



**CORROSION  
CONSIDERATIONS  
FOR  
HSS  
DESIGNS &  
INSPECTIONS**



ER 1110-2-8157

Paragraph 4.c.

“Corrosion is also a common form of distress, but is often more readily apparent before resulting in failure than fatigue cracking or incipient fracture.”

Note: There is a correlation between corrosion and fatigue cracking that may not be so readily apparent. Engineers need to be familiar with this relationship and account for it in design and inspection.



ER 1110-2-8157

Paragraph 6.a

“The Engineer shall ensure that the following types of design requirements are satisfied: strength, serviceability, fatigue and fracture, corrosion and wear.”

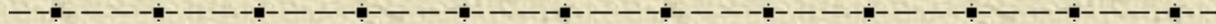


**FATIGUE:** The phenomenon leading to fracture under repeated or fluctuating stresses having a maximum value less than the tensile strength of the material.

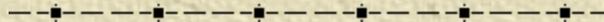


**CORROSION FATIGUE:** Fatigue-type cracking of metal caused by repeated or fluctuating stresses in a corrosive environment characterized by shorter life than would be encountered as a result of either the repeated or fluctuating stress alone or the corrosive environment alone.

# FATIGUE CRACKING

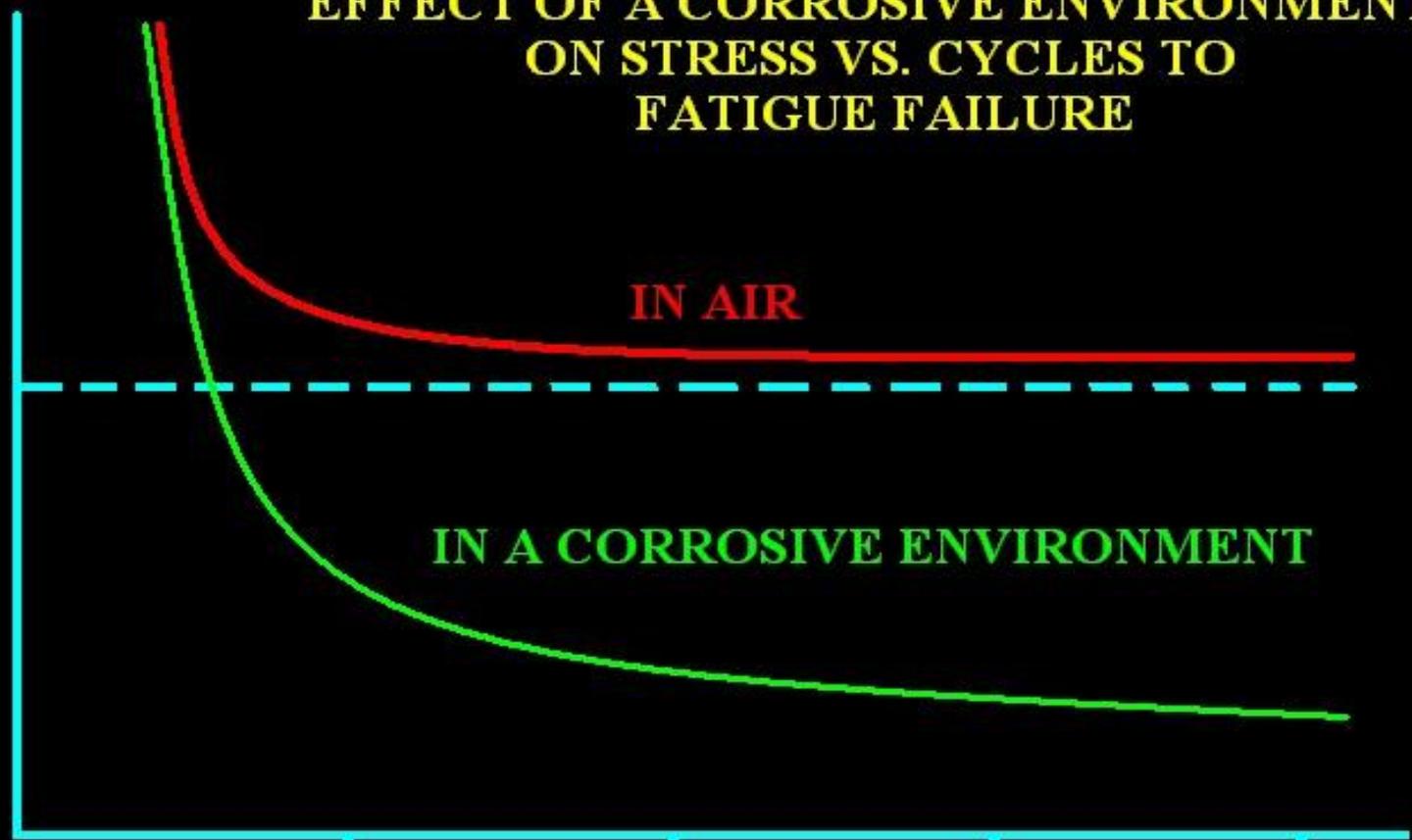


Corrosion, in combination with other factors such as fatigue, can lead to more rapid deterioration than would be expected from either corrosion or fatigue separately.



**EFFECT OF A CORROSIVE ENVIRONMENT  
ON STRESS VS. CYCLES TO  
FATIGUE FAILURE**

**S  
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S**



**IN AIR**

**IN A CORROSIVE ENVIRONMENT**

**$10^4$**

**$10^6$**

**$10^8$**

**$10^{10}$**

**CYCLES**

# FACTORS AFFECTING CORROSION

- ✦ Stresses in Gates
- ✦ Coal Mining Causes More Corrosive Waters
  - Reduces water resistivity
  - Typically decreases pH, i.e. increases acidity
  - Typically adds sulfides, salts, and other harmful chemicals to water
- ✦ Possible Damage to Coating System
- ✦ Ineffectiveness of Cathodic Protection Systems
- ✦ Dissimilar Metals Used in Quoin/Miter Areas

# Stress and Corrosion

- ✦ Molecular structure of steel is granular
- ✦ Granules are made up of variety of metals and impurities.
- ✦ Stresses occurring at granular boundaries increases corrosive interactions
- ✦ Some gates have unusual amount of stresses due to repairs (such as at Bankhead Lock)

# BANKHEAD LOCK

- ✦ The following slides are relating specifically to Bankhead Lock, but could just as well be applicable to many other locks

# COATING EFFECTIVENESS

- ✦ Coating is first line of corrosion control
- ✦ Coating probably not returned to initial level of quality after first repairs
- ✦ Each subsequent repair probably reduced effectiveness of coating more
- ✦ It is known that no coating work was done on repairs done in Dec. 1999.

# CATHODIC PROTECTION

- ✦ Cathodic protection is a proven electrical method of preventing corrosion
- ✦ Cathodic protection is used to protect metal areas where the coating is absent
- ✦ Cathodic protection rendered ineffective by initial gate repairs
- ✦ Cathodic protection not able to be adjusted properly so has never been effective

# QUOIN CORROSION

- ✦ Unpainted Stainless Steel and Carbon Steel in close proximity
- ✦ Water is relatively corrosive (coal mining activities in vicinity)
- ✦ SS and CS electrically bonded together (Classic corrosion cell)
- ✦ Cathodic protection ineffective

# ADDITIONAL INVESTIGATION NEEDED

- ✦ Additional data collected at site (potentials, current measurements, etc.)
- ✦ Sample of cracked steel tested
- ✦ Sample of water analyzed for pH and chemical and mineral content

# CORROSION MITIGATION

- ✦ Reduce stresses as much as possible
- ✦ Apply the standard coating system used for Corps hydraulic structures on ALL surfaces
- ✦ Provide impressed current cathodic protection systems
- ✦ Test and maintain cathodic protection systems

# MAJOR NOTE

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It must be clearly noted that coating and cathodic protection will stop any further corrosion,

**BUT**

**THEY WILL NOT REPAIR  
EXISTING CORROSION**

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# RECOMMENDATIONS

- ✦ SANDBLAST AND COAT ALL METAL SURFACES AS SOON AS POSSIBLE
- ✦ ATTEMPT TO GET EXISTING CP SYSTEMS BACK IN FULL OPERATION
- ✦ ADD SUPPLEMENTAL CP FOR QUOIN AREA PROTECTION
- ✦ REPLACE, NOT REPAIR, GATES ASAP
- ✦ COAT GATES—INSTALL AND MAINTAIN NEW CP SYSTEMS