Accelerated Crevice Corrosion of Duplex Stainless Steels in Wet Limestone FGD Environments

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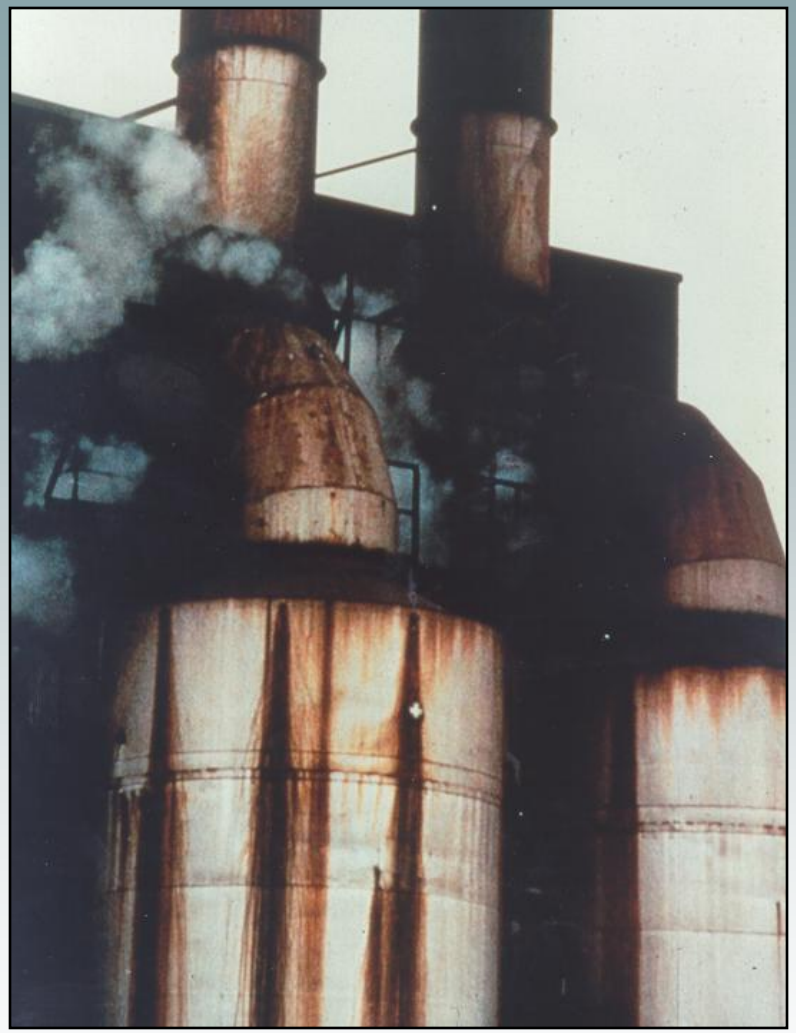
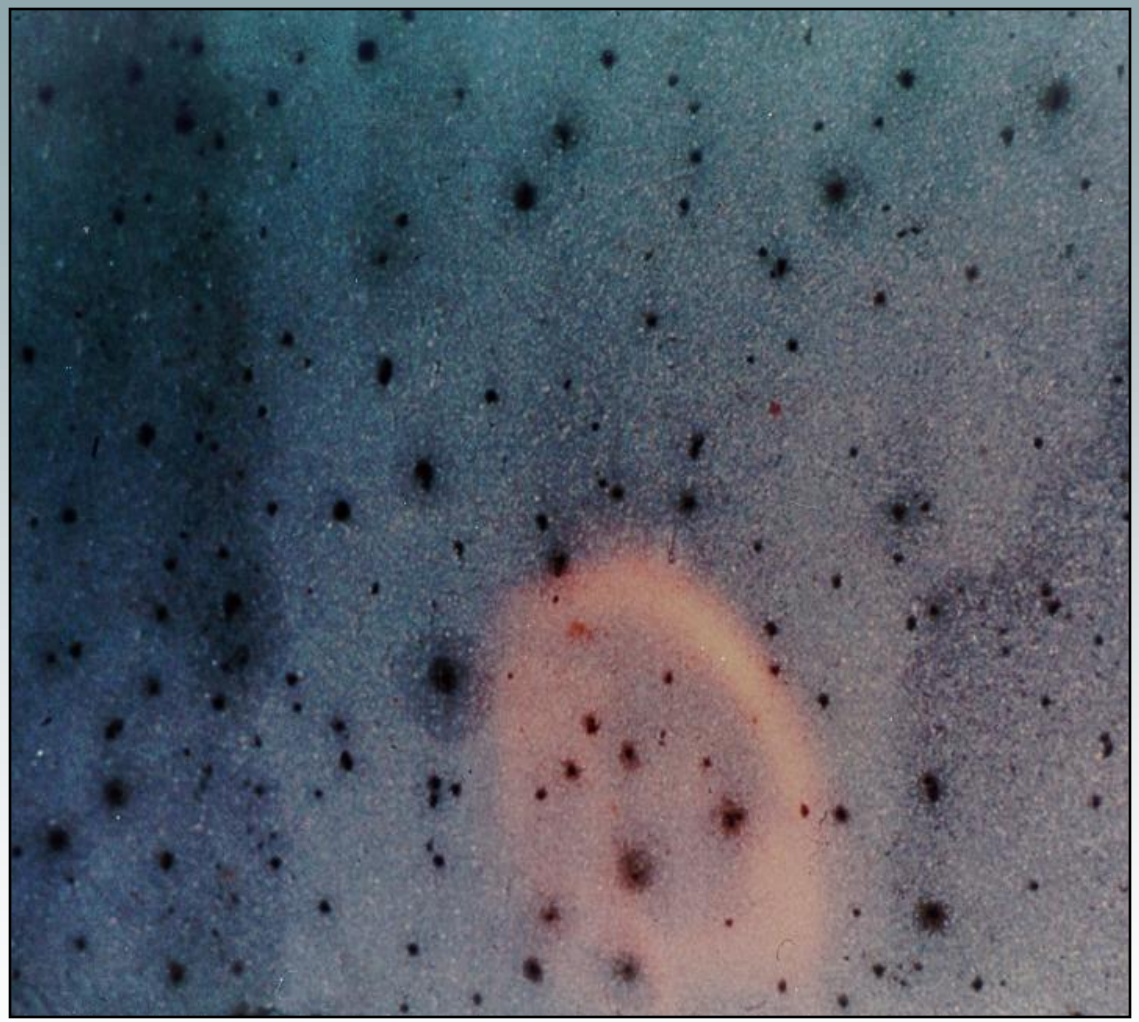
Outline

- General comments on alloy crevice corrosion and conditions in FGD systems
- Recent observations of crevice corrosion in absorber vessels
- Results from on-site panel exposures
- Laboratory simulations
- Weld metal behavior



Premature Failure of Absorber Vessels due to Corrosion

Pitting Corrosion



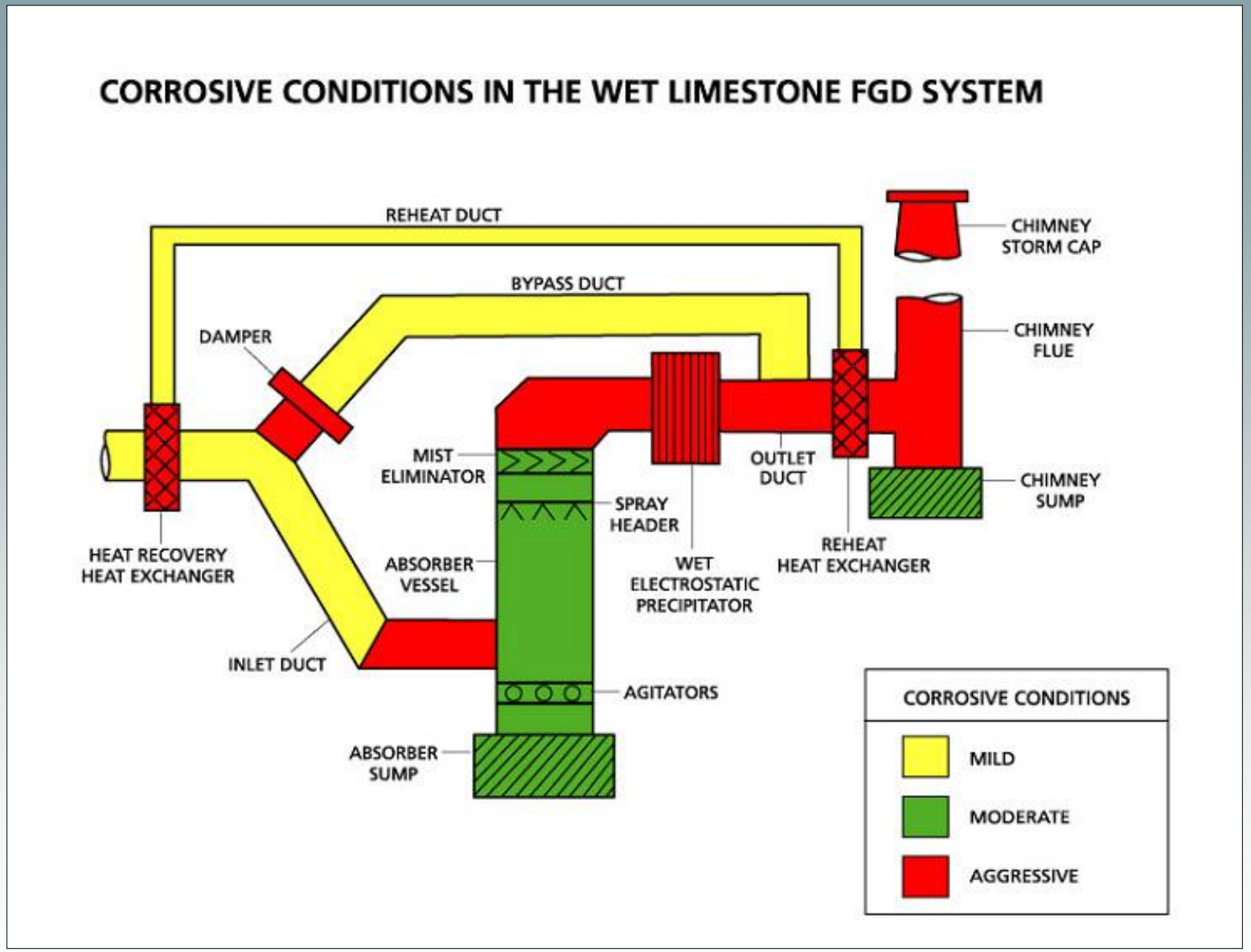
Isolated pits widespread across surface

Crevice Corrosion

Corrosion under ash deposit

Conditions in FGD Systems

- Sulfuric / sulfurous acids - pH 5.5 to <1
- Temperature - 125°F to boiling
- Halides - chlorides & fluorides
- Wet / dry (boiling) interfaces
- Crevice formers - flyash, lime, gypsum
- Salts - oxidizing and reducing
- Traces of hydrochloric & nitric acids
- Solution may be much more corrosive under deposits



Generic diagram for illustration, individual plants vary in detail

Recent Absorber Vessel Construction in the USA

- Shortage of Ni and Mo caused spike in alloy prices
- Ni-Cr-Mo alloys became too expensive
- Duplex stainless steels became an affordable alloy option
- In USA 85 FGD absorber vessels fabricated from 2205 duplex steel plate
- Severe corrosion and in some cases perforation experienced
- Following is an investigation Special Metals made at two mid-western plants

Field Observations

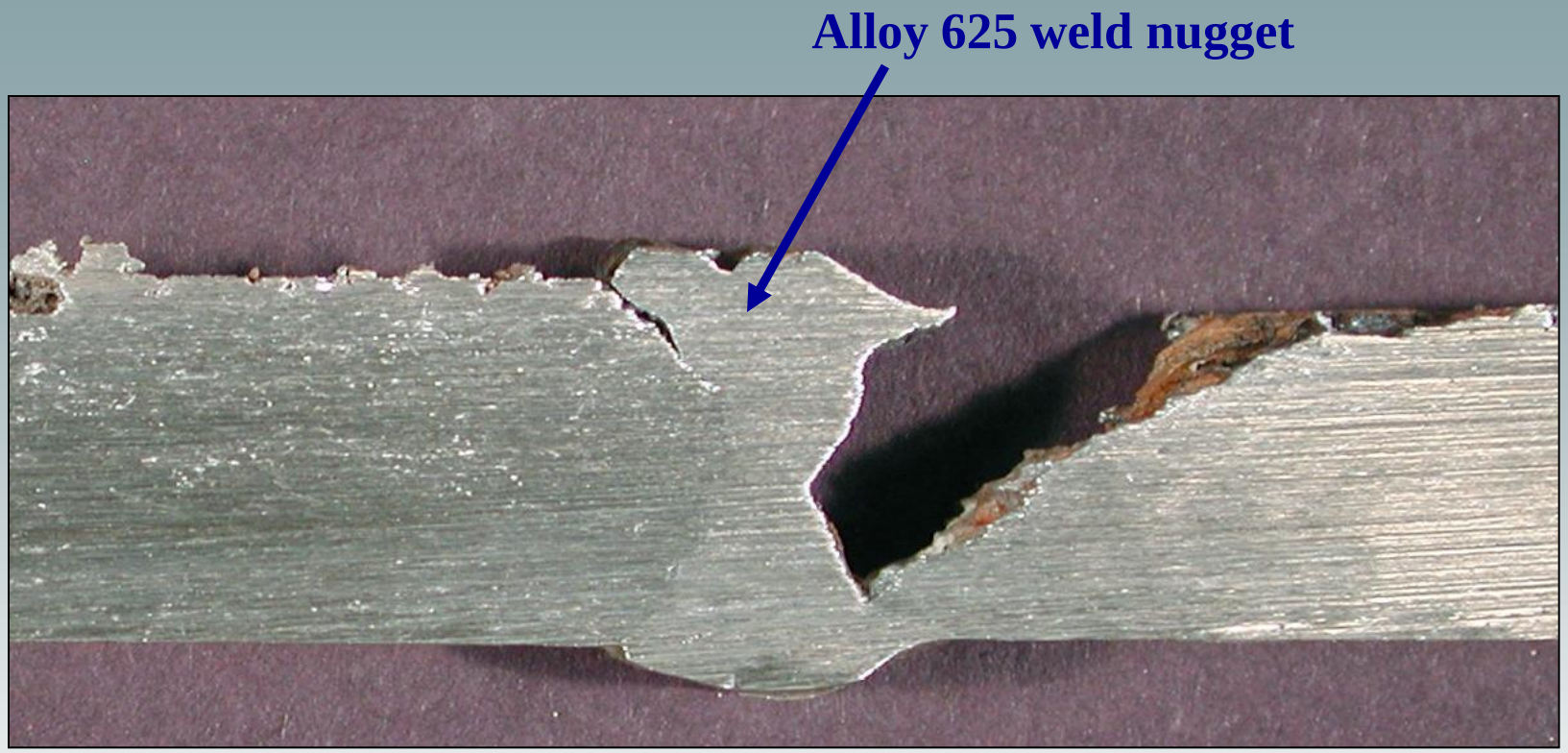
- Two wet limestone FGD absorber vessels constructed of duplex steel plate were severely corroded after 7 months of operation.
- Severe attack was found adjacent to welds as well as remote from them. Crevice corrosion was believed to be the mode of attack.
- One scrubber was shut down for repair. The vessel was inspected and test samples were installed.

Crevice corrosion under the seal of 2205 duplex steel (S31803) entry cover of a wet limestone FGD absorber vessel after less than one year of operation

HAZ Attack

Widespread crevice corrosion under deposits

Crevice corrosion of duplex steel absorber wall adjacent to alloy 625 weld



Corroded duplex stainless steel absorber wall joined with NiCrMo 625 welding product. The weld nugget was not attacked but the base metal was nearly penetrated at the HAZ.

Corrosion of duplex steel absorber vessel. The nickel alloy 625 weld was not attacked.

Attack of 2205 duplex steel absorber. Bottom plate is original construction. Upper plate is repair. Weld is alloy 625.

Crevice corrosion of a section of the duplex steel absorber wall that appears to be weld-related, perhaps due to mineral deposit build-up by “proud” welds. The alloy 625 weld metal was not attacked.

Crevice corrosion of duplex steel absorber vessel wall located well away from weldment

Field Testing

One foot square test specimens of were welded to the absorber wall

Materials tested were:

- **Nickel Base alloys: N10276, N06686**
- **Super-austenitic stainless steels: N08926, S31277**
- **Duplex steel (as control sample) - S31803**

Prior to installation, a weld was deposited on each sample to evaluate the effect of welding

Duplex Steel (S31803) **Super-Austenitic Steel (S31277)**

Test panels exposed 7 months on the absorber vessel wall. Mineral buildup is believed to have induced crevice condition. Note adherent black film.

Duplex steel test panel after cleaning. Attack is evident, especially near the weld.

Super-austenitic steel (S31277) test panel after cleaning. No attack was found.

NiCrMo alloy N10276

NiCrMo alloy N06686

Ni-base alloy test panels after cleaning. No attack was found.

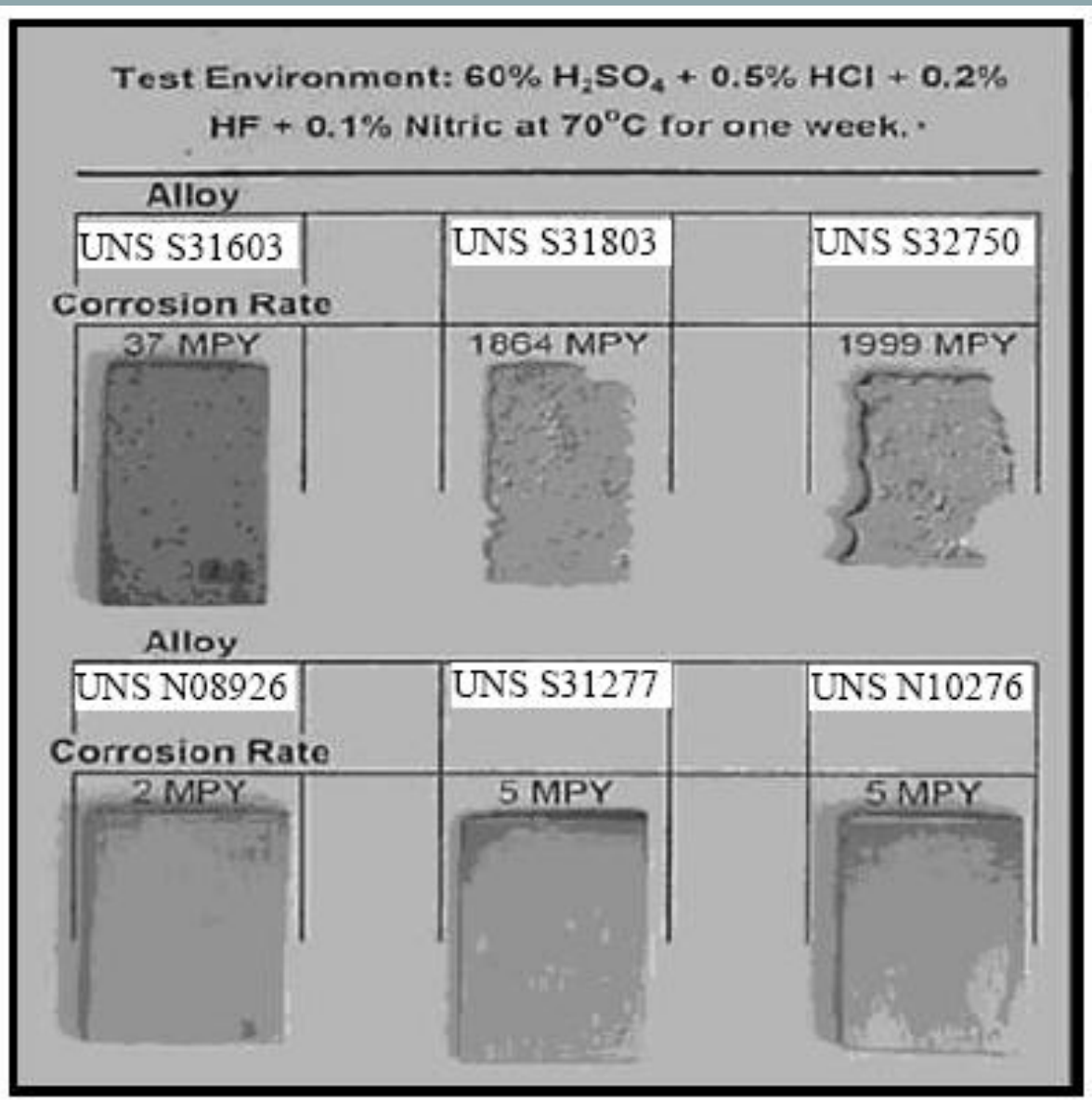
Laboratory Testing Nickel Alloys & Stainless Steels in a Simulated FGD Solution

Objective was to reproduce conditions under a deposit

Alloy	2205	2507	316L	25-6MO	27-7MO	C-276
Rate (mpy)	1864	1999	37	2	5	5

- 60% H_2SO_4 + 0.5% HCl + 0.2% HF + 0.1% HNO_3
- 70 C (158 F)

Appearance of Coupons After Test



Welding Product Selection

Use overmatching composition welding products to offset iron dilution & elemental segregation in NiCrMo & FeNiCrMo corrosion resistant alloys and stainless steels

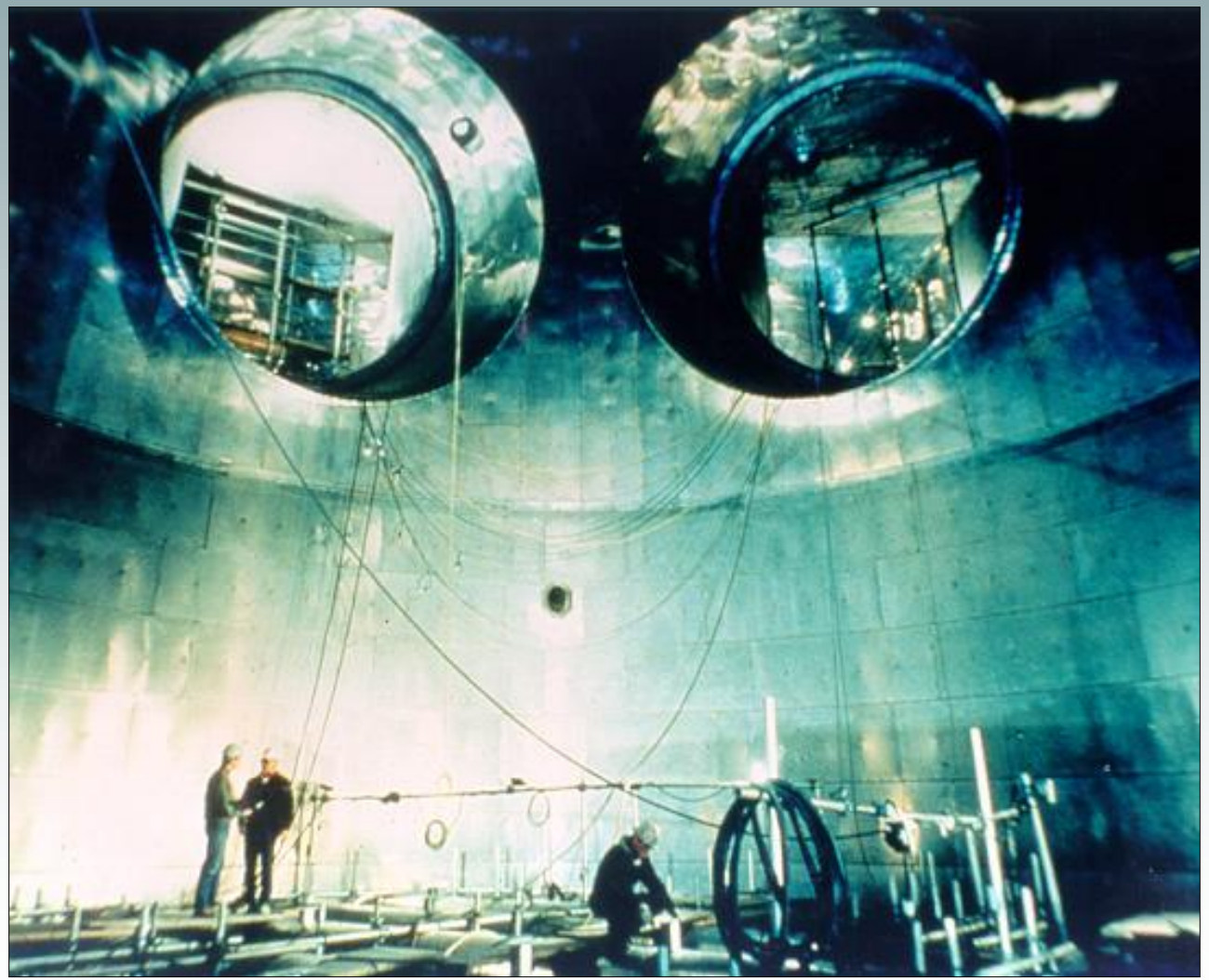
Preferential attack of NiCrMo C-276 filler metal welds in FGD outlet duct

Alloy C-276 base plate

Overmatched NiCrMo 686 filler metal welds after six months FGD service

Alloy C-276 Base plate

Nickel-Alloy, Wallpaper-Lined FGD Absorber Vessel



Nickel-Alloy Lined FGD Duct

Super-Austenitic Steel Chimney Flue at APS-Cholla Station

27-7MO (S31277) plate joined with 686 (N06686) welding product

In Summary

- Corrosive conditions under tightly adhering deposits may lead to unpredicted crevice corrosion attack
- Super-austenitic stainless steels offer an economical alternative to high nickel alloys in some sections of the wet FGD scrubber
- Wallpaper cladding offers a proven repair strategy
- Overmatching composition welding products are required to produce fully resistant welds.

Clean Air & Clear Skies