**Introduction**

Unexpected or premature failure of chemical process equipment constitutes a serious hazard in terms of safety of personnel, operating facilities, and the environment. By weakening reliability, such failures also adversely affect productivity and profitability. Modern industrial experience in chemical plants has been that failures due to environmental cracking are among the most serious of such problems, making up about 20 to 30% of all corrosion failures. The subject of stress corrosion cracking (SCC) is extensive, and the focus of this issue is to discuss in simple terms some of the pertinent information.

**General Description**

SCC has been defined as failure by cracking under the combined action of corrosion and typically tensile stress. The stress and corrosion components interact synergistically to produce cracks, which initiate on the surface exposed to the corroding media and propagate in response to the stress state.

- Metallurgical variables (heat treatment, structure, cold work) which render the alloy susceptible
- Environmental boundary conditions for cracking such as temperature, solution composition, pH, electrode potential, necessary impurities, etc.

It is important to realize that the conditions causing SCC may not occur during normal operation of equipment but also during startup, shutdown, idle periods, or system upsets. Stresses and environmental conditions under these circumstances can be quite different than those encountered during normal operation.

**Identification**

Visual identification prior to failure is difficult due to the typical tightness of stress-corrosion cracks. A low-power hand lens will greatly aid determination. Detection of cracks can be enhanced by using ultrasonic, radiographic, liquid penetrant or acoustic emission techniques.

Stress-corrosion cracks tend to branch along the metal surfaces. Typically, evidence of corrosion, such as accumulations of corrosion products, is not observed, although stains in the cracked region may be apparent. Stress-corrosion cracks tend to originate at physical discontinuities, such as pits, notches, and corners. Areas that may possess high-residual stresses, such as welds or arc strikes, are also susceptible.

**Cracking Locations**

**REACTORS:** All weldments; circumferential welds by which nozzles are attached; radius of dished head; external jackets especially half-pipe coils.
HEAT EXCHANGERS: Weldments; nozzles; areas immediately adjacent to the tube-sheets; U-bends.

COLUMNS: Weldments, especially circumferential nozzle welds; radii of dished heads; packing (e.g. Rasching rings); Expanded metal packing or mesh; Trays.

PIPING: Bends; welds

Preventive Measures

There are a number of different ways to control SCC. The method used depends on the application and may involve changing the mechanical, metallurgical and environmental conditions.

- **Mechanical**
  - Avoid stress concentrators
  - Relieve fabrication stresses
  - Introduce surface compressive stresses
- **Metallurgical**
  - Change alloy composition
  - Change alloy structure
  - Use metallic conversion coating
- **Environmental**
  - Modify environment
  - Apply anodic or cathodic protection
  - Add inhibitor
  - Use organic coating
  - Modify temperature

Laboratory and Plant SCC Testing

Material engineers use SCC tests for the following tasks;

- Identifying environments which cause cracking on certain materials
- Ranking materials for relative SCC resistance in certain environments
- Evaluating preventive measures.

In plant equipment, stress corrosion cracks may take years to develop. Tests which precisely duplicate the stress level, metallurgical condition and environment anticipated in the plant might therefore require months to produce meaningful results. Since engineering decisions seldom allow the luxury of such extensive test times, almost all SCC tests are accelerated in one of several ways to truncate the time to failure. Laboratory and plant SCC testing are important sources of qualitative data for materials engineers.

Reference: Materials Technology Institute Manuals.
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