

Ni Alloy Corrosion



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HF Acid Corrosion (37) Type 7

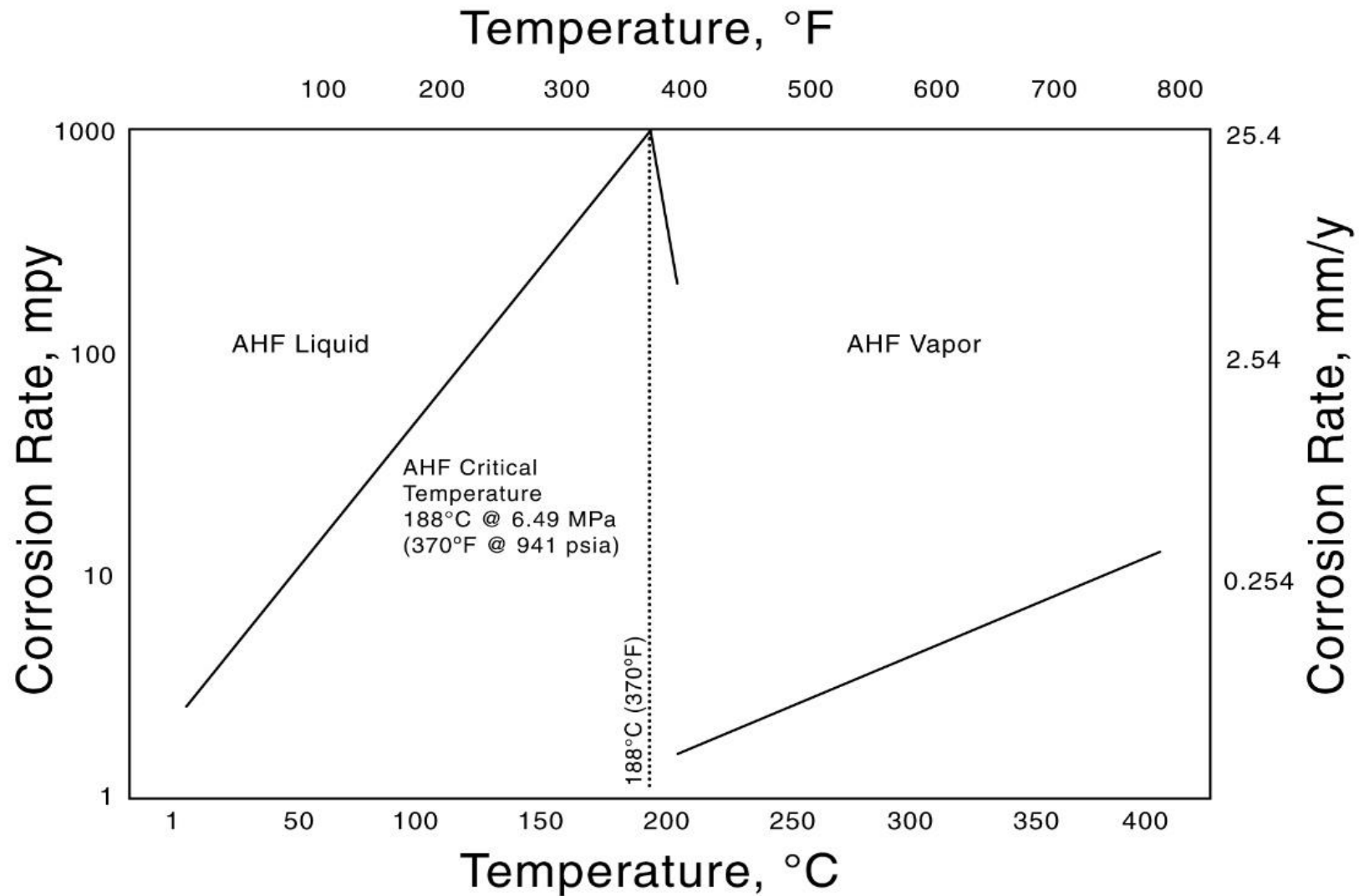
- 37-7 Hot RHF Corrosion

- Regeneration of Rich HF will create various corrosive conditions due to the higher temperatures and concentrating the corrosive water rich HF.
- 37-7A Regenerator/Rerun
 - Above 160°F carbon steel will have high corrosion rates if the incoming streams are still liquid and containing RHF, and hence when the Rerun preheat system crosses this temperature while still containing free liquid RHF, Alloy 400 is required..
 - Inspections and IOW temperatures to limit corrosion exposure.
- 37-7B CBM and ASO/Polymer (Rerun bottoms)
 - The leftover combination of material (primarily ASO and some CBM) in the Regenerator/Rerun at high temperatures (> 300°F) is quite corrosive even to Alloy 400.
- 37-7C Hot HF Vapor
 - Hot HF (with residual water only) is sent from some regeneration units. CS can tolerate this hot HF as long as it does not condense. Localized corrosion issues where mixed into settler (Phillips) or fractionation (UOP) system.
 - Inspections and IOW temperatures to limit corrosion exposure.

Regenerator Corrosion Exposures

- Hot regeneration corrosion
- Primarily Alloy 400 construction
- Regeneration of Rich HF will create various corrosive conditions due to the higher temperatures and concentrating the corrosive water rich HF.
- Regenerator/Rerun
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Vapor HF Corrosion



HF Acid Corrosion (37) Type 9

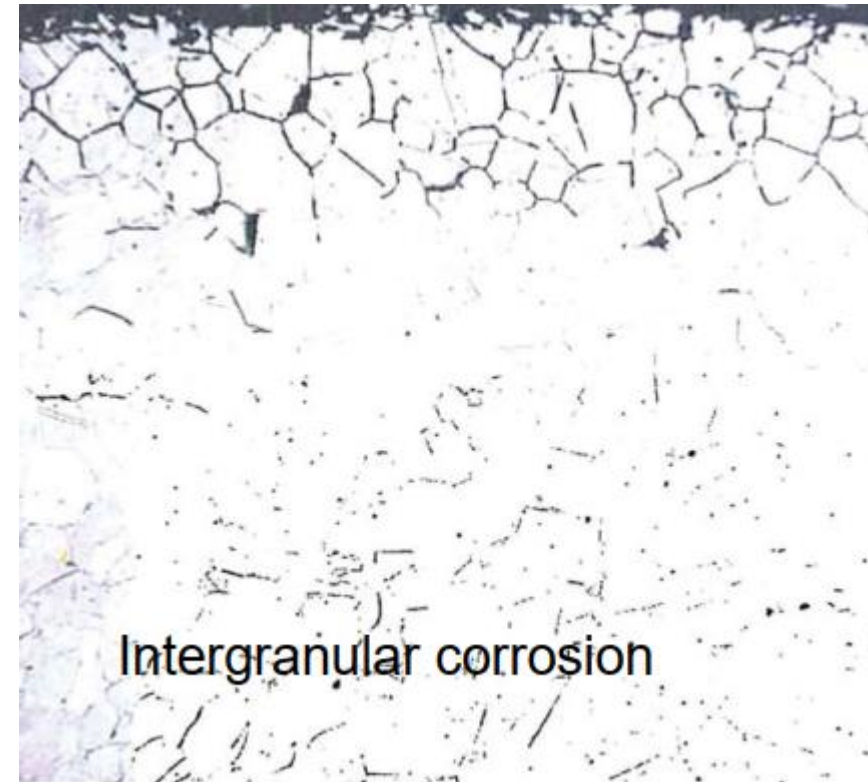
- 37-9 Alloy 400/CuNi Corrosion
 - Alloy 400 and 70/30 CuNi can be used in Type 3A services to be resistant to the azeotrope acid.
 - Alloy 400 used in Type 6 which is fully resistant to dilute HF services
 - Alloy 400 used in Type 7 services for resistance to hot HF corrosion.
 - Oxygen/oxidizers though can cause intergranular and denickelification corrosion (and more importantly SCC) problems.
 - Oxygen ingress or high oxygen in purge gases should be avoided.
 - Thorough neutralization of exchanger bundles when pulled.
 - **Warning: Avoid Alloy 400 to CS galvanic couples in any HF service as this leads to accelerated galvanic corrosion of the CS.**

Alloy 400 SCC (40a) and LME (52)

- Alloy 400 Stress Corrosion Cracking
 - Oxygen/oxidizer converting cuprous fluoride to cupric fluoride will trigger stress corrosion cracking of Alloy 400. Sensitive to residual stresses.
 - High Temperature PWHT (1300°F) for welded construction and stress relief (1150°F) of tube u-bends.
 - Minimize use of K-500 version of Monel (high strength) version very susceptible.
 - Used by some valve/pump manufacturers but limit to maximum hardness of HRC 30.
 - CuNi can also SCC under high stresses. Stress Relief U-bends at 750°F
- Alloy 400 Liquid Metal Embrittlement
 - Mercury (Hg) may be found in some sources of feed (beware of purchased) to the HFA.
 - Hg condenses (particularly in recycle iC4) in Alloy 400 components (instruments) may trigger LME.
 - A few plants have installed Hg traps in the feeds that contain Hg.

Nickel and Copper Alloys

- Alloy 400
 - Resistant to HF acid corrosion up to ~300-330°F
 - IOW limits are often at 300°F
 - Oxidizing conditions increase corrosion
 - HF and oxygen can lead to increased corrosion and cracking potential
 - Nitrogen
 - Venting
 - Startup/shutdown
 - Neutralization
 - Denickelification
 - Mercury contamination
 - Often from crude
 - Purchased feed



Alloy 400

- SCC potential
- Oxygen significantly increase potential of SCC
- Cold working (tube bending) and residual stress from welding are generally enough stress to initiate SCC in the presence of oxygen
- Stress relief at 1300°F may be required vs. 1175°F

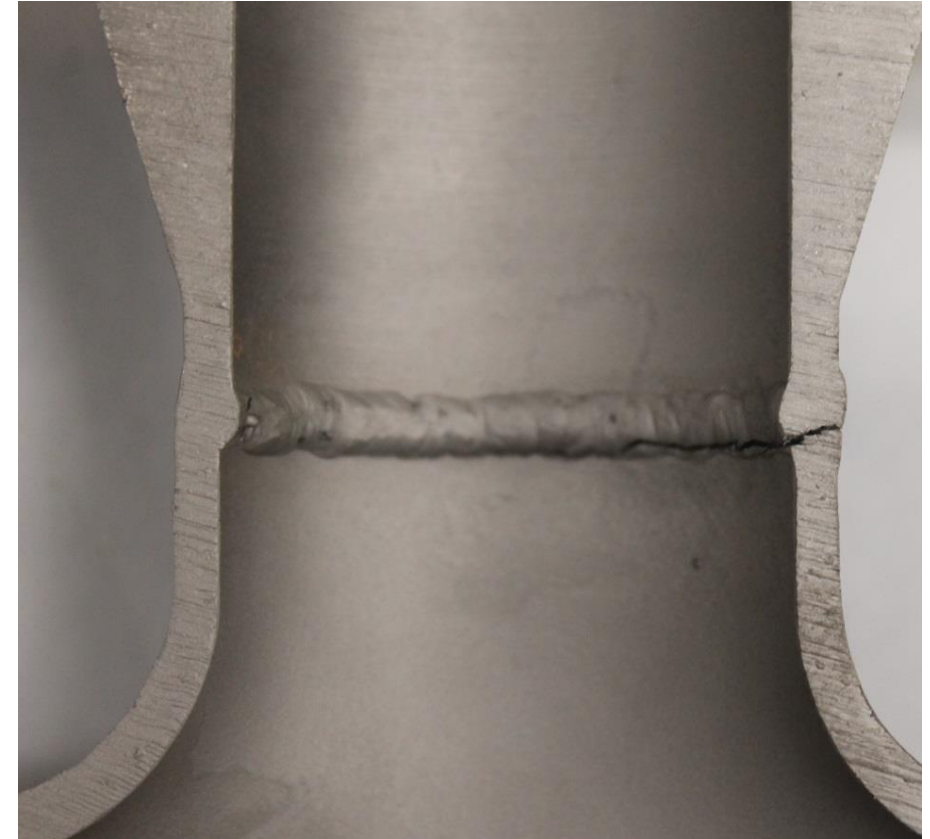


Alloy 400



Copper and Nickel Alloys

- A program shall be in place to minimize the potential for SCC
 - Procedures to neutralize the internal surfaces of equipment and piping that has been previously exposed to HF (e.g. placed in HF service) prior to performing any maintenance activities that may expose those surfaces to oxygen.
 - Procedures to purge equipment to remove oxygen before placing equipment and piping in service and after any maintenance activities prior to exposing to HF (e.g. placing in HF service).
 - Procedures to maintain a nitrogen purge on equipment that may not be neutralized and planned to be opened—to address oxygen ingress while idling



Copper and Nickel Alloys

- C276 often resistant to different forms of HF corrosion
- Similar SCC concerns of Alloy 400
- Specialized PWHT required
 - Solution Anneal Required
- All Ni alloys subject to LME from Mercury
- New should statement highlight need to evaluate SCC potential
- Per API 751 (6.2.3.3) suggestion is that C-276 has improved oxygen SCC resistance (per Dilute HF, not immune*).
- Example experience.
 - Depropanizer overhead accumulator PSV Alloy 400 bellows failed (cracked) multiple times. Replaced with C-276 bellows successful so far after 6 years in service. (Both cold worked.)
 - *Limited empirical experience based only.
 - Suggestion that C-22 without W may be more resistant. C alloys may have higher threshold tolerance.



Pure copper rarely used

Some success in tubing applications

API RP751 ANNEX G, G.2.7

- Alloys C-276 (UNS N10276), C-2000 (UNS N06200), and C-22 (UNS N06022) have been used for instrumentation, tubing, piping, valves, pump cases, and in locations where condensation of HF is an issue. These alloys are more resistant to corrosion than Alloy 400 when the system contains oxygen but have been reported to be less resistant to corrosion than Alloy 400 when oxygen is not present. They also show higher resistance to HF SCC than Alloy 400 in some circumstances but are can still susceptible to SCC.

"C" Alloy Summary

- Single phase FCC with uniform distribution of chemistry (MTI Atlas of Micro for Alloy C276)
- 1200F + exposure can create Mo grain boundary denuded zones (HAZ).
- Welded dendritic cores can have less Mo, interdendritic zone phases = less pitting resistance

Alloy Comp (wt%)	Ni	Cr	Mo	Fe	W	Other
UNS N10276	57	25	16	6	4	
UNS N06200	59	23	16	3	0	1.6 Cu
UNS N06022	56	22	13	4	3	

Regenerator/Rerun

- Has been most common attempted “upgrade” application due to Alloy 400 corrosion issues.
- All three “C” alloys been used.
- Found no better than Alloy 400
- Tower Internals, Linings, Coupon Testing
- ASO piping/LCV and neutralization hardware
- Corrosion issues are very dependent on operation. Alloy 400 can be quite successful within a defined IOW envelope.
- **Tower Corrosion experience.**
 - C-276 used to replace corroded Alloy 400 in 2017 but still corroding at 20 mpy. Replaced again in 2019 with C-276 thicker trays.

Rich HF

- C276 now being used/specified for RHF sampling/analyzer valves/tubing/instrumentation.
 - Driven by suggestion (later slide) that more resistant to SCC associated with potential oxygen exposure. (Given these services will potentially see air exposure.)
 - No public reported issues to date.
 - There are some significant cold worked components in these systems (compression tubing, bellows seals).
 - Would suggest that need to monitor for potential and still minimize HF plus air exposure.

Fractionation Zone

- C276 now being used/specified for Magnetic Level Gauges (towers).
 - Driven by magnetic (Currie Temperature) issues with Alloy 400.
 - No public reported issues reported to date.

Dilute HF Zone

- C276 attempted for defluorination system deadleg exposure.
 - Driven by downtime/change out air exposure and oxygen SCC risk of Alloy 400.
 - 205X Info Exchange has reported SCC of C276 here. Solution annealing suggested (difficult to implement).
- Specialty isolation bellows sealed globe valves now starting to be specified (in licensor specification) for shutoff services. CS and C276 body construction (larger valves CW12MW castings), with C276 trim including C276 plug/bellows), seats of CoCrMo (Stellite®21).
 - Anecdotal info of some issues though limited service experience.

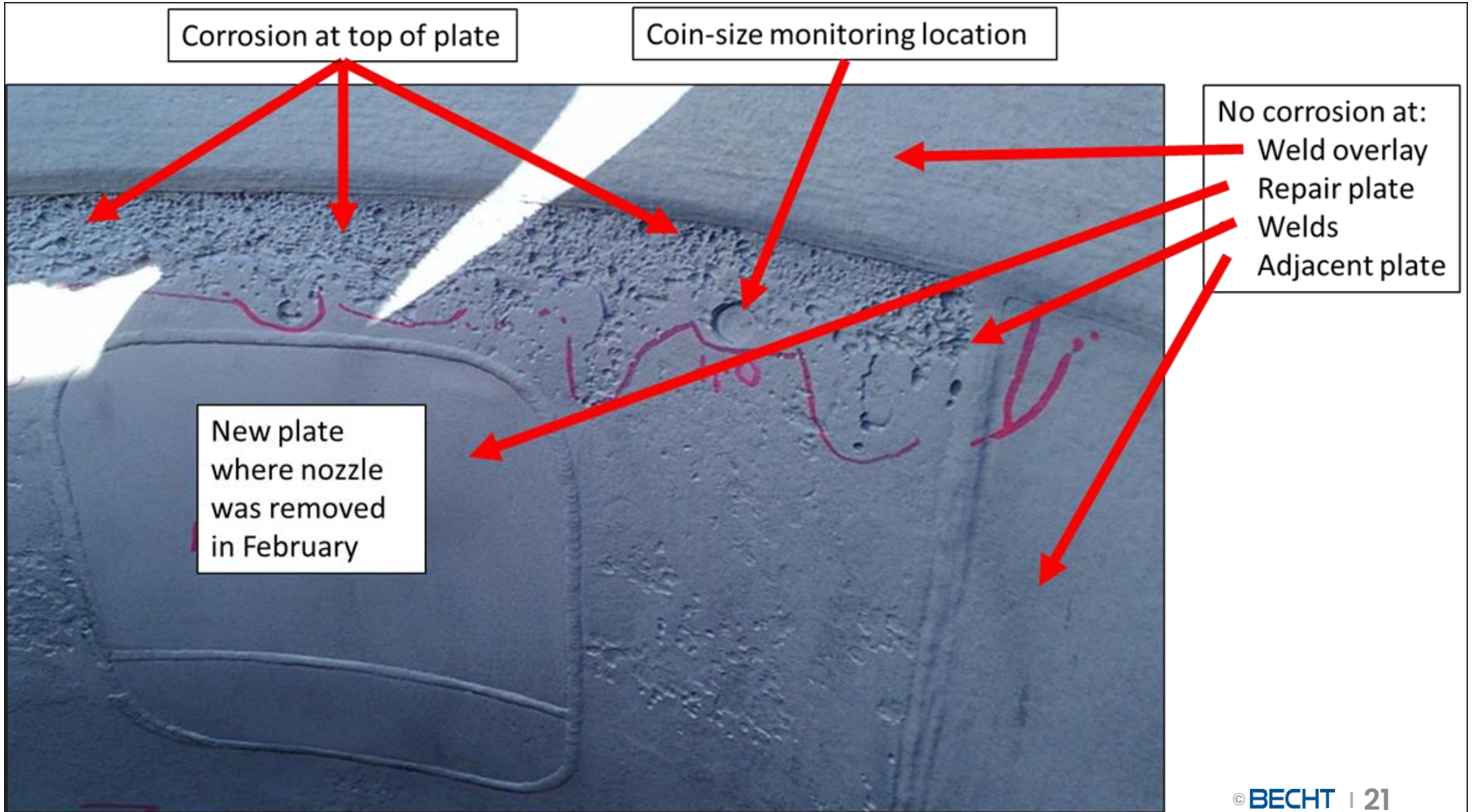
Case Studies

Additional Sharings

- Monel corrosion in the rerun column and downstream piping.
 - Have seen up to 100mpy corrosion in Monel and similar rates with Hastelloy. Solution was just to get thicker piping, inspect and plan on replacements at TA.

Additional Sharings

- Corrosion in rerun constructed from two Monel plates that came from different heats
- A nozzle caused liquid to condense and drain into the tower, leading to local damage due to a small phase change area under the nozzle
- One of the Monel plates in the tower was significantly less resistant to corrosion than the other plate or the welds and overlay in the tower



Additional Sharings

- Cracked Hastelloy C PSV bellows in Isostripper overhead receiver relief
- Alloy C2000 is insufficient in aggressive tower operation.
 - significant corrosion of C2000 internals and C2000 overlay
 - coupon testing showed no significant difference
- C276 level instrument magnetic floats often used in this zone have no reported issues to date (?)



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