Engineering Consulting & Training Services

CARMAGEN Engineering, Inc.

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Systemic Design Failure of Reformer Heater Pigtails

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Catalyst-filled tubes in hydrogen, ammonia and methanol reformer heaters operate with metal temperatures in the range of 1,475°F to 1,750°F [800°C-950°C] with internal pressures between 250 to 500 psig [3.6-7.2 MPa]. They require high Ni-Cr alloyed and micro-alloyed metallurgies in cast and wrought form. The industry practice standard to design tubes for a 100,000 hour [11.4 year] life based on creep rupture criteria is API 530, "Calculation of Heater Tube Thickness in Petroleum Refineries."

Pigtails are specified as short piping segments that connect the catalyst-filled tubes to the subheaders, and hence are often fabricated from piping and fittings. A commonly specified material is SB 407 N08811 [alloy 800HT] with nominal composition of 33Ni-42Fe-21Cr, and combined with Al + Ti elements in the range, 0.85-20%.

Premature creep-rupture failure of pigtails has occurred after some 25,000 hours of service. Industry practice document API TR 942–A, "Materials, Fabrication, and Repair Considerations for Hydrogen Reformer Furnace Outlet Pigtails and Manifolds," was developed to highlight reliability concerns among hydrogen reformer heater operators and to address their contradictory service experience; while some operators experience problems, others do not. A case study in the technical report cited repeated rupture and [creep] cracking failures of reformer furnace pigtails at three (3) year (26,000 hour) intervals.

Investigation done by Carmagen for a client of a specific failure incident revealed a number of factors as contributors, which aligned with the guidance of API TR 942–A; however, the root cause failure analysis in this case appeared to be systemic failure in basic engineering design methodology.

Industry practice documents such as ASME VIII Division 1, Division 2 and API 530 contain mandatory requirements and guidance to construct safe and reliable facilities. However, it is incumbent on designers to implement practice document requirements with the background knowledge of the engineering principles upon which Codes and Standards are developed, and be alert to provisions that require attentive involvement of the designer.

In this specific case, tube design for the extremely high temperatures, though apparently in conformance with API 530, was nonetheless inadequate. Replicating the mechanical design process using the appropriate design methodology showed that failure was to be expected in approximately 40,000 hours. A large portion of the remaining tubes in the heater exhibited creep damage greatly in excess of expectations.

During an upcoming presentation at a pressure equipment conference, Carmagen Engineering will present these design methodology deficiencies and invite attendees to share their experiences with reformer heater reliability issues. Or, operators may contact Carmagen directly for customized assistance.

About the Author

John Aumuller has over 35 years' experience as a project manager and mechanical engineering specialist. He has expert knowledge of industry relevant codes, such as ASME, Boiler and Pressure Vessel Code Section VIII Div 1 and 2, Section I, B31.1, B31.3, CSA Z662, and related standards, including API standards.

Please contact Vince Carucci (vcarucci@carmagen.com) if you'd like more information on Carmagen's expertise.

Upcoming Training Courses

- *API 936 Refractory Inspection & Code*
  November 14-16, 2017
  Edmonton, Alberta, Canada
- *API 579 Delayed Coke Drum FFS & Damage Assessment to ASME FFS-1*
  November 21-23, 2017
  Edmonton, Alberta, Canada

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Work Highlights

Marine Terminal

- *Onsite safety assessment made of large refinery marine terminal and associated tank farm. While good site practice and installations were noted, deficiencies were identified in both areas and were prioritized High, Medium, and Low for potential following action by the refinery. High and Medium priority observations also included a recommendation to address the issue and mitigate risk.*

Piping Inspection

- *Gap assessment made of chemical plant's API 570 piping inspection program by materials engineering and inspection personnel. Numerous gaps with respect to API 570 and other industry requirements were identified and recommendations to close these gaps were provided.*