



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

The Incident

During a restart of the hydrocracker unit (HCU), the low pressure (LP) separator vessel suffered an explosive failure releasing the vapour and liquid contents of the vessel to atmosphere as a cloud or mist which subsequently ignited. This caused a fireball and blast effects due to the semi-confined nature of the plant and a contract crane driver in the vicinity was killed. The force generated by the explosion was equivalent to 90 kg (198 lb) of TNT and large fragments from the disintegrated vessel were projected over 1 km (0.6 miles) away. Fortunately, none of the fragments hit any personnel or vulnerable plant. Waxy material from ruptured pipework blocked drains, causing firewater to accumulate in a large pool. Leaking petroleum spirit spread over a large area of the pooled water and ignited some 5 hours after the initial explosion, engulfing a number of adjacent process units on the hydrocracker complex in flames. Fortunately, the incident occurred on a Sunday morning when there were far fewer personnel on site than a normal weekday.

Background

There were 9 operators and 1 contract crane driver present on the hydrocracker complex at the time of the incident. Eight operators were inside the brick-built local operating house (LOH) which contains a local control room and a mess room. One operator and the contract crane driver were outside. All 8 operators in the LOH escaped unharmed. The operator outside was far enough away to escape the worst effects of the blast but the contract crane driver died.

The investigation found that the liquid level in the upstream high pressure (HP) separator had drained away through 1 of 2 flow control valves configured in parallel on its liquid outlet line. Two low low (“extra-low”) level switches on the HP separator were considered unreliable because wax often solidified in their small bore piping and float chambers in cold weather. The trip mechanism that was supposed to act on the parallel flow control valves in case of extra-low level had been deliberately disconnected some years earlier. The horizontal LP separator vessel had a single pressure safety valve (PSV) which operated correctly at its set pressure of 10.7 barg (160 psig). However, it had not been designed for a gas breakthrough case because the extra-low level trip system was intended to preclude this possibility. Metallurgical examination found that LP separator rupture originated in the heat affected zone (HAZ) of a saddle weld on the underside of the vessel. This meant the blast was directed downwards with fragments projected upwards.

Causes

The immediate cause of the explosion was a loss of primary containment (LOPC) due to overpressure and subsequent catastrophic failure of the LP separator vessel due to gas breakthrough from the upstream HP separator vessel. Critical factors included 1) the alarms on the HP separator extra-low level detection system failed (operators not alerted to imminent danger), 2) the low level trip system on the HP separator had been deliberately taken out of service (no automatic shutoff capability on liquid outlet) and 3) the gas outlet line on the HP separator was isolated (valved closed) while the HCU was on standby with no feed to the unit (PSV was only available route for gas disposal). Root causes included inadequate risk assessment, failure to conduct a proper Management of Change (MOC) review, inadequate design of liquid shutoff system (independent extra-low level detection and secondary shutoff valve), inadequate design of PSV (not sized for gas breakthrough) and inadequate heat tracing and insulation (extra-low level switches).

Lessons

Trip systems should only be disconnected after careful risk assessment and an MOC review have been completed to verify that alternative means are in place to adequately control the associated hazards. The basis for the risk assessment should be properly documented and highlight any conditions affecting validity of the change (eg. maximum duration).