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Avoiding Caustic Stress Corrosion Cracking of Refinery Equipment and Piping

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Foreword

Caustic is used in many petroleum refinery applications in a wide range of concentrations and temperatures. Caustic stress corrosion cracking (SCC) of carbon steel (CS) equipment has been reported in industry since the 1930s, e.g., in riveted steam boilers. NACE has published guidance for handling sodium hydroxide (NaOH) in the form of a "Caustic Service Chart" since at least the mid-1960s. It is believed that the majority of the data used to produce the curves in the chart were developed by H.W. Schmidt, et al.[1] The Caustic Service Chart is currently published in the NACE Corrosion Engineer's Reference Book.[2] A modified copy of the chart is included as Figure 1 in this standard practice.

Scope

This standard practice is intended to provide guidance to those designing, fabricating, and/or maintaining refinery equipment and piping that are exposed to caustic environments.

Rationale

This standard has been revised in order to clarify considerations for the application of nickel-based alloys in area "C" of the Caustic Service Chart.

In AMPP standards, the terms *shall* and *must* are used to state requirements and are considered mandatory. The term *should* is used to state something that is recommended, but is not considered mandatory. The term *may* is used to state something considered optional.

Section 1: General

1.1 This standard practice establishes guidelines to avoid caustic SCC of equipment and piping. It addresses applications that use "fresh" caustic.

1.1.1 In some services that involve contaminated caustic, SCC has been observed at conditions within area "A" of the Caustic Service Chart shown in Figure 1 (particularly when contaminated with sulfide compounds). The need for thermal stress relief should be considered when the service contains contaminated caustic.

1.2 The practices detailed below are specifically intended for handling aqueous solutions containing sodium hydroxide (NaOH). However, several companies extend these practices to include aqueous solutions of other strong alkali compounds such as potassium hydroxide (KOH) and lithium hydroxide (LiOH). Although amines form a high pH solution and may cause SCC, it is considered a different mechanism for the purposes of this standard, and amine SCC is not addressed. A good reference on amine SCC is API[(1)] 945.[3] Carbonate SCC is another "different" SCC mechanism occurring at high pH, which is not included in the scope of this standard. It is covered by NACE Publication 34108.[4]

1.3 Some proprietary caustic solutions are used in the industry, e.g., potassium carbonate/bicarbonate solutions for carbon dioxide removal in hydrogen manufacturing units. Some of these systems rely on post-weld heat treatment (PWHT) to avoid SCC. These systems are outside the scope of this standard.

1.4 Other terms for caustic SCC used in past literature include caustic embrittlement, caustic cracking, and alkaline cracking.

Section 2: Cracking Mechanism and Prevention

2.1 Early cases of caustic SCC in CS were associated with steam boilers, more specifically, riveted boilers. In the riveted structures, cracks started in metal that was highly stressed. The majority of more recent industry cases of caustic SCC in CS equipment and piping are associated with non-stress-relieved welds, typically in the heat-affected zone (HAZ) and adjacent base metal. Although rare, cracking also occurs away from welds if high tensile stresses are present.

(1) American Petroleum Institute (API), 1220 L St. NW, Washington, DC 20005-4070, www.api.org.