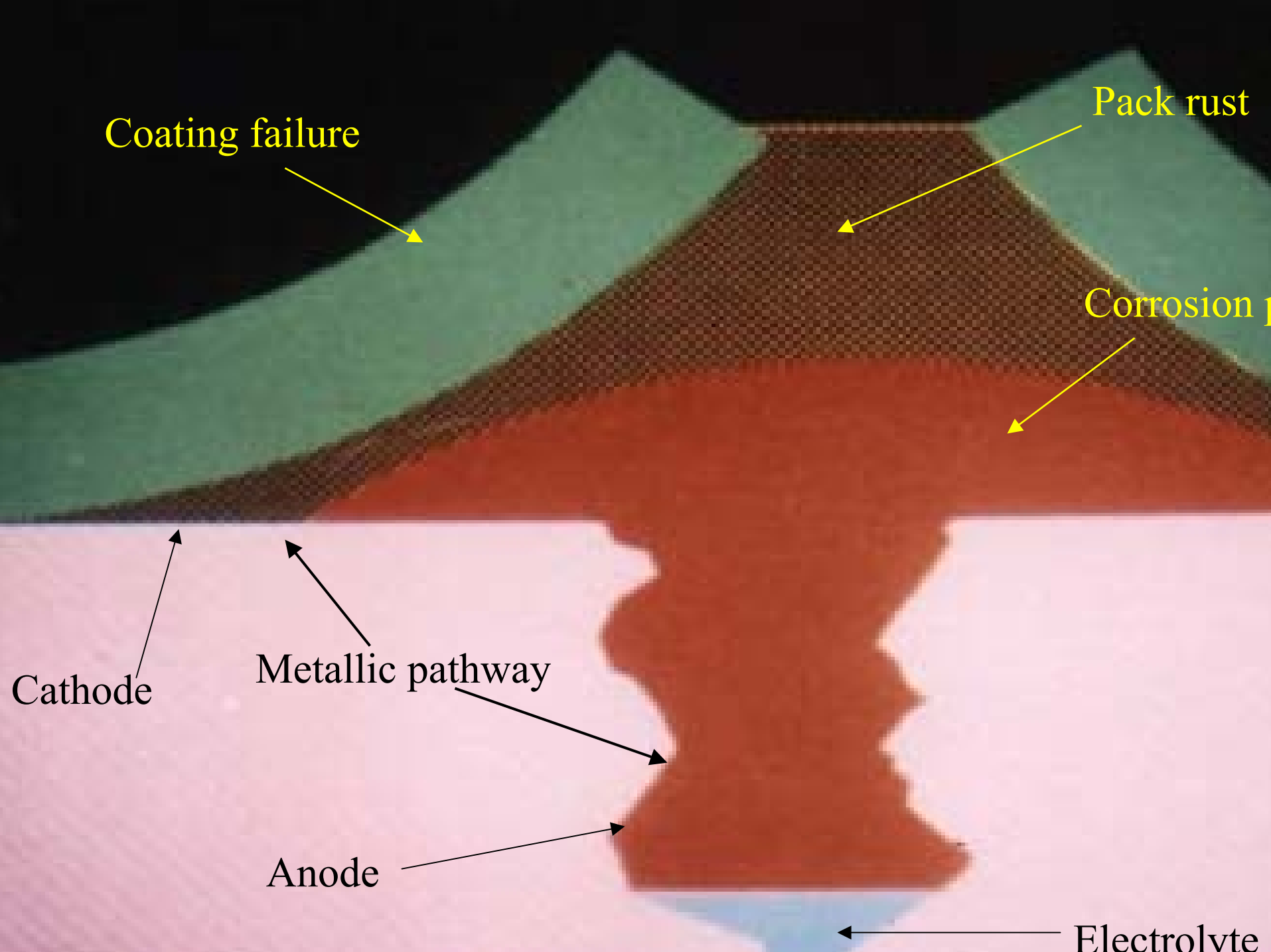
What are Soluble Salts?

- Ionic contaminants
- Water soluble inorganic compounds
- Primarily chlorides, sulfates and nitrates
- Non-visible contaminants

Bonding strength

Why are salts left behind if they are water soluble?

The electrochemical attachment of salts to the substrate are greater than the forces applied to remove them.



Coating failure

Pack rust

Corrosion product

Cathode

Metallic pathway

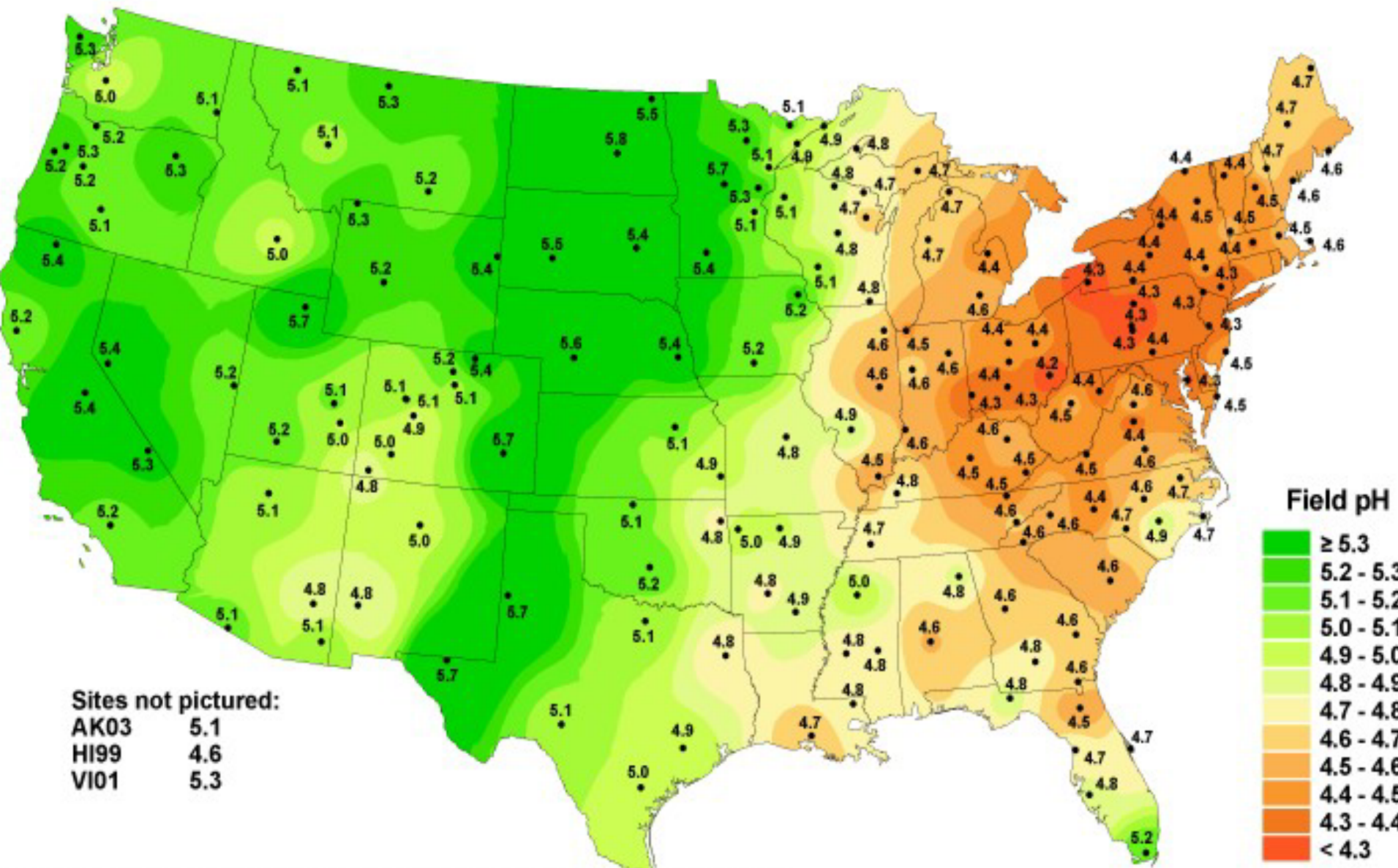
Anode

Electrolyte

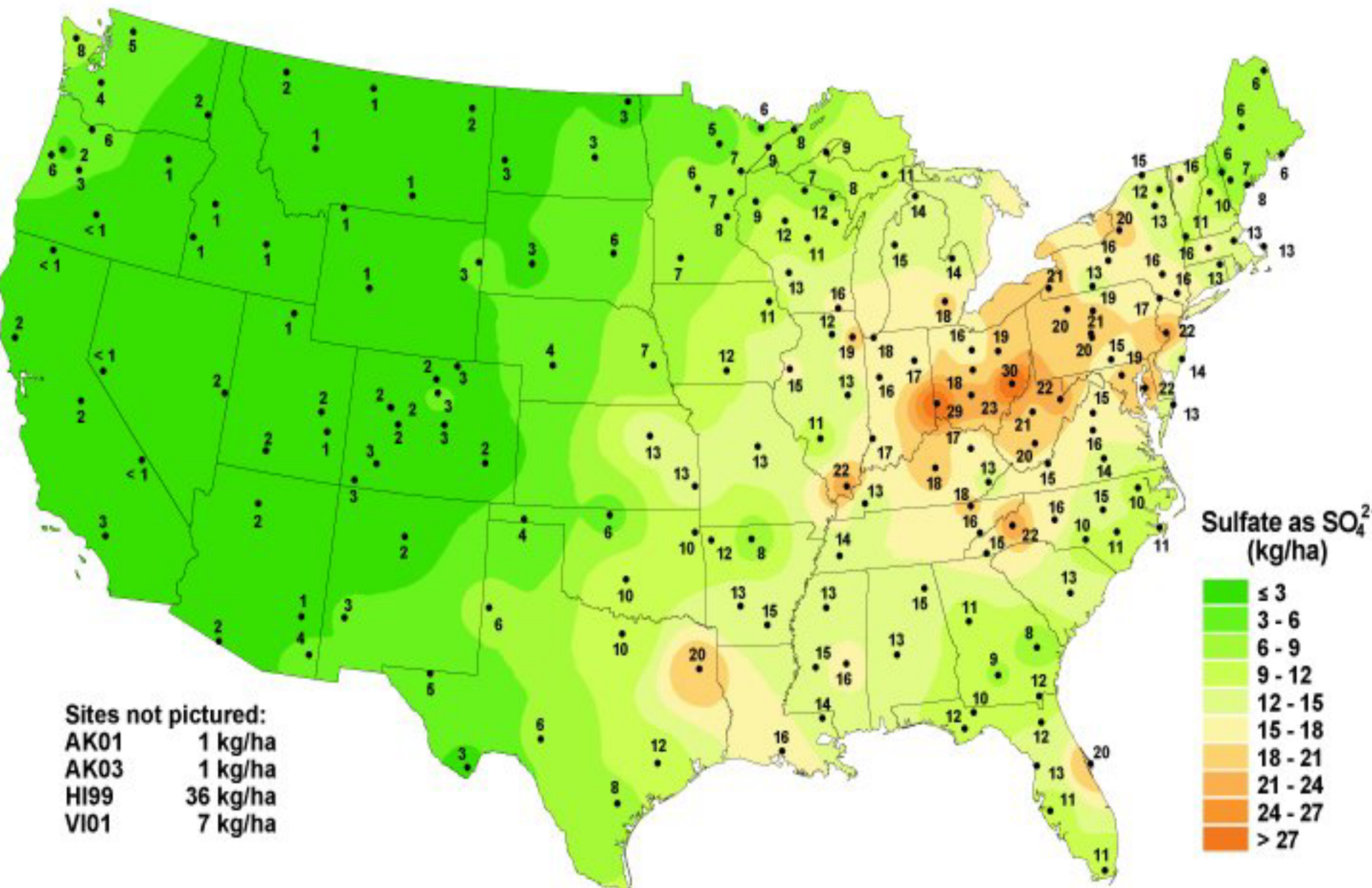
Sources

- Marine bodies (sea water-chlorides)
- De-icing salts (chlorides)
- Acid rain (sulfates/nitrates)
- Chemical process (many combinations of salts)
- Abrasives (chlorides/sulfates)

Hydrogen ion concentration as pH from measurements made at the field laboratories, 2001



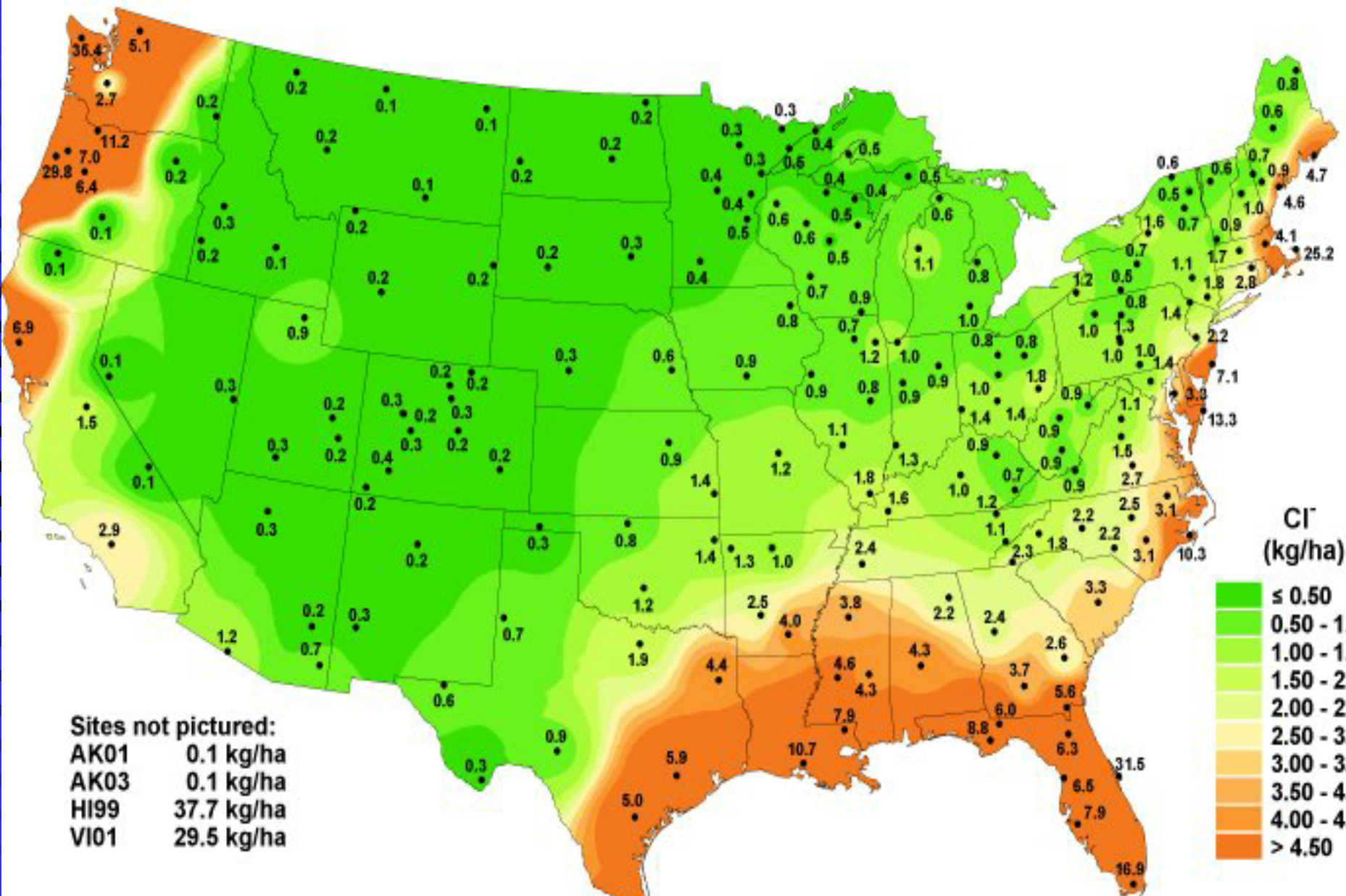
Sulfate ion wet deposition, 2001



National Atmospheric Deposition Program/National Trends Network

<http://nadp.sws.uiuc.edu>

Chloride ion wet deposition, 2001



Acceleration of Corrosion

- Salts absorb and retain moisture
- Salts increase anode reaction
- Salts concentrate in and promote pitting

Estimated Osmotic Pressure

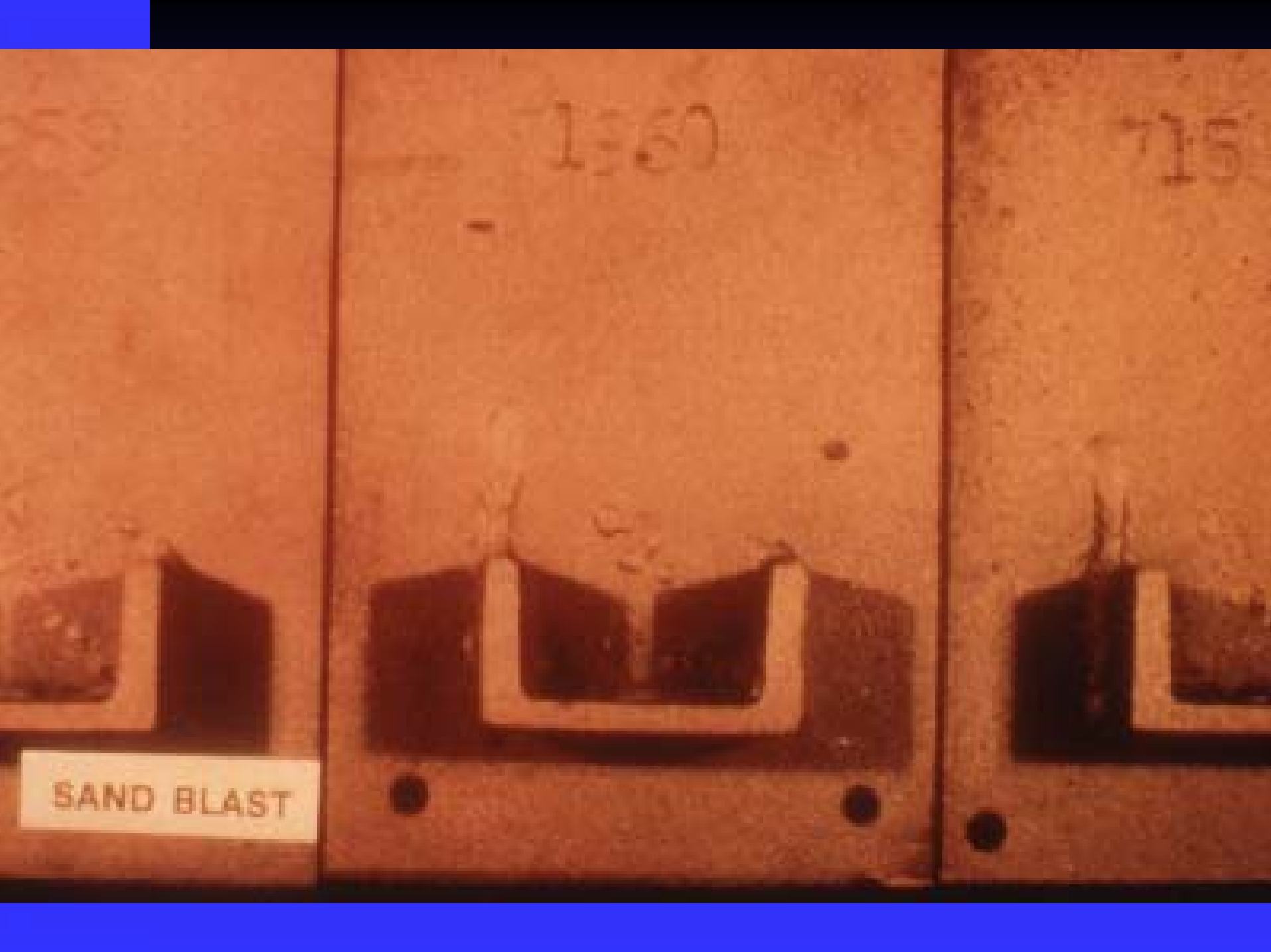
| Salt | Pressure psi (bar) |
|------------------|--------------------|
| Sodium Chloride | Up to 2200 (152) |
| Ferrous Chloride | Up to 3700 (255) |
| Zinc Chloride | Up to 22900 (1578) |
| Calcium Chloride | Up to 3900 (269) |

STEEL GRIT BLAST

3 TIMES TO WHITE METAL

100 MICRONS

A micrograph showing the surface of a metal after being blasted with steel grit three times to achieve a white metal finish. The surface is highly textured and irregular, with a scale bar indicating 100 microns.

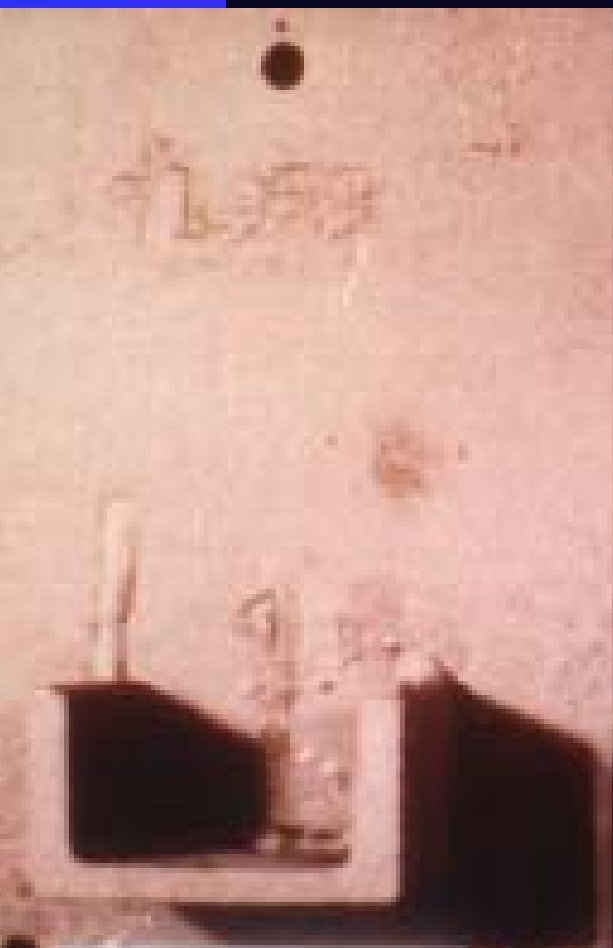


59

1360

715

SAND BLAST



SAND BLAST



24 HOURS LATER



LOCALIZED CORROSION



Criteria for Soluble Salts (Cl⁻)

| <u>Source</u> | <u>Immersion</u> | <u>Atmospheric</u> |
|---------------|------------------|--------------------|
| Suppliers | 2-10 | 5-20 |
| US Navy | 3 | 5 |
| DNV | 2 | - |

Units = $\mu\text{g}/\text{cm}^2$

Shipbuilding Research Study

Chloride results*

- black corrosion spots on substrate at 0.5 to 1 $\mu\text{g}/\text{cm}^2$ (4500 hrs)
 - blistering observed at 5 to 8 $\mu\text{g}/\text{cm}^2$ (200-500 hrs)
 - blistering failure at 10 to 16 $\mu\text{g}/\text{cm}^2$ (500 to 1000 hrs)
- *Immersion in seawater 90F, 50 psi

Shipbuilding Research Study

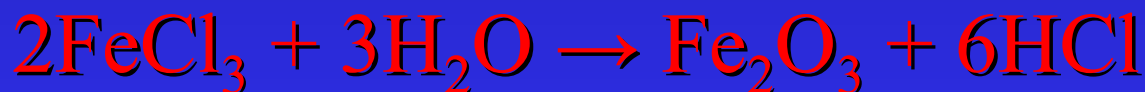
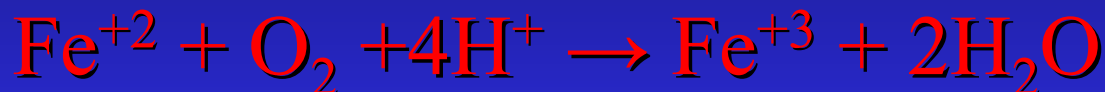
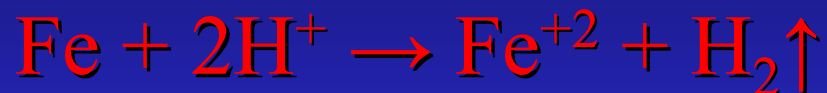
Sulfate results*

- It requires about 10 times the sulfate contamination as chlorides to generate osmotic blisters.

*Immersion in seawater 90°F, 50 psi

Salt Corrosion Cycle

Iron + Salt + Moisture = RUST + Acid



Without remediation, repeat
reaction cycle

Detecting Soluble Salts

■ Extraction methods

◆ Less accurate:

- ☞ Swabbing (DI water)
- ☞ Patch Cell (DI water)
- ☞ Wet filter paper (DI water)
- ☞ Magnetic cell (DI water)

◆ More accurate:

- ☞ CHLOR*TEST (proprietary acid solution)
- ☞ Boiling (lab; destructive field sample)

■ Quantitative analysis

Analysis of Salts (Field Methods)

- **Higher accuracy:**
 - ✓ Chloride ion specific
 - ✓ Sulfate ion specific
 - ✓ Nitrate ion specific
- **Lesser accuracy:**
 - ✓ Potassium ferricyanide (inferential)
 - ✓ Conductivity (measures all conductive species)
- **Units and conversions**

Field Surface Prep. Costs, \$/ft²

| | |
|-----------------------------------|-------------|
| ■ Power tool – bare metal (SP-11) | 4.40 - 6.10 |
| ■ Near white blast (SP-10) | 1.95 - 2.55 |
| ■ White metal blast (SP-5) | 2.20 - 2.90 |
| ■ Brush blast (SP-7) | 0.60 – 0.95 |
| ■ UHP water (WJ-1) | 4.41 - 5.37 |
| ■ CHLOR*RID 1% wash | 0.19 - 0.23 |
| ■ HOLD*BLAST 2% | 0.13 – 0.17 |

Conditions: Maintenance painting of light to heavy paint
breakdown, pitting and light to medium rusting; 100K ft².

Sources: MP (Feb '97); Industry survey