N. American Site #7 - Fluid Catalytic Cracker (FCC) Slurry Piping Pup Piece Rupture

Safety Impact			Environmental Impact		Production Impact		Damage
Fatalities	Injuries	First Aid	Leak Volume	Reportable	Days	Cost	Cost
0	0	1	Medium	Yes	?	$$$$	$$$

The Incident

A suspected leak was observed on the tubeside (slurry) inlet line to 1 of 3 parallel trains of Slurry/Feed Preheat exchangers on a Fluid Catalytic Cracking (FCC) unit. The leak rate appeared to be increasing so two sets of operators were sent to isolate the leak using block valves upstream and downstream of the leak location. The downstream valve was closed successfully but the upstream valve could not be closed because the chainwheel broke off after just a couple of turns. Approximately 1 minute later, the pup piece ruptured, resulting in a heavy oil/vapour cloud release which ignited, causing a significant unit fire. The FCC throughput was quickly reduced and the release/fire was contained by the emergency response team until the breach was finally isolated from the process. Public roads downwind of the release were closed for a brief period as a precaution. The fire took approximately 42 minutes to extinguish. One employee sustained a minor first aid injury while evacuating the unit. Three personnel were examined at the emergency room as a precaution and released and 133 personnel were examined and decontaminated (on site) as a result of potential oil overspray.

Background

Most of the piping in this circuit was installed in 1965 although there was no record indicating in which year the ruptured pup piece was installed. Metallurgical analysis revealed the pup piece was fabricated from carbon steel pipe with a silicon content of 0.03 – 0.04 wt% (ASTM A53). It had not been identified as a thickness measurement location (TML) as it was not shown on any drawings and could not be seen as the piping was insulated. However, the rupture location was less than 610 mm (24") away from a TML that was routinely monitored. Pipe and fittings immediately upstream of the pup piece had a silicon content of 0.07 – 0.25 wt% and had suffered much less thinning. The FCC unit had been running steadily for a couple of years prior to the incident with no significant operational upsets and had been running smoothly on the day of the incident. However, the total sulphur content of the feed to the FCC unit had gradually increased by approximately 20% since the end of 2000 as a result of refinery-wide optimisation activity.

Causes

The immediate cause of the rupture was high temperature sulphidic corrosion (HTSC) of an unmonitored low silicon carbon steel pup piece. A contributory factor was inability to close the inlet valve because the chainwheel came off (this caused the line to be isolated on the downstream side of the leak and impacted the extent of fire damage). Root causes included 1) inadequate material specifications (low silicon carbon steel), 2) failure to carry out a Management of Change (MOC) review to understand the impact of running high sulphur feedstocks, 3) inadequate communication with Inspection Department about the existence of the pup piece and the increase in FCC unit feed sulphur content, and 4) failure to learn lessons from other HTSC incidents at this and other refineries.

Lessons

Sulphidation corrosion causes thinning over a relatively large area so failures tend to involve ruptures or large leaks rather than pinhole leaks. It can be insidious in that moderately high corrosion rates can go undetected for years before failure. Process changes that result in higher temperatures or sulphur content can creep up over time and multiply corrosion rates so that systems which historically had low corrosion rates can become corrosive enough to fail before the increased corrosion rate is recognised. The addition of silicon in the manufacturing process reduces the amount of oxygen in carbon steel ("silicon killed") and increases its resistance to HTSC. High chrome alloys offer excellent resistance to HTSC and are inherently safer than carbon steels when operating at temperatures above 260 °C (500 °F).

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