

Environmental Cracking in Structural Alloys

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What Is It?

Environmental cracking encompasses two well-known failure phenomena, corrosion fatigue and stress-corrosion cracking. In simplest terms, corrosion fatigue refers to the interaction of environment and cyclic stress, and stress-corrosion cracking involves the interaction of environment and sustained tensile stress. The two phenomena may be related, especially at the basic mechanism level, but they also exhibit important differences which can be of engineering significance, especially at the phenomenological level. Both phenomena can exhibit two stages of failure: (i) crack initiation, where previously unflawed material slowly develops a crack due to the combined action of environment and stress and (ii) crack propagation, where the crack grows slowly due to the combined action of environment and stress. In stress-corrosion cracking, an intermediate stage referred to as incubation can also occur, where an existing crack remains dormant, prior to initiating growth, under stress while crack-tip reactions are occurring. If left unchecked, environmental cracking can lead to mechanical failure. Generally, the mechanical fracture process that subsequently occurs, be it of a brittle or ductile nature, is unaffected by the environmentally-assisted process that preceded it. Also, the two environmental cracking phenomena can interact synergistically.

Corrosion fatigue and stress-corrosion cracking have been recognized for many years as potentially dangerous failure mechanisms in structural alloys. One of the more dramatic examples of failure involving environmental cracking was the collapse of the Point Pleasant Bridge at Point Pleasant, West Virginia on December 15, 1967.¹ This bridge collapsed without warning as a result of environmental cracking which led to brittle fracture of a high-strength steel eyebar suspension member.

Because of its complexity and because of its importance to modern technological activities such as defense, transportation and energy, research into environmental cracking has been very active in recent years. So far in