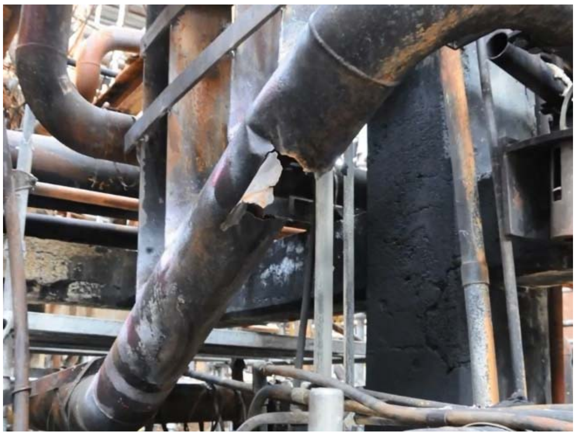
N. American Site #39 - Crude Distillation Unit (CDU) Light Gas Oil Sidedraw Line Rupture



Safety Impact			Environmental Impact		Production Impact		Damage
Fatalities	Injuries	First Aid	Leak Volume	Reportable	Days	Cost	Cost
0	26	~ 15,000	Large	Yes	?	$$$$	$$$$

The Incident

The light gas oil (LGO) sidedraw from a crude distillation unit (CDU) experienced a catastrophic pipe rupture releasing a large volume of hot LGO to grade. The hot LGO partially vapourised and formed a large vapour cloud which engulfed 19 company employees. Approximately 2 minutes after the rupture occurred, the fluid ignited. Eighteen employees managed to escape from the vapour cloud before it ignited; the other was engulfed in the fireball but was wearing full-body firefighting protective equipment and managed to make his way to safety. Six employees suffered minor injuries during the incident and subsequent emergency response activity. A large plume of vapour, particulates and black smoke travelled across the surrounding area and, over the next few weeks, approximately 15,000 people from neighbouring communities sought medical treatment for a range of ailments such as breathing problems, chest pains, sore throat and headaches. Twenty of these were admitted to local hospitals for treatment as inpatients.

Background

The CDU was built in 1976, several years before piping manufacturers had standardised their carbon steel piping specifications to include a minimum of 0.10 wt% silicon consistent with ASTM A106. The section of line that failed was fabricated from DN 200 (8" NS) carbon steel pipe (ASTM A53B) and had a silicon content of 0.01 wt%. It had suffered severe thinning. However, an elbow immediately upstream of the rupture location manufactured to the same (ASTM A53B) specification had a silicon content of 0.16 wt% and exhibited considerably less thinning. This elbow was one of a number of Corrosion Monitoring Locations (CMLs) which had been used to determine the condition of the entire LGO sidedraw system. However, due to specifics of the manufacturing process, carbon steel elbows and pipe fittings, even when manufactured to the ASTM A53B specification, generally contain high percentages of silicon. The operating conditions at the rupture location were approximately 338 ^{o}C (640 ^{o}F) and 3.8 barg (55 psig).

Causes

The immediate cause of the fire was loss of primary containment (LOPC) due to rupture of the LGO piping as a result of wall thinning caused by high temperature sulphidation corrosion (HTSC). Critical factors were failure to identify high corrosion rates in unmonitored low silicon carbon steel straight-run piping (due to CMLs being located in high silicon fittings) and inability to isolate the LGO sidedraw line from the process (this resulted in firefighters attempting to remove insulation from the leak area to enable Operations and Maintenance specialists to determine if an on-line repair using a pipe clamp was feasible or if a unit shutdown would be required). Root causes included inadequate material selection (carbon steel with low silicon content) and failure to implement industry-recognised HTSC risk mitigation measures (either conducting 100% component inspection on all high temperature carbon steel piping susceptible to sulphidic corrosion or upgrading to inherently safer materials of construction such as 5 Cr/0.5 Mo steel).

Lessons

Sulphidation corrosion (also known as sulphidic corrosion) is a result of naturally occurring sulphur compounds found in crude oils. It can be localised or general in nature although general thinning is most common. In the absence of hydrogen, the rate of sulphidation corrosion depends on many factors such as the concentration and type of sulphur compounds present and the fluid temperature and flow rate. Hydrogen sulphide (H_2S) is the most active sulphur species from a corrosion perspective and sulphidic corrosion rates increase rapidly above 260 ^{o}C (500 ^{o}F), especially for carbon steel. Carbon steels with a silicon content of 0.10 wt% or less are especially susceptible and can corrode at accelerated rates up to 16 times faster than carbon steel with a high silicon content. High chrome alloys offer excellent resistance to HTSC and are inherently safer than carbon steels when operating at temperatures above 260 ^{o}C (500 ^{o}F).

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