Den Helder, chlorine gas intoxication in the "Bever" damage simulator on 4 July 2005

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ABBREVIATIONS USED

AMMS	Working Conditions and Environmental Management System
ARBO	Working Conditions
BDZ	Commanding Officer of the Royal Netherlands Navy
Bhvbz	Swimming Facilities Hygiene and Safety Decree
BVMA	Division of Occupational Safety, Environment Affairs and Working Conditions of the Naval Staff
CDC	Support Command
CRVE	Commander of a Results-Accountable Unit
CZMNED	Commander of Naval Forces in the Netherlands
DGW&T	Buildings, Works and Sites Service
DIRAM	Management Representative for Working Conditions and the Environment
DPKM	Director of Personnel of the Royal Netherlands Navy
EHBO	First Aid for Accidents
EMMV	Basic Maritime Military Training
FAC	Free Available Chlorine
HOKM	Head of Education of the Royal Netherlands Navy
ILS	Integrated Logistic Support
ISO	International Organization for Standardization
KM	Royal Netherlands Navy
KMar	Royal Netherlands Marechaussee
MinDef	Minister of Defence
MP	Ministerial Publication
NBCD&BV	Nuclear, Biological and Chemical Warfare, Damage Control and Occupational Safety
pH	Potential Hydrogenium
RDM	Rotterdam Drydock Company
RI&E	Risk Inventorisation and Evaluation
RVE	Results-Accountable Unit
SNBCD&BV	School for Nuclear, Biological and Chemical Warfare, Damage Control and Occupational Safety
SOINFRA	Infrastructure Staff Officer
TCOD	Temporary Defence Committee for Accident Investigation
TRIPOD	Incident Analysis Method
VMS	Safety Management System
VROM	Ministry of Housing, Regional Development and the Environment
VVKM	Collection of Ordinances for the Royal Netherlands Navy
Whvbz	Swimming Facilities Hygiene and Safety Act

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CONSIDERATION

THE INCIDENT

At the School for Nuclear, Biological and Chemical Warfare, Damage Control and Occupational Safety (SNBCD&BV) of the Royal Netherlands Navy (KM) in Den Helder, a class of students were undergoing an exercise in the damage simulator (the “Bever”) on 4 July 2005. During this exercise, they were being taught how to repair a heavily damaged ship under simulated conditions. The students had to make sure that the ship’s impact and splinter holes and deformed doors and hatches were sealed temporarily by buttressing and shoring with auxiliary materials. During this process, water gushed in via the impact and splinter holes and deformed doors and hatches. The students ended up standing in water that was chest-high. To disinfect this water, chemicals are added to it, like in a swimming pool (hydrochloric acid and chlorine bleach lye). During the exercise, the chemical composition of the water gushing in was such that chlorine gas was released as the water poured in. Of the 17 people who came into contact with the chlorine gas, 13 suffered breathing difficulties. Two people were admitted to hospital. The other eleven were treated in the sickbay at the naval base. All were discharged from the hospital or sickbay 24 hours after the incident.

This situation involves a specialist simulator that is only used by the KM and is fitted with a water treatment installation. This chemical treatment installation with an automatic dosing device bears a strong resemblance to a treatment installation for a swimming pool. A similar incident may, therefore, occur at swimming pools within the Ministry of Defence as well as at swimming baths used by the civilian population.

ANALYSIS

Risk awareness
The specifications of the damage simulator were drawn up in 1989. At that time, people had no idea that there were wide-ranging requirements that the quality of the training water had to satisfy. Contracting legionnaires’ disease was the only risk recognised.

The “Bever” was commissioned in 1991 with an ioniser as the water treatment installation. In 1998, it was recommended that the ioniser be replaced because the disinfection guarantees in place were no longer adequate according to the latest applicable technological developments at that time. During the same period, chemicals were being dosed manually. For this purpose, the water was sampled daily to check whether further chemicals needed to be added. In 2003, the ioniser installation for the purification of used water was replaced by a chemical treatment installation with an automatic dosing installation.

For the “Bever”, the KM applied the water quality standards specified by the Swimming Facilities Hygiene and Safety Decree (Bhvbz). The schedule to the decree also refers to investigation frequencies. Among other things, the acidity, the free available chlorine and the bound available chlorine are to be examined “*daily, as often as is necessary from the point of view of operational management, and at the very least at opening and closing times*”, while a laboratory investigation must take place once a month. Sampling during the period of manual dosing of chemicals certainly did not satisfy this requirement, and from the moment that dosing became an entirely automated operation in 2003 the personnel stopped the daily manual sampling. The monthly laboratory investigation was not performed either.

This investigation reveals that at no time did the KM recognise that there was a risk of chlorine gas being created. Risk inventorisation and evaluation procedures (RI&Es) are part of any safety management system (VMS) and are required by law. When the “Bever” was completed in 1991, there were currently no RI&Es being implemented within the KM. An RI&E was made of the “Bever” in April 2000. Even though chemicals were being added manually back then, this RI&E reveals that there was no thought given to the possibility of chlorine gas being created. Even the modification of the installation in 2003 did not result in any addition to the existing RI&E. Work began on updating the RI&E at the start of 2005. Despite the fact that reports regularly appear in the media of incidents in swimming pools that relate to chlorine gas intoxication, the chance of chlorine gas being generated was never recognised in the RI&E.

Disinfection
Chlorine bleach lye and acid were dosed to disinfect the water. An excess dose of acid can ultimately lead to the generation of chlorine gas. The measuring plate of the water treatment installation includes a flow sensor. If there is no flow or too little flow over the measuring plate, no chemicals should be dosed. The flow sensor was jammed such that a flow was constantly being signalled regardless of the actual flow. In this jammed set-up, there was in fact no or practically no water flow over the measuring plate. As a result, more acid and chlorine bleach lye were dosed than necessary.

An important phenomenon in this is the buffer capacity of the water. If fresh water is added to the system at regular intervals, the buffer capacity of the water remains at a sufficient level to deal with an occasional excess dose of chemicals. The reservoir's automatic level control had been faulty for some seven months. This meant that the reservoir had had to be topped up manually. This was done once a week on average. As a result, the buffer capacity of the water in the simulator decreased. What is more, a connection had been fitted between the measuring plate and the feed funnel for water conservation purposes. This caused some of the water to re-circulate to the reservoir, which further served to lower the buffer capacity of the water.

Procedure and evacuation
The control rooms in the damage simulator where the instructors were, have their own ventilation system. The instructors in the control rooms cannot detect the presence of chlorine gas. The students were inexperienced and unfamiliar with the effects of chlorine gas. Since the instructors had no immediate clue as to the presence of chlorine gas in the training compartments, and given the inexperience of the students, there was a delay in recognising the problems and carrying out the evacuation.

Ventilation
The simulator is equipped with a mechanical supply system. The air escapes naturally through a number of grates. In one of the compartments where students were working, a ventilation grate had been taped up. Since this grate was taped, the air supplied to the compartment could not be extracted adequately in the normal way.

Maintenance
The supplier of the partially modernised installation did not include any maintenance instructions with the delivery in 2003 because maintenance had not been part of the supply contract. The maintenance contract offered had been rejected by the KM. They had decided they would take care of the maintenance themselves. The KM uses the Integrated Logistic Support (ILS) methodology to formulate the various types of maintenance. ILS takes all aspects of upkeep into consideration. The maintenance to the (water treatment installation of the) "Bever" was not carried out using ILS but was performed with the help of lists drawn up over time by the personnel of the school themselves. These personnel had received no training specially geared to maintaining the "Bever", nor had they otherwise acquired any specific expertise in relation to this water treatment installation.

ASSESSMENT

It is impossible to establish with absolute certainty how exactly the chlorine gas came to be released. However, it is highly probable that:

- due to incorrect dosing as a result of a faulty flow sensor,
- no longer topping up with fresh water on a daily basis
- and the modification with the hose connection

the buffer capacity had decreased such that chlorine gas was present in the water. The chlorine gas was released from the water when water flowed from the cracks and holes in the simulator.

The flow sensor of the measuring and regulating system was jammed. This meant that a flow was constantly being signalled, which led to excessive amounts of acid and chlorine bleach lye being dosed. How the flow sensor came to be in the state it was found in could not be discovered. An inspection of the flow sensor revealed that it had been in this position for several weeks. If maintenance work had been planned and executed on the installation using a correct methodology, then the fact that the flow sensor was sending out the wrong signal would have been detected at any moment.

If the instructors had had an indication of the concentration of chlorine gas, the personnel could have been evacuated from the “Bever” promptly, possibly making the consequences less serious for the personnel.

Observing the water quality standards without, however, applying the corresponding investigation frequency meant that it was possible for the dosing problems to remain unnoticed for too long. More generally, it can be said that observing elements of a specific regulation without including all the other corresponding aspects can pose a risk.

Since one of the air extraction grates had been taped up, the air supplied to the compartment could not be extracted adequately in the normal way. So, the air supplied and the chlorine gas present were being partly recycled through the simulator.

The maintenance for the “Bever” had not been organised using the ILS methodology. The absence of maintenance instructions meant that maintenance to the water treatment installation was performed based on self-penned lists. Given that there was no consultation with DGW&T, a balanced maintenance plan for the “Bever” was never drawn up.

THE SAFETY MANAGEMENT SYSTEM

To bridge the period until the formation of the Dutch Safety Board, the Minister of Defence set up the Temporary Defence Committee for Accident Investigation (TCOD) in 2003. The TCOD formulated a number of recommendations in two reports[1].

Just like the Dutch Safety Board is now, the TCOD was particularly interested in the underlying causes and circumstances. It is these, usually latent, factors that make the incident possible. They determine the risk that is taken by an organisation and therefore the chance of incidents happening. The reason why these latest problems have not been detected and corrected sooner must always be sought in the manner in which an organisation approaches the issue of safety – its safety management (system).

Underlying factors emerging from these two investigations by the TCOD were the absence of a good analysis of the risks, the lack of clear procedures and inadequate awareness of the consequences of shortcomings. In addition, it was observed in the report of 10 December 2004 (torpedo fall in tubes room in bow) that the combination of controls, inspections and audits used did not lead to a management report providing a holistic insight into the control of the risks. A well-functioning assurance and feedback system was missing at every level.

The main recommendations from the report of 16 January 2004 (collision between YPR armoured vehicle and train) were also geared towards essential improvements to the VMS. Within the Ministry of Defence, the VMS is part of the Working Conditions Management System. It was recommended that a uniform Working Conditions Management System be introduced for the Defence organisation and that execution of RI&Es and working conditions audits be assured.

In response to the recommendation in the report of 16 January 2004 (collision between YPR armoured vehicle and train), the Ministry of Defence drew up an action plan[2]. This includes implementation of a certifiable Ministry of Defence Working Conditions Management System as from 1 January 2007.

In the report of 10 December 2004 (torpedo fall in tubes room in bow), besides the reference to the recommendation in the YPR report, it was recommended that the KM ensure that a VMS be put in place incorporating feedback and the assurance of adequate RI&Es so that a fully implemented and functioning Working Conditions and Environmental Management System (AMMS) could help provide an insight into safety management aspects in order to realise continuous improvement. It is the RI&E, in particular, in addition to controls, inspections and audits, that provides an insight into safety aspects.

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[1] I. “Collision between YPR armoured vehicle and train near Assen on 17 June 2003” (“Botsing YPR met trein nabij Assen op 17 juni 2003”) dated 16 January 2004.
II. “Torpedo fall in tubes room in bow of submarine on 16 March 2004 in Den Helder” (“Val torpedo in boegbuiskamer onderzeeboot op 16 maart 2004 te Den Helder”) dated 10 December 2004.

[2] Letter by State Secretary for Defence no. P/2004002570, dated 13 July 2004, appendix point 7.1.2: implementation of a certifiable Ministry of Defence working conditions management system is planned for 01-2007 onwards.

In the response by the Ministry of Defence to this report it was indicated that the Ministry of Defence would examine how the TCOD's recommendations could be incorporated into a Working Conditions Management System to improve the assurance and substance of incident prevention and investigation[3].

Owing to the ongoing reorganisation at the Ministry of Defence, the organisation of the entire armed forces, and therefore also the KM, has undergone radical changes. Duties, responsibilities and powers have been reinvested and an administrative tier has been removed from the armed forces. The staff of the air force, army and navy, including the commanding officers, disappeared with effect from 5 September 2005 and were integrated within the central staff organisation.

The TCOD had already indicated in its report of 10 December 2004 (torpedo fall in tubes room in bow) that it was carefully considering the reorganisations underway at the Ministry of Defence from a safety point of view. It turns out that this care was not unmerited. The present investigation revealed that one of the consequences of the reorganisation is that the navy's AMMS had to be rewritten and fitted into the new organisation. A decision was taken to make the rewriting of the AMMS the priority and to suspend audits from spring 2005.

It must be noted that there are no visible results as yet with regard to the TCOD's recommendation that the KM ensure that a VMS be put in place incorporating feedback and assurance of adequate RI&Es, audits, controls and inspections so that an insight is gained into safety management aspects in order to realise continuous improvement.

This investigation endorses the conclusion in the TCOD's reports that, in view of the risks to which everyone involved in Defence activities may be exposed, safety within the Defence organisation should be allocated a higher, explicit priority. It is a challenge for any organisation, particularly a larger one, to bring everyday practice into line with rules and procedures and to keep it that way. However, this is an absolute must if dangers are to be controlled and recognised (with the help of an RI&E).

CONCLUSIONS

- Despite the fact that there is ample familiarity with, and experience of, drawing up a Risk Inventorisation and Evaluation as well as Integrated Logistic Support within the Royal Netherlands Navy, these methodologies are not applied everywhere to an adequate extent, making it possible for the risk of chlorine gas being released to go unrecognised, for maintenance of this installation to be performed using plans and schedules drawn up on the basis of merely general technical acumen and for operational management not to be carried out in line with the latest technological developments.

- The shortcomings or bottlenecks uncovered in this investigation could have been overcome with a fully functioning system or a combination of systematic risk analysis, periodic controls, inspections and audits.

RECOMMENDATIONS

The following recommendations apply specifically to the "Bever":

- Make sure that all possible improvements indicated in this report are installed in the "Bever" and applied to the operational management, such as the installation of chlorine gas detectors and triggered ventilation, the application of operations pursuant to the Bhvbz, adequate maintenance, and so on, and that the (technical) inadequacies are rectified.

In terms of the underlying causes, the Dutch Safety Board is of the opinion that there is nothing to add to the recommendation previously expressed by the Temporary Defence Committee for Accident Investigation, which the Board fully embraces:

- In the near future, ensure that a safety management system for the entire Ministry of Defence is put in place incorporating feedback and assurance, as well as adequate Risk Inventorisation and Evaluation procedures, so that, for the sake of realising continuous

[3] Letter by State Secretary for Defence no. P/2005008900, dated 29 June 2005.

improvement, an insight is gained into safety management aspects at all command and policy levels partly by means of a fully implemented and functioning working conditions and environmental management system, audits, controls and inspections, with the help of performance indicators.

For the sake of completeness, it is noted that the Dutch Safety Board regards a safety management system as the entire body of (organisational) structures, related agreements and procedures that make a positive contribution to the level of safety throughout the life cycle of a system. The safety management system plays a crucial role in efforts to demonstrably manage and continuously improve safety. The Dutch Safety Board regards the following as issues requiring special attention:

- Creation of a demonstrable record of the policy to prevent unwelcome events, including general objectives and principles for preventing and managing the unwelcome events identified. An explicit link must be drawn here between the laws and regulations, the standards that apply to the industry and the safety objectives specifically prepared for the business.

- Description of the way in which the policy applied is implemented, the concrete objectives, plans and resulting preventive and repressive measures.

- Unambiguous allocation of responsibilities with regard to the execution of safety plans and measures, and clear and active central coordination of safety activities.

- System for monitoring and investigating incidents, near-accidents and accidents, as well as an expert analysis thereof in order to hone elements of the plan cycle if necessary.

- Periodic implementation of (risk) analyses, observations, inspections and audits in order to reveal and actively target areas for improvement.

- Clear and recorded agreements with the neighbourhood concerning the general procedure, the method for testing it and approaches in the event of deviations, etc.

- Periodic evaluation and any necessary adjustment by the management (management review) of the safety policy.

1. THE COURSE OF EVENTS

1.1. GENERAL

Every serviceman and servicewoman who will be spending time at sea is obliged to complete a course with the KM in Den Helder at the SNBCD&BV. The duties of the SNBCD&BV are as follows:

- Function-oriented instruction of all KM personnel in the field of NBCD&BV. The SNBCD&BV offers a number of fire fighting, NBC and occupational safety courses for this purpose.
- Monitoring of the NBCD&BV skills of KM personnel in seafaring units.

New KM crewmembers take the Basic Maritime Military Training (EMMV) and also complete a course with the SNBCD&BV. The purpose of this course is as follows:

- Acquisition of knowledge and skills regarding collective and personal nuclear, biological and chemical safety and "Damage Control", which are required for positions with no rank attached;
- Ability to provide "self-help and assistance to comrades", i.e. ability to apply elementary EHBO actions to situations of war;
- Ability to use "sea survival techniques";
- Gaining of insight into risks and safety measures associated with future duties.

The SNBCD&BV uses a variety of simulators. One of these simulators is the "Bever" damage unit. The damage unit is a simulator consisting of a mock-up segment of a frigate, specifically two decks assembled to create a "box". The damaged "vessel" is swayed to simulate the movements of a ship, whereby the list and yaw angle as well as the number of rolls per minute can be adjusted (maximum yaw angle is 15º). Water can be pumped into the simulator, with chemicals (sodium hypochlorite, also known as chlorine bleach lye, and hydrochloric acid) added for disinfection purposes. The water is drawn from a reservoir measuring some 30 m^3.

Illustration 1. The "Bever" simulator

In the simulator, students are taught how to repair a heavily damaged ship under simulated conditions. The trainees must make sure that the damaged and leaking pipes of the mock fire extinguishing system are insulated and that the simulated impact and splinter holes and deformed doors and hatches are sealed temporarily using auxiliary materials. Water pours in through the holes, doors and hatches. Students may also be trained in freeing (partially) flooded compartments from water with the help of fixed and mobile pumps.

1.2. CIRCUMSTANCES SURROUNDING THE INCIDENT

On 4 July 2005, a class of EMMV students were undergoing an exercise in the “Bever” damage simulator. The students had to make sure that the ship’s impact and splinter holes and deformed doors and hatches were sealed temporarily by buttressing and shoring with auxiliary materials. During this process, water gushed in via the impact and splinter holes and through the deformed doors and hatches. The students ended up standing in water that was chest-high. To disinfect this water, chemicals are added to it, like in a swimming pool (hydrochloric acid and chlorine bleach lye). During the exercise, the chemical composition of the water was such that chlorine gas was released as the water poured in. Of the 17 people who came into contact with the chlorine gas (14 students, two instructors and the operator of the simulator), 13 students and one instructor suffered breathing difficulties, mainly after leaving the damage unit. Two students were admitted to hospital. The other eleven students and the instructor were treated in the sickbay at the naval base. All were discharged from the hospital or sickbay 24 hours after the incident.

Illustration 2a. V-shoring against crack

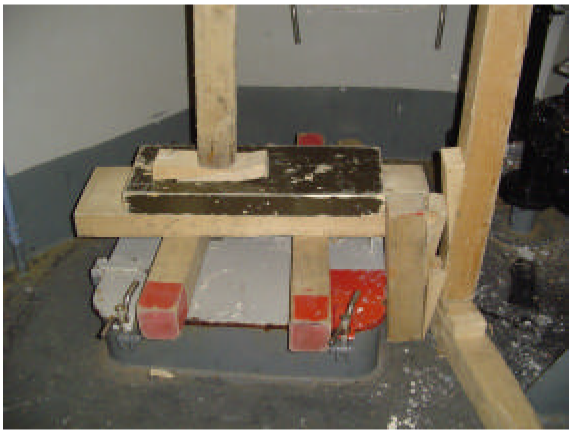

Illustration 2b. Buttress on hatch

2. SCOPE AND ASSESSMENT FRAMEWORK

2.1 GENERAL

The scope and assessment framework for the investigation into the incident in Den Helder on 4 July 2005 are discussed in this chapter.

The scope of the investigation indicates the issues included in it and its scale[4].

An assessment framework constitutes an essential part of the investigation given that it is extremely important in an investigation to state what criteria have been used. The Dutch Safety Board observes the assessment framework in the analysis of the incident and applies it to the circumstances, the ascertainment of the (probable) causes, the scale of the consequences, the establishment of structural safety deficiencies and the formulation of the recommendations.

2.2 SCOPE

The Dutch Safety's Board investigation focuses on the underlying factors that led to this incident.

This situation involves a specialist simulator that is only used by the SNBCD&BV of the KM and is fitted with a water treatment installation. This installation bears a strong resemblance to a water treatment installation for a swimming pool. A similar incident may, therefore, occur at swimming pools within the Ministry of Defence as well as at swimming baths used by the civilian population.

The TCOD formulated recommendations relating to safety management systems in two reports[5]. Broadly speaking, it can be said that the Ministry of Defence has accepted these recommendations, but they have not been implemented yet.
In view of the above, the scope of the investigation was geared initially towards the SNBCD&BV as well as swimming pools run by the Ministry of Defence. However, it emerged early on in the investigation that swimming pools within the Ministry of Defence were being run correctly in accordance with the provisions of the Whvbz and Bhvbz, and so the swimming pools were omitted from the investigation.

On account of the recommendations already formulated by the TCOD, the KM's AMMS was not covered in the investigation.

2.3 ASSESSMENT FRAMEWORK FOR SAFETY MANAGEMENT

In theory, the way in which an organisation meets its personal responsibility for safety can be tested and assessed from various angles. For this reason, there is no universal handbook that can be used in all situations. This is despite the fact that since the 1990s more and more emphasis has been placed on an organisation's own responsibility for safety. The Dutch Safety Board has therefore selected five safety issues for attention that give an idea of what aspects may play a role (to a greater or lesser extent). The Board believes that this choice is justified because these issues are included in numerous (inter)national laws and regulations and in a great number of widely accepted and implemented standards.

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[4] Cf. also annex A: account of the investigation.
[5] I. "Collision between YPR armoured vehicle and train near Assen on 17 June 2003" ("Botsing YPR met trein nabij Assen op 17 juni 2003") dated 16 January 2004.
II. "Torpedo fall in tubes room in bow of submarine on 16 March 2004 in Den Helder" ("Val torpedo in boegbuiskamer onderzeeboot op 16 maart 2004 te Den Helder") dated 10 December 2004.

A distinction is made between the following issues that require attention:
- Insight into risks as basis for safety action plan
- Demonstrable and realistic safety action plan
- Execution and maintenance of safety action plan
- Tightening-up of safety action plan
- Management of administration, involvement and communication

It has been shown in the past that the structure and substance of the VMS play a crucial role in efforts to demonstrably manage and continuously improve safety. Every organisation should strive to achieve optimum safety. The Dutch Safety Board recognises that any assessment of the manner in which organisations meet their own responsibility regarding safety is dependent on the organisations involved. Aspects such as the nature of the organisation or the scale may be a factor in this and should therefore be included in the assessment. Although the judgement may differ from one incident to the next, the way of thinking remains the same.

Organisations that may have to deal with extremely dangerous circumstances by virtue of their profession may be expected to have highly developed safety awareness. One such organisation is the armed forces. High priority for safety and the application of the latest technological developments in order to safeguard that safety should therefore be the standard in the armed forces. The Dutch Safety Board therefore expects the armed forces to manage risks in a well-considered manner so that these risks for the given circumstances are as low as is reasonably possible.

2.4 LAWS AND REGULATIONS

The assessment framework that is based on national laws and specific Ministry of Defence and KM regulations is outlined below (for details see annex B).

2.4.1 National laws

The national regulations that apply are:
- The Working Conditions Act
- The Working Conditions Decree

The “Bever” does not fall under the Whvbz and the associated Decree(s). Nor does the “Bever” fall under the Decree on the Safety of Fairground Rides and Games (cf. annex B).

However, the Whvbz and the associated decrees may well be regarded as an illustration of the minimum technology and minimum standards to be observed. At the time of delivery, the water treatment installation of the “Bever” satisfied the requirements of the Whvbz and Bhvbz. The KM also applies the water quality standards of the Bhvbz.

The Working Conditions Act

This Act indicates a number of obligations for the employer with regard to working conditions. It includes obligations relating to policy (art. 3.1a), execution of the RI&E (art. 5), information (art. 8) and work consultation (art. 13).

The Working Conditions Decree

The Decree is a differentiated analysis of the general provisions of the Working Conditions Act. Articles 1.26 to 1.33 (Defence Part) deal specifically with Defence. This is partly linked to international obligations and various circumstances (in times of war, threat of war, extraordinary circumstances and exercises).

2.4.2 Defence regulations

- **Framework of the Defence working conditions policy**
  The framework of the working conditions policy stems from the 2000 Defence Paper. The framework of the working conditions policy stipulates, among other things, that the sections of the armed forces must introduce a working conditions assurance system and that the Central Organisation must conduct working conditions audits for the sections of the armed forces. Objectives are included on an annual basis. The sections of the armed forces must incorporate them into their own procedures and regulations. According to the policy framework, the relationship between the central department and the section of the armed

forces involves making agreements and conducting working conditions audits (central department) and preparing a self-assessment and top report (section of the armed forces).

- **2005 General Organisation Decree of the Ministry of Defence** (in force from 1-1-2005)
  This states that the KM is a "service component" of the Ministry of Defence. Because the reorganisation of the sections of the armed forces into Operational Commands took place as of September 2005, a few articles in the General Organisation Decree of 1992 remained in force until this time (including the role of the Commanding Officer of the Royal Netherlands Navy (BDZ).

2.4.3 KM regulations

- **Ordinance concerning the mandate and organisation of the Royal Netherlands Navy** (1 VVKM 1).
  This ordinance contains rules concerning the organisation and power structure of the Royal Netherlands Navy as well as command instructions.

  In annex 2 of this part of the Collection of Ordinances for the Royal Netherlands Navy (VVKM), commanders are charged with preparing their personnel to prevent and combat disasters. They must also set up their organisation to do this and lay down their own rules to help keep their personnel safe. They must also ensure that their personnel strictly comply with the provisions of the Working Conditions Act and Working Conditions Decree in relation to occupational safety.

- **Ordinance concerning the Working Conditions and Environmental Management System for the Royal Netherlands Navy, part 1 to 4** (1 VVKM 25).
  This ordinance states, among other things, that the AMMS model is based on ISO 14001 and OHSAS 18001. These two international standards represent the prevailing state of knowledge for environmental, safety and health management systems and meet the criteria as mentioned above in 2.2.

  On 1 January 2000, the KM began introducing the AMMS, as laid down in 1 VVKM 25, with the intention of making sure that the AMMS had been introduced in all units by 1 January 2002, with an extension until 1 January 2003 to eliminate any shortcomings. According to the AMMS (procedure 15, point 3303), the head of the Division of Occupational Safety, Environmental Affairs and Working Conditions (BVMA) of the Naval Staff should check the AMMS annually to see whether it "still satisfies all the elements of ISO 14001 and OHSAS 18001". The KM states that it had this done in 2003 by an external agency (Lloyds). The TCOD pointed out, in its report on the torpedo fall, that Lloyds had assessed the policy-related part of the management system, in particular. For the AMMS to be certified, practical audits should also have been conducted, according to Lloyds.

2.4.4 Manufacturer's documentation

The documentation for the damage simulator completed in 1992 comes from the Rotterdam Drydock Company (RDM). This documentation contains the following elements:

- General RDM descriptions and guidelines
- Instructions for the water purification and heating installation
- Instructions for the hydraulic installation
- Instructions for the electronic control
- Electrical installation data
- Description of the ventilation system
- Technical information about various components used in the damage unit.

In 2003, the water treatment installation was partly replaced. The supplier of the partially modernised installation delivered a set of documents to add to the existing documents from RDM. The "maintenance" tab in the supplier's documentation was left empty because this had not been part of the supply contract.

3. PARTIES INVOLVED AND THEIR RESPONSIBILITIES

The incident involves various parties with different responsibilities. The overview below lists the parties who played a direct or indirect role in the incident. The relationship between them is illustrated in diagram form in annex C (Organisation Chart dated 04/07/2005). This describes the organisational structure, positions and responsibilities at the time of the incident. The organisational structure, together with the positions and responsibilities, changed radically as of 1 September 2005 as part of the reorganisation at the Ministry of Defence. Some positions and responsibilities disappeared or were filled elsewhere within the Defence organisations, and new positions were created.

Minister of Defence / State Secretary for Defence
The minister bears ultimate responsibility for the general Defence policy and its implementation. The state secretary is responsible for issues concerning the armed forces, such as: personnel policy, provision of equipment, national administrative affairs, operational management and cooperation between the sections of the armed forces.

The Working Conditions Act and the Decrees based on it provide various obligations for the employer. The Minister of Defence is the central Defence employer and is consequently responsible for these (employer) obligations.

The minister and state secretary are responsible for (the implementation of) the framework of the Defence working conditions policy. In line with this policy framework, the Director-General of Personnel, on behalf of the Minister of Defence, is charged with developing, advising on, coordinating, assigning, evaluating and controlling implementation of the main aspects of the working conditions policy that is to be pursued.

Commanding Officer of the Royal Netherlands Navy
The BDZ is charged with official leadership, command, operational management and internal management of the KM. The Commanding Officer, on behalf of the Minister of Defence, is responsible for, among other things, "maximum possible safety, maximum possible protection of health and advancement of welfare at work for all employees" during performance of naval duties. The BDZ is a local Defence employer and is consequently responsible for the (employer) obligations stemming from working conditions legislation.

By virtue of his integral responsibility for the operational and internal management of the KM, the BDZ is charged with the derived development of the working conditions policy (the interpretation or transfer of the policy as connected with own circumstances) and with implementation of the established working conditions policy within the sections of the KM. This means that the commanding officer must ensure that, by imposing and applying reporting, monitoring and investigation of incidents, inspections, audits and reviews, assurance of the above takes place with the help of a VMS. To this end, he has the BVMA division at his disposal. Therefore, in addition to his employer responsibilities and obligations, the BDZ also has a supervisory duty.

The framework of the working conditions policy indicates that to ensure that the Working Conditions Act and relevant regulations are implemented properly at all levels within the section of the armed forces the BDZ instructs his seconds-in-command/commanders, heads or directors of (results-accountable) units to implement the established working conditions policy on his behalf.

The Head of Education of the Royal Netherlands Navy
One of the directorates of the KM is the Directorate of Personnel (DPKM). The Head of Education of the KM (HOKM), among others, comes under this. The HOKM manages all schools within the KM in terms of education policy except for the Royal Netherlands Naval College. The HOKM's staff officer for working conditions and the environment is employed at the working conditions and environment staff office of the Commander of Naval Forces in the Netherlands (CZMNED), from where he advises all schools managed by the HOKM.

Commander of Naval Forces in the Netherlands
The CZMNED is second-in-command to the BDZ. As commander of an operational RVE, the CZMNED is the operational management level of the working conditions and environment organisation. As a local employer, CZMNED is responsible for the (employer) obligations stemming from working conditions legislation. Besides the obligations to implement the established working conditions policy, he is also personally responsible for taking good care of the personnel and the conditions under which they work.

In addition to these responsibilities and obligations, the CZMNED has a supervisory duty. He is responsible for concerns relating to working conditions and the environment within his branch and also for ensuring that reporting, monitoring and investigation of incidents, inspections, audits and reviews all take place within the branch.

The Head of the School for Nuclear, Biological and Chemical Warfare, Damage Control and Occupational Safety
Within the context of the incident in question, the head of the SNBCD&BV is the lowest local employer and is responsible for the (employer) obligations stemming from working conditions legislation with regard to the SNBCD&BV. He must put the established working conditions policy into practice and is responsible for the RI&Es, the resulting plans for action, implementation of the measures they contain, evaluation and execution of the reports. As a local employer, he is also personally responsible for looking after the personnel and students at the SNBCD&BV and the conditions under which they work.

Head of Trainers at SNBCD&BV
The Head of Trainers coordinates the exercises at the SNBCD&BV and assesses whether there is sufficient personnel and equipment available to be able to perform the exercises in a safe and sound manner. He is also charged with maintaining the equipment at the SNBCD&BV and assisting the head of internal service with the maintenance of the other infrastructure of the SNBCD&BV. He is foreman and supervisor within the framework of the established working conditions policy and the resulting directives. Within that context he is also personally responsible for taking corrective action or initiating new measures.

Assistant Non-Commissioned Officer in Charge of Safety / Maintenance Employee
The Assistant Non-Commissioned Officer in Charge of Safety/Maintenance Employee operates the “Bever” during practical lessons. He also helps with the upkeep of the “Bever” by, among other things, performing regular maintenance, cleaning and inspection work, keeping availability up to standard, submitting requests relating to equipment and logistics, and so on. Besides implementing working conditions and safety guidelines, he is also personally responsible for working as safely as possible and ensuring that working conditions for other employees and students are as safe as they can be.

The Support Command
The Support Command (CDC) is an umbrella organisation consisting of defence companies that supply supporting products and services. It is a defence-wide service organisation enabling the sections of the armed forces to perform their primary duty. The Commander of the Support Command is ultimately responsible to the Minister of Defence for the DGW&T.

Buildings, Works and Sites Service
The DGW&T, as a service organisation, takes care of the realisation and maintenance of immovable property for the Ministry of Defence. The service portfolio consists of: general and technical management, engineering services, user support and policy preparation, specialist research and consultancy.

The DGW&T comprises a Central Directorate, a Directorate of Internal Services and four regional directorates, spread throughout the Netherlands. One regional directorate is made up of a number of service districts. The Den Helder service district of the Directorate for the West Region supplies services to the organisational elements of the KM present in Den Helder.

The supplier of the water treatment installation
Besides making sure that the water treatment installation satisfies statutory requirements, the supplier also bears personal responsibility for the minimum requirements relating to the ability to handle and use the installations supplied by the supplier safely in respect of working conditions.

4. ANALYSIS

4.1 GENERAL

This chapter will discuss first of all the key technical systems of the “Bever”. It will then go on to specify which defects were detected in them. This information can be used to formulate the most likely scenario that would explain the generation of the chlorine gas. Finally, the chapter will deal with technical modifications to the installation and points of operational management that might have been able to prevent the incident.

4.2 NEW “BEVER” DEVELOPMENT

At the time the order was placed in November 1990, the damage simulator was still called the “Damage Repair Instructional Unit”. The total installation consists of three components: the pump, the reservoir and the actual damage simulator. However, when people in Den Helder talk about the simulator, they are actually referring to all three components together. After the installation was installed it was given the name “Bever”, and with this name too no distinction is made between the different components.

In 1989, the KM drew up the specifications for the damage mock-up, but at that time it had not yet realised that there were wide-ranging requirements that the quality of the training water could or had to satisfy. Contracting Legionnaires’ disease was the only risk recognised during the design phase.

RDM was the only one of the six potential suppliers to incorporate a (chemical) water treatment installation in the tender. The definitive order for delivery was given to RDM and included the (chemical) treatment installation. It is evident from the report on the first project meeting and from the documentation produced that at the start of the project research was permitted into whether chlorinating could be replaced by ionising, with no impact on the budget. A decision was then taken to proceed with an ionising system.

The “Bever” was commissioned in 1991. In 1998, it was recommended that the ioniser be replaced because it was not fit to guarantee adequate disinfection. During the same period, chemicals were being dosed manually. With the replacement of the ioniser it would be possible to transform the manual dosing of chemicals into an automated process, which would keep the chlorine content and acidity at the required level at all times.

4.3 THE COMPOSITION OF THE “BEVER”

The “Bever” is made up of the following key components:

- the damage simulator
- the pump chamber
- the training water reservoir

These components are also visualised in annex D (Schematic Illustration of Water Flow).

4.3.1 Damage simulator

The simulator consists of a mock-up portion of a frigate, specifically an H-deck section and, below that, a J-deck section assembled to create a “box” with a storeroom on top (on the G-deck). The entire “vessel” has been placed in spherical bearings on a double A-frame using two axle journals.

The unit contains two control rooms (one per deck) where the instructors and the operator are based during the exercises. From the control rooms, water can be transported to a number of specially installed “leaks” by means of a training water system or a mock fire extinguishing system. And, from the control room, lighting can also be switched off and the sound system operated. Both during and after the exercise, the simulator can be drained using four valves operated remotely from the control room.

Moreover, in the storeroom on the G-deck there is a hatch built into a vent duct to allow gasses to be injected into the training compartment.

The simulator is equipped with a ventilation system. This system mechanically conducts air to the various compartments. These compartments house grates in the walls that allow the air back out again.

The ventilation for the control rooms is separate from that of the training compartments.

4.3.2 The pump chamber

The following components are installed in the pump chamber:

- Power cabinet and supply transformer, plus cabling.
- Hydraulic unit to move the damage simulator.
- Pumps to pump training water and water for the mock fire extinguishing system.
- Water treatment and heating installation.

4.3.3 Training water reservoir

The reservoir in which the training water is stored is located beneath the simulator and contains some 30m^3 of water.

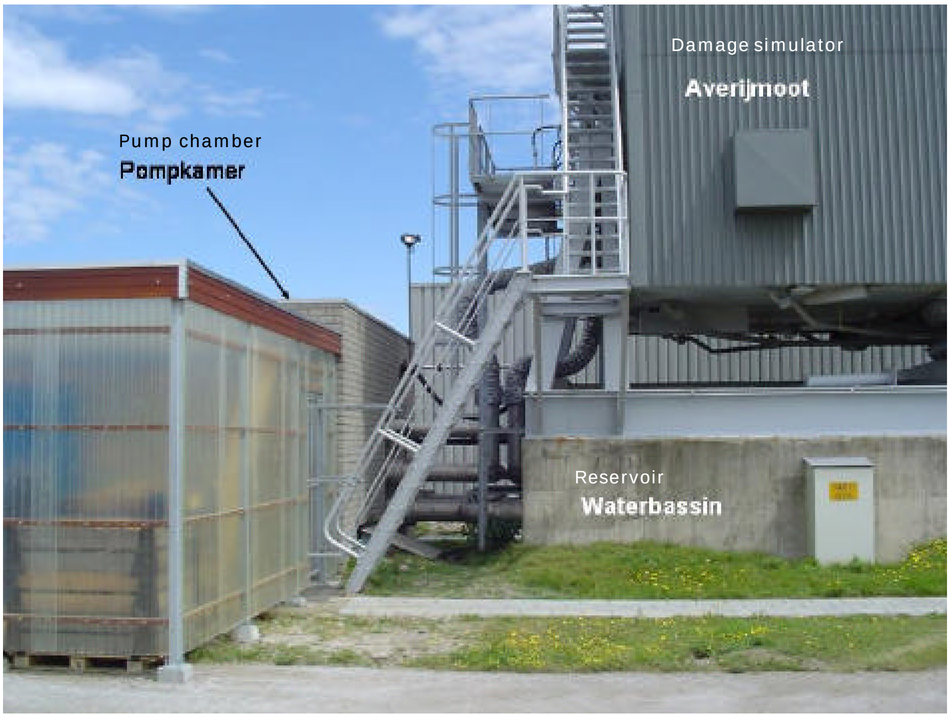

Illustration 4. The key components of the "Bever"

4.4 THE WATER FLOW IN THE "BEVER"

Annex D gives a schematic illustration of the water flow.

A distinction is made between the following three principal systems for the water flow:

- The mock fire extinguishing system in the damage simulator
- The water system leading to the various holes, cracks or buckled doors
- A system for disinfecting and temperature monitoring

4.4.1 The mock fire extinguishing system in the damage simulator

In the mock fire extinguishing system, the water is pumped from the reservoir to the damage simulator with the help of one centrifugal pump. The water arriving in the damage simulator from the mock fire extinguishing system via a crack created in a pipe flows back to the reservoir via drains.

4.4.2 The water system leading to the various holes, cracks or buckled doors

In the second system, the water is pumped from the reservoir to the damage simulator with the help of two centrifugal pumps. A special pipe system makes sure that water is supplied to the different holes, cracks or buckled doors. The water is returned to the reservoir via the drains.

4.4.3 A system for disinfecting and temperature monitoring

The third system serves to disinfect the water as well as to bring it to the right temperature and keep it there. The principle of disinfecting using chemicals is explained in annex E.

To condition and disinfect the water, it is transported via a separate system from the reservoir through a water treatment installation at a flow rate of roughly 30m^3/h. The water for treatment is circulated via a bulk dirt trap with the help of a centrifugal pump. The water is conveyed across a sand filter to remove any solid substances from the water. Hydrochloric acid and chlorine bleach lye are added to the filtered water. In both cases, the dosing takes place with the help of diaphragm dosing pumps. These pumps are controlled using a measuring and regulating system.

This measuring and regulating system works as follows. A small quantity of the water being fed back to the reservoir is passed over a measuring plate. This plate contains a flow sensor, a Potential Hydrogenium (pH) electrode and a chlorine electrode. The flow sensor checks whether there is sufficient flow over the measuring plate to perform the precise measurement. The pH electrode assesses the acidity, while the chlorine electrode measures the free available[6] chlorine and the bound available chlorine[7]. The measurements taken are processed in the regulating system, and the dosing pump in question is then activated or otherwise.

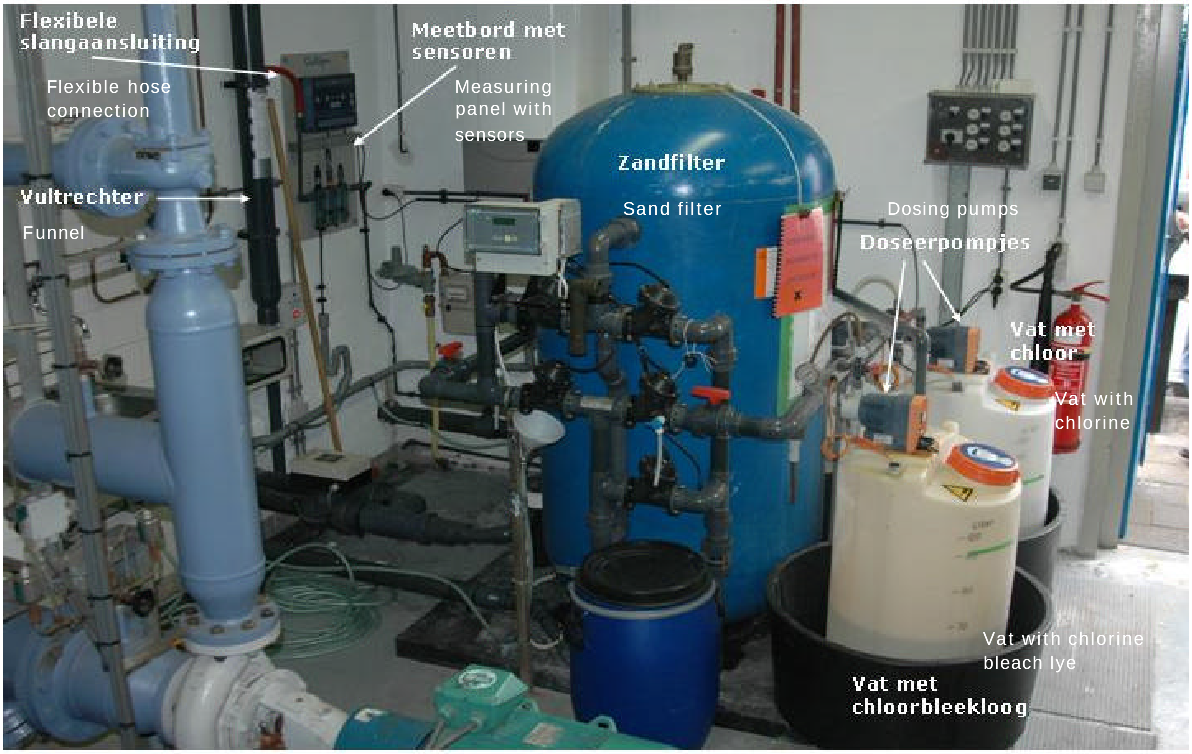

Illustration 5. The water treatment installation[8]

[6] The concentration of free available chlorine (FAC) is, by definition, the sum of the concentrations of free chlorine (CL_2), hypochlorous acid (HOCl) and hypochlorite (OCl^-).
[7] Bound available chlorine is created as an intermediate step when free available chlorine reacts with nitrogen compounds such as ammonia, urea and creatine.
[8] Source: Netherlands Forensic Institute

Besides purification and the addition of two chemicals, the water is also heated with the help of a central heating installation.

The complete installation is not continuously in operation. The system is controlled with the help of three time switches. First of all, there is a timer controlling the circulation through the water treatment installation (incl. measuring and regulating system). Secondly, there is a timer that makes sure the sand filter is cleaned at set times: filter backwash. During this process, which takes 5 to 10 minutes, the water is transported from the reservoir through the filter from bottom to top (in other words, in the opposite direction to normal). The water and the dirt caught during operation of the filter are drained away. This causes the water level in the reservoir to fall. This drop is rectified by means of a level control, and fresh tap water is added to the reservoir. The third time switch is for the heating installation.

4.4.4 The water quality standards

Although the Whvbz was not formally applicable, the KM applied the water quality standards of the Bhvbz. These standards concern, among other things, the acidity of the water (standard: 6.8 = acidity= 7.8), buffer capacity[9] (standard: = 1 mmol/l), free available chlorine (FAC) (standard: 0.5 = FAC = 1.5 mg/l) and bound available chlorine (standard: = 1.0 mg/l). The standards comply with Schedule 1 to the Bhvbz.

Schedule 1 to the Bhvbz also refers to investigation frequencies. The proprietor must examine, among other things, acidity, free available chlorine and bound available chlorine "*daily, as often as is necessary from the point of view of operational management, and at the very least at opening and closing times*", while a laboratory investigation must take place once a month. However, these daily and monthly analyses were not conducted. Observing the water quality standards without, however, applying the corresponding investigation frequency meant that it was possible in this case for the dosing problems to remain unnoticed for too long. More generally, it can be said that observing elements of a law or regulation without including other corresponding aspects can pose a risk. A law or regulation tends to form a complete whole.

4.5 MOST LIKELY SCENARIO FOR THE GENERATION OF CHLORINE GAS

It is impossible to establish with absolute certainty how exactly the chlorine gas came to be released.

To condition and disinfect the water, it is conveyed via a separate system across a sand filter to remove any solid substances from the water. Some of the filtered water is passed over a measuring plate where the chemical composition of the water is measured. A flow sensor is supposed to guarantee that the flow over the measuring plate is representative so the system can dose chemicals, if necessary. The flow sensor was jammed such that it constantly signalled a flow regardless of the actual flow. And, because the flow sensor was jammed like this, there was in fact no water flow or purely an inadequate flow over the measuring plate. If there is water of insufficient quality in the measuring plate at the point when the sand filter begins rinsing, the system will begin or continue dosing chemicals. Dosing only stops once water of the right quality starts flowing over the measuring plate.

Given that the flow over the measuring plate was poor because the flow sensor was not properly set up, more acid was dosed than necessary and, because of a low buffer capacity, the acidity dropped to a very low value. The buffer capacity may well have already been low because the level control was faulty, which meant that the water was no longer being topped up daily and on account of the modification with the hose connection, which meant that some of the water was being re-circulated to the reservoir.

The low acidity caused the hypochlorous acid to convert into chlorine and be present in the water in the reservoir as chlorine gas.

[9] The range within which the acidity of a buffer hardly changes following the addition of acid or base is called the buffer capacity.

It was possible for chlorine gas to be generated because there was no flow over the measuring plate several times during rinsing of the sand filter yet the measuring and regulating system began dosing despite the fact that a flow sensor should prevent this.

As the water was pumped from the reservoir to the damage simulator, the chlorine gas was released from the water the moment the water flowed from the cracks and holes in the simulator.

4.6 GENERAL ANALYTICAL DESCRIPTION OF THE INCIDENT

The various events, dangers and targets can be described as follows. The event (or incident) that ultimately took place is the exposure to chlorine gas, with which personnel in the “Bever” were intoxicated. The exposure was caused by the release of chlorine gas in the “Bever”.
Releasing chlorine gas in the “Bever” has an effect on the concentration of chlorine gas in the air of the “Bever”. Chlorine gas was released because of a build-up of acid in the water.
The accumulation of acid in the reservoir water has an effect on the concentration of acid in the reservoir water. The accumulation of acid was caused by the addition of acid to the water.

The analysis assumes that by implementing measures (barriers) it is possible to control the danger to prevent the event from happening or – if the measures fail – to protect people and equipment against the consequences of an event (incident). For a detailed description of the analysis method used, please refer to annex F.

4.6.1 Failing barriers

The following failing barriers are recognised. For each barrier, there will be a description of the principle of the barrier first, followed by a sub-conclusion.

Measuring and regulating system (1) [10]
If the measuring and regulating system is working correctly, this will prevent the danger “Addition of chlorine bleach lye and acid to water” leading to the event “Accumulation of acid in reservoir water”.

The measuring and regulating system serves to disinfect the water and continue to provide a disinfecting effect after the treatment by dosing the right quantity of chemicals. The addition of the two chemicals is supposed to be implemented in such a way that there is no build-up of chemicals in the water.

Illustration 6. The measuring plate with sensors

[10] The barrier can be located in the figure in annex F using the number that appears after the text.

The measuring plate for this system (see also annex D) includes, in succession, a flow sensor, a pH electrode and a chlorine electrode. The regulating system uses the electrodes to determine how much chlorine bleach lye and/or hydrochloric acid should be added to the water. The investigation did not reveal any defects to the regulating unit itself. The pH measurement was also checked and found to be in good order. The pH electrode showed a correct value[11].

The flow sensor is supposed to guarantee the measurement of a representative flow over the measuring plate. If there is no flow or too little flow over the measuring plate, no chemicals should be dosed. The flow sensor was jammed such that it constantly signalled a flow regardless of the actual flow. How the flow sensor came to be in this state has not been ascertained. An inspection of the flow sensor revealed that it had been in this position for several weeks.

If maintenance work had been planned and executed on the installation using a correct methodology, then the fact that the flow sensor was sending out the wrong signal would have been detected at any moment. However, because an inspection of the flow sensor was not included in the maintenance lists used, the fault to the flow sensor could not be identified.

Sub-conclusion 1.
The measuring and regulating system dosed the two chemicals wrongly because the flow sensor was not working properly.

Sub-conclusion 2.
Because an inspection of the flow sensor was not included in the maintenance lists used, the fault to the flow sensor could not be identified.

Freshening of water (2)
If the water is freshened adequately, this will prevent the danger “Addition of chlorine bleach lye and acid to water” leading to the event “Accumulation of acid in reservoir water”.

If fresh water is added to the system at regular intervals, the buffer capacity of the water remains at a sufficient level to deal with an occasional excess dose of acid. The addition of fresh water was necessary because water consumption was created in three places in the system as a whole. Firstly, use of the simulator caused water to be consumed. Secondly, the rinse water for the sand filter was drained away. And thirdly, the water transported to the measuring plate was also discharged to the drain.

The automatic level control (see also annex D) of the reservoir had not been working properly for approximately seven months because of a faulty PCB. Under normal circumstances, the level control was switched on every afternoon after the last exercise had been completed, thereby automatically restoring the reservoir to the right level every night. Given that the level control was now faulty, someone had to be present at all times to top the reservoir up manually. Because there was not someone available every day to carry out the topping up, visual checks were performed to see whether there was still enough water in the reservoir. In practice, this meant that the reservoir was topped up once a week on average.

During the same period, the school began a campaign to save water. One of the actions involved examining whether savings could also be made within the “Bever”. This led to the attachment of a flexible connection (see also annex D) between the measuring plate and the funnel so that the water transported over the measuring plate would no longer be drained away. It is not clear how much water this connection actually saved because the “Bever” does not have its own water meter. The installation of a connection between the measuring plate and the funnel means that some of the water is re-circulated causing a reduction in the water's buffer capacity.

[11] The Commander of the Royal Netherlands Navy commented, among other things, that the report passes over the later detected defect to the pH measuring sensor. This means that the most likely scenario for the generation of the chlorine gas would not be correct and would lack the foundations for the sub-conclusions based on this scenario. It emerged from an inquiry to the KM that there were no written investigation results to indicate a fault to the pH sensor or that investigations had been carried out by the KM into the operation of the sensor. The report has been amended in the sense that it now indicates that the investigation (conducted shortly after the incident) revealed that the pH sensor was working correctly.

Sub-conclusion 3.
The buffer capacity of the water had become low because insufficient fresh water had been added to the system.

Timely evacuation (3)
If the personnel had spotted the danger sooner and had been evacuated promptly, then the exposure of the target "Bever personnel" to the event "Exposure to chlorine gas (intoxication)" would have been prevented.

The students had only been with the KM for a few months and can therefore be labelled as inexperienced. The students had conducted an exercise in the "Bever" without water first and were therefore familiar with several aspects, such as the motion, compartments and work procedures to be followed in the "Bever".

The students were not sufficiently aware of what effects were part of the exercise (e.g. gushing water, leaking doors, slightly chlorinated air) and what effects were not (e.g. streaming eyes, pain in the airways). Because of their inexperience, the students were also less critical towards the exercise to be performed and "underwent" the exercise partly on the directions of the instructors.

There are two control rooms in the simulator (one per deck), from where the instructors coach the students and from where water can be transported to a number of specially installed "leaks" by means of a training water system or a mock fire extinguishing system. The ventilation for the control rooms is separate from that of the training compartments. The instructors cannot detect the chlorinated air experienced by the students. Two instructors were exposed to the chlorine gas during the evacuation of the "Bever".

Illustration 7. A control room seen from the training compartment

Sub-conclusion 4.
The fact that the instructors' rooms and students' compartments each have their own ventilation system and the fact that the students were inexperienced led to a delay in the realisation that the situation was dangerous and in the evacuation.

4.6.2 Missing barriers

The following missing barriers can be recognised. For each barrier, there will be a description of the principle of the barrier first, followed by a sub-conclusion.

Daily manual control of water quality (4) [12]
If the water is checked manually on a daily basis, this will prevent the danger "Accumulation of acid in water" leading to the event "Release of chlorine gas in Bever".

The automatic dosing installation was installed at the start of 2003. Prior to this, chemicals had been added to the water manually, with the dose determined using a manual control of the water quality. The personnel stopped this manual control at the start of 2003 because they were switching from then onwards to fully automated dosing. The head of the SNBCD&BV was convinced that this daily manual control was still taking place.

The schedule to the Bhvbz stipulates that swimming water should be checked daily in relation to, among other things, acidity and free available chlorine. Although the Whvbz and, with it, the Bhvbz are not formally applicable to this installation, they do describe the minimum technological standard in this area and the KM did want the technical installation to comply with the Whvbz and the Bhvbz. Indeed, the KM applies the water quality standards of the Bhvbz.

The pump room contained a list of articles from the Whvbz that should be applicable to the "Bever". For each article, it was indicated whether or not the "Bever" was compliant. The list refers, among other things, to the schedule to the Bhvbz, which stipulates that samples of the pool water must be taken at regular intervals. If these regular checks had been performed, it is highly likely that the incident would not have happened.

Observing the water quality standards without, however, applying the corresponding investigation frequency meant that it was possible in this case for the ever-decreasing buffer capacity to remain unnoticed for too long. More generally, it can be said that observing elements of a law or regulation without including other corresponding aspects can pose a risk. A law and the decrees based on it form a complete whole.

If, in addition to the technical standards, the applicable operational management element of the Whvbz and the Bhvbz had been adopted too, the fact that the water did not comply with the standards would have been identified early.

Sub-conclusion 5.
If, in addition to the technical standards, the applicable operational management element of the regulations had been adopted too, the fact that the water did not comply with the standards would have been identified early.

Water control after treatment (5)
If the water is checked after chemicals have been added, this will prevent the danger "Addition of chlorine bleach lye and acid to water" leading to the event "Accumulation of acid in reservoir water".

It is technically possible to re-check water that has already been treated before it is returned to the reservoir. This control measurement can be coupled to the water treatment installation. This measurement stops water with too many or too few chemicals for a lengthy period from being returned to the reservoir.

Sub-conclusion 6.
The absence of an automated control measurement allowed water that contained too much acid to accumulate.

Triggered ventilation (6)
If triggered ventilation is applied, this will prevent the target "Bever personnel" from being exposed to the event "Exposure to chlorine gas (intoxication)".

The basic principles applied in the design of the ventilation system are unknown.

A normal ventilation system on board a naval ship has a mechanical air supply and exhaust system. Connecting such a system in a certain way can create excess pressure in certain compartments, enabling, for example, smoke or other harmful or irritating gases to be removed.

[12] The barrier can be located in the figure in annex F using the number that appears after the text.

The simulator had only been equipped with a mechanical supply system. The air had to escape naturally through a number of grates in the walls of a number of compartments. With this particular ventilation system it is not possible to create triggered ventilation that would have been sufficient to remove the chlorine gas outside quickly.

Furthermore, in one of the simulator's compartments where students were working, a ventilation grate had been taped up as part of an earlier exercise involving divers. Since this grate was taped, the air supplied to the compartment could not be extracted adequately in the normal way. So, the air supplied and the chlorine gas present were being partly recycled through the simulator.

Illustration 8a. A ventilation grate

Illustration 8b. The taped-up grate[13]

Sub-conclusion 7.
With the ventilation system present in the "Bever" it is not possible to create triggered ventilation that would have been sufficient to remove the chlorine gas outside quickly.

Sub-conclusion 8.
Because a ventilation grate in one of the training compartments had been taped up, some of the chlorine gas present could not be removed.

Air control in simulator (7)
If the air is continuously checked for chlorine gas, this will prevent the target "Level of chlorine gas in air in Bever" from being exposed to the event "Release of chlorine gas in Bever".

It is technically possible to fit sensors in the simulator that can detect whether the content of chlorine gas is (too) high. These sensors can engage with the installation or they can be used to alert the instructors and/or students.

Sub-conclusion 9.
The absence of sensors meant that it was not possible to notice that the content of chlorine gas in the air was (too) high in good time.

4.6.3 Underlying factors

If a number of points are brought together, the following underlying factors can be identified.

Maintenance
Maintenance covers a very broad range of issues from daily inspection rounds to major repairs. The KM strives to apply the Integrated Logistic Support (ILS) methodology[14] to formulate the various types of maintenance.

[13] Source: Health & Safety Inspectorate.

ILS can be seen as a methodology that enables designers of technical systems to model and analyse the product life cycle. ILS is a procedure that influences the choice of a particular existing system or the design process of a new system in order to ensure and obtain the best possible logistic support against minimal life cycle costs. ILS is geared towards having and maintaining equipment so it is perfectly usable and easily maintainable. ILS takes into account all aspects of maintenance that may affect equipment design at the correct time.

The maintenance to (the water treatment installation of) the "Bever" was not carried out using ILS but was performed with the help of lists drawn up over time by the personnel of the school themselves on the basis of merely general technical acu men.

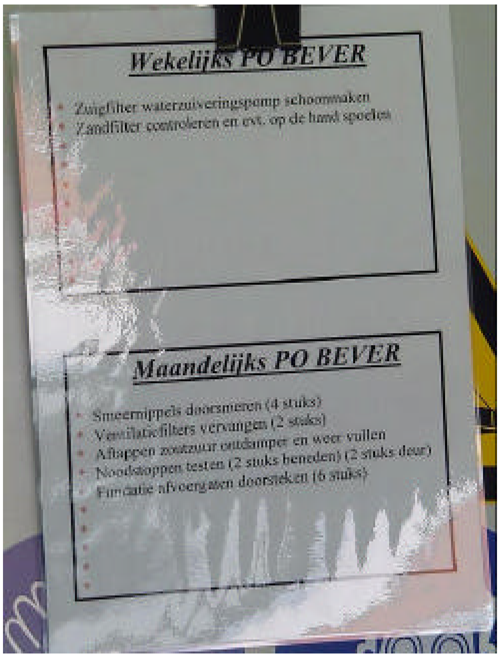

Illustration 8. A self-penned maintenance list

This process failed to involve the use of other service organisations such as the DGW&T or the supplier of the water treatment installation, or even draw on the knowledge that was already present at the school. For example, the supplier of the water treatment installation gives the following warning under the safety information for the swimming pool controller:
"In the event that chlorine installations are used, you must comply with the relevant requirements of the WHVBZ."

The pump room also contained a list of articles from the Bhvbz that should be applicable to the "Bever". For each article, it was indicated whether or not the "Bever" was compliant. It is not known when this list was made and what was done with it.

It also emerged from interviews that the personnel of the SNBCD&BV had received no training specially geared to maintaining the "Bever". Nor had they otherwise acquired any specific expertise in relation to this water treatment installation.

For the maintenance of the hydraulic installation the school makes use of the knowledge and expertise of the Maintenance Establishment.

During the investigation it turned out that there was a distinct lack of clarity concerning the relations between the SNBCD&BV and the service district of DGW&T. Conversations with representatives of the DGW&T service district revealed that consultative structures and contact positions have been established and filled at various levels.

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[14] The ILS methodology is based on the "Materiel Maintenance Philosophy of the Royal Netherlands Navy" ("Instandhoudingsfilosofie voor het materieel der Koninklijke Marine") laid down by the Admiralty Council on 19 March 1991.

Within the service district a number of people have been appointed as contacts for the various units in the Den Helder region. These people meet with the respective unit once a month to discuss matters of detail. Furthermore, the head of the service district has been designated a general contact for all units in the Den Helder region.

In addition to this, a regular consultative meeting is held, in respect of all units in Den Helder and the surrounding area, between representatives of the staff of the CZMNED, the service district of DGW&T and the units concerned. This meeting is known as the Infrastructure Consultation.

The SNBCD&BV is the only unit in the Den Helder region where the infrastructure consultation does not take place. This is due to the fact that the position of Head of Support at the SNBCD&BV had not been filled for quite some time and, therefore, it had been necessary to establish priorities with regard to the duties performed by this particular official. Added to this is the fact that most of the school's employees were not aware that permanent contacts had been appointed within the service district of DGW&T for each unit.

If either the school or DGW&T had made use of the contacts or if an infrastructure consultation had taken place, then it would have been possible to draw up a balanced maintenance plan for the "Bever" installation as a whole and for the water treatment installation in particular.

The supplier of the water treatment installation supplied documentation that excluded maintenance instructions. The supplier has indicated that it did previously offer the maintenance contract. This offer was rejected by the KM. They had decided they would take care of the maintenance themselves. It is unusual for documentation for an installation not to include any maintenance guidelines whatsoever and for no attention apparently to be given to this at the time of delivery.

Maintenance should also be geared to laws or regulations, and indeed the KM did accept the Whvbz as the prevailing state of knowledge. If an installation is purchased according to a particular standard and this installation is then not used or maintained in accordance with that standard, this may have a negative effect on the entire installation. The laws and regulations state, for example, that a number of parameters should be inspected on a daily and monthly basis. In addition, the dosing installation must also be checked to make sure it is in good working order. If this is never done, then there can be no guarantee that the water will be of the right quality.

Sub-conclusion 10.
The maintenance for the "Bever" had been determined on the basis of merely general technical acumen and not based on a maintenance philosophy, maintenance structure or an RI&E. The maintenance was performed by personnel with no special training for this purpose.

Sub-conclusion 11.
Despite the fact that structural consultation is set up for all units of the KM in the Den Helder region for handling infrastructural maintenance, no such consultative meeting is held with the school for NBCD&BV. This means that problems were not recognised as such and there was no mutual insight into the problems that arose.

The (safety) management system
The Temporary Defence Committee for Accident Investigation (TCOD), in its report[15] in response to the torpedo fall, recommended that the KM set up a (safety) management system. It must be noted that this recommendation has yet to lead to any visible results at the KM.

Owing to the ongoing reorganisation at the Ministry of Defence, the organisation of the entire armed forces, and therefore also the KM, has undergone radical changes. Duties, responsibilities

[15] TCOD report "Torpedo fall in tubes room in bow of submarine on 16 March 2004 in Den Helder" ("Val van een torpedo in boegbuiskamer onderzeeboot op 16 maart 2004 te Den Helder") dated 10 December 2004:
"In the near future, ensure that a management system is put in place incorporating feedback and assurance, as well as adequate RI&Es, so that, for the sake of realising continuous improvement, an insight is gained into safety management aspects at all command and policy levels partly by means of the fully implemented and functioning AMMS, audits, controls and inspections, with the help of performance indicators."

and powers have been reinvested and an administrative tier has been removed from the armed forces. The staff of the air force, army and navy, including the commanding officers, disappeared with effect from 5 September 2005 and were integrated within the central staff organisation.

One of the consequences of the reorganisation is that the working conditions and environment management system (AMMS) had to be rewritten and fitted into the new organisation. A decision was taken to make the rewriting of the AMMS the priority and to suspend audits, which are an essential part of a well-functioning safety management system, from spring 2005. Given that audits are no longer being performed there is no added value to be gained from further investigation by the Dutch Safety Board into the quality of performed audits.

In May 2001 and October 2002, two audits were conducted at the SNBCD&BV. These audits related to the introduction of the AMMS within the school. The audit reports state which actions had to be implemented by the school so that the AMMS could function as well as possible. The reports indicate, for example, whether or not an RI&E is present. However, no judgement is passed on the quality of the RI&E.

Risk inventorisation and evaluation (RI&E) is part of any (safety) management system and is required by law. When the “Bever” was completed in 1991, there were currently no RI&Es being implemented within the KM. An RI&E was made of the “Bever” in April 2000. At the start of 2003, the water treatment installation was installed and the dosing of chemicals became an automated process. This modification of the installation did not result in any addition to the existing RI&E. The reason for this is unknown. Work began on updating the RI&E at the start of 2005. Despite the fact that reports regularly appear in the media of incidents in swimming pools that relate to chlorine gas intoxication, the chance of chlorine gas being generated was never recognised in the RI&E.

Sub-conclusion 12.
The TCOD’s recommendation that a (safety) management system be set up at the KM has yet to lead to any visible results.

Sub-conclusion 13.
Despite the fact that the KM had introduced an AMMS in its operational management and devoted attention to formulating and updating the RI&E in 2005, the risk of chlorine gas generation is not recognised therein.

4.7 ACTIONS TAKEN BY THE KM IN RESPONSE TO THE INCIDENT

The KM has set up an investigation committee. The Dutch Safety Board has not yet received the report.

In advance of the results of the investigation, the water treatment installation has been completely replaced and adapted to the latest technological developments. A maintenance contract has been concluded with the supplier for the performance of maintenance and the provision of a 24-hour trouble-shooting service. In addition, the Assistant Non-Commissioned Officer in Charge of Safety/Maintenance Employee has had lessons in primary maintenance to the “Bever” and has acquired a measuring case that can be used to calibrate the various sensors.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 SUB-CONCLUSIONS

In the analysis the following sub-conclusions have been identified with regard to the various barriers.

1. The measuring and regulating system dosed the two chemicals wrongly because the flow sensor was not working properly.

2. Because an inspection of the flow sensor was not included in the maintenance lists used, the fault to the flow sensor could not be identified.

3. The buffer capacity of the water had become low because insufficient fresh water had been added to the system.

4. The fact that the instructors' rooms and students' compartments each have their own ventilation system and the fact that the students were inexperienced led to a delay in the realisation that the situation was dangerous and in the evacuation.

5. If, in addition to the technical standards, the applicable operational management element of the regulations had been adopted too, the fact that the water did not comply with the standards would have been identified early.

6. The absence of an automated control measurement allowed water that contained too much acid to accumulate.

7. With the ventilation system present in the "Bever" it is not possible to create triggered ventilation that would have been sufficient to remove the chlorine gas outside quickly.

8. Because a ventilation grate in one of the training compartments had been taped up, some of the chlorine gas present could not be removed.

9. The absence of sensors meant that it was not possible to notice that the content of chlorine gas in the air was (too) high in good time.

10. The maintenance for the "Bever" had been determined on the basis of merely general technical acumen and not based on a maintenance philosophy, maintenance structure or an RI&E. The maintenance was performed by personnel with no special training for this purpose.

11. Despite the fact that structural consultation is set up for all units of the KM in the Den Helder region for handling infrastructural maintenance, no such consultative meeting is held with the school for NBCD&BV. This means that problems were not recognised as such and there was no mutual insight into the problems that arose.

12. The TCOD's recommendation that a (safety) management system be set up at the KM has yet to lead to any visible results.

13. Despite the fact that the KM had introduced an AMMS in its operational management and devoted attention to formulating and updating the RI&E in 2005, the risk of chlorine gas generation is not recognised therein.

5.2 Final conclusions

In addition to the details of the sub-conclusions, the essence can be conveyed in the following final conclusions.

- Despite the fact that there is ample familiarity with, and experience of, drawing up a Risk Inventorisation and Evaluation as well as Integrated Logistic Support within the Royal Netherlands Navy, these methodologies are not applied everywhere to an adequate extent, making it possible for the risk of chlorine gas being released to go unrecognised, for maintenance of this installation to be performed using plans and schedules drawn up on the basis of merely general technical acumen and for operational management not to be carried out in line with the latest technological developments.

- The shortcomings or bottlenecks uncovered in this investigation could have been overcome with a fully functioning system or a combination of systematic risk analysis, periodic controls, inspections and audits.

5.3 Recommendations

The following recommendations apply specifically to the “Bever”:

- Make sure that all possible improvements indicated in this report are installed in the “Bever” and applied to the operational management, such as the installation of chlorine gas detectors and triggered ventilation, the application of operations pursuant to the Bhvbz, adequate maintenance, and so on, and that the (technical) inadequacies are rectified.

In terms of the underlying causes, the Dutch Safety Board is of the opinion that there is nothing to add to the recommendation previously expressed by the Temporary Defence Committee for Accident Investigation, which the Board fully embraces:

- In the near future, ensure that a safety management system for the entire Ministry of Defence is put in place incorporating feedback and assurance, as well as adequate Risk Inventorisation and Evaluation procedures, so that, for the sake of realising continuous improvement, an insight is gained into safety management aspects at all command and policy levels partly by means of a fully implemented and functioning working conditions and environmental management system, audits, controls and inspections, with the help of performance indicators.

  For the sake of completeness, it is noted that the Dutch Safety Board regards a safety management system as the entire body of (organisational) structures, related agreements and procedures that make a positive contribution to the level of safety throughout the life cycle of a system. The safety management system plays a crucial role in efforts to demonstrably manage and continuously improve safety. The Dutch Safety Board regards the following as issues requiring special attention:

  - Creation of a demonstrable record of the policy to prevent unwelcome events, including general objectives and principles for preventing and managing the unwelcome events identified. An explicit link must be drawn here between the laws and regulations, the standards that apply to the industry and the safety objectives specifically prepared for the business.

  - Description of the way in which the policy applied is implemented, the concrete objectives, plans and resulting preventive and repressive measures.

  - Unambiguous allocation of responsibilities with regard to the execution of safety plans and measures, and clear and active central coordination of safety activities.

  - System for monitoring and investigating incidents, near-accidents and accidents, as well as an expert analysis thereof in order to hone elements of the plan cycle if necessary.

  - Periodic implementation of (risk) analyses, observations, inspections and audits in order to reveal and actively target areas for improvement.

- Clear and recorded agreements with the neighbourhood concerning the general procedure, the method for testing it and approaches in the event of deviations, etc.

- Periodic evaluation and any necessary adjustment by the management (management review) of the safety policy.

Governmental bodies for which a recommendation has been issued must voice a stance regarding the follow-up to this recommendation within six months of publication of this report to the minister concerned. Non-governmental bodies or individuals for which/whom a recommendation has been issued must voice their stance regarding the follow-up to this recommendation within one year to the minister concerned. A copy of this reaction must simultaneously be sent to the Chairman of the Dutch Safety Board and to the Minister of the Interior and Kingdom Affairs of the Netherlands.

ANNEX A. ACCOUNT OF THE INVESTIGATION

Report and investigation by the Dutch Safety Board
After the incident had occurred on 4 July 2005, the requisite (internal and external) bodies were notified by the Royal Netherlands Navy. The Dutch Safety Board received the report on 4 July.

On 26 July 2005, the Board accepted the investigation proposal.

Scope
The Dutch Safety's Board investigation focuses on the underlying factors that led to this incident.

This situation involves a specialist simulator that is only used by the SNBCD&BV of the KM and is fitted with a water treatment installation. This installation bears a strong resemblance to a water treatment installation for a swimming pool. A similar incident may, therefore, occur at other places within the Ministry of Defence as well as outside this organisation at swimming baths used by the civilian population.

The TCOD formulated recommendations relating to safety management systems in two reports[16]. Broadly speaking, it can be said that the Ministry of Defence has accepted these recommendations, but they have not been implemented yet.

In view of the above, the scope of the investigation was geared initially towards the SNBCD&BV as well as swimming pools run by the Ministry of Defence. However, it emerged early on in the investigation that swimming pools within the Ministry of Defence were being run correctly in accordance with the provisions of the Whvbz and Bhvbz, and so the swimming pools were omitted from the investigation.

On account of the recommendations already formulated by the TCOD, the AMMS was not covered in the investigation.

Other investigations
The incident is being investigated by the Royal Netherlands Navy (private investigation).

The Den Helder Brigade of the Royal Netherlands Marechaussee (KMar) has conducted a criminal investigation into the incident. The results of the forensic investigation of the water treatment installation have been presented to the Dutch Safety Board.

Interviews
As part of the investigation, interviews were conducted with superiors and people directly involved within the SNBCD&BV. Interviews were also held with representatives of DGW&T and the staff of CZMNED. The Dutch Safety Board also has access to the statements from a number of victims taken by the KMar.

Analysis
The analysis was geared towards the reconstruction of the incident and the immediate and underlying causes.

Drafts
The draft final report (excluding consideration and recommendations) was submitted to the Defence organisation concerned (Minister of Defence and CZMNED), as well as to persons involved from the SNBCD&BV, for an assessment in relation to factual inaccuracies. The Dutch Safety Board incorporated any relevant feedback received into the definitive final report.

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[16] I. "Collision between YPR armoured vehicle and train near Assen on 17 June 2003" ("Botsing YPR met trein nabij Assen op 17 juni 2003") dated 16 January 2004.
II. "Torpedo fall in tubes room in bow of submarine on 16 March 2004 in Den Helder" ("Val torpedo in boegbuiskamer onderzeeboot op 16 maart 2004 te Den Helder") dated 10 December 2004.

ANNEX B. ARTICLES RELEVANT TO THE ASSESSMENT FRAMEWORK

Details of the assessment framework have been provided in chapter 2. For the purposes of determining whether any national laws and regulations apply and, if so, which ones, the following facts are relevant in the case of the "Bever" damage simulator:

- the situation concerns a naval occupational training centre;
- the exercises are carried out in a mock-up segment of a ship, which can be (partially) submerged in order to practise tackling disasters;
- the exercises are performed by employees working in water ranging from knee-high to chest-high;
- there are instructors on stand-by who can pump out the water quickly;
- the water is reused, with a buffer reservoir as the crux of the water supply;
- the water treatment installation itself is the same as in a swimming pool.

These specific characteristics raise the question as to whether the Whvbz or the Working Conditions Act is applicable to this set-up, or whether the set-up comes under both laws.

The objective of the Whvbz is to give the public the opportunity to bathe and swim safely and hygienically. It is primarily focussed on regulating recreational swimming. The Whvbz and Bhvbz also protect swimming/bathing in relation to clubs and schools, as well as saunas and medical facilities. These regulations contain standards concerning the quality of the water for bathing and swimming, and prohibit unsafe situations.

The objective of the Working Conditions Act is to tailor working conditions to suit the employee. Safety, health and welfare are the focal points here. This law is also applicable to the working conditions of military personnel; the Decree based on it even contains a whole part devoted to defence.

The activities that take place in the damage simulator involving employees of the KM are an element of the work they perform for the navy. The activities are conducted inside working hours. Safety and hygiene in an occupational training centre such as the "Bever" are entirely work-related. It follows that working conditions legislation is applicable.

The occupational training centre is not accessible to the public within the meaning of the Whvbz and Bhvbz. And, although people regularly stand in the water during an exercise, the simulator is not intended for bathing. It is, therefore, not a bathing facility or swimming pool. Given that the "Bever" is the only damage simulator in the Netherlands, there is no precedent in this matter. The question regarding the applicability of the Whvbz has been thrown out by the Province of North Holland and the Ministry of Housing, Regional Development and the Environment (VROM). The province and the Expert Committee on Swimming Water (consultative body of experts from VROM and the provinces) have concluded that the Whvbz and Bhvbz are not applicable.

In view of the above, the "Bever" does not fall under the Whvbz and the associated Decrees. However, this law may well be regarded as an illustration of the latest technological developments and standards.

Installations that are comparable to some extent, which are not bathing facilities or swimming pools either, but where people do come into contact with water, can be found in amusement parks. These installations come under the Decree on the Safety of Fairground Rides and Games (Attractions Decree). The decisive factor in the applicability of the Attractions Decree is whether the installation is "intended for amusement or recreation" (Art. 1 of the Attractions Decree). The "Bever" is intended for training purposes and does not, therefore, come under the Attractions Decree.

Consequently, the national regulations that apply are:

- The Working Conditions Act.
- The Working Conditions Decree.

B.1 Laws and regulations relating to working conditions

B1.1 Working Conditions Act 1998 (Working Conditions Act)

Article 3, paragraph 1a (working conditions policy)

1. The employer shall conduct a working conditions policy that is as sound as possible and, given the prevailing state of knowledge and professional service, shall duly observe the following points:
   a. unless this cannot reasonably be required, the employer must organise the work in such a way that it does not have any adverse effect on the safety and health of the employee.

Article 5, paragraph 1 and 3 (risk inventory and evaluation)

1. In conducting the working conditions policy the employer shall lay down a written inventory and evaluation of the risks inherent to the work carried out by the employees. This risk inventory and evaluation shall also include a description of the dangers and the risk-limiting measures and the risks inherent to special categories of employees.

3. A plan of action, containing an indication of the measures that will be taken in relation to the stated risks and their mutual relationship, in accordance with article 3, shall form part of the risk inventory and evaluation. The plan of action, a written report on the implementation of which shall be drawn up yearly, shall also indicate the time period within which these measures will be taken. (….).

Article 8, paragraph 1, 3 and 4 (informatio n and instruction)

1. The employer shall ensure that the employees are properly informed about the work to be carried out and the related risks, as well as about the measures aimed at preventing or limiting those risks. (….).

3. If personal protection equipment is made available to the employees, and if safety devices are fitted to work resources or are otherwise installed, the employer shall ensure that the employees are aware of their purpose and operation and the way in which they should be used.

4. The employer shall supervise compliance with the instructions and regulations aimed at preventing or limiting the risks referred to in the first paragraph and the correct use of the personal protection equipment.

Article 13 (work consultation)

If a company or an institution consists of departments that can be regarded as a work unit, regular consultations shall be held in each of those departments, as far as required by the working conditions, between those in charge of the department and the people working in it. These consultations may also be held with persons elected by the employees concerned from among their number.

B.1.2 Working Conditions Decree

Article 1.5 Definitions of Defence

In this Decree and the provisions pursuant to it the following terms have the following meaning:
(...)

c. defence personnel: military personnel and civilian personnel at the Ministry of Defence;
d. exercise: any putting into practice of skills theoretically taught by defence personnel in war simulations in order to acquire, increase or maintain proficiency in carrying out war duties;
e. military vessel: a Dutch warship, marine auxiliary vessel or other ship used for carrying out military duties;
   (...)

Article 1.30 Partial exceptions to articles 3 and 16 of the Act

Article 3, paragraph one, of the Act and articles 1.37 and 1.41 (based on article 16 of the Act), parts 5 and 6 of chapter 2, chapters 3, 4, 5, 6 and 7 and parts 1 and 2 of chapter 8 of this Decree do not apply:

a. during, immediately before and immediately after exercises;
b. with respect to military vessels, military aircraft, manned weapon systems and stand-by units:
   1°. insofar as at Our Minister's discretion deviation from these articles, chapters or parts is required in connection with the building, construction, fitting out or equipment of these vessels and weapon systems;

B.2 Defence regulations

B.2.1 Framework of Defence working conditions policy

Objectives in the Defence working conditions policy

Year 2001

3. Clear division of working conditions responsibilities in own organisation per section of the armed forces and discussion with the corresponding committees for the organised consultations. For the division of responsibilities, a connection is sought with the national directive for working conditions assurance systems (NPR 5001 or KEMA 18001) and with the international standard for quality assurance systems (ISO 9000).

8. Development of a defence -wide system for the RI&E for operational circumstances with due regard for situational and context-specific aspects in order to guarantee effective preparation for and execution of the working conditions policy in special circumstances.

Year 2003

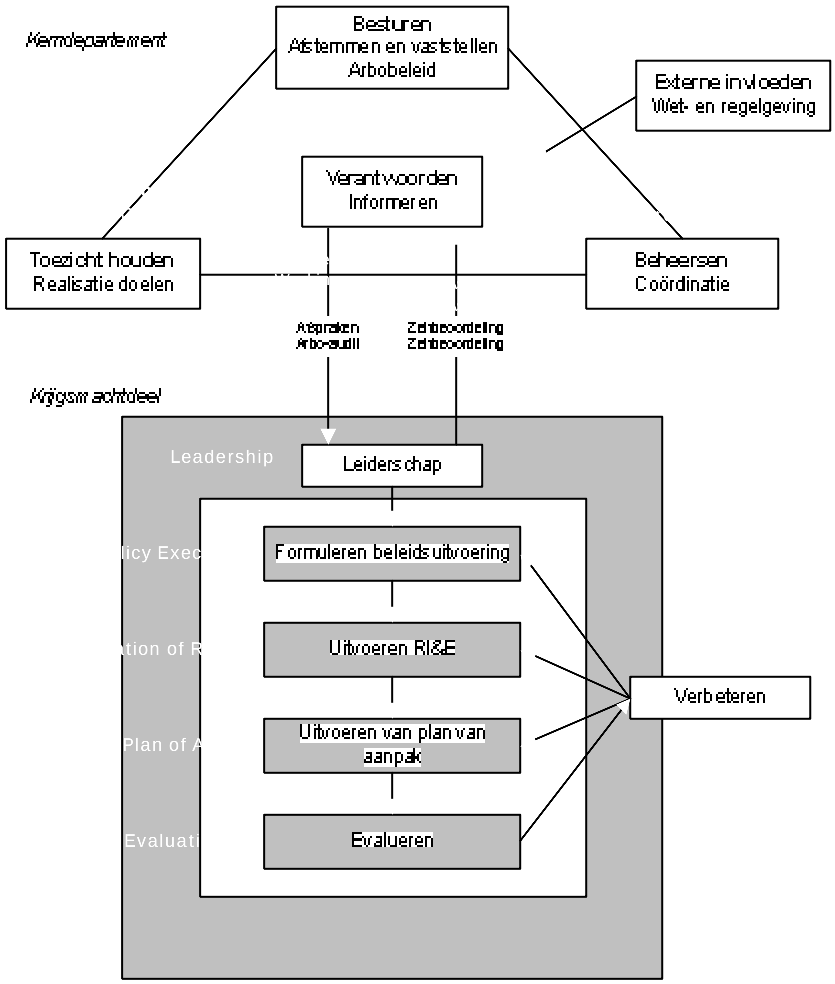
21. Availability of a working conditions assurance system per section of the armed forces, which is tailored to the circumstances of that element of the armed forces, standardised within the section concerned and certifiable in the future.

Preamble

(...) This policy framework brings a balance between application of laws and regulations where possible and exceptions where necessary. The policy framework intends to help prevent working conditions incidents and accidents. (...) And finally, the policy framework intends to bring about an improvement in the administration and justification of the working conditions policy. (...)
(...) Operational commanders assess what risks may and can be taken;
an inventory and assessment is made of the risks to personnel beforehand and, where necessary, suitable measures are taken. (...)

Previous history and scope

(...) assurance of the working conditions policy would be best secured by classifying this policy area as part of the personnel policy with the Directorate -General of Personnel. This transfer was realised as of 1 November 1991.
The working conditions authority arrangement in existence since 1985 was abolished in August 1998 because it assumed that the Chief of Defence Staff (CDS) was still responsible for policy. No new arrangement was drawn up to replace it because the duty and mandate structure in existence within the Ministry of Defence since 1991/1992 would sufficiently indicate the officials assigned the various responsibilities and powers under working conditions legislation. (...)



Kerndepartement
Besturen
Afstemmen en vaststellen
Arbobeleid
Externe invloeden
Wet- en regelgeving
Verantwoorden
Informeren
Toezicht houden
Realisatie doelen
Beheersen
Coördinatie
Afspraken
Arbo-audit
Zelfbeoordeling
Zelfbeoordeling
Krijgsmachtdeel
Leadership
Leiderschap
Formuleren beleidsuitvoering
Uitvoeren RI&E
Uitvoeren van plan van aanpak
Evalueren
Verbeteren

Working Conditions and Environmental Management System: the entire connected body of policy-related, organisational and administrative measures that provides an insight into the way in which the KM manages assurance for working conditions and the environment and executes the working conditions and environmental policy;

Audit: the examination, using the AMMS, of the extent to which work within the organisation is carried out in accordance with the AMMS; the reasons for any deviations from the AMMS must be examined; corrective action can be taken based on this insight; the findings of the audit are recorded in a report;

Parts of AMMS
2541. The operation of the AMMS, or key parts thereof, is assessed and evaluated periodically (at least once a year) at a unit or Results-Accountable Unit (RVE) by means of an audit. The audit is performed by one or more auditors not employed by the unit or RVE concerned. The audit involves an assessment of whether the requirements of the AMMS are being met.

Procedures
Procedure 3, Core working conditions duties
3101. The Commander of the RVE, as the employer liable for RI&Es, is responsible for the execution of an RI&E. The commander of the unit initiates an RI&E on the basis of the Working Conditions Act, on behalf of the CRVE, at regular intervals (according to the directive of the Health and Safety Inspectorate: every 3 to 4 years) and whenever there is a change in operational management (organisational, procedural or infrastructural). The RI&E must be laid down in writing. In the event of changes in operational management, only the elements involved and their relationship with the environment have to be examined. The commander of the unit informs the CRVE, the Co-Determination Committee (MC) and the KM Working Conditions Board (ABDKM) (through the relationship manager) of his intention to perform an RI&E. Where necessary, the CRVE will assist the unit in the performance of the RI&E.

3102. The following subjects must be included in the RI&E:
a. business features (such as a description of the organisation, the various positions, the number of employees, working hours, Company Emergency Response organisation, absenteeism, accidents/incidents, special target groups (young people, old people, pregnant women, etc.) and the number of occupational illnesses;
b. organisational aspects, such as work consultation, duties and powers;
c. a description of all risky activities and processes and the way in which the consequences of risky activities and processes are limited for the employees; a format for this is included in ten 5110; under 5200, details are provided of what needs to be included for each part of the format;
d. welfare aspects;
e. statutory inventorisation procedures.

3103. The statutory inventorisation procedures include:
a. young people;
b. pregnant women;
c. dangerous substances in general;
d. carcinogens in general;
e. vinyl chloride monomer;
f. asbestos;
g. lead;
h. biological agents;
i. physical strain;
j. VDU work;
k. noise;
l. personal protection equipment

Procedure 8, Internal information
2001. This procedure focuses on the dissemination of information relating to working conditions and the environment to employees so that they are aware of the following:

a. the positive value of better performance in relation to working conditions and the environment, both for themselves and for colleagues;
b. their own role in and responsibilities for the realisation of the policy, the objectives and tasks and the performance of the working conditions and environmental management system;
c. the possible consequences if work procedures are not followed to the letter.

2002. This procedure concerns the following players:
a. Director of Personnel of the Royal Netherlands Navy (DPKM);
b. Head of the BVMA;
c. Management Representative for Working Conditions and the Environment (DIRAM) of the RVE;
d. DIRAM of the unit.

Procedure 12, Process control
1001. The purpose of this procedure is to ensure that work is performed in accordance with the policy as well as the laws and regulations (with the help of the RI&E and the register of environmental aspects).

2001. This procedure concerns the following players:
a. DIRAM of the RVE;
b. DIRAM of the unit;
c. BVMA officials;
d. Directorate of Infrastructure/Regional Development and the Environment (DGW&T/ROM);
e. Infrastructure Staff Officer (SOINFRA) of the RVE.

Procedure 15, Internal working conditions and environmental audits
1001. The purpose of this procedure is to establish, periodically and independently, whether:
a. the applicable system documentation that forms part of the AMMS is being implemented effectively and efficiently;
b. the AMMS has been set up in accordance with ISO 14001 and OHSAS 18001.

3303. Every year, the head of the BVMA also checks whether the AMMS still satisfies all the elements of ISO 14001 and OHSAS 18001.

B.3.3 1 VVKM 27, Ordinance concerning the regulations within the Royal Netherlands Navy (2003 edition)

Preface
1. In the year 2000, an audit was conducted by the Policy Evaluation and Audit Division of the Directorate of Economic Management of the Royal Netherlands Navy into management affairs in respect of regulations. The audit revealed an enormous shortage of regulations within the Royal Netherlands Navy regarding the realisation and amendment of ordinances.
2. The present ordinance is intended to answer the questions that exist within the organisation with regard to that issue. This ordinance has been brought about partly in response to the final report of that audit.
3. The Ordinance Concerning the Regulations within the Royal Netherlands Navy (1 VVKM 27)(2003 edition) is to be monitored by the head of the Regulations Office of the Naval Staff Legal Affairs Division, who can also be contacted regarding content.
(...)

2211. The regulations of the Royal Netherlands Navy are organised into various levels, from top to bottom, as follows:
- international agreements (treaties),
- (Kingdom) acts, general measures of the (Kingdom) government;
- ministerial rules;
- orders from the Commanding Officer of the Royal Netherlands Navy;
- instructions and orders from a regional commanding officer or commander of a results-accountable unit;
- instructions and orders from a group commander or commander of maritime resources;

- (standard) orders from a commander, director or head of a naval forces unit.

2212. The system of regulations has been stratified to convey the hierarchy of regulations (articulated standards). Every form of regulations is bounded by regulations of higher authorities.

2213. At the levels referred to in 2211, under c to g, policy rules, procedure rules and instructions can also be issued.

4221. Pursuant to the mandate arrangement for the BDZ to lay down official KM ordinances in 2000 (BDZ decree of 4 February 2000, no. S 2000008810), the head of the Naval Staff Legal Affairs Division is authorised to lay down *official ordinances* applicable to the Royal Netherlands Navy, on behalf of the BDZ.

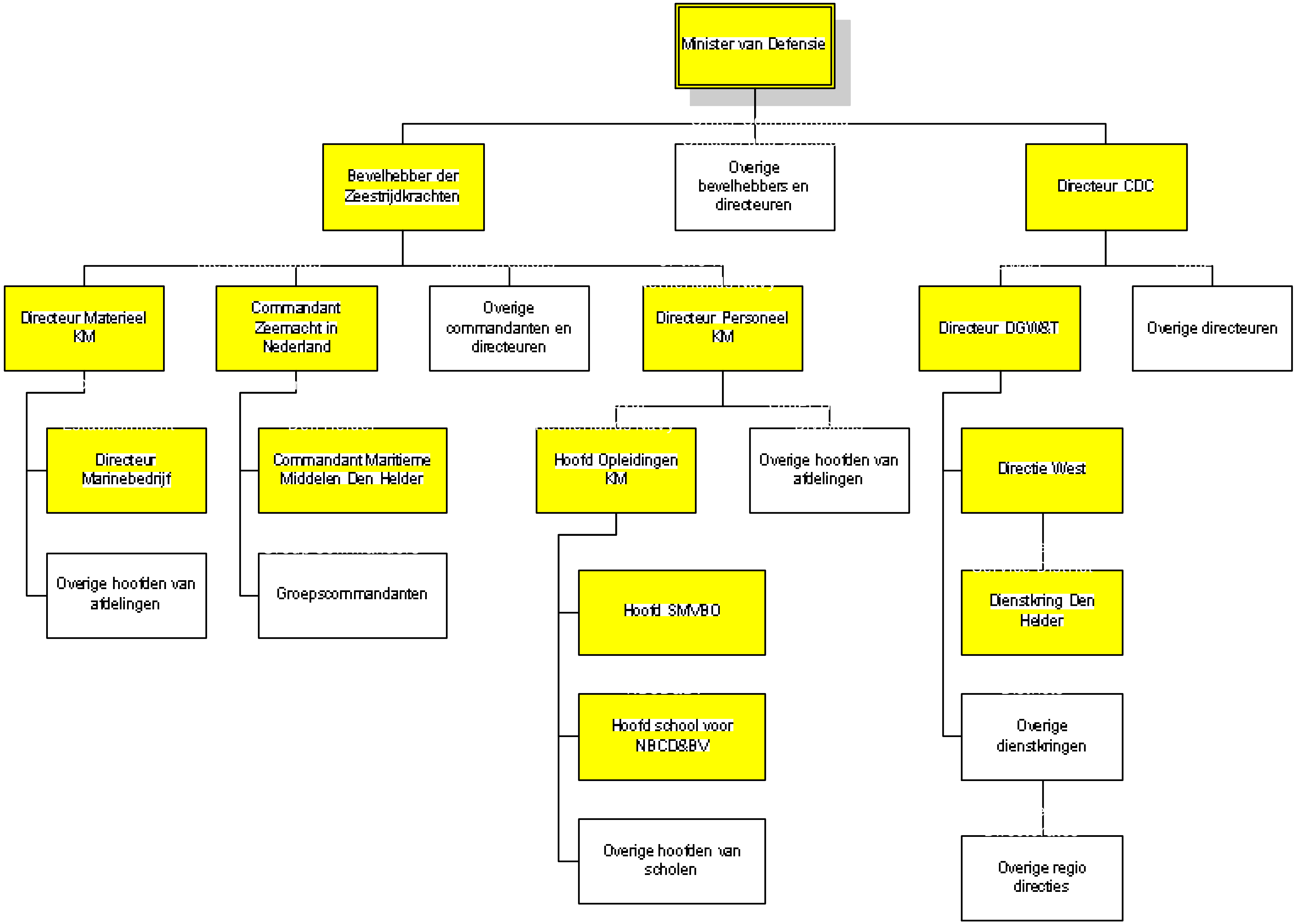
4222. Ordinances that contain *internal management rules*, applicable to the entire Royal Netherlands Navy, are laid down by the head of the Legal Affairs Division on behalf of the BDZ, in the form of a VVKM.

4321. The assessment of the quality and effectiveness of the KM regulations is part of the periodic audits conducted by the Policy Evaluation and Audit Division (BEA) of the Directorate of Economic Management of the Royal Netherlands Navy. If a deficiency is detected in the regulations, this is reported to the head of the Regulations Office.

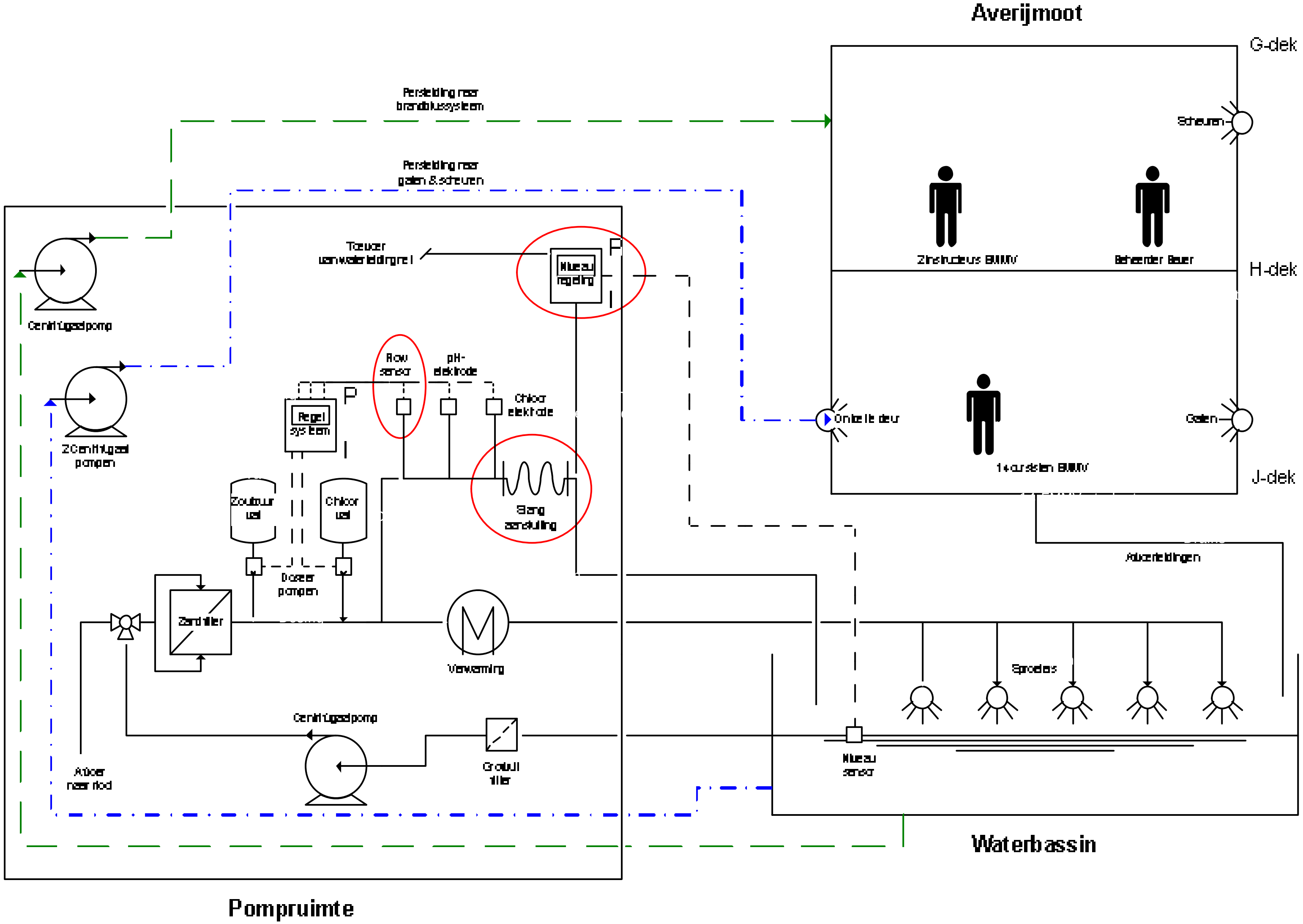
4511. All those to whom a KM ordinance applies are obliged to comply with it.

4512. If anyone to whom a KM ordinance applies is of the opinion that he cannot comply with the ordinance in question, he must report this to his superior.

ANNEX C. ORGANISATION CHART DATED 04/07/2005



ANNEX D. SCHEMATIC ILLUSTRATION OF WATER FLOW



ANNEX E. THE PRINCIPLE OF DISINFECTING

To disinfect the water and continue to provide a disinfecting effect after the treatment, an excess dose of chlorine bleach lye is administered (approx. 1 mg/l). Chlorine bleach lye, as used in the damage simulator, is a sodium hypochlorite solution with an excess dose of caustic soda. This gives the solution a high acidity level, making it more stable. The addition of chlorine bleach lye to the water that requires treatment will therefore lead to an increase in acidity.

However, the disinfecting effect is reduced if the acid content is high. Consequently, it is necessary to dose acid to bring the acidity level to an acceptable low value of 6.8 to 7.8. At this acidity level, some of the hypochlorite is converted into the more active hypochlorous acid. If the acidity continues to drop below 6.8, as a consequence of acid dosing, the remaining hypochlorite will also be converted into hypochlorous acid. If it drops even further, this will cause the hypochlorous acid to convert into chlorine gas. Chlorine gas dissolves readily in water (at 25ºC approx. 6.5 g/l). The amount of chlorine gas that escapes from the water will depend on the acid content, the quantity of free available chlorine, the chloride content and the agitation of the water.

The upshot of this is that if chlorine bleach lye is applied as a disinfectant it is necessary to (downwards) correct the acidity with the help of acid. However, an excess dose of acid (acidity < 4.5) in the water will lead to the generation of chlorine gas. If the water comes into contact with air (atomisation), chlorine gas will also be released into the air.

An important phenomenon in the addition of chemicals is the buffer capacity of the water. This is the range within which the acidity of a buffer hardly changes following the addition of acid or base. The higher the buffer capacity, the more acid is needed to lower the water's acidity. In the absence of any buffer capacity, even a low acid dose will lead to a huge reduction in acidity. Tap water contains a buffer capacity in the form of hydrogen carbonate. The longer the water is in the water treatment installation, the more the concentration of hydrogen carbonate (i.e. buffer capacity) will be reduced. The repeated dosing of acid is the reason for this. The norm for buffer capacity is: >1 mmol/l.

ANNEX F. TRIPOD ANALYSIS

The TRIPOD method was used in the analysis of the incident. This method was developed to trace the direct causes of an incident back to shortcomings in organisations responsible for the safe operation of the (sub-)system in question. The TRIPOD theory on which the analysis method is based assumes that people act and behave the way they do in specific situations because the system allows them to (wittingly or otherwise) and that circumstances are easier to influence than people. The circumstances under which it has been possible to make the active error then lead to the latent factors that are regarded as (indirect) causes of the incident.

According to the TRIPOD theory, unwelcome events/accidents are the result of a loss of control for (business) processes. In other words, an accident/unwelcome event occurs because barriers that should regulate the process are missing or failing. Missing barriers are the consequence of latent errors; failing barriers are the consequence of active errors. These active errors can be explained by the context in which they take place. The context is established by errors at system level (underlying factors or latent errors). Questions for the investigation can be formulated by identifying the specific hazards, the event and targets and then the barriers, active errors, context and underlying factors.

As indicated, the basis for TRIPOD is formed by a HET (**H**azard **E**vent **T**arget) diagram. In the diagrams, dangers are depicted with yellow and black stripes, events/accidents are shown red and targets are presented in green. TRIPOD assumes that by implementing measures (barriers) it is possible to control the danger to prevent the event from happening or – if the measures fail – to protect people and equipment against the consequences of an accident.
TRIPOD makes a distinction between failing barriers, inadequate barriers and missing barriers. A failing barrier is a barrier that has always been in place and has always worked. At the time of the event or accident something went wrong causing the barrier as a whole to fail. An inadequate barrier is a measure that the owner or user of an installation believes offers sufficient protection. A missing barrier is a barrier that could have been installed to offer sufficient protection, but was not.