# ACRYLONITRILE LEAKAGE
# AMERSFOORT STATION
# 20 AUGUST 2002

The Hague, September 2004

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BOARD FOR TRANSPORT SAFETY

The Board for Transport Safety is an Independent Administrative Body and an individual legal entity instituted in law and tasked with investigating and determining the causes or probable causes of individual or categories of accidents and incidents in all transport sectors, namely shipping, air transport, rail transport and road transport, as well as pipeline transport. The sole objective of such investigations is to prevent future accidents or incidents, and if considered meaningful on the basis of the results, issuing related safety recommendations. The organisation structure consists of an umbrella Board for Transport Safety, above a structure of Chambers and one Committee for each transport sector. These are supported by a research staff and a secretariat.

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## PREAMBLE

The transport of hazardous substances engenders unavoidable risks. However, this does not mean that all the risks arising from the current transport of hazardous substances should simply be accepted. Such transport, and the majority of rail transport, should be organised in such a way that only exceptional factors represent any risk. The investigation by the Board for Transport Safety into the accident involving acrylonitrile, which occurred at the Amersfoort station complex on 20 August 2002, has shown that in practice, the transport of hazardous substances is very far from being organised in this way, as yet.

On this day, at Amersfoort Station, a goods train was present, with a destination in Germany, with immediately behind the locomotive a tank wagon filled with more than 70,000 litres of extremely hazardous acrylonitrile. The train had been parked in this location from five o'clock in the morning. Following arrival, the driver had returned home, so that the train was effectively parked in the centre of the city without any monitoring or supervision. At 11:03 hours, the discovery was made that the tank wagon was leaking acrylonitrile. At 11:28 hours, the decision was taken to evacuate an area with a radius of 100 metres. Not until a further 25 minutes had passed was train traffic passing within only a few metres of the tank wagon also halted. The fire brigade called in the regional hazardous substances officer. The municipal crisis team which by this time had been appointed, opted for the safest course of action, on the basis of the limited information available, and at 13:20 hours had the area within a radius of 500 metres around the train shut off.

The major risks accompanying the transport of hazardous substances led the Board for Transport Safety to investigate this accident. The results of the investigation thus initiated both surprised and disturbed the Board. The system of international rules for the transport of hazardous substances by rail: the RID[1] are an impressive example of professionalism, expertise and consistency. Nonetheless, on the basis of this investigation, the Board has reached the conclusion that within these highly valuable and important international agreements, there remain a number of fundamental lacunas. The central theme in this connection is above all the integrated duty of care, a basic term from the ISO 9000 standard approach. The duty of care approach, which demands permanent attention at all levels within a company, from grass roots through to management, goes far further than merely complying with the rules imposed. The safety of the transport of hazardous substances is at present above all based on rules which are assumed to be complied with. Supervision of compliance with these rules and inspections by government represent an essential element in this system, for the maintenance of a responsible level of safety. However, such supervision and such inspections are marginal. The Hazardous Substances Inspection Agency (Korps Controleurs Gevaarlijke Stoffen) responsible solely for inspection of compliance with the rules for hazardous substances, was done away with years ago. Such inspections are now one of the tasks of the officers of the Inspectorate for Transport, Public Works and Water Management (IVW), an organisation that supervises compliance with a large number of laws and regulations.

Within safety management systems, too, the duty of care plays a key role. These aspects have come to occupy an important place within companies, because many experiences have shown that the principle "compliance with rules" offers no guarantee for achieving the level of safety demanded by society today. The duty of care calls for far greater efforts from those involved than merely complying with rules. For a complex system such as the transport of hazardous substances, however, the duty of care is an absolute precondition if a safer system is to be achieved.

In fact, this represents an improvement in the responsibility of the sector itself.

[1] Règlement concernant le transport International ferroviaire des marchandises Dangereuses

Supervision by government, however important it may be, remains additional to what the sector itself should be doing. Government supervision is therefore not able to prevent every violation of the rules, or all mistakes. As indicated in the report from the Oosting Commission on the firework disaster in Enschede, such a role can indeed not be expected from government. What can, however, be expected from government, what can be expected from the responsibility of the sector itself, and how the balance between these two should take form is not yet entirely clear. The Board has come up against these very questions in a number of its investigations, and has undertaken to initiate a separate study into these matters.

The transport of hazardous substances is a complex process. Legally, it is based on a system of licences. National governments allow the transport of specific hazardous substances if a number of parameters are met. It should be noted in this connection that national governments grant permission for the transport of hazardous substances, but the "know-how" in respect of the technical requirements to be imposed to a considerable extent lies with the manufacturers and users of the specific hazardous substances.

The national governments of 42 countries have jointly determined the technical requirements which must be met for the transport of hazardous substances. These requirements are laid down in the RID, which is part of an agreement between the governments of these countries. The RID can look back on a long history. The founding principle behind the RID was the facilitation of cross-border transport of hazardous substances by standardising the often widely divergent national rules for such transport. The RID therefore specifies that the individual parties who form part of the transport chain must be able to rely on the fact that each other party complies accurately with the rules. As a consequence, the safety responsibility of each party involved is limited exclusively to that party's own activities. Who is responsible for the total transport chain, for the safe transport from manufacturer to user, is thus an open-ended question.

The basic system operated by the RID to guarantee the safety of tank wagons complies with the system employed in many technical sectors. It consists of three elements, namely type inspection, periodic inspections and inspection during use.

- Type inspection

During this inspection, a determination is made as to whether the tank has been constructed in accordance with the technical regulations of the RID and specific national (in this case German) requirements.

- Periodic inspection

Once every four years, a tank wagon is inspected with a view to determining the technical condition of the wagon and the tank itself. The core of this inspection is a test as to whether the tank can resist an overpressure of 3 bar.

- Inspection during use

After filling tank wagons with acrylonitrile, the filler must check whether the tank is hermetically sealed.

**In the investigation into the accident in Amersfoort, it was determined that the type inspection proved insufficient, various periodic inspections had also been insufficient, and that there was no reasonable check of the proofness of the tank. These shortcomings apply both to the case in point, and regular business operation. The (now outdated) instructions to the filler in question (see appendix 2), applicable for normal business operations, provided for no inspection of proofness.**

The basic starting point employed by the RID is that all parties involved precisely fulfil their obligations. It is not necessary for the parties involved to inspect one another's activities in the transport chain. In the organisation form selected by the RID, consisting of independent, self-managing units, supervision is the cornerstone of the safety system.

Against this background, one would expect that the Inspectorate for Transport, Public Works and Water Management would supervise the integrated transport chain for hazardous substances. However, this proves to not be the case. The Inspectorate plays no role in type inspections or in periodic inspections. The Inspectorate is not authorised for these activities. Nonetheless, serious shortcomings were identified in both these respects.

The Inspectorate above all focuses on inspections during transport itself. The major disadvantage of such a work approach is that the possibilities are extremely limited. Inspections en-route lead solely to the discovery of visible shortcomings. However, it is not possible to determine through visual inspection whether a tank is hermetically sealed or is in good technical condition. The two latter aspects can only be determined using technical equipment at locations specially equipped for that purpose.

**RECOMMENDATIONS**

**It is recommended that the Association for the Netherlands Chemical Industry advises its members to monitor in an integrated manner the entire transport chain for hazardous substances, in such a way that safe transport is guaranteed at all times.**

**It is recommended that VOPAK Terminal TRR draws up a clear, uniform filling instruction, geared towards the users, for each type of tank wagon, and ensures that work is carried out in accordance with those instructions.[2]**

**It is recommended that the VdTÜV terminates as rapidly as possible the type approval for the ball cock, which applies until 2004.**

**It is recommended that the VdTÜV reviews the inspection regime for tank wagons for the transport of hazardous substances in such a way that the proofness of the reservoirs is guaranteed at all times and that if relevant, at least the ball cocks and blind flanges be tested for proofness independently of one another, so that one of the two always guarantees proofness, in the event of failure of the other.**

**It is recommended that the Minister of Transport, Public Works and Water Management (in this case the Directorate General for Goods Transport) ensures, through international consultation under the auspices of the RID:**

- **that the inspection and testing of tank wagons is organised in such a way that the safe transport of hazardous substances is guaranteed at all times.**
- **that the technical regulations for the loading and discharge openings of tank wagons in the RID be tightened up, such that in these openings, at least 2 safety barriers are present.**
- **that the tank wagons be provided with an escape code.**

**It is recommended that the Ministry of Transport, Public Works and Water Management (in this case the Directorate General for Goods Transport) adapt the Decree on the Transport of Hazardous Substances by Rail (VSG) in such a way that trains carrying hazardous substances may only be parked at locations where there are no or practically no risks for the surrounding environment.**

Mr. Pieter van Vollenhoven
Chairman of the Board

Drs. J.H. Pongers
Dep. Secretary-Director

[2] Documents made available indicate that VOPAK TERMINAL TRR has already altered these instructions.

# 1. INTRODUCTION

On 20 August 2002, a tank wagon (a reservoir mounted on a rail wagon with a capacity of 80,000 litres) parked at Amersfoort station leaked acrylonitrile. In total, more than 600 litres[3] of acrylonitrile were lost. This substance is toxic, represents a dangerous fire risk and is viewed in the Netherlands as a carcinogen. Once it had been determined that the tank wagon was leaking, the immediate vicinity of the station was screened off whereby office buildings were evacuated, train traffic was halted and the voltage taken off the catenaries. These measures, which were taken around 12.00 hours, remained in place until 7 p.m. The leakage and the measures taken had massive consequences for the functioning of a major proportion of Amersfoort city centre and for train traffic between the Randstad conurbation and the northern and eastern provinces of the Netherlands.

Any of the escaping acrylonitrile which did not evaporate leaked into the soil. In this case, the soil contamination related to a relatively small volume. On 16 February 2002, an accident occurred in Osnabrück (a city in Germany with 250,000 inhabitants) whereby a tank wagon lost 65,000 litres of acrylonitrile. Part of this volume was burned, and the remainder, between 10 and 20,000 litres, seeped into the groundwater. This occurred in the city centre. The cleaning of the groundwater will take at least four more years, and to date has cost € 1,600,000, whilst the success of this operation is not even guaranteed. By pumping 50 m3 of groundwater each day from the centre of the contaminated area, the contaminated groundwater from the surrounding area flows back to this point.

The risks and consequences of this leakage led the Board to take the decision to further investigate this accident in Amersfoort. The manner in which the fire service and other public emergency services tackled the consequences was considered beyond the scope of the investigation. The Municipality of Amersfoort charged an external consultant with investigating these aspects. This consultant has now issued his report, which has been discussed in the Amersfoort Municipal Council. The Board for Transport Safety for this reason concentrated on those aspects of the accident relating to the railways. This alone proved an extensive task.

The investigation consisted of a number of phases. The first was focused on the cause of the leakage. The situation at the location was determined. Shortly following the accident, the tank wagon itself also underwent a technical examination. In accordance with the Board for Transport Safety Act, the disturbing results of this investigation were immediately notified to the Minister of Transport, Public Works and Water Management. Also in this phase, an investigation was carried out into how the tank wagon had been loaded. In the subsequent phase, an investigation was made into what rules apply for the safe transport of hazardous substances, and a determination was made as to whether these rules had actually been complied with, and whether they are adequate for the purpose.

This approach reflects the system or chain approach whereby the accent is placed primarily on interfaces. This means that an analysis was carried out into how the various components of the system – the companies, institutions and emergency services involved – view their own role and how the parties involved fulfil that role. Subsequently the consequences of the fulfilling of these roles for other parties involved were investigated.

[3] This volume is based on the gross weight of the tank wagon, determined by measurement, immediately following filling, minus the gross weight also determined by measurement immediately following the leakage. The specific weight is 0.8 kg per litre.

It has emerged from the investigation that the transport of acrylonitrile engenders certain risks. A number of these risks are inherent to the transport of this hazardous substance. However, this transport of acrylonitrile took place under conditions engendering unnecessarily high risks. The Board believes that these risks could have been avoided. With the results of this investigation, the Board hopes to contribute to the improvement of the safety of the transport of this particularly hazardous substance.

## 2. COURSE OF EVENTS

### *2.1. THE LEAKAGE IN AMERSFOORT*

In the night of Saturday 17 to Sunday 18 August 2002, having first completed an inspection, the tank wagon was filled with acrylonitrile by employees of Vopak Terminal TRR at the loading station in the Botlek in Rotterdam. The filling of the maximum volume of 71,000 litres started on **Sunday** at **4:45** hours and lasted 1 hour and 45 minutes.

Acrylonitrile is particularly hazardous. It may not be in open contact with the outside air, to protect the fillers. Filling took place via a pipe connected to the filler opening of the tank. To prevent acrylonitrile vapour entering the outside air a return pipe was fitted simultaneously. A return pipe serves to discharge any air present in the tank, forced out by the acrylonitrile. The fillers responsible for this work were wearing special protective suits and a special cap over the head and shoulders. This cap was connected to a pipe supplying clean air.

Following filling, the valves were closed, the pipes disconnected and the filler openings of the tank wagon closed with gaskets and blind flanges. The checklist was then completed. Subsequently, the filled wagon was carried to a siding of the Vopak Terminal TRR. The wagon stood there until Monday **19 August 18:00**.

On Monday **19 August** at **14:00**, the tank wagon was visually inspected at the Vopak Terminal TRR (for apparent shortcomings) by a Vopak Terminal TRR inspector. No leakage or anything special was observed. At **18:00**, following inspection, the tank wagon was moved by the transporter to the Botlek yard. Subsequently (once again following inspection) at **22:06**, this wagon, together with others, was transported to the Kijfhoek yard. At this yard, a train was assembled, with destination Germany. The tank wagon containing acrylonitrile was located immediately behind the locomotive. When coupling the locomotive to the train, no special circumstances were observed. According to the timetable, this train was due to depart for Germany that same night, at **2:40** (on Tuesday 20 August).

At 23:00, the message was received at Kijfhoek that all train traffic had been halted in Deventer, due to a lightning strike in the protection device. Later, it was reported that around 4:00 train traffic would be possible through Deventer, via a single track. There was no reason for retaining a goods train to Germany at Kijfhoek. At **2:52**, the goods train with the tank wagon filled with acrylonitrile left for Germany, only slightly delayed.


Fig. 1 The city of Amersfoort with the so-called “cross-over” station that fulfils a hub function in connections between the Randstad conurbation and North Eastern Netherlands

At approximately **4:50**, this train was approaching Amersfoort. According to the journey plan, drivers would be changed at Amersfoort. For this reason, the goods train was taken to siding 9a, which offered a possibility of immediately continuing the journey. Following arrival at track 9a, the driver lowered the locomotive’s pantograph, carried out a number of other actions, and finally shut down the locomotive. This was at approximately **5:00**. After leaving the locomotive, the driver walked to the left, along the train. He noticed nothing particular. He signed off with the process coordinator and went home. The driver taking over his service had to come from Deventer. Due to the blockage, this driver was not on station.

Following a request from Railion transport control, in the course of the morning, ProRail (Rail Traffic Control Amersfoort) requested two employees of Railion to connect the wagons from another goods train behind the stationary goods train on track 9a. As a result, a single train movement towards Deventer was made unnecessary. A driver and a carriage and wagon inspector carried out this work.

Implementation was somewhat delayed because shortly beforehand, a platform supervisor from Amersfoort had seen a section of scaffolding tube laying in track 9. This scaffolding tube had probably fallen from an office building under construction. The tracks in question were briefly taken out of service. Following removal of the tube, normal service was reinstated.

After the goods wagons had been placed behind the goods train on track 9a, a specified inspection was carried out immediately behind the locomotive. The carriage and wagon inspector who carried out this inspection felt several drops falling onto his arm at one point and simultaneously smelt an unpleasant odour. He took several steps sideways and saw a thin layer of liquid approximately 20 cm wide flowing down the wall of the reservoir of the tank wagon positioned immediately behind the locomotive. The carriage and wagon inspector determined the wind direction[4], subsequently ensured that he was standing upwind, and via his radio telephone immediate warned the Railion complex coordinator. He also immediately passed on the required information: the wagon number, the location in the train, the hazard identification code (336) and the UN number (1093). The coordinator immediately passed on the information by telephone to ProRail (Rail Traffic Control Amersfoort). The report was registered at **11:03.**

## *2.2. THE RESPONSE5*

ProRail (Rail Traffic Control) immediately passed on the message to the Central Control Room (CMK) of the railway police of the National Police Agency (KLPD). The CMK passed on the message to the regional control room of the police who informed the control room of the police in Amersfoort. The Amersfoort control room notified the regional alarm centre (RAC). The message issued at that time was as follows: "*on track 9 at Amersfoort station, a tank wagon containing hazardous substances has been hit by a falling scaffolding tube. (...) for reasons of safety, the station is being evacuated. The hazard is known (UN no. 1093 hazard identification code 336), however, it is not yet known whether fluid is leaking.*"


Fig. 2 The train at Amersfoort station. The tank wagon immediately behind the locomotive is the leaking wagon filled with acrylonitrile.

At **11:25**, the first consultation took place with the Coordination Team Incident Location (CTPI – this is the consultation between the fire brigade, police and ambulance service at the incident location). The decision was taken to shut down the area within a radius of 100 metres around the tank wagon. This area includes the station, the station square and part of the Soesterkwartier district. At **11:44**, the

[4] North-West. 320°

[5] Based on the investigation by B&A Groep (carried out on behalf of the Municipality of Amersfoort) supplemented by own investigation.

leaking tank wagon was reconnoitred by a number of fire officers dressed in chemical suits. At this time, the catenary was still being fed with the standard 1500 Volts The fire officers approached the tank wagon to within 20 metres. At **11:49**, notice was issued that a falling scaffolding tube could not have been the cause of the leakage. Train traffic in and around Amersfoort was shut down at **11:50**. Several minutes after **12:00**, the NedTrain accident service arrived on location. This service is expert in respect of hazardous substances and tank wagons. At **12:12,** ProRail (Rail Traffic Control) was requested to switch off the voltage on the catenary. This was an essential precondition for enabling inspection of the leak on top of the tank wagon. At **12:30**, a combined inspection of the leaking tank wagon was started by both the accident service of NedTrain and the fire brigade.

At **13:08**, it was decided to shut off the entire area within a radius of 500 metres. As a consequence, at **13:20**, the sirens in the area in question were sounded. At **14.23**, notice was issued that the leakage in the tank wagon had been halted. By opening a valve, the NedTrain team had removed the overpressure in the reservoir. At **15:10**, the message was issued to the public that the incident was under control, and that almost all measures had been withdrawn. The shut-off area was limited to a radius of 50 metres around the tank wagon.

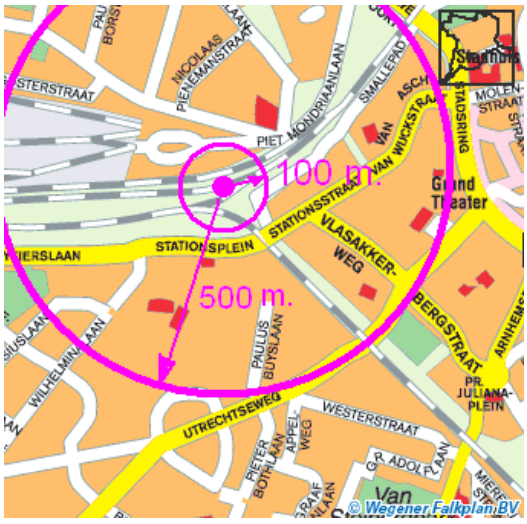


Fig. 3 The station and immediate environment. The consecutively shut-off areas are roughly indicated.

At **15:17** doubts arose. An expert on acrylonitrile from DSM had stated that the cause of the problem first had to be clarified, before the “all clear” signal could be issued. A possible cause put forward could include the absence of a stabiliser in the acrylonitrile. This would first have to be determined. A simple temperature measurement from long range would be sufficient. At **15:20**, the decision was taken that all previous measures would be reinstated, and the shut-off radius was once again raised to 500 metres. The intention at all times was to evacuate the closed-off area. At **16:05**, it was determined that there was no pressure build-up in the tank wagon. It was also determined by the fire brigade that a faulty gasket was the cause of the leak. The manufacturer of the acrylonitrile also issued notice that a stabiliser had been added to the liquid.

The towing away of the tank wagon containing acrylonitrile to a location outside the city was one possibility considered. Consultation on this question took place with the Inspectorate for Transport, Public Works and Water management (IVW). At **16:35**, the message was received that the inspectorate was against this move. An hour later, the IVW halted the transport of the tank wagon to its destination in Germany, to permit an investigation into the cause. At **18:30**, permission was given to transfer the tank wagon to the sender, for investigation. Eventually at **18:53**, the decision was announced that all safety measures had been lifted.

Amersfoort station – an important intersection in the railway network – was shut down entirely for a large part of this day. A large area in the centre of Amersfoort was also shut off and inaccessible during the same period and the presence of persons in this area was discouraged.

**Overview of the key events on 20 August 2002**

| | |
|---|---|
| 5:00 | Arrival of the train with acrylonitrile in Amersfoort. |
| 11:03 | Report of acrylonitrile leakage. |
| 11:25 | Closing off of an area with a radius of 100 metres around the tank wagon. |
| 11:44 | Initial reconnoitring by fire brigade from 20 metres. |
| 11:50 | Fire brigade reports that falling pipe cannot be cause of leakage. |
| 11:50 | Train traffic halted at station. |
| 12:30 | NedTrain support group on tank wagon. |
| 13:20 | Sirens sounded and shut-off area extended to 500 metres. |
| 14:23 | NedTrain support group halts leakage. |
| 15:10 | Notice issued that everything is under control and measures withdrawn. |
| 15:20 | Message recalled and old measures reinstated. |
| 16:05 | Determination of no pressure build-up in the reservoir. |
| 18:05 | The IVW announced that the tank wagon could be towed away for investigation. |
| 18:53 | All measures withdrawn. |

## 3. THE PARTIES INVOLVED

The incident involves a number of parties. In the transport of hazardous substances, the role of all parties and their involvement is laid down in the RID[6], an agreement between the governments of 42 countries, including the countries of the European Union.

***Transpetrol GmbH (with registered offices in Germany)***
SENDER
Transpetrol employs some 30 staff. This company rented the tank wagon and was responsible for the logistic aspects such as time planning and administration of the acrylonitrile transport. Transpetrol is part of the VTG-Lehnkering group.

***Railion Benelux NV (with registered offices in the Netherlands)***
CARRIER
Railion Benelux NV is the largest rail transport company in the Netherlands and is part of Railion Deutschland AG (27,000 employees) that in turn is part of the Stinnes group. Stinnes is a joint venture established by the Deutsche Bundesbahn, the purpose of which is to develop international activities. Railion Benelux in its current form in principle grew from the goods wing of the former Dutch national railway company (NS – Netherlands Railways). In the Netherlands, Railion employs some 1200 staff. Railion has its own locomotives, goods wagons and drivers. In addition, Railion also carries out various traffic control tasks at a number of marshalling yards.

Railion was transporting the tank wagon containing acrylonitrile on behalf of the sender. This means that the empty tank wagon was delivered to the filler in Rotterdam. Once the tank wagon had been filled with acrylonitrile, it was collected and carried towards Germany. During this process, a number of visual inspections were carried out. The obligations with which Railion must comply as carrier are listed in the RID. Obligations are also laid down in the Rail Transport Regulations and standard M-012 from the IVW Rail Division. These are not focused on the transport of hazardous substances but on general rail aspects.

***VTG-Lehnkering AG (with registered offices in Germany)***
OPERATOR OF TANK WAGON
The acrylonitrile was carried in a tank wagon owned by VTG-Lehnkering AG. In total, this company has 50,000 railway tank wagons. Approximately 600 of these wagons are exclusively intended for the transport of acrylonitrile.

The head office of this company is in Hamburg. VTG-Lehnkering is part of the internationally-operating business Hapag-Lloyd. This company itself was purchased several years ago by TUI AG, active in the tourist sector. TUI AG has 70,000 employees and annual turnover of € 20 billion. VTG-Lehnkering has a turnover of € 940 million and has 3000 employees.

VTG-Lehnkering leased the tank wagon in which the acrylonitrile was transported to Transpetrol GmbH. In specific terms this means that at a given moment, the tank wagon was delivered to a marshalling yard. At that yard, Railion collected the tank wagon to actually implement the requested transport of acrylonitrile. The obligations upon the parties involved in this situation are also laid down in the RID.

***Vopak Terminal TTR BV (with registered offices in the Netherlands)***
FILLER

[6] Règlement concernant le transport International ferroviaire des marchandises Dangereuses

The tank wagon involved in this accident was loaded at the Vopak Terminal TRR BV in Rotterdam. This company is part of the Vopak group, an internationally-operating business that runs 71 tank storage facilities in 29 countries.

Filling of the tank wagon was carried out by employees of Vopak Terminal TRR BV. The obligations in this situation are laid down in the RID.

Fig. 4 The Vopak Terminal TRR storage facility for chemical substances in Botlek, Rotterdam. Left, in the open air, is the filling station for tank wagons.

***ProRail***
TRACK MANAGER
ProRail is the government-appointed manager of the Dutch railway network. It is an independently-operating company financed almost entirely by the government. ProRail has almost 2900 employees. ProRail is only involved in this occurrence as manager of the track.

One part of ProRail, Rail Traffic Control, that at the time of the accident was still an independent business, regulates train travel throughout the network, and is responsible for tackling the consequences of disasters and incidents, in respect of rail aspects.

## *3.1. COMPETENT AUTHORITIES*

A competent authority is a legal term from the RID. Inspections, checks and examinations specified in the RID may only be carried out by competent authorities. For specific articles from the RID, the Minister appoints specific businesses and institutions as the competent authority. In the Netherlands, these appointments are laid down in appendix 3 to the Transport of Hazardous Substances by Rail Decree (VSG).

The RID specifies that tank wagons used for the transport of hazardous substances must be periodically inspected. The acrylonitrile was transported with a German tank wagon. The inspections and tests are carried out in Germany by institutions identified in the Ministerial Decree (Gefahrgutverortnung Strasse und Eisenbahn dated 10 September 2003) or which are approved as such by the Eisenbahn-Bundesamt. The last tests were carried out by the following competent authorities.

***Verband der Technischen Überwachungs-Vereine e.V. (VdTÜV with registered offices in Germany)***
The Verband is the representative group for all Technische Überwachungs-Vereine in the Federal Republic of Germany. This group consists of a wide range of companies and institutions, for example not only the Landesbetrieb of Hamburg that for example bears responsibility for the approval of motor vehicles and the issuing of driving licences in the Hamburg region, but also independent safety departments of large industrial companies.

The activities of the Verband focus not only on the specific safety tasks of the Technische Überwachungs-Vereine, but also on participation in the process of drawing up draft directives for the EU, laws, regulations, technical rules and standards. The Verband supplies the parliament, Ministries and public and private organisations at national and international level with relevant information.

In the present case, two components issued the statutory required licences to admit the tank wagon for the transport of acrylonitrile. The department: Zertifizierungen und Registrierungen

Gefahrguttransporte did so on behalf of the Verband. The Verein für die technische Überwachung von Güterwagen (VTÜG) in Hamburg did the same, on its own behalf. The first is identified in the Decree described above, and the latter is approved by the Eisenbahn-Bundesamt.

In as much as no generally-applicable rules are laid down, competent authorities designated by national government are free in their decision making. It was not possible to determine whether such rules actually exist. Appointment as a competent authority can be withdrawn by the government.

## *3.2. POLICY AND SUPERVISION*

***Directorate General for Goods Transport of the Ministry of Transport, Public Works and Water Management***

The policy in respect of goods transport has been placed by the Ministry of Transport, Public Works and Water Management with the Directorate General for Goods Transport (DGG). This Directorate General represents the economic side and the safety side of goods transport in the Netherlands. Within the DGG, both fields receive equal attention. One key objective (alongside others) of the policy of the DGG is to promote the safe transport of goods. The policy is aimed at the safety of goods transport by road, rail and water (internal safety) and the safety of the transport environment (external safety). To this end, measures are developed and maintained in respect of means of transport, traffic participants, traffic management, cargo handling and infrastructure, including the equipment of transport locations and track complexes.

The policy of DGG is for example based on input from other inspectorates, following accidents, by other parties involved (local governments, fire brigade, Ministry of Public Housing, Spatial Planning and the Environment, etc.) and technological developments. For structured incident investigations, no funds are available. The Transport, Public Works and Water Management Inspectorate is kept up to date on incidents by means of incident forms (on the basis of article 47 of the Transport of Hazardous Substances Act). The majority are so-called “drip leakages on the railways” and the direct causes of these leakages (approx. 50 per year).

To facilitate the transport of hazardous substances across the border, the first agreements were reached with other countries, many years ago. In 1893, the first Treaty relating to international rail transport was introduced. As appendices to this Treaty, a number of stipulations were outlined for the transport of hazardous substances. These were the forerunners of the RID. In the further development of these stipulations, the OTIF (Organisation intergouvernementale pour les Transports Internationaux Ferroviaires) has played a leading role. Today, the United Nations issues recommendations for regulations for transport of this kind the railways (RID), road, water and air. Regulations for the various transport modalities have as a consequence been structured the same and offer the same character, for several years, now. In addition to the RID, the Minister has laid down a number of rules that apply only for the Netherlands. These rules, for example, regulate the stationary (parking) of trains.

The RID is constantly being adapted to the most recent knowledge. To this end, a large number of working groups are active. These working groups bring together the carriers, the builders of tank wagons and representatives of the Ministries involved from the participating countries. In Europe, these activities are coordinated by the OTIF, currently established in Bern (Switzerland). On behalf of the Minister, employees of the Directorate General for Goods Transport participate in these working groups.

***Inspectorate for Transport, Public Works and Water Management (IVW)***
The IVW, the general inspection service of the Ministry of Transport, Public Works and Water Management, is for example responsible for supervising compliance with the rules for the transport of hazardous substances. The Inspection Service has its own responsibility and works together with the Directorate General for Goods Transport. The Inspection Service and this Directorate General are immediately responsible to the Minister of Transport, Public Works and Water Management. The service, when fully staffed, has 117 inspectors able to carry out inspections for compliance with the rules for the transport of hazardous substances by rail, by road, by air and by ship. What percentage of available working hours is spent on these specific inspections is not known.

IVW investigates whether the rules laid down (effectively the RID) for transport are complied with, in the Netherlands. The technical inspections of tank wagons are not to date covered by their field of work. The Inspectorate is not (yet) competent to carry out such inspections. The tank wagons are inspected once every four years by foreign competent authorities, for proofness, etc. During the inspection by the IVW, the labelling is checked, and the administration is consulted as to whether the tank wagon is permitted to transport this substance. These inspections generally take place at the ProRail Kijfhoek yard. A check is also made to determine whether the wagon is leaking. On a tank wagon with filler openings at the top (as specified by the RID), this inspection is impossible during actual transport, because these openings are located immediately beneath the catenary, which is powered with 1500 Volts. The IVW can have the train placed on a siding, for inspection.

## 4. THE ANALYSIS

### *4.1. TECHNICAL ASPECTS*

#### *4.1.1. THE CAUSE OF THE LEAKAGE*

***The leakage was caused by overpressure in combination with technical shortcomings in the reservoir of the tank wagon. The leakage was possible due to a valve which was technically unsuitable for the purpose for which it was used, which leaked when closed due to inexpertly carried out welding, and which furthermore was closed with a blind flange which over time had become rough due to rust formation and gasket residues.***

The acrylonitrile was transported in a tank wagon with a capacity of 80 m3, built in 1972. A tank wagon is a large cylindrical reservoir in thin sheet steel mounted on a flat railway wagon. This wagon effectively consists of nothing more than a simple steel frame mounted on two bogies. Acrylonitrile may only be transported in so-called top loaders. The substance is so hazardous that in the event of collisions, damage to the valves must be avoided, such that acrylonitrile cannot escape into the environment. The RID specifies for this reason that tank wagons for acrylonitrile may only have openings on top of the reservoir. These tank wagons are filled and emptied via a riser pipe (covered with a red blind flange, see illustration).

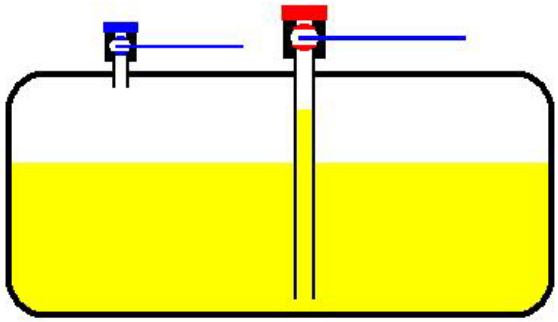

Fig. 5. Diagram of the reservoir of the tank wagon with a closed filling system. The red flange (red rectangle) closes off the filler pipe and the blue blind flange, the vapour return pipe.

At Vopak Terminal TRR, acrylonitrile is only loaded with a connected return pipe for the discharge of vapour and air. The vapour return pipe is not a requirement in the RID, but is specified in Dutch regulations. The vapour return pipe is connected to the blue cock which in opened condition connects to the area above the liquid in the reservoir (see illustration).

If the reservoir is emptied or filled via a closed system with vapour return pipe, cocks are required – one for the filler pipe and one for the return pipe. Without cocks, during the connection of the pipes, an open connection would be achieved with the outside air.

Fig. 6 Photograph of filler pipe (red) and return pipe (blue) and opened protective cover on top of the tank wagon, taken during testing following the incident (without acrylonitrile, i.e. without protective gas suits).

The accident team of NedTrain climbed onto the loading platform of the tank wagon at 12.30. Once the team had opened the protective cover placed over the connections during transport, the connections became visible (see photograph). It was determined that acrylonitrile was leaking from beneath the red blind flange. In addition, the team determined that the handle of the accompanying ball cock was not in the horizontal position. Also once this handle had

been placed in the horizontal position, the leakage continued. Some time later, after the accident team had collected new bottles for their breathing apparatus, the blue blind flange was released. As a result, vapour and air could escape, the overpressure was eradicated in the reservoir, and the leakage halted.


Fig.7. ***Top left***. The stripped down stainless steel ball cock in a test bed. The handle has been pressed down until it comes into contact with the bent end stop. Even then, the cock is not closed. The handle is then not horizontal. In its horizontal position (closed position), the cock is parallel to the side of the table on which the ball cock is mounted. This ball cock has the special feature that there are only two positions in which the cock is closed. In all other positions, the cock is opened.

***Top right.*** The bent end stop. With the handle in horizontal and closed position. The handle is now not resting against the end stop. A bent end stop effectively means a cock which can no longer be sealed.

***Bottom left.*** Detail of the hole for the bolt. The bolt itself has been removed. The hole for the bolt of the end stop has been drilled too close to the top edge. The soft stainless steel has been bent out of shape. The top of the cock should be smooth. In this case, it is bent out due to the major forces applied on the bolt.

***Bottom right.*** A magnification of the underside of the red blind flange. One of the bolts passes through the hole. The rough, uneven, circular strip is the location of the gasket. The flange should be even. The lighting for this photograph was perfect. Under normal light conditions, this unevenness is less obvious.

On behalf of the Board, a technical examination was carried out on the cock in the riser pipe and the accompanying red blind flange [7]. This examination showed that the cock (the ball valve) demonstrated two faults, as a result of which it leaked.

- Such considerable forces had been exercised on the handle for closing the cock that the end stop which guarantees the correct closed position had been bent (see figure 7). If the end of the handle was against the stop, the cock was still approximately 3 mm open.
- In addition, the inexpert placement of a metal name plate had damaged the ball. As a result, the seal was no longer complete. The name plate had been installed to prevent theft.

The ball cock is sealed off by a steel blind flange (the red flange in figure 5 and 6), fitted with a gasket. This blind flange is connected to the tank wagon by a chain. The ball cock is manufactured from stainless steel. The top edge of this cock, to which the blind flange is attached, can therefore not corrode, and remains smooth. The steel blind flange, however, had rusted and was soiled, as demonstrated by the examination carried out, and fig. 7. The gasket found following the accident between the cock and the blind flange is not used frequently, and matched the type fitted at the last inspection.

The investigation carried out showed that with this flange, due to its condition as a result of the rust and soiling, a hermetic seal of the reservoir as specified in the RID was practically technically impossible. It should be noted that the RID merely specifies that the reservoir must be hermetically sealed. For substances from classes 3 to 9, which includes acrylonitrile, the RID contains no regulations for the valves and blind flanges. These are designed and manufactured in accordance with the requirements of the competent authorities for admission, in as much as they exist, and the wishes of the client who has the tank wagons built.

According to the rules of the RID, the reservoir of a tank wagon must be tested every 4 years by a competent authority, through the application of overpressure in the tank of at least 3 bar (atmosphere). Also in this case, the test was carried out. The leakage of the ball cock was not identified during this inspection, although it was present at that time, as outlined in the relevant investigation report by AEA Technology[8]. If the reservoir is placed under pressure, in fact the closed cock should be inspected without a blind flange, as should the blind flange itself be inspected, with the cock open. In this way, both are independently checked. In practice, testing is only carried out with a closed cock. The seal with gasket and blind flange is therefore not tested. According to the RID, this is also not necessary. The RID requests merely a hermetic seal. In practice, therefore, there is only one seal: the ball cock.

From a technical viewpoint, at least three barriers failed. The design of the ball cock was faulty. The blind flange was not smooth enough and the technical inspections of these aspects, required to be carried out by law every 4 years, failed to bring these faults to light.

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7 Report: Investigation into the cause of the leakage of a tank wagon filled with acrylonitrile on 20 August, in Amersfoort, issued in November 2002 by AEA Technology Rail BV

8 See previously referred to report: investigation into the cause of the leakage of a tank wagon.

*4.1.2. THE CAUSE OF THE OVERPRESSURE IN THE TANK WAGON*

***The overpressure in the reservoir of the tank wagon may have been caused by inexpert filling of the reservoir with acrylonitrile, or by heating by the sun. After the event it is no longer possible to objectively determine the precise cause.***

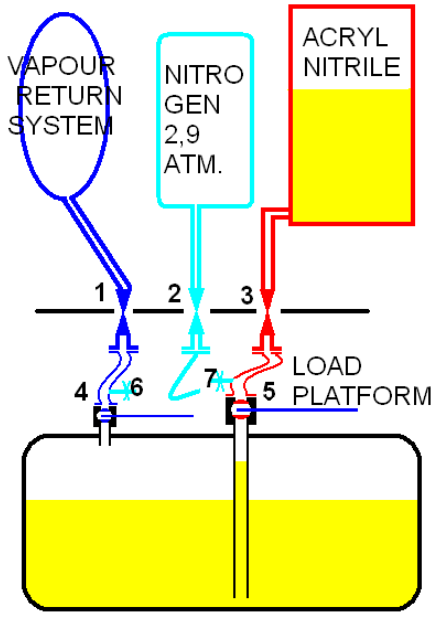


Fig. 8 Diagram filling of tank wagon.

the users' manual provided by the operator of the tank wagon, supplemented with other details about the filling installation. In fact, these employees (the filling of wagons with acrylonitrile is always carried out by 2 workers, for safety reasons) are provided with only very general non-specific instructions (see appendix 2).

Filling occupies a central position in leakage due both to heating and overpressure. As a consequence, the Board decided to further analyse the procedure for filling the reservoir. From this analysis it immediately emerged that the operator of the tank wagon supplies these tank wagons with their complex loading and unloading systems to the filler, without any specific users' manual. There is a manual, produced by the operator of the tank wagon containing general information about the various types of tank wagons with their capabilities and characteristics. The tank wagon used in Amersfoort, however, is not described in this manual. This publication also contains no user's instructions.

The filler should provide his staff who are actually responsible for the filling work with a manual, based on

Fig. 9 The top of a reservoir with cocks 4, 5, 6 and 7. This reservoir matches the type of the reservoir in Amersfoort. The coupling pipes are connected.

Nonetheless, the way in which the reservoir is filled with acrylonitrile is not simple. In this process, on the basis of a logical analysis, at least the following steps must be carried out.

1. *connection of flexible hoses between cocks 1 and 4 and cocks 3 and 5*
2. *opening of cock 4*
3. *checking the pressure in the reservoir*
4. *opening cocks 1, 5 and 3*
5. *pumping the specified quantity of acrylonitrile into the tank wagon*
6. *closing cock 5*
7. *connecting the nitrogen hose to cock 7 and blowing back acrylonitrile into the storage tank*
8. *closing cock 3*
9. *opening and closing cock 5 for the residue of acrylonitrile in the coupling (not always carried out)*
10. *checking pressure in the reservoir*
11. *disconnecting the nitrogen hose*
12. *closing cock 1*
13. *installing gasket and blind flange on cock 5*
14. *closing other cocks and disconnecting flexible hoses and fitting gasket and blind flange on cock 4*

As shown by this overview, the filling of the reservoir consists of a series of different tasks carried out in open air conditions in wind and all weathers, irrespective of the outside temperature. If the correct order is not strictly followed for the various actions, overpressure can occur in the reservoir relatively simply. For example, first closing the vapour return pipe by shutting cock no. 4 (step 14) and only then closing cock 5 in the filler pipe (step 6) already leads to overpressure in the reservoir. There are more conceivable actions which could relatively simply result in overpressure.

The large number of degrees of freedom and as a result the considerable risk of errors in combination with working in the open air, in all weathers, means at least that a simple and accurate description of the filling procedure should be provided. The only information available to the filler appears in appendix 2. This information says nothing of the importance of the correct order of the actions to prevent overpressure, nor is any mention made of the importance of fitting a new gasket.

**If acrylonitrile is transported with overpressure, the safety margin is lower than in the event of transport without overpressure. The pressures in the wall of the filled reservoir are in that case considerably higher, so that due to forces in the train as a result of braking, acceleration and possible collision, the threshold values are reached more rapidly.**

## *4.2. RULES*

### *4.2.1. DISTRIBUTION OF RESPONSIBILITIES*

***The government has distributed responsibility for the transport of hazardous substances by rail amongst a large number of participants, whereby each participant must trust that all others behave precisely in accordance with the rules. An outsider, namely the railway operator (in effect the government) is liable for any damages.***

The rules that apply for the transport of hazardous goods by rail are laid down in the RID, an international set of rules applicable for the whole of Europe. A number of rules, for example relating to parking policy, are laid down in the VSG, a ministerial set of regulations. The RID

(Règlement concernant le transport International ferroviaire des marchandises Dangereuses) is an impressively large collection of rules. The Dutch version contains 1124 pages, the majority of which are extremely technical stipulations.

In section 1.4.2[9]), the obligations of all parties involved are laid down. For the transport of hazardous substances, various parties are identified, each with their own responsibilities. For Amersfoort, in the first instance, two parties are important, namely the sender and the carrier. According to the RID, their obligations are as follows:

> *Subsection 1.4.2.1.1 (Sender)*
> *The sender of hazardous goods is required to offer a batch for transport, that complies with the regulations of the RID.*
> *Subsection 1.4.2.1.2*
> *If the sender uses services of other parties (…) he must take suitable measures to guarantee that the batch complies with the regulations of the RID. However, in cases described in 1.4.2.1.1 a), b), c) and e), he may rely on information and data made available to him by other parties.*
> *Subsection 1.4.2.2 (Carrier)*
> *(----)*
>
> The obligations of the carrier are laid down in a number of rules. In essence, these mean that the carrier is not permitted to blindly assume that the sender has complied with all his obligations. The carrier must carry out random (visual) inspections to determine whether everything is as it should be.

The basic obligations of sender and carrier are clear. For the transport of hazardous substances, however, use is often made of third parties such as loaders, fillers and operators of tank wagons. ***The basic principle of the RID is that the sender and the carrier must be able to trust that all other parties have complied with their obligations imposed by the RID.*** The filler must make certain that the tanks and the equipment parts are in good condition and, after filling the tanks, he must check that the sealing devices are indeed sealed. (Subsection 1.4.3.3). How this should be carried out is not specified.

The obligations upon an operator of a tank wagon are laid down in subsection 1.4.3.5, which reads as follows:

> *Subsection 1.4.3.5. (Operator of a tank wagon)*
> *In the framework of 1.4.1 (general safety policy), the operator of a tank wagon must in particular ensure that:*
> *a) the regulations relating to construction, equipment, testing and characteristics are complied with;*
> *b) the maintenance of the tanks and the equipment thereof is carried out in a way that guarantees that under normal operating circumstances, the tank wagon will comply with the regulations of the RID until the next test; (…)*

This subsection states that the operator ***must ensure that***. The actual implementation of the task does not lie with the operator. On the basis of subsection 6.8.2.3, only tank wagons may be admitted that have been technically examined and approved by a competent authority (designated and approved by the national government in the country in question). In addition, before commissioning, each tank wagon must be tested (subsection 6.8.2.4). This test and inspections must be repeated periodically. This too must be carried out by a competent authority. The results of these inspections must be laid down in writing. Type approval, testing and technical inspection are organised by each country individually.

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[9] In the RID, the various sections are specified by numbers the first figure of which indicates the section (1 to 7), the 2nd the chapter, the 3rd the paragraph, possibly followed by a 4th figure that indicates the number of the subsection. The figures are separated by decimal points.

The regulations for the construction and building of tank wagons differ from country to country, and are not uniform throughout Europe. On the other hand, the RID does contain a number of essential construction requirements for tank wagons such as the pressure which the reservoirs must be able to withstand, and the maximum material pressure that is permitted to occur. These requirements may be fundamental, but are not sufficient for the construction of tank wagons. In the RID, for example, no regulations are included as to how the longitudinal forces in the train as a result of braking, acceleration and possible collisions should be absorbed. These may be absorbed in several ways: solely by the chassis of the tank wagon (type 1), by the chassis and the tank (type 2) or by the tank alone (type 3). In the first case, the tank is mounted on a full rail vehicle which absorbs all train forces, whilst in the latter case, the tank is in fact used itself as the chassis. The tank is then fitted with two bogies, and is required to absorb all longitudinal forces. The RID leaves each country free in its choice. The tank wagon in Amersfoort was of the 2nd type. Tank wagons of the 3rd type are not banned but are no longer in use.

The tank wagon involved in the accident in Amersfoort was approved in 1972 by the then Deutsche Bundesbahn. On construction, 30 years is viewed as a normal service life. The tank wagon was inspected every four years in accordance with the regulations, and every eight years hydraulically tested to a pressure of 4 bar. These inspections and tests were carried out by competent authorities. The latest inspection and test were carried out in 2002. According to the RID, this inspection may be relied upon.

The type approval for the subsequently added ball cock was carried out by the Verein für die technische Überwachung von Güterwagen (VTÜG), a competent authority designated by the German Eisenbahn Bundesamt.

The tank wagon underwent technical inspection on behalf of VTG-Lehnkering AG, as an additional safety measure, immediately prior to the transport on 10 June 2002, in other words, approximately two months prior to the accident, and was tested for proofness at an overpressure of 3 bar. The RID indicates that this can also be relied upon.

The RID contains primarily technical rules relating to the conditions which must be complied with for the transport of hazardous substances. The RID further lays down no legal, organisational or financial requirements upon businesses responsible for the transport. This could for example include the minimum number of employees, insurance against liability or the use of a safety management system. It should be noted that on the basis of an EU regulation, since 1 January 2000, transport companies must have access to an expert in the field of the transport of hazardous substances, who supervises compliance with the rules within the company. This obligation was later taken on board by the RID. For the RID, this obligation has applied since 1 January 2003. In addition, in the Netherlands, a system of concessions is employed for all transport by rail. In that framework, requirements are imposed on the organisation.

In the Dutch Civil Code, ProRail, the railway operator, is held liable for damages resulting from the transport of hazardous substances. The relevant article reads as follows:

> *Article 8:1673 of the Dutch Civil Code (BW) paragraph 1. The party who, at the moment of an occurrence with a rail carriage on board of which a hazardous substance is located, is operator of the railway upon which that event occurred, shall be liable for the damages caused by that substance as a result of that occurrence. If the occurrence consists of a series of facts with the same cause, liability shall be upon the party who was operator at the moment of the first fact.*

On the basis of this article, the railways have a special position in the transport of hazardous substances. Neither in transport by water nor in transport by road or by air is the operator of

the infrastructure liable for the damage resulting from the transport of hazardous substances. The involvement of ProRail in this transport is also in fact negligible. ProRail is responsible for the traffic control within the parameters laid down by the Minister, in that respect. ProRail has no influence on the loading of goods trains. ProRail simply provides the routes necessary for the train movements for example from Kijfhoek to the German border, from traffic centres.

The objective of holding a party liable for the consequences of an accident is not primarily to increase safety but more to collect any losses suffered. It must be noted that placing ProRail, a party with practically no influence on the transport of hazardous substances, in a special position in no way contributes to increasing the safety of that transport. It would seem more apparent to hold liable those parties actually providing the transport, and in a position to exercise an influence thereupon[10].

### *4.2.2. RULES FOR FILLER OPENINGS AND FILLING*

***There are practically no formal rules for the filling of reservoirs and the checking of the loaded tank wagons.***

The objective intended by international consultation resulting in the RID was to facilitate the international transport of hazardous substances by rail. The RID still retains this character today. Attention for and hence rules relating to the loading and unloading of hazardous substances in the RID are marginal. For the transport of acrylonitrile, the RID merely indicates that this must be carried out in a hermetically-sealed reservoir without openings below the liquid level. This requirement applies for toxic substances. This measure prevents acrylonitrile entering the environment through collision or some other accidental action.

A tank wagon with acrylonitrile is unloaded by pumping the acrylonitrile outside under overpressure, via a riser tube at the top, or by pumping the tank empty via this tube. For a tank wagon with which acrylonitrile is transported, it is stated in the RID that the reservoir must be designed for a theoretical calculated pressure of 10 bar; a test pressure of 4 bar must be withstood; the tension in the material of the reservoir must not exceed a specified value, and the reservoir must be hermetically sealed. For substances from classes 3 to 9, which includes acrylonitrile, no specific regulations are given for the valves and blind flanges.

**Requirements on shut-off valves and blind flanges would appear obvious, given the nature of the substance. In this case, the RID should at least have indicated how the reservoir, fitted with a ball cock, should have been tested. On logical grounds, the pressure test should have been carried out once with a closed ball valve without a blind flange, and once with an opened ball cock and closed blind flange. In practice, simply a test loading of the reservoir with closed ball cock without blind flange was (and remains) considered sufficient. The application of a blind flange is labour-intensive and as a result takes a relatively long time. However, test loading only with a closed ball cock is absolutely insufficient. If a filler pipe contains two shut-off valves (barriers), these must be tested independently of one another. The RID considers sufficient the requirement that the reservoir must be hermetically sealed. The test method meets this requirement.**

Following loading, the filler must check whether the reservoir is hermetically sealed (RID subsection 1.4.3.3). No indication is given as to how this should be carried out. In practice, a visual inspection is considered sufficient: closed is closed. From a technical viewpoint, it is only possible to determine whether a reservoir is indeed hermetically sealed by applying considerable overpressure. This surely cannot be the intention of this article. In that case, a

[10] Government notices have suggested that the Ministry of Justice is preparing just such a change.

filled reservoir containing more than 70,000 litres of acrylonitrile would be placed under pressure merely for inspection purposes. This engenders unnecessary risks for the operators and the environment. It should be noted that at certain locations acrylonitrile is discharged via overpressure. Technical inspections must be carried out in advance. Tank wagons made available to the filler must be guaranteed in good condition.

### *4.2.3. PARKING REGULATIONS*

***The regulations for allowing trains to wait on tracks can be interpreted in several ways.***

The RID contains no stipulations about leaving trains standing or parked with hazardous substances. Indeed, this would not tie in with the philosophy of the RID. The RID is not intended to ensure the safety of the entire transport process, but aims to lay down conditions according to which the hazardous substances cross national borders.

The parking of trains with hazardous substances on the railway is therefore regulated in: Regulation for the transport by rail of hazardous substances (Netherlands Government Gazette 1998, no. 240[11]). These regulations apply to the Dutch railway network, main tracks, side tracks and marshalling yards. For the latter category, a separate licence is also required on the basis of the Environmental Management Act. This means that municipalities can impose additional requirements for the use of these track complexes. For main tracks and side tracks this is not possible. In Amersfoort, the train containing acrylonitrile was not on the marshalling yard. For this reason, only the parking regulations referred to above were applicable.

These regulations state the following in respect of the parking of trains:

> *1.11.1 In this section, the term "leave standing" shall be taken to mean: the actual presence of a wagon or wagons in a stationary position, on a railway outside the facilities of the sender or the addressee, once the shunting process at the marshalling yard in question has been concluded;*
> *(2) Leaving standing the tank wagons, wagons on which tank containers are mounted and wagons on which road vehicles with fixed or removable tanks as intended in paragraph (3) – used in accordance with subsection 1.1.4.4 in combined rail/road transport – are to be found is only permitted if paragraphs (4) to (7) are taken into consideration. (Note: Paragraphs 4 to 7 specify a compulsory visual inspection and written reporting).*

The parking of the train with acrylonitrile as took place in Amersfoort is viewed by ProRail (Rail Traffic Control) as formally permitted. The question must be posed as to whether this is indeed in the spirit of the regulations. After all, in the regulation, it is implicitly assumed that the train will be located in a marshalling yard subject to strict rules. The regulations do not refer to the parking of trains on main tracks or sidings. Whether this latter situation is or is not formally permitted is not truly made clear by these regulations.

### *4.2.4. INFORMATION TRANSFER*

***To facilitate the responsible operation of the fire service, in addition to a hazard identification code and UN number, wagons loaded with hazardous substances must***

[11] These regulations are periodically updated, see Netherlands Government Gazette dated 2 March 2004 no. 42/p. 18, 12 December 2002 no. 240/p. 22, 15 November 2001 no. 222/ p. 16, 23 March 2001 no. 59/p.16, 20 June 2000 no. 116/p.15 and 1998, no. 250/p. 5, 1998 no. 240/p.13, 1998 no. 160/p. 11, 1998 no. 73/p. 17, 1997 no. 178/p. 15.

***also bear an escape code, which indicates to what distance and with what urgency individuals should remove themselves, in the event of leaks.***

In the event of accidents such as that in Amersfoort, those responsible for tackling the consequences must be informed as quickly as possible of the nature of the substance with which they are dealing. In accordance with the regulations, a number code on the tank wagon indicates the substance in question. In this case, the substance was acrylonitrile with UN number 1093. In addition, a hazard code is applied to the tank wagon. For acrylonitrile, the number is 336. Only experts know that this means: high fire risk and toxic, i.e. qualitative information. Every kitchen cabinet contains substances with the same characteristics. If the parties involved require further background information relating to acrylonitrile, they can contact specific emergency rooms able to provide them with further information, 24 hours a day. This information is primarily the data about acrylonitrile stored in a database, for this purpose. The information from this database is presented as appendix 1. Other information is not available as standard. If further information is required, specific experts must be consulted by telephone.

The regional fire brigade has special units with expertise in the field of hazardous substances. One unit travels to the location and carries out chemical analyses, primarily to determine the concentration in the air of the hazardous substance. The fire brigade must know in advance which substance they are dealing with, in order to be able to carry out the chemical analysis. On that basis, decisions can be taken to whether or not to evacuate a specified area.

In Amersfoort, it became clear that in crisis situations, little value is attached to the measurements carried out by the hazardous substances unit of the fire brigade[12]. The measurements indicated that there was no risk. Nonetheless, the worst case was assumed and far-reaching measures were taken. This is in fact quite logical. Certainly with a substance like acrylonitrile, the vapours of which are heavier than air, it is not easily possible to determine the spatial spread into the atmosphere on the basis of few measurements at a limited number of locations. Limited incidental measurements, in situations such as this, say very little indeed, and at the very least barely reduce any uncertainties present.

**However, these are not the only opportunities available. The spatial spread of the acrylonitrile vapour occurs according to normal, generally-applicable physical laws. Using these laws, on the basis of a number of assumed parameters, it is relatively simple to determine in advance a spread model for the acrylonitrile vapour. Using such a theoretical spread model, the zone within which evacuation is necessary can be immediately identified. As more reliable information relating to the spread becomes available, the measures taken can be refined. The theoretical spread model which could be used in the event of accidents should be developed in advance by the chemical sector in collaboration with the fire brigade. One party is expert and responsible for the chemical aspects, whilst the other is expert and responsible for tackling the consequences.**

[12] Based on the investigations by B&A Groep, carried out on behalf of the Municipality of Amersfoort and own investigations

## 5. CONCLUSIONS

### *5.1. DESIGN OF THE BALL COCK*

***The design of the ball cock does not meet the requirements which should be imposed on the cock.***

The design of this ball cock is unusual (see figure 7). The cock consists of a pierced sphere, able to rotate around a horizontal shaft. All elements of this cock are produced in stainless steel. The stainless steel used is much softer than normal steel. If the hole in the sphere is vertical, the cock is open. The cock is operated by a long handle. This length is necessary. In order to ensure a good seal, the large nut with which the sphere is enclosed in the housing is screwed down tightly, so that considerable force has to be applied to operate the cock.

The special feature of this cock is that the pierced sphere can be freely rotated (through 360 degrees). This would not be a problem if it were not the case that the cock is only actually sealed in two positions. In all other positions, the cock is open. In sealed position, one end of the handle is in contact with an end stop (see figure 7). Because this stop is required to guarantee the closure of the cock, the design of this end stop is important. In the design, however, insufficient attention was paid to this end stop. It is a simple steel bolt placed far too close to the corner of the housing. As a result, only a slight force is required to bend this bolt out of true. In this case, this is indeed what happened.

The bending force may have occurred in one of two ways: by operating the handle with excessive force, or through the continuous vibration of the handle during travel. This handle is very long and as a consequence is as it were top heavy. The long vibrating handle need only be held in its position by the bolt of the end stop. The precise cause of the bending of this end stop cannot be stated with any certainty, after the event. It is clear, however, that the construction of the end stop is not sufficient to withstand the forces exercised on it, in day-to-day practice.

**The competent authority in Germany that in this case inspected the cock operates the principle that cocks submitted for approval and other similar components can only be rejected if there is a statutory requirement which prevents approval. The only requirement imposed by the RID is that the cock must be resistant to a pressure of 4 atmosphere. There are no other statutory requirements. Because the cock meets this requirement, it is approved. This approval expires in 2004. Experiences acquired in Amersfoort represent no reason for the TÜV to not issue approval for the subsequent period of 4 years. A 'good' design is not a statutory requirement; a poor design is therefore no ground to reject a cock.**

The Board believes that the design of this cock is unsafe. Competent authorities should have the capability of rejecting cocks and similar components if such components, in their judgement, no longer fulfil reasonable safety requirements, whether or not contained in law.

### *5.2. REJECTION OF THE TANK WAGON*

***The technical condition of this tank wagon should have led to rejection.***

Tank wagons are periodically inspected. The last periodic inspection of the wagon involved in the accident in Amersfoort was carried out in January 2002. The wagon had been once again inspected two months prior to the accident, on behalf of the operator, as an extra safety measure. This inspection was intended to ensure that the tank wagon was delivered in optimum condition. The importance of these technical inspections is very considerable. Only

the inspection bodies have the technical knowledge and the equipment necessary to determine whether a tank wagon is technically in good order. Potential weak points are above all the welded seams in the tank wall, the wall thickness and the appendages applied such as valves and cocks. Without technical equipment, these cannot be inspected. Visual inspections only bring to light “visible faults”. In other words, faults which are observable from the point where the inspector is standing. Of all possible faults, only a limited proportion can be observed by visual inspection.

The persons responsible for filling tank wagons of course also look out for “visible faults” but in general they have no technical construction background. In addition, as in this case, they work in the open air in all wind and weather conditions. Major visible shortcomings will probably be observed. However, it cannot be assumed that faults which can only poorly or hardly be seen will be discovered. The rejection of a tank wagon by the filler will also result in considerable economic damages. It is not a particularly customer-friendly action, making it a difficult decision in practice.

The riser tube in the tank wagon has two valves: the cock and the blind flange. Each individually should be capable of guaranteeing a hermetic seal. In fact, neither was capable of providing this seal. The cock could not be correctly closed due to the bent end stop and scratches on the sphere. The bending of the end stop could have occurred following the inspection. The scratches on the sphere were the consequence of the inexpert welding of a name plate, which had taken place years before, prior to a number of inspections. The blind flange was rusted and soiled. Each of the two shut-off valves were therefore suffering from serious to very serious shortcomings.

In the inspection procedures as currently applicable in Germany, only the ball cock is inspected for proofness. This fulfils the requirement of the RID that the reservoir must be hermetically sealed. The blind flange is thereby viewed as an additional provision, and is therefore beyond the scope of the inspection. During the latest inspections, under all circumstances the scratches on the ball of the cock must have been present. These should have resulted in rejection of the ball cock. The investigation showed that a test procedure carried out too simply could have been the cause. It is possible that the ball cock does not leak at a test pressure of 3 atmospheres, whilst it does leak at a lower pressure of between 1 and 3 atmospheres. The pressure of 3 atmospheres forces the ball into the plastic seat with such force, that it maintains a complete seal. At a lower pressure leakage does however occur. A test protocol was not made available.

The tank wagon was incorrectly approved. The Board considers it unacceptable that tank wagons carrying hazardous substances such as acrylonitrile can be approved despite showing the shortcomings identified. The Board further believes that both shut-off valves – both the ball cock and the blind flange – should be separately tested independently of one another.

### *5.3. WORK INSTRUCTION FOR FILLING*

***The work instruction for filling a tank wagon with acrylonitrile does not contain the information necessary for this task, and therefore does not fulfil the requirement.***

There was overpressure in the reservoir. This overpressure may either have been caused by the heating of the reservoir by the sun or by an error during filling. The filling of tank wagons is an extremely critical activity. It is the final opportunity to take corrective measures. Once the tank wagon is en route (after Kijfhoek), it is located beneath the catenary which is subject to high voltage. The loading platform of the wagon is then inaccessible. For that reason alone, inspections are impossible. En route, there are also no technical facilities to be able to determine in the event of breakdowns what is wrong, let alone to carry out any necessary

repairs. The filling and inspection of a tank wagon with acrylonitrile must therefore be carried out carefully, accurately and precisely according to a predetermined procedure. This must be laid down in writing in a brief, clear manual, made available subject to the responsibility of the management, to the operator in question. This manual should be based on a clear written instruction for use of the tank wagon, to be issued by the operator of the wagon. Neither document exists.

As indicated in the work instruction (appendix 2), the practice is different. The filling of the tank wagon with acrylonitrile includes a large number of complex actions, which must be carried out in the correct order. Neither the actions nor the order in which they must be carried out are described. Instructions for use by the operator are not available. At no point is a warning issued that following the incorrect order could result in overpressure. An inspection for proofness of the blind flange applied to the filler openings is not part of the work instruction. The Board judges the existing work instruction for the filling of the reservoir with acrylonitrile to be absolutely insufficient, and that the filling method using connectors is entirely outdated.

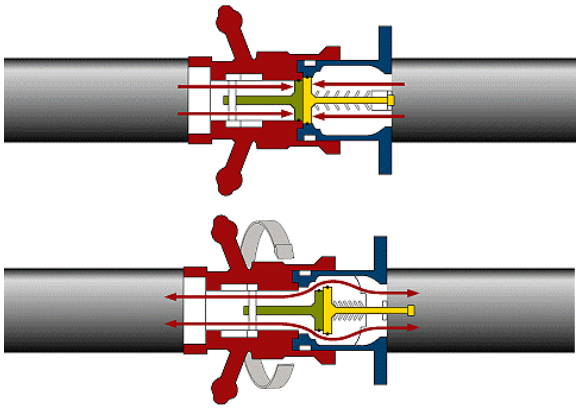

Fig. 10 An example of a modern coupling with far less risk of errors and leakage. The use of this coupling is recommended by Cefic, the European organisation for the chemical industry.

### *5.4. ATTENTION FOR AN INTEGRATED APPROACH*

***The RID rules are focused too much on the conditions under which transport is carried out, and too little on the conditions during loading and unloading, technical requirements on the transport equipment and other aspects of the transport chain.***

The conditions according to which transport takes place are effectively primarily determined by the technical requirements, the inspections and checks of tank wagons and by loading and unloading. For this reason, a filler should be provided with simple, usable, formally determined filling procedures for each type of tank wagon. The aspects specified can only be investigated at specific locations and/or loading and unloading points. Once en route, during transport, there is little to check, and even less to correct.

The transport of hazardous substances is undertaken by a large number of different companies. Each company provides only a small component of the overall transport. The RID determines, however, that each company must be able to rely on the fact that each other company operates precisely according to the rules. The transport of hazardous substances is thus a chain the strength of which is determined by the weakest link. It is a system without built-in extra safety provisions, in other words a system without any redundancy.

A system of this kind demands considerable effort in respect of supervision. Only if the government closely enforces the rules are internal and external safety guaranteed. The available capacity for inspection (the number of inspectors of the Transport, Public Works and Water Management Inspectorate) however, is extremely low. On average, some 50 drip leaks are reported each year to the Inspectorate, but there is no capacity for investigation of incidents. Initiatives have been taken to ensure that such investigations are carried out in the near future.

The RID also contains stipulations relating to inspection. The inspection is broadly speaking laid down in the Transport of hazardous substances Act, of which the RID is an integral part.

According to article 1.8.1 of the RID, only duly appointed competent authorities are permitted to inspect whether the regulations are complied with, for the transport of hazardous substances. In the Decree: Regulations for the Transport by rail of hazardous substances, in which these instructions are laid down, the Minister designated the NS (effectively NedTrain), the Dienst van het Stoomwezen (Steam Equipment Supervision Service) and Classification agencies and others as competent authorities for inspections. In the Netherlands, no tank wagons are built any more, so that approvals are no longer carried out in the Netherlands. In the Netherlands, there is no body designated to carry out technical inspections on tank wagons. Formally speaking, for such to be possible, a designation is required on the basis of article 1.8.1 of the RID. In the previously referred to Regulations for the transport by rail of hazardous substances, in article 1.8.1, no body whatsoever is designated as the competent authority for inspection[13].

## *5.5. PARKING POLICY AND INFORMATION PROVISION*

***Trains carrying hazardous substances may not be parked in the centre of cities.***

It is possible that the existing regulations for permitting trains carrying hazardous substances to stand stationary can be interpreted in the way that took place in Amersfoort. This would mean that such trains can be parked unguarded (without a driver), on any track that is available, for a long period of time (8 hours). In practice, at least, this is the interpretation of the rules that is employed. The parking of the train carrying acrylonitrile in the centre of Amersfoort was due to a request from Railion. The driver was switched at this location. Due to the blockage, however, the new driver did not arrive, as a consequence of which the train was left behind, unguarded. The Board considers this latter situation irresponsible. In road traffic, it is laid down that drivers of trucks carrying hazardous substances must always remain with a truck, unless the truck is parked in a car park facility intended for this purpose, with sufficient supervision. In Amersfoort, Railion should have immediately provided a replacement driver. In that case, at the first opportunity, the train could have travelled further or ProRail (Rail Traffic Control) should have had the train placed before or after Amersfoort, in a less hazardous location, on a siding. The Board believes that in the Regulations on Transport by rail of hazardous substances, the rules for having trains stand stationary (parking) must be tightened up.

***Tank wagons must not only feature a hazard identification code and a UN number, but also an escape code.***

During the investigation, it emerged that a number of experts from the chemical sector evaluated the response of the municipal authorities and the fire brigade to the leakage in Amersfoort as excessive. This in itself could be correct. After all, the chemical sector has far more knowledge, expertise and experience with acrylonitrile than the crisis team of the municipality of Amersfoort. As a consequence, the chemical sector is far better able to answer the core question which arises in the event of accidents: to what distance should people be evacuated, and with what urgency should such evacuation take place?

If no reliable information is available, a crisis team can do nothing else but apply its own options (whether or not predetermined). In Amersfoort, immediately following the initial report, the option was to evacuate to 100 metres, subsequently extended to 500 metres. These choices were in the first instance based on the only information available from the chemical sector, namely hazard identification code 336 and UN number 1093. The first code is a qualitative fact, and the latter code refers above all to a number of physical and chemical properties. Details relating to the spread of acrylonitrile vapour were not available. In other words, no form whatsoever of previously analysed and predetermined “emergency response”

[13] In the latest change to these regulations dated 2 March 2004, the IVW was appointed as an inspection service.

is available. Everything must be considered and “invented” during the crisis. This proves to be extremely difficult and is not the only possibility. The information on the tank wagon is focused on the characteristics of the hazard, but does not indicate how emergency services should deal with this hazard. In England, such transports are provided with Emergency Actions Codes, which following an accident provide the emergency services with the required information about measures to be taken immediately[14]. Immediately following an accident, as also emerged in Amersfoort, it is above all important to know how far people should remain distanced from the accident location, in order to remain healthy.

The Board believes that tank wagons should not only bear a hazard identification code and a UN number but also an escape code which designates the area within which people present should be evacuated.

## *5.6. KEY THEMES*

1. The original objective of the RID was to facilitate cross-border transport of hazardous substances by means of uniform agreements, with no unilateral special requirements. This effectively still remains the character of the RID today. The RID is not aimed at a chain approach whereby a body or a number of intensively cooperating companies ensure the safety of the entire transport process. In the Netherlands, no tank wagons for the transport of hazardous substances are built, maintained or approved. The RID assumes that the organisations abroad can adequately provide these services. This assumption has been shown to be premature.

2. The transport of hazardous substances has the special characteristic that once en route, corrective measures are practically impossible. The safety of the transport is above all determined by the design, construction, maintenance, periodic inspection, route, parking and loading and unloading of the tank wagons. This chain cannot be monitored by visual inspections alone, during transport. An integrated cross-border monitoring programme for this chain is an essential precondition for the responsible transport of hazardous substances. The Board believes that there is no evidence of such integrated monitoring. Such monitoring is however necessary.

3. The transport of hazardous substances is now carried out by a large number of different companies. There are almost no counter-checks. The inspection service of the Ministry of Transport, Public Works and Water Management, a service itself with limited manpower and investigation capacity, has now become an essential component of the safety monitoring that takes place within this transport chain. The Board believes that such a situation is undesirable. The overall safety of the transport of hazardous substances by rail should in fact be determined by the effort made by the parties actually using, trading in and transporting the substances. A government inspection service should simply guarantee additional safety, and should not be an essential and vital component in the monitoring of safety in the transport chain. Safety is primarily the task of the sector itself.

4. If problems occur with the transport of hazardous substances en route, the fire brigade and other public emergency services are required to solve these problems. The only information which these services can immediately access is: a qualitative hazard identification code and a UN number on the basis of which further information can be consulted. The Board believes that to this information an escape code must be added, which indicates the scale of the area that should be evacuated. In addition, the formal rules for parking and the route to be followed must as far as possible limit risks to the surrounding environment.

[14] see: www.the-ncec.com consult HazchemGuide

## 6. RECOMMENDATIONS

**It is recommended that the Association for the Netherlands Chemical Industry advises its members to monitor in an integrated manner the entire transport chain for hazardous substances, in such a way that safe transport is guaranteed at all times.**

**It is recommended that VOPAK Terminal TRR draws up a clear, uniform filling instruction, geared towards the users, for each type of tank wagon, and ensures that work is carried out in accordance with those instructions.[15]**

**It is recommended that the VdTÜV terminates as rapidly as possible the type approval for the ball cock, which applies until 2004.**

**It is recommended that the VdTÜV reviews the inspection regime for tank wagons for the transport of hazardous substances in such a way that the proofness of the reservoirs is guaranteed at all times and that if relevant, at least the ball cocks and blind flanges be tested for proofness independently of one another, so that one of the two always guarantees proofness, in the event of failure of the other.**

**It is recommended that the Minister of Transport, Public Works and Water Management (in this case the Directorate General for Goods Transport) ensures, through international consultation under the auspices of the RID:**

- **that the inspection and testing of tank wagons is organised in such a way that the safe transport of hazardous substances is guaranteed at all times.**
- **that the technical regulations for the loading and discharge openings of tank wagons in the RID be tightened up, such that in these openings, at least 2 safety barriers are present.**
- **that the tank wagons be provided with an escape code.**

**It is recommended that the Ministry of Transport, Public Works and Water Management (in this case the Directorate General for Goods Transport) adapt the Decree on the Transport of Hazardous Substances by Rail (VSG) in such a way that trains carrying hazardous substances may only be parked at locations where there are no or practically no risks for the surrounding environment.**

On the basis of articles 69 and 70 of the Board for Transport Safety Act, bodies or persons to whom a recommendation is addressed, if established in the Netherlands, must deliver to the Minister of Transport, Public Works and Water Management a position in respect of the following up of this recommendation, within one year following the publication of this report. A copy of this reaction must simultaneously be sent to the Chair of the Board.

[15] Documents made available indicate that VOPAK TERMINAL TRR has already altered these instructions.

# APPENDIX 1

*The Dutch version of the following overview has been translated into English, to simplify comparison with identical data sheets for acrylonitrile from other countries.* Each country uses its own table layout.

2-propenenitrile
acrylonitrile
Vinyl cyanide

$CH_2$=CHC==N

## ACRYLONITRILE

| PHYSICAL PROPERTIES | | IMPORTANT DATA |
|---|---|---|
| Boiling point °C | 77 | **COLOURLESS OR PALE YELLOW LIQUID, WITH PUNGENT ODOUR**<br>The vapour is heavier than air and may travel along the ground; distant ignition possible. The substance can polymerise violently due to heating or under the influence of light, in the event of contact with strong bases, strong acids and certain peroxides *causing possible fire and explosion hazard*. The substance decomposes on heating or incineration, producing toxic fumes (including *nitrogen oxide and hydrogen cyanide*, see under those headings). Attacks leather, aluminium, copper and alloys. Reacts violently with oxidants, strong bases and strong acids. |
| Melting point °C | 83 | |
| Flash point °C | -5 | |
| Auto-ignition temperature °C | 480 | |
| Explosive limits, volume % in air | 2.8-28 | |
| Minimum ignition energy, mJ | 0.16 | |
| Vapour pressure in mbar at 20°C | 124 | **MAC value 4 ppm 9 mg/m3 H**<br>**MAC TGG – 15 min [1] 10 ppm 22 mg/m3 H**<br>**The MAC value may be exceeded before the odour is noted.** |
| Relative vapour density (air = 1) | 1.8 | |
| Relative density of the saturated vapour/air mixture at 20°C (air = 1) | 1.1 | |
| Relative density (water = 1) | 0.8 | Routes of exposure/inhalation risk: **The substance can be absorbed into the body by inhalation of the vapour, through the skin and by ingestion. A harmful contamination of the air can be reached very quickly on evaporation of this substance at 20**°C.<br>**Immediate effects**: Lacrimatory. The substance is irritating to the eyes, the skin and the respiratory tract. The substance may cause effects on the central nervous system. Disorders of the gastrointestinal tracts, the lungs, the adrenal glands and to a lesser extent the kidneys can occur. Exposure to high concentrations may result in death. Following exposure, medical observation is indicated.<br>**Effects of long-term or repeated exposure**: Contact with the skin may cause an eczema-like skin disorder due to damage. The substance is viewed as carcinogenic to humans [2]. The substance is suspected of possibly having effects on hereditary properties. |
| Solubility in water, g/100 ml | 7.3 | |
| Octanol/water partition coefficient g/100 ml as log P | 0.9 | |
| Formula | C3H3N | |
| Relative molecular mass | 53.1 | |

| ACUTE HAZARDS | PREVENTION | FIRE FIGHTING |
|---|---|---|
| Fire: highly flammable | No open flames, no sparks and no smoking | powder, AFFF, foam, carbon dioxide |
| Explosion: vapour/air mixtures are explosive | Closed system ventilation, explosion-proof electrical equipment and lighting, when filling, tapping or processing, avoid using compressed air, used non-sparking hand tools | in case of fire: keep tanks/drums cool by spraying with water. |
| **SYMPTOMS** | **PREVENTION** | **FIRST AID** |
| IS ABSORBED THROUGH THE SKIN | AVOID ALL CONTACT! | IN ALL CASES CONSULT A DOCTOR! |
| **Inhalation:** throat pain and coughing, dizziness, confusion, nausea, vomiting, cramps, blueness of the skin, shortness of breath, difficulty breathing, unconsciousness | closed system and ventilation (no recirculation!) | fresh air, rest, half-sitting position and immediately transfer to hospital |
| **Skin:** redness, pain, blisters, burns | protective gloves (butyl rubber), protective clothing | remove contaminated clothing, rinse skin with plenty of water or shower, refer to doctor and if necessary transfer to hospital |
| **Eyes:** *caustic*, redness, pain, serious burns | safety goggles or eye protection in combination with breathing protection | rinse with plenty of water for at least 15 minutes (possibly remove contact lenses), then take to (eye) doctor, continue rinsing or drops during transport |
| **Ingestion:** *caustic*, burning feeling, nausea, vomiting, further see 'Inhalation'. | | rinse mouth, DO NOT induce vomiting, have person drink two glasses of water, and immediately transfer to hospital |

| EMERGENCY SITUATION / SPILLAGE DISPOSAL / STORAGE | LABELLING |
|---|---|
| **Emergency situation:** Explosion hazard! Acute health hazard! If more than 50 litres: immediately evacuate the hazard zone, and have area shut off. Consult an expert!<br>**Spillage disposal:** Observe regulations according to P 100. Wear chemical protection suit including fresh air cap/compressed air mask. Extra ventilation.<br>Limit spread of *spilt product* and make harmless with bleach (beware of reaction). Absorb *reaction product* in inert absorbent and store safely in drums (not hermetically sealed). Remove *any final residues* with water. Collect *rinsing water*[3].<br>Label drums and dispose of according to BAGA/KCA rules.<br>**Storage:** Fire proof, separated from strong oxidants, strong acids, strong bases and peroxides, cool, dark, store only if stabilised. | **Delivery label:**<br><br>highly flammable toxic<br><br>NFPA:<br>R: 45-11-23/24/25-38 4 3 2<br>S: 53-45<br>Note D+E<br><br>BAGA: B.16<br>KCA : 03 |
| **NOTES** | |

[1] Short-term exposure not exceeding 15 minutes, separated by periods of at least 120 minutes. [2] Detailed registration required according to Health and Safety at Work Decree, article 4.13 (Netherlands Government Gazette 60,1997). [3] Discharge is subject to special regulations.
Specific first aid treatment is necessary in case of poisoning with this substance; the appropriate means with instructions (oxygen 100%, 4-DMAP and sodium thiosulphate) must be available. Have doctor call NVIC (+31(0)30-274 88 88) for instructions on further treatment.
Use unbreakable packaging; put breakable packaging into closed unbreakable container.
Detailed instructions for safe working with acrylonitrile are provided in publication sheet P100 from the Health and Safety Inspectorate.

TREM card: 30G45; ERIC card: 3-17 GEVI: 336; UN-number: 1093 (stabilised)

Card number C-0003
Chemical cards fourteenth edition 1999

*(Text copied from original instructions)*

**Work instruction TTR Operational Service**
**Wagon loading**

**Nature of revision:**
alteration to points 3 and 4

**Objective:**
Description of the correct handling (both administrative and operational) of wagon loads.

**Definition:**

**Responsible and authorised:**
Operational service

**Method**
Implementation

1 Preparatory work

1. Dispatch prepares order in duplicate.
2. Before preparing work note check whether sufficient product is available for delivery via main delivery.
3. If follow-up delivery must be used, notify senior operator day shift.
4. Dispatch to check whether quantity to be loaded matches the capacity of the wagon and legally permitted level of filling. In the case of deviation, consult C.S. in advance.

2 Tasks before loading

1. Shunting according to daily compiled wagon list.
2. Wagon inspected by operator or external inspection. Inspection with all shut-off valves open, also inspect pipes (sign on work order)
3. If product residues are present, contact C.S.
4. For internal inspection, first test O2 percentage.
5. Check whether manhole cover and bottom valve are in good order.
6. Operator checks whether tank is connected to correct pipe (sign on work order) and earthing has been correctly fitted.
7. Weigh wagon before loading.

3 Activities during loading

1. If operator doubts the cleanness of pipe, first place small quantity of product in wagon, then compare sample from bottom pipe with original sample.
2. In the case of deviation, inform senior operator for the procedure to be followed.
3. During loading, the brake shoes must be placed in front of the wheels. The hand brake should be free, in connection with becoming blocked, or damage to the brake blocks during loading.
4. As far as possible place loading arm in wagon in connection with static electricity.
5. Do not take initial sample unless otherwise indicated. For sample, allow 10 minutes waiting time. In the case of doubts about quality, warn the senior operator.

4 Tasks following loading

1. If an external inspector wishes to take a sample, allow a waiting time of 10 minutes.
2. Administrative processing:
    1. Compare weighing card with loading order in respect of product name, tank number, weight and violation of permissible gross weight.

2. If special measures are imposed during loading, for example:
    - - loading on behalf of customer if wagon is rejected;
    - - rinsing of pipes before loading.
    - -etc.

   record these special requirements on the order
3. Check wagons for leaks. Pay particular attention to shut-off valves and shut-off caps. Do not dispatch wagons without shut-off caps. Check labelling. See checklist wagons.

5. Miscellaneous

1. Compare tare weight before loading with sole bar weight appearing on wagon.
2. In the event of deviations and inspection:
    - Is wagon correctly on weighbridge.
    - Are there residues in the wagon.
    - Is the weighbridge faulty
3. In the event of residues which following verification show no quality deviations, check the weight to be loaded in connection with level of filling/wagon overflow.
4. For loading from phenol tanks, set correctly via follow-up delivery.

6. Environment

Operational service checks that leaks from automatic or pump systems are captured in trays and that spills are prevented.

# APPENDIX 3

## *JUSTIFICATION OF THE INVESTIGATION*

Several days following the leakage of acrylonitrile from a tank wagon in Amersfoort, the Board for Transport Safety decided to investigate this accident. An investigator from the Board, assisted by a specialist consultant, immediately thereafter had the liquid tank wagon placed under pressure in Kijfhoek, using compressed air, and had the tank wagon tested for leakage.

On the basis of the findings, the decision was taken to charge a specialist consultant with carrying out a further technical investigation into the cause of the leakage of the liquid tank wagon with top loading device. This technical investigation concentrated on a number of components (the flange with ball valve and the red blind flange) of the liquid tank wagon, which were seized for this purpose. The consultant issued a written report on the results of this investigation.

In parallel to this investigation, the Board implemented an investigation into the occurrence of the leakage according to the standard working method for railway accidents. This standard working method entails that a broad-based investigation is initiated, whereby in essence three aspects are examined or reconstructed, as well as possible. These are:

1. What would an observer have seen if he had been present at the location of the accident?
2. What actions were taken prior to the accident, and what communication took place?
3. What are the frameworks, rules and standards applicable for the players involved in the accident?

The final aspect is the most extensive. It deals not only with the formal frameworks, rules and standards, but also their informal counterparts. During the investigation process, use was made of various analysis techniques such as Tripod, the error tree analysis and the barrier analysis. In order to avoid missing any relevant aspects, the investigation was kept as broad as possible in the initial stages, with the exception of the investigation into the aspect of tackling consequences, excluded by the Board; in addition, no hypotheses were formulated or positions taken up.

For the investigation, use was also made of investigators of the Rail Division of the Transport, Public Works and Water Management Inspectorate (Dutch abbreviation: IVW). For the purposes of this investigation, two investigators were made available by the Rail Division of the IVW, who worked under the supervision and management of the Board. The investigation into the role of the IVW and the Directorate General for Goods Transport (Dutch abbreviation: DGG) was carried out by investigators of the Board. Once a picture had been established of what had taken place, based on the available information such as the building and construction drawings, photographs, overview drawings of tracks, points and signals, press releases and other sources, a list was drawn up of the individuals to be interviewed. The questions to be asked were also formulated in advance. In this case, interviews were held with (amongst others): the train traffic controller of ProRail Rail Traffic Control, wagon fillers, employees and managers of Vopak Terminal TRR BV, a manager of Transpetrol GmbH, managers and specialists at VTG Lehnkering AG, the driver, wagon and railway carriage inspectors, shunters and specialists at Railion Benelux NV, specialists and managers of the Ministry of Transport, Public Works and Water Management (DGG and IVW Transport). Reports were made of all these interviews. In addition, a number of working visits were held to gain a greater insight into the process of the design, production, admission and testing of tank wagons.

The investigation results were recorded in writing in two sub-investigations. In this reporting, close attention was paid to ensure that no positions were taken up, and no judgements passed. The sub-investigations for this reason contained exclusively relevant facts. The sub-investigations, in which the collected facts and their interrelationships are outlined, were assessed. The sub-investigations were sent to the bodies involved: ProRail Rail Traffic Control, Vopak Terminal TRR BV, Transpetrol GmbH, VTG Lehnkering AG, Railion Benelux NV, Ministry of Transport, Public Works and Water Management (DGG and IVW) whereby these bodies were invited to attend a verification meeting. During this consultation, the parties involved had an opportunity to issue comments about the facts as determined. The parties involved approved the final version of these sub-reports. Holding the verification meeting meant that the bodies involved were informed at an early stage, and approved the facts which formed the basis for the analyses by the Rail Traffic Chamber of the Board.

Once the collection of facts had been concluded and the sub-reports and the technical investigation report were ready, under the supervision and management of the Rail Transport Chamber, the draft final report was prepared. This report was presented to the parties involved. All parties responded to the report in writing. The responses from the parties involved have been taken into account in this report if, in the judgement of the Board, these responses coincided with the actual course of events, or if the responses were the result of a different vision on the events which, following a reconsideration of the facts by the Board, proved relevant.

Finally, the Board drew up a number of recommendations to prevent similar accidents occurring in the future, and to increase the safety of the transport of hazardous substances.