Incident Title	**Hydrocracker Reactor Nitrogen Asphyxiation**	
Incident Type	Asphyxiation	
Date	5th November 2005	
Country	USA	
Location	Delaware City, DE	
Fatalities	**Injuries**	**Cost**
2	0	Unknown

Incident Description

Credit: US Chemical Safety Board

Two contract workers were preparing to "box up" a hydrocracker reactor by reinstating the piping inlet elbow at the top manway. The reactor was being purged with nitrogen (N_2) from a temporary supply and vented to atmosphere through the open manway. A roll of duct tape had inadvertently been dropped into the reactor, landing on a vapour/liquid distribution tray about 1.5 m (5 ft) below the manway opening. One of the workers tried recovering the duct tape from outside the reactor with a long wire hook but either fell in or climbed into the reactor and passed out. A second worker hurriedly inserted a ladder and climbed into the reactor to attempt a rescue. A third worker approached the manway, observed the 2 workers lying motionless on the distribution tray, and radioed for emergency assistance. The stricken workers were recovered from the reactor, but both were unresponsive and could not be revived.

Incident Analysis

Basic cause of fatalities was deprivation of oxygen initially resulting in loss of co-ordination followed by loss of strength, and ultimately respiratory failure.

Critical factors included: 1) Work permit did not mention nitrogen hazard and did not specify use of special breathing apparatus, 2) Warning sign did not mention nitrogen hazard, 3) Second worker attempted rescue of first worker without "fresh air" breathing equipment.

Root causes included: 1) Inadequate hazard awareness (oxygen-deficient atmosphere also present above reactor manway opening), 2) Inadequate control of work (jobsite inspection and permitry), 3) Failure to follow safe rescue procedure (stay safe distance away and call for qualified rescue crew), 4) Inadequate company training programmes and industry good practices on hazards of oxygen-deficient atmospheres in and around confined spaces.

Lessons Learned

1) Nitrogen (N_2) is a colourless, odourless, tasteless, non-irritant gas at ambient conditions and can displace oxygen (O_2) in air.
2) Deprivation of oxygen can cause impaired perception and judgement, dizziness, nausea, loss of consciousness, coma, respiratory failure or death, depending on the extent of oxygen deficiency and duration of exposure.
3) Permit signatories should visit the job site to discuss hazards and controls.
4) Warning signs should be posted on any process equipment or piping being purged with nitrogen to alert personnel to the potential presence of a life-threatening oxygen-deficient atmosphere.
5) All access and egress points around vessels being purged with nitrogen should be barricaded and an access control system should be set up to log all personnel entering/leaving the barricaded area.
6) All personnel entering the barricaded area should wear a personal gas monitor with an audible and visible alarm set at 19% O_2 concentration.
7) Never enter a confined space alone to attempt rescue (misguided bravery resulted in death of would-be rescuers in 34 of 88 cases studied – Ref. 1).
8) Only properly trained personnel with all appropriate safety equipment and protection should attempt a rescue in oxygen-deficient atmospheres (refinery standard respiratory equipment is only suitable for use in unconfined spaces).

More Information

1) “Case Study: Confined Space Entry - Worker and Would-be Rescuer Asphyxiated”, US Chemical Safety and Hazard Investigation Board (CSB), Report No. 2006-02-I-DE.
2) “Hazards of Nitrogen and Catalyst Handling”, BP Process Safety Series, 6th Edition, IChemE (2006), ISBN: 978-0-85295-540-6.

Industry Sector	Process Type	Incident Type
Oil & Gas	Hydrocracking	Asphyxiation
Equipment Category	**Equipment Class**	**Equipment Type**
Not equipment-related	Not applicable	Not applicable

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