



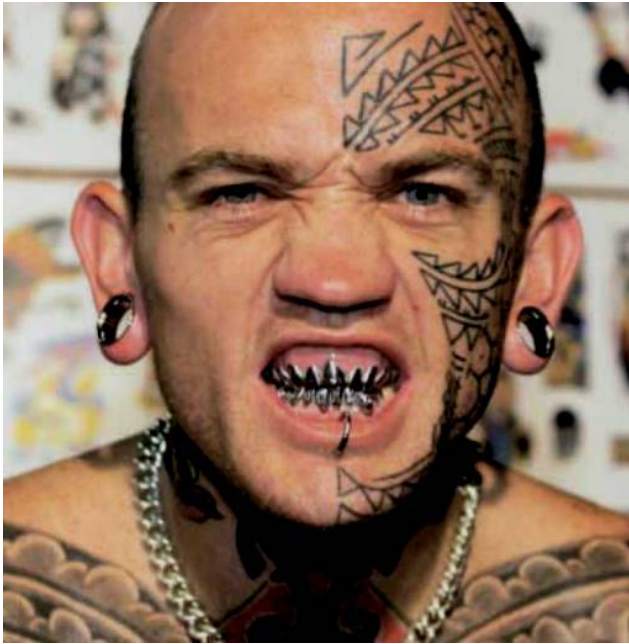
How to avoid pitting of Stainless Steel Tank Trucks

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SS Applications



What is “pitting”

Environmental factors

What to avoid

What is “Pitting” ?

“Practical pitting”:

- Corrosion engineering divides into 4 phenomena
 - ‘pitting’ = “pin holes” caving out below the stainless surface
 - Local areas where “uniform” corrosion has occurred
 - Areas that have corroded due to “crevice corrosion”
 - Areas that have corroded under debris

Does it matter?.....YES – if you want to avoid it (again)!

Pitting

- Uniform Corrosion
- Pitting Corrosion
- Crevice Corrosion
- Under deposit Corrosion



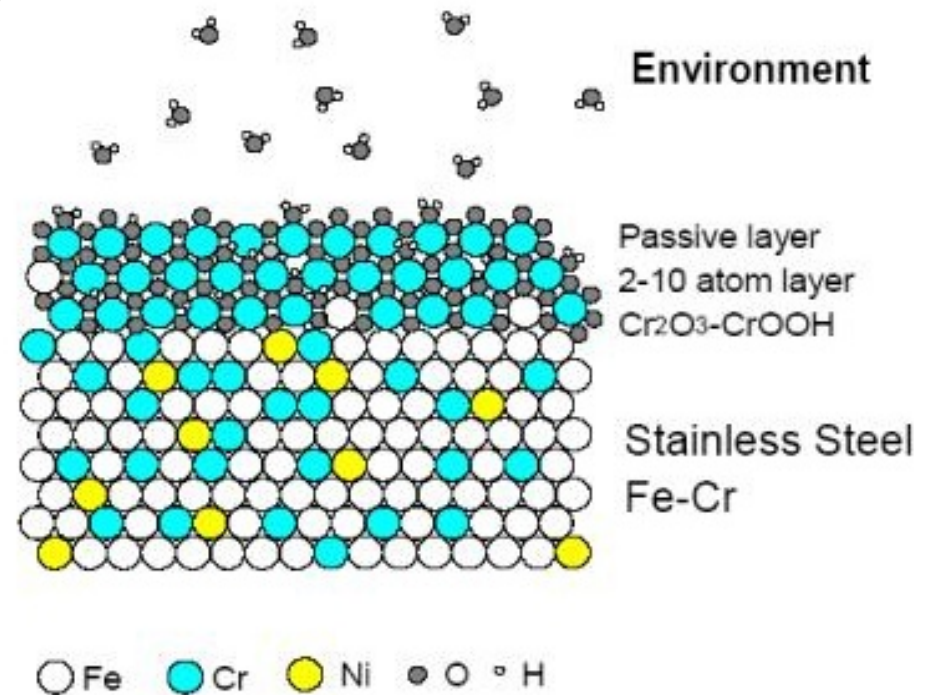
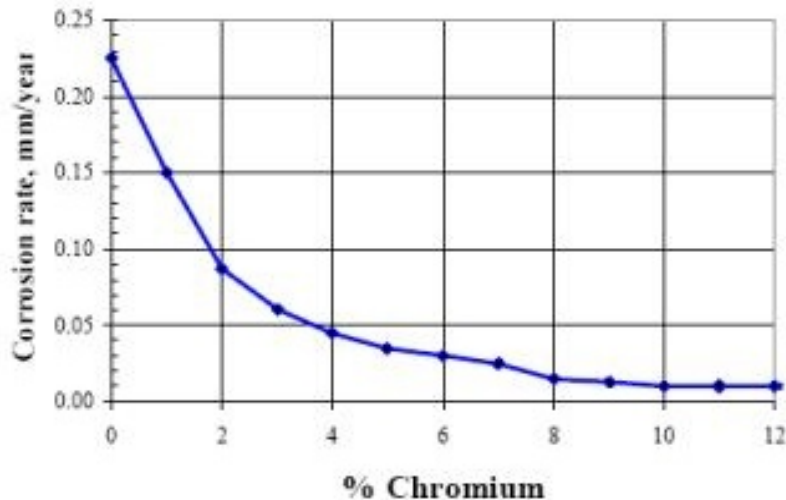
Stainless Steel

>12 % Cr

↳ Passiv film

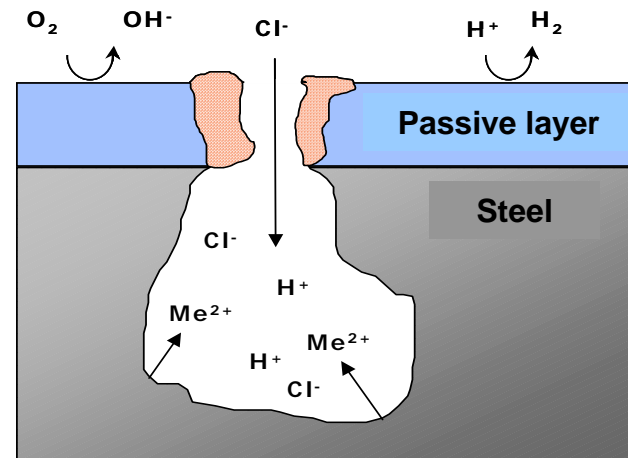
↳ Corrosion rate drops

Oxygen is necessary to maintain the passivfilm



Pitting

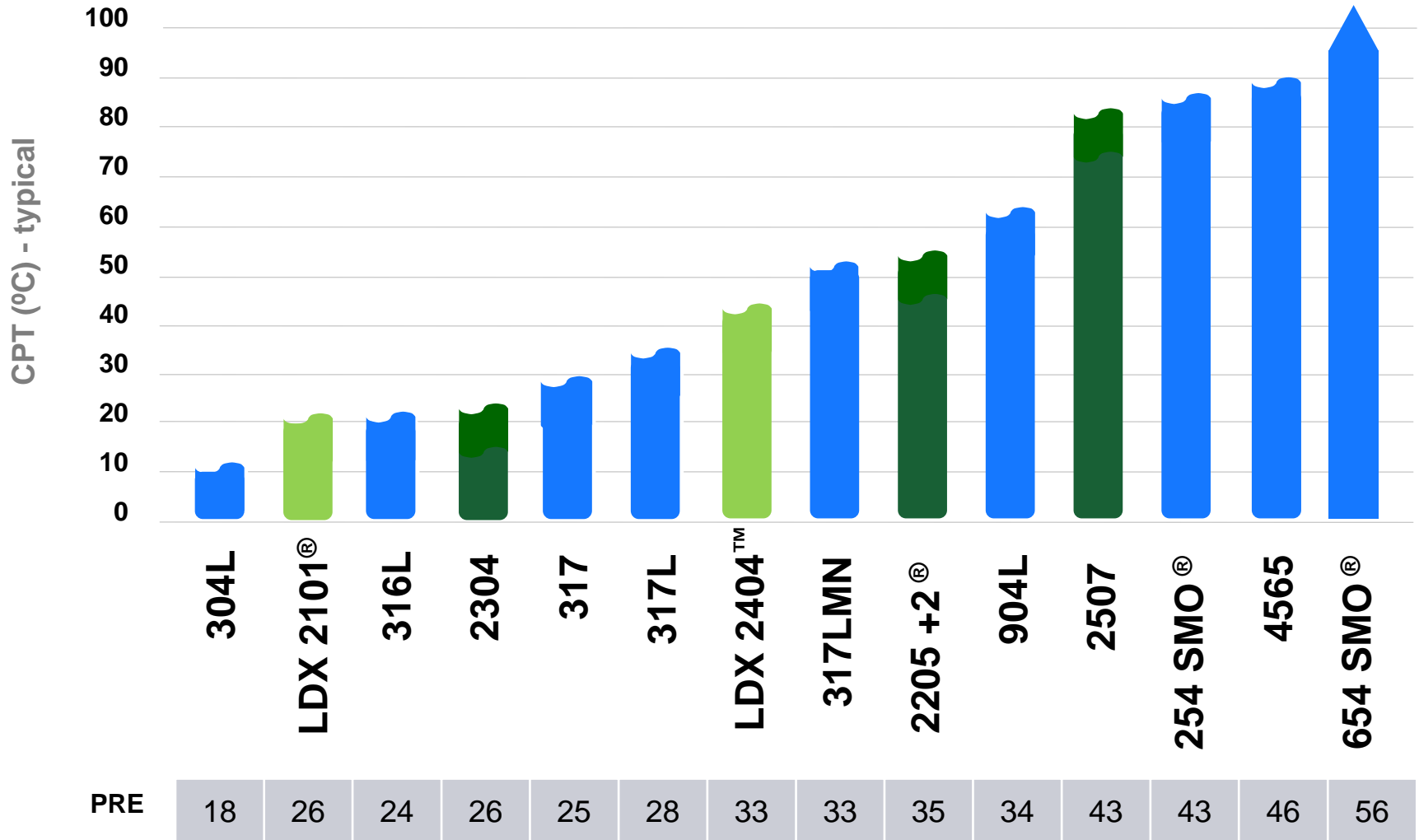
- Chlorides (halides) needed as “catalyzer”
- More chlorides = higher ease of formation
- Oxygen or other oxidizer is the driving force.... No driving force = no corrosion
- Near neutral pH environments ($\text{pH} > 2$)
- Temperature increases risk and speed
- Self sustaining based on local environment



Pit cross section

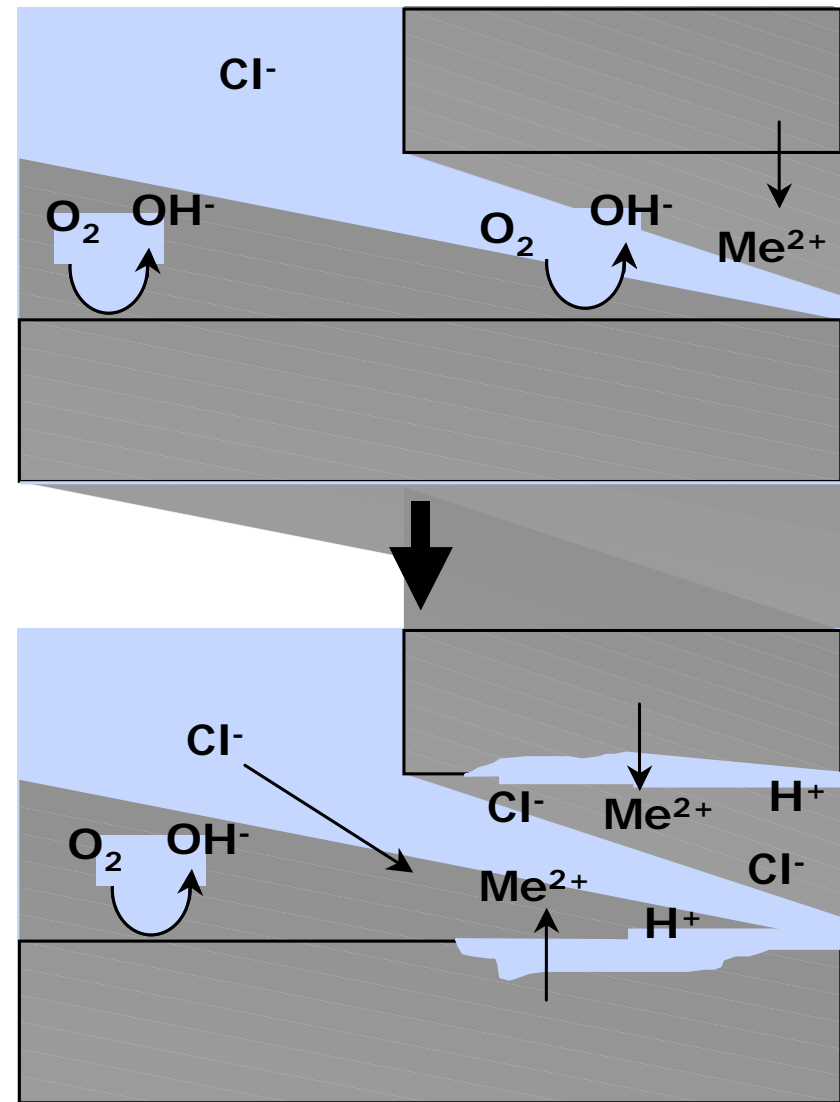


Corrosion resistance ranking according to ASTM G150

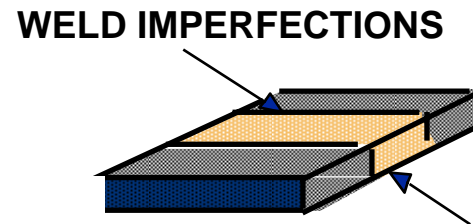
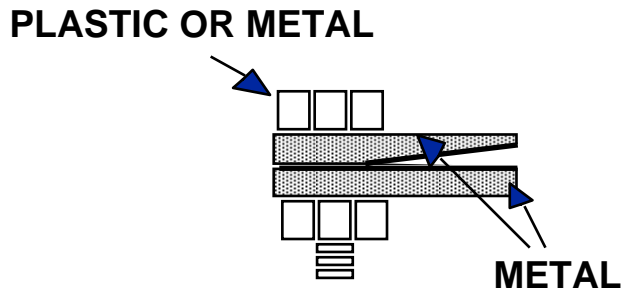
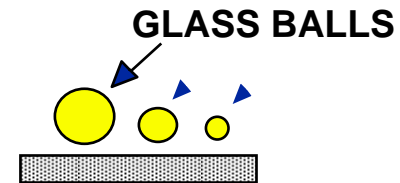
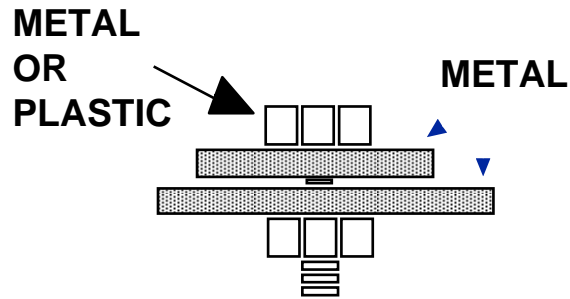
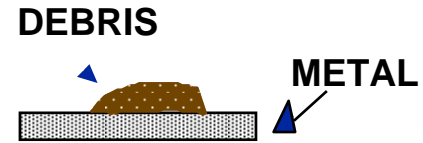
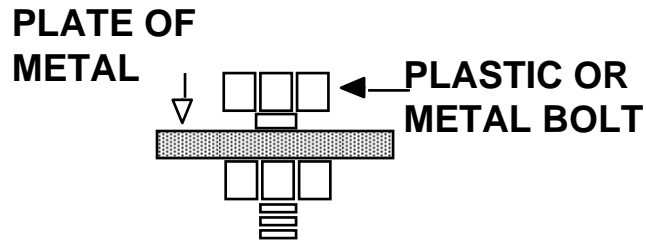


Crevice Corrosion

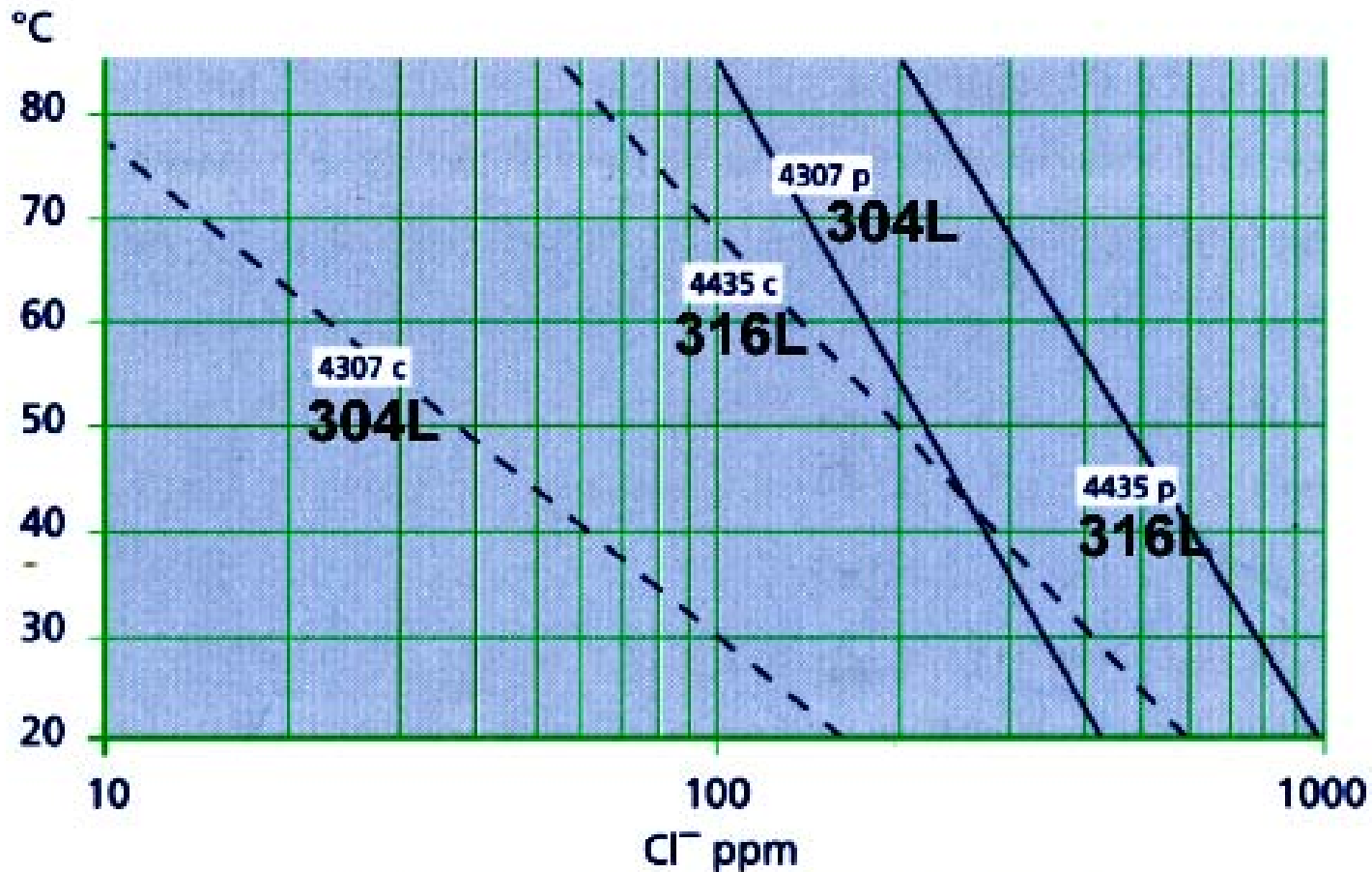
- **Similar to pitting**
- **Sustained by already existing restricted area (crevice)**
- **Takes less severe conditions to initiate, but.... It takes time!**



Sites for Crevice Corrosion

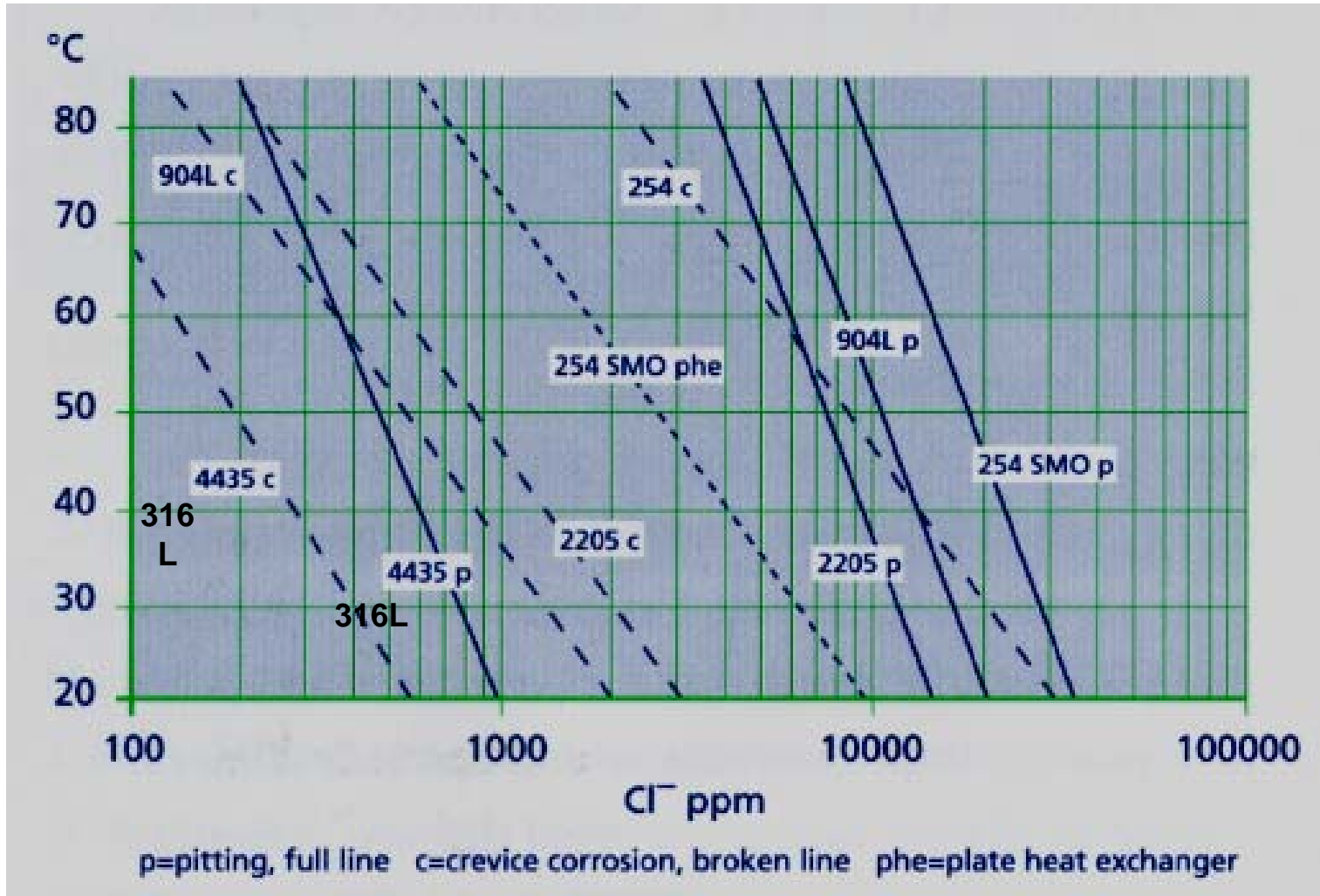


Pitting and crevice corrosion thresholds



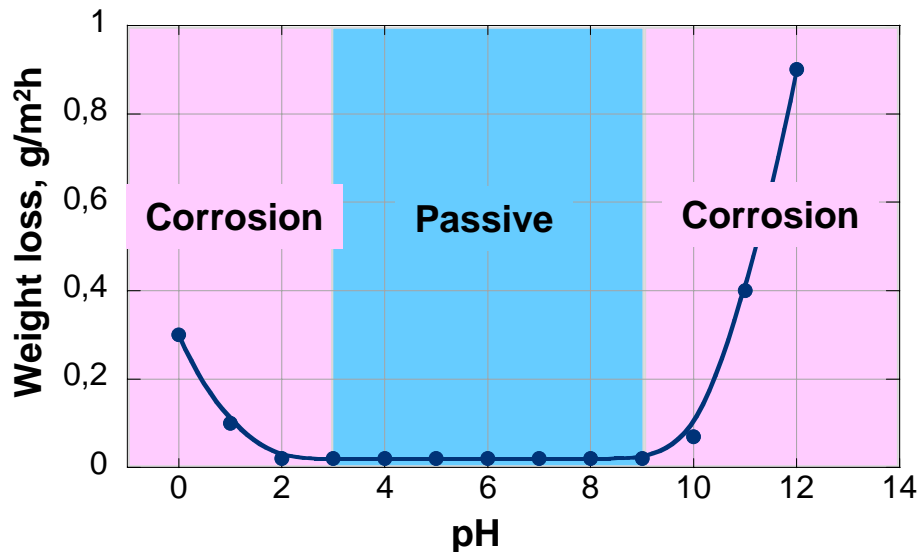
p=pitting, full line c=crevice corrosion, broken line

Pitting and Crevice Corrosion Thresholds

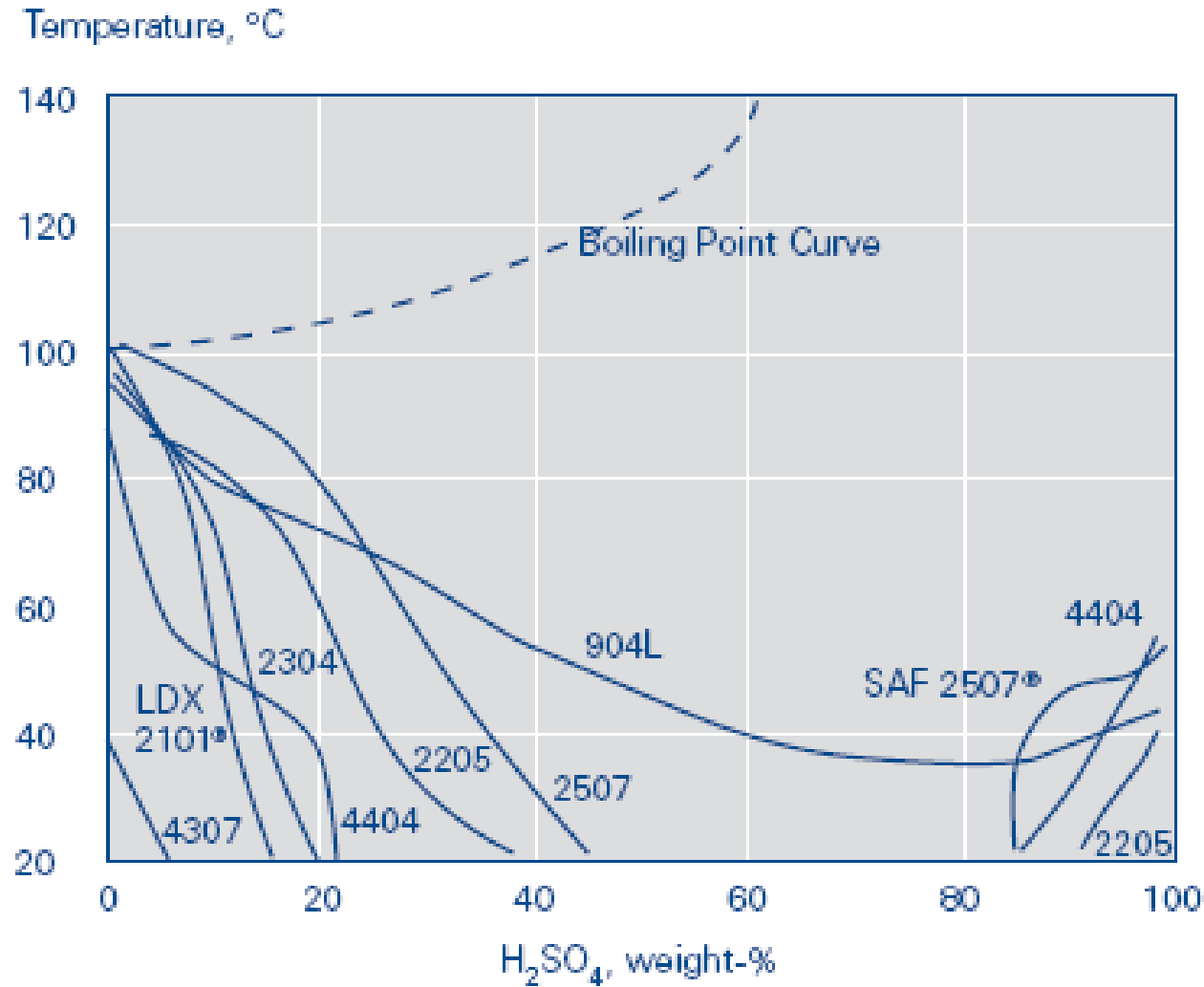


Uniform Corrosion

- The corrosion process proceeds uniformly over the entire exposed surface or over a large area
- Most cases of uniform corrosion or general corrosion occurs in strong acids or in hot alkaline solutions

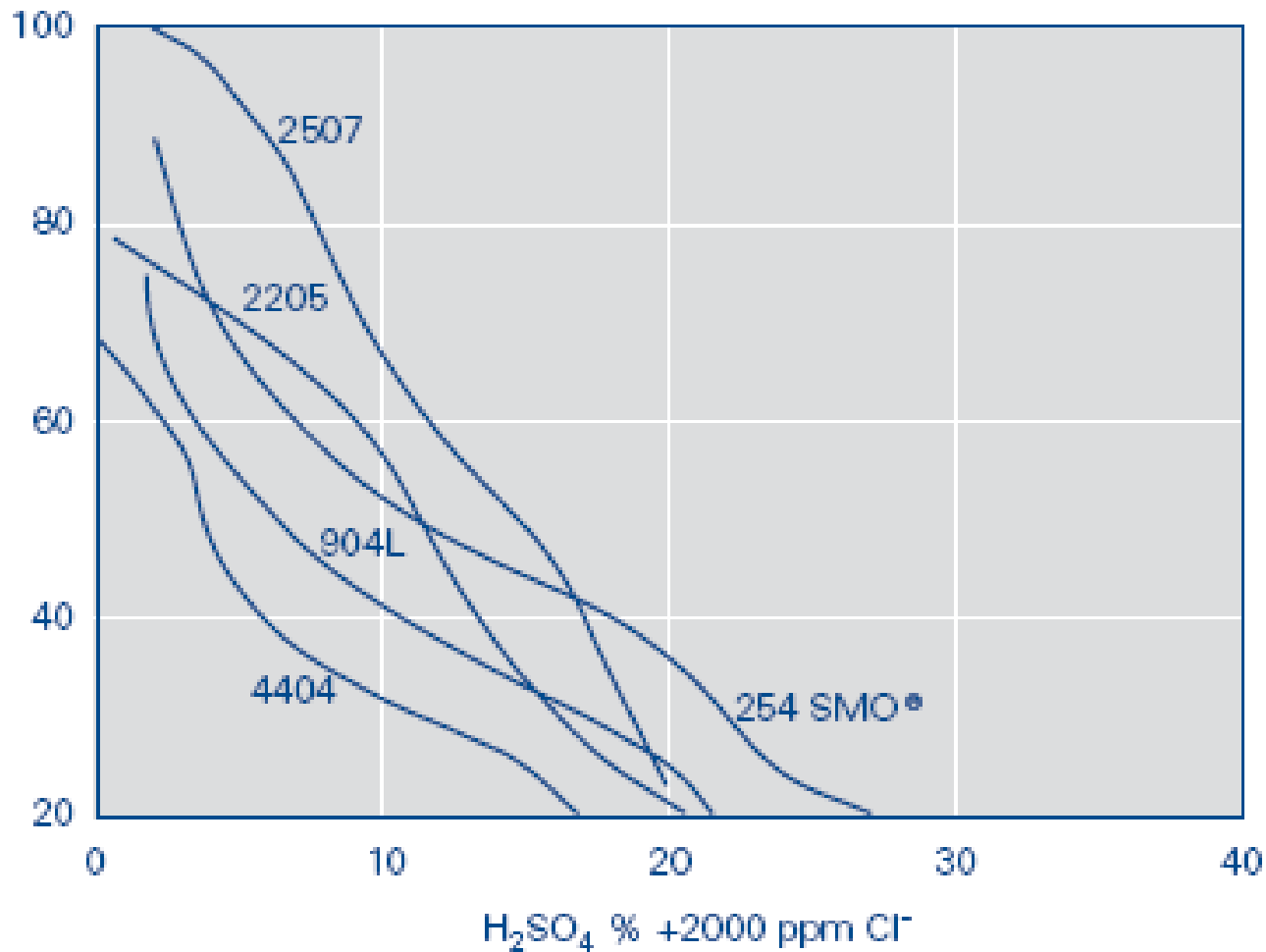


Uniform Corrosion

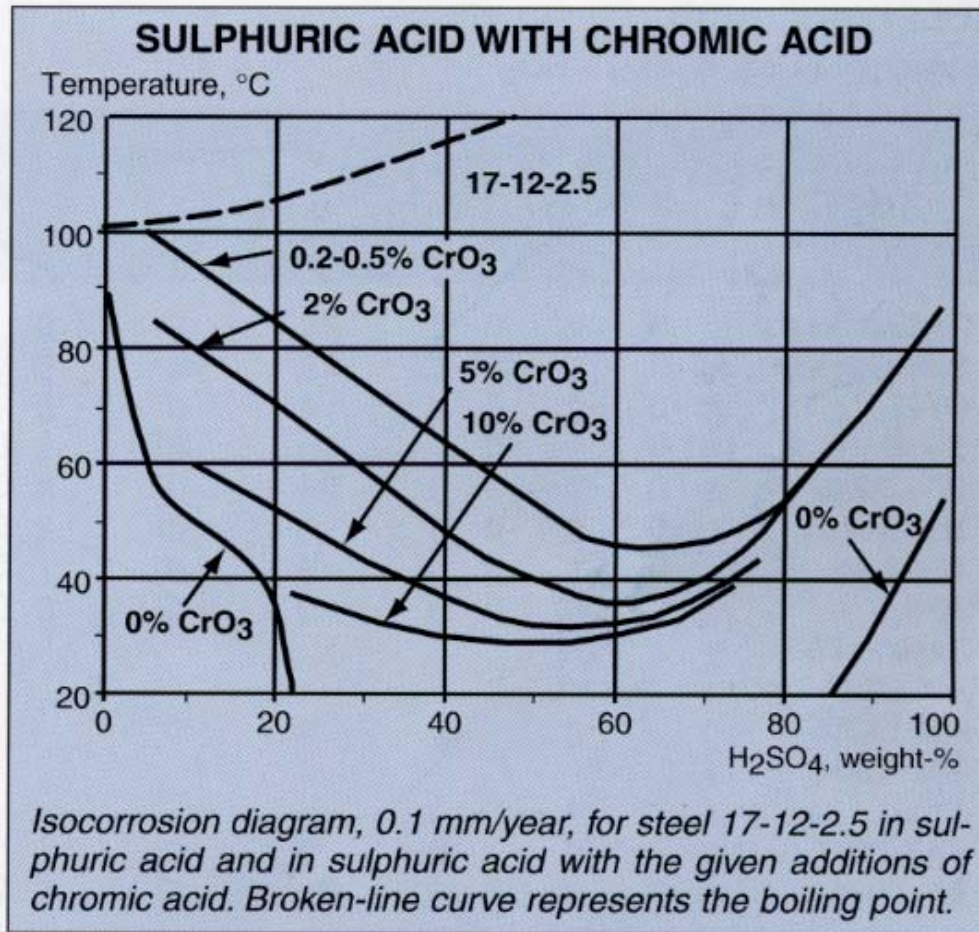


Uniform Corrosion

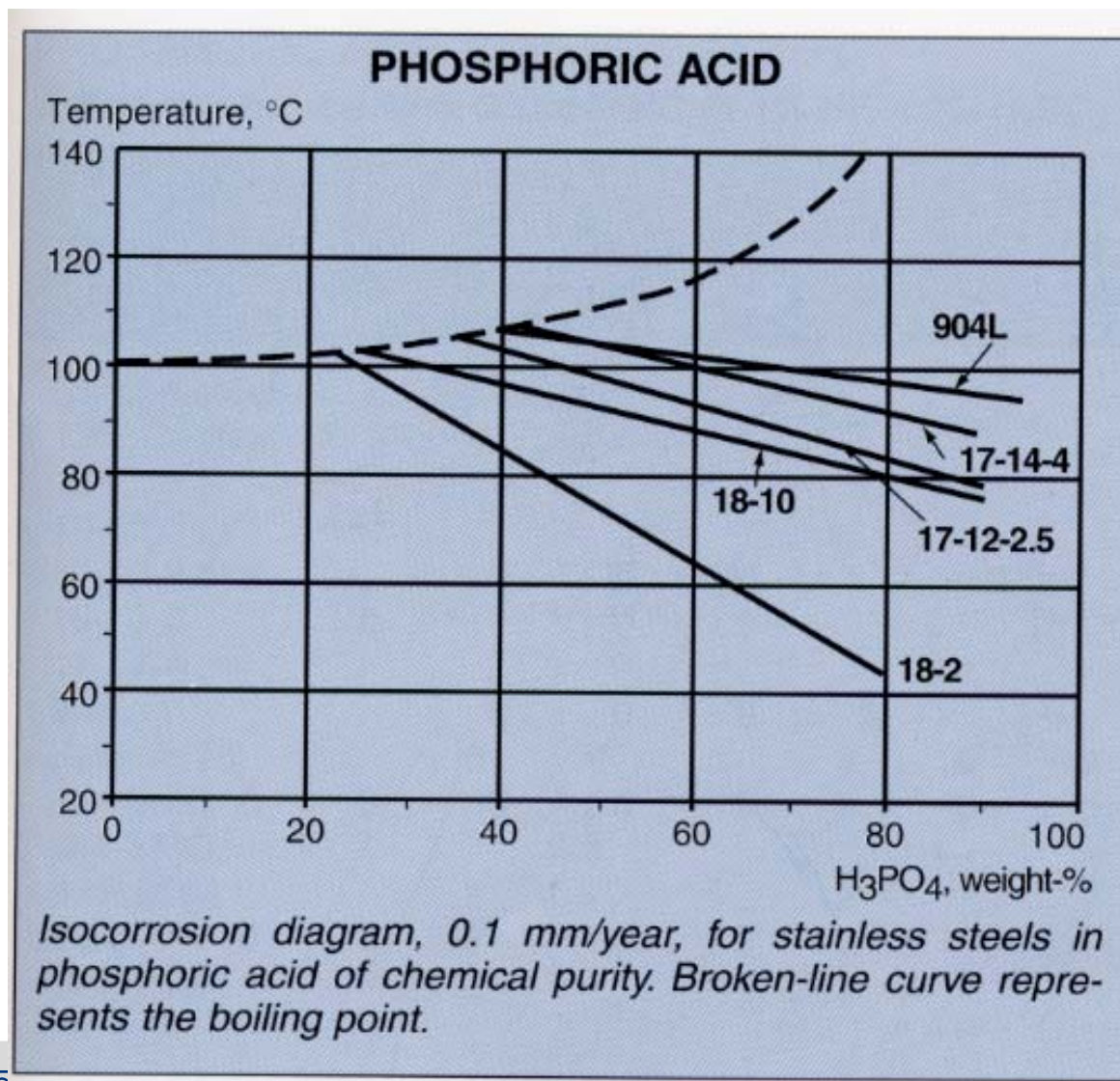
Temperature, °C



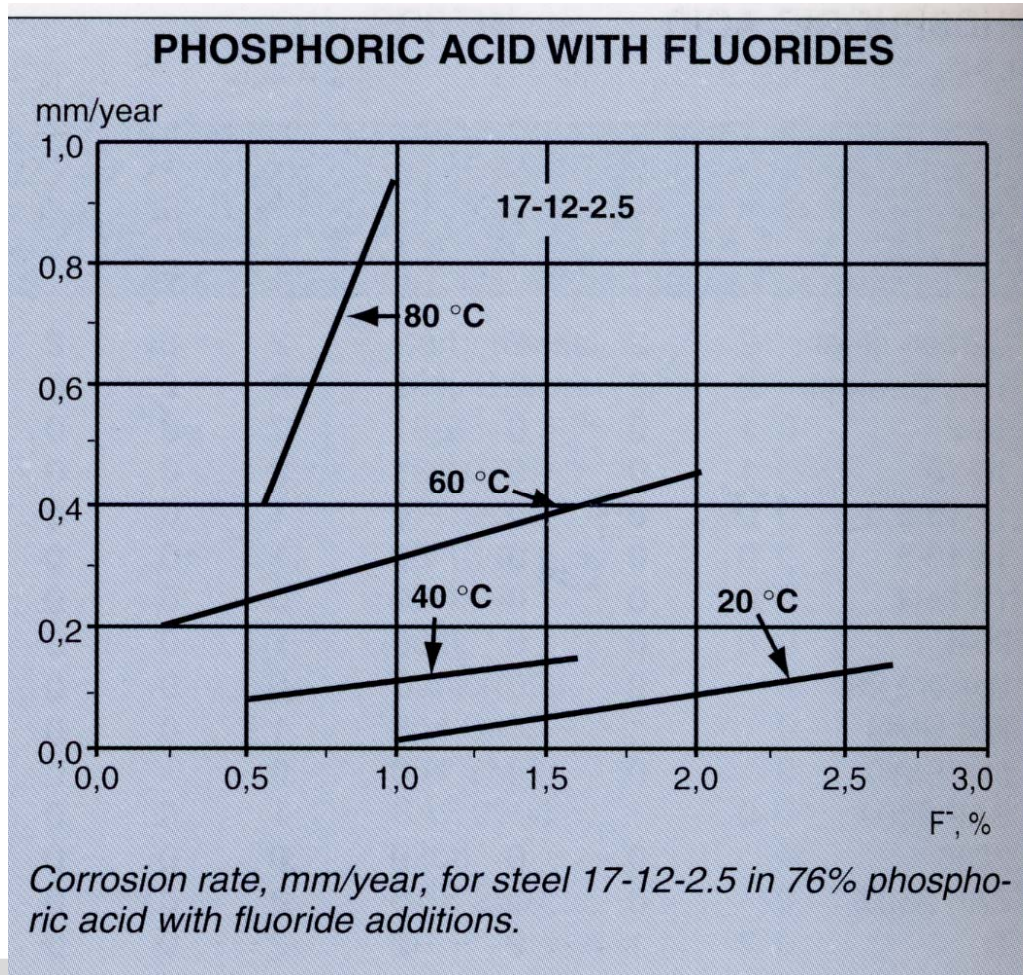
Iso-corrosion diagram - ($\text{H}_2\text{SO}_4 + \text{CrO}_3$)



Iso-corrosion diagram - Pure H_3PO_4



Corrosion rate of 316/316L stainless steel in 76% H_3PO_4 with F^- -additions



More factors influencing corrosion outcome

- Temperature, chlorides, pH
- Liquid/vapor interfaces
- Condensation
- More oxidizing conditions
 - Not good in neutral conditions
 - **Sometimes** helpful in acid conditions
- Gravitation
- Condensation
- Surface finish
- Weldments
- Inhibitors (grease, other inorganic salts)

The time factor

- **Pitting**

- Initiates very fast once critical condition has been established
- Propagates fast (few weeks or maybe days to penetrate tank wall)

- **Crevice corrosion**

- Takes longer than pitting to initiate
- Slower propagation than pitting (but still fast)

- **Uniform corrosion**

- Initiates typically immediately once critical condition has been reached
- Penetration speed typically much less than real pitting, but larger area is attacked

Reactions to “trouble”

Good “crime scene investigation” includes:

- Most likely cause can be found in your latest load or cleaning procedure...
- Take samples and analyze
 - Cleaning water
 - Transported load
 - Corrosion products
- Note down
 - Location of pitting relative to weldments, deposits, above or below “liquid line”
- Take pictures

Repair:

- Clean
- Grind and polish smooth
- Pickle or passivate
- If welding:
 - Check weld recommendations for material
 - Use overalloyed filler
 - Watch out for cumulative heat input
 - Pickle

Avoiding trouble... 1

- Know your water!
- Keep stainless steel tanks clean
 - drain and dry out the tank
- Avoid stagnate conditions



Avoiding trouble... 2

Watch out for

- Unforeseen contamination
- Unexpected temperature excursions
- Unexpected dilution of non-aggressive acids

Avoiding trouble... 3



Water contamination of organic chlorinated compounds

- Can form hydrochloric acid (*risk of pitting and SCC*)
- Susceptible compounds include;
 - Dichloroethylene, ethylchloride, ethylene chloride, trichloroethylene, carbon tetrachloride, chlorobenzene, Boron trichloride, ethylene bromide, etc.

Avoiding trouble... 4

After transport of concentrated sulfuric acid

- Avoid exposure to moist air
- Keep tanks clean and dry
- Clean tanks with care
- Avoid uncontrolled dilution
- Inspect after cleaning

Avoiding trouble... 5

When using disinfectants



- Don't use chloride containing agents (clorox and similar) including those that can decompose to HCl
- Avoid excessive temperatures (use lowest possible temperature)
- Keep exposure time down (but keep temperature low first)
- Keep tanks clean and dry after disinfection
- Inspect after cleaning

Thank you!

Activating Your Ideas

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