European Site #59 - Fluid Catalytic Cracker (FCC) Flare Knockout Drum Outlet Line Rupture

Safety Impact			Environmental Impact		Production Impact		Damage
Fatalities	Injuries	First Aid	Leak Volume	Reportable	Days	Cost	Cost
0	26	0	Large	Yes	~ 128	$$$$	$$$$

The Incident
A lightning strike on the crude distillation unit (CDU) caused a fire which triggered a shutdown of the CDU and domino shutdowns of all other process units except for the fluid catalytic cracker (FCC). Approximately 5 hours later, the FCC flare knockout drum outlet line ruptured, releasing flammable hydrocarbons which found an ignition source some 110 m away and subsequently exploded. A major fire ensued at the FCC flare knockout drum and a number of secondary fires erupted in adjacent plant. The explosion had incapacitated the flare system so the fires were allowed to burn themselves out. The last of the fires was extinguished some 2½ days after the explosion. The site suffered severe damage to process plant, storage tanks and buildings. Properties in the nearest town 3 km away suffered some glass damage. The refinery remained shut down for some 9 weeks and took a further 9 weeks to reach full capacity.

Background
The refinery-wide upset caused major operational problems at the FCC vapour recovery section. While attempting to re-establish normal levels, a sticking level control valve (LCV) blocked in the debutaniser, causing it to overfill. The overfill condition was not recognised by the board operator because the bottoms flowmeter was indicating a false positive flow (the downstream naphtha splitter remained empty) and he was distracted by the large number of alarms annunciating (“alarm flood”). The debutaniser pressure rose until the pressure safety valves (PSVs) lifted, sending light hydrocarbon liquids and vapours to the flare knockout (KO) drum. The debutaniser reflux drum offgas line to the wet gas compressor (WGC) interstage KO drum was manually opened to help relieve the pressure. However, the reflux drum was full so this caused liquid to puke to the interstage drum and trip the WGC. The flare dump valve at the WGC suction opened automatically which created a very high liquid level in the flare KO drum. The WGC trip meant there was insufficient dP between the interstage drum and the fractionator overhead accumulator to force the liquid out. So an unauthorised temporary modification was made using 2 steam hoses to drain the interstage drum to the flare header, enabling the WGC to be restarted. However, restarting the WGC caused the debutaniser pressure to rise again and the PSVs to re-open. The interstage drum level continued to rise and the WGC tripped again. The flare dump valve re-opened, passing high velocity gas into the overfilled flare KO drum. The resulting slugging caused hydraulic hammer which ruptured the outlet line and released 20 tonnes of flammable hydrocarbons to atmosphere. Fortunately, the incident occurred on a Sunday afternoon when there were fewer people on site than normal.

Causes
The immediate cause of the explosion was loss of primary containment (LOPC) due to rupture of a corroded DN 750 (30" NS) elbow on the FCC flare knockout drum outlet line. Critical factors were failure of the FCC debutaniser level control valve and inability of the board operator to diagnose liquid overfill. Root causes included inadequate maintenance (plant and instrumentation), inadequate monitoring tools (control panel graphics did not provide necessary process overviews), inadequate warning systems (too many alarms, poorly prioritised), inadequate training (troubleshooting skills), inadequate risk assessment (supervisors failed to assess risk of continuing operation under extreme upset conditions) and inadequate Management of Change (WGC interstage KO drum temporary drain hoses).

Lessons
Control panel graphics should provide a process overview including mass and heat balance data. Operators should be trained to properly interpret anomalous or inconsistent data. The number of alarms should be limited to a quantity that the operator can effectively monitor. Critical alarms should be highlighted and the required operator responses should be documented for each. All plant modifications (including emergencies) should undergo a formal hazard analysis.