Fastener Corrosion Issues: Testing, Codes, and Design

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Overview

- *Fundamentals of Corrosion*
- *Designing to Minimize Corrosion*
- *Codes & Standards*
  - *AWC*
  - *ICC-ES*
  - *AWPA E-12*
- *Current Research*
  - *Simpson Strong Tie*
  - *Forest Products Laboratory*

Fundamentals

- *All metals corrode*
  - *Metastable*
- *Corrosion rate*
  - *Reaction kinetics*
  - *Key figure of merit*
  - *Depends on*
    - *Chemical environment*
    - *Physical environment*
    - *Corrosion products*

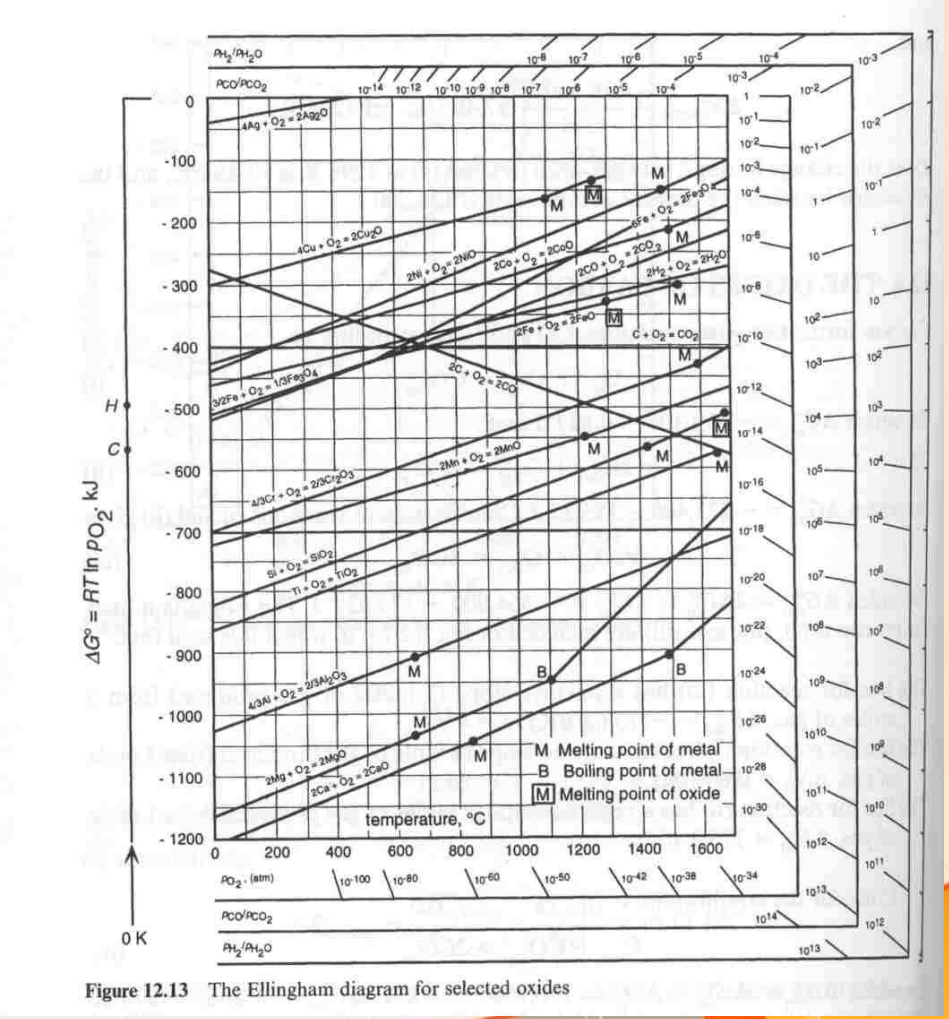


Figure 12.13 The Ellingham diagram for selected oxides

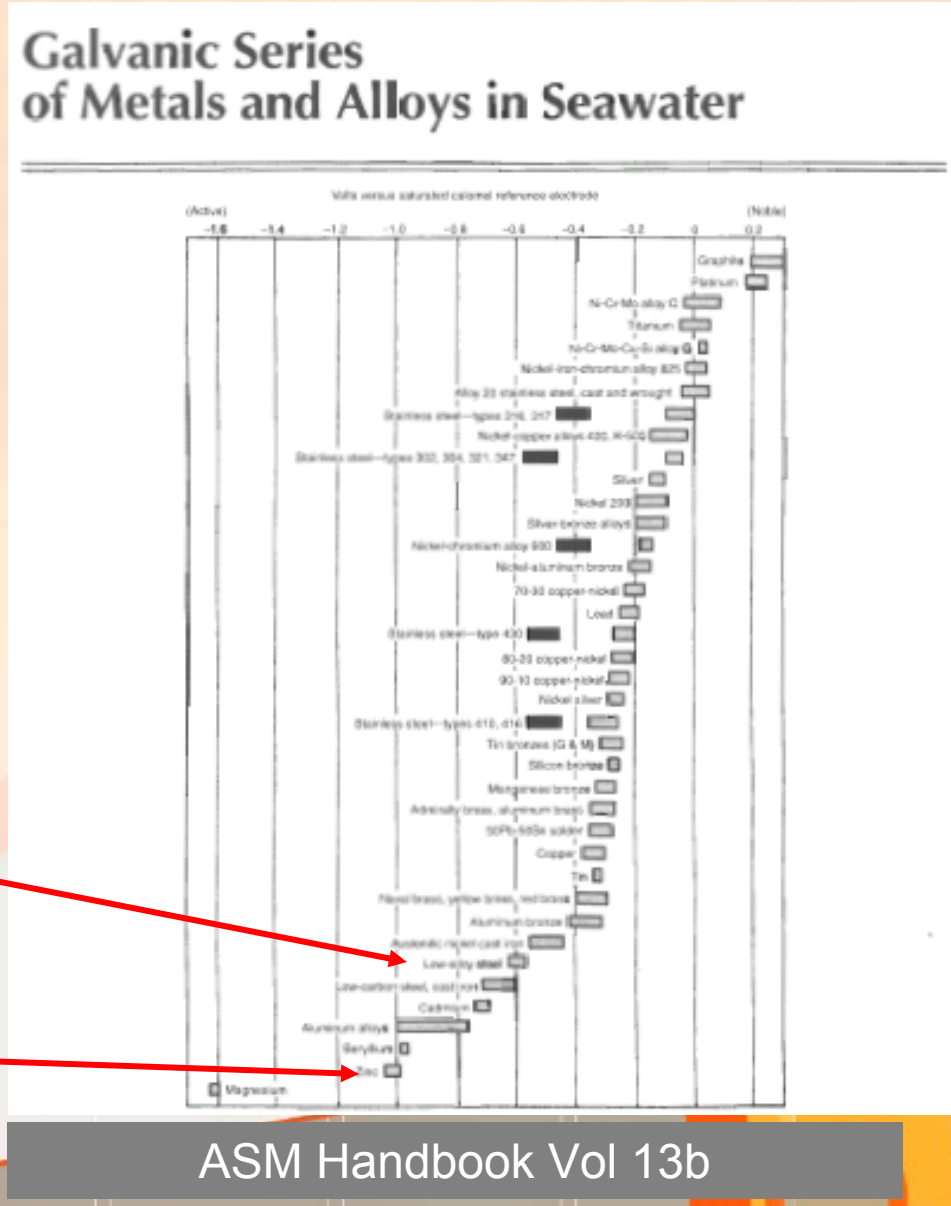
Introduction to the Thermodynamics of Materials - Gaskell

Fundamentals

- *Galvanic Series*
  - *Only valid for seawater*
  - *Thermodynamic ranking*
    - *Does NOT rank corrosion rates*

Low Alloy Steel
2.9 mils/year

Zinc 0.6 mils/year



ASM Handbook Vol 13b

Design Considerations

- *Protective Coatings*
  - *Metallic Coatings*
    - *Anodic coatings (galvanizing)*
      - *“Self healing”*
    - *Cathodic coatings*
      - *Pitting corrosion at defects*
  - *Corrosion performance*
    - *Corrosion rate of coating*
    - *Defects in coating*

Design Considerations

- *Non-Metallic Coatings & Barriers*
  - *Coatings do not “corrode”*
    - *Subject to degradation*
    - *Pitting corrosion at defects*
  - *Currently researched at FPL*
    - *Based on epoxy coated rebar techniques*
  - *Barriers*
    - *Same concerns as coatings*

Codes & Standards

- *AF&PA AWC*
  - *Corrosion fact sheet*
    - *Minimum of hot-dip galvanized or equivalent*
  - *PWF Design Specifications (Draft)*
    - *“Fasteners in contact with preservative treated wood shall be of Type 304 or 316 stainless steel”*
    - *Exception: CCA treated wood, moisture content less than 19%,*
      - *hot-dip galvanized allowed*

Codes & Standards

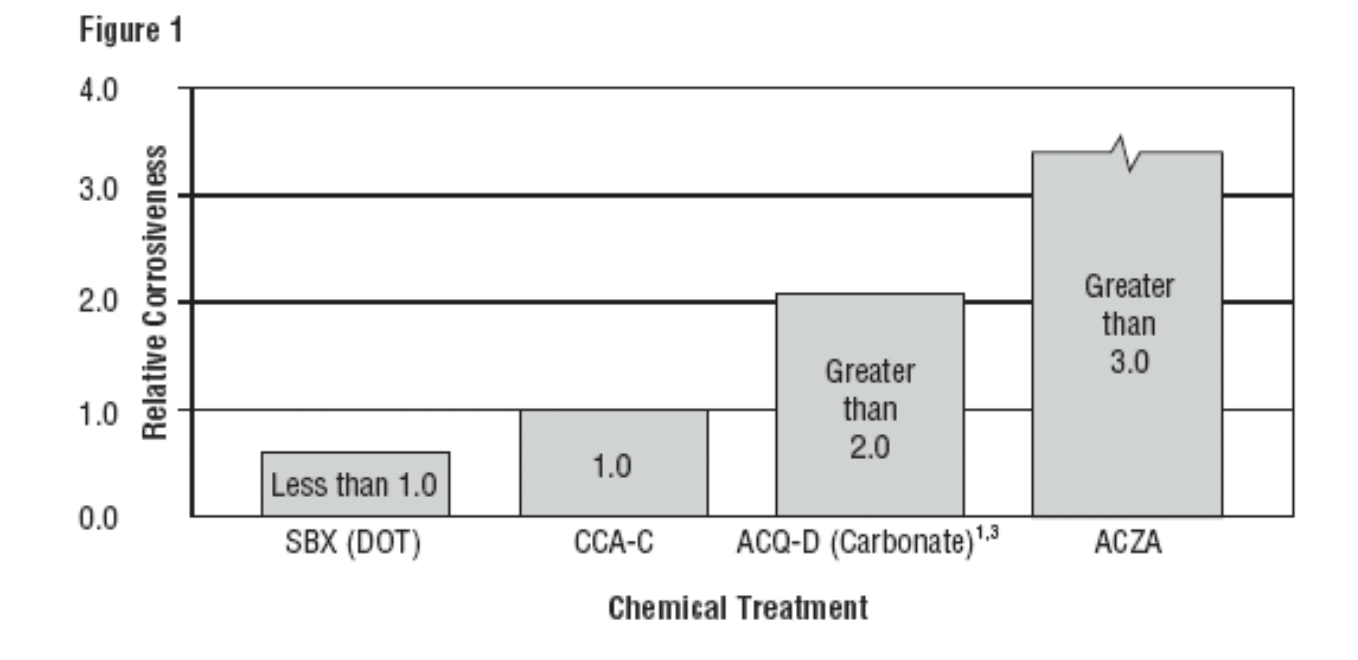
- *AWPA E-12*
  - *Metal coupons held between wood blocks*
  - 49°C ± 1°C (120°F± 2°F) with RH of 90% ± 1%
    - Minimum 240 hours exposure
  - *Coupons cleaned, corrosion rate reported*

Codes & Standards

- *ICC-ES Acceptance Criteria A326*
  - *Approved March 1, 2006*
  - *Min 10 replicates*
  - *Fasteners driven into wood*
    - *Then follows AWPA E12 exposures*
  - *Fasteners cleaned & visually inspected*
  - *Fastener shall pass if it has less than 25% surface corrosion*

Current Testing

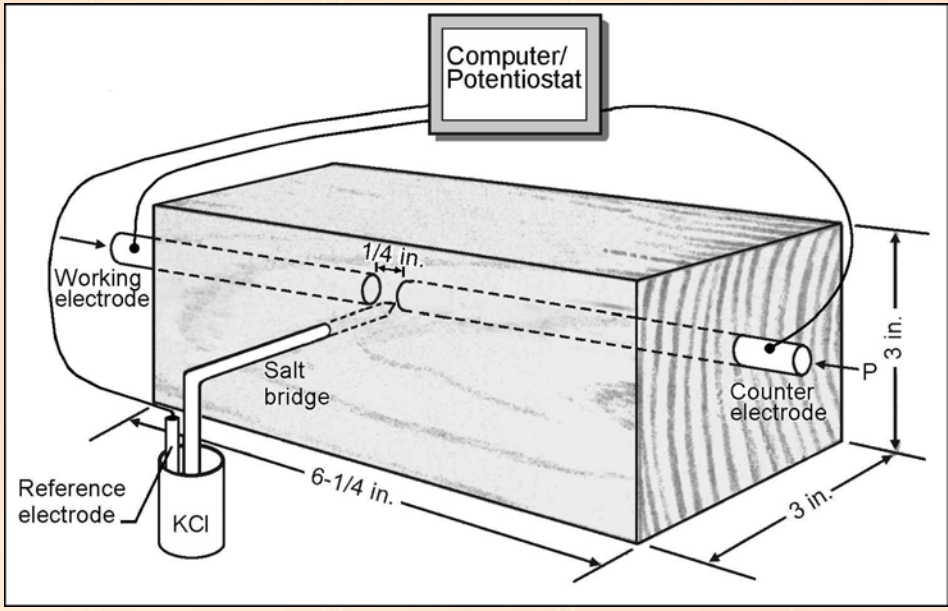
- *Simpson Strong Tie*
  - *1,800 AWPA E12 Tests*
  - *3,000+ Modified E12 Tests*
    - *Using actual fasteners*



Simpson Strong Tie Technical Bulletin T-PTWOOD06

Current Testing

- *Forest Products Laboratory*
  - *Electrical Impedance Spectroscopy (EIS)*



TMS Lett. 2(1) pp.15-16

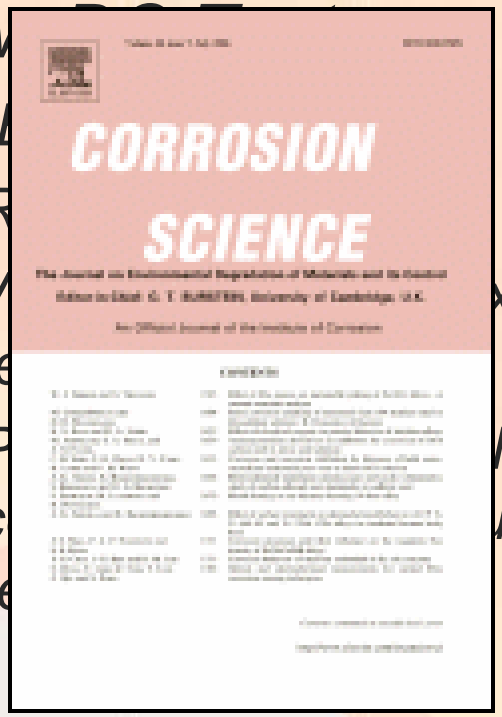
- *Pros*
  - *Test at MC or T of interest*
  - *Measure diffusion controlled reactions*
  - *Prevent permanent polarization of preservative*
  - *Model corrosion via equivalent circuit*
- *Cons*
  - *Requires expensive equipment*
  - *Data analysis requires modeling*

Current Testing

- *Forest Products Laboratory*
  - *DC methods*
    - *LPR, Polarization*
- *Pros*
  - *Simple data analysis*
  - *Rapid*
  - *Test at temperature of interest*
  - *Theory well studied*
- *Cons*
  - *Affected by solution resistance*
    - *Not well suited to solid wood*

Current Testing

- *Forest Products Laboratory*
- *Original DC Tests*
  - *Solutions of CCA, ACQ*
  - *Diluted to 0.25 pcf (etc.)*
  - *1018 steel, 304 stainless, zinc, and 430 stainless*
- *Results*
  - *Steels < 4μm/yr*
  - *Zinc (no results)*
- *Conclusions*
  - *Preservatives change corrosiveness upon entering wood*
- *New*
  - *"*
  - *R*
  - *V* *xposure te*
  - *P* *ll c* *ure re*



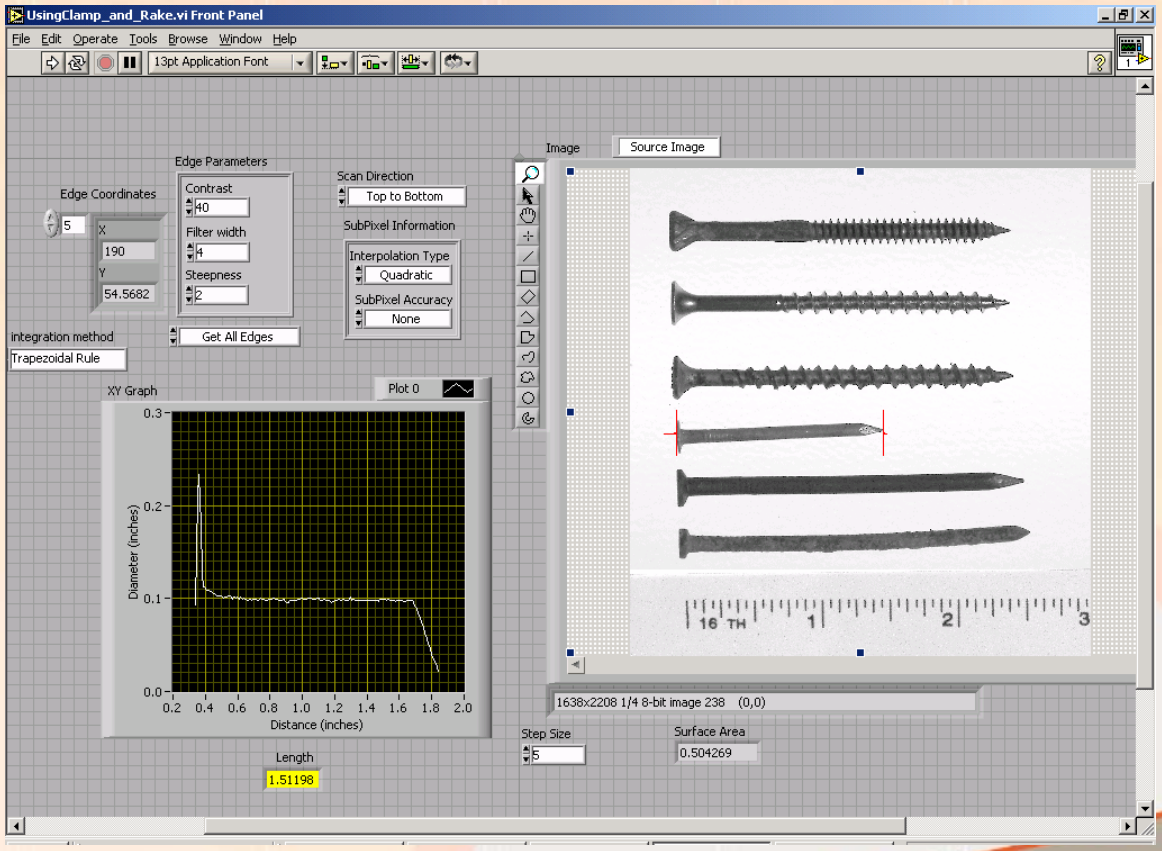
Current Testing

- *Forest Products Laboratory*
- 

- *Cons*
  - *Time consuming*
  - *Cleaning techniques cause additional uncertainties*
  - *Surface areas not well defined*

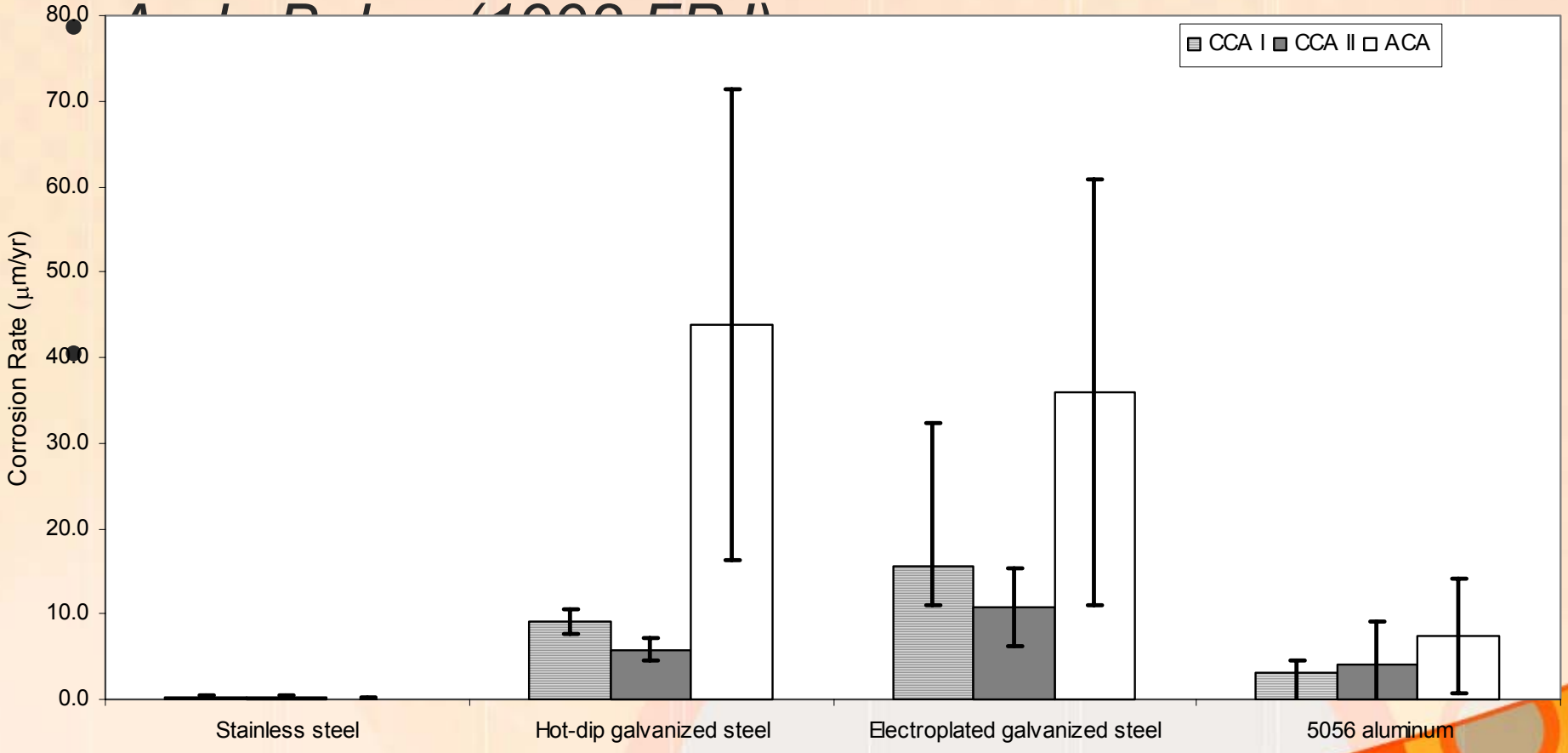
Current Testing

- *Forest Products Laboratory*
  - *Surface Area Algorithm*



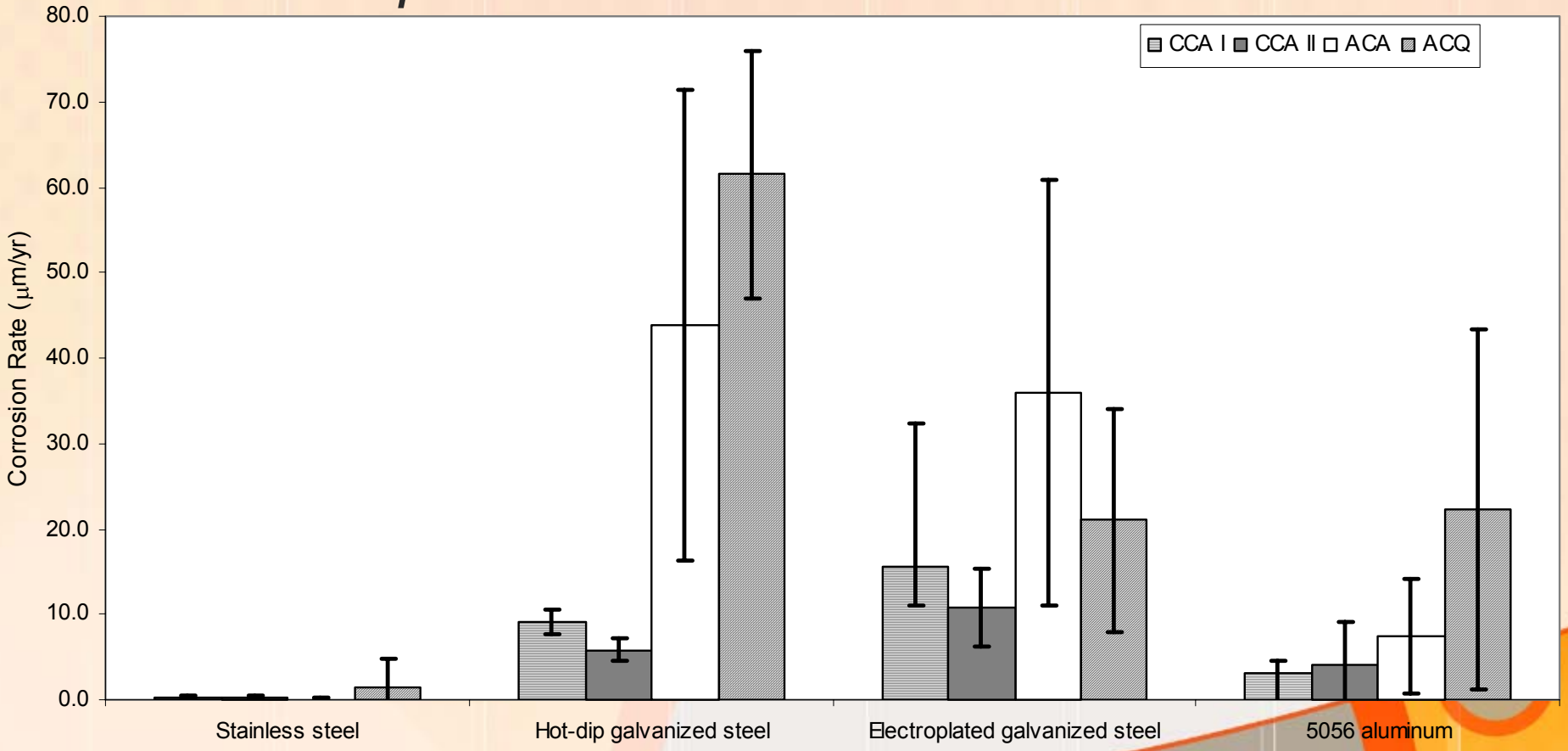
Current Testing

- *Forest Products Laboratory*



Current Testing

- *Forest Products Laboratory*
  - *Data Comparison*



Summary

- *Corrosion- A kinetic phenomenon*
- *Testing- Quantitative methods being developed*
- *Design*

Product	*Design Consideration*
Stainless Steel	*Combining with a different metal*
Metallic Coatings (anodic)	*Combining with a different metal* *Corrosion rate of coating*
Metallic Coatings (cathodic)	*Combining with a different metal* *Defects in coating* *Construction damage to coatings*
Organic/Ceramic Coatings	*Defects in coating* *Damage to coating during construction*
Barriers	*Defects in barrier* *Damage to barrier during construction*