



DUTCH  
SAFETY BOARD

# Summary

## Emission of ethylene oxide at Shell Moerdijk



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*Photo cover: Police / national unit*

## **Dutch Safety Board**

When accidents or disasters happen, the Dutch Safety Board investigates how it was possible for them to occur, with the aim of learning lessons for the future and, ultimately, improving safety in the Netherlands. The Safety Board is independent and is free to decide which incidents to investigate. In particular, it focuses on situations in which people's personal safety is dependent on third parties, such as the government or companies. In certain cases the Board is under an obligation to carry out an investigation. Its investigations do not address issues of blame or liability.

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On 27 January 2016, Shell Nederland Chemie B.V. in Moerdijk, the Netherlands, (referred to hereafter as: Shell Moerdijk) discovered that a valve was open at the MEOD (Moerdijk Ethylene Oxide and Derivatives) plant, creating a direct connection to the atmosphere (open air). Via this route, carcinogenic ethylene oxide had been emitted without being noticed for more than two months. Shell Moerdijk estimated the total quantity of ethylene oxide emitted to be 27.7 tonnes.

Ethylene oxide is classed as a substance of very high concern (SVHC) subject to a minimisation requirement. Businesses must prevent emissions of such substances or, if this is not possible, minimise them to prevent employees and local residents being exposed to these substances. The quantity of ethylene oxide released, according to Shell's estimate, is more than ten times the permitted threshold of 2.5 tonnes during normal operation of the plant. Therefore, this constitutes a major accident. Based on the investigation into this release, the Dutch Safety Board concludes that Shell Moerdijk did not act as responsibly as may be expected from a company subject to the Major Accident Risks Decree (Brzo).

## **Consequences of the release**

According to investigations conducted by Shell Moerdijk and the Public Health Service (GGD) the release of ethylene oxide has had a negligible effect on the health of employees and residents in the surrounding local authority areas. The Dutch Safety Board sought a second expert opinion on the method used by Shell Moerdijk to calculate the amounts released and on the assessment of the health effects resulting from the ethylene oxide release. The investigation by the Dutch Safety Board did not make any findings that point to a different conclusion. Nevertheless, employees and local residents ran the risk of being exposed to an SVHC for more than two months. Moreover, this release was discovered more or less by coincidence. This demonstrates that Shell Moerdijk did not control the risk of unintentional release. Therefore, it is the opinion of the Dutch Safety Board that this constitutes a serious incident.

## **The release**

The release of toxic ethylene oxide at Shell Moerdijk was possible due to a valve (Valve A) that had to be opened some time earlier during a shutdown not being closed once the plant concerned was put back into operation. The plant subsequently operated for more than two months while residual gases, containing ethylene oxide, were discharged directly into the atmosphere via the valve that had been left open.

This incident raises a number of questions. How could the valve have been left open when the plant was put back into operation? And why did it then take more than two months for the valve to be closed, thus halting the release?

The opening of Valve A at the time the plant was shut down took place in accordance with an instruction aimed at preventing excessive pressure build-up in the system during

a plant shutdown. However, the investigation found that, due to an earlier modification to the procedure, the situation involving overpressure could no longer occur. Therefore, from the perspective of process safety, there was no longer any reason to open Valve A. (The instruction for) opening Valve A was necessary to be able to close another valve (Valve B). The key system used on the valves necessitates this.

Maintenance was carried out during the plant shutdown. When the maintenance was completed, Valve B was opened while this valve should have remained closed given the fact the plant was still in shutdown. The instructions for carrying out this maintenance work did not provide for a situation in which the plant was in shutdown and its consequences. When the plant was later put back into operation and it was found that Valve B was open, it was assumed that Valve A was closed. It was incorrectly assumed that the two valves could not be open at the same time. Nobody checked whether Valve A was in fact closed.

During the period that followed, the plant produced ethylene oxide while the residual gas was discharged directly into the atmosphere via the open valve. No one was aware of this. Throughout this time there was no sign whatsoever to indicate the valve was open or the fact that the system was leaking ethylene oxide into the open air. A fault elsewhere in the system finally resulted in the discovery of the open valve. In this way, the release of ethylene oxide was discovered by coincidence and halted after 68 days.

### **Risk management**

Companies such as Shell Moerdijk, that work with hazardous substances, are legally obliged to have a safety management system in place to manage risks and prevent (major) accidents. At Shell Moerdijk this is the company management system (BBS). The procedures in the BBS stipulate how employees should work in order to maintain safety.

Employees have to use their knowledge and experience to effectively apply the procedures. The operators at Shell Moerdijk had followed a training programme and training courses, but - even though they had worked there for many years - they had little practical experience of shutting down the plant and putting it back into operation, the use of Valves A and B, and the related key system.

The documentation available to the operators when shutting down and restarting the MEOD plant and keeping it running was incomplete and/or contradictory. Therefore, operators could not obtain an accurate picture of the operation and function of Valves A and B, including the key system, and the associated risk of the open connection to the atmosphere.

Furthermore, the investigation revealed that the procedures applied by Shell Moerdijk did not provide for a concurrence of works, and the possibility that activities could negatively impact on one another. In this case, it appears the maintenance work contributed to the fact that restarting the MEOD plant did not go as it should have, with the release as the ultimate consequence.

The risk assessment of an open connection to the atmosphere via Valve A was based on managing process safety. Originally the valve had been intended to control pressure in

the system when the plant was in shutdown. This changed following the modification to a work procedure (no further loads while the plant was in shutdown). This measure was focused on eliminating a process risk. As a result, Valve A lost its purpose. Nevertheless, Valve A remained a component of the plant. Shell Moerdijk did not recognise that in this way a risk to the environment remained. Shell Moerdijk did not have any recent risk assessments describing Valve A and/or the open connection to the atmosphere, nor were they part of any discussion.

In the opinion of the Dutch Safety Board this demonstrates that, although process safety is an important condition for managing risks in a plant such as Shell Moerdijk, it is not sufficient for managing the risk of exposing employees or local residents to hazardous substances, or risks to the environment (environmental safety). When assessing the risk of an ethylene oxide release, Shell Moerdijk based its assessment solely on the severity of potential consequences, namely acute and chronic effects on health, safety and the environment, and not on the striving for zero emissions. Therefore, the Dutch Safety Board concludes that Shell Moerdijk did not assume its responsibility to take all measures necessary to operate in a safe manner.

The Dutch Safety Board concludes that Shell Moerdijk did not manage the risk of ethylene oxide being released via the open valve. Even though it was recognised that the valve might be open during normal operation of the plant, the assumption was that working according to procedures offered sufficient guarantee against Valve A being left open unintentionally. The fact that this is not the case was demonstrated by the release, which left both employees and local residents with a risk of exposure to an SVHC.

During the period between 23 November 2015 and 27 January 2016, more than 27 tonnes of ethylene oxide was discharged into the open air at Shell Moerdijk, the emission of which went unnoticed. Ethylene oxide is a substance of very high concern (SVHC), exposure to which can cause serious health damage and which, in its purest form, is highly explosive. Any emission of ethylene oxide greater than 2.5 tonnes is classed as a major accident under European Directive Seveso III. Although the emission at Shell Moerdijk proved not to have posed an acute risk to employees, local residents or the environment, the Dutch Safety Board believes that the fact that the release was able to continue for more than two months without being noticed is extremely concerning.

The investigation conducted by the Dutch Safety Board into the release of ethylene oxide at Shell Moerdijk demonstrates that the company did not adequately control the risks of such releases. Shell Moerdijk is a company that is subject to the requirements of the Dutch Major Accident Risks Decree (Brzo), that also implements the European Seveso III directive. One of the key provisions of this decree stipulates that Brzo companies must put in place all measures necessary to prevent a major accident, and in the unlikely event that one does occur, limit the effects on public health and the environment.

Brzo companies must prevent the release of hazardous substances as much as possible, in particular of SVHCs, whatever the extent of such release and irrespective of the potential harm to people and the environment. Therefore, the emission of ethylene oxide at Shell Moerdijk constitutes a serious incident from which lessons must be learned, not only by Shell Moerdijk but by all companies involved in producing and processing hazardous substances.

Based on its investigation, the Dutch Safety Board finds that Shell Moerdijk was predominantly focused on managing process safety, but in doing so devoted insufficient attention to environmental safety.

### **Environmental safety in the approach to risk**

Shell Moerdijk assumed that in the production of ethylene oxide, safeguarding process safety was adequate to fulfil its responsibility with regard to the safety of its employees, local residents and the environment. The focus on process safety was aimed at the integrity of the installation(s) and the management and proper running of the production process. Among other things, this means hazardous substances should not be released without being noticed. If the process is running properly this is also good for the environment, the company argued. It is the opinion of the Dutch Safety Board that this view is too narrow. The responsibility of companies that work with hazardous substances goes beyond just managing process safety; it also involves managing environmental safety. These companies have a responsibility to put in place all measures necessary in order to be able to operate in a safe manner.

Brzo companies must ensure any release is detected as soon as possible, so that it can be limited. Shell Moerdijk's one-sided focus on process safety meant the emission of ethylene oxide went unnoticed for more than two months. The production process appeared to be in good order, while a hazardous substance was escaping into the open air.

The fact that the company only discovered the release by coincidence demonstrates that the company's operational management was inadequate. Prior to this, Shell Moerdijk assessed the risk of a major emission of ethylene oxide to be low. The safeguards to prevent an unplanned release of ethylene oxide from the plant were inadequate.

The Dutch Safety Board emphasizes the need to safeguard environmental safety in the company's operational management, as well as process safety. This requires companies that work with hazardous substances to take a broad approach to risk.

### **Lessons for other companies**

This occurrence shows that if a Brzo company's focus is biased towards process safety, it may create a blind spot for a severe environmental safety risk. Assessing potential environmental effects of a release as part of a process safety assessment can be inadequate.

It is not true that if process safety is in order, all environmental risks are eliminated too. By applying a focus as established in this investigation, limiting the effects of a release instead of preventing it altogether, the chemical industry is failing to respect environmental safety. The Dutch Safety Board expects other Brzo companies to take these lessons to heart too. They may be expected not only to respond reactively following an incident, but also to proactively and on a regular basis assess processes and installations in conjunction with each other, in terms of environmental risks.

### **Recommendations**

The release at Shell Moerdijk was a major accident. It is expected of Brzo companies such as Shell Moerdijk that they will put in place all measures necessary to prevent a major accident. Process safety is an important condition for achieving this, but is not always sufficient for controlling the risks of exposure of its employees and local residents to hazardous substances, and environmental risks. This means, for example, striving for zero emissions of substances of very high concern into the open air.

The Board consequently arrives at the following recommendations:

#### **To Shell Moerdijk**

##### **Active environmental risk management**

As a result of this emission of ethylene oxide, Shell Moerdijk has put various measures in place to prevent a similar incident from occurring in the future. This is a necessary step on the part of the company.

The Dutch Safety Board notes that, in its response to the occurrence and the Board's draft report, Shell Moerdijk primarily focused on its compliance with (components of) statutory regulations and industry standards. In doing so, Shell Moerdijk is not respecting its social responsibility as a Brzo company in terms of managing environmental safety risks. The Dutch Safety Board finds this not encouraging, given also its previous reports on incidents at Shell. The company may be expected to take a more fundamental and proactive approach, all the more since Shell presents itself publicly as a company with safety as its top priority.

- 1a. Adopt environmental safety as one of the key basic principles for risk management. To this end, include the objective of zero emissions of substances of very high concern in the risk matrix.
- 1b. Consider where measures for achieving process safety could have negative consequences for environmental safety, such as hazardous substances escaping without being noticed, and implement measures to prevent these negative consequences.

#### **Take a proactive approach to changes**

The Dutch Safety Board believes that integrated risk management must be firmly embedded in the way Brzo companies approach risks. This requires an ongoing proactive approach by these companies, including when new insights into working with hazardous substances necessitate modifications to plants. Modifications to the design of and procedures at the various plants must go hand in hand with risk management from the perspective of process safety as well as environmental safety.

2. Based on the investigation the Board stresses once more the importance of implementing the recommendation it made in 2015 following the explosions at the Shell Moerdijk MSPO2 plant:

*“Ensure that all Shell employees are constantly alert to the safety risks arising from modifications made to plants, processes and procedures. Re-evaluate earlier presumptions and assumptions. Conduct (new) risk analyses, put adequate control measures in place and ensure that the team that performs these analyses has sufficient critical ability. Pay particular attention to assumptions based on risks that had previously been ruled out.”*

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