Use of Duplex Stainless Steels in Hydroprocessing Reactor Effluent Air Coolers (REACs)

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1 Executive Summary

This technical report covers results of a survey of the petroleum refining industry concerning the use of duplex stainless steel (DSS) in hydroprocessing reactor effluent air cooler (REAC) systems. The API Committee on Refining Equipment Subcommittee on Corrosion and Materials (SCCM) commissioned this survey after several industry reports of weldment cracking failures with DSS REAC system components, including REAC header boxes, tube-to-tubesheet welds, and associated piping. REAC component weldment cracking has been addressed in SCCM documents, including API Recommended Practice 932-B and API Technical Report 938-C, in published conference papers, and in a report issued by the Materials Technology Institute (MTI).

Survey results and information from prior studies are used to summarize the weldment cracking issue and to prepare an approach for assessing the likelihood for in-service weldment cracking of DSS REAC system components.

Two types of weldment cracking are discussed:

1) in-service sulfide stress cracking (SSC) at weldments; and

2) hydrogen environment assisted cracking (HEAC) occurring during tightness testing in high-pressure hydrogen.

Most previously reported cases of REAC weldment cracking were from SSC due to elevated ferrite content in welds and heat affected zones (HAZ). An issue with DSS use in REAC environments has been that no effective nondestructive method for measuring ferrite at weld HAZ is available. Ferrite is controlled through control of welding parameters and welding procedure specification development. However, without a nondestructive test method for effectively measuring localized regions of high ferrite at weld HAZ, there is no assurance that high ferrite zones are not present.

This report provides a three-step process for assessing the likelihood of SSC in existing DSS REAC system components. It involves an evaluation of ferrite control during fabrication, a measure of environmental severity, and a consideration of in-service crack detection inspection results. It is suggested that this assessment process be used to prioritize metallurgy upgrades and in-service inspections.

For new hydroprocessing REAC system components, most refining operators are specifying Alloy 825 or Alloy 625 to avoid the risk of weldment cracking with DSS. Also, many refineries are upgrading existing DSS REAC components to Alloy 825 or 625 to avoid weldment cracking. Where DSS remains in service, the following may be evaluated:

— degree of confidence that highly effective crack-detection inspections can be completed and what inspection frequency is required to detect cracks prior to loss of containment;

— accessibility of weldments for inspection that is often limited; this influences the ability to perform highly effective crack-detection inspections;

— effect of surface temperature on inspection quality if crack-detection inspection is to be done while the unit is operating.