


Incident Title		FCC Explosion and Asphalt Fire	
Incident Type		Explosion and Fire	
Date		26 th April 2018	
Country		USA	
Location		Superior, WI	
Fatalities		Injuries	Cost
0		36	US\$ 457 m (2021) – Ref. 2
Incident Description		<p>The primary absorber and sponge absorber towers at the Fluid Catalytic Cracking (FCC) unit exploded while it was being shut down for a planned maintenance turnaround. More than 100 metal fragments were propelled up to 366 m (1200 ft) away. Explosion debris punctured the top section of a nearby asphalt tank. Over the next 2 hours, approx. 2780 m³ (17,000 barrels) leaked out of the hole and spread through the refinery. The asphalt ignited and multiple large fires erupted in several operating areas of the refinery. The City of Superior (WI), in which the refinery is located, evacuated 2507 residents because of the potential for release of highly toxic hydrofluoric (HF) acid. The nearby City of Duluth (MI) issued a shelter in place advisory. Fortunately, the HF storage vessel was not damaged even though it was located closer to the epicentre of the explosion(s) than the asphalt tank.</p>	
 <p>Credit: WDIO ABC News/US CSB</p>			
Incident Analysis		<p>Basic cause of the 2 explosions was brittle fracture of the primary absorber and sponge absorber due to inadvertent mixing of air and hydrocarbon and ignition by pyrophoric material in the vessels. Basic cause of the large asphalt fire was believed to be pyrophoric material inside the asphalt tank smouldering on exposure to air entering through the punctured tank wall.</p> <p>Critical factors included: 1) The FCC was in transient operation mode, 2) The regenerator pressure was higher than the reactor and main fractionator pressures during the transient, 3) The spent catalyst slide valve (SCSV) internals were severely eroded (increased leak rate), 4) A “steam barrier” had not been established in the reactor to keep air (in regenerator) separated from hydrocarbons (in main fractionator), 5) A main fractionator “gas purge” to remove oxygen from the system had been omitted, 6) One (reciprocating) wet gas compressor was still running, 7) The absorbers were constructed from a grade of steel susceptible to brittle fracture, 8) The asphalt tank bund was too close to the tank (head pressure created leak path above the bund).</p> <p>Root causes included: 1) Inadequate hazard identification (air leakage from regenerator to reactor to main fractionator), 2) Inadequate transient operation safeguards (catalyst slide valves, steam barrier, gas purge), 3) Inadequate instrumentation (differential pressures between inter-connected vessels), 4) Inadequate shutdown procedures (incorrect pressure profile specified across unit), 5) Inadequate operator training (hazard awareness, abnormal situation response, venting, purging), 6) Inadequate process safety management (reliance on in-house FCC knowledge, limited use of external expertise).</p>	
Lessons Learned		<p>1) Transient operations (e.g. startup, shutdown, safe park) on process plant may require different safe operating limits compared with normal operation. 2) Process hazard analysis (PHA) studies (e.g. Hazop) should consider hazards arising during transient conditions as well as normal operation. 3) FCC reactor pressure should exceed regenerator and main fractionator in transient mode until an isolation blind is inserted at the fractionator inlet. 4) Materials exhibiting ductile behaviour in all operating modes are inherently safer than those exhibiting brittle behaviour in extreme (transient) conditions.</p>	
More Information		<p>1) “FCC Unit Explosion and Asphalt Fire at Husky Superior Refinery”, US Chemical Safety and Hazard Investigation Board, Report No. 2018-02-I-WI (2022): https://www.csb.gov/husky-energy-superior-refinery-explosion-and-fire/. 2) “100 Largest Losses in the Hydrocarbon Industry”, Marsh Property Risk Consulting Practice, 27th Edition (2022).</p>	
Industry Sector		Process Type	Incident Type
Oil & Gas		Fluid Catalytic Cracking	Explosion & Fire
Equipment Category		Equipment Class	Equipment Type
Mechanical		Vessel	Absorber