



[Visit Suncam.com for more courses](http://www.suncam.com)

Continuing Education Course #284
Forensic Engineering - Part C
Case Histories: Metallurgical & Mechanical Failure Analyses

1. A valuable procedure used here in solving these cases and in most root-cause failure analyses is as follows:
 - a. The Fishbone Procedure.
 - b. The Scientific Method.
 - c. The Miner Rule.
 - d. The Negotiated Settlement Approach.
2. What failure mechanism involves time-dependent plastic (permanent) strain produced at a constant stress and high temperatures?
 - a. Creep.
 - b. Sulfurization.
 - c. Thermal fatigue.
 - d. High temperature oxidation.
3. The three forms of heat transfer are:
 - a. Turbulent flow, laminar flow and conduction.
 - b. Laminar flow, shearing transfer and boundary layer flow.
 - c. Conduction, convection and radiation.
 - d. Vortex shedding, subsonic transfer and black body radiation.
4. Overheating of steel can result in what material characteristic seen in polished and etched cross-sections of the steel during metallographic examinations?
 - a. Copper oxides.
 - b. Manganese sulfides.
 - c. Small grain sizes.
 - d. Enlarged grain sizes.
5. The ultimate tensile strength (UTS) of plain carbon steel decreases rapidly at temperatures above this approximate value:
 - a. 300 °F
 - b. 400 °F
 - c. 1000 °F
 - d. 1350 °F
6. The typical pitting corrosion sites that appear on aluminum alloys have these features:
 - a. Generally, are large in diameter, closely spaced and show large amounts of corrosion product.
 - b. Generally, are oblong in shape, widely spaced and have high pH corrosion products.
 - c. Generally, are small in diameter, closely spaced and show only small amounts of corrosion product.
 - d. Generally, are large in diameter, widely spaced and corrosion product is brownish red in color.

7. In the often used aluminum alloy 6061-T6, the levels of which three critical alloying elements are limited because they can promote several types of corrosion?
- a. Manganese, carbon and copper.
 - b. Copper, iron and lead.
 - c. Chromium, nickel and calcium.
 - d. Sulfur, iron and calcium.
8. A specific feature of pitting corrosion on many metals in a chloride-containing environment is that the pH of the corrosion product in pits has this property:
- a. It becomes much more acidic than that of the service environment.
 - b. It is the same as the service environment.
 - c. It becomes much more alkaline than that of the service environment.
 - d. Its value depends on the zinc content of the metal.
9. What compound, identified here in a case, is very aggressive in promoting corrosion of aluminum alloys?
- a. Iron oxide.
 - b. Calcium carbonate.
 - c. Manganese sulfide.
 - d. Calcium chloride.
10. The typical chloride concentration in seawater is:
- a. Lower than the concentration in brackish water.
 - b. 20000 ppm or more.
 - c. Lower than the concentration in atmospheric air in a marine area.
 - d. About 2000 ppm or less.
11. If a galvanic corrosion cell is created because of physical contact between aluminum and stainless steel in a wetted environment, what will occur?
- a. Both metals will corrode at about the same rate.
 - b. The aluminum will corrode at a faster rate than if not in contact with the stainless.
 - c. The stainless will corrode at a faster rate than if not in contact with the aluminum.
 - d. The stainless will become the anode and the aluminum will become the cathode in the cell.
12. Stress relief annealing is a heat-treating process that entails the following steps:
- a. Heating the part to a high temperature, holding it there for an extended period and then rapidly cooling the part.
 - b. Heating the part to a relatively low temperature, holding it there for a short period and then slowly cooling the part.
 - c. Heating the part to near its melting temperature, holding it there for a short period and then rapidly cooling the part.
 - d. Heating the part to a relatively low temperature, immediately rapidly cooling it and then repeating the first two steps two more times.
13. In Case 3, the type of fracture of the copper fitting was confirmed to be brittle because of the following characteristic seen when the fracture surface was viewed in a SEM:
- a. The smooth texture and appearance.
 - b. The presence of significant macro-scale plastic deformation.
 - c. The uneven dimpled appearance.
 - d. The presence of distinct striations.
14. One reason that etching a mounted and polished metallographic metal specimen is useful is because?
- a. Small size grains are preferentially attacked by the corrosive etchant and only large size grains remain.
 - b. Less polishing steps are needed to complete a thorough examination of the microstructure.

- c. Very corrosion-resistant alloys can then be closely examined.
- d. Grain boundaries are preferentially corroded by the etchant and thus the grain sizes in the metal are revealed.

15. A deficient stress relief annealing process that involves either a holding temperature that is too high, a holding period that is too long or both can produce what result?

- a. Large grain sizes that weaken the metal.
- b. Reduced corrosion resistance.
- c. Lower ductility in the metal.
- d. More sulfide inclusions in the microstructure.

16. Which less expensive laboratory technique can be used to analyze the chemical composition of a metal when there is sufficient material available?

- a. Inductively coupled spectrometer (ICP).
- b. Atomic absorption (AA).
- c. Optical emission Spectroscopy (OES).
- d. Metallography.

17. A direct indicator of a material's ductility that is defined in the ASTM E8 standard tensile test is:

- a. Ultimate tensile strength.
- b. Percentage elongation.
- c. Yield strength.
- d. Endurance limit.

18. If large enough (as defined by ASTM F788), these metallurgical features created during the rolling of threads on smooth rods to create bolts can act as stress concentration points that lower the resistance of the finished bolt to the initiation of fatigue. What are these features?

- a. Laps.
- b. Banding.
- c. Small grain sizes.
- d. Homogeneous microstructure.

19. In most waters, corrosion of vertically installed carbon steel is most severe in the splash zone just above and slightly below the low water level for what reason?

- a. The chloride concentration of the water is greatest in that region.
- b. Oxygen from the air is most readily available to the wetted steel there to promote the common cathodic reduction corrosion reaction.
- c. The electrochemical anodic and cathodic corrosion reactions occur at different rates in that region.
- d. The steel stays wetted for the longest period in that region.

20. Older manufactured ERW pipe (made before about 1978) typically was welded using low frequency AC electric current. Older pipe also had this additional characteristic that made it much more susceptible to grooving corrosion compared modern ERW pipe. What is it?

- a. It had high percentages of copper and chromium.
- b. It had very low percentages of sulfur.
- c. It had significant amounts of sulfur.
- d. It contained no manganese.

21. The non-homogenous microstructure of welds makes them more likely to experience this metallurgical property compared to the parent metal:

- a. Higher ductility.
- b. Accelerated corrosion rates.

- c. Reduced corrosion rates.
- d. Lower strength.

22. In a typical photomicrograph of a steel specimen that has been polished and etched, the areas of the microstructure that have a high concentration of ferrite have what characteristic?

- a. They contain significant amounts of carbon and appear dark in color.
- b. They are mixed dark and white in color.
- c. They are essentially a white phase in color that is void of carbon.
- d. They are not magnetic.

23. Small chevron-shaped markings on a fracture surface provide this information:

- a. They indicate the failure was by fatigue.
- b. They point in the direction of crack growth.
- c. They point towards the origin of the cracks.
- d. They indicate the failure was ductile.

24. A specific, minimum ratio (3.0) of the manganese-to-carbon contents in steels is known to be required to provide what property?

- a. Yield strength.
- b. Resistance to brittle fracture at low temperatures.
- c. Adequate fatigue strength.
- d. Ultimate tensile strength.

25. Susceptibility to brittle fracture of steels at low temperature, i.e., as defined by their DBTT property, is often determined by what?

- a. Percentage elongation as established in a standard tensile test.
- b. Average grain sizes as determined by metallographic examination.
- c. Measured impact energies of multiple Charpy V-notch specimens tested over a range of temperatures.
- d. Yield strength as defined in a standard tensile test.

[Purchase this course on Suncam.com](http://Suncam.com)