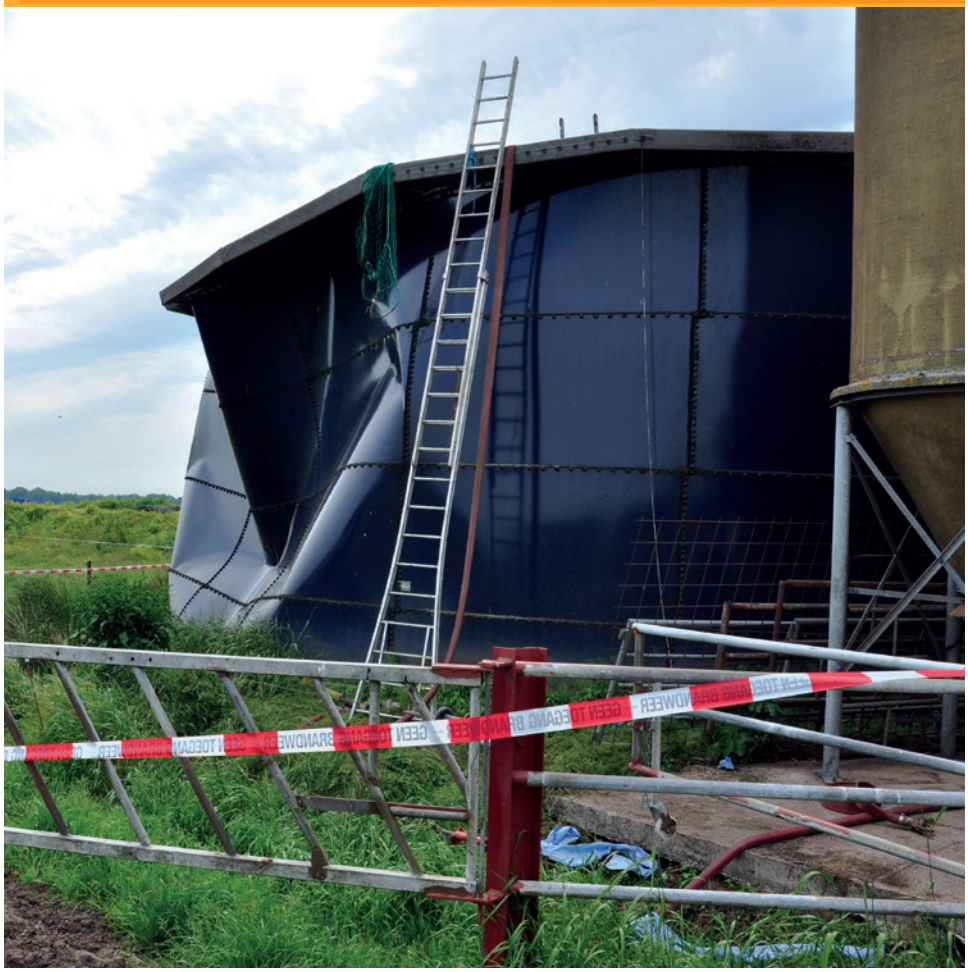
DUTCH
SAFETY BOARD

Summary
Fatal accident in a manure silo in Makkinga



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Fatal accident in a manure silo in Makkinga

The Hague, March 2014

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Dutch Safety Board

The aim in the Netherlands is to limit the risk of accidents and incidents as much as possible. If accidents or near accidents nevertheless occur, a thorough investigation into the causes, irrespective of who are to blame, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of independence with respect to authorities and businesses. In some cases the Dutch Safety Board is required by law to conduct an investigation.

Dutch Safety Board

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NB: The full report is published in Dutch. The English summary is the translation of the the consideration, recommendations and conclusions of the report. In the event of any discrepancy between these versions, the Dutch text shall prevail.

CONTENT

CONSIDERATIONS AND RECOMMENDATIONS

Accidents with manure

A fatal accident occurred in a manure silo at a dairy farm in Makkinga, the Netherlands, on 19 June 2013. The manure silo was being cleaned by two employees from a specialised contractor when one employee who was working in the silo became unwell. His colleague, who was on watch at the edge, responded to the situation by entering the silo. Three other men who were at work on the farm also rushed to help and entered the silo. One of these men was then sent back while he was climbing down the ladder. The four men inside were stupefied from the inhalation of manure gases in the silo. This caused the death of three of the men. The fourth man was admitted to hospital with serious injuries.

This accident in Makkinga is not unique. An inventory of the period since 1980 revealed 35 accidents resulting in fatalities or serious injuries. In recent years, an average of at least three serious manure accidents have occurred per annum. Moreover, it has become clear that many manure accidents with less serious consequences – in particular, when the emergency relief services are not involved – are not reported in the media and are not included in the statistics. When viewed from this perspective, the inventory of manure accidents enclosed in this report constitute no more than the tip of the iceberg.

A distinction can be made between two situations in the manure gas accidents reviewed in this report: accidents that occurred while mixing manure slurry in a cellar under the shed and accidents that occurred on entering more-or-less confined spaces (such as cellars, tanks and silos) that contained or had contained manure slurry. It is also striking to note that in almost half the accidents the victims included persons who had tried to rescue someone by entering a confined space containing a hazardous concentration of manure gases without personal protective equipment. Once again, in this respect the accident in Makkinga is not unique.

The Dutch Safety Board decided to conduct this investigation because of the serious consequences of the accident in Makkinga and because of the relatively large number of manure accidents that occur in spite of the agricultural sector's apparent awareness of manure gas hazards. As the accident in Makkinga was not an isolated incident, the Dutch Safety Board is of the opinion that the entire sector needs to learn from the circumstances that led to this accident.

Findings from the investigation

The members of the professional groups involved (dairy farmers/pig farmers, contract workers, manure haulage drivers and cleaners/inspectors of manure silos) are, in general, aware that the inhalation of manure gases can be hazardous. Nevertheless, they regularly

become overwhelmed by the gas, which results in an accident. Many of the manure gas accidents could have been avoided by taking safety precautions commensurate with the nature and extent of the risks.

In essence, the problem is apparently due to the failure to take sufficient account of manure gas hazards. Work involving manure is not preceded by a review of the risks to determine the equipment needed to provide adequate protection and the manner in which the work needs to be organised. In the case of the accident in Makkinga, the respiratory protection equipment was not compatible with the level of risks in the manure silo and no equipment was available to perform a rescue attempt. A recurrent phenomenon in other accidents was the need to enter a cellar or tank/container 'for a second' to rectify a malfunction. While mixing manure underneath a shed is not always preceded by the implementation of adequate measures to provide ventilation and to prevent persons/animals from entering potentially hazardous zones (on slatted floors in sheds and near the cellar openings, etc.)

The natural tendency of people to help in an emergency is often enhanced when a manure accident is involved, as it is very evident that the situation is an acute emergency, few or no other potential rescuers are in the area and the victim is often a member of the family or a colleague. As a result, any bystanders witnessing a manure accident are relatively likely to instinctively rush to help the victim even when there is a real hazard that they will suffer severe injury or death. This makes the implementation of adequate safety precautions to prevent exposure to manure gases and measures to provide effective means of rescue all the more important.

The investigation revealed that the failure to implement adequate safety precautions and measures is due to the following underlying factors: insufficient knowledge or awareness of the magnitude of the risks, inadequate attention to safety during developments in the agricultural sector, the absence of specific work instructions and limited supervision of occupational safety.

Knowledge and awareness of manure gas risks

The large majority of the persons involved do not know or realise that at high(er) concentrations of manure gases just one breath is enough to cause complete stupefaction. Nor is there sufficient awareness of the risk that in specific situations the concentration of manure gases can suddenly rise to hazardous levels. This lack of knowledge and/or awareness of the risks plays an important role in the cause of manure gas accidents and in the tendency of bystanders to rush to help. More knowledge and an increased awareness of the risks could not only promote the adoption of safer working methods but could also reduce the tendency of bystanders rushing to rescue someone without protecting their personal safety. This is impeded by the tendency to hush up manure accidents, especially when the emergency relief services are not involved. As a result, learning of the safety lessons from accidents and dissemination of the relevant knowledge take place only to a limited extent.

For this reason the Dutch Safety Board is of the opinion that explicit attention must be given to manure gas hazards during the training provided to the various professional groups to increase their knowledge and awareness of these risks. Very few agricultural training centres and universities of applied agricultural sciences currently address these hazards. This is also applicable to the training given to members of the fire brigade, who may also be confronted with manure gases in the performance of their emergency relief duties.

Attention to safety during developments in the agricultural sector

The development of the manure policy and the design of sheds, manure storage reservoirs and manure processing (such as adding other fertilizers) devote no attention to occupational safety, even though these developments exert an influence on the risk of persons being exposed to hazardous concentrations of manure gases. Substantial increases in scale in both the cattle and pig farming sectors have resulted in larger sheds with more animals. These increases in scale have not only resulted in more manure and larger cellars, but have also resulted in the development of manure surpluses at farms and in regions and, consequently, an increase of tanker transports of manure. An increase in manure gas risks is inherent to this development. Moreover, the intensification of the livestock farming sector has resulted in the government's introduction of a more stringent manure policy to protect the environment. This has resulted in the introduction of measures including the obligation to cover manure storage (roofs on silos and the promotion of low emission slatted floors in sheds) that have introduced new occupational safety risks.

Manure gas risks have also risen on the increasing addition of other materials to manure slurry, such as flushing water from air scrubbers (as additional fertilizer). Mixing these materials, which is carried out for business–economic reasons, can promote the formation of hazardous manure gases. The Dutch Safety Board is concerned about the adoption of this step – which, it should be noted, is not formally permitted – as it is carried out without an adequate insight into the consequences for the formation of manure gases and, consequently, the potential consequences for occupational safety.

The production and processing of manure is expected to continue to increase in the coming years. The abolition of milk quotas in 2015, for example, is expected to result in the further growth of dairy farms. Three interests play a role in these developments: the protection of the environment, the economic interests of the livestock holders and the (occupational) safety of the persons involved. The Dutch Safety Board is of the opinion that more importance needs to be attached to the health and safety of the persons concerned.

Work instructions

The agricultural sector is governed – in analogy with other sectors – by occupational safety instructions laid down in *arbocatalogi* ('working conditions catalogues'). However, these do not lay down specific safety measures to be implemented when working in confined spaces that may contain manure gases. In the absence of these instructions the

relevant companies and their employees are left to determine the safety measures they should implement in these situations. Practice reveals that many livestock holders and service companies (such as manure silo inspection companies) do not adopt a conscious and professional approach to manure gas risks. However, it should be noted that a working party of manure silo inspectors and cleaners (*Kiek uut met stront*, ('Watch out with shit')) was formed in response to the accident in Makkinga that has since drawn up guidelines for safe work in manure reservoirs.

Supervision

It is striking to note that there is no supervisory authority that is charged with the proactive monitoring of occupational safety in the livestock farming sector. The Inspectorate SZW (the former Labour Inspectorate) plays a role in the adoption of the instructions to be included in the *arbocatalogi*, but its activities in the agricultural sector are limited to responses to serious accidents, complaints and indications. Moreover, the Inspectorates' investigations of accidents do not extend to accidents in which solely self-employed persons were involved. As a relatively large number of cattle and pig farms are operated by self-employed persons, the Inspectorate SZW has no insight into manure gas accidents at these farms.

Recommendations

The large number of manure accidents over the course of many years indicates that the agricultural sector lacks the learning capacity and sense of urgency required to improve occupational safety. As the sector is comprised of thousands of smallholdings, the Dutch Supervisory Board especially expects improvement in the knowledge and awareness of manure gas risks on the part of those involved.

The Dutch Safety Board has arrived at the following recommendations:

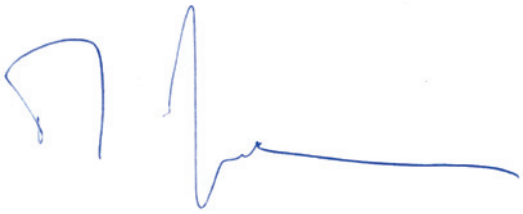
To the Dutch Organisation for Agriculture and Horticulture (LTO Nederland):

1. Ensure, in cooperation with other agricultural interest organisations (such as the Dutch Dairy Farmers' Union, NMV, the Dutch Pig Farmers' Union, NVV, and the Cumela association of farming, landscaping, manure spreading and agricultural contractors) that a platform is created for the collection of knowledge about manure gas hazards and safety lessons learnt from manure gas accidents. Also ensure that persons who work with manure in their professional capacity (livestock holders, contract workers, manure haulage drivers and manure silo inspectors, etc.) and their employers are actively and regularly informed about working safely with manure gases.

2. Ensure, in cooperation with the agricultural training centres and universities of applied agricultural sciences, that 'working safely with manure' is included as a structural element of their study programmes.

To the Minister of Social Affairs and Employment

3. Ensure, in cooperation with the Stigas occupational health service for the agricultural and horticultural sector, that the *arbocatalogi* for the agricultural sector are supplemented with specific instructions on the safety measures to be implemented when working in confined spaces that contain or have contained manure. These can be based on the *Leidraad veilig werken in mestopslagen* ('Guidelines for safe work in manure storage reservoirs') safety protocol.



T.H.J. Joustra
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M. Visser
General Secretary

CONCLUSIONS

General

Some of the gases released by manure slurry (including hydrogen sulphide) are very dangerous: inhalation of higher concentrations of these gases can result in loss of consciousness and to acute and fatal toxic reactions. These result in many accidents each year. The majority of these accidents occur while mixing/pumping manure slurry and while working in confined spaces (such as cellars, tanks and silos) that contain or have contained manure slurry. In the past 33 years, 35 manure accidents are known to have occurred which resulted in fatalities and/or severe injuries. These accidents constitute no more than the tip of the iceberg: many manure accidents (involving persons and/or animals) are not included in the statistics and are not reported in the media. It has been established that in recent years an average of at least three serious manure accidents have occurred per annum. The Dutch Safety Board is alarmed by the failure to reduce the number of accidents any further.

The accident in Makkinga

When viewed from a safety perspective, a number of problems occurred during the work that resulted in the accident in Makkinga. Firstly, the multigas detector did not ensure that the employee left the silo in time: it is not clear whether the detector did not give a warning or the warning was not heeded. Secondly, the respiratory protection did not prevent the employee's inhalation of hazardous concentrations of manure gases. The extent to which the respiratory protection was used correctly is not clear. However, the type of equipment that was used was not suitable for work in confined spaces that could contain hazardous concentrations of manure gases. This is applicable both in a general sense and, in particular, to the situation in Makkinga, where a thickened layer of manure had been stored during a period of four months and had not been mixed. Moreover, the formation of manure gases may have been exacerbated by the presence of flushing water from pig-house air scrubbers in the silo. Thirdly, no equipment was available to enable rescuers to get the victim out of the silo quickly and safely. The persons who rushed to help the victim entered the silo without any protective equipment whatsoever. All-in-all, this results in the conclusion that the safety precautions taken for cleaning the manure silo in Makkinga were not compatible with the high risks in this situation.

Safety problems

The accident in Makkinga is not unique. A series of examples reveals that this is a wider problem. The investigation of this series revealed the following problems.

The safety precautions are inadequate
As manure gases are hazardous substances, safety precautions must be taken when working with manure which are compatible with the magnitude of the hazards associated with the work. The investigation has revealed that in practice the safety precautions taken when working with manure are often insufficient to achieve adequate control of the risks. This is applicable to mixing and spreading manure, and to entering cellars, silos and tanks used for the storage and transport of manure.

Manure inspectors and cleaners adopt an unprofessional approach to the risks
Within this context, this is illustrated by the fact that the companies specialised in cleaning and/or inspecting manure silos each adopt their individual working methods. A comparison with equivalent work in the chemical industry reveals that the precautions that are taken often fail to do justice to the risks associated with manure gases in manure silos. This sector is not organised and is not governed by specific safety instructions for work with manure. However, it should be noted that some of the aforementioned companies (members of the *Kiek uut met stront* ('Watch out with shit') working party) have drawn up a *Leidraad veilig werken in mestopslagen* ('Guidelines for safe work in manure storage reservoirs') safety protocol in response to the accident in Makkinga.[1]

Rescue attempts increase the number of victims in the accidents
It is striking to note that a substantial majority of the rescue attempts were made by persons who were more-or-less coincidentally in the area and that these rescuers were often injured or died during their rescue attempt. Once again, in this respect the accident in Makkinga is not unique. The natural tendency of people to help in an emergency is often enhanced in manure accidents, as it is very evident that the situation is an acute emergency, few or no other potential rescuers are in the area and, moreover, the victim is often a member of the family or a colleague.

Underlying factors

The Dutch Safety Board is of the opinion that the following factors play a role in the cause of the aforementioned safety problems.

Insufficient attention is given to manure gas hazards
Accidents with manure gases often receive attention from the (local) media and the issue is occasionally placed on the agenda of information meetings held for livestock holders and contract workers. However, the investigation has revealed that persons active in the agricultural sector are insufficiently aware of the magnitude of the risks associated with manure gases. The large majority of the persons involved do not know or realise that at high concentrations of manure gases just one breath is enough to cause complete stupefaction. Nor are they sufficiently aware of the risk of the concentrations of manure gases suddenly rising to hazardous levels. This lack of knowledge and/or awareness of the risks probably also plays a role in the cause of manure gas accidents and in the tendency of bystanders to rush to help. It is then alarming to note that new workers

1 The Dutch Safety Board has not made a substantive assessment of these guidelines.

entering the agricultural sector are not prepared properly for their future work: agricultural study programmes – from lower vocational secondary education (VMBO) to higher vocational education (HBO) – devote little or no attention to the manure gas hazards.

Inadequate instructions
The *arbocatalogi* ('health and safety working conditions catalogues') for the agricultural sector do not lay down specific safety measures to be implemented when working in confined spaces containing manure gases. In the absence of these instructions the relevant companies and their employees are left to determine the safety measures they should implement in these situations. The instructions laid down in the *arbocatalogi* for working in confined spaces do not prescribe that preparations must be made in order to be able to provide assistance in an emergency safely. The Dutch Safety Board is of the opinion that this is irresponsible in view of the potential consequences.

Limited learning capacity
Although there have been manure gas accidents over the course of many years, the number has not declined in the recent past. This indicates that the sector has a limited capacity to learn from these accidents. This is also apparent from the sector's aforementioned limited awareness of the risks. Moreover, the supervisory authorities' proactive monitoring of occupational safety in the agricultural sector is limited. The Inspectorate SZW's activities in the agricultural sector are limited to responses to serious accidents, complaints and indications and it restricts its activities to accidents involving employees.[2] As a large number of cattle and pig farms are operated by self-employed persons, many manure gas accidents fall outside the Inspectorate SZW's field of work.

Developments that increase risks
The Dutch Supervisory Board has observed a number of developments in the agricultural sector that also, as a side-effect, increase the risk that people (and animals) are confronted with hazardous concentrations of manure gases.

- *Increase in the scale of manure storage.* The continual further restriction of the period in which manure may be spread on land and the intensification of livestock farming have resulted in larger slurry manure cellars under sheds and in the construction of manure silos. An increase in manure gas risks is inherent to this larger storage capacity and the longer period of the storage.
- *Sealed manure storage reservoirs.* The government's manure policy for the protection of the environment has imposed an obligation to cover manure silos and promoted the installation of low-emission slatted floors on manure cellars. These measures trap manure gases in cellars and silos, as a result of which persons mixing and removing manure or entering silos can be confronted with high(er) concentrations of manure gases. Virtually no attention has been devoted to the consequences for safety during the formulation of this policy and its subsequent implementation.

2 Within this context 'employees' are also understood as persons who work under the authority of the entrepreneur: this can include members of the entrepreneur's family.

- *Addition of other materials.* Other materials, such as flushing water from air scrubbers, have increasingly been added to manure slurry in recent years. However, mixing other materials in animal manure can promote the formation of manure gases. Although there is a formal prohibition on the addition of flushing water from air scrubbers the practice is customary and, moreover, is not subject to supervision or sanctions.

Final conclusions

Substantial increases in scale in both the cattle and pig farming sectors that have taken place in the past decades have resulted in larger sheds with more animals. At the same time the government has increased the stringency of the environmental regulations, pursuant to which manure reservoirs must be sealed and manure may not be spread on the land for a longer period of the year. During these developments the authorities and the agricultural sector have devoted insufficient attention to the control of the risks associated with manure gases. This has resulted in an increasing number of situations in which persons and animals are exposed to hazardous concentrations of manure gases.

The Dutch Safety Board is of the opinion that this is largely due to an underestimation of the risks and a limited learning capacity. This is also manifested by the agricultural education institutions' failure to address manure gas hazards in their study programmes and by the absence of clear instructions in the *arbocatalogi* laying down the safety measures to be implemented when working in confined spaces containing manure gases. The parties in the sector need to make the necessary improvements. In addition, due consideration needs to be devoted to safety from the very beginning of new developments in the sector (in the policy, operations or technology).

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