DUTCH
SAFETY BOARD

Summary

Fatal accident in a reactor

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Cover photograph: Flying Holland / John Gundlach

The Dutch Safety Board

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N.B. This report is published in the Dutch language, with a translation in English. If there is a difference in interpretation between the Dutch and English version, the Dutch text will prevail.

SUMMARY

On the morning of Friday 3 February 2023, an employee of T.I.M.E. Service Catalyst Handling (the contractor) lost his life in an accident at the oil refinery operated by Zeeland Refinery (the client). This happened while removing catalyst from a reactor. Catalyst used in a reactor must be replaced periodically. There are various methods for doing this, and they are often used in combination. One of those methods involves an employee entering the reactor to vacuum up the catalyst with a vacuum hose, and to chip it off if necessary. The employee is referred to as a 'diver'. Because spent catalyst ignites if it comes into contact with oxygen, the reactor must be made oxygen-free before the work begins. This involves filling the reactor with nitrogen, thus creating an inert atmosphere. To be able to breathe in that inert atmosphere, the diver requires breathing apparatus.

In the occurrence we are dealing with, the diver was buried under catalyst. Oxygen-containing air was released from his breathing air helmet and came into contact with the catalyst that was on top of him, leading to the catalyst igniting. Colleagues attempted to extract the casualty from the reactor; they succeeded at the third attempt. After he had been extracted from the reactor, it became clear that the casualty had died.

Entering a reactor under an inert atmosphere in order to remove catalyst involves various risks in terms of occupational safety. During his work, the diver is exposed to the following risks: suffocation, falling, becoming buried, and burns. Moreover, the options for escape and rescue are limited. An accident in an inert reactor therefore often has a fatal outcome. This means that a reactor under an inert atmosphere is a life-threatening work environment.

The client and the contractor were aware of the risks associated with unloading[1] a reactor by means of inert entry[2]. Nevertheless, they were convinced that this could be accomplished safely if the proper management measures were in place, both individual and generic measures. The individual measures included the provision of a safety line and Personal Protective Equipment (PPE). The generic measures included filling the reactor with nitrogen and issuing work instructions.

1 Unloading a reactor means that all the spent catalyst is removed from the reactor.
2 Inert entry means entering a confined space in which no oxygen is present or only a very low percentage of oxygen. A reactor is rendered inert by filling it with nitrogen.

An important safeguard for working safely in the reactor was to follow the work instructions. In practice, the work instructions are deviated from, either intentionally or unintentionally. The risk of a fatal accident therefore remains real, and dangerous situations will continue to arise when a reactor is being unloaded under an inert atmosphere, despite the applicable work instructions.

The aforementioned measures focussed mainly on preventing an accident from occurring. Additionally, the client and contractor had drawn up procedures for a rescue operation if the diver were to become unwell, have an accident, or be unable for any other reason to escape from the reactor by himself. The success of a rescue is highly dependent on the position of the diver and whether he is able to cooperate. The parties involved overestimated the possibilities of a successful rescue.

It is possible to unload a reactor without the need for inert entry. There are disadvantages to this, however. It is often costly and detrimental to the environment. Multiple companies in the sector therefore prefer to unload reactors by means of inert entry. The development of robotics and discussions within the sector about necessary modifications to reactors are currently ongoing.

Primary conclusion
The fatal accident at Zeeland Refinery has shown that unloading reactors by means of inert entry is inherently unsafe for the employee who enters the reactor as a diver. The measures that had been put in place – which in this occurrence were intended to guarantee safety – were not sufficiently robust. The parties involved wrongly assumed that the measures that had been put in place could sufficiently guarantee the safety of the employee and reduce the safety risk to an acceptable level.

CONSIDERATION

Reactors are one of the means used to convert crude oil into usable substances (for example diesel or LPG). They are filled with catalyst that must be replaced periodically. The working method frequently still involves a person entering the reactor under an inert atmosphere. 'Inert entry' is dangerous, and a single mistake can quickly lead to a fatal accident. The fact that it is impossible (or virtually impossible) to limit the safety risks sufficiently by taking measures means that working inside a reactor under inert conditions is inherently unsafe.

It is possible to completely unload a reactor without the need for inert entry. Often – when all else fails – the catalyst will need to be wetted and removed manually after all. There are significant disadvantages to this method, however; it is costly and detrimental to the environment. It also involves safety risks, because a person still has to enter the reactor. Although the atmosphere in the reactor is then not inert, it is still hazardous work, for example due to the risk of falling and the danger of becoming buried.

Despite the disadvantages and risks associated with this alternative, we believe that the process of unloading reactors by means of inert entry must cease immediately. It is simply too risky to continue to have people work inside reactors under an inert atmosphere. A number of refineries, including the one where this occurrence took place, are setting a good example and have ceased using inert entry into reactors. Others must follow that example.

The sector is already working on methods for unloading that eliminate the need for anybody to enter a reactor. It is important that clients give contractors the scope they need for applying new methods, even if that means that unloading a reactor will initially take longer, produce a poorer result, or be more expensive. The client and contractor involved in the occurrence concerned here can take the lead in advancing the development of these methods.

Despite the fact that we expect sector parties to take responsibility themselves, it will be a good thing for government to promote these methods as well. This can be accomplished by means of a statutory ban on working inside a reactor under inert conditions, but other ways of encouraging the sector to abandon this method and develop and use safer methods can also be considered.

LESSONS LEARNED AND RECOMMENDATIONS

Unloading reactors by means of inert entry involves major safety risks, which cannot be sufficiently controlled. With a view to improving the safety of reactor unloading, the Dutch Safety Board has drawn up a number of lessons learned and recommendations.

Lessons for the sector

Cease unloading reactors by means of inert entry
The measures that are put in place to control the risks involved in inert entry into reactors consist largely of work instructions. These are effective as long as they are properly complied with. In practice, however, the work instructions are not always complied with, either intentionally or unintentionally, and therefore provide insufficient safeguards as regards the safety of employees. The fact that it is impossible (or virtually impossible) to further limit the safety risks by means of other kinds of measures means that working inside a reactor under inert conditions is inherently unsafe. The sector must therefore cease using this method.

Develop new and safer methods for unloading reactors
In order to make the unloading of reactors safer, the sector should continue to develop new working methods. To achieve this, clients and contractors need one another. A contractor has the know-how needed for removing, storing, and disposing of catalyst, but it needs both the time and scope for developing and testing new working methods. When calling for tenders for unloading a reactor, a client can stipulate requirements and give contractors scope for applying new working methods.

Share information about accidents and near-accidents within the sector
In order to ensure a safe working environment, it is important to learn from accidents and near-accidents. Currently, parties share only limited information within the sector about accidents and near-accidents that occur during the unloading of a reactor. This deprives other companies of the opportunity to learn from other occurrences and to adapt their working methods accordingly. The parties in the sector must share information about incidents more effectively in order to promote awareness of the risks involved in the work.

Recommendations

To T.I.M.E. Service Catalyst Handling:

1. Cease unloading reactors by means of inert entry.

To both Zeeland Refinery and T.I.M.E. Service Catalyst Handling:

2. Share the above lessons with colleagues within the industry so as to encourage them to cease using inert entry and to develop safer methods for unloading reactors. In doing so, make use of the relevant national and international associations, such as Vemobin, SIR, and ECMA.

3. Take the lead in the further development of new and safer methods for unloading reactors.

To the Dutch State Secretary for Social Affairs and Employment:

4. Ensure that the sector ceases unloading reactors by means of inert entry.

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