Continuing Education Course #466
Forensic Engineering - Part D
Case Histories: Corrosion Failure Analyses

1. Which one of the following statements is true?

○ a. Tubercules are defects that may exist in the metallurgical cross-section of piping material

○ b. Tubercules are flat deposits sometimes found on the inner surfaces of piping

○ c. Tubercules are generally round or semi-conical shaped, raised deposits consisting of the chemical results of corrosion, i.e., they are a specific type of corrosion product.

2. Which one of the following statements is true?

○ a. The morphology of the pipe cross-sectional areas of corrosion pits on stainless steels are generally much wider than their depths.

○ b. The morphology of the pipe cross-sectional areas of corrosion pits on carbon steels are generally much wider than their depths.

○ c. The morphology of the pipe cross-sectional areas of corrosion pits on stainless steels and carbon steels are generally similar.

3. Which one of the following statements is true?

○ a. It is generally seen that iron and steel plus many other metals have low rates of corrosion in corrosive liquids having a pH above 5 but less than 10 when other variables that affect corrosion rates are also not aggressive.

○ b. It is generally seen that iron and steel plus many other metals have low rates of corrosion in corrosive liquids having a pH less than 5 when other variables that affect corrosion rates are also not aggressive.

○ c. It is generally seen that iron and steel plus many other metals have low rates of corrosion in corrosive liquids having a pH above 10 when other variables that affect corrosion rates are also not aggressive.

4. Which one of the following statements about two methods used to detect the presence and numbers of bacteria, traditionally associated with MIC, in solid or water samples is true?

○ a. The culturing method identifies only live bacteria.

○ b. The DNA method requires that the samples be kept a given temperature and arrive at the lab within a limited time period.

○ c. The DNA method identifies only dead bacteria.

5. Which one of the following statements about oxygen concentration cell corrosion is true?

○ a. Oxygen concentration cell corrosion never occurs when MIC is also active.

○ b. The anodic corrosion reaction in the electrochemical cell that is formed occurs under the surface deposit where there is a low concentration of oxygen.

○ c. The anodic corrosion reaction in the electrochemical cell that is formed occurs outside of the surface deposit where there is little or no corrosion product deposited and a low concentration of oxygen exists.

6. Which one of the following statements is true?

○ a. Researchers are now confident that they understand how bacteria associated with MIC produces accelerated corrosion that in the absence of those bacteria corrosion would go at a slower rate.

○ b. The morphology of corrosion under tubercles is generally like that found in general corrosion.

○ c. The characteristics of the slime, called a biofilm, created by slime -forming bacteria in a water environment, are that it is mostly water plus some nutrients necessary for bacteria to multiply, it is initially microscopically thin and it is sticky.

7. Which one of the following statements is correct?

○ a. As the temperature of humid ambient air decreases, the probability of water condensation increases.

○ b. As the temperature of humid ambient air decreases, the probability of water condensation decreases.

○ c. Water condensation from humid air cannot occur at temperatures below the Dew Point temperature.

8. Which one of the following statements is true?

○ a. A corrosion rate of 11 mpy is not considered a high corrosion rate for plain carbon steel exposed to only fresh water at normal ambient air temperatures.

○ b. One mil is equivalent to 0.01-inch.

○ c. One mil is equivalent to 0.0001-inch.

9. Which one of the following statements is correct?

○ a. Barlow's formula can be used to calculate the rate of corrosion of a metal if the depth of corrosion penetration is carefully measured with a manual pit gauge.

○ b. Barlow's formula can be used to calculate the maximum allowable internal pressure in a pipe for a given set of input variables.

○ c. The length of the pipe section is a necessary input variable in correct usage of Barlow's formula.

10. Which one of the following statements is true?

○ a. Rust Bloom is often seen after the corrosion of all metals.

○ b. Rust Bloom can only occur after the corrosion of non-ferrous alloys

○ c. The volume of Rust Bloom usually is 2 to 4 times the total volume of the solid metal that was consumed in the corrosion process.

11. Which one of the following statements is most useful in conducting interviews?

○ a. Separate interviews with each knowledgeable party in a failure case are usually advisable to obtain the most unfiltered and objective information.

○ b. In most failure analyses it is advisable when gathering information to conduct a joint questioning session with all of the knowledgeable parties to simultaneously obtain needed facts.

○ c. In most failure analyses it is advisable when gathering facts through interviews to conduct a session only with the knowledgeable individual responsible for approving the analyst's invoice. That individual has the best information.

12. Which one of the following statements is correct?

○ a. Type 304 austenitic stainless steel can provide many good properties including its high resistance to pitting and crevice corrosion in saltwater.

○ b. Type 304 austenitic stainless steel can provide many good properties but its high cost limits its widespread use compared to other stainless steel alloys.

○ c. Type 304 austenitic stainless steel can provide many good properties but its corrosion resistance often is marginal depending on the specific application.

13. Which one of the following statements is correct?

○ a. A favorable area ratio to decrease aggressive galvanic corrosion between two dissimilar metals is one in which the anodic (more active) metal area is smaller than the cathodic (less active) metal area.

○ b. Using an electrical insulating material between two dissimilar metals is much less important to decrease aggressive galvanic corrosion than the metals' area ratio.

○ c. A favorable area ratio to decrease aggressive galvanic corrosion between two dissimilar metals is one in which the anodic (more active) metal area is larger than the cathodic (less active) metal area.

14. Which one of the following statements is true?

○ a. When a vertical section of metal is exposed to a water/air interface more corrosion will occur further below that level because the metal is continually wetted there.

○ b. When a vertical section of metal is exposed to a water/air interface more corrosion will occur at that level because of the simultaneous availability of both water and free air. Oxygen in the free air is necessary for the common oxygen reduction cathodic reaction.

○ c. The anodic reduction corrosion reaction at a water/air interface is primarily dependent on the availability of oxygen from the free air at that level. The cathodic reaction depends on the metal being wetted.

15. Which one of the following statements is true?

○ a. Generally, the most impactful alloying element compared to other additions to stainless steels to provide resistance to pitting and crevice corrosion in corrosive media having a high level of chloride ions is chromium (Cr).

○ b. Stainless steel alloys 316 and 317 are inferior to the 304 for imparting high resistance to pitting and crevice corrosion in corrosive media having a high level of chloride ions because they have no molybdenum (Mo).

○ c. Generally, the most impactful alloying element compared to other additions to stainless steels to provide resistance to pitting and crevice corrosion in corrosive media having a high level of chloride ions is molybdenum (Mo).

16. Which one of the following statements is true?

○ a. Nitrogen is added to stainless steels in large quantities. Therefore, it is more beneficial than Mo is imparting pitting and crevice corrosion resistance in high chloride corrosive media as predicted by the PREN relationship.

○ b. The PREN relationship can be used to make approximate comparisons of the relative chloride pitting and crevice corrosion resistances of different wrought austenitic and duplex stainless steels in terms of the weight percentages of certain elements in their compositions.

○ c. The value of the PREN relationship for a given stainless steel alloy is always more important than its heat treatment or service variables in predicting its pitting resistance in high chloride corrosive media.

17. Which one of the following statements is true?

○ a. Cementation is a galvanic corrosion process that occurs on aluminum alloys due to ions generated from the corrosion of heavy metals such as iron, copper, lead and mercury that collect on aluminum and initiate a pit at many separate spots.

○ b. Cementation is a galvanic corrosion process that occurs on aluminum alloys due to ions generated from the corrosion of heavy metals such as iron, copper, lead and mercury. It occurs because aluminum alloys are cathodic to each of these ions that are anodic to aluminum so pitting of the aluminum initiates.

○ c. Cementation is a galvanic corrosion process that occurs on aluminum alloys due to the chromium ions that are generated by the corrosion of 304 stainless steel. Chromium (Cr) ions are anodic to cathodic aluminum so pitting on the aluminum occurs at separate spots.

18. Which one of the following statements is correct?

○ a. Significant deformation is often seen after brittle fracture of metals.

○ b. Significant deformation is often seen after ductile fracture of metals.

○ c. A small amount of plate deformation after fracture is a primary indicator of ductile failure of a metal.

19. Which one of the following statements is correct?

○ a. The cost of the optical emission spectroscopy (OES) method to determine the chemical composition metals is high but it requires only small amounts of the metal to complete an analysis.

○ b. The cost of the inductively coupled plasma spectrometer (ICP) method to determine the chemical composition metals is low but it requires an only very small amount of the metal to complete the analysis.

○ c. Both the ICP and the atomic absorption (AA) methods to determine the chemical compositions of metals have high costs but they require only small amounts of the metal to complete valid analyses.

20. Which one of the following statements is correct?

○ a. Inclusion are defects on the surface of a metal that are often provide sites for the initiation of fatigue

○ b. Inclusions are non-metallic particles in a metal that are foreign to the normal microstructure and that can be initiation sites for cracks that eventually lead to ductile fracture.

○ c. Inclusions are metallic compounds in a metal that are a normal part of a metal's microstructure and that contribute resistance to internal crack formation.

21. Which one of the following statements is true?

○ a. Natural soft rubber provides a good tank liner material for transporting hydrochloric acid but its cost is high

○ b. Natural soft rubber provides a good tank liner material for transporting hydrochloric acid and its cost is lower than chlorobutyl rubber.

○ c. Tanks constructed of certain aluminum alloys offer more beneficial properties for transporting hydrochloric acid than any type of rubber lining material on a steel substrate.

22. Which one of the following statements is true?

○ a. The plaintiff in a law suit has the burden of proof to show its claim against the defendant is valid.

○ b. The defendant in a law suit has the burden of proof to show its case against the plaintiff is valid.

○ c. The plaintiff and the defendant in a law suit each have an equal responsibility to show their case is valid and that the other party's case is not valid.

23. Which one of the following statements is correct?

○ a. When photographing evidence for use in a failure analysis report, it is most important to take several photos of the specific area of failure.

○ b. When photographing evidence for use in a failure analysis report, it is often better to initially take one or more photos that illustrate the overall scene followed by close-up shots that provide details of the failure.

○ c. When photographing evidence for use in a failure analysis report, a brief verbal description of the general scene of the failure is sufficient because close-up photos of the details of the failure are most critical for the report reader to understand.

24. Which one of the following statements is true?

○ a. A reduced chemical compound is formed after an element gains electrons, i.e., its valence becomes more negative, during a chemical oxidation/reduction reaction and the new compound is created.

○ b. A reduced chemical compound is formed after an element losses electrons, i.e., its valence becomes more negative, during a chemical oxidation/reduction reaction and the new compound is created.

○ c. A reduced chemical compound is formed after an element gains electrons, i.e., its valence becomes more positive, during a chemical oxidation/reduction reaction and the new compound is created.

25. Which one of the following statements is true?

○ a. The EDS auxiliary to a scanning electron microscope (SEM) is able to identify and accurately quantity the concentration levels of all compounds present in a sample according to spectrum peak heights provided.

○ b. The EDS auxiliary to a scanning electron microscope (SEM) is able to identify and accurately quantity the concentration levels of reduced sulfur compounds present in a sample according to spectrum peak heights provided.

○ c. The EDS auxiliary to a scanning electron microscope (SEM) is able to identify and provide approximate relative concentration levels of the elements present in a sample according to spectrum peak heights provided.

26. Which one of the following statements is correct?

○ a. Failure or on and off "glitches" in normal operation of electronic devices can occur due to the presence of tarnish or corrosion product on contact points if the tarnish thickness is small but the operating voltage is high.

○ b. Failure or on and off "glitches" in normal operation of electronic devices can occur due to high resistance on contact points if the tarnish thickness is too small but the operating voltage is high.

○ c. Failure or on and off "glitches" in normal operation of electronic devices can occur when the resistances of contact points are high and the general operating voltage is low.