Incident Title	**Hydrogen Preheat Exchanger Outlet Elbow Rupture**	
Incident Type	Jet Fire	
Date	28th July 2005	
Country	USA	
Location	Texas City (now Galveston Bay), TX	
Fatalities	**Injuries**	**Cost**
0	1	US$ 30 m (2006) – Ref. 1

Incident Description

Credit: US Chemical Safety Board

The Residue Hydrocracking Unit (RHU) comprises 3 parallel trains of ebullated catalyst bed reactors systems. Each train has 2 hydrogen preheat exchangers connected in series with reactor effluent as the heating medium. The RHU was shut down on 04-Jan-05 for a maintenance turnaround during which 2 hydrogen preheat exchangers on 1 train had been blinded/deblinded before/after maintenance by contractors. On the shell (hydrogen) side, this involved removal/reinstallation of 3 drop-out piping elbows (2 off 1¼ Cr/½ Mo elbows and 1 off carbon steel elbow) from the 2 exchangers.

The RHU was restarted post-turnaround on 23-Apr-05 and operated normally until 28-Jul-05 when the outlet elbow of the downstream shell of a hydrogen preheat exchanger in 1 of the 3 trains suddenly ruptured. Line conditions at the failure location were ~ 20.7 barg (300 psig) and 260 °C (500 °F). The escaping hot hydrogen ignited, causing a huge fireball and a jet fire extending ~ 23 m (75 ft). One employee suffered a minor injury while assisting with the emergency shutdown of the RHU, but there were no fatalities. The hydrogen fire burned for ~ 2 hrs and a shelter-in-place order was issued to neighbouring residents. The RHU sustained major damage along the path of the jet flame and the affected reactor train remained shut down for more than 3 years.

Incident Analysis

Basic cause was rupture of a DN 200 (8" NPS) carbon steel elbow at the shellside (hot hydrogen) outlet of the hydrogen preheat exchanger due to high temperature hydrogen attack (HTHA).

Critical factors included: 1) The carbon steel inlet elbow removed from the first hydrogen preheat exchanger was inadvertently reinstalled in the outlet elbow position of the second (hottest) hydrogen preheat exchanger on the affected reactor train, 2) The three drop-out piping elbows from the two hydrogen preheat exchangers had different metallurgies but the same overall dimensions, pressure ratings and visual appearance, 3) The maintenance contractor was not made aware of these metallurgical differences.

Root causes included: 1) Inadequate equipment design (interchangeable elbows with different metallurgies), 2) Failure to apply inherently safer design principles (replace carbon steel elbow with chrome alloy for greater HTHA resistance or change carbon steel elbow dimensions to make incompatible with incorrect location), 3) Poor maintenance procedures (existence and risk posed by use of different elbow metallurgies not highlighted), 4) Inadequate communication (between maintenance team and contractor), 5) Inadequate quality control (QC) procedure (elbows not labelled/tagged before removal and positive material identification not carried out before/after reinstallation).

Lessons Learned

1) Piping designers should avoid configurations that allow critical alloy piping components to be inadvertently interchanged with carbon steel components. 2) Positive material identification (PMI) testing should be carried out using portable hand-held X-Ray Fluorescence (XRF) devices (or similar) for all critical alloy steel components removed and reinstated during maintenance.

More Information

1) "Positive Material Verification: Prevent Errors During Alloy Steel Systems Maintenance", US Chemical Safety and Hazard Investigation Board (CSB), Safety Bulletin No. 2005-04-B (2006).
2) API RP 578: "Guidelines for a Material Verification Program (MVP) for New and Existing Assets", 4th Edition (2023).

Industry Sector	Process Type	Incident Type
Oil & Gas	Hydrocracking	Fire
Equipment Category	**Equipment Class**	**Equipment Type**
Mechanical	Piping	Fittings (Elbow)

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