N. American Site #5 - Naphtha Splitter Unit (NSU) Blowdown Vent Stack Vapour Cloud Explosion

Safety Impact			Environmental Impact		Production Impact		Damage
Fatalities	Injuries	First Aid	Leak Volume	Reportable	Days	Cost	Cost
15	66	114	Large	Yes	Shuttered	$$$$$$	$$$$

The Incident

A raffinate splitter was inadvertently overfilled with liquid during startup. As the splitter warmed up (pressure normal), liquid puked into the overhead line creating enough static head to cause the pressure safety valves (PSVs) to lift. The PSVs discharged a large quantity of hydrocarbons to an atmospheric blowdown vent stack which was not equipped with a flare. Most of the liquid released flowed to a closed sewer but some puked like a geyser from the top of the stack. The puked liquid vapourised, forming a large vapour cloud covering an approximate area of 112 m x 97 m (367 ft x 318 ft). The vapour cloud found an ignition source in a confined area and exploded (most likely ignited by an idling diesel vehicle engine parked at the perimeter of the unit). The explosion killed 15 people and injured 180 others.

Background

The function of the raffinate splitter is to separate the non-aromatic product from the Aromatics Recovery Unit (ARU) into light (~40 LV%) and heavy (~60 LV%) raffinate streams. The light raffinate is pumped to an intermediate storage tank and is used as a supplementary feed to the C5/C6 Isomerisation unit (ISOM). The splitter column is (164 ft) tall and contains 70 fractionation trays. The splitter PSVs are located on the overhead line at a similar elevation to the air-cooled condensers, below the top of the column. The function of the blowdown stack is to receive, quench and disperse hot hydrocarbon vapours and minor associated liquids from the ISOM relief, vent and pumpout systems during upsets or shutdowns. The blowdown stack is a 3.5 m (10 ft) diameter vertical drum with a 34 m (113 ft) high stack.

Heavy raffinate rundown to tankage had only been started some 3 hours after feed had been introduced to the splitter and burners had been lit in the fired splitter reboiler. When the heavy raffinate finally started to flow, the splitter feed temperature rose rapidly due to heat exchange in the feed/bottoms exchanger. This caused liquid to puke overhead and lift the PSVs. Several trailers (temporary offices) had been sited close to the ISOM battery limit for use by the turnaround contractors working on adjoining units. Consequently, there were far more personnel in close proximity to the unit than normal and they had not been informed of the impending startup. Fortunately, most of the fuel in the vapour cloud did not contribute to the blast (some was consumed in the fire and some dispersed harmlessly).

Causes

The immediate cause of the explosion was a loss of primary containment (LOPC) due to liquid overfill of the raffinate splitter and blowdown vent stack. Critical factors included faulty instrumentation (splitter and vent stack high level alarms), failure to institute liquid rundown before commencing heatup and inadequate control of work (trailers sited too close to process unit). Root causes included inadequate design (blowdown stacks are an obsolete design for venting and relief), failure to conduct a proper risk assessment (trailer siting), inadequate maintenance (instruments), failure to follow the startup procedure, inadequate training (troubleshooting skills), poor communication (shift handover) and inadequate investigation of previous raffinate splitter and blowdown vent stack incidents.

Lessons

Process unit startups are significantly more hazardous than normal operation so non-essential personnel must not be permitted on the unit or adjoining areas during startups. Instruments and alarms must be tested before startup to verify that they are functioning properly. Operating procedures for startup, normal operation and shutdown must be kept up to date and strictly enforced. Deviations from these procedures should be subjected to a formal Management of Change (MoC) review process. Vehicles must not be driven in classified areas (eg. process units, bunds) without first obtaining a hot work permit and vehicles must not be left running unattended anywhere on a refinery.

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