



# **Corrosion in process pipeline in breweries**

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- Corrosion
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  - Common corrosive environments
  - Effect of corrosive environments on the metal
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# What is Corrosion?

The natural tendency of a material to return to its most stable (thermo dynamic) form

This can be an Oxide, Sulfide, Sulfate, Chloride or other compounds

- All metals will corrode in some environment
- Not all metals corrode in the same environment

# Main factors that drive corrosion

- Chlorides
- High Temperatures  $\uparrow$
- Low pH  $\downarrow$



# Types of corrosion

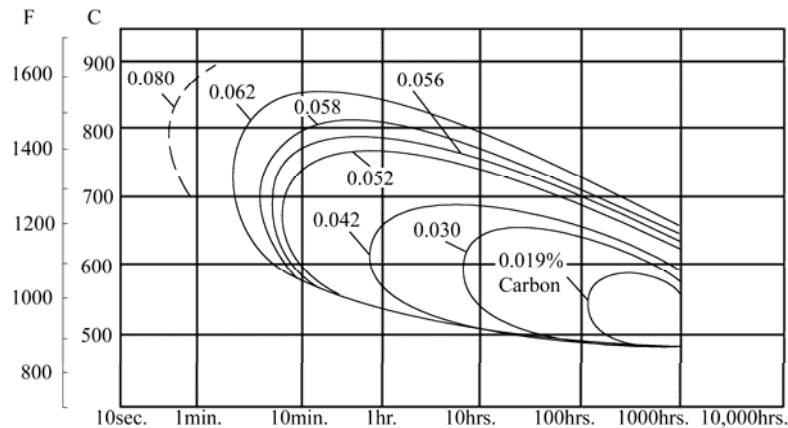
- General or uniform corrosion
- Intergranular
- Galvanic
  - Pitting
  - Crevice
- Stress corrosion cracking
- MIC or microbiological induced corrosion

# General (Uniform) Corrosion

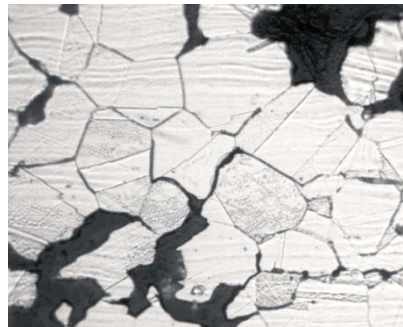
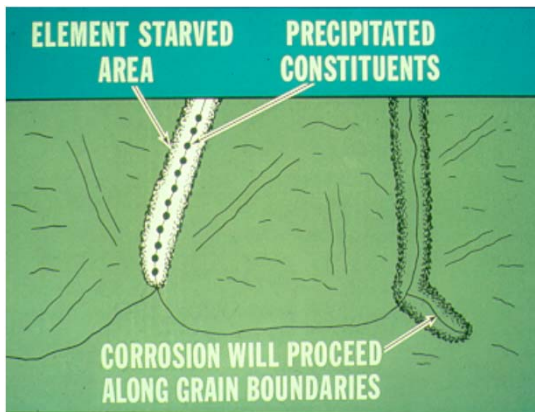
- Occurs Uniformly On All Exposed Surfaces
  - Carbon Steel Rusting
- Expressed as a Corrosion Rate - mpy
  - Increased Wall Thickness gives Longer Life
  - Corrosion Rate Increases with Temperature
- This is the ONLY Corrosion Mechanism Where Increased Metal Thickness Means Increased Life!!!!

# Intergranular Corrosion

## Effect of Carbon



Effect of carbon on the time required for formation of harmful chromium carbide. Carbide precipitation occurs inside the loop, to the right of the various carbon content curves



# Types of Galvanic Corrosion

- True Galvanic Corrosion

Example: Carbon Steel bolted to Stainless Steel

- Pitting Corrosion (3a) , Where both active and passive cells exist in the same metal
- Crevice Corrosion (3b), Where the active cell is artificially forced to exist

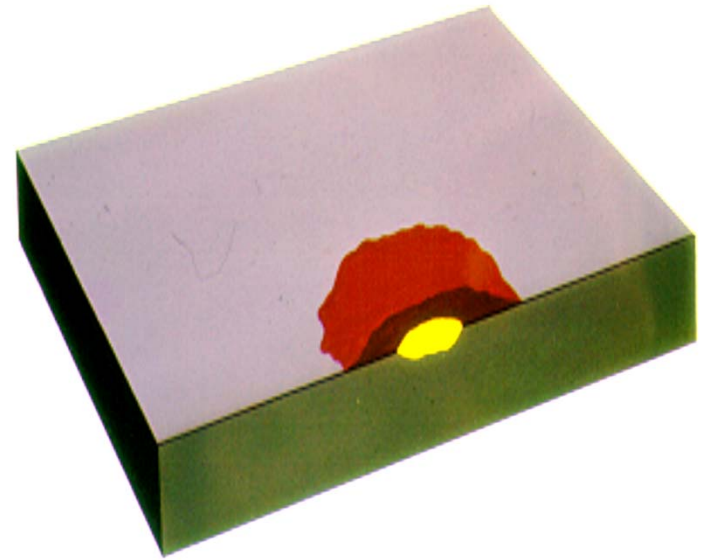
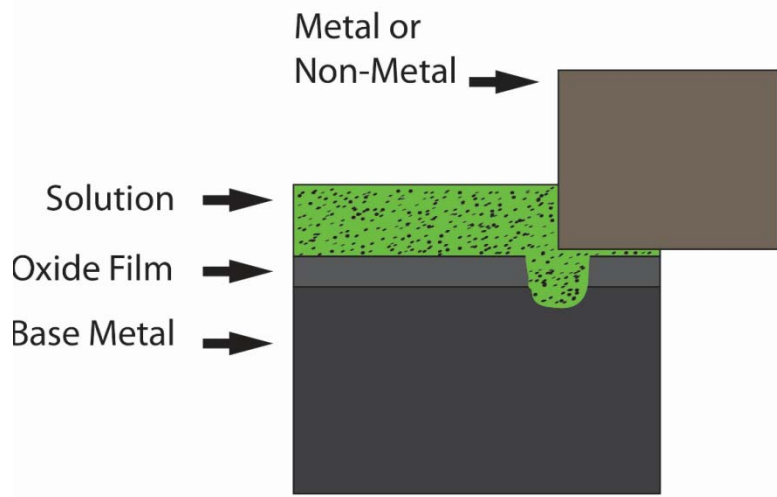


# Pitting Corrosion

- Pitting is exacerbated at higher temperatures and lower pH for a certain chloride content and is completely random where it attacks
- Pitting Resistance Equivalent Number (PREN)  
**PRE Number = %Cr + 3.3(%Mo) + 16(%N)**
- For eg. Under the right conditions of chloride content, pH and temperature, a type 304 tube with a 0.035 inch (0.89 mm) wall will pit through in less than 8 hours

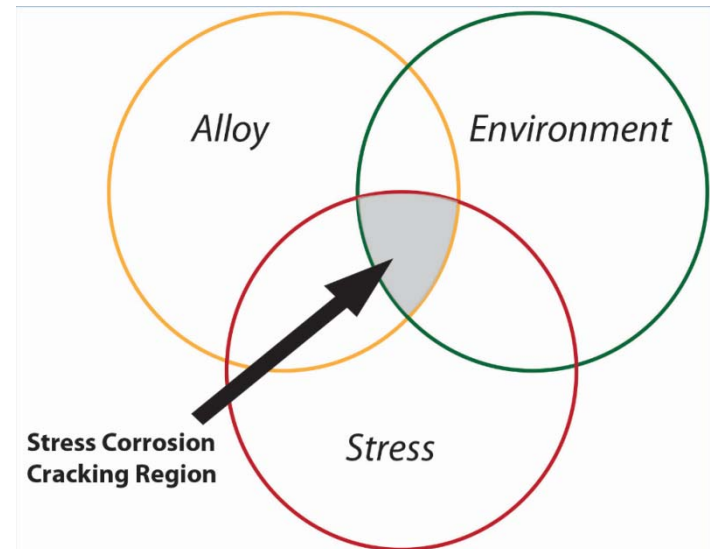
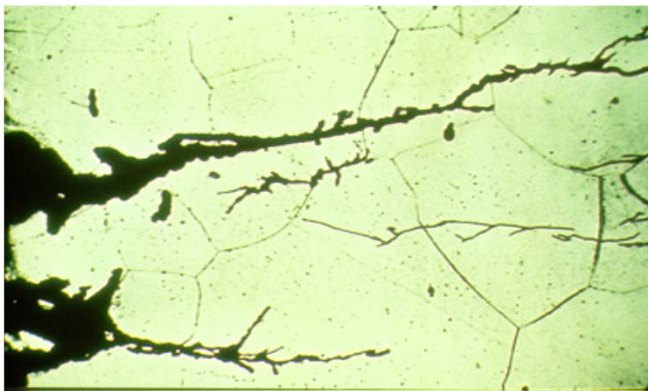
# Crevice Corrosion

- Localized
- Predictable Time for Onset
- Very Little Additional Life With Thicker Metal Sections



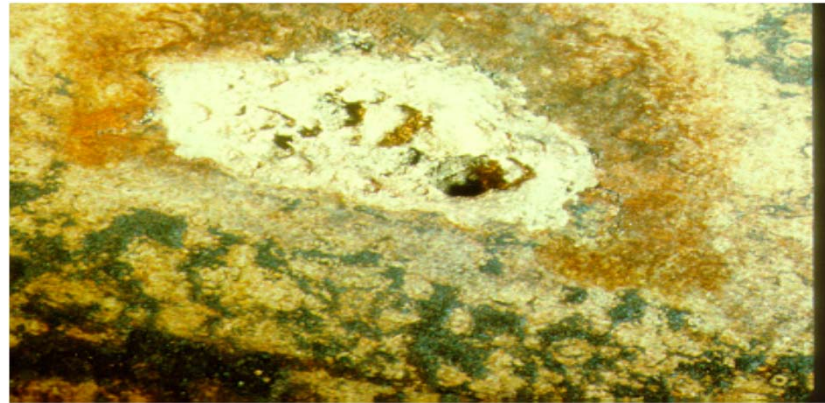
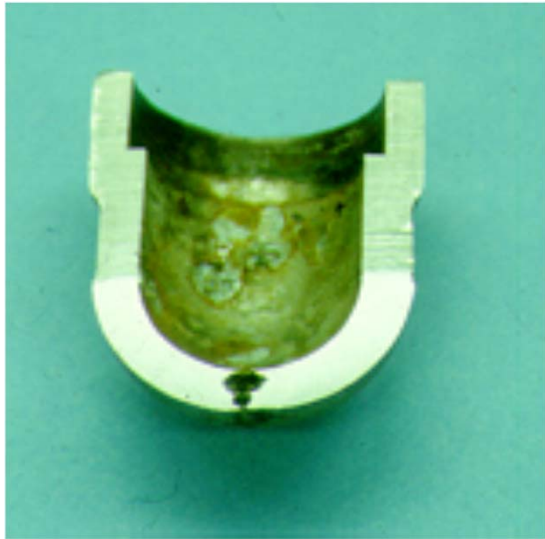
# Stress Corrosion Cracking

- A preferential attack of areas under stress in a corrosive environment, where such an environment alone would not have caused corrosion
- A cracking procedure that requires the simultaneous action of a corrosion and sustained tensile strength



# Microbiologically Influenced Corrosion (MIC)

- Bacteria *per se* do Not Attack Metals
- Corrosion is by One of the Other Recognized Mechanisms
  - More Highly Alloyed Metals are Resistant
  - Exotic Metals (Titanium) are Resistant



# Common corrosive environments-Product

- In the food processing industry, where salt and acidic conditions are present:

- Sports drinks
- Ketchup



- In the personal care industry

- Cosmetic products
- Deodorant
- Hair care



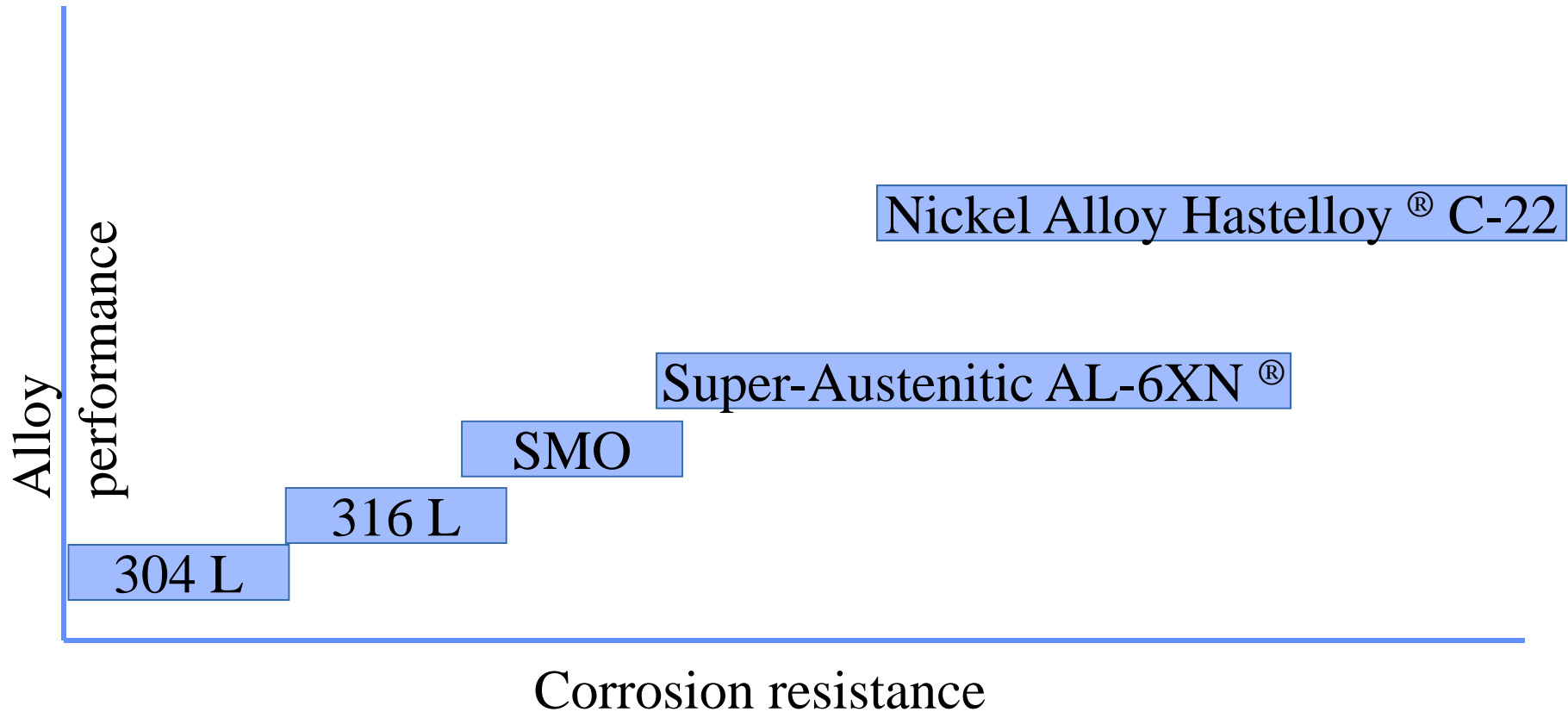
In Beverage:

- Hot water system

# Common corrosive environments-CIP

- For cleaning and disinfection operation in breweries
  - ✓ Sterilizing solutions such as bleach (sodium hypochlorite).
  - ✓ Remove product residues
- Applied in processing lines such as pipes, vessels, and tanks
  - ✓ Salt water (brine)
  - ✓ Water supplies having chlorine or hydrochloric acids to prevent bacterial growth

# Alloy Offering in the Market for sanitary/high purity market



# Branding of Super Austenite Alloys

- AL-6XN<sup>®</sup>
  - Allegheny Ludlum mill
  - Budweiser- American
- 254 SMO<sup>®</sup>
  - Outokumpu mill
  - Heineken- European
- 904L<sup>®</sup>
  - ATI mill
  - SABMiller -European

## Comparison with 316L, Duplex & Other 6 Mo Alloys

ALLOY	UNS NUMBER	CHROMIUM	NICKEL	MOLYBDENUM	NITROGEN	PREN*
<b>AL-6XN<sup>®</sup></b>	<b>N08367</b>	<b>20-22%</b>	<b>23.5-25.5%</b>	<b>6-7%</b>	<b>0.18-0.25%</b>	<b>45.89</b>
316L	S31603	16-20%	10-15%	2-3%	0.05%	<b>27.05</b>
254 SMO <sup>®</sup>	S31254	19.5-20.5%	17.5-18.5	6.0-6.5%	0.18-0.22%	<b>43.83</b>
904L	N08904	19-23%	23-28%	4-5%	-	<b>35.85</b>



# Alloy Selection

- Is sanitary-grade tubing available?
- Is round bar also available in the same material?
- Can the alloy be practically polished?
- Can the alloy be welded?

*A particular alloy may be better for specific applications, but sometimes finding 100 ft of product with the required accessories can be a challenge.*

*So, a product must not only be meeting the technical standards of application but also be on the shelf – in all the necessary forms such as sheet, plate, pipe, tube, bar, fittings both sanitary and commercial grade – .*

# Standard, Alloys Raw Material Types

Raw Material Type	316L		AL6XN UNS : N08367		Hastelloy C-22/Alloy 22 UNS: N06022	
	ASME	ASTM	ASME	ASTM	ASME	ASTM
Plate, Sheet & Strip	SA-240 SA-480	A-240 A-480	SA-240 SB-688	A-240 B-688	SB-575	B-575
Wire, Rod & Bar	SA-276 SA-479	A-276 A-479	SB-691	B-691	SB-574	B-574
Welded pipe	SA-312 SA-778	A-312 A-778	SA-358 SA-409	A-358,B-804,A- 409,B-675, B-691	SB-619	B-619
Heat Exchanger Tubing	SA-249 SA-213	A-249 A-213	SA-249	A-249		
Sanitary Tubing		A-270		A-270		
Welded Tube (General Application)	SA-269 SA-450 SA-1016	A-269 A-450 A-1016	SB-676 SA-269	B-676 A-269	SB-626	B-626
Seamless Pipe & Tube	SA-213 SA-511	A-213 A-511	SB-690	B-690	SB-622	B-622
Forging	SA-182 SA-484 SA-479	A-182 A-484 A-479	SB-564	B-564 B-472		B-462 B-472 B-564
Pipe Fittings	SA-815 SA-403	A-815 A-403	SB-366	B-366	SB-366	B-366

# AL-6XN and Hastelloy C-22 Tubing & Tube Fittings

- Elbows
- Tees
- Adapters
- Ferrules
- Reducers
- Specialty Fab
- Tubing



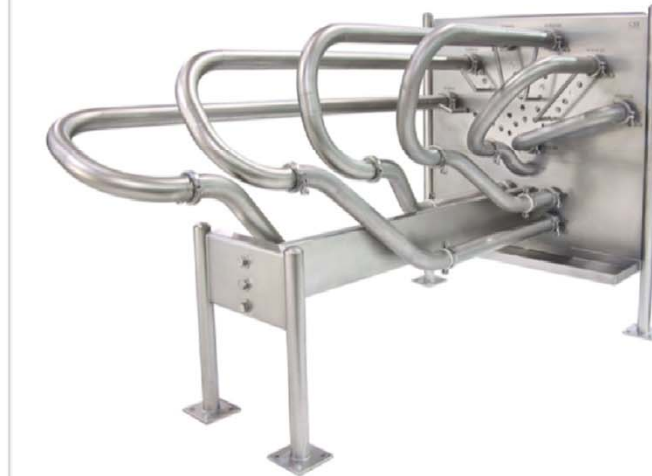
# Other Products offered in AL-6XN or Hastelloy C

- Tote Unloading Systems
- Product Recovery Systems
- Tank Cleaning Equipment
- Pumps
- Valves
- Filters & Strainers



# Other Products offered in AL-6XN or Hastelloy C

- Valve Manifolds
- Transfer Panels
- Utility Stations
- Valve Modifications
- Jacketed Tubing



# More Information

[www.al6xn.com](http://www.al6xn.com)

[www.csialloys.com](http://www.csialloys.com)

AL-6XN Super Austenitic Stainless Steel

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## Hastelloy® C-22®

Superior Corrosion Resistance

HASTELLOY C-22

CSI has always been an industry leader when it comes to the requirements of sanitary and high purity market segments such as the Food-Dairy-Beverage, Pharmaceutical, and Personal Care industries.

Processes continue to evolve, and so does the technology. This holds true for engineering processes, in terms of both design and material. They constantly need to be upgraded due to limitations in more aggressive conditions.

Every material has its design limitations. Some processes operate well with the traditional stainless steels 304 and 316L. For more aggressive conditions, however, higher-grade materials are required.

CSI has selected the super-austenitic stainless steel AL-6XN® (6% Mo alloy), and Hastelloy® C-22® (Nickel alloy) to provide excellent corrosion resistance.

CSI has responded to the need of our customers and developed a stocking program for Hastelloy C-22. [Contact CSI](#) to discuss your application with one of our specialists.

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