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Degradation Mechanisms in Waste Tanks

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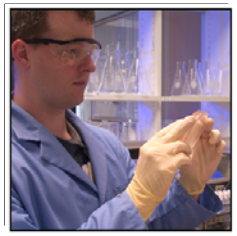
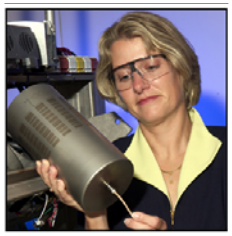
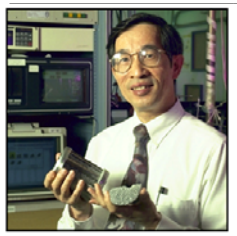




Summary

- General corrosion of the waste tanks is not a significant degradation mechanism
- Older waste tanks at Hanford and SRS have leaked in the past due to stress corrosion cracking (SCC)
- Recently constructed waste tanks are not as susceptible to SCC, however, they may be susceptible to pitting
- Service-induced pitting of the waste tanks and associated carbon steel components has occurred in cases where the waste has not been in compliance with the requirements of the chemistry control program

Summary (cont.)

- Pre-service pitting has also been observed
  - Evidence from in-service inspections suggest that there has been no preferential growth of these pits during exposure to waste

Corrosion Degradation Mechanisms

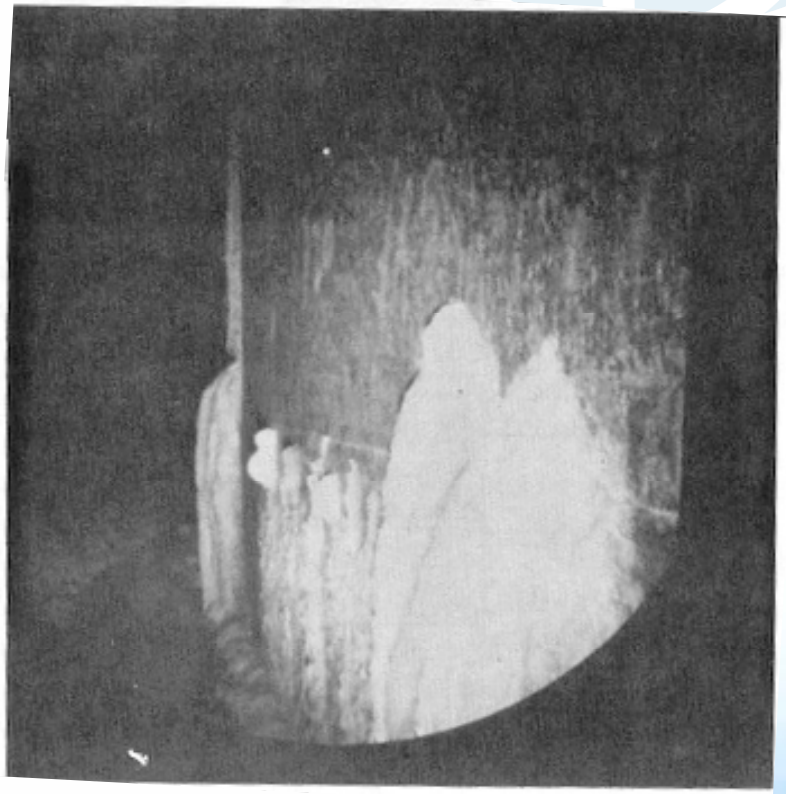
- General Corrosion
- Stress Corrosion Cracking
- Pitting
  - Service induced
  - Laboratory
  - Pre-service

General Corrosion

- Caustic (pH >> 13), mild temperature (< 100 °C) waste environment
- Maintains a stable, passive oxide film on the carbon steel surface
- Low general corrosion rates are expected (i.e., < 0.5 mils/yr)
  - Laboratory coupon tests
  - In-tank coupons
  - Ultrasonic measurements of the tank walls

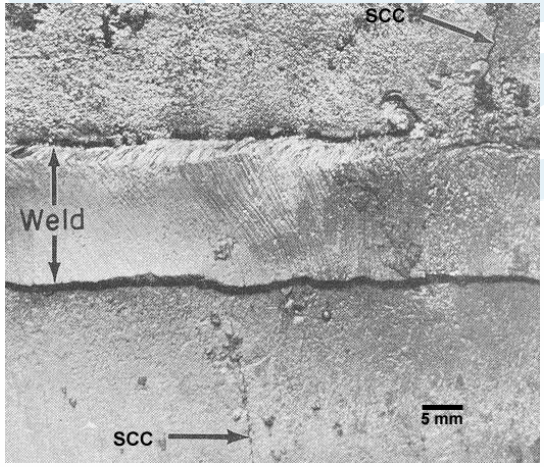
Stress Corrosion Cracking: Nitrate Induced

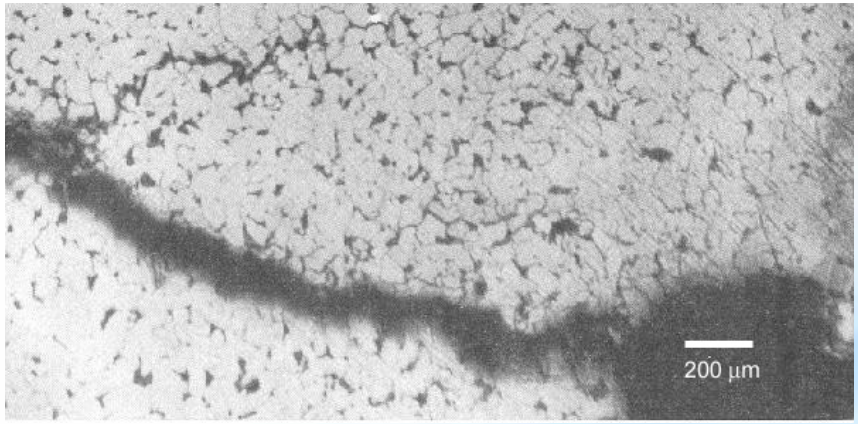
- Fresh waste from canyon facilities
  - Nitrate: 2 – 5 M
  - pH min 8 in tank supernate; maximum 6 wt.% hydroxide in stream to tank
  - Temperatures: Supernate 55 – 75 °C; Sludge ~ 100 °C
- Type I and II waste tanks
  - Material: ASTM A285 Grade B
- Non-stress relieved
- Leak sites confined to seam welds, weld attachments, and weld repairs



Stress Corrosion Cracking: Nitrate Induced

- 9 of 16 waste tanks exhibited cracks early in service (< 2 years)
- Cracks grew perpendicular to welds
- Cracks are short range, typically less than 6 inches
- Intergranular cracks
- Extensive laboratory study to demonstrate benefits of post-weld heat treatment to relieve weld residual stresses
- Corrosion testing to determine inhibitor requirements that prevent initiation of new cracks and further growth of existing cracks



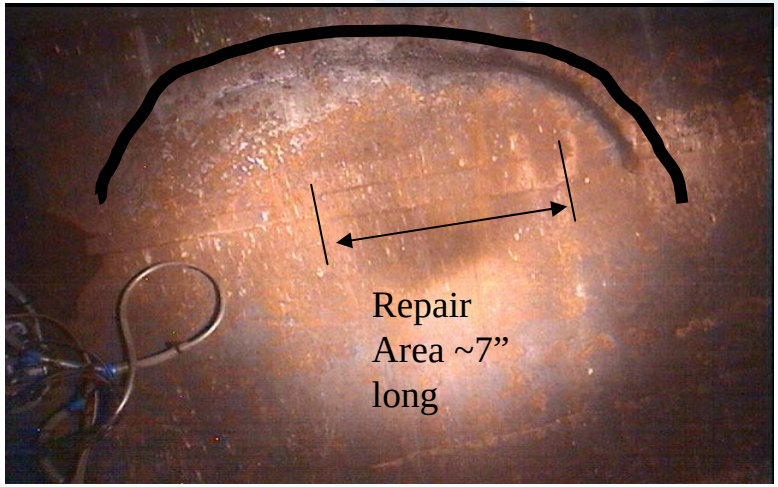


Stress Corrosion Cracking: Caustic Induced

- Type IV single shell tank in F-Area
  - A285 Carbon steel
  - No stress relief
  - Utilized as evaporator receipt tank
- Waste Chemistry
  - Nitrate: 1.9 - 2.6 M
  - Nitrite: 0.74 - 1.6 M
  - Hydroxide: 7- 8 M
- Supernate temp: 50 - 100 °C
- Mechanism for cracking: caustic SCC

Stress Corrosion Cracking: Vapor Space

- Type I and II Tanks at SRS
  - 4 of 16 waste tanks have exhibited these types of cracks since 1994
  - Exposed to tank vapor space for ~ 10 years
  - Through-wall cracks appeared several years after exposure to liquid waste
  - Performed UT measurements on cracks in one Type II tank in 2002 and 2007
  - Cracks associated with welds, weld attachments, and weld repairs- cracks typically short range
  - Mechanism of initiation and growth not reproduced in the laboratory



Pitting Corrosion: Service-Induced

- Waste Tank Cooling Coils in Type I Waste Tank at SRS
  - Materials: Carbon steel pipe
  - Sludge removal operations in the 1960's
  - Environment: Caustic nitrate waste diluted by raw well water
  - Failures of coils occurred within 2 weeks
  - 33 cooling coils failed in 4 tanks over a 7 month period
  - Associated with dilution of waste
    - Nitrite and hydroxide inhibitor depletion
    - Aggressive sulfate species leached from the sludge
  - Addition of evaporator bottoms stopped further coil failures
  - Inhibited water (pH >12, nitrite > 0.01 M) utilized for sludge removal

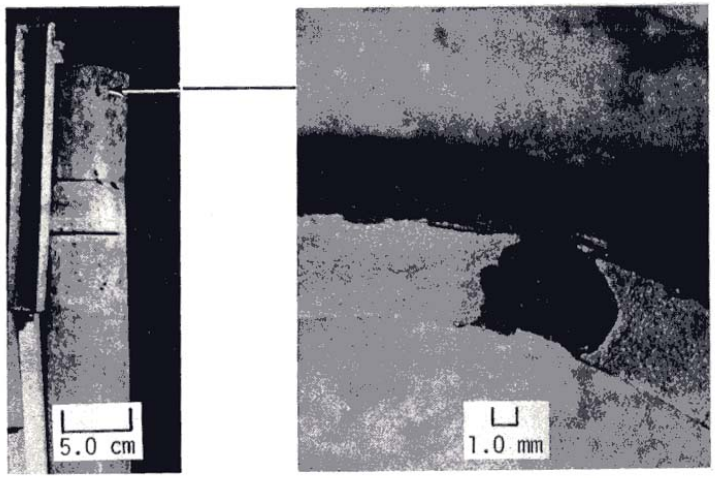
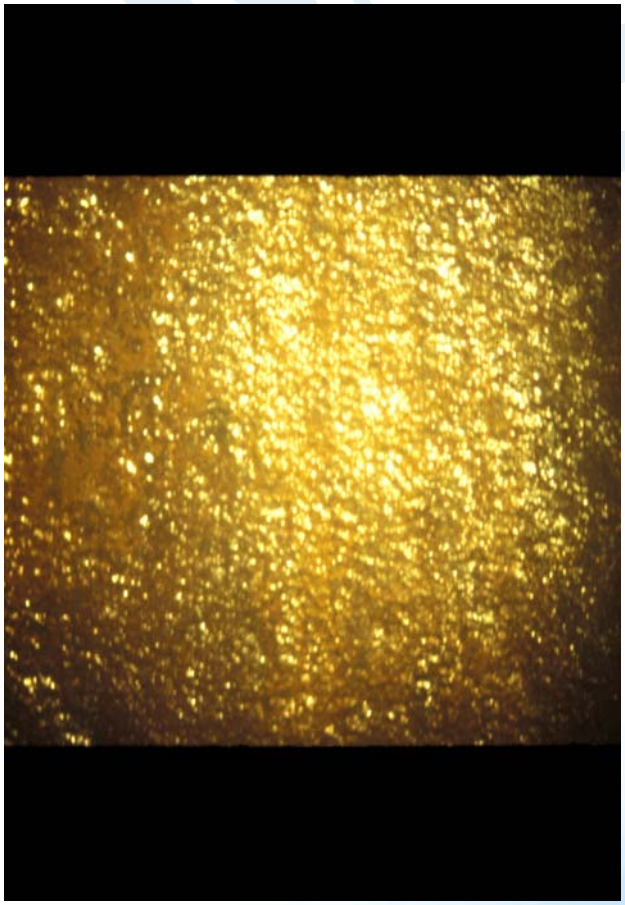


FIGURE 3. Perforated Upper Horizontal Cooling Coil, Tank 2F

Pitting Corrosion: Service-Induced

- H-Area Type IV Tank at SRS
  - Tank level less than half full for 20 yrs
  - Stored dilute low heat waste from the Receiving Basin for Off-Site Fuel (RBOF) facility and overhead effluent from the evaporator
  - Waste forms: Supernate/Sludge
  - Corrosion chemistry (1965-78)
    - Nitrate: 0.006-0.2 M
    - Nitrite: 0.0014 M
    - Hydroxide: 0.001-0.07 M
  - Supernate temp (1965-1980): Avg: ~50 °C; Range: 30-80 °C
  - Likely in and out of corrosion control requirements
  - High density of broad, shallow pitting observed on the vapor space area of the tank observed in ~ 1980
  - Surface was cleaned; visual inspections indicate no significant growth since that time. Chemistry and temperature controls instituted since that time.



Pitting Corrosion: Laboratory and Service-Induced

- Pitting at liquid/air interface
  - Observed in the laboratory environment: High pH (>10) dilute supernate
  - Stagnant interface
  - Depletion of hydroxide inhibitor due to absorption and reaction with carbon dioxide; Insufficient nitrite inhibitor
  - Pitting at interface extending slightly into the vapor space region
  - Observed in Tank AY-101 at Hanford and possibly in Tank 49 at SRS

Localized Pitting

Pitting Corrosion: Pre-Service

- Pitting observed in the interior of the primary liner in 14 of the Type IIIA waste tanks prior to being placed in service
- Mechanism related to flame retardant (i.e., phosphate) present in plywood boards that covered the tank bottom during construction
- Maximum pit depth: 170 mils
- Several tanks had 1000 to 6000 pit depths greater than 31 mils (1/32”)
- Tank bottom was grit blasted prior to placing in-service

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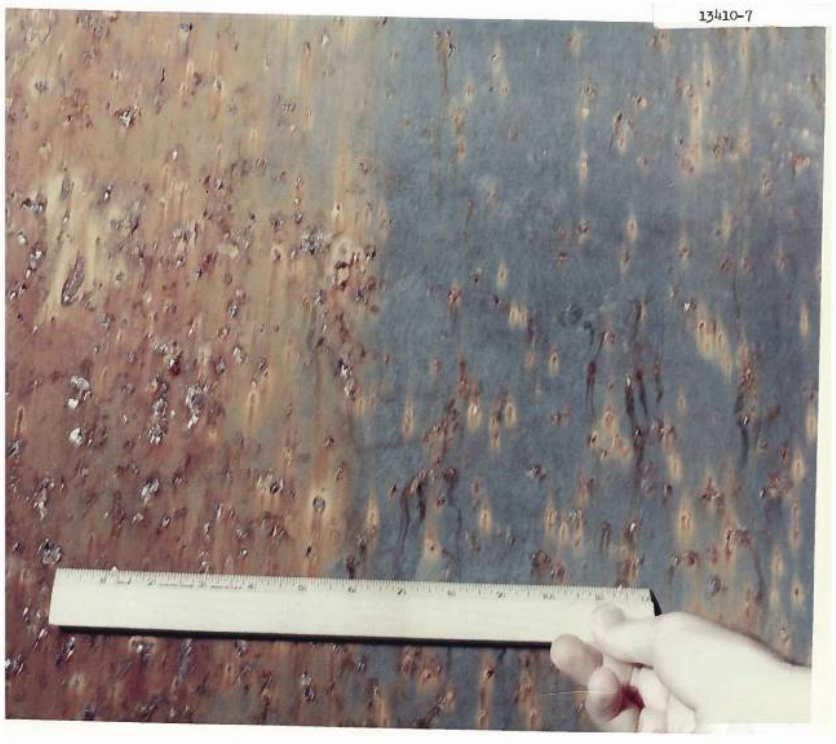
FIGURE 2. TANK 40 FOLLOWING 100% INSPECTION OF BOTTOM. NUMEROUS PITS ARE SEEN DISTRIBUTED AROUND THE BOTTOM, IDENTIFIED BY CHALK CIRCLES.

Pitting Corrosion: Pre-Service

- Pits observed in the annulus space of Type IIIA waste tanks during construction
- Mound-like tubercles formed over the welds near the lower knuckle weld of the secondary liner
- Suspected mechanism was microbiologically influenced corrosion
- Max. pit depth observed: 85 mils
- Recent UT measurements of pits suggest that there has been no further growth

Pitting Corrosion: Pre-Service

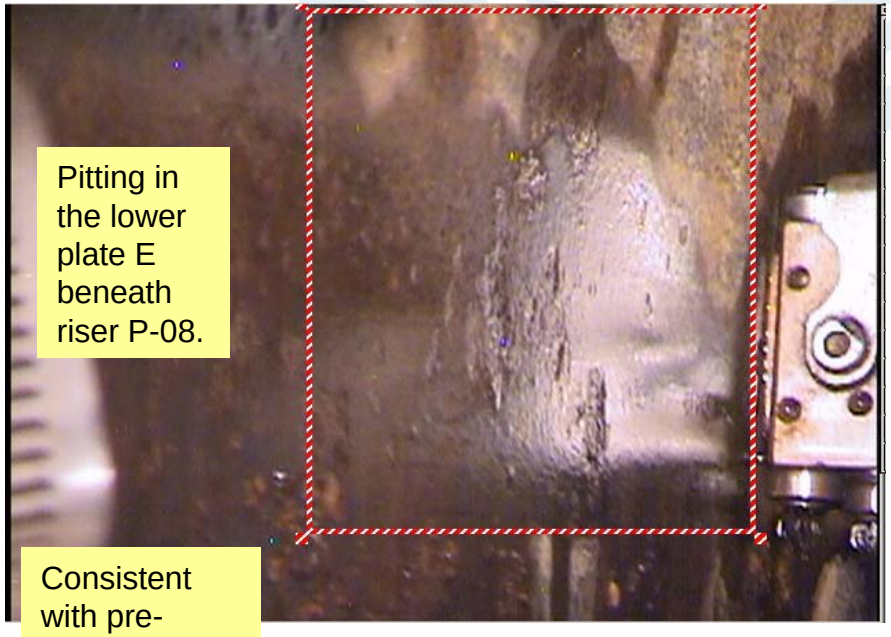
- Isolated, random pits form on the steel during construction
- Pitting is due to oxygen concentration cells that formed during exposure to condensation or standing water
- Pits are broad and shallow
- Distribution of pits depends upon the exposure history of the plate



Tank 29 Interior

Pitting Corrosion: Pre-service

- Tank 21
  - Type IV tank in H-Area inspected in 1960 before being placed in-service
  - More than 1000 pits observed on the tank bottom and sidewalls
  - Average pit depth: 25 mils
    Maximum pit depth: 50 mils
  - Pits due to oxygen concentration cell corrosion at defects in the mill scale



Tank 29 Exterior of Primary

Observations

- The purpose of the in-service inspection program is to verify that the corrosion control program and the post-weld stress-relief procedure mitigate general, pitting and stress corrosion cracking in the newer waste tanks.

- Visual and ultrasonic inspections performed to date indicate that these mechanisms are being controlled as there is no generic evidence of degradation.

Questions

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