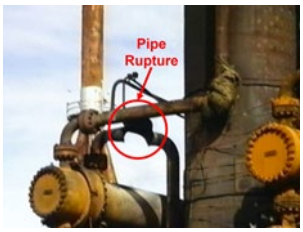
Incident Title	**Hydrocracker Reactor Temperature Runaway**	
Incident Type	Explosion and Fire	
Date	21st January 1997	
Country	USA	
Location	Avon (Martinez), CA	
Fatalities	**Injuries**	**Cost**
1	46	US$ 22 m (2002) – Ref. 2

Incident Description



Credit: US EPA/CEPP

Hydrocrackers convert heavy feeds to lighter, more valuable products (mainly gasoline and diesel) using a bifunctional catalyst (acid and metal functions) at high pressure and temperature in the presence of excess hydrogen. The main hydrocracking reactions are cracking and hydrogenation (overall highly exothermic). The higher the temperature, the faster the reaction rate. The catalyst is split into multiple fixed beds and cool hydrogen ("quench") gas is injected between the beds to control bed temperatures and reaction rate.

On 21-Jan-97, abnormal operation of the upstream pretreat section resulted in organic nitrogen slip to the 3 hydrocracking reactors, temporarily poisoning the catalyst. The control board operator gradually increased the catalyst bed inlet temperatures to drive off the nitrogen. A few hours later, a temperature excursion was seen in bed 4 of the 5-bed Hydrocracking Reactor #3. Bed 5 inlet temperature rose rapidly. The quench valve initially opened wide but fluctuated because temperature readings were bouncing from zero to normal to high and back. Only 40 of 96 Reactor #3 temperature measurements were routed to the control board screens and a PC-based data logger; the rest were displayed on a field instrument panel at the base of Reactor #3. The data logger had a history of poor reliability, so an operator was sent out to the field panel to check the temperatures. Reactor #3 effluent piping ruptured and the escaping reaction mixture autoignited causing an explosion and fire.

Incident Analysis

Basic cause was rupture of a section of Hydrocracking Reactor #3 effluent pipe due to overheating initiated by a temperature runaway in the reactor.

Critical factors included: 1) The manually-operated depressuring system was not activated when the maximum catalyst bed temperature limit was exceeded, 2) The PC-based data logger was unreliable (not trusted by the operators), 3) The field instrument panel was located below Reactor #3, 4) Time between onset of temperature excursion and pipe rupture was 7 mins.

Root causes included: 1) Violation of emergency procedures (failure to activate depressuring system), 2) Inadequate supervision (enforcement of emergency procedures), 3) Human factors (poor design of temperature monitoring system), 4) Inadequate operator training (abnormal operations, emergency procedures), 5) Inadequate testing/maintenance of safety-critical equipment (data logger), 6) Inadequate process safety management (failure to learn from previous incidents, poor emergency procedure documentation).

Lessons Learned

1) Automatic depressuring facilities should be provided for hydrocracking reactor systems as bed temperatures can rise at ≥ 50 °C (90 °F) per minute in a runaway scenario leaving insufficient time for reliable operator response.
2) All hydrocracker reactor temperature sensor readings should be displayed in the central control room on the distributed control system (DCS) screens.
3) High temperature alarms anywhere in hydrocracking reactors and immediately upstream or downstream should be designated 'critical' alarms.

More Information

1) "EPA Chemical Accident Investigation Report", US Environmental Protection Agency, Report No. EPA 550-R-98-009 (1998).
2) "100 Largest Losses in the Hydrocarbon Industry", Marsh Property Risk Consulting Practice, 20th Edition (2003).
3) "Seven Minutes to Failure – The Tosco Hydrocracker Runaway", R. Abhari and H.L. Tomlinson, IChemE Loss Prevention Bulletin 291 (2023).

Industry Sector	Process Type	Incident Type
Oil & Gas	Hydrocracking	Explosion & Fire
Equipment Category	**Equipment Class**	**Equipment Type**
Mechanical	Piping	Pipe

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