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MARINE CORROSION FORUM

FOR ALL WET CORROSION ISSUES

Marine Corrosion Forum and Institute of Corrosion partnering with

Carol Powell

Consultant to the Nickel Institute

30th April 2020

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“An Overview of the Corrosion of Metals in Seawater (and What to Look for)”

About Me

Carol Powell has been an independent consultant for 30 years and has specialised in stainless steels, copper and nickel alloys. Over this time, she has been involved in development projects for the Nickel Institute involving the water, nuclear and marine industries. She also ran the Copper-Nickel Task Group for the Copper Development Association for over 10 years.

Earlier in her career, she worked 8 years, first in the corrosion laboratories and then as a marketing engineer for a high nickel alloy manufacturer and then 5 years for a firm of engineering consultants to the Royal Navy. Carol has a BSc in Metallurgy and Science of Materials, and is a Fellow of the Institute of Materials, Minerals and Mining. She has written over 40 papers and publications and been a member of the MCF since its inception.

Q&A

Selection of Questions to **Carol Powell**, Post-Presentation 30/04/2020

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** What are some typical mechanisms for degradation of nickel alloys in stagnant sea water conditions?
  - **A.** For the high nickel alloys I have mentioned with high levels of Mo, corrosion is not an issue. There have been some crevice corrosion instances for alloy 625 in severe environments but in straight stagnant sea water this is unlikely. The Ni-Cu alloys 400 and K-500 can be susceptible to pitting and crevice corrosion unless galvanically protected.
- **Q.** what is ambient temperature for seawater for PREN>40?
  - **A.** If I understand the question correctly, PREN>40 normally applies to stainless steels from ambient temperature up to their limits in seawater; 35°C for 6% Mo and 40°C for superduplex.
- **Q.** What are the minimum quantities of mentioned elements for PERN?
  - A. As long as they are within specification for the particular alloy, the alloy content is not of particular concern from a corrosion point of view. Individual manufacturers would have their own melting methods and internal preferences to achieve this. It is also important that if PREN>40 is specified that every heat satisfies this requirement and that is checked

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** If Ni-resist is used for bodies of rotating equipment, which material can be used in seawater for impeller?
  - **A.** Usually alloys which are more noble so that the body can give added protection to the internals. I believe Stainless steels 316L and 2205 have been used.
- **Q.** Can you comment on influence of Fe contamination and heat tint on corrosion of SS in seawater?
  - **A.** Iron pickup from fabrication can lead to ferric chloride formation and pitting and so removal is recommended. Heat tint is a thick chromium oxide layer with chromium depletion underneath which means a lower corrosion resistance. Thus removal is preferred before going into service. This is particularly important for the lower grades of stainless steel.
- **Q. Can you comment on effect of iron content in Cu-Ni alloys on corrosion properties?**
  - **A.** Yes iron is a small but important addition to copper nickels and helps in the resistance to erosion. For 90-10 Cu-Ni the composition can range from 1-2%, 1.5-2% provides the optimum performance particularly in the solution treated condition. The iron out of solution can lead to a small magnetic response. If non magnetic material is required say for Naval service a final solution anneal is required.

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** This question might not have simple answer, but for pipe/pump transporting ambient tropical seawater condition, which metallic material options do you recommend to use from performance, cost, and life cycle cost point of view?
  - **A.** Just in terms of alloys mentioned in the presentation Cu-Ni or Titanium could be considered and also depending on temperature super stainlesses. Cu-Ni can be very good for firewater systems in tropical climates where piping can get up to 70°C with no water.
- **Q.** How can Ni-Cr-Mo resist corrosion in a see water (mechanism) and what is the role of Molybdenum in this case?
  - A. The high Ni-Cr-Mo alloys have a very protective oxide surface film which is very resilient and the high molybdenum alloys would be resistant to corrosion. The Mo helps the film formation and also influences the corrosion potential. It also accelerates repassivation after film breakdown
- Q. Can SCC occur at lower temperatures than 50°C in austenitic stainless steels?
  - A. In theory it might initiate from the bottom of pits when the alloy is warm say 30 to 35°C and stresses are high but in practice I have never heard of it. SCC has occurred at lower temperatures in swimming pools but the mechanism and environment is different.

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** What is your viewpoint please on the varying resistance of Duplex and Super Duplex St. Grades to MIC ?
  - **A.** There have been occasional instances of MIC with Duplex but it is very rare with super
- **Q.** Does heat treatment influence the corrosion resistance of stainless steel in sea water in terms of passive/surface layer? If so, how significant is its effect?
  - A. The main problem occurs is if the heat tint or surface has a dark layer as there will be chromium depletion underneath. As a rule if you can see the surface film, it is much thicker than the protective one, and has a lower resistance and should be removed for optimum performance. This is also why all SS are pickled after heat treatment
- Q. Do you have a good source of data for splashzone corrosion rates for the various materials (especially for elements with higher temperatures such as risers)
  - A. Data can be found on the website.

Questions and Answers – MCF / ICorr Joint Event Aberdeen – April.2020

- **Q.** Given the cost of corrosion, should industries start investing on more corrosion elimination rather than control?
  - A. Good question and could form the basis for a forum debate!
- **Q.** What is a recommended material for piping to desalters
  - A. If this refers to desalination then it depends whether it is SWRO, MED or MSF. Roger Francis has recently written a book on desalination for NACE which discusses the different material options for all three types of desalination.
- Q. What are limiting temp for titanium from crevice point of view.
  - A. It is normally accepted that Ti grades 1, 2 and 5 are good up to about 70°C in seawater with tight crevices. With mild crevices higher temperatures are possible. NB Schutz put this as 76-80°C for Grades 1,2,3,5,9,23 and 32. Other alloys were much higher and over 200°C.

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- **Q.** The Black beast in corrosion and corrosion protection is the mechanism of action. How can chloride attack the surface of a copper alloy (brass)
  - A. As with other copper alloys, chlorides are not really a problem in sea water, sulphides can be and ferrous sulphate dosing can improve the corrosion resistance for such as Aluminium brass. Ammonia can also lead to SCC but usually in the atmosphere. As mentioned in the presentation surface films on copper alloys in sea water are complex. In fact for Al-brass in natural seawater the protective film is hydrotalcite which requires bacteria to complex the copper and zinc for it to form. It buffers the pH at the metal film interface by adjusting its composition and restricts access of chloride. In synthetic seawater or sodium chloride you just get Cu2O-which emphasises why testing should be in live sea water.
- Q. What is the best method of field SS pickling and repassivation?
  - A. There are pickling pastes that can be applied by brush and washed off. Care is needed with the disposal of the effluent.