Fatal asphyxiation accident in a refinery

5 November 2005

Delaware City

United States

Refinery
Maintenance / work
Nitrogen / inerting
Victims
Manhole
Human factor / training
Subcontracting

THE FACILITIES INVOLVED

The site:

In operation since 1957, the Delaware City refinery, with a daily production capacity of 210,000 barrels, is located along the Delaware River and spans a 5,000-hectare site. The facility employs a workforce of 566 in its activity of transforming crude oil into fuels (gasoline, diesel, kerosene) and both domestic and industrial heating oil. It also produces non-energy products such as light gasoline (naphtha) and road bitumen. The installation comprises all of the oil processing units: atmospheric distillation, catalytic cracker, catalytic reforming, etc.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

On 5 November 2005, two employees of a subcontracting firm died by suffocation during maintenance work conducted on the hydro-cracking unit, as they were raising a pipe onto a reactor inerted with nitrogen. One of the technicians fainted and fell into the reactor while attempting to pick up a roll of adhesive tape; the second victim was also asphyxiated in trying to save his colleague.

The European scale of industrial accidents

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the "SEVESO" Directive on handling hazardous substances and in light of the information available, this accident can be characterised by the four following indices:

The parameters composing these indices and their corresponding rating protocol are available from the following Website: http://www.aria.developpement-durable.gouv.fr.

One parameter enters into consideration in determining the rating assigned to the "human and social consequences" index: Parameter H3 reached a level 3 since two employees were killed (i.e. between 2 and 5 deaths).

The overall "human and social consequences" index was thus scored a level "3".

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

Breathable air contains 78% nitrogen, 21% oxygen and 1% trace gases. A drop in oxygen concentration in air can have direct consequences for humans, namely:

- breathing difficulties, inability to make reasoned judgment and quick physical exhaustion all appear once oxygen content dips below 16%;
- fainting occurs at 12% oxygen;
- death within a few seconds at 6% oxygen.

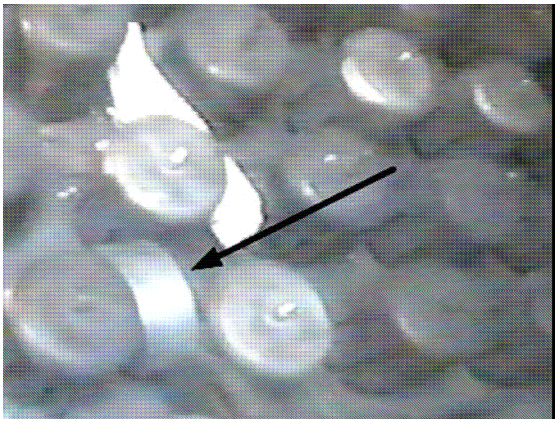
The loss of oxygen concentration in air following its substitution by an inert gas like nitrogen can thus lead to dramatic consequences in just a few moments, all the more critical given the widespread use of nitrogen throughout this industry.

Picture 1

Picture 2

Nitrogen was being used inside this steam cracker in order to lower the oxygen content circulating in the pipes and machines, thereby preventing deterioration of the catalyst due to oxygen in the air.

This hydro-cracking reactor had been shut down for maintenance; its nitrogen supply line had been momentarily closed to enable reloading the reactor catalyst. This operation required preliminary dismantling of a large-sized pipe bend (see Picture 1). Once the reloading step had been completed, the manhole was protected by a plastic tarp and nitrogen could once again be injected. Refinery employees placed red tape around this manhole along with a sign reading "Danger: Confined space / Do not enter without permit", yet without indicating the type of hazard present or the risk of asphyxiation (Picture 2).



Picture 3

A subcontracting company raised the elbow to restart unit operations after receiving the refinery's authorisation to initiate work. A permit was issued for the operation, though this document did not specify that the reactor was filled with nitrogen. In response to the permit form's question whether a nitrogen purge was required as part of the operation, the "N/A" box had been ticked.

One of the subcontractor's employees removed the protection and noticed plastic tape inside the reactor (Picture 3). Reactor cleanliness criteria prohibited leaving the tape inside the reactor, so the workers looked for a way to retrieve it.

Any entry into the reactor requires a specialised team and specific approvals. The technicians assigned to this task expressed concern over the appropriate course of action: installation of the elbow had to be completed before the end of the shift, but sticking closely to the procedure would have slowed their progress. Moreover, the crane needed to conduct this operation would not be available afterwards.

To avoid this inconvenience, a technician unsuccessfully attempted to pick up the tape using an iron wire. Whether accidentally or intentionally, he fell or entered the reactor and passed out. His co-worker on the exterior platform then climbed down to rescue his fellow team member and also fell unconscious. A third technician sounded the alarm. Within 10 minutes, the emergency crew made its way into the reactor fitted with self-breathing apparatuses and evacuated the two unconscious employees, yet neither could be resuscitated. The oxygen content measured by rescue workers inside the reactor was less than 1%.

ACTIONS TAKEN

The subsequent investigation carried out highlighted: inadequate danger warning signs (no "risk of asphyxiation by nitrogen" signs were posted, no barriers preventing site employees from getting close to the reactor entry opening); an erroneous work authorisation form that did not make mention of the presence of nitrogen inside the reactor; and a lack of both information and training provided to personnel working onsite relative to the inherent hazards of environments with depleted oxygen levels.

As a result of this accident, the American Petroleum Institute Safety Guide was revised in order to strengthen the training offered to technicians working in confined spaces in the oil and petrochemical industry by emphasising the following points:

- An oxygen-depleted atmosphere is hazardous not only inside the confined space itself, but also nearby;
- This type of danger is especially deceptive;
- First responders must strictly implement all applicable procedures prior to intervention.

LESSONS LEARNT

This accident, like many similar cases of asphyxiation in oxygen-poor spaces, illustrates the importance of:

- risk identification, which must take into account the hazards associated with oxygen-depleted atmospheres (given the risk of death within just a few seconds);
- personnel training in the hazards present when working inside these spaces;
- procedures and instructions to ensure installation operations under optimal safety conditions, i.e.:

- marking of all pertinent volumes, posting of danger warning signs and availability to personnel of appropriate protective gear: masks, gas detectors, etc…
- verification of the good working order of all such equipment prior to use,
- presence of a distinct and easily recognisable sound or visual alarm to warn the workforce,
- intervention procedures specific to confined spaces or special authorisations for entering these spaces,
- information relative to onsite dangers provided when issuing work permits to subcontracting companies,
- preliminary atmospheric testing both before and during any type of site intervention and, if necessary, until the return to a normal operating mode,
- third-party monitoring to ensure the installations are running smoothly.