Continuing Education Course #110
Corrosion Control and Tactics

1. A 2002 study funded by the Federal Highway Administration estimated that in 1998 the total direct cost of corrosion – across all U.S. industries – was approximately:
- a. $2 trillion or more than 13% of the GDP
- b. 276 billion or more than 3% of the GDP
- c. $28 million or more than 0.3% of the GDP
- d. $30 billion or more than 3% of the GDP

2. The two fundamental electrochemical reactions in aqueous corrosion are:
- a. Galvanic corrosion and intergranular fracture
- b. Oxidation at the cathodes and reduction at the anodes
- c. Oxidation at the anodic areas and reduction at the cathodic areas
- d. Thermodynamic factors governed by kinetic factors

3. All of the following liquids might be potential electrolytes except:
- a. Acid solutions
- b. Seawater
- c. Caustic (NaOH) solutions
- d. Gasoline

4. Corrosion rates are directly proportional to the rate of measured:
- a. Current or current density
- b. Thermodynamic equilibrium electrode potential, E_q
- c. Ionization
- d. Ability to passivate

5. In active-passive metals such as stainless steels, localized forms of corrosion, e.g., pitting, are likely when the metal's electrode potential first becomes more noble than this value:
- a. Primary passive potential, E_{pp}
- b. Equilibrium potential, E_q
- c. Protection or Breakdown potential, E_{loc}
- d. The potential of maximum current density

6. Adding extra thickness to a metal as a corrosion allowance - above the thickness needed to meet mechanical stress requirements - is most effective for this form of corrosion:
- a. Galvanic
- b. General
- c. SCC
- d. MIC

7. All of the following statements concerning crevice corrosion are true except:
- ○ a. The size of the crevice opening directly affects whether attack will occur
- ○ b. Two metallic surfaces in near proximity to each other are required
- ○ c. It is more likely on no-flow, stagnant conditions
- ○ d. It is a localized form of corrosion

8. All of the following application conditions apply to corrosion fatigue except:
- ○ a. The frequency of the applied stress is not important to the extent of attack
- ○ b. Cyclic, tensile stress is required
- ○ c. Relatively benign corrosive media can cause attack
- ○ d. Often if an alloy is susceptible to pitting in a given electrolyte, it is also susceptible to this form of attack in that same medium

9. Most metallic materials are susceptible to MIC with this one, possible exception:
- ○ a. Stainless steels with high levels of chromium
- ○ b. Nickel alloys with low carbon levels
- ○ c. Titanium alloys
- ○ d. Weathering steels, e.g., A588

10. The corrosion rate of steel does not continue to increase with continual increases in electrolyte temperature in this application:
- ○ a. The only possible reduction reaction is oxygen reduction in a recirculating, cooling water system that is open to the atmosphere
- ○ b. The only possible reduction reaction is hydrogen ion reduction to produce hydrogen gas in an acid transporting system that is open to the atmosphere at select locations
- ○ c. The inner surface of the steel – exposed to an acid electrolyte – has sacrificial CP anodes installed to protect it
- ○ d. E-C is the only form of corrosion occurring and it is insensitive to temperature changes

11. In general, the presence of hard water is less aggressive than soft water in causing corrosion because:
- ○ a. Hard water is more thermodynamically stable
- ○ b. Small increases in velocity of soft water cause major increases in corrosion rates
- ○ c. Hard water contains minerals that often precipitate as carbonates that form scales on the metal surfaces. Scales act as barriers to corrosion when uniformly distributed.
- ○ d. Soft water produces large quantities of soap lather that is known to promote corrosion

12. Which of the following statements is true concerning the anodic polarization behavior of a typical active-passive alloy IF one or more of the following application variables change, 1) the electrolyte temperature increases and/or 2) the chloride ion concentration in the electrolyte increases and/or 3) the pH of the electrolyte decreases:
- ○ a. The rate of attack in the active corrosion range decreases
- ○ b. The potential range over which the alloy is passive decreases
- ○ c. The potential at which passive film breakdown occurs becomes more noble
- ○ d. The protection potential, E_{pp}, occurs at a lower corrosion rate

13. Carbon steels and other metals often show a critical velocity above which there is a significant increase in the rate of corrosion in certain electrolytes. The form of corrosion that occurs when this critical value is exceeded is usually:
- ○ a. Pitting
- ○ b. SCC
- ○ c. E-C
- ○ d. MIC

14. Greater extents of corrosion are often seen on partially buried steel or iron objects at the air-to-soil interface. This is primarily because:

○ a. Soil is never a good electrolyte
○ b. The upper portions of the objects are wetted by rain but the buried portions are not
○ c. Atmospheric corrosion is always more severe than the corrosion that occurs underground
○ d. Air (specifically, oxygen) to support the common oxygen reduction cathodic reaction in corrosion of the steel or iron is readily available in the atmosphere above ground and slightly below the ground level but it must diffuse through the soil to reach deeply buried portions of the metal. Thus below ground corrosion rates are typically much slower.

15. All of the following represent heterogeneous conditions in an application that often produce accelerated corrosion except:
○ a. Galvanic couplings of dissimilar metals
○ b. Use of commercially pure metals rather than alloys of those metals
○ c. Crevices
○ d. Welded areas

16. This classic form of corrosion control is likely the most widely used of the four types:
○ a. Chemical inhibitors
○ b. Good material selection
○ c. Coatings and linings
○ d. Cathodic protection

17. The compressive stresses created by shot peening an exposed metallic surface are helpful in providing resistance to both of these two forms of corrosion:
○ a. HE and pitting
○ b. SCC and galvanic attack
○ c. MIC and IGA
○ d. Corrosion fatigue and SCC

18. A high percentage of this alloying element in stainless steels and in nickel alloys (that contain chromium) is particularly important for imparting increased resistance to pitting and crevice corrosion for exposure to water and other media that have high concentrations of chloride ions:
○ a. Carbon
○ b. Titanium
○ c. Molybdenum
○ d. Copper

19. Which of the following statements best describes an impressed current cathodic protection (ICCP) system:
○ a. A rectifier/transformer and slowly-corroding anodes are used
○ b. The system will have lower initial and operating costs relative to a sacrificial anode CP system
○ c. A rectifier/transformer and sacrificial anodes are used
○ d. Unlike a sacrificial anode CP system, once it is installed correctly no follow-up attention is required to keep it operating as intended

20. Probably the most common applications of chemical corrosion inhibitors are in:
○ a. Facilities that manufacture food-quality products
○ b. The mix water for concrete that will be poured to surround bare, steel rebar
○ c. Recirculating cooling water or oil field production systems
○ d. Applications where HE will occur if an inhibitor is not used

21. This design feature should always be considered as the one essential in any application where one of the forms of corrosion may occur:
○ a. Minimize the number of welds used
○ b. Include geometry, sloping and sufficiently sized outlet openings to provide for consistent, complete drainage of

any electrolyte

- ○ c. Recognize that a stainless steel will always provide more corrosion resistance than plain carbon steel
- ○ d. Recognize that applied stresses are much more important in promoting attack compared to residual stresses

22. Analyzing and effectively controlling the many aspects of aqueous corrosion often requires persons experienced in particular subjects. This need for specialized knowledge is particularly important for practical success in these two areas:

- ○ a. Pitting and crevice attack
- ○ b. Rebar corrosion in concrete and SCC
- ○ c. Inhibitors and MIC
- ○ d. Coatings and dealloying

23. The abilities of stainless steels and nickel alloys to resist SCC in waters with high concentrations of chlorides are strongly influenced by the percentage of nickel in the given material. Which of the following statements best describes that relationship?

- ○ a. High purity ferritic stainless steels that contain little or no nickel are very susceptible to SCC
- ○ b. Stainless alloys or nickel alloys that contain 20% nickel or more provide similar good resistance to SCC and, surprisingly, so do high purity ferritic stainless steels with little or no nickel
- ○ c. 304 and 316 austenitic stainless steels with 8 to 14 % nickel have optimal levels of this element to provide the best SCC resistance
- ○ d. Nickel-based alloys, i.e., those with more than 50% nickel, have higher costs but while they are preferred for other service environments; they are no better in resisting SCC than 304 or 316 stainless steels in this particular electrolyte

24. If galvanic corrosion cannot be controlled by any other means, use this approach:

- ○ a. Apply a suitable coating to the anodic metal in the galvanic couple
- ○ b. Join metals that are widely separated in a traditional galvanic series
- ○ c. Make the anodic metal area much larger than the area of the cathodic metal
- ○ d. Make the cathodic metal area much larger than the area of the anodic metal

25. All of the following may be useful in the early stages of engineering to achieve optimal control of corrosion in a perspective project except:

- ○ a. Using the FMEA procedure to assess the importance of possible failure modes
- ○ b. Basing decisions on alternative control approaches solely on their initial costs
- ○ c. Carefully reviewing design details that may be detrimental to good control
- ○ d. Investigating the use of non-metallic materials that won't corrode