Root Cause Analysis Software Helps Refiner End Valve-Actuator Failures

At the Lyondell-Citgo petroleum refinery in Houston, TX, a decision was made some years ago to replace manually operated wedge-plug isolation and switch valves on the coker drums with motor operated, metal-seated ball valves. The change was expected to improve efficiency of these valve operations, critical to the refining process. The motor-operated valves are moved by actuators, and include a steam-purging system to reduce fouling and the residue build up that increases torque requirements on the actuator.

Twenty motor valves were installed at coker unit 736 in 1994; 34 were installed at coker unit 737 in 1996. The results were not as desired, and by 1998 recurring failures were causing reduced throughput and increased maintenance costs. Field replacement of the motor-operated valve actuators due to failed bearings, gears and motors became a recurring problem. Not only did this bring with it the obvious cost increases associated with replacement, but it put additional strain on the limited maintenance resources at the site.

In September 2000, the site purchased and installed the enterprise version of PROACT root cause analysis (RCA) software from Reliability Center, Inc., Hopewell, VA. The facility created an RCA team to determine the root cause of these failures. Using the software, it identified three main failure modes.

The first was that the actuators were undersized, even at maximum possible torque output, for the valves they were operating. For example, a 12-in.-feed isolation valve that was used requires a constant 19,000 ft. lbs. of torque through the valve travel cycle. The actuators in use, however, were only capable of delivering 7,500 ft. lbs., even after the short-term modifications to maximize torque output. Actuators for other motor-operated valves were similarly undersized.

The second failure mode discovered was insufficient steam-purge supply and distribution. The steam purge helps prevent residue from entering the seats and valve cavity, where it eventually turns to hard coke. This fouling significantly increases the torque requirement of the undersized actuators. It was discovered that some of the valves' purge points were too large, resulting in too much steam at those locations and not enough at other locations. In addition, the steam supply was determined to be below manufacturer recommendations, due to leaks and other factors.

The third failure mode discovered by the RCA team was inadequate protection for overload and heat in the motors. Overheating connected to the single phasing of the motor windings, often connected to moisture or contamination of power switches, resulted in failures. Overload protection was only on one phase of the motor windings, not all three.

The RCA team came up with a series of recommendations to resolve the three failure modes identified during the PROACT RCA process. They were:

1. Replace the actuators with properly sized units during the upcoming 736 Coker unit turnaround and on the 737 Coker unit as actuators fail, or by the next planned turnaround in 2004, whichever comes first.

2. Evaluate and modify steam-purge supply-flow orifices to better distribute steam purge to valve components, eliminate steam leaks, evaluate piping and pressure controls to better maintain purge pressure, and review standard operating procedures for possible valve sequencing changes to prevent valve cycles when pressure is low.
3. Finally, the team recommended updating the motor specifications to include 3-phase protection of windings against overloads, specifically from single phase loading.

Cost estimates for implementing the recommendations were $550,000 to $800,000 for both Coker units. Benefits were estimated at an annual savings of $300,000 per year in production losses based on documented losses in 1999 and 2000. After reduced maintenance costs of $200,000 per year based on SAP data for the same two years were calcluated, complete payback occurred within two years and an annual savings of $500,000 each year thereafter.

Implementation began in December 2001 with the replacement of the 20 actuators on coker unit 736. The new design meets the requirements for the service, in both size and torque design, and have been in service since that time without failure. The steam-purge design and distribution for the valves was optimized during the actuator replacement. Also, the steam-system design pressure was evaluated for possible improvements at a later date.

"The successful installation of these actuators highlights the efforts of a multi-discipline team using the PROACT RCA process to identify the root causes of these problems and develop a long term solution," says Eric Ellis, the plant's fixed equipment engineer and member of the RCA team. "The new actuators will be a major contributor to safe and reliable operation of the coker unit."

The total cost avoidance for not having any failures since the modification was implemented on Coker unit 736 is more than $300,000, which includes maintenance and production cost.