


<b>Incident Title</b>		<b>Flare Knockout Drum Outlet Line Rupture</b>	
<b>Incident Type</b>		Explosion and Fire	
<b>Date</b>		24 <sup>th</sup> July 1994	
<b>Country</b>		UK	
<b>Location</b>		Milford Haven (Pembrokeshire)	
<b>Fatalities</b>		<b>Injuries</b>	
0		26	
		<b>Cost</b>	
		\$154 m – Ref. 2	
<b>Incident Description</b>		<p>A lightning strike on the crude distillation unit (CDU) caused a fire, so the CDU and all other process units except the fluid catalytic cracker (FCC) were shut down. Approximately 5 hours later, amid the confusion of a cascade of alarms and attempts to restart the FCC wet gas compressor, the FCC flare knockout (KO) drum outlet line ruptured, releasing 20 tonnes (44,000 lbs) of flammable hydrocarbons which found an ignition source 110 m (360 ft) away and exploded. A major fire erupted at the FCC flare KO drum and several secondary fires ensued in adjacent units. The flare system was incapacitated by the explosion, so fires were allowed to burn themselves out over 2½ days. Fortunately, there were no fatalities (the explosion took place on a Sunday afternoon when very few people were on site). The site suffered severe damage to process plant, storage tanks and buildings. Properties in the nearest town 3 km (2 miles) away were also damaged. The refinery remained shut down for 9 weeks and took a further 9 weeks to restore full capacity.</p>	
			
<b>Incident Analysis</b>		<p><b>Basic cause</b> was rupture of a corroded DN 750 (30" NS) elbow on the FCC flare KO drum vapour outlet line due to liquid carryover and two-phase flow.</p> <p><b>Critical factors</b> included: 1) The FCC debutaniser level control valve failed closed but the distributed control system (DCS) indicated it was open, 2) Control board operator was overwhelmed by alarm flood in an emergency situation, 3) The FCC flare KO drum automatic high-rate pumpout system to slops tankage had been modified years earlier to a low-rate recycle system to the FCC vapour recovery section to minimise hydrocarbon loss and reprocessing costs, 4) The FCC flare KO drum vapour outlet line was not designed for two-phase flow and had been weakened by internal corrosion.</p> <p><b>Root causes</b> included: 1) Overpressure of the FCC debutaniser (blocked in due to level control valve failure), 2) Inadequate monitoring (DCS graphics did not provide the process overviews required to facilitate troubleshooting), 3) Inadequate warning systems (too many alarms, poorly prioritised), 4) Inadequate risk assessment (continuing operation of the FCC under extreme upset conditions), 5) Inadequate maintenance (defective control valve function and corroded flare header), 6) Inadequate Management of Change (FCC flare KO drum automatic pumpout system modification).</p>	
<b>Lessons Learned</b>		<p>1) Control panel graphics should provide a process overview including mass and heat balance data, 2) Safety-critical alarms requiring immediate operator intervention should be prioritised and the necessary operator responses documented for each, 3) The total number of alarms should be limited to a quantity that the control board operator can effectively monitor, 4) All plant modifications (including emergency modifications) should undergo a formal hazard analysis, 5) Flare KO drums should be designed with critical high level alarms (LAHH) to promptly initiate removal of liquid slops at a high enough rate to prevent overflow of the drum and carryover to the flare header.</p>	
<b>More Information</b>		<p>1) "The Explosion And Fires At The Texaco Milford Haven Refinery, 24th July 1994", Report of the Investigations by the Health &amp; Safety Executive into the Explosion and Fires at the Pembroke Cracking Company Plant at the Texaco Refinery, Milford Haven", HSE Books, ISBN 0-7176-1413-1, (1997), 2) "The 100 Largest Losses 1978 - 2017", Marsh Property Risk Consulting Practice, 25th Edition (2018).</p>	
<b>Industry Sector</b>		<b>Process Type</b>	
Oil & Gas		Fluid Catalytic Cracking	
<b>Equipment Category</b>		<b>Equipment Type</b>	
Mechanical		Explosion & Fire	
		<b>Equipment Class</b>	
		Piping	
		<b>Equipment Type</b>	
		Fittings (Elbow)	