ISSN 1018-5593

INSTITUTE FOR SYSTEMS ENGINEERING AND INFORMATICS

Support activities for the Directorate-General for Environment, Nuclear Safety and Civil Protection
on the implementation of the Council Directive
on the major accident hazards of certain industrial activities

COMMUNITY DOCUMENTATION CENTRE ON INDUSTRIAL RISK

EC STUDY - LESSONS LEARNT FROM EMERGENCIES AFTER ACCIDENTS IN DENMARK INVOLVING DANGEROUS SUBSTANCES

Report EUR 15562 EN

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION

INSTITUTE FOR SYSTEMS ENGINEERING
AND INFORMATICS

Support activities for the Directorate-General for Environment, Nuclear Safety and Civil Protection
on the implementation of the Council Directive
on the major accident hazards of certain industrial activities

COMMUNITY DOCUMENTATION CENTRE ON INDUSTRIAL RISK

EC STUDY - LESSONS LEARNT FROM EMERGENCIES AFTER ACCIDENTS IN DENMARK INVOLVING DANGEROUS SUBSTANCES

C.D. Grønberg, L. Smith-Hansen, D.S. Nielsen
Risø National Laboratory
Roskilde, Denmark

Contract No.. 51-18-92-12 PC ISP DK

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION

1994

EUR 15562 EN

Published by the
EUROPEAN COMMISSION

Directorate-General XIII
Information Technologies and Industries, and Telecommunications

L-2920 Luxembourg

LEGAL NOTICE

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Community, 1994

ISBN 92-826-7515-7

Printed in Italy

Contents

1 Introduction

This study belongs to a series of investigations on emergency response experience in the EEC countries with the aim of gaining valuable knowledge on emergency management and supplying information to the Community Documentation Centre on Industrial Risks. Similar studies have been performed in the United Kingdom, France and the Federal Republic of Germany and are currently being completed in all other EEC countries.

The Danish study on emergencies after accidents involving dangerous substances has been conducted by the Risk Analysis Group, Risø National Laboratory. Work on this contract was done by Lene Smith-Hansen, Dan S.Nielsen and Carsten D.Grønberg (project manager). The work was supervised by Kurt E.Petersen.

To support the work with information on emergency organizations and establishing contacts to personnel involved in the actual cases a contact group was set up:

- Erling Vangsted, National Agency of Environmental Protection.
- Hans Hagen, Danish Working Environment Service.
- Jan Petersen, Emergency Management Agency.
- Jørgen Jacobsen, Emergency Management Agency.
- Kent Bergstrøm, Commissioner of Police.

2 Scope

Risø has detailed the scope as follows:

- Accident period: 1980-1992.
- Place of accident: land, sea, air.
- Consequence type: specific harm or threat to humans or the environment.
- Activity or process (accident domain): production, industry, storage, transport.
- Accident type: no a priori limitation.
- Criteria for selection of cases:
    - One or more dangerous chemical substances should play a significant role for accident course or consequences, no matter if it was present at the time of the accident, if it was produced during the accident course, or was introduced during mitigation.
    - Cases with only minor effects from the dangerous substances may be studied, if there is a prospect of significant emergency experience, which could be important under different circumstances.
- Besides reporting the lessons learnt, the study will report briefly on the status and principal changes under way in Danish emergency organizations, which may be significant with respect to chemical emergencies.

The second criterion for case selection was added, because Danish industry and Danish transport activities would hardly be able to contribute significant accidents to the European picture, and thus we could miss opportunities to highlight the qualities of the Danish emergency organizations.

3 Selection of accidents

The Danish authorities are reporting greater accidents with dangerous substances to the Major Accident Reporting System at Ispra, and the study group therefore first looked into eight Danish MARS cases acquired from the contact group. After reviewing the MARS material and relevant periodicals from the period 1980-1992, the following cases were chosen for closer studies:

- Dansk Sojakagefabrik, explosion, 1980.
- Mustard gas bombs in fishing trawl, Baltic Sea, 1984.
- Nordisk Alkali Biokemi, decomposition of pesticide, 1985.
- Valdemar Larsen metal working, release of chlorine, 1985.
- Matas warehouse fire, Aarhus, 1988.
- Maribo seeds company, fire involving toxic substances and dust, 1989.
- Næstved railway accident, release of acrylonitrile, 1992.

None of these cases caused fatalities.

Three of the selected cases are included in the MARS database, i.e. Dansk Sojakagefabrik, Valdemar Larsen metal working and Maribo seeds company. The accident at Dansk Sojakagefabrik has been studied previously (Rasmussen et al, 1987). The remaining five MARS cases were left out of this study, because the related emergency experience was judged less significant.

4 Data collection form

Below follows a general data collection form to be used for description of the selected accidents. The data collection form has been constructed using the same main entries as in the MARS database. However, since the purpose of the present study is to evaluate the emergency response after chemical accidents the importance of the accident causes is reduced.

Furthermore, the content of the FIRE database has also been used as inspiration. This database has been constructed as part of the CEC STEP project "Combustion of Chemical Substances and the Impact on the Environment of the Fire Products" (Contract no. STEP CT91-0109), (Koivisto & Nielsen, 1993). Finally, the data collection forms shown in the similar British, German, Greek and French studies have been examined.

The content of the present data collection form does not differ substantially from the content of the forms in the other studies. However, the structure is somewhat different and the form used in the present study comprises fewer entries. On the other hand a large number of keywords and examples are given.

The completed forms for the selected cases are brought in appendix A.

Table 1. Data collection form

Type of information		Keywords, examples
1. General information	1 1 Date	
	1 2 Time	
	1.3 Place	
	1 4 Activity type	Chemical process plant, chemical warehouse, rail transport, ship transport, road transport...
	1.5 Name of company	
	1 6 Topology	Characterization of land surrounding the accident site, population density...
	1.7 Description of buildings, train wagons etc.	
	1 8 Regulations involved	EEC directive on "Major Accident Hazards of Certain Industrial Activities", international transport regulations.
	1.9 Accident preparedness	Safety analysis carried out, external and internal emergency response plan, staff and equipment available for emergency response, monitors installed and/or available
	1 10 Information to the public prior to the accident	General information, emergency instructions...

(Table continued on next page.)

Table 2. Data collection form, continued

Type of information		Keywords, examples
2. The accident	2.1 Accident type	Liquid release, gaseous release, fire, chemical decomposition, deflagration, detonation, BLEVE. Toxic/-flammable...
	2.2 Substance(s) involved	Name, CAS-no., involved mass, toxicity, mode of storage...
	2.3 Other substances at the site	Gases, liquids. Toxic/flammable...
3. Accident course	3.1 Weather conditions	Wind direction, wind speed, temperature, humidity, stability class...
	3.2. Detection of accident	How the accident was detected, time of detection, time of alarming, within/outside working hours, day/night...
	3.3 Description of accident	Event sequence...
	3.4 Behaviour of plant staff and management	
	3.5 Behaviour of the public	
4. Emergency measures	4.1 Emergency services involved	Fire brigade (public/local), police, health service, number of persons...
	4.2 Emergency actions	Fire fighting, rescue...
	4.3 Equipment used	Fire nozzles, fire engines...
	4.4 Prevention of consecutive damage	Protection of computer systems, disposal of polluted fire fighting water...
	4.5 Medical treatment of victims	
	4.6 Care for the plant staff	
	4.7 Care for the public	Evacuation, information on safe behaviour...
5. Cause of accident	5.1 Primary cause	Human error, component failure, natural event...
	5.2 Underlying causes	Managerial/organizational omissions, design inadequacy...
6. Consequences of accident	6.1 Actual number of persons killed	
	6.2 Actual number of persons injured	
	6.3 Economic losses	
	6.4 Environmental effects	Effects on plants, grass, fish, ground water, lakes, rivers...
	6.5 Map of area affected	
	6.6 Potential harm to humans and the environment	Potential number of persons killed or injured, potential pollution of rivers, lakes, ground water...

(Table continued on next page.)

Table 3. Data collection form, continued

Type of information		Keywords, examples
7. Post incident actions	7.1 Plant modifications	
	7.2 Recommendations	
	7 3 Precautions taken to prevent or limit consequences	Pollution of soil, rivers, ground water, structural damage...
	7.4 Does dangerous situation still exist?	
	7.5 Post incident investigations	
	7.6 Information to the public	
	7.7 Emergency management, lessons learnt	Collaboration between authorities, revision of emergency plans, revision of mitigation equipment...
	7.8 Authority requirements	Installation of spill basins, safety valves...
	7.9 Initiated research	Development of improved consequence models, improved protection equipment ..

5 Emergency organization

In the following, an account is given of the organization valid in the accident period considered. In the beginning of 1993 the Danish emergency organizations were changed from a system with independency between civil defence forces and fire brigades into a more integrated system. The planned modifications are sketched briefly in section 5.3.

Traditionally, there are separate emergency organizations for performing the following functions:

- Fire fighting.
- Police work.
- Ambulance transport.
- Civil defence.

The first three organizations have been designed and operated for peacetime applications, whereas civil defence forces could be viewed as the wartime supplement increasing the power of fire brigades and ambulance services and adding special services for specific war incidents. During greater accidents and on occasions where the ordinary mitigation forces were occupied, civil defence forces have been called upon to assist the fire brigades.

In 1974, a step towards integration was taken, when plans were developed for emergency actions in case of accidents involving chemical substances, pollution etc. These plans operated with three emergency levels:

- On the lowest level, the fire brigade performs the actions necessary with rather simple means.
- On an intermediate level, the fire brigade uses special equipment and protection in order to handle dangerous substances.
- On the highest level, civil defence forces are mobilized.

All fire stations are equipped for the lowest level response and approximately 50 fire stations can operate on the next level, too.

Information support systems were developed with descriptions, precautions and handling procedures for the most common dangerous substances, and besides written information, a 24 hours telephone service was organized with a pharmaceutical expert on duty. Today several information sources are available for chemical emergencies in Denmark:

- Safety cards for road transport (CEFIC-cards).
- Handbook for emergency response leaders.
- Chemical emergency response service, 24 hours telephone service.

• Poison information centre on the National University Hospital.

• Police data bases.

The chemical response service was opened in 1974 by the civil defence authorities in collaboration with the Royal Danish School of Pharmacy in Copenhagen and has served both fire brigades, police, military, civil defence, Danish State Railways, doctors and hospitals in case of chemical emergencies. The expert on duty has informed on dangerous and toxic effects and precautions, he has analysed samples from the emergency site, and identified the chemical contents in products and unlabelled substances. From 1990 the service was changed, so that the information service is open mainly to officers in fire brigade and police, whereas the analytical service is still open for the same group of users as before.

The poison information centre is a 24 hours telephone service for doctors, nurses and related personnel, giving advice on the treatment of patients who have been exposed to chemicals or chemical products.

Most emergencies are handled by fire brigades with assistance from ambulance services and police as required, with a fire brigade officer as the chief-in-command at the accident site.

Figure 1 shows the structure of the Danish emergency organization in case of a major accident. When emergency actions imply the use of command centres and involves such things as large-scale evacuations, coordination with several hospitals, etc. the command structure is as follows:

• The leading police officer is emergency leader and coordinates actions of fire brigades, ambulance services and hospitals etc.

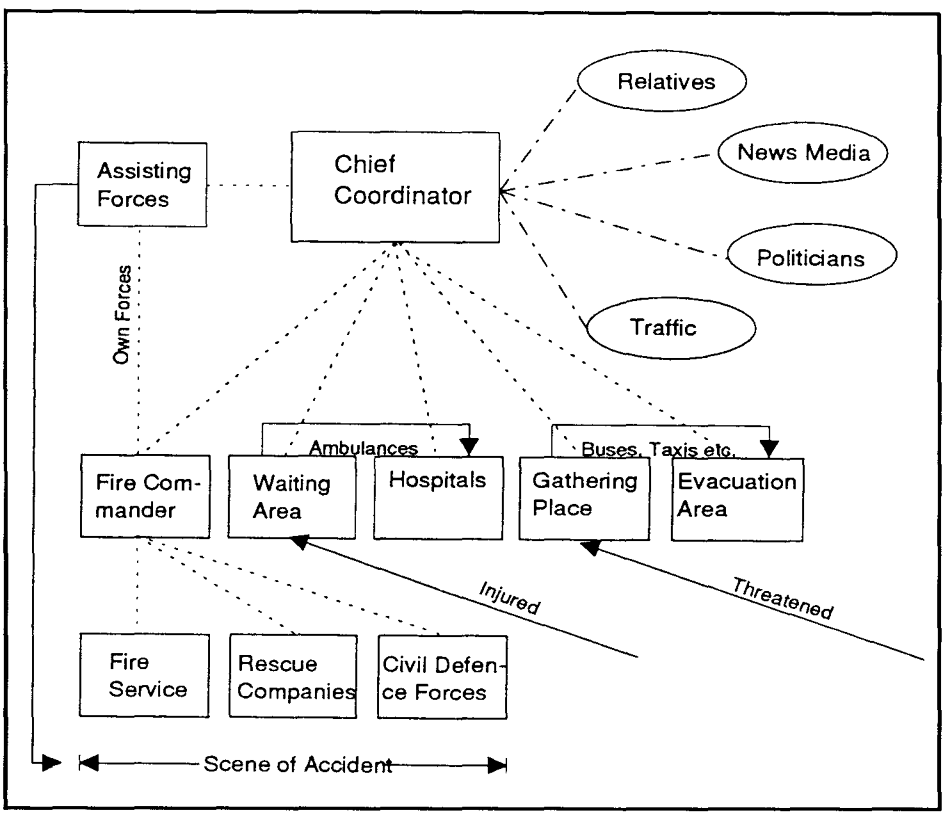

Figure 1. Structure of emergency organization for a major accident

- The leading fire brigade officer is in command of all operations at the accident site.

Fire brigades and police forces are organised and administered locally, on district level, both covered by rules and regulation by the Ministry of Justice, whereas the civil defence organization relates to the Ministry of the Interior. Ambulance services in Denmark are with four exceptions (Copenhagen, Frederiksberg, Gentofte and Roskilde) operated by a private company (Falck) which has contracts with the local administrations. In several cases, also the fire brigades are operated by the private Falck. The "National Fire Inspectorate" has worked out rules and standards and performed education of fire brigade officers and made inspection of forces and equipment. The central law is the "Fire Act" of 1976, with job specifications and command rules detailed in "Instruction for Fire Commanders", 1983. Specific instructions include:

- Response to chemical accidents on land.
- Guidelines for accident response.
- Instruction/guidelines for transport accidents.
- Guidelines for the contingency of fire brigades.

Special medical emergency organizations are not developed, as hospitals are already using all resources most of the time, so only minor modifications can be found that are specifically directed towards accident situations. One such element is the medical team sent to the accident site, when many persons are injured or the handling of victims is delicate, like injured persons trapped in collided transport vehicles, or groups of people exposed to dangerous substances, requiring a first screening to save ambulance capacity. Special communication schemes for dealing with visitation and coordination in the bigger cities are also set up. During visitation, patients are distributed to the different hospitals from an accidents site after a short medical evaluation, considering both the patient needs, hospital capacities and transport delays.

5.1 Emergency organizations on factory level

Local fire brigades are organized in airports, oil refineries and other plants, where adequate reactions demand an immediate response by locally trained forces. Local fire brigades are dimensioned and educated in close collaboration with the public fire brigades.

Plants where dangerous substances are processed, handled or stored are required to keep the public fire administrations informed on:

- Which substances are dealt with.
- Amounts stored and processed.
- Plant lay-out.

- Plant organization.

- Access route, communications etc.

This information is necessary for the fire administration in order to perform regulation and inspection, and they form the basis for special arrangements with alarm lines to the public fire brigade or special equipment or education. For instance there are a few storage facilities for ammonia (used in farming as a fertilizing agent), where direct alarm lines are connected to the public fire brigade which is supposed to react in case of ammonia release. Personnel on the storage facility is too scarce to form an emergency corps.

Generally it has been preferred to rely on the public fire brigades, as their response times are below 10 minutes in urban areas and below 15 minutes elsewhere, the critical points are therefore:

- Access to the plant.

- Updated knowledge for the fire brigade, on substances, precautions and plant topology.

- Contact persons under emergency.

The Civil Defence Act has required all working places employing more than 75 persons to have organized local civil defence units that can be activated in case of war, to protect employees and working facilities. Where such organizations have been made, they are in possession of materials and equipment that may be useful even under peacetime accidents.

5.2 Training, drills and exercises

Drills and exercises are part of the basic emergency education, and drills are arranged regularly, both at the public emergency corps and at the local fire brigades in the industry. The minimum frequencies have been prescribed by the national "National Fire Inspectorate", as well as the themes to be rehearsed. Also the police forces carry out drills regularly.

The quality of drills and exercises conducted by industrial fire brigades depends on the responsible management, and some industrial organizations give low priority to the emergency exercise subject. The different attitudes to emergency preparedness partly reflect different attitudes to safety matters in general in different branches of industry, but sometimes attitudes are also seen to follow changes in ownership.

The proceedings edited by Gow and Kay (op.cit.) include some papers on the exercise issue, that touch upon both the need for more large exercises and possible means for planning and analyzing exercises. Neuhoff (1987) presents the practical difficulties clearly, and mentions shortly the antidote administration problem (compare the Næstved case, section 6.7 below). Max-Lino et al (1987) recommend a mixture of "high fidelity" exercises and functional analysis to be used in the assessment of emergency plans, where the functional analysis can supplement the exercises and take over in regions, where high fidelity exercises cannot be tolerated. Risø has some experience using cause consequence diagrams as a planning tool in the arrangement of emergency exercises. These diagrams are useful for presenting and administrating both possible event patterns and possible communication flows, time delays etc. This facilitates pointing out the trouble centres, possible communication overflow, and the best observation posts on beforehand. It is also a useful presentation for selecting the points (time, space) most suitable for intervention to control or stimulate the game (Øvelsen på Behandlingsstationen, 1976).

There seems to be a need both to develop tools for planning and evaluating emergency exercises and to motivate responsible key persons to take the emergency exercise and the derived recommendations more seriously. Improved tools can improve the exercise work, but maybe only the accidents influence motivation?

5.3 Planned changes of emergency organizations

From 1993, i.e. after the period considered in this report, the emergency organization in Denmark is being changed towards a more integrated structure. The most important change is the closer relation between fire brigades and civil defence, that earlier operated as separate organizations with rather limited collaboration in the daily work. Inspirations to the change can be seen in the American FEMA and in the Swedish "Räddningsverket", but actual motivations have been changes in the prospects of war, together with a general need for higher efficiency in public enterprises in general. Background information for the decision to restructure the emergency organizations can be found in Katastofeberedskab (1991). The primary changes are:

- The formation of an "Emergency Management Agency" uniting the earlier Civil Defence Authority and the Fire Inspectorate.
- The responsibility for fire safety and mitigation is thereby moved from the Ministry of Justice to the Ministry of the Interior.
- After the basic education, all education and training is common for fire brigade and civil defence personnel.
- The local fire brigades gain immediate access to civil defence material and equipment.

The Emergency Management Agency is organised with eleven operational branches:

- Organisations for peacetime emergencies.
- Regulation of emergency organisations.
- Organisations for war time emergencies.
- Nuclear regulatory authority.
- Disaster prevention.

- Personnel.
- Education.
- Logistics.
- Planning and economics.
- Administration.
- Chemical laboratory.

This structure has been described in Brandværn (1993, no.5), where the tasks of every branch are listed. The picture reflects both the intention to make a new start, and the intention to keep things running with the same staff and experts. The agency's unit for peacetime emergencies will be a national authority on emergency planning and coordination of the local emergency organisations, the hospitals' emergency organisations and large drills and exercises etc. The unit for regulation of emergency organisations works with dimensioning and requirements and supervises the local emergency organisations, but the office also has associated issues like water supplies, alarm planning and personnel on duty schemes. It probably means a large step forward, i.e. fire brigades, civil defence and hospital contingencies are now related to one central authority in emergency matters, but collaboration is still needed on environment issues, police matters and military assistance.

Future emergency plans and actions will also reflect changes in the EEC Directive on Major Industrial Hazards of Certain Industrial Activities. In the past, most emphasis in emergency preparation has been put on fire safety, alarm systems and meeting plans. Rather few industrial sites have been objects for public information on potential dangers and appropriate emergency rules, communicated to nearby residents as a general precaution. Sharpened focus on that matter in article 8 of Directive 82/501 leads to more regular information activities of this kind and will probably also have the police playing a more active part in future emergency planning.

5.4 Regulatory authorities

Emergency planning and emergency actions are controlled by different authorities according to both type of production/storage involved and type of accident site.

The safety of production and storage plants is regulated by the National Agency of Environmental Protection and the National Labour Inspection. Internal emergency planning is considered an occupational safety issue, and risk control - which is also a means for pollution control - is at the same time part of the environment protection.

Handling and storage of flammable or highly reactive substances and explosives are regulated by the fire authorities, who also perform regulation and control of fire safety in building construction, storage and siting, operation and maintenance etc. The necessary special arrangements, equipment and mitigation plans are prepared by the fire authorities in collaboration with the involved owners/operators. The fire authorities belong to the domain of the new Emergency Management Agency.

External emergency plans for accidents at an industrial site are the responsibility of the police. Therefore, up to four different authorities, belonging to three ministries, can have their shares of emergency planning for an actual industrial plant.

Oil and gas production in Denmark takes place off-shore also, and the risk issues including emergency operations at sea are regulated by the Energy Agency. Environmental protection operations in connection with such emergencies are under regulation by the National Agency of Environmental Protection.

The transport area is covered by special international conventions and introduces two further ministries to our subject, chemical emergencies.

- Road accidents are treated by the so-called ADR convention, European Agreement Concerning the International Carriage of Dangerous Goods by Road.

- Railway accidents are covered by RID, Reglement concernant le transport international ferroviaire des marchandise dangereuses, with a Danish supplement, RID A.

- Sea transport accidents are treated by the IMDG code, with Danish supplements.

- Air transport accidents are treated by ICAO, especially ICAO TI, Technical Instructions for the Safe Transport of Dangerous Goods by Air.

In addition to the Ministry of Justice and from 1993 the Ministry of the Interior, the following ministries are relevant for traffic accidents: the Traffic Ministry, for road, railway and air accidents, and the Industry Ministry for sea accidents.

5.5 Reorganizing for emergency

An accident type, that may in general activate several organizations, is the chemical accident at sea. According to Katastrofeberedskab (1991) p. 39 the National Agency of Environmental Protection is responsible for the emergency operations and collaborates with a branch of the marine (SOK) on operations at sea, and with civil defence units on fighting pollution in waters closer to the shore. As pollution reaches land areas, the responsibility for fighting pollution moves to the fire brigade officer on duty, and the operations are conducted by workers from the local administration, by hired entrepreneurs or by the same civil defence units as before. In cases with severe character or extension, the minister for the environment can decide that the National Agency of Environmental Protection directs all operations.

This construction is simplified by the closer relations from 1993 between fire brigade and civil defence, but a representative of the National Agency of Environmental Protection heading the operations will still get a difficult job. Both this rather special accident type and the more common case with a large emergency, where the police is conducting all emergency operations, are examples of necessary adjustments with built in weaknesses. New managers and coordinators are introduced for very obvious reasons: the job grows and the scope is broadened, but troubles may arise, when the prescribed new managers are not professional emergency operators. As difficulties may arise typically at the interface between the emergency units and the extraordinaire "external" leader, this collaboration must be rehearsed frequently with all relevant personnel.

A sound emergency organization has power, flexibility and control built in on all levels in order to be operational and efficient. The *military* spirit is cultivated with uniforms, ranks and strict rules, just as education and training are based on military traditions. Civil servants and politicians are usually working in environments with other sorts of communication and different dynamics of operations, one therefore needs very demanding accidents or rather extensive emergency drills and exercises before one is able to evaluate the collaboration in the larger organization schemes.

The seven cases of this study did not expose the integral emergency organisation to a real life test like for instance the French case from Nantes 1987 (Lequime & Brette, 1993). By that occasion, an NPK-fire caused a large scale evacuation to be carried out, and the French report emphasizes the extremely important role played by the mayors and their personnel in evacuation and reception of the displaced people. It would be of interest to study real life experience with orders flowing from mayors and representatives of the Environmental Protection Agencies etc. into fire brigades and other operational units in an emergency situation. Exercises with higher level command structures are often conducted using simulated operations, and cannot reveal adverse effects on the interface to the practical units.

The detailed arrangement of such collaboration and coordination may differ between countries with differently structured administrations and different traditions, so both the citizen and the fire officer may react differently to a mayor's order in different European countries.

6 Case Stories

6.1 Dansk Sojakagefabrik

Early in the night, 15 July, 1980, Copenhagen experienced the largest explosion since World War II. An industrial company processing vegetable fats, "Dansk Sojakagefabrik", included an extraction plant, which was destroyed in an explosion leading to broken windows in central Copenhagen in distances of several hundreds metres.

The source of accident was an extraction process using a light type petrol (hexane), which was retrieved afterwards by distillation in a toaster. The operation crew had some troubles controlling the process temperature, and therefore increased heat supply to the toaster. The smell of petrol grew to such an extent, that the staff had to leave the extraction plant. The first alarm message to the public Alarm Centre at the fire station came from a bus driver passing the premises of the plant, who stated, that "airplane fuel was spilled on the road in front of Dansk Sojakagefabrik".

The explosion occurred half an hour later, after an attempt to turn off the electric power supply to the extraction plant. Material losses were enormous, and many persons suffered severe burns on hands and faces. However, there were no fatalities. It has been assumed, that approximately 40 tonnes of hexane was burning immediately after the explosion.

The accident was caused by an unlucky combination of operation difficulties and what seems to be decision errors. The actions are not reflecting the condition, that afterwards was ascribed the leading role in the release of evaporated hexane: the displaced "safety bell". This item was constructed to serve as an overpressure relief component, but it is supposed, that for some reason it did not settle correctly after a relief, and thereafter allowed a continuous leak of evaporated hexane.

The case raises some questions:

- The adequacy of the technical knowledge of fire officers.
- A comment on a delicate balance: who is actually controlling the plant, when fire mitigation forces have arrived?
- Were emergency plans and alarm systems up to date before the accident?

Description of the event sequence

At 0.17 am, 15 July 1980, the first alarm message was received by the alarm centre of the Main Fire Station of Copenhagen, 1 kilometre driving distance from the accident place. It was delivered by a public bus driver, who had been warned about the petrol vapours. He informed the alarm centre that airplane fuel had been spilled on Islands Brygge (street name) outside Dansk Sojakagefabrik. The Fire Station sent one fire engine without alarm horn and light activated (night time, moderate traffic and low alarm classification).

The fire engine was stopped at a certain distance from the plant due to the information about petrol vapours, and the fire commander on duty approaches by feet. After contacting the operation crew, he calls the chief fire commander.

At approximately 0.35 am the chief fire commander arrives. He calls two more fire engines and he declares *No Admittance* to the area.

The plant management has arrived and the chief fire commander asks for ignition sources to be removed, which includes shutting off the electricity to the extraction plant at the main transformers. The department head thereafter makes a contact to the power control unit, where the leader on duty rejects to turn off the two transformers under load due to spark risks. As he thereafter turned off one of the three transformers connected to the extraction plant, a sudden fire was observed outside the extraction plant, this fire was supposed to have an extent of approximately 3 m^3. It has not been documented, whether the disconnected line was actually loaded or "unloaded" at the time.

At 0.47.30 am a violent explosion came, that destroyed the extraction plant and nearby buildings, that gave some persons serious burns, but did not cause fatalities. According to the reporting in Brandværn (Petersen, 1981), the explosion occurred after the order was given to turn off electricity supply, but the exact time pattern between the explosion and the disconnection of the power can not be found. No matter what the exact times were, the explosion could have been caused by another event than switching off the main current.

Following the explosion, 40 tonnes of hexane took fire and there was a large roof fire and some minor fires. There was a common fear of new explosions to occur in addition.

Immediately after the explosion, the chauffeur of the fire chief in command called the alarm centre for enforcement. More fire engines (whole Fire Station H) were sent together with 8 ambulances.

The Alarm Centre was drowned with alarms due to the violent nature of the explosion, and the distant effects: broken windows in apartment houses and in shops etc. The public alarm telephone line "000" broke down.

The Alarm Centre acted according to plans and informed:

- Central Visitating Unit for the capital's hospitals.
- Copenhagen Harbour Administration.
- Falck's Ambulance Service.
- Leading Fire Chief / Vice Leading Fire Chief.

Approximately 0.58 am the first report from the fire chief in command at the fire scene came:

- No account of the situation is given.
- More assistance is required.
- Request for a command post to be established.

At 1.11 an additional fire station (Adelgade) was called.

At 1.41 am the Alarm Centre received the second report from the fire place, this time including an account of the situation.

Approximately 3.30 am an overview was made, showing no fatalities.

At 4.00 am, the first crew of firemen was shifted, and on 16 July around 3 pm - 40 hours after the first alarm was received, the last firemen left the accident place.

Lessons learnt

The first alarm message "airplane fuel spilled on the road" originated from a public bus driver and gave no very precise information on the situation. The message was sent by the bus driver as a traffic warning to the bus centre, where they relayed the information to the police radio service, who finally reported the spilled airplane fuel to the public alarm centre. The first reaction from the fire brigade was therefore a moderate one, approaching the site very cautiously, parking the fire engine on safe distance and walking the last hundreds of meters. After making observations at the site, they alarmed the brigade officer on duty, who arrived approximately 12 minutes before the explosion.

Thorough investigations by the occupational safety authorities and the police have pointed out several factors leading to a condition with extraordinary amounts of hexane vapours, creating the potential for a large explosion. However, exact details on the initiating factor of the explosion are difficult to obtain. A discussion took place between the brigade officer on duty and representatives from the plant management on means to stop the emission of hexane and avoid fire/explosion. It was decided to stop electricity supply to the plant in order to remove ignition sources. Three supply transformers lead to the extraction plant and only one was unloaded at the time. The power line operator refused to disconnect the lines actually loaded, as he feared the formation of sparks due to electrical inductance in transformers, motors etc. Both the investigation of the occupational safety authorities and reports from fire brigade representatives state that the explosion came at the time, where the operator actually tried to turn one of the three supply lines off. It is unclear, if this line was under load or "unloaded". Electrical installations in the extraction plant were made explosion proof, but hexane vapours had spread to nearby areas and buildings with ordinary installations.

The dilemma obviously was, that an urgent need for stopping the emission of vapours was contradicted by the risk of creating a spark when electrical power was disconnected. An emergency shut down procedure seems not to have existed for the extraction plant. To disconnect an unloaded transformer might seem a safe operation at first sight, but turning off an unloaded supply line could never in the first term implement the intended effect, that was to remove energy. A gradual reduction of energy supply to the plant would be preferable, but this alternative may not have been relevant, as it would imply operations at the plant area.

The fire brigade officer is responsible for the emergency operations at the accident site and these include actions initiated at the involved plant and equipment in order to control the threat. But the officer in command always has to rely strongly upon the site personnel and company representatives, as long as there is a plant to control.

The technical knowledge and experience of a fire brigade officer may vary considerably when it comes to operations on industrial equipment. Plant representatives may feel the threat from an approaching disaster and at the same time they are not used to taking orders from an external person. The scenario at a plant with boiling hexane and a leaking safety valve is worth a close analysis in order to produce useful advice on:

- How deep in the structure and function shall the officer try to control the decisions?
- On which level (in which operational domain) should ordered actions be formulated?

In the terms of the hexane case there is a spectrum for choice, from "reduce heating" to "turn power line x off".

6.2 Mustard gas bombs

While trawling at a location near Gotland, a Faroeish cutter caught a mustard gas bomb. This resulted in serious injuries to the seven crew members who had not been fully aware of the risk of catching chemical ammunition within certain areas of the Baltic Sea. The accident was the most serious one that has occurred since large amounts of chemical ammunition were dumped into the sea around Denmark fifty years ago.

Description of event sequence

The following description of the event sequence is based on information material received from the Danish navy (Søværnets Minørtjeneste, Holmen) and the Emergency Management Agency.

In the afternoon on Thursday the 22. March 1984, a Faroeish cutter caught a mustard gas bomb in the trawl while it was fishing near Gotland. The trawl was emptied and the content was by a conveyer belt brought below the deck where some of the crew members started to cut the fish open. It was noticed that the quarterdeck was contaminated with a greenish liquid and that jelly-like lumps were spread among the fish. It was also noticed that an object had been caught, but nobody suspected that it could be a bomb from which mustard gas was leaking out.

Not until three of the crew members below the deck showed poisoning symptoms, the unknown object was identified as being a mustard gas bomb. An illustration of the bomb was found in the Danish yearbook for fishermen. An emergency call was then received by Rønne radio in Bornholm and the Swedish life-saving service. The three intoxicated fishermen were then picked up by helicopters and brought to a hospital in Gotland.

As the remaining four crew members had no symptoms they tried to reach Bornholm, but after some time they all became blind and had to give up. After having sent an emergency call they were also transported by helicopters to the Swedish hospital.

However, the correct treatment could not be given at this hospital and all the fishermen were therefore transferred to a Danish hospital (Hvidovre hospital near Copenhagen) where the injuries - blindness and severe 'burnings' of hands and legs - could be treated correctly. They all recovered after 1 - 2 weeks.

The Danish navy is responsible for disablement of chemical ammunition being caught by Danish, Faroeish or Greenland fishermen. The cutter that was left empty on the sea, was therefore boarded by a sapper team from the naval district of Bornholm (at 05.30 the 23. March) and taken in tow to the port of Rønne (the towing lasted 15 hours). Here a safety zone was established by throwing a cordon round the ship.

The ship, trawl and movables were decontaminated by the civil defence and the military. This work lasted 6 days before the control tracking indicated that everything had been cleaned completely.

Lessons learnt

The lessons learnt from the mustard gas bomb accident are given below:

- The detection of the released mustard gas was late because the fishermen did not immediately identify the caught object as being a mustard gas bomb and because mustard gas has a delayed action effect varying from 1 to 48 hours to the onset of symptoms. *Comment: After the accident the information material has been improved and courses for fishermen are being held regularly. This has apparently had an effect on the alertness of the fishermen. No serious accidents have occurred since this accident. In most cases mustard gas ammunition is now being detected before the trawl is emptied.*

- There was no first-aid kit for treatment of injuries caused by mustard gas in the cutter. According to a national regulation from 1970, fishing boats, which are trawling within certain areas of the Baltic Sea, shall be provided with such first-aid kits.

- The Swedish emergency resources for mustard gas accidents were limited. The helicopters which picked up the first three men could not supply the fishermen who remained on the ship with first-aid kits and breathing apparatus.

- The leader of the decontamination team stated in the log that the decontamination work was difficult because equipment for effective detection of mustard gas and DS 2 were not available. (DS 2 is a blend of chemical substances which is used for breaking down the mustard gas. Since the DS 2 vapours are toxic and skin contact can cause cauterization, protective clothing and breathing apparatus are used).

6.3 Nordisk Alkali Biokemi

The accident occurred at the company Nordisk Alkali Biokemi (NAB). Approximately 200 kg of the fungicide Orthocide 83 (83 % captan - N-trichloromethylthiotetrahydrophthalimide) was decomposed releasing hydrogen chloride and sulphur dioxide. No acute health effects to people in the neighbourhood were observed.

The activities at the plant comprised mixing, diluting, repackaging and distributing solid and liquid pesticides. None of the substances were synthesized at the plant. Normally about 50 tons of raw chemical compounds, 50 tons of manufactured goods, and 20 m^3 of various organic solvents were stored at the plant.

The company was covered by the CEC directive 82/501/EEC on "Major Accident Hazards of Certain Industrial Activities" as more than a specific amount of a number of pesticides were handled which according to the directive may lead to major accident hazards.

It may be added that the company recently has been closed.

Information on the accident has been obtained from discussions with S. Thorup, Copenhagen fire brigade.

Description of the event sequence

An employee observed a white chemical cloud from one of the buildings at 7.30 pm on Sunday 14.04.1985. He then alarmed the fire brigade and the management of the company.

It was observed that the toxic gases were released from a silo containing about 200 kg of the fungicide Orthocide 83. Furthermore, it was observed that the stirrer in the silo was running. It is probable that the stirrer had done so since the night before and that heat evolving from friction had initiated a decomposition of the chemical compound. The thermal decomposition of captan is an exothermal process, i.e. heat is produced.

The fire brigade used water as cooling agent in order to stop the decomposition. The content of the silo (i.e. water, Orthocide 83, decomposition products) was then transferred to drums for later transport to a chemical waste treatment plant. Furthermore, samples were taken of the content of the silo for later chemical analysis in order to clarify the event sequence.

During the operations the fire brigade had to use breathing apparatus and protective clothing.

Due to corrosion of machinery at the plant caused by the released acid cleaning with large amounts of water was finally carried out. The water contaminated with acid was discharged to the sewer system. This action was carried out in agreement with the environmental authorities.

Later chemical analyses of the samples from the silo confirmed that a polymerization had occurred and that the gases released were mainly hydrogen chloride and sulphur dioxide. The incident was probably a decomposition combined with a smouldering fire. The maximum possible amounts of released gases were 70 kg HCl and 20 kg SO_2. Even if these amounts of gases were released in a relatively short period (e.g. 60 min.) no acute health effects to people in the neighbourhood would occur.

Lessons learnt

The most important point observed in this accident relates to the breathing apparatus used by the fire brigade.

The equipment is always inspected after use, and it was by this occasion observed, that the parts of the equipment made of metal were corroded. This corrosion was caused by exposure of the equipment to acids. However, even if the concentrations of the actual acids had been larger or the exposure time had been longer it is not expected that problems to the firemen would have occurred. On other occasions with different acids, these effects may lead to drastic consequences, therefore some general observations are made:

- No real good protective clothing to be used by the firemen in relation to chemical fires exists. It would be desirable to develop clothing, which could protect the firemen against chemical exposure as well as heat.

- Parts of the breathing apparatus made by plastic materials could be affected by released chemicals.

- The equipment will only be checked immediately after use. No periodical inspection is carried out. This means that chemical effects to the equipment occuring later will not be seen.

6.4 Valdemar Larsen Metal Working

The accident involved a release of chlorine from a metal and casting factory. The production comprised aluminium melting in three foundry furnaces at 800-100 °C. The capacity of one of the furnaces was 20 tons/charge and the capacity of each of the two other furnaces was 6 tons/charge. Chlorine was used to remove magnesium from the melt.

Information on the accident has been obtained from the MARS data base and other documents available by the Danish authorities.

Description of event sequence

The accident took place on Thursday 25 April 1985. Even though some occupants were actually working at the plant when the release occurred, it was a person who passed the plant and smelled chlorine, that alarmed the police at 5.43 pm. When the police arrived, the fire brigade was immediately alarmed.

The police sealed off the area and initiated a warning of the public via the radio. People were instructed to remain indoor and close doors and windows. The bus routes were also changed.

The chlorine was leaking from a 500 kg drum. In total 2 drums were present at the plant. The drums were placed in a special chlorine room. The leaking drum was connected to the chlorinating facility. A hot water spray was in operation in order to facilitate the evaporation of the chlorine (the liquid chlorine is evaporting when released from the drum. Evaporation of chlorine requires large amounts of heat and the temperature of the liquid chlorine will therefore rapidly decrease and the evaporation rate will therefore also decrease). The accidental release took place via the valve at the drum. The bushing was loose and the stem had thereby been ejected causing a rapid relase to the surroundings.

The stem was connected to a handle outside the chlorine room to make an emergency shut down of the valve possible in case of release of chlorine from hoses and tubes. However, since the stem was not fitted at all such a shut down procedure would not be possible.

The fire brigade (fire men with breathing apparatus) located the point of release, stopped the hot water spray system and found and refitted the bushing and valve stem thus stopping the release of chorine.

The release of chlorine was terminated approximately at 7.20 pm. The area was re-opened at 7.35 pm.

Four staff members, three police men and a fire man were hospitalized for 24 hours. No permanent injuries were observed.

It was demonstrated later, that the cause of the accident apparently was incorrect handling of the chlorine drum by one of the staff members working in the chlorine room. The valve stem and the bushing had been unscrewed by force thereby overriding the locking provided by a screw. After unscrewing the bushing and valve stem were ejected and the chlorine was released. In total approximately 160 kg chlorine was released.

It was estimated that the concentration of chlorine immediately outside the plant was approximately 6-20 ppm.

Lessons learnt

Two lessons should be emphasized in relation to the accident at Valdemar Larsen Metal Working:

- Written instructions for handling of the valve at the chlorine drums were available. However, the workers present at the time of the accident were all foreigners and language problems may have contributed to the accident. The workers' level of education is inadequate under the circumstances.

- The people living in the area complained that they were only warned via the radio and not by loudspeaker vans.

6.5 Matas warehouse fire

The fire occurred at the Matas warehouse in Brabrand. A large number of different products were involved in the fire (e.g. soap, cosmetics, pesticides, solvents). The fire and the fire fighting were rather traditional, however, the discharge of contaminated fire fighting water turned out to be a problem.

The accident is described by Eriksen (1988) and Lindgaard-Jørgensen (1989).

Description of the event sequence

On Sunday 5 June 1988 at 5.49 pm the fire brigade was called for a fire at the Matas central warehouse in Brabrand. The size of the building was approximately 3000 m^3. In the warehouse various products were stored, e.g. soap, cosmetics, pesticides, solvents and different packaging materials. The fire brigade did not have any detailed knowledge on the type and amount of products.

About 2 km from the site a large residential area was situated. The police initiated warning of the local population through radio and television to close doors and windows and remain indoor. Initially a large flame lift was observed, later, when then extinguishing was carried out, the plume came closer to ground level. Therefore, the population was informed that doors and windows should be kept closed until the next morning. The warnings did not have very much effect since a large number of people came to the fire site in order to watch what was going on.

The main problem was the large amount of fire fighting water contaminated with chemicals and soap. No spill basins to collect the fire fighting water were available. The total amount of water released was approximately 1000 m^3. Due to the large amount of soap in the water the pH value was quite high.

If nothing had been done the contaminated water would be discharged to a stream and via a pond and a lake to a small river. The lake and the small river had a high ecological classification and actions should be taken in order to protect them. In collaboration with the local environmental authorities the fire brigade decided to transfer part of the fire fighting water to the biological waste water treatment plant via the sewer system. Furthermore, additional water was led to the stream in order to dilute the contaminated fire fighting water.

The next day death fish were found in the pond but not in the lake and the small river. Obviously, the actions taken had not been sufficient to obtain a neutral pH-value and an acceptable oxygen content in the water. Minor effects at the biological waste water treatment plant were also observed.

Lessons learnt

The Matas warehouse fire has shown that even fire fighting water from fires in warehouses involving quite harmless chemical substances could give rise to substantial short term effects in the environment. However, it seems difficult for ecotoxicologists to predict the environmental consequences of such releases.
It is observed, that:

- It could be necessary for the fire brigade to limit the amount of water to be used for fire fighting.

- Not only streams, lakes, rivers etc. but also the ground water could be contaminated with the fire fighting water if the water is spilled on the ground.

- Waste water treatment plants could be affected if the fire fighting water is discharged to the sewer system.

- The local fire brigade should have more knowledge on the substances stored in the Matas type warehouses.

- Preventive measures should be taken in order to collect the fire fighting water from fires in chemical warehouses if a sensitive recipient is threatened.

The volumes of warehouses increase and a large number of different substances are often stored together. More specific rules for organization of storages for large amounts of relatively harmless chemicals (such as mixed storages of soap, cosmetics, solvents and pesticides) are needed.

6.6 Maribo Seeds Company

A fire occurred at the storage plant of Maribo Seeds in Holeby involving a storage of insecticides and fungicides. In fighting the fire a large amount of water was used and part of the chemicals and their combustion products were thereby spread to nearby watercourses.

Description of the event sequence

The description is based on the following information sources: (Miljøkontoret, Storstrøms Amt, 1990), (Bostrup, 1989) and private information material received from Maribo Seeds.

At 7.16 pm on Sunday the 22 October 1989, a works manager called the fire brigade at a fire which an employee had started deliberately in the NE corner of a warehouse (around 1200 m^2). After having started the fire, the employee went to the manager and told him that a fire had arisen in the warehouse.
The warehouse was divided into fire sections. The section, in which the fire had been started, contained 119 tonnes of seed, 88 tonnes of saw dust, 25 tonnes of starch glue, 3.5 tonnes of calcium peroxide and about 6 tonnes of agrochemicals (insecticides and fungicides).

The fire brigade from Rødby arrived at the premises at 7.25 pm. A little later the fire brigades from Nakskov and Maribo were requested to participate in the fire fighting.

The fire was initially a smouldering fire. Water cooling of walls and entry limited the fire to one fire section. At around 9.00 pm the fire was thought to be extinguished. Eight firemen, wearing protective clothing and breathing apparatus, were therefore sent into the building for damping down operations. However, there was a dense smoke in the building, and the fire brigade officer decided to withdraw his men as he judged there was a risk of dust explosion.

A dust explosion occurred - and the fire escalated violently within the fire section; it spread rapidly to the nearby stocks of toxic and flammable chemicals. It was the brigade officer's opinion that a contributing cause of the fire escalation was fire fighting water coming into contact with the calcium peroxide. The fire brigade was a priori acquainted with the stored chemicals except the calcium peroxide.

Two firemen, still inside the building when the explosion occurred, were hospitalised.

A police patrol went to Holeby (Holeby is about one kilometre north of Maribo Seeds) and there a nuisance of smoke was noted. At 9.42 pm the local radio and TV requested the inhabitants in Holeby to remain indoors and keep doors and windows closed. This request was also given via police loudspeaker vehicles. People were also warned against a possible pollution of vegetables in the area that had been passed by the smoke plume.

Not until after midnight the fire was under control but the store was burned out and the stored material destroyed. About 1500 m^3 of water had been used in the fire fighting. The fire brigade succeeded in collecting part of the water into a basin for washing of beets.

The day after the fire, biologists from the local environmental authorities discovered dead fish and microorganisms in a nearby stream. The stream flows into a channel, which via a pump station leads the water to the Baltic Sea.

The water flow in the channel was very low. It was therefore decided to build a dam a few kilometres downstream of the scene of fire in order to limit the immediate damages; and also to delay the discharge to the Baltic Sea so that the pesticides were decomposed as much as possible before the discharge.

The extent of the pollution and its reduction with time were monitored by currently taking water samples from the stream and the polluted soil. Analyses indicated that about 10 kg of pesticides had been washed into the stream. Large amounts of seeds and saw dust were also washed into the stream and the resulting reduction of the oxygen content was considered a contributory cause of the damage to the stream fauna. After about 5 weeks the fauna began to restore.

Lessons learnt

In December 1989 the involved parties and authorities (the fire brigade officer, the police, Maribo Seeds, Holeby municipality and the local health authority) held a meeting with the aim of deriving lessons learnt. According to a "lessons learnt" report, issued by the environmental authorities, the following lessons learnt were all agreed upon:

- The activities of the local environmental authority should be extended to include accidental pollution of air, soil and ground water, i.e. the field of activity should not only concern watercourses, lakes and coastal waters as it was originally planned when the environmental authority was established in September 1989.

- In the event of an environmental incident as that at Maribo Seeds, a group of technicians from involved parties should be established rapidly. The group shall ensure that relevant information as fast as possible is accessible to the fire brigade officer, the police, the authorities and the public.

- The contact to the press should be made by as few persons from each part as possible; and these persons should be experienced in press contact. *Comment: The police has the duty to inform journalists at a press meeting when a comprehensive view of the situation is obtained. General lines for the contact to the press is included in the police education. A training module is only included in courses for leaders. In connection with the fire at Maribo Seeds, many persons - besides the police - spoke to the press and contradictory views and incorrect information were given. This resulted in misinformation to the public and unnecessary fear.*

- There is a need for rules/regulations for storage of chemicals with respect to stock size, location, segregation, fire protection and possibilities for collection of fire water. *Comment: The experiences from the fire in the legal storage of chemicals at Maribo Seeds show that there is a need for more specific rules for chemical storages that are not covered by the Seveso Directive and the requirements of the fire authorities.*

6.7 Næstved railway accident

At 4.50 am on Friday, September 25, 1992, a goods train on its way from Rødby to Copenhagen (the DANLINK-route) collided with an empty passenger train which was waiting at Næstved railway station. A tank wagon, containing 67 000 litres of acrylonitrile turned over and a leakage from a weld seam arose resulting in a spillage of approximately 600 litres. The accident occurred because the engine driver overlooked a signal and the speed of the train was too high when he noticed that the next signal was a stop signal. Although nobody was seriously injured or poisoned, the accident revealed several flaws in the preparedness against chemical accidents in the transport sector.

Description of the event sequence

The description is based on the following information sources: (Jensen, 1992) and information material received from DSB (the Danish State Railways) and the Emergency Management Agency.

After the collision had occurred, DSB called the police and the Emergency Service in Roskilde from the central signalling post. At 5.00 am the police and ambulance service, Falck, arrived at the accident area.

The public fire brigade was called by the police at 4.59 am, but the only information received was that two trains had collided and that diesel oil was leaking from an engine tank. The first turn-out therefore only brought cars with drums and equipment for reception of oil (a "reduced" turn-out).

When the fire brigade officer on duty (the on scene commander) arrived at 5.08 am he observed that liquid was also flowing from a leakage in the middle of the overturned tank wagon. At 5.14 am further fire brigade assistance was requested.

To identify the content of the tank wagon the brigade officer mounted the wagon so that he could see the up-turned danger sign. After having identified the substance acrylonitrile (at around 5.17 am) by means of "Handbook for Emergency Response Leaders" and "Safety Cards for Road Transport" (CEFIC-cards), the police was at 5.20 am informed about name and properties of this substance; and the police was also requested to pass this information on to Næstved county hospital.

After having identified the substance, the brigade officer receives the RID-list from DSB (this list includes information on wagons with dangerous goods).

At 5.30 am Falck informed the hospital that two persons, injured at a train accident, were on the way to the hospital.

The first fire brigade response, initiated at 5.35 am, was to blanket the tank and the surrounding ground with a thick layer of foam in order to prevent evaporation and ignition of the spilled liquid. Four men, wearing protective clothing and breathing apparatus, then stopped the leakage by means of a wedge of wood and sealing compound. However, due to the location and irregular shape of the untight weld seem a complete tightening could not be obtained.

At 6.02 am the Chemical Emergency Response Service was called. The service verified the properties of acrylonitrile.

At 6.13 am the environmental authorities were called.

At 6.15 am Falck informed the hospital that the train accident had involved spillage of a chemical and that three possibly poisoned persons were on their way to the hospital. One of these persons brought the CEFIC-card for acrylonitrile which was delivered to the hospital personnel.

At 6.35 am the civil defence was requested to assist with its environmental preparedness: a team of people, wearing special protective clothing and breathing apparatus, sucked spilled liquid into vessels.

After the situation was considered stable the police established a 100 metres safety zone on the advice of the brigade officer.

At 6.44 am the brigade officer received the wagon information from DSB.

At 7.00 am the radio informed the public about the accident.

At 6.50 am (according to the police report) or 7.10 am (according to the hospital report) the police informed the hospital about the accident - i.e. around 2 hours after it had occurred. After having received this information the hospital called the poison information centre at the National University Hospital in Copenhagen and was at 8.45 am informed about the antidote to be applied against poisoning from cyanide arising from acrylonitrile.

The hospital then tried to get the antidote from a drug firm in Copenhagen but the firm would not deliver the antidote without permission from the National Health Board. The hospital got the permission at 10.00 am and the antidote was then sent by taxi to the hospital where it was received at 11.45 am - i.e. nearly 7 hours after the accident occurred.

During the morning about 30 persons (people from the fire brigade and the civil defence) arrived at the hospital and complained about symptoms such as nausea and dizziness. Practically all wore contaminated clothing. The hospital has a flushing room (decontamination room) but this was not used since nobody had informed the hospital about the potential of contamination. The arrived persons were therefore just undressed and observed for some time. (Apparently nobody at the hospital considered the possibility of contamination after having received - at 6.15 am - the information that the accident involved a spillage of acrylonitrile and the information on its toxic properties).

In the accident area a safe transfer of the liquid in the tank wagon to pressure tanks turned out to be a problem; neither the civil defense nor DSB possessed the necessary containers. After contact to BASF in Denmark, containers and equipment for reloading were ordered in Germany.

Late in the evening the containers and connecting equipment arrived together with specially educated fire fighters from BAYER AG in Brunsbüttel, Germany. After a short briefing the reloading was started and it lasted all the night. During the reloading and subsequent clearing of the rail track, the safety zone was extended to 200 metres and the south-going train traffic was stopped. Since the extended safety zone included nearby housing estates, police loudspeaker vehicles drove around warning people to remain indoors and keep doors and windows closed. This warning was also given by the local radio.

The further clearing - removal of contaminated soil, pumping of contaminated water from a reserve boring for water close to the accident area and cleaning of the tank wagon - was rendered to DSB and the environmental authorities. 306 m^3 soil and 606 m^3 water, contaminated with acrylonitrile, were removed and sent to Kommunekemi (plant for destruction of chemical waste). Also 155 m^3 oil-contaminated ballast and soil were removed. The handling of contaminated ballast and soil increased the concentration of acrylonitrile in the air to about 100 ppm.

Lessons learnt

The involved fire brigade officer summarizes lessons learned (Jensen, 1992):

- It is crucial that the alarm message given to the fire brigade is as correct as possible. If the goods train contains dangerous substances, this information should be given. The existing GTS system with its RID-list should be applied in this connection.

- The Handbook for Emergency Response Leaders is not precise; sludge pumps approved for inflammable liquids could not be used as indicated in the handbook.

- The "Emergency Response Manual", issued by the Civil Defence Board, did not contain information on acrylonitrile. *Comment: If information on a substance is not given by the manual or by the booklet "Dangerous Substances", the fire officer should contact the Chemical Emergency Response Service.*

- Radiocommunication was not established between DSB, the coordinating leader and the technical leader.

- The fire brigade should be acquainted with tank wagon constructions. Connecting branches for loading and unloading should be standardized so that these components could form parts of the preparedness equipment.

- It should be possible - from a depot - to procure clean containers for reloading of special substances. *Comment: The Emergency Management Agency intends to establish a central register containing information about depots with clean containers for reloading.*

- Tank wagons with a capacity of 67 000 litres should be considered unacceptable. They should be considerably less or be divided into sections.

- Cleaning of contaminated personnel must be carried out carefully at the incident area.

- The press should be kept away from the incident area. *Comment: The police has the duty to inform journalists at a press meeting when a comprehensive view of the situation is obtained. General lines for the contact to the press is included in the police education and a training module is included in courses for leaders.*

The Emergency Management Agency, Chemical Laboratory, states the following lessons learnt from the acrylonitrile-incident:

- Early, but distinct briefing of the response teams (fire-fighters, police) about chemical and toxicological properties of the chemical in order to prevent mistakes or apprehension.

- Early installation of a wind indicator visible at the site.

- The effluent from rinsing of protective clothing should be continuously decontaminated.

Some further lessons learnt should be added to the above mentioned:

- By overturning of a tank wagon containing a dangerous substance, the danger signs on the wagon sides cannot be seen from the ground level. An improvement could be to place danger signs also on the top of the tank, e.g. two signs of which at least one is non-inverted when read from the ground level.

- It is crucial that the brigade officer - as fast as possible - acquires information about dangerous goods in wrecked tank wagons. The RID-list with this information is kept with the engine driver, but he may be unable to pass it on, or it may be impossible for others to get hold of it. Even if the list is procured, it could turn out to be difficult to identify a specific wagon if it is wrecked in a mess of wagons. Whatever occurs it should therefore be possible to identify the tank content by means of the labelling. A dangerous goods list - procured from the engine driver or elsewhere - should be considered a back-up source of information in relation to the tank labelling.

- The RID-list should as fast as possible be telefaxed to the police who has the duty to inform the hospital.

- DSB should work out and maintain a list of dangerous goods transported in Denmark so that the Emergency Response Manual as far as possible contains cards for all relevant substances. On this basis also the relevant antidotes can be identified. *Comment: As a post-incident action DSB has worked out such a list and it has been sent to hospitals and to the Emergency Management Agency.*

- The antidote-preparedness system was insufficient; the antidote against acrylonitrile could have been procured from a nearby hospital that had a depot of antidotes, but nobody at the Næstved hospital was aware of its existence. *Comment: As a post-incident action the Emergency Management Agency intends to establish a central register from which doctors can get information about existing hospital depots and their contents.*

7 Selected lessons

7.1 Dansk Sojakagefabrik

One set of lessons incorporates the preparedness of the operating crew and proper instructions and directives. These lessons are dealt with in Arbejdstilsynet (1981). Lessons learnt on emergency management point to two issues:

- The first lesson confirms the urge to operating plant crews to send timely and precise alarm messages.

- After the fire brigade arrived, the first actions were directed at controlling the threat and not at protecting the public by warnings etc.

The rescue services were not alarmed by the company, but by a bus driver whose bus were passing the site. The operators were at the time more occupied with the operation troubles than with a developing disaster.

Viewed as case in disaster control then, the case demonstrates the two aspects in controlling threat: the damaging potential of the chemical and the ability to control the chemical itself. Studies in the United States (Quarantelli, 1987) showed among other things a typical difference between in-transit accidents and in-site accidents. In-transit accidents are usually by the first responders seen as transport accidents, whereas accidents occurring at a chemical plant are seen as chemical accidents. The first actions in site are aimed at controlling the threat, and initial activities in in-transit cases are devoted to protecting the public. The decision to switch off electricity to the extraction plant was made by the chief fire officer and plant representatives in some sort of collaboration, but the fire officer is always formally responsible for emergency decisions. It may not be possible to reconstruct the very last moments leading to the explosion, but the case is unique for speculations on the collaboration of external fire brigades and plant personnel facing dilemmas in disaster control. The case is useful for educating and instructing fire brigade officers.

7.2 Mustard gas bombs

As a category these incidents are not easy to classify: the meeting of fishing trawls with dangerous substances dumped from other ships fifty years ago. These chemical weapons are still dangerously active and appear sometimes in undamaged bombs, sometimes as the spread contents of corroded bombs.

The emergency operations are difficult, because detection is sometimes late, the actual fishermen are inexperienced with the gas, and coming to assistance on open sea is both difficult and time consuming. The actual case chosen for this study took place close to Swedish territory and directed the focus towards:

- Late detection of gas spread on cargo, ship and crew.

- Limited Swedish emergency resources for mustard gas accidents.

- Difficulties in cleaning operations.

Experience at this occasion specially called the attention to:

- Better instruction of fishermen.

- Better tools for detection of remnants of mustard gas and the cleaning substance DS 2 during the decontamination work.

- Better protection of fishermen.

For economic reasons it is considered impossible to locate, collect and destroy the dumped mustard gas bombs and other types of gas bombs in the sea around Denmark. But dangerous substances have been - and are still being - dumped in sea waters anywhere, and techniques for handling the special threats from these undersea storages have to be developed in any case. The Danish experience from fishing mustard gas bombs may serve as one input to improved tools and improved emergency management.

7.3 Nordisk Alkali Biokemi

The most important lessons learnt from the Nordisk Alkali Biokemi incident concern the breathing apparatus and the protective clothing used by the fire brigade:

- The breathing apparatus could be affected by the released chemicals. Furthermore, inspection of the equipment is only carried out immediately after use. Delayed effects from the chemical exposure are therefore not detected through periodic inspections. It is eight years ago since the incident occurred at NAB, however, the same type of breathing apparatus is still used.

- There is a need to develop protective clothing which could protect the firemen against chemical exposure as well as heat in case of a chemical warehouse fire.

7.4 Valdemar Larsen Metal Working

Two important lessons learnt from the accident at Valdemar Larsen Metal Working are:

- Problems may occur when foreigners are employed, since written instruction for normal operations and emergency situations might not be understood.

- It is an urge to operating crews on duty to send alarm messages. The emergency services were not alarmed by plant personnel, but by a person who passed the plant.

7.5 Matas warehouse fire

The lessons learnt from the Matas warehouse fire relate particulary to contaminated fire fighting water:

- Disposal of contaminated fire fighting water should be considered in case of warehouse fires.

- More specific rules concerning organization of storages for relatively harmless chemicals are needed.

- The fire brigade should have more information on the substances (such as soap, cosmetics, solvents and pesticides) stored in warehouses.

- Rules for disposal of contaminated fire fighting water are needed.

7.6 Maribo Seeds company

The lessons learnt from the fire at Maribo Seeds concern particularly the procurement of information which is relevant for the emergency management, the organization of storages for chemicals and the disposal of contaminated fire fighting water:

- In the event of a fire in a warehouse containing dangerous chemicals, a group of technicians/specialists from involved parties could be needed for procuring information relevant to the emergency management.

- There is a need for rules/regulations for storage of chemicals which in case of fire may expose people or environment to risk.

- Rules are required for disposal of contaminated fire fighting water.

7.7 Næstved railway accident

Several lessons can be learnt from the Næstved railway accident:

- In order to insure that the alarm message given to the fire brigade is as correct as possible, the RID-list should be applied. DSB (Danish State Railway) should as fast as possible telefax the list to the police.

- The danger signs on the sides of a rail tank wagon cannot be seen from the ground level if the wagon is turned over.

- It is important that doctors easily can acquire information on the antidote to be applied against a special dangerous substance; and from which hospital depot it can be procured.

- It is important that the emergency teams easily can acquire information on where clean containers for reloading of special substances can be procured.

- The fire brigade should be acquainted with tank wagon constructions.

- Cleaning of contaminated personnel must be carried out carefully at the incident site. The effluent from rinsing of protective clothing should be continuously decontaminated.

8 Conclusions

After reviewing the Danish emergency organisations and lessons learnt through the seven cases, an overview shall be sketched, where issues of general interest are pointed out.

The fire brigades are the emergency forces that have been most exposed in our study. They play a central role at most accident sites, where chemicals are involved, and they arrive early after alarming. We have noticed important lessons concerning these matters: protection means, fire brigade officers' specific plant knowledge and their general chemical/physical knowledge.

Breathing apparatus may develop malfunctioning after being exposed to some chemicals. This equipment is checked after use, however, some sort of regular testing ought to be added, for both breathing apparatus and chemical protection clothing, in order to cover even delayed effects of such exposure.

During discussions it was revealed, that generally there is a need for developing protective clothing, that shields both against heat and chemicals.

Information needs caused delays or troubles in these cases:

- Næstved, identifying the leaking substance, and finding proper handling instructions.
- Maribo Seeds and Matas, identifying the inventory of large stores of chemicals and other substances.

Large efforts are invested in producing and maintaining the principal information sources - cards and handbooks and more modern data banks - but a serious limitation on the use of such means derives from the knowledge and experience with the average user. Only rather rough messages can be communicated through passive sources to firemen who are not used to that sort of information - this matter was discussed further in Rasmussen et al (1987). In the actual cases, the fire brigade officers relied much on both plant representatives and advisors like the chemical expert on duty in Copenhagen, but it is not always possible to obtain advisory support in due time. It must be considered, whether fire brigades in general could be better prepared for chemical emergencies in one or both of the following ways:

- By acquiring more basic knowledge about chemical properties and about the behaviour of liquids, vapours and gases etc.
- By collecting and utilising more specific information on plants, processes and storages in their operational area.

There are short lines to the fire brigades from the local administrations, that regulate fire safety, but the actual officer on duty may be called to an industrial accident site, only knowing how he gets there. The plans show routes and addresses, telephone numbers and names, but contain little technical information.

Experience with transport accidents involving chemicals is scarce: the Næstved case with acrylonitrile is investigated in this study, and some cases with gasoline transport and liquified gas on a train were described in an earlier study (Rasmussen et al, 1987). Railway transport of chemicals is an operation, where a very little crew handles vast amounts of chemicals in a rather tight scheme with time schedules and other trains, and the train operators can not possibly know much about the many chemicals and products on one out of several trains. Therefore the train personnel has to treat the cargoes in a very schematic way.

The impression of hospitals' preparedness for larger accidents is at present, that while conventional injuries can be handled even in cases with several injured persons, injuries demanding special treatment, decontamination, antidotes and perhaps protection of hospital personnel, are still a new challenge to many hospitals. Plans and arrangements for cooperation between hospitals and with rescue services and police are rehearsed through more common road accidents, railway accidents etc. The seldom and in some respects much more demanding chemical accidents and injuries must be trained in exercises.

The establishment of the newly formed Emergency Management Agency placing fire brigades and civil defence forces under one administrative unit is motivated by other factors than those found among the lessons learnt in this study. The change will ease collaboration between the two branches of the emergency organisation and the new organisation may hopefully bear potential for the development of high class exercises in all branches of Danish emergency organization.

Denmark can offer accident experience of a rather special type: the mustard bombs caught in fishing trawls in the Baltic Sea. The case included here showed few difficulties, but the most prominent message to emergency organizators is this: what is going to happen to elderly weapon arsenals like those in the Baltic Sea, and how are we going to handle emergencies arising from weapon arsenals anywhere in the world? Emergency schemes have to be constructed in connection with the planned deconstrution of bombs and chemical weapons, but there must be other storages of more or less known sort than those in the Danish subsea regions.

In none of the seven cases, the public had been informed in advance about the specific threats, in fact there are very few places in Denmark, where the public is informed about specific risks from industrial plants or railways etc. This situation is probably going to change in the coming years. But on several occasions, warnings through radio or by police cars with loudspeakers have been given in actual emergency situations. The "whens" and "hows" of public warning clearly needs some development work, as some emergency managers may hesitate too long in front of warning or evacuation decisions, and on the other side some citizens see the warning as an invitation, like in the Matas case of this study. From the Mississauga accident in Ontario (Canada) 1979 it has been reported, that responsible actors were reluctant about having people evacuated *during the night*, thereby delaying one of the biggest peace time evacuations at accidents with dangerous substances. As referred in chapter 5.5 above, the French Lessons Learnt study reported positive experience with deciding and conducting a large evacuation in Nantes. In Denmark we may have to learn both about warning and evacuation schemes from lessons learnt elsewhere, because we are lucky with the chemical accidents until now.

Acknowledgements

The authors would like to express their gratitude to the members of the contact group who have contributed to the project with valuable advice. The group was helpful already during accident selection, and they guided us safely through the land of emergencies.

Bibliography

Arbejdstilsynet (1981). Eksplosionsulykken på Dansk Sojakagefabrik tirsdag d. 15 juli 1980 kl. 0.47.30. 42 pp. **[Case 6.1]**

Bostrup, O. (1989). Branden i Holeby hos Maribo Frø. *Dansk Kemi,* no. 11. p. 316-317. **[Case 6.6]**

Brandværn (1993). Endelig ny organisation. *Brandværn* no.5. p 16-18. **[Chapter 5.3]**

Eriksen, K. Aa. (1988). Matasbranden i Brabrand. *Brandværn* no. 9. p 2-7. **[Case 6.5]**

Jensen, S. Aa. (1992). Toguheld, Næstved Banegård. *Brandværn* no. 12. p 28-29. **[Case 6.7]**

Katastrofeberedskab (1991). Betænkning no. 1226. Statens Information, Copenhagen. 73 pp. **[Chapter 5.3]**

Koivisto, R. and D. Nielsen (1993). Database on warehouse fire accidents. VTT Safety Engineering Laboratory. 35 pp.

Lequime & Brette (1993). Lessons learnt from emergencies after accidents involving dangerous substances. EUR 15059 EN.

Lindgaard-Jørgensen, P. (1989). Vandforurening som følge af brand. Brand og Miljø II. Dansk Brandværns Komité. Temadag. 9. February and 18 May 1989. 5 pp. **[Case 6.5]**

Max-Lino, R., P. Harrison and C.G. Ramsey (1987): Assessing the response capability and vulnerability of an emergency plan: Some important issues. Proceeding of the European conference on emergency planning for industrial hazards. Varese, Italy, 4-6 November 1987. H.B.F. Gow & R.W. Kay (eds.). Elsevier Applied Science 1988.

Miljøkontoret, Storstrøms Amt (1990). Erfaringer fra branden på Maribo Frø d. 22 oktober 1989. 48 pp. **[Case 6.6]**

Neuhoff, S. (1987): Exercises and auditing: Experience gained in the FRG. Proceeding of the European conference on emergency planning for industrial hazards. Varese, Italy, 4-6 November 1987. H.B.F. Gow & R.W. Kay (eds.). Elsevier Applied Science 1988.

Petersen, B. (1981). Eksplosionsulykken på Dansk Sojakagefabrik A/S. *Brandværn* no.2. p 18-23. **[Case 6.1]**

Quarantelli, E.L. (1987). Community and organizational preparations for and responses to acute chemical emergencies and disasters in the United States: Research Findings and their wider applicability. Proceeding of the European conference on emergency planning for industrial hazards. Varese, Italy, 4-6 November 1987. H.B.F. Gow & R.W. Kay (eds.). Elsevier Applied Science 1988.

Rasmussen, J., O.M. Pedersen and C.D. Grønberg (1987). Evaluation of the use of advanced information technology (Expert Systems) for data base system development and emergency management in non-nuclear industries. Review Report for JRC-Ispra. Final Report 17. Dec. 1985. Risø-M-2639 and EUR 11228 EN.

Øvelsen på behandlingsstationen (1976). Risø National Laboratory. Internal report. **[Chapter 5.2]**

Appendix

Completed forms for selected cases

A.1 Dansk sojakagefabrik

General information

1.1 Date: 15.07.1980.

1.2 Time: 0:30 a.m.

1.3 Place: Islands Brygge 34, DK-2300 Copenhagen S.

1.4 Activity type: Extraction plant for soy beans. The company processed vegetable fat from soy beans, whale oil etc. and delivered the products to many different industries, mainly for food production. Among the products were hydrogen, used on the plant for fat hardening, and chlorine.

1.5 Name of company: Dansk Sojakagefabrik (later DS Industries).

1.6 Topology: The company is situated in the harbour area of Copenhagen with easy access to ships and railway. The neighbourhood is a mixture of other industries and residential areas, but the latter only occupies approximately one quarter of the periphery.

1.7 Description of buildings: The area of the extraction plant was approximately 100 meters x 50 meters and was situated with a facade to a public road. This road also hold a double railway track. The buildings were typical mid-century chemical industry, with most structures made from armed concrete. The roof of the extraction building was a light wooden construction covered by eternite. The processing equipment for extraction had been installed in 1958 to substitute an older plant.

1.8 Regulations involved: The company was covered by the EEC directive 82/501/EEC on "Major Industrial Hazards of Certain Industrial Activities".

1.9 Accident preparedness: None.

1.10 Information to the public prior to the accident: Prior to the accident, no general information on the explosion had been sent out to nearby residents. But people were well aware of the potentials of a chlorine release from the premises of Dansk Sojakagefabrik.

2. The accident

2.1 Accident type: Explosion.

2.2 Substance(s) involved: Hexane, used as a solvent in extraction of soy beans. CAS-no. 7782-50-5. Assumed weight 15.000 kg.

2.3 Other substances at the site: Several substances processed and stored. Hydrogen was both produced and used, large amounts of chlorine were stored for sale.

3. Accident course

3.1 Weather conditions: No influence on the course of the accident.

3.2 Detection of accident: Gradually increasing amounts of hexane vapours caused a kind of "fog" to invade the plant surroundings, detection of the abnormal state occurred when these were an obstacle to traffic in the street outside. The fire brigade was alarmed by coincidence shortly after midnight, as the alarm centre received a message through the police about airplane fuel on the road in front of the site.

3.3 Description of accident: The accident occurred after a build up of large amounts of evaporated hexane due to unstable flows and pressure excursions. A large explosion followed, when it was tried to remove ignition sources by disconnecting a power supply line.

3.4 Behaviour of plant staff and management: The plant was left before the explosion, due to hexane vapours.

3.5 Behaviour of the public: Not reported.

4. Emergency measures

4.1 Emergency services involved: No. of fire brigade and police personnel approximately 20. Ambulance and medical personnel were activated too, corresponding to the number of injured persons.

4.2 Emergency actions: In collaboration with the plant management, the fire brigade officer decided to have the power supply to the plant disconnected. After the explosion, resulting fires at the plant had to be extinguished.

4.3 Equipment used: All fire engines from the Central Fire Station of Copenhagen plus two engines from other stations. Eight ambulances called immediately after the explosion.

4.4 Prevention of consecutive damage: Not reported.

4.5 Medical treatment of victims: The injured brought to hospitals.

4.6 Care for the plant staff: Not reported.

4.7 Care for the public: No warnings were given, except to the bus driver who was about to drive his bus through the "foggy" area.

5. Cause of accident

5.1 Primary cause: The explosion was probably initiated by the attempt to disconnect the unloaded one out of three power supply lines to the extraction plant.

5.2 Underlying causes: Several factors leading to the abnormal process state include unstable characteristics of the process flow and inadequate safety instructions. A significant part of the emission is ascribed a special component serving as a safety valve for overpressure, which could have been activated during start up, and left partly open. Contributing factors are unexperienced staff and language difficulties.

6. Consequences of accident

6.1 Actual number of person killed: 0.

6.2 Actual number of persons injured: 27.

6.3 Economic losses: The extraction plant was totally destroyed. Insurance pay = approx.200 mio DKr.

6.4 Environmental effects: The explosion caused windows breaking in many quarters of Copenhagen, in distances up to 1.5 kilometres. No other significant effect to the environment.

6.5 Map of area affected: None.

6.6 Potential harm to humans and the environment: The potential harm was considerable, both to humans and to surrounding estates, especially if the chlorine tanks had been damaged by the explosion.

7. Post incident actions

7.1 Plant modifications: The plant has not been reestablished.

7.2 Recommendations: Several, including improvements of safety interlocks, gas detection, fire protection and safety management.

7.3 Precautions taken to prevent or limit consequences: None.

7.4 Does dangerous situation still exist: No.

7.5 Post-incident investigations: The nearby chlorine plant was stopped and checked for damages.

7.6 Information to the public: Not reported.

7.7 Emergency management, lessons learnt: Inadequate alarm routine. Dilemma when stopping the vapour production may initiate explosion.

7.8 Authority requirements:

7.9 Initiated research: None.

A.2 Mustard gas bombs

1. General information

1.1 Date: 22.03.1984

2.2 Time: In the afternoon.

1.3 Place: The Baltic Sea, near Gotland.

1.4 Activity Type: Trawling.

1.5 Name of company: Private Faroeish cutter, VA 36 "Heldarstindur".

1.6 Topology: Not relevant.

1.7 Description of buildings: The cutter was build as a "floating factory" where the fish was cut up and packed into fish boxes.

1.8 Regulations involved: Act on the Protection of the Marine Environment. According to a government circular, the Navy is responsible for the disablement of chemical ammunition that has driven ashore or has been fished up.

1.9 Accident preparedness: None. According to a national regulation from 1970, fishing boats, which are using trawl within certain regions of the Baltic Sea, shall be provided with first-aid kit for treatment of injuries caused by mustard gas. Information on chemical ammunition and warfare agents and precautions to be taken is given in a Danish handbook for fishermen.

1.10 Information to the public prior to the accident: None.

2. The accident

2.1 Accident type: Release of mustard gas from a bomb which had been caught in the trawl.

2.2 Substance(s) involved: Mustard gas, an oily liquid. Deadly vesicant. The poisoning symptoms include severe blisters to the skin, injuries to the eyes leading in some cases to temporary or permanent blindness, and injuries to the lungs which may be lethal.

2.3 Other substances at the site: None.

3. Accident course

3.1 Weather conditions: Not reported.

3.2 Detection of accident: It was noticed that the quarterdeck was contaminated with a greenish liquid, but nobody knew what it was. The liquid was not identified as being mustard gas until some of the crew members showed intoxication symptoms and an object, which had been caught in the trawl, had been identified as being a mustard gas bomb. An illustration of it was found in the Danish handbook for fishermen. An emergency call was then made.

3.3 Description of accident: A mustard gas bomb was caught in the trawl and brought on board. The trawl was emptied and by means of a conveyer belt the content was brought below the deck where the crew cut the fish open. The bomb was leaky and, in the confined space below the deck, the fish became contaminated and the vapour pressure of mustard gas reached a dangerous level; after some time all crew members showed severe intoxication symptoms.

3.4 Behaviour of plant staff and management: Not reported.

3.5 Behaviour of the public: Not relevant.

4. Emergency measures

4.1 Emergency services involved: The Swedish life-saving service, The Danish navy, the civil defence, the ambulance service, hospitals in Sweden an Denmark.

4.2 Emergency actions: The seven crew members were picked up by helicopters and brought to a hospital in Gotland (Sweden). As the correct treatment could not be given at this hospital, they were transferred to a Danish hospital where they could be treated. The cutter that was left empty on the sea, was boarded by sappers from the Danish navy (the naval district of Bornholm) and then towed to the port of Rønne where a cordon was threwed round the ship in order to establish a safety zone.

4.3 Equipment used: helicopters, gas-proof chemical protective clothing and breathing apparatus (used by the sappers while they were onboard the cutter) and a ship for towing.

4.4 Prevention of consecutive damage: Not relevant.

4.5 Medical treatment of victims: At the Danish hospital the crew members were treated for injuries to the eyes and severe 'burnings' on hands and legs. They all recovered after 1 - 2 weeks.

4.6 Care for the plant staff: Not relevant.

4.7 Care for the public: A cordon was threwed round the ship while it was cleaned.

5. Cause of accident

5.1 Primary cause: After the termination of the second world war, large amounts of chemical ammunition were dumped into the Baltic Sea.

5.2 Underlying causes: Not known.

6. Consequences of accident

6.1 Actual number of persons killed: 0

6.2 Actual number of persons injured: 7

6.3 Economic losses: Not reported.

6.4 Environmental effects: None.

6.5 Map of area affected: Not relevant.

6.6 Potential harm to humans and the environment: The amount of released mustard gas was large enough to cause the death of all the fishermen if they had stayed sufficiently long below the deck. If the fishermen had dumped the contaminated fish, the effect on the marine fauna would probably have been negligible compared with the effect of mustard gas stemming from leaky bombs on the bottom of the sea.

7. Post-incident actions

7.1 Plant modifications: Not relevant.

7.2 Recommendations: On the background of this accident and others as well, the National Agency of Environmental Protection initiated in 1984 an evaluation of the environmental, health and safety aspects of the depositing of chemical ammunition. As far as the safety of fishermen and other involved persons is concerned, the evaluation group concluded that the safety precautions taken by the military and civil defence are adequate. To improve the safety of fishermen, the following recommendations were made:

The information material should be improved, particularly with respect to the information on symptoms and the precautions to be taken in the event of poisoning.

The first-aid kit should be improved and supplemented with breathing apparatus.

The areas within which there is a risk of catching chemical ammunition should be marked on the charts.

7.3 Precautions taken to prevent or limit consequences: In the port of Rønne the ship, trawl and movables were decontaminated by people from the civil defense and the military. This work lasted 6 days before the control tracking indicated that the ship was clean.

7.4 Does dangerous situation still exist: Yes. Particularly fishermen are exposed to a risk from chemical ammunition if they are fishing with trawl within certain areas in the Baltic Sea.

7.5 Post-incident investigations: None.

7.6 Information to the public: Information about the accident was given in newspapers.

7.7 Emergency management, lessons learnt: The leader of the decontamination team stated in the log that the decontamination work was difficult because equipment for effective detection of mustard gas and DS 2 were not available. (DS 2 is a blend of chemical substances which is used for breaking down the gas. Since the DS 2 vapours are toxic and skin contact can cause cauterization, protective clothing and breathing apparatus are used).

7.8 Authority requirements: The national regulation on the contents of first-aid kits was revised in 1986. Breathing apparatus is now included in each kit.

7.9 Initiated research: None.

A.3 Nordisk Alkali Biokemi

1. General information

1.1 Date: 14.04.1985.

1.2 Time: 7.30 pm.

1.3 Place: Islands Brygge 91-93, Copenhagen.

1.4 Activity type: Chemical warehouse.

1.5 Name of company: Nordisk Alkali Biokemi A/S.

1.6 Topology: Industrial area and residences.

1.7 Description of buildings: Most buildings were made of concrete or bricks.

1.8 Regulations involved: The company was covered by the EEC directive 82/501/EEC on "Major Industrial Hazards of Certain Industrial Activities".

1.9 Accident preparedness: No emergency response plans were worked out. No safety analysis was carried out.

1.10 Information to the public prior to the accident: No information had been given to the public.

2. The accident

2.1 Accident type: Chemical decomposition.

2.2 Substance(s) involved: Orthocide 83 (83 % captan - N-trichloromethyl-thio-tetrahydrophthalimide), CAS-no. 133-06-2. 200 kg.

2.3 Other substances at the site: A large number of different pesticides and organic solvents.

3. Accident course

3.1 Weather conditions: Not important.

3.2 Detection of accident: An employee observed a white chemical cloud from one of the buildings at 7.30 pm on Sunday 14.04.1985.

3.3 Description of accident: Toxic gases were released from a silo containing about 200 kg of the fungicide Orthocide 83. It was observed that the stirrer in the silo was running. It was probable that the stirrer had done that since the night before and that heat evolved from friction had initiated a decomposition of the chemical compound. The thermal decomposition of captan is an exothermal process, i.e. heat is produced.

3.4 Behaviour of plant staff and management: The management decided that cleaning of the equipment with large amounts of water should be carried out in order to avoid corrosion.

3.5 Behaviour of the public: The neighbours were not aware that the accident had occurred.

4. Emergency measures

4.1 Emergency services involved: Fire brigade, (environmental authorities to give advise on discharge of contaminated water).

4.2 Emergency actions: Cooling water to stop the decomposition.

4.3 Equipment used: Fire hoses, breathing apparatus and protective clothing.

4.4 Prevention of consecutive damage: Cleaning of the equipment with large amounts of water was carried out in order to avoid corrosion.

4.5 Medical treatment of victims: No victims.

4.6 Care for the plant staff: No information available.

4.7 Care for the public: No actions were necessary.

5. Cause of accident

5.1 Primary cause: Stirrer in the silo with the substance was erroneously running.

5.2 Underlying causes: Managerial omissions.

6. Consequences of accident

6.1 Actual number of persons killed: 0.

6.2 Actual number of persons injured: 0.

6.3 Economic losses: At least DKR 80.000.

6.4 Environmental effects: None.

6.5 Map of area affected: No area affected.

6.6 Potential harm to humans and the environment: If larger amounts of chemicals and/or other pesticides stored at the plant had been involved, persons in the neighbourhood could have been killed or injured.

7. Post-incident actions

7.1 Plant modifications: None.

7.2 Recommendations: None.

7.3 Precautions taken to prevent or limit consequences: Due to corrosion of machinery at the plant caused by the released acid cleaning with large amounts of water was carried out in order to limit the economical losses. The water contaminated with acid was discharged to the sewer system. This action was carried out in agreement with the environmental authorities.

7.4 Does dangerous situation still exist: No. Furthermore, the plant has recently been closed for other reasons.

7.5 Post-incident investigations: Chemical analyses of the samples from the silo were carried out. It was confirmed that a polymerization had occurred and that the gases released were mainly hydrogen chloride and sulphur dioxide. The incident was probably a decomposition combined with a smouldering fire. The maximum possible amounts of released gases were 70 kg HCl and 20 kg SO_2. Even if these amounts of gases were released in a relatively short period (e.g. 60 min.) no acute health effects to people in the neighbourhood would occur.

7.6 Information to the public: No information was given.

7.7 Emergency management, lessons learnt: The breathing apparatus used by the fire brigade could be affected by the released chemicals.

7.8 Authority requirements: A safety analysis should be carried out.

7.9 Initiated research: None.

A.4 Valdemar Larsen Metal Working

1. General information

1.1 Date: 25.04.1985.

1.2 Time: 5.43 pm.

1.3 Place: Carl Jacobsensvej 19, Valby, Copenhagen.

1.4 Activity type: Metal and casting factory.

1.5 Name of company: Valdemar Larsen Metal Working.

1.6 Topology: Industrial area and residences.

1.7 Description of buildings: Traditional industrial style.

1.8 Regulations involved: Environmental Protection Act.

1.9 Accident preparedness: A two page emergency plan for the chlorination facility was worked out.

1.10 Information to the public prior to the accident: No information had been given to the public.

2. The accident

2.1 Accident type: Toxic gas release.

2.2 Substance(s) involved: Chlorine. CAS-no. 7782-50-5. 160 kg.

2.3 Other substances at the site: No information available.

3. Accident course

3.1 Weather conditions: wind from the west. Wind speed 5-11 m/s. Humidity 50 %.

3.2 Detection of accident: A person who passed the plant smelled chlorine and alarmed the police at 5.43 pm. When the police arrived the fire brigade was immediately alarmed.

3.3 Description of accident: The chlorine was leaking from a 500 kg drum. The leaking drum was connected to the chlorinating facility. A hot water spray was in operation in order to facilitate the evaporation of the chlorine (the liquid chlorine is evaporting when released from the drum. Evaporation of chlorine requires large amounts of heat and the temperature of the liquid chlorine will rapidly decrease and the evaporation rate will therefore also decrease). The accidental release took place via the valve at the drum. The bushing was loose and the stem had thereby been ejected causing a rapid relase to the surroundings.

3.4 Behaviour of plant staff and management: The management came to the site when they learnt that an accident had occurred.

3.5 Behaviour of the public: No information available.

4. Emergency measures

4.1 Emergency services involved: Fire brigade, police.

4.2 Emergency actions: The fire brigade located the point of release, stopped the hot water spray system and found and refitted the bushing and valve stem thus stopping the release of chorine.

4.3 Equipment used: Breathing apparatus.

4.4 Prevention of consecutive damage: None.

4.5 Medical treatment of victims: Four staff members, three police men and a fire man were hospitalized for 24 hours. No permanent injuries were however observed.

4.6 Care for the plant staff: No information available.

4.7 Care for the public: The police sealed off the area and initiated a warning of the population via the radio. The population was instructed to remain indoor and close doors and windows. The bus routes were also changed.

5. Cause of accident

5.1 Primary cause: The cause of the accident apparently was incorrect handling of the chlorine drum by one of the staff members working in the chlorine room. The valve stem and the bushing had been unscrewed by force overriding the locking provided by a screw. After unscrewing the bushing and valve stem were ejected and the chlorine was released.

5.2 Underlying causes: Education of the staff might not have been sufficient. Language problems might also have had relation to the cause of accident.

6. Consequences of accident

6.1 Actual number of persons killed: 0.

6.2 Actual number of persons injured: 0.

6.3 Economic losses: No information available, but the losses were probably not significant.

6.4 Environmental effects: None.

6.5 Map of area affected: No area affected.

6.6 Potential harm to humans and the environment: The potential consequences would not have been substantially higher even if the total amount of chlorine (i.e. 1000 kg) had been released. A release of 1000 kg chlorine is assessed not to have a potential to cause toxic effects to people in the neighbourhood.

7. Post-incident actions

7.1 Plant modifications: None.

7.2 Recommendations: It has been recommended to provide the extension rod with a one way retcket key assuring that operation from the outside can only result in valve closing. However, such an installation would not have had any influence on the actual accident.

7.3 Precautions taken to prevent or limit consequences: None.

7.4 Does dangerous situation still exist: No. The plant is now closed.

7.5 Post-incident investigations: None.

7.6 Information to the public: No information was given.

7.7 Emergency management, lessons learnt: When plant staff comprises persons from other countries language problems might occur.

7.8 Authority requirements: None.

7.9 Initiated research: None.

A.5 Matas warehouse fire

1. General information

1.1 Date: 05.06.1988.

1.2 Time: 5.49 pm.

1.3 Place: Brabrand, Århus.

1.4 Activity type: Warehouse.

1.5 Name of company: Matas.

1.6 Topology: Industrial area and residences.

1.7 Description of buildings: 3000 m^2 concrete building.

1.8 Regulations involved: Environmental Protection Act.

1.9 Accident preparedness: No emergency response plans were made. No safety analysis was carried out.

1.10 Information to the public prior to the accident: No information had been given to the public.

2. The accident

2.1 Accident type: Fire.

2.2 Substance(s) involved: Soap, cosmetics, pesticides, solvents.

2.3 Other substances at the site: All substances present were involved.

3. Accident course

3.1 Weather conditions: Not specified.

3.2 Detection of accident: Not specified.

3.3 Description of accident: The fire itself could be described as a rather traditional warehouse fire. In the warehouse various products were stored, e.g. soap, cosmetics, pesticides, solvents and different packaging materials. The fire brigade did not have any detailed knowledge on the type and amount of products.

3.4 Behaviour of plant staff and management: Not specified.

3.5 Behaviour of the public: Even though the people in the area was told to stay indoor a large number of persons came to the fire site in order to watch what was going on.

4. Emergency measures

4.1 Emergency services involved: Fire brigade, (environmental authorities to give advise on discharge of contaminated fire fighting water).

4.2 Emergency actions: Fire fighting.

4.3 Equipment used: Usual fire fighting equipment.

4.4 Prevention of consecutive damage: The main problem was the large amount of fire fighting water contaminated with chemicals and soap. No spill basins to collect the fire fighting water were available. The total amount of water released was approximately 1000 m^3. Due to the large amount of soap in the water the pH value was quite high. If nothing had been done the contaminated water would have been discharged to a stream and via a pond and a lake to a small river. The lake and the small river had a high ecological classification. Additional water was therefore led to local stream in order to dilute the contaminated fire fighting water and protect the ecosystem. Furthermore, parts of the contaminated fire fighting water was transferred via the sewer system to the biological waste water treatment plant.

4.5 Medical treatment of victims: No victims.

4.6 Care for the plant staff: No specific actions.

4.7 Care for the public: The population was informed through radio and television to stay indoor and keep doors and windows closed until the next morning.

5. Cause of accident:

5.1 Primary cause: Failure of loading station for electrical trucks.

5.2 Underlying causes: Unknown.

6. Consequences of accident

6.1 Actual number of persons killed: 0.

6.2 Actual number of persons injured: 0.

6.3 Economic losses: Unknown.

6.4 Environmental effects: Death fish in the local ecosystem. Effects at the biological waste water treatment plant.

6.5 Map of area affected: No area affected.

6.6 Potential harm to humans and the environment: Effects to the local ecosystems. It is uncertain if the fire plume had the potential to cause toxic effects to people.

7. Post-incident actions

7.1 Plant modifications: None.

7.2 Recommendations: None.

7.3 Precautions taken to prevent or limit consequences: Additional water was led to the local stream in order to dilute the contaminated fire fighting water and protect the ecosystem. Furthermore, parts of the contaminated fire fighting water was transferred via the sewer system to the biological waste water treatment plant.

7.4 Does dangerous situation still exist: No.

7.5 Post-incident investigations: None.

7.6 Information to the public: No specific information was given to the public.

7.7 Emergency management, lessons learnt: In case of warehouse fires it should carefully be considered how the contaminated fire fighting water should be handled.

7.8 Authority requirements: None.

7.9 Initiated research: None.

A.6 Maribo Seeds Company

1. General information

1.1 Date: 22.10.1989.

1.2 Time: Around 7.00 pm.

1.3 Place: Højbygårdvej 14, DK 4960 Holeby.

1.4 Activity type: Seed production and treatment.

1.5 Name of company: Maribo Seeds Company.

1.6 Topology: Flat and sparse populated agricultural area. The nearest town, Holeby, is about one kilometre north of Maribo Seeds Company.

1.7 Description of buildings: The building hit by fire was a 1200 m^2 storage building with a flat roof. The building was divided into fire cells/sections. The fire was limited to one of the sections.

1.8 Regulations involved: Environmental Protection Act.

1.9 Accident preparedness: No emergency response plans were made. A safety analysis, carried out in January 1989 by a consultancy firm, included recommendations as to preventing fire spreading and toxic substances in being discharged to the environment via the fire water. When the fire brigade officer arrived at the fire scene, representatives from the firm informed about which chemicals were stored. However, a stock of calcium peroxide was not mentioned.

1.10 Information to the public prior to the accident: None.

2. The accident

2.1 Accident type: Fire and dust explosion.

2.2 Substance(s) involved: 88000 kg of saw dust, 25000 kg of starch glue, 119000 kg of seed, 2600 kg of Merusol (trade name) containing 50% methiocarb, CAS-no 2032-65-7, 200 kg of thiram, CAS-no 137-26-8, 325 kg of hymexazol, CAS-no 10004-44-1, 200 kg of iprodione, CAS-no 36734-19-7, 30 kg of carbofuran, CAS-no 1563-66-2, 7600 kg of calcium peroxide.

2.3 Other substances at the site: Seed and packing materials and were stored in the other fire sections of the building.

3. Accident course

3.1 Weather conditions: Wind from south.

3.2 Detection of accident: An employee started the fire deliberately at around 6.00 pm. Shortly after at 7.00 pm he alarmed a works manager who ascertained the fire and called the fire brigade at 7.16 pm.

3.3 Description of accident: The fire had been started in a corner of a fire section and involved in the beginning saw dust, starch glue and seed. After a dust explosion the fire spread rapidly to the nearby storage of pesticides and fungicides. A contributing cause of the fire escalation might be that fire water had come into contact with the stock of calcium peroxide. In fighting the fire a large amount of fire water was used - about 1500 m^3. Only part of the fire water could be collected. The finding of dead fish and microorganisms in a nearby stream indicated that pesticides and decomposition products had been discharged to the environment. It is estimated that about 10 kg of toxic substances had been released via the fire water.

3.4 Behaviour of plant staff and management: Not specified.

3.5 Behaviour of the public: Not specified.

4. Emergency measures

4.1 Emergency services involved: The public fire brigade, the ambulance service (Falck), the police, the civil defence, biologists from the local environmental authority and the local health authority (medical officer of health).

4.2 Emergency actions: The fire fighting involved water cooling of wall and entry so that the fire was limited to one fire section.

4.3 Equipment used: Usual fire fighting equipment. The fire fighters wore breathing apparatus when they were inside the building (special protective clothing was not used).

4.4 Prevention of consecutive damage: A main problem was the large amount of contaminated fire water. Part of the fire water was collected into a basin for washing of beets.

4.5 Medical treatment of victims: Two firemen were hospitalised. They were inside the building when the dust explosion occurred and they caught a shock.

4.6 Care for the plant staff: No specific actions/requirements. 10 - 12 employees participated in the clearing work without use of breathing apparatus - and they worked together with ambulance people who all wore breathing apparatus.

4.7 Care for the public: The public was informed on radio and TV to stay indoors and keep doors and windows closed. People were also warned against a possible pollution of vegetables in the area that had been passed by the smoke plume.

5. Cause of accident

5.1 Primary cause: A pyromaniac set on fire in some papers and packing material.

5.2 Underlying causes: Not known.

6. Consequences of accident

6.1 Actual number of persons killed: 0.

6.2 Actual number of persons injured: Two firemen were hospitalised.

6.3 Economic losses: Not reported. The fire section and its content of products were destroyed.

6.4 Environmental effects: Dead fish and microorganisms in a nearby stream.

6.5 Map of area affected: None.

6.6 Potential harm to humans and the environment: In addition to damage to the fauna from contaminated fire water, toxic combustion products in the plume of smoke might influence the health of people hit by the plume.

7. Post-incident actions

7.1 Plant modifications: 1) The storage building has been rebuild with a separate storage for chemicals consisting of four fire cells with concrete walls and roofs. The products stored in the cells are liquid chemicals, powdered chemicals, oxidizing chemicals and empty packing. The products in a cell can, if necessary, be removed via a door leading to the open. 2) Installation of a fire alarm system with direct alarm to the fire brigade. 3) Fire water in the cells can now be collected in a well from which it can be pumped into tank trucks.

7.2 Recommendations: None.

7.3 Precautions taken to prevent or limit consequences: After having found dead fish and microorganisms in the nearby stream, which flows into a channel leading water to the Baltic Sea, a dam was build a few kilometres downstream of the fire scene in order to limit the immediate damages; and also to delay the discharge to the Baltic Sea so that the toxic substances were decomposed as much as possible before the discharge. Contaminated soil was filled into drums which were sent to Kommunekemi (plant for destruction of chemical waste). During this work breathing apparatus was used.

7.4 Does dangerous situation still exist: No.

7.5 Post-incident investigations: The extent of the water stream pollution and its reduction with time were currently monitored by taking samples. Also the collected fire water was currently monitored.

7.6 Information to the public: Some newspapers gave incorrect information and overdramatized the incident.

7.7 Emergency management, lessons learnt: In the event of fire in a warehouse containing dangerous chemicals, a working group consisting of technicians from involved parties should be established rapidly after the incident. The group shall ensure that relevant information as fast as possible is accessible to the fire brigade, the police, the authorities and the public.

The contact to the press should be made by as few people as possible; and these persons should be experienced in press contact. At the fire at Maribo Seeds many people - besides the police - spoke to the press and contradictory views and incorrect information were given. This resulted in misinformation to the public and unnecessary fear.

The fire revealed a need for rules/regulations for chemical storages which are not covered by the Seveso Directive and the requirements of the fire authorities. *Comment: According to the Danish Preparedness Act (1993), the Minister of the Interior shall lay down rules for storage of "substances which as a consequence of fire or other damage may expose people, property or environment to a risk".*

7.8 Authority requirements: None.

7.9 Initiated research: None.

A.7 Næstved railway accident

1. General information

1.1 Date: 25.09.1992.

1.2 Time: 4.50 a.m.

1.3 Place: Næstved railway station.

1.4 Activity type: Goods train transport.

1.5 Name of company: DSB (the Danish State Railways).

1.6 Topology: The railway station is on all sides adjacent to private houses and a bus station.

1.7 Description of buildings: Not relevant.

1.8 Regulations involved: RID, RID A (contains national regulations in addition to the international rules in RID) and DSB's own security regulations.

1.9 Accident preparedness: Preparedness for alarm calling and clearing operations.

1.10 Information to the public prior to the accident: None.

2. The accident

2.1 Accident type: Spill of dangerous substance when a goods train crashed into a passenger train waiting at the railway station.

2.2 Substance(s) involved: 600 litres of acrylonitrile (UN no. 336-1093, CAS-no. 107-13-1, a flammable, toxic liquid with vapours heavier than air).

2.3 Other substances at the site: Diesel oil (diesel oil from the engines was spilled but not ignited).

3. Accident course

3.1 Weather conditions: Light breeze from South East.

3.2 Detection of accident: A railwayman on the platform gave the alarm, emphasizing the presence of two injured and a spill of diesel oil from the engines. After arrival, the fire brigade officer in duty discovered a leaking tank wagon.

3.3 Description of accident: A goods train on its way from Rødby to Copenhagen (the DANLINK-route, a transport route for goods between the continent and Sweden, Norway and Finland) collided with an empty passenger train waiting for passengers at the railway station. The engines of the two trains clashed, and goods wagons were scattered all over the rails. A tank wagon, containing 67000 litres of acrylonitrile, turned over and a leakage from a weld seem arose resulting in a spillage of approximately 600 litres.

3.4 Behaviour of plant staff and management: The collaboration between the response teams and the staff of DSB was satisfactory.

3.5 Behaviour of the public: No remarks.

4. Emergency measures

4.1 Emergency services involved: The public fire brigade, the police, the civil defence, the ambulance service (Falck), Næstved hospital, the Chemical Emergency Response Service.

4.2 Emergency actions: After the fire brigade officer had identified that the leaking substance was acrylonitrile and had got the information on its chemical and toxicological properties, the first brigade response was to blanket the tank and spill with foam. The hole was then proofed and the remaining dripping catched.

A civil defence group, wearing special protective clothing and breathing apparatus, sucked spilled liquid into vessels.

After the situation was considered stable, the police established on the advice of the fire brigade officer a 100 metres safety zone and informed the hospital about the accident.

The following night the load of 67000 l acrylonitrile was pumped into special tank containers that were procured from Germany. The tank wagon was lifted and removed. During that session the safety zone was expanded to 200 m due to the flammability of the product.

4.3 Equipment used: Vehicles with water tanks and foam equipment, gas-proof chemical clothing, breathing apparatus, wedges of wood and sealing compound, gas detectors, containers and equipment for reloading (pumps and connecting equipment).

4.4 Prevention of consecutive damage: None.

4.5 Medical treatment of victims: The hospital actions included treatment of injured railwaymen, and observation of 24 responders and policemen for intoxication. An antidote against acrylonitrile was procured.

4.6 Care for the plant staff: DSB-people were not involved in emergency actions.

4.7 Care for the public: Since the extended safety zone of 200 metres included nearby housing estates, police loudspeaker vehicles drove around warning people to remain indoors and keep doors and windows closed.

5. Cause of accident

5.1 Primary cause: The engine driver overlooked a signal and the speed of the train was too high when he noticed that the next signal was a stop signal.

5.2 Underlying causes: The signal system (the I- and SI-signal system) has a low tolerance to simple human errors.

6. Consequences of accident

6.1 Actual number of persons killed: 0.

6.2 Actual number of persons injured: 2.

6.3 Economic losses: Not available.

6.4 Environmental effects: The degassing of acrylonitrile persisted down to the appearance of the ground water. A sample drilling near the incident area confirmed the presence of acrylonitrile in the first level of ground water.

6.5 Map of area affected: Not available.

6.6 Potential harm to humans and the environment: If 67000 litres of acrylonitrile had been released rapidly, then the situation had been very serious. The number of intoxicated people in the vicinity might have been several hundreds and the ground water would have been seriously polluted. In the event of fire, the smoke plume would have contained very toxic components such as HCN.

7. Post-incident actions

7.1 Plant modifications: Not relevant.

7.2 Recommendations: No recommendations from authorities. DSB is responsible for the security.

7.3 Precautions taken to prevent or limit consequences: Acrylonitrile-contaminated soil was removed and sent to Kommunekemi (plant for destruction of chemical waste). The percolate from sample drillings was pumped up to prevent dispersion. The content of acrylonitrile in the percolate was stripped off in a charcoal filter before disposal in the sewerage. Also oil contaminated ballast and soil were removed.

7.4 Does dangerous situation still exist: No

7.5 Post-incident investigations: DSB has carried out a comprehensive post-incident investigation.

7.6 Information to the public: None, except the incident information received via radio and newspapers.

7.7 Emergency management, lessons learnt: In order to ensure that the alarm message given to the fire brigade is as correct as possible, the GTS system with its RID-list should be applied. DSB should as fast as possible telefax the RID-list to the police.

The fire brigade should be acquainted with tank wagon constructions.

Connecting branches for unloading should be standardized so that these components form parts of the preparedness system.

The Emergency Management Agency intends to establish a central register containing information on depots from which clean containers for reloading of special substances can be procured.

Cleaning of contaminated personnel must be carried out carefully at the incident area. The effluent from rinsing of protective clothing should be continuously decontaminated.

The danger signs on the sides of a rail tank wagon cannot be seen from the ground level if the wagon is turned over.

In order to ensure that the information system on dangerous substances include those transported by rail, DSB has worked out a list of the transported dangerous goods. The list, that will be maintained, has been sent to the Emergency Management Agency and to hospitals.

To improve the antidote-preparedness system, the Emergency Management Agency intends to establish a central register from which doctors can get information about existing hospital depots and their contents.

7.8 Authority requirements: None.

7.9 Initiated research: None.

European Commission

EUR 15562 – EC study - Lessons learnt from emergencies after accidents in Denmark involving dangerous substances

C.D. Grønberg, L. Smith-Hansen, D.S. Nielsen

Luxembourg: Office for Official Publications of the European Community

1994 – 66 pp. – 21.0 x 29.7 cm

Environment Quality of Life series

ISBN 92-826-7515-7

Price (excluding VAT) in Luxembourg: ECU 8,50

Danish accidents involving dangerous substances have been reviewed in order to analyze experience with mitigation and emergency organization. Seven cases from the period 1980-1992 were selected for investigation.

The central events were: hexane explosion, mustard gas bombs in fishing trawl, decomposing pesticide, chlorine release, two warehouse fires and acrolynitrile release from a railway tank wagon. The lessons learnt concern: a need for proper and timely alarm from plant crew to fire brigade, difficulties with identification and provision of antidote, exposure of breathing apparatus to aggressive chemicals, inadequate or missing knowledge with fire brigade on the inventory of ware-houses, and finally disposal of fire fighting water. The study points out, that the technical knowledge of the average fire brigade might be improved in areas like basic chemistry and physics and in knowing the construction of ordinary railway tank wagons.

Data sheets for the investigated cases are brought in appendix.

Venta y suscripciones • Salg og abonnement • Verkauf und Abonnement • Πωλήσεις και συνδρομές
Sales and subscriptions • Vente et abonnements • Vendita e abbonamenti
Verkoop en abonnementen • Venda e assinaturas

BELGIQUE / BELGIË

Moniteur belge / Belgisch Staatsblad
Rue de Louvain 42 / Leuvenseweg 42
B-1000 Bruxelles / B-1000 Brussel
Tél. (02) 512 00 26
Fax (02) 511 01 84

Autres distributeurs / Overige verkooppunten

Librairie européenne/ Europese boekhandel
Rue de la Loi 244/Wetstraat 244
B-1040 Bruxelles / B-1040 Brussel
Tél. (02) 231 04 35
Fax (02) 735 08 60

Jean De Lannoy
Avenue du Roi 202 /Koningslaan 202
B-1060 Bruxelles / B-1060 Brussel
Tél. (02) 538 51 69
Télex 63220 UNBOOK B
Fax (02) 538 08 41

Document delivery:
Credoc
Rue de la Montagne 34 / Bergstraat 34
Bte 11 / Bus 11
B-1000 Bruxelles / B-1000 Brussel
Tél. (02) 511 69 41
Fax (02) 513 31 95

DANMARK

J. H. Schultz Information A/S
Herstedvang 10-12
DK-2620 Albertslund
Tlf. 43 63 23 00
Fax (Sales) 43 63 19 69
Fax (Management) 43 63 19 49

DEUTSCHLAND

Bundesanzeiger Verlag
Breite Straße 78-80
Postfach 10 05 34
D-50445 Köln
Tel. (02 21) 20 29-0
Telex ANZEIGER BONN 8 882 595
Fax 2 02 92 78

GREECE/ΕΛΛΑΔΑ

G.C. Eleftheroudakis SA
International Bookstore
Nikis Street 4
GR-10563 Athens
Tel. (01) 322 63 23
Telex 219410 ELEF
Fax 323 98 21

ESPAÑA

Boletín Oficial del Estado
Trafalgar, 29
E-28071 Madrid
Tel. (91) 538 22 95
Fax (91) 538 23 49

Mundi-Prensa Libros, SA
Castelló, 37
E-28001 Madrid
Tel. (91) 431 33 99 (Libros)
431 32 22 (Suscripciones)
435 36 37 (Dirección)
Télex 49370-MPLI-E
Fax (91) 575 39 98

Sucursal:

Librería Internacional AEDOS
Consejo de Ciento, 391
E-08009 Barcelona
Tel. (93) 488 34 92
Fax (93) 487 76 59

Llibreria de la Generalitat de Catalunya
Rambla dels Estudis, 118 (Palau Moja)
E-08002 Barcelona
Tel. (93) 302 68 35
302 64 62
Fax (93) 302 12 99

FRANCE

Journal officiel
Service des publications des Communautés européennes
26, rue Desaix
F-75727 Paris Cedex 15
Tél. (1) 40 58 75 00
Fax (1) 40 58 77 00

IRELAND

Government Supplies Agency
4-5 Harcourt Road
Dublin 2
Tel. (1) 66 13 111
Fax (1) 47 80 645

ITALIA

Licosa SpA
Via Duca di Calabria 1/1
Casella postale 552
I-50125 Firenze
Tel. (055) 64 54 15
Fax 64 12 57
Telex 570466 LICOSA I

GRAND-DUCHÉ DE LUXEMBOURG

Messageries du livre
5, rue Raiffeisen
L-2411 Luxembourg
Tél. 40 10 20
Fax 40 10 24 01

NEDERLAND

SDU Overheidsinformatie
Externe Fondsen
Postbus 20014
2500 EA 's-Gravenhage
Tel. (070) 37 89 911
Fax (070) 34 75 778

PORTUGAL

Imprensa Nacional
Casa da Moeda, EP
Rua D. Francisco Manuel de Melo, 5
P-1092 Lisboa Codex
Tel. (01) 69 34 14

Distribuidora de Livros Bertrand, Ld.ª
Grupo Bertrand, SA
Rua das Terras dos Vales, 4-A
Apartado 37
P-2700 Amadora Codex
Tel. (01) 49 59 050
Telex 15798 BERDIS
Fax 49 60 255

UNITED KINGDOM

HMSO Books (Agency section)
HMSO Publications Centre
51 Nine Elms Lane
London SW8 5DR
Tel. (071) 873 9090
Fax 873 8463
Telex 29 71 138

ÖSTERREICH

Manz'sche Verlags- und Universitätsbuchhandlung
Kohlmarkt 16
A-1014 Wien
Tel. (0222) 531 61-133
Telex 112 500 BOX A
Fax (0222) 531 61-181

SUOMI/FINLAND

Akateeminen Kirjakauppa
Keskuskatu 1
PO Box 128
SF-00101 Helsinki
Tel. (0) 121 41
Fax (0) 121 44 41

NORGE

Narvesen Info Center
Bertrand Narvesens vei 2
PO Box 6125 Etterstad
N-0602 Oslo 6
Tel. (22) 57 33 00
Telex 79668 NIC N
Fax (22) 68 19 01

SVERIGE

BTJ AB
Traktorvägen 13
S-22100 Lund
Tel. (046) 18 00 00
Fax (046) 18 01 25
30 79 47

SCHWEIZ / SUISSE / SVIZZERA

OSEC
Stampfenbachstraße 85
CH-8035 Zürich
Tel. (01) 365 54 49
Fax (01) 365 54 11

ČESKÁ REPUBLIKA

NIS ČR
Havelkova 22
130 00 Praha 3
Tel. (2) 235 84 46
Fax (2) 235 97 88

MAGYARORSZÁG

Euro-Info-Service
Club Sziget
Margitsziget
1138 Budapest
Tel./Fax 1 111 60 61
1 111 62 16

POLSKA

Business Foundation
ul. Krucza 38/42
00-512 Warszawa
Tel. (22) 21 99 93, 628-28-82
International Fax&Phone
(0-39) 12-00-77

ROMÂNIA

Euromedia
65, Strada Dionisie Lupu
70184 Bucuresti
Tel./Fax 0 12 96 46

BĂLGARIJA

Europress Klassica BK Ltd
66, bd Vitosha
1463 Sofia
Tel./Fax 2 52 74 75

RUSSIA

CCEC
9,60-letiya Oktyabrya Avenue
117312 Moscow
Tel./Fax (095) 135 52 27

CYPRUS

Cyprus Chamber of Commerce and Industry
Chamber Building
38 Grivas Dhigenis Ave
3 Deligiorgis Street
PO Box 1455
Nicosia
Tel. (2) 449500/462312
Fax (2) 458630

MALTA

Miller distributors Ltd
Scots House, M.A. Vassalli street
PO Box 272
Valletta
Tel. 24 73 01
Fax 23 49 14

TÜRKIYE

Pres Gazete Kitap Dergi Pazarlama Dağitim Ticaret ve sanayi AŞ
Narlibahçe Sokak N. 15
Istanbul-Cağaloğlu
Tel. (1) 520 92 96 - 528 55 66
Fax 520 64 57
Telex 23822 DSVO-TR

ISRAEL

ROY International
PO Box 13056
41 Mishmar Hayarden Street
Tel Aviv 61130
Tel. 3 496 108
Fax 3 544 60 39

UNITED STATES OF AMERICA / CANADA

UNIPUB
4611-F Assembly Drive
Lanham, MD 20706-4391
Tel. Toll Free (800) 274 4888
Fax (301) 459 0056

CANADA

Subscriptions only
Uniquement abonnements

Renouf Publishing Co. Ltd
1294 Algoma Road
Ottawa, Ontario K1B 3W8
Tel. (613) 741 43 33
Fax (613) 741 54 39
Telex 0534783

AUSTRALIA

Hunter Publications
58A Gipps Street
Collingwood
Victoria 3066
Tel. (3) 417 5361
Fax (3) 419 7154

JAPAN

Kinokuniya Company Ltd
17-7 Shinjuku 3-Chome
Shinjuku-ku
Tokyo 160-91
Tel. (03) 3439-0121

Journal Department
PO Box 55 Chitose
Tokyo 156
Tel. (03) 3439-0124

SOUTH-EAST ASIA

Legal Library Services Ltd
STK Agency
Robinson Road
PO Box 1817
Singapore 9036

SOUTH AFRICA

Safto
5th Floor, Export House
Cnr Maude & West Streets
Sandton 2146
Tel. (011) 883-3737
Fax (011) 883-6569

AUTRES PAYS
OTHER COUNTRIES
ANDERE LÄNDER

Office des publications officielles des Communautés européennes
2, rue Mercier
L-2985 Luxembourg
Tél. 499 28-1
Télex PUBOF LU 1324 b
Fax 48 85 73/48 68 17

CL-NA-15502-EN-C

NOTICE TO READER

All scientific and technical reports published by the European Commission are announced in the monthly periodical **'euro abstracts'**. For subscription (1 year: ECU 60) please write to the address below.

Price (excluding VAT) in Luxembourg: ECU 8,50

ISBN 92-826-7515-7

OFFICE FOR OFFICIAL PUBLICATIONS
OF THE EUROPEAN COMMUNITIES
L-2985 Luxembourg

9 789282 675151