THE DUTCH
SAFETY BOARD

Tank fires, BOPEC Bonaire,

8-11 September 2010

TANK FIRES, BOPEC BONAIRE,
8-11 SEPTEMBER 2010

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THE DUTCH SAFETY BOARD

The Dutch Safety Board has been set up to carry out the task of investigating and determining the causes or probable causes of individual or categories of incidents in all sectors. The objective of these investigations is solely to prevent future accidents or incidents and, when the results give cause to do so, issue recommendations. The organization consists of a Board with five permanent members and a professional bureau. The Dutch Safety Board appoints guidance committees for specific investigations.

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CONSIDERATION

At around noon on 8 September 2010, fire broke out in two Bonaire Petroleum Corporation (BOPEC) storage tanks on Bonaire, caused by a lightning strike during severe weather. The two burning tanks were approximately 800 metres apart. The vapour along the rim seal of the floating roofs of both tanks had ignited at various points. The two tanks held liquids classified as highly inflammable: crude oil in the case of tank 1901 and naphtha in tank 1931. While the fire in the tank containing crude oil was extinguished later the same afternoon, the fire in the tank containing naphtha escalated and the tank was burnt out completely by the evening of 8 September. The naphtha tank fire was put out completely on 11 September. While the fires resulted in no injuries, there was damage to property.

Thanks to the efforts of the island fire service and BOPEC's own fire officers, the fire in the crude oil tank was extinguished the same afternoon and it was possible to save the tank. The naval vessel HMS Zuiderkruis also came to offer assistance in the form of extinguishing water pumps, foaming agent and two fire fighting teams.

This investigation into the BOPEC tank fires was conducted at the request of the then-Governor of the Netherlands Antilles and the Lieutenant Governor of the island territory of Bonaire.

BOPEC

Fire caused by lightning strikes is always a risk when products such as crude oil and naphtha are stored in floating-roof tanks. The sector and governments worldwide accept this risk, providing a number of conditions are met in order to minimise the risk of fire and limit the consequences in the event of a fire. The risk is accepted, because a floating-roof tank is the safest way (i.e. best technology available) to store large volumes of liquid fuels. Global standards were drawn up to establish a uniform approach. Some of the most widely applied standards are those of the American Petroleum Institute (API), a sector organisation which has laid down parameters for the storage of liquid fuels in storage tanks in documents called 'Standards' and 'Recommended Practices'. The API documents address the following subject areas:

- Design and construction of storage tanks;
- Inspection, maintenance and renovation of storage tanks;
- Protection of storage tanks against ignition caused by a lightning strike and static electricity;
- Fire safety;
- Fire fighting.

According to the BOPEC handbook, the design, construction, maintenance and operation of the storage tanks complied with the API standards. However, the investigation revealed that in September 2010 BOPEC was not in compliance with several points of the conditions of the API Standards and Recommended Practices.

The general impression from the investigation is that the storage tanks were designed and built in 1973 in accordance with the then-prevailing API Standards and Recommended Practices. BOPEC failed to demonstrate that the tanks were inspected and maintained in accordance with the Standards and Recommended Practices. BOPEC was aware of these shortcomings, but opted to do anything about them.

BOPEC is situated in a remote part of Bonaire and is surrounded by a nature reserve, which means that BOPEC initially relies on its own resources when it has to fight fires. This is one of the reasons why the Safety Board believes it is important that the government of Bonaire set quality requirements for fire safety at BOPEC.

BOPEC had an emergency manual outlining the fire fighting procedure. The storage tanks also had a fixed fire-extinguishing installation that was connected to an extinguishing system. In addition, BOPEC had mobile extinguishing equipment. However, due to lack of maintenance, the fixed and mobile equipment either did not work properly or did not work at all.
The pumps were unable to provide a sufficient level of water pressure, preventing fire fighting efforts from proceeding as planned and as described in the emergency manual.
A rim seal fire is extinguished by squirting foam created by mixing water and foaming agent through openings in the tank wall onto the fire. Although BOPEC had a supply of foaming agent in two storage tanks containing enough foaming agent to extinguish the two fires, the investigation revealed that BOPEC's foaming agent was nearly all gone after the fire in the crude oil tank had been extinguished. In addition, some foaming agent was lost in the various attempts to use the poorly functioning equipment to extinguish the fires. The crude oil tank's fixed extinguishing installation was not working, so the fire service put the fire out in this tank using foaming agent and water from the fire engines belonging to the island fire service.
The foam proportioner near the naphtha tank failed to work properly, as a result of which no foam mixture was formed. In addition, the openings from the fixed fire-extinguishing installation on the naphtha tank were blocked. BOPEC's mobile extinguishing equipment was also in a poor state of repair. After the fire in the crude oil tank had been extinguished around 5.30 p.m., the burning naphtha in the other tank could not be tackled immediately due to the lack of sufficient foaming agent. The fire officers were also unable to climb up the staircase along the tank wall, as the fire generated excessively hot conditions.
At 6 p.m. on 8 September 2010, fire fighters were present from BOPEC, the Bonaire island fire service, the Venezuelan parent company PDVSA and the naval vessel HMS Zuiderkruis. The fire fighters waited from 5.30 p.m. to 10 p.m. for more foaming agent to arrive. During the wait, the roof and the wall of the still burning naphtha tank were alternately sprayed and cooled from one side using a single water cannon. The first meeting of all the fire fighters about a joint approach was convened at 10 p.m. During preparations for joint deployment, between 11 p.m. and 11.30 p.m., the floating roof sank – very probably as a result of spraying large quantities of water into the tank from one side and the roof's pontoons giving way – causing the fire to escalate and ignite the entire surface of the tank. The usual practice is not to begin fighting a tank fire until there are sufficient resources present to fight the fire effectively. After the fire had escalated, lack of resources meant that the fire service was unable to do more than protect the surrounding area and allow the tank to burn out under controlled conditions. The tank did not fully burn out until Saturday 11 September.

Government of Bonaire

On 8 September 2010, when the fires occurred, the island of Bonaire was part of the Netherlands Antilles. In accordance with the Islands Regulation of the Netherlands Antilles, the administration of each island (territory) consisted of an Island Council, a Governing Council and a Lieutenant Governor.
The Island Council of Bonaire drew up the legal framework for fighting and preventing fires at BOPEC by adopting the Bonaire Nuisance Ordinance (1995) and the Island Ordinance on the Fire Service (1999). Although this provided the government with the statutory framework to set requirements for operations and fire fighting at BOPEC, detailed rules and the accompanying supervision system within this statutory framework were never worked out. The situation was the result of historical factors dating back to BOPEC's founding in 1973. The Governing Council therefore neglected to set requirements and supervise BOPEC's activities and organisation.
Although the statutory framework had also been established for how the government was supposed to organise crisis management and emergency response when the Island Council of Bonaire adopted the Island Ordinance on Disaster Response (2002), the Lieutenant Governor did not draft a disaster response plan for BOPEC under this Island Ordinance. In 2008, the Lieutenant Governor asked the Netherlands for assistance in gaining a better understanding of foreseeable disasters on Bonaire. However, the fires occurred before work began on drafting a disaster response plan for BOPEC.
Even though the Lieutenant Governor of Bonaire is in supreme command in the event of fire and emergency response, which therefore includes the BOPEC tank fires, the island fire service was nonetheless ill prepared to fight tank fires. Instead, the island fire service focussed specifically on fire fighting in the event of aviation accidents. Until 2007, BOPEC took part in joint exercises with

the island fire service. Starting in 2007, BOPEC took the unilateral decision to stop taking part in these joint exercises.

Constitutional change as of 10 October 2010

Bonaire was part of the Netherlands Antilles when the fires occurred. However, on 10 October 2010, one month after the fires, a constitutional change took place that made Bonaire a special municipality of the Netherlands. Before the fires, in the run-up to the constitutional change, the administration expressed the intention to test safety at BOPEC and to resume joint exercises with BOPEC.

Following the change, Bonaire now has two layers of government, namely the local government and the Dutch National Government. The Dutch National Government has largely taken over the former national duties of the Netherlands Antilles. Local government is under the control of the people's own representatives on the Island Council. Bonaire's statutory framework remained in place after 10 October 2010 and has been or will be extended and updated where necessary with new laws.

The Dutch Minister of Security and Justice has had overall control of the Bonaire fire service since the constitutional change on 10 October 2010. After the Housing, Spatial Planning and Environmental Management Act BES[1] comes into effect, the Minister of Infrastructure and the Environment will be ultimately responsible for issuing an environmental permit to BOPEC and for its supervision.

If BOPEC were based in the Netherlands, the company would have to comply with the strictest category of requirements of the Major Accidents (Risks) Decree 1999 (*BRZO'99*)) given the possible threats to the surrounding area (external safety). However, the BRZO'99 does not apply on Bonaire, as it is not a Kingdom Decree. Instead, it represents the Dutch implementation of European regulations, namely the Seveso II Directive. As part of the Netherlands Antilles prior to 10 October 2010 and as a public body of the Netherlands ever since, Bonaire falls into the category of European Union 'Overseas Countries and Territories' (OCT). European law and European rules have not been declared applicable to OCT. Although Dutch legislation (i.e. the BRZO'99) does not apply on the BES Islands, the ideas in BRZO'99 have been incorporated into the legislative proposal developed by the Ministry of Housing, Spatial Development and the Environment (VROM) for the BES Islands. Following on from the fire at Chemie Pack in Moerdijk on 5 January 2011, the VROM Inspectorate conducted a quick scan of high-risk companies. Based on the results of this quick scan, the State Secretary of Infrastructure and the Environment informed the Lower House of Parliament about follow-up actions:
"*As regards the group of high-risk companies, I will conduct an exploratory study of the possible ways of strengthening the grip on the safety and security situation at those companies from the national government level, allowing for the establishment of a national network of robust Regional Implementation Agencies (RUDs)".*

Given the fact that the State Secretary spoke about 'national government level', the Safety Board had expected that the high-risk companies on the BES Islands would be included in this exploratory study in anticipation of the introduction of the Housing, Spatial Planning and Environmental Management (BES Islands) Act. However, the VROM Inspectorate did not include the BES Islands or Curacao, Aruba and Saint Martin in the study.

The Safety Board concludes that BOPEC and the government of Bonaire did not have matters properly in order in September 2010. Two tank fires broke out and one of them was able to escalate because BOPEC had not fulfilled its responsibilities as regards fighting and preventing fires in the storage tanks. The government of Bonaire had not imposed any rules on BOPEC.

1 'BES' stands for Bonaire, Saint Eustatius and Saba.

Recommendations

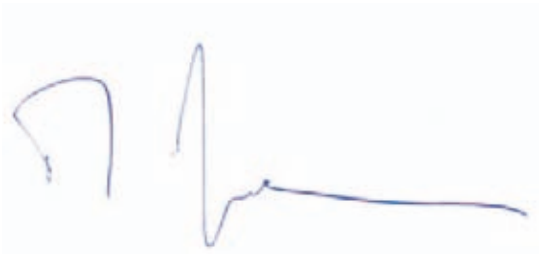
The Safety Board is aware of the developments on Bonaire after the fires (see Appendix 9). As the Lieutenant Governor felt it was important to assess the extent to which the BOPEC site could resume work after operations had been suspended on 10 September 2010, a group was established to advise on the matter. Based on the advisory group's findings, Bonaire's Lieutenant Governor gave BOPEC permission to resume operations – subject to strict conditions – on 7 October 2010. One of the conditions stipulates that only fuel oil shall be stored on the site, as it has a higher flash point than naphtha and crude oil and is therefore less flammable.

The Ministry of Infrastructure and the Environment is now processing BOPEC's environmental permit, which the Minister will grant under the Housing, Spatial Planning and Environmental Management (BES Islands) Act. The bill for this Act was passed by the Lower House of Dutch Parliament on 8 February 2011. The preliminary inquiry by the Upper House Committee for Kingdom Relations is not yet complete. The Plants and Activities (BES Islands Environmental Management) Decree that will ensue from the Act is currently expected to enter into force on 1 January 2012. The Minister will then be able to grant a permit to BOPEC.

However, in order to prevent any repeat of the subject of this investigation, the Safety Board considers it extremely important in the interests of fire safety that the following recommendations are implemented as soon as possible:

1. BOPEC
   Give verifiable priority to safety. Ensure in any event that the conductivity and earthing of the tanks and the maintenance and inspections of the installations and firefighting equipment meet BOPEC's own corporate standards, e.g. the Standards and Recommended Practices of the American Petroleum Institute and the National Fire Protection Association.

2. Governing Council of Bonaire
   Ensure that fire safety at BOPEC is and remains guaranteed by setting clear conditions. In this regard, the Safety Board believes it should be mandatory for BOPEC to have its own company fire service including joint exercises under the Island Ordinance on the Fire Service and its supervision.



T.H.J. Joustra
Chair of the Dutch Safety Board

M. Visser
General Secretary

LIST OF ABBREVAIATIONS AND TERMS

API	American Petroleum Institute
BES Islands	Bonaire, Saint Eustatius and Saba
BOPEC	Bonaire Petroleum Corporation
BOT-mi	Policy-Supporting Team for Environmental Incidents
BRZO'99	Major Accidents (Risks) Decree 1999
CoPI	Incident Location Command Team
Crash tender	Type of fire engine
DROB	Spatial Development and Management Department
ERC	Island Disasters Coordinator
ESF Group	Emergency Support Functions Group
Full surface fire	Fire in which the entire surface of the tank burns
GPM	Gallons per minute
ICAO	International Civil Aviation Organisation
NBBe	Netherlands Bureau of Fire Services Exams
NIFV	Netherlands Institute for Safety
OCT	Overseas Countries and Territories
PDVSA	Petróleos de Venezuela S.A.
Pontoon	Float under the tank roof
Rim seal fire	Fire in/on the seal of the tank's floating roof
Seal	The flexible seal between the floating roof and the tank wall
STIRANA	Netherlands Antilles Disaster Response Foundation
VROM	Dutch Ministry of Housing, Spatial Planning and the Environment (until 2011)

1 INTRODUCTION

At around noon on 8 September 2010, fire broke out in two Bonaire Petroleum Corporation (BOPEC) storage tanks on Bonaire, caused by a lightning strike during severe weather. The two burning tanks were approximately 800 metres apart. The vapour along the rim seal of the floating roofs of both tanks had ignited at various points. The two tanks held liquids classified as highly inflammable: crude oil in tank 1901 and naphtha in tank 1931. While the fire in the tank containing crude oil was extinguished later the same afternoon, the fire in the tank containing naphtha escalated and the tank was burnt out completely by the evening of 8 September. The naphtha tank fire was put out completely on 11 September.

1.1 Reason for the investigation

On 10 September 2010, the Lieutenant Governor of Bonaire, in agreement with the Prime Minister of the Netherlands Antilles, asked the Governor of the Netherlands Antilles to ask the Dutch Safety Board to initiate an investigation into the tank fires at BOPEC[2].

1.2 Objective of the investigation

The objective of the Safety Board's investigations is to prevent future incidents or at least to limit their consequences. It is the task of the Safety Board to investigate and determine the causes or probable causes of individual incidents or categories of incidents, to determine the scale of the consequences and where necessary to make recommendations.
The request from the Lieutenant Governor of Bonaire asked the Safety Board to investigate the *circumstances of the incident, to analyse and describe the actions of those involved and to make recommendations for the future*[3].

1.3 Questions to be answered and investigation method

The Safety Board set the following questions for the investigation into this incident to answer:
- How was it possible for the fires to start?
- How was it possible for the fire in naphtha tank 1931 to develop into a fire of uncontrollable proportions?

In order to answer these questions, the Safety Board first uncovered the direct causes of the incident based on the facts. The Board then investigated the underlying causes with a view to producing recommendations that would help to achieve structural improvements in physical safety on Bonaire. A detailed explanation of the basis for the investigation can be found in Appendix 1.

This report describes the administrative structure of the Netherlands Antilles as it was at the time of the incident between 8 and 11 September 2010. On 10 October 2010, i.e. not long after the incident occurred, the Kingdom of the Netherlands underwent constitutional reform in relation to the Netherlands Antilles (see Appendix 3). As part of this reform, Bonaire was given the status of a 'public body' of the Netherlands. There were also changes to laws and regulations, new names for various organisations and certain organisations became accountable to a different Ministry. These changes are stated in the present report. The Safety Board took the new situation into account when drawing up its recommendations based on the findings from the investigation.

2 Pursuant to Article 4(1)(b) of the Kingdom Act concerning Safety Investigation Board, the Dutch Safety Board was until 10 October 2010 authorised to respond to such a request by initiating an investigation into an incident on the Netherlands Antilles, including Bonaire. Since 10 October 2010, Bonaire has been a public body of the Netherlands and the Dutch Safety Board is authorised to initiate an investigation with or without a request accordingly.
3 Letter from the Lieutenant Governor of the Island Territory of Bonaire, dated 10 September 2010.

1.4 Reader's guide to this report

This report begins with an overview by the Safety Board based on the results of the investigation. The overview is an introductory section and states what was investigated, why it was investigated and how it was investigated. The questions for investigation are answered in the analysis in Chapter 3, which is followed by the conclusions and the recommendations. Chapter 2 contains the building blocks for the analysis, a description of the parties involved and a description of the different stages of the incident. A description of the geography and climate of the island of Bonaire can also be found in Chapter 2. Background information has been collected together in the report's appendices.

2 BACKGROUND INFORMATION AND CIRCUMSTANCES

At around 12 p.m. on 8 September 2010, fire broke out in two storage tanks belonging to the company BOPEC on Bonaire following a lightning strike during severe weather conditions. The vapour along the rim seal of the floating roofs of both tanks had ignited at various points. The fire in the tank containing crude oil (tank 1901) was extinguished later the same afternoon. The fire in the tank containing naphtha (tank 1931) escalated and the tank was completely burnt out by the evening of 8 September. The fire in the naphtha tank was put out on 11 September.

This chapter contains the information needed for the analysis in Section 3. The first part of this section provides an overview of the parties involved; the second part is about the location and climate of the island of Bonaire and the area around the BOPEC terminal; the third and final part of this section describes the various stages of the incident.

2.1 Parties involved

2.1.1 Bonaire Petroleum Corporation (BOPEC)

BOPEC operates a tank terminal for liquid petroleum products which arrive at the terminal and leave by ship. The products are stored in twelve large and eleven small storage tanks (a large tank can contain approximately 103,000 m^3 to 120,000 m^3 and a small tank approximately 27,000 m^3 to 32,000 m^3). The company also has a number of smaller tanks called 'utility tanks' for the support processes. The tanks are grouped together in a tank pit surrounded by a dike. BOPEC has four tank pits: A, B, C and utilities.

In 1973, BOPEC signed an agreement with the Netherlands Antilles and Bonaire to build and operate a tank terminal at the current location. The first tanks were built in 1974 by the then owners, the American company Northville and the Dutch company Paktank B.V. BOPEC has been a subsidiary of Petróleos de Venezuela, S.A. (PDVSA), the Venezuelan state oil company, since 1989. The name 'BOPEC' was retained after the new owners took over. The parent company PDVSA is also BOPEC's biggest client. One of the reasons why PDVSA owns a tank terminal on Bonaire is because the super mammoth tankers[4] carrying crude oil and liquid petroleum products to and from the terminal have a draught that is too deep for them to moor in Venezuela. They can moor at Bonaire, however. The large ocean-going vessels therefore load and unload from and into the storage tanks at the BOPEC terminal. Smaller vessels transport the liquid products to and from Venezuela. BOPEC stores fuel oil for the Bonaire power station. One of BOPEC's secondary activities was to collect and process waste oil for the community on Bonaire, but BOPEC discontinued this activity in March 2011 because no crude oil has been stored at the terminal since then.

4 Super mammoth tankers are the largest of the various different designs of tankers that moor at the BOPEC terminal.

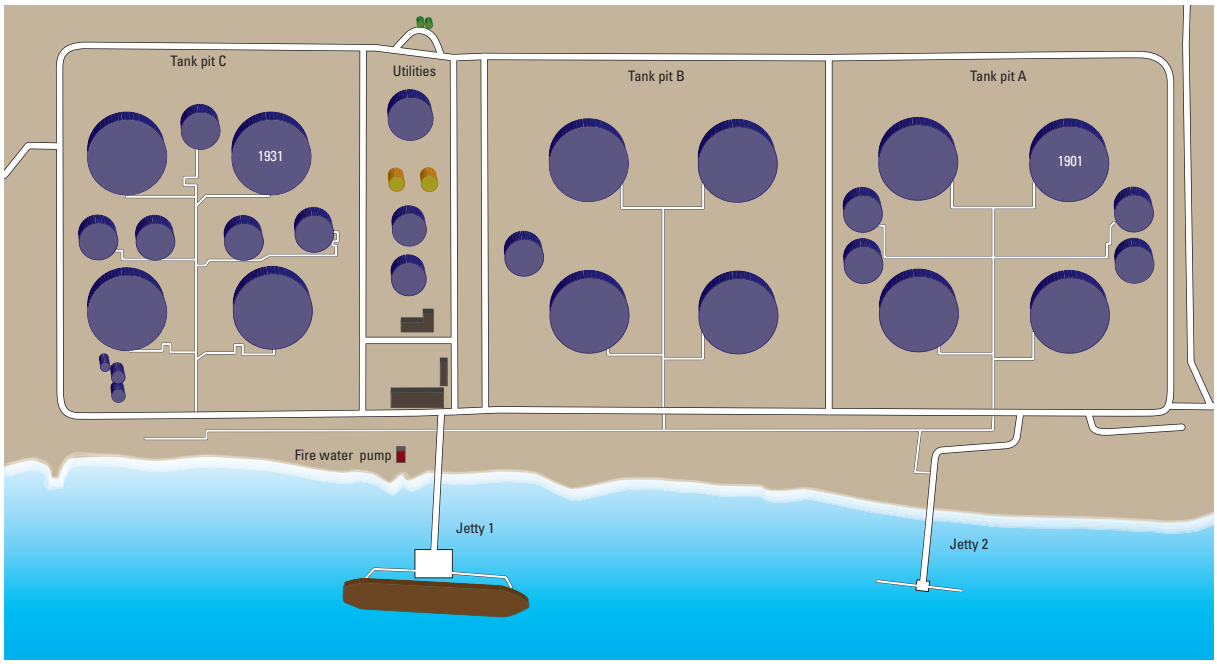


Figure 1: Map of the location

Storage tanks
The fires broke out in two storage tanks – numbers 1901 and 1931 – with a so-called 'floating roof'. Tank 1931 was lost in the fire, but tank 1901 was saved. Tank 1901 had a diameter of 83 metres and was 20 metres tall, whereas tank 1931 had a diameter of approximately 84 metres and was approximately 22.5 metres tall. A staircase running along the outside of the tank wall led up to the rim. At the top of the staircase there was a second staircase at a right angle to the inside of the wall, leading down onto the floating roof.[5] An illustration of a tank with a floating roof can be seen below.

Tank 1901 contained crude oil and had and has a single-deck floating roof. Tank 1931 contained naphtha and had a double-deck floating roof. There was a flexible seal between the floating roof and the tank wall. A foam dam ran around the edge of both roofs half a metre from the tank wall. If a fire breaks out, the foam dam ensures that the foam sprayed between the wall and the dam remains on the seal. This prevents the entire roof from being covered with a blanket of fire-extinguishing foam.

5 The roof's surface area is approximately 5,500 m^2.

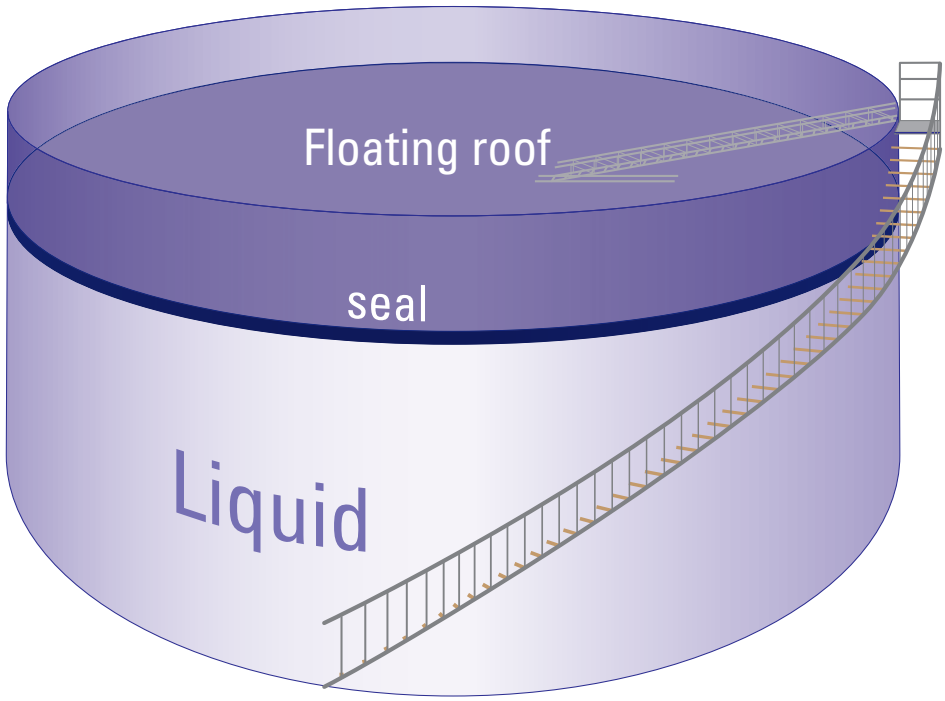


Figure 2: A schematic representation of a floating-roof storage tank.

BOPEC had and still does have a certified quality management system (ISO 9001) and a certified environmental management system (ISO 14001) with the accompanying handbooks, BOPEC also has a safety management system. BOPEC applies the Standards and Recommended Practices published by the American Petroleum Institute (API). There is also an agreement between BOPEC, the Netherlands Antilles and the administration on the island of Bonaire from 1973. This agreement states:
"All stages and components of the Project must be constructed and operated in accordance with the latest specifications of the American Petroleum Institute, and with all laws, rules and regulations of the Central Government valid within the Netherlands Antilles applied and enforced as to all petroleum enterprises in the Netherlands Antilles and as may be supplemented by the Island Government within the authority granted by the Central Government or the fundamental laws of the Netherlands Antilles, in order to avoid to the maximum extent possible all pollution of air, water and land or other disturbances to third parties".

The American Petroleum Institute (API) is the American sector association for the oil and gas industry. API has 400 members, including producers, refineries, suppliers, managers of pipelines and shipping companies, and also service and supply companies that provide the sector with products and services. The Dutch guidelines[6] refer to the Standards published by the API.

2.1.2 Authorities

At the time of the fires, the island of Bonaire was part of the Netherlands Antilles.[7] The Islands Regulation of the Netherlands Antilles stated that the administration of each island (territory) consisted of the Island Council, the Governing Council and the Lieutenant Governor. The Island Secretary was head of the civil service.

6 PGS 29, ['Guidelines for the above-ground storage of flammable liquids in vertical cylindrical tanks']. PGS 29 was previously CPR 9-2 and CPR 9-3. These guidelines have existed since 1975.
7 Following the constitutional changes of 10 October 2010, Bonaire became a public body of the Netherlands.

Since the constitutional changes of 10 October 2010, Bonaire[8] has been a public body answerable to the Dutch National Government which has largely taken the place of the Netherlands Antilles. The local Bonaire government is under the control of the people's own representatives on the Island Council.

Bonaire's legal framework remained intact after 10 October 2010 and where necessary it was updated and expanded by the addition of new laws (so-called 'BES laws') because of the new ministerial responsibilities.[9] A draft national ordinance on the principles of environmental protection was prepared by the civil service with a view to providing the necessary frameworks and standards for environmental protection. This draft ordinance was not put forward for debate in the Parliament of the Netherlands Antilles, however. The new law which is supposed to fill this gap is the Housing, Spatial Planning and Environmental Management (Bonaire, Saint Eustatius and Saba) Act which is currently under consideration by the Upper House.
The Island Ordinance on the Fire Service and the Island Ordinance on Disaster Response were replaced by the Safety (BES Islands) Act as of 30 September 2010.

Island Council of Bonaire
The Island Council is a body of elected representatives of the people of Bonaire. The Island Council represents the entire population of the island territory of Bonaire. The Lieutenant Governor is the Chairman of the Island Council and has an advisory vote in the Council. The following resolutions passed by the Island Council are relevant to this investigation:
- Island Ordinance on Disaster Response on Bonaire (2002);
  - Island Disaster Plan (1997);
- Island Ordinance on the Fire Service (1999);
- Bonaire Nuisance Ordinance (1995).

Island Ordinance on Disaster Response on Bonaire
The Island Ordinance on Disaster Response lays down rules about preparing for and responding to disasters. This ordinance states, for example, that an island disaster plan must be drawn up. The disaster plan must state in general terms how the various parties are required to act to ensure an effective response to disasters (Article 3). This ordinance also describes the tasks and responsibilities of the Governing Council, the Island Council, the Lieutenant Governor and the Head of the Fire Service, as regards both preparation for and action in the event of a disaster. The Island Ordinance also prescribes that a disaster response plan must be laid down for specific disasters where the location, nature and consequences of the disaster are foreseeable. That plan must include the measures to prepare for the response to the specific disaster (Article 4).

Island Disaster Plan
According to Article 3 of the Island Ordinance, the Island Disaster Plan must include the following:
- a list of the types of disasters that might affect the island;
- a list – per disaster – of the agencies and organisations involved, together with a description of their tasks and a statement of their human and material resources (including numbers);
- rules about alerting, informing and deploying the agencies and organisations involved.

Island Ordinance on the Fire Service of Bonaire
The Island Ordinance on the Fire Service describes corrective, preventive and preparatory tasks of the Fire Service of Bonaire (Article 1). Other important points in this ordinance include:
- requirements regarding the composition of the fire service;
- the requirement that rules must be drawn up regarding training, exams, service regulations and testing of suitability to be a member of the fire service;
- laying down rules about how the fire service is required to test permit applications against fire safety requirements, possibly in collaboration with other agencies;
- the obligation to establish a company fire service for companies that present a particular risk to public safety in the event of a fire.

8 The same also applies to Saint Eustatius and Saba.
9 Explanatory Memorandum accompanying the Housing, Spatial Planning and Environmental Management (BES Islands) Act, Lower House of Parliament record TK 2009-2010, 32 473, page 2.

In Article 13, the ordinance lays down the details of supervision of compliance and the accompanying powers for the people who conduct that supervision.

Bonaire Nuisance Ordinance
The Nuisance Ordinance regulates the obligation of designated plants to obtain a permit. Under this ordinance, activities are designated by Island Order as requiring a permit from the Governing Council.[10] The agreements reached at a meeting of representatives of the BES Islands administrations and representatives of the Dutch national government on 20 November 2008 including the following: *"From 2009 onwards, the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) shall arrange for new environmental permits for NuStar*[11] *and BOPEC. The planned date of entry into effect of these permits shall be 1 January 2011".*[12] Bonaire does not have any specific rules regarding external safety.

Governing Council of Bonaire
Chaired by the Lieutenant Governor, the Governing Council conducts the day-to-day administration of Bonaire. In addition to the Lieutenant Governor, the Governing Council also had four members in September 2010 (now three). The tasks of the Governing Council include the provision of a fire service and the supervision of any potential fire hazards.[13] The Governing Council arranges for the training of all personnel in the parts of the island organisation stated in the disaster plan that respond to disasters and serious accidents. The Governing Council also ensures that these people are so accustomed to each other and make such a good team that effective deployment is guaranteed.[14] Furthermore, the Governing Council is responsible for ensuring that the disaster plan is in line with the national coordination plan[15] and for the distribution of a copy of the plan to the Minister of General Affairs, the island councils and the governing councils of the other island territories.[16]

Based on the Island Ordinance on the Fire Service, the Governing Council determines the number of fire officers and the amount of materials.[17] The Governing Council is also responsible for:[18]
- the vehicles, buildings and equipment of the Bonaire fire service being in good condition;
- reporting stations and alarm systems to ensure an effective alert;
- fire-extinguishing facilities so that firefighting capacity is guaranteed as far as possible at all times.

The Governing Council laid down the general service regulations for fire service personnel, which include a description of the various jobs and ranks and the related tasks in the fire service.

BOPEC was not and is not one of the companies designated as having to have a company fire service. The Governing Council knew that BOPEC had an *emergency reaction team*. The Governing Council can determine that a company (plant) must have its own fire service because it presents a significant danger to public safety in the event of a fire or accident. The head or the board of a designated company is obliged to ensure that the company has a company fire service that complies with the personnel and equipment requirements stated in the designation[19]. The Island Ordinance on the Fire Service states that the Governing Council must designate persons who will supervise compliance with these requirements in the Ordinance.[20]

10 Bonaire Nuisance Ordinance, Article 3(1)(b).
11 NuStar operates a tank terminal on St. Eustatius.
12 List of resolutions, talks between BES and Dutch national government bodies on 20 November 2008 in The Hague.
13 Article 2, Island Ordinance on Disaster Response on Bonaire.
14 'Disaster plan for the island territory of Bonaire'.
15 The national coordination plan is the disaster plan for the entire Netherlands Antilles. Article 3(4), Island Ordinance on Disaster Response on Bonaire.
16 Article 3(7), Island Ordinance on Disaster Response on Bonaire.
17 Article 9, Island Ordinance on the Fire Service on Bonaire.
18 Article 10, Island Ordinance on the Fire Service on Bonaire.
19 Article 11, Island Ordinance on the Fire Service on Bonaire.
20 Article 13, Island Ordinance on the Fire Service on Bonaire.

The Governing Council also states that the Island Disasters Coordinator – in this case the chief of the fire service – is responsible for the operational coordination of preparations for disaster response.

In December 2009, the Governing Council of Bonaire decided, under the Nuisance Ordinance, that BOPEC's activities required a permit.[21] Transitional arrangements were subsequently adopted on 16 June 2010, under which designated companies that had submitted a permit application before 1 July 2010 would be permitted to continue the activities in question without a permit until 31 December 2010.[22] The Governing Council did not attach any conditions to these transitional arrangements in respect of BOPEC's activities. BOPEC had not applied for a permit from the Governing Council by 8 September 2010. After the Housing, Spatial Planning and Environmental Management (BES Islands) Act enters into force, the Minister of Infrastructure and the Environment will bear final responsibility for issuing an environmental permit and for supervision thereof.

The Dutch Minister of Security and Justice has had overall control of the fire service on Bonaire, Saint Eustatius and Saba since the constitutional reform on 10 October 2010. The Minister is responsible for appointing, promoting, suspending and dismissing the fire service personnel. The Minister can set disaster response and crisis management objectives which are then announced to the Dutch Parliament and the Governing Council.

The Governing Council neglected to set requirements for and to supervise BOPEC's activities and company fire service.
The Island Council of Bonaire had drawn up the legal framework for fighting and preventing fires at BOPEC. The Island Council adopted the Bonaire Nuisance Ordinance (1995) and the Island Ordinance on the Fire Service (1999).

- In 2009, the Governing Council of Bonaire decided that BOPEC's activities required a permit under the Nuisance Ordinance of 1995.
- In June 2010, the Governing Council gave BOPEC permission to conduct activities without a permit until 31 December 2010 and attached no conditions to that permission.
- The Governing Council did not designate BOPEC as a company that must establish its own fire service under the Island Ordinance on the Fire Service and, in not doing so, the Council failed to apply this local law.

Lieutenant Governor of Bonaire
In addition to his administrative tasks, the Lieutenant Governor is also in overall command of the fire service.[23] He is supported in that position by a disaster management committee which includes at least the operational leaders in any event. The Lieutenant Governor is authorised to give any orders that he deems necessary in response to a disaster.[24] The Lieutenant Governor will evaluate the disaster within six months of the end of the disaster and will inform the Island Council and the Minister of General Affairs of the Netherlands Antilles about the results of the evaluation. The Lieutenant Governor adopts a disaster response plan per type of disaster[25] and is responsible for the periodic updating of that plan. The Lieutenant Governor will lay down any changes to the disaster response plan in an Order. The Lieutenant Governor is also responsible for ensuring that the disaster response plans fit in with other similar plans and for sending the disaster response plan to the Minister of General Affairs of the Netherlands Antilles, island councils and governing councils of other island territories.[26]

Supporting parties from the Netherlands
In 1995, the Dutch Ministry of the Interior and Kingdom Relations launched a project to improve disaster response on the Netherlands Antilles following Hurricane Louis. The project was led by STIRANA (the Netherlands Antilles Disaster Response Foundation) and was commissioned by

21 Official Bulletin of Bonaire, no. 16, 22 December 2009, Article I(1).
22 Official Bulletin of Bonaire, no. 7, 16 July 2010, Article II.
23 Article 5(1), Island Ordinance on the Fire Service on Bonaire.
24 Article 8(3), Island Ordinance on Disaster Response.
25 Article 4, Island Ordinance on Disaster Response on Bonaire.
26 Article 4, Island Ordinance on Disaster Response on Bonaire.

the Ministry of the Interior and Kingdom Relations and the Lieutenant Governors. The Board of the STIRANA foundation consisted of the Lieutenant Governors of the five islands and the Prime Minister of the Antilles. Various representatives of the Netherlands were stationed on the Antilles for the duration of the project. After the project was finished, twinning arrangements were initiated between the various islands and cities in the Netherlands[27].

When the programme started that would lead to the change in the constitutional status of the BES Islands, the Ministry of the Interior and Kingdom Relations once again stationed a number of people on the Antilles to represent the Dutch Government. Their tasks included preparing for the transformation of the fire service from an island service to an agency of the Dutch central government. One of the main issues was the drafting of the new Safety (BES Islands) Act. The representatives of the Dutch National Government were also expected to raise the performance of the Bonaire fire service to Dutch national standards while taking into account the local circumstances on Bonaire. The Ministry of Housing, Spatial Planning and the Environment (VROM) also stationed a number of officials on Bonaire in preparation for the change in constitutional status on 10 October 2010. These VROM coordinators were given the task of familiarising themselves with the local situation.[28]

The Policy-Supporting Team for Environmental Incidents (BOT-mi) gave advice during the fires at BOPEC. BOT-mi is a Dutch partnership formed by knowledge centres, government departments and implementing organisations that helps crisis teams and the Dutch emergency services respond to disasters involving hazardous chemical substances. On request, BOT-mi will use its cumulative knowledge and experience to give advice about the consequences (for public health and the environment in particular) of accidents involving hazardous substances and about how to prevent or restrict those consequences.

2.2 Bonaire

Bonaire is an island with a surface area of 288 m^2 and over 16,000 inhabitants. Located off the coast of Venezuela to the east of Aruba and Curacao (see map), Bonaire is surrounded by coral reefs with enormous biodiversity that are a sensitive area and a major tourist attraction for the island.

Climate
Bonaire has a tropical climate with an average temperature of 30°C. The rainy season lasts from September to January. Rainstorms and thunderstorms during that part of the year usually begin in the late evening or early morning. The island is also in an area hit by the thunder, lightning and rain from an average of five to ten tropical storms every year between June and November.[29] Heavy rain and thunderstorms had occurred on the days preceding the tank fires.

The area around the BOPEC site
The tank terminal is located on the north-west point of the island, on the edge of the protected Washington Slagbaai National Park nature reserve. The nature reserve covers an area of 60 km^2 across the entire northern point of the island. The subsoil under the BOPEC site consists of coral debris (bioclastic limestone) down to approximately 25 m below sea level. Coral debris is a type of rock that is very permeable to seawater.
Bonaire's power station is on the east side of the island about 1 kilometre from the BOPEC site.
Bonaire has two major population centres: the capital city of Kralendijk (approx. 11,300 inhabitants) and Rincon about five kilometres away from BOPEC (approx. 1,700 inhabitants). There are no residences in the immediate vicinity of BOPEC.

27 'Twinning' is a bond of friendship between two institutions.
28 Explanatory Memorandum accompanying the Housing, Spatial Planning and Environmental Management (Bonaire, Saint Eustatius and Saba) Act, Lower House of Parliament record (*TK*) 2009-2010, 32 473, no. 3, page 4.
29 KNMI hurricane season.

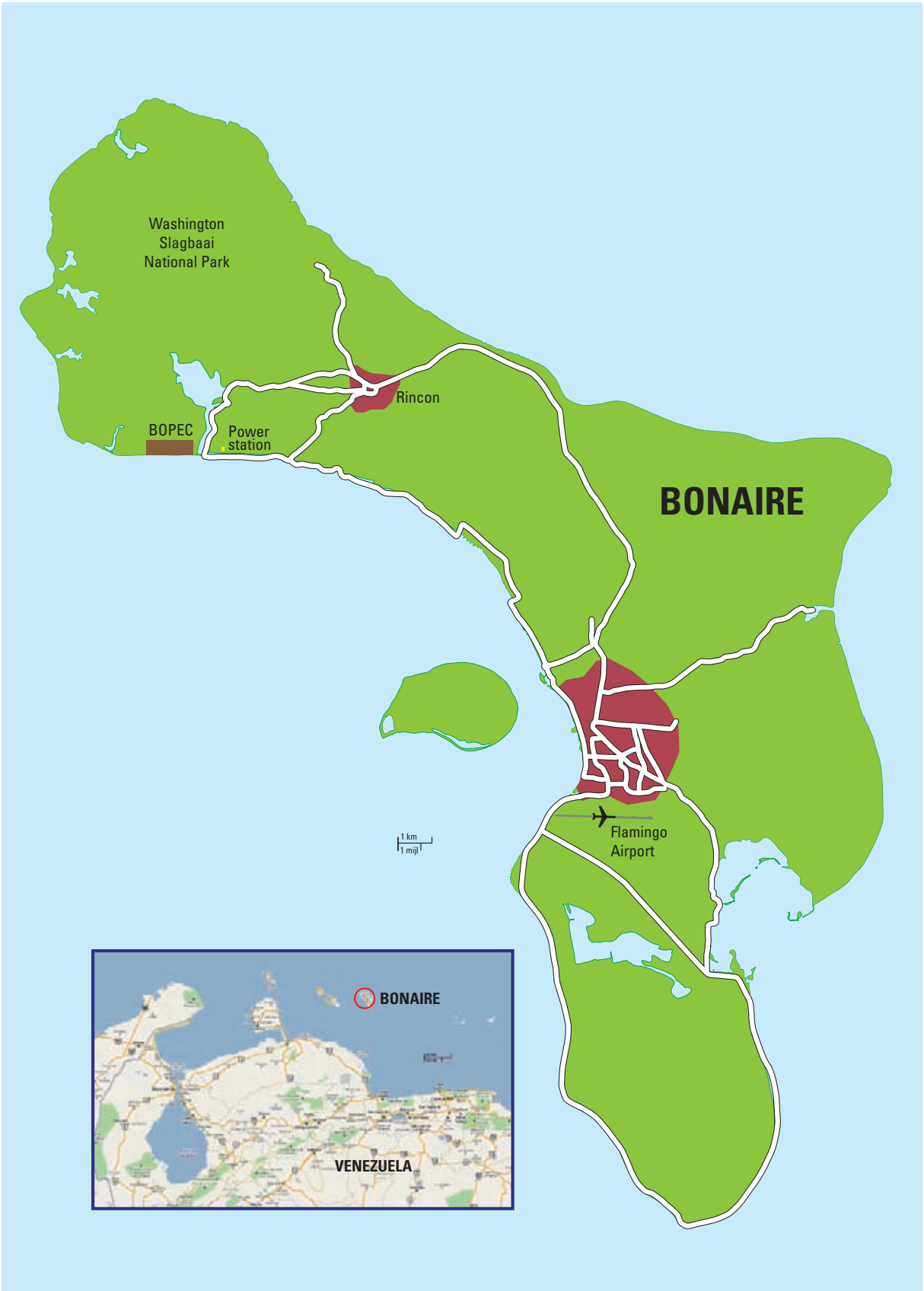


Figure 3: Map of Bonaire showing the BOPEC site and the geographical situation

2.3 Course of the incident

The weather on Bonaire on 8 September 2010 was severe with not much wind, but a lot of thunder and rain. Following a flash of lightning, the fire alarm for tank 1901 went off in the BOPEC control room at around 12 p.m. Staff from the operations department confirmed that a so-called 'rim seal fire'[30] had broken out in this tank. This information was passed on to BOPEC's Emergency Reaction Team. Employees then saw smoke coming from a second tank approximately 800 m away (tank 1931)[31], although the fire detection system had not triggered a fire alarm in the control room. This second fire was also a rim seal fire. BOPEC immediately requested extra supplies of foaming agent from sister companies on Curacao and in Venezuela. The fire fighters tackled both fires at the same time.
In order to enhance the clarity of this report, however, the situation in relation to each fire will be described separately, starting with the fire in tank 1901 and then moving on to the fire in tank 1931.

The crude oil tank (1901)
Tank 1901 contained crude oil which was classed as highly inflammable. The tank was approximately one sixth full (approx. 14,500 m^3) when the fire broke out. When the fire was discovered in this tank, BOPEC staff in the control room opened the delivery pipe from the tank's fixed fire-extinguishing installation. Staff then started the fire-extinguishing pumps by hand in the pump house. Two of the four pumps were out of order. The fixed fire-extinguishing installation did not work because the water pressure caused the foam pipe to rupture at the tank and a number of holes appeared in the pipe. Five BOPEC employees used the staircase to climb onto the tank. Three of the five attempted to extinguish the fire using six hand-held extinguishers, while the two others monitored the situation from the side platform. These employees were unable to put out the fire.

In the meantime, BOPEC's Emergency Reaction Team contacted the company's General Manager who, in turn, contacted the Lieutenant Governor and asked for the island fire service to be deployed. The island fire service received a report of a tank fire from BOPEC at their main station at Flamingo Airport near Kralendijk at 12.15 p.m. Two fire engines (water tenders) with a full load of foaming agent left for BOPEC immediately.
The fire engines arrived at BOPEC at around 12.45 p.m., where they each went to one tank fire and were given instructions by BOPEC employees regarding their part in the fire fighting operation. The chief and deputy chief of the fire service and the head of the response department travelled together from the fire service headquarters in Kralendijk to BOPEC where they arrived at around 1 p.m. The chief remained at the entrance gate to the site to coordinate the fire fighting efforts. The police cordoned off the road in order to keep access to the BOPEC site clear for the emergency services.

The fire service chief called in one crash tender[32] with a full load of foaming agent which was initially deployed to extinguish the fire in the crude oil tank (no. 1901) before moving later to the naphtha tank (no. 1931). The fire in the crude oil tank (1901) was finally extinguished manually at the end of the afternoon of 8 September in joint action taken by the island and BOPEC fire services. The BOPEC firefighters stood on the platform along the side of the tank wall to carry out this manual extinguishing operation. The fire officers carried two fire hoses up the tank's staircase to the platform for the extinguishing operation. Once on the platform, they connected two extinguishing hoses to these fire hoses. Foaming agent from the crash tender was sprayed onto the fire.

30 The tank was equipped with a flexible seal around the entire circumference between the floating roof and the tank wall. The fire in the tank broke out along this seal and was therefore what is known as a 'rim seal fire'.
31 Statements vary as regards when the fire in tank 1931 was discovered. Some of those interviewed stated that the fire was discovered at the same time as the fire in tank 1901, while others said that it was not discovered until BOPEC staff started spraying the fire in tank 1901.
32 A crash tender is a special type of fire engine that is mainly used to fight aircraft fires.

Once he had been informed about the fire at BOPEC, the Lieutenant Governor contacted the chief of the fire service who gave him an update on the situation. The Lieutenant Governor was subsequently given information by phone by the Dutch government coordinators[33] who were on site at the Lieutenant Governor's request because of the fire.[34] At 2 p.m. the Lieutenant Governor decided to go to BOPEC, where he arrived some time between 2.30 p.m. and 3 p.m. In order that they could provide the Lieutenant Governor with specific information about tank fires, the Dutch government coordinators suggested that advice should be requested from the Policy-Supporting Team for Environmental Incidents (BOT-mi) in the Netherlands. BOT-mi gave their advice around 2.30 p.m. After the Lieutenant Governor had been updated on site about the latest situation, he decided to stay and concentrate on finding more people, vehicles and resources for the ongoing operation. The Lieutenant Governor eventually left the BOPEC site around 5 p.m. after the fire had been extinguished in the crude oil tank (1901).

The harbour master in Kralendijk was informed by phone at approximately 12.30 p.m. that there was a fire in two tanks at BOPEC. At that time, two ships were moored at the BOPEC terminal. BOPEC informed the harbour master about the decision to disconnect these two ships from the BOPEC facility. The harbour master spoke to the captains of both ships in this regard before driving from Kralendijk to BOPEC. Two tugs also made the journey from Kralendijk to the BOPEC terminal. It took a while before the ships were unmoored, but after approximately an hour and a half, at around 3 p.m., the ships had moved away from the BOPEC jetties.

In a phone call to the harbour master after both ships had disengaged from the terminal, the coastguard (Netherlands Antilles & Aruba Coastguard) offered to send the Netherlands Navy vessel HMS Zuiderkruis to help fight the fires at BOPEC. The harbour master contacted the chief of the fire service about deployment of the coastguard. The chief of the fire service said he needed pumps to pressurise the water for fighting the fires as well as extra supplies of foaming agent. The HMS Zuiderkruis was deployed through the Lieutenant Governor. The HMS Zuiderkruis was initially sent to Bonaire by the Rescue Coordination Centre (RCC) of the Netherlands Antilles & Aruba Coastguard to stand by to provide emergency assistance. The HMS Zuiderkruis arrived at BOPEC at around 4 p.m. Initially, BOPEC did not give permission for the vessel to moor at the terminal, but after about an hour and a half BOPEC was urgently requested via the Lieutenant Governor to grant permission and they did so at approximately 6.25 p.m. At 8.25 p.m., the Lieutenant Governor asked the Governor of the Netherlands Antilles for military assistance so that crew and equipment from the HMS Zuiderkruis could be deployed onshore. The Flag Officer Netherlands Forces Caribbean subsequently ordered the HMS Zuiderkruis to provide the requested assistance.

The HMS Zuiderkruis had two fire fighting teams, a support team and a supply of foaming agent on board, as well as pumps to deliver sufficiently pressurised water to the BOPEC terminal. The pumps on the HMS Zuiderkruis were connected to BOPEC's water grid but this facility was not used.
The HMS Zuiderkruis also provided forty 20-litre drums of foaming agent. Around ten of these drums were manually unloaded onto the BOPEC jetty.

33 From the Ministry of Housing, Spatial Planning and the Environment (VROM) and the Ministry of the Interior and Kingdom Relations.
34 They were there to gather information for the intended updating of the disaster response plan.

Figure 4: Arrival of the HMS Zuiderkruis with the burning naphtha tank in the background[35]

The naphtha tank (tank 1931)
Tank 1931 contained naphtha and was a quarter full (approximately 22,300 m^3). In this case, the delivery pipe from the tank's fixed fire fighting installation was also opened from the control room, but the fire continued to burn. The deputy chief of the island fire service arrived at around 1 p.m. and went to the naphtha tank. One of the water tenders belonging to the island fire service had almost used up all of its supply of foam already at tank 1931. A BOPEC water cannon was also being used to cool the outside of the tank wall. An extra pump - a so-called 'booster pump' – was connected to the fire-extinguishing system to supply sufficiently pressurised water to the water cannon, but the booster pump broke down. A replacement was found, but it was not in working order either. No other mobile fire-extinguishing equipment was available because it was being used on the crude oil tank (1901).The island fire service also ran out of foaming agent.
Some of the foaming agent supplied by BOPEC was lost in the attempts to extinguish the fires using the fixed installations because of the need to connect and disconnect and because of the blockages in the system.

The attempts to extinguish the fire in the naphtha tank using mobile equipment were discontinued around 2.30 p.m. because the booster pump broke down. The chief of the fire service decided to call in a crash tender because a leak was preventing the fixed fire-extinguishing installation from working properly and the foam from the fire engines belonging to the island fire service had run out. When the tender arrived, it was first deployed to fight the fire in the crude oil tank (1901) before being moved later to the naphtha tank (1931).

Following advice now received from the Policy-Supporting Team for Environmental Incidents (BOT-mi), the efforts to cool the naphtha tank using a water jet were discontinued at around 4.15 p.m.

At around 4.30 p.m., two fire officers from the sister company on Curacao and four from the parent company in Venezuela (PDVSA) arrived on site, having been called in by BOPEC.

35 Source: Coastguard for the Netherlands Antilles and Aruba

As soon as the fire in the crude oil tank (1901) was extinguished at around 5 p.m., all of the fire-extinguishing equipment was available to tackle the fire in the naphtha tank (1931). Certain parts of the fire along the rim of the tank's floating roof had been extinguished using the faulty fixed installation, but in other places the fire continued to burn and was in fact able to escalate. The fire at the level of the external staircase was still burning, for example, and the staircase became too hot to walk on as a result of the heat from the fire. Access to the rim of the tank wall and the tank roof was therefore cut off.

A heat-sensitive camera belonging to the Navy was used at approximately 8.20 p.m. to measure the temperature under the fire. The reading showed that the temperature under the fire was in line with the ambient temperature. The temperature at the level of the fire had reached several hundred degrees Celsius. At that moment there was one water cannon spraying water onto the tank wall.

At 9.35 p.m., fire officers from PDVSA attempted to fight the fire from BOPEC's hoisting crane, but their efforts were unsuccessful. In the meantime, a tug arrived from Curacao carrying foaming agent in 200-litre drums[36] as well as water cannons. BOPEC's crane and the crew of the HMS Zuiderkruis were deployed to unload the tug from Curacao.

On the initiative of PDVSA fire officers, an initial meeting took place at 10 p.m. to draw up a joint deployment plan. The meeting was attended by BOPEC's General Manager, the island fire service, the PDVSA fire service team and the Navy.

It was agreed that a joint, coordinated attempt to use foam to extinguish the fire would be made at 11 p.m. Everyone then started preparing for this joint effort but the preparations were not completed on time and the agreed deadline of 11 p.m. was missed.

An explosion was heard at approximately 11.15 p.m. Around 11.30 p.m., the fire in the naphtha tank escalated before the planned joint deployment could be carried out. An enormous sea of fire rose up and came over the wall on one side of the tank. The flames rolled over the tank wall. Various small explosions and a single dull thud were heard. When the fire escalated, HMS Zuiderkruis decided to leave immediately to protect the safety of the ship, leaving Navy personnel behind onshore to help with the relief effort.

Disaster management committee
After he had been informed about the escalation of the fire, the Lieutenant Governor decided to call a meeting of part of the disaster management committee on the BOPEC site. The committee meeting was attended by the Public Prosecutor, the chief of the fire service, the police chief, a representative of the Spatial Development and Management Department, the Healthcare and Hygiene Department, the principal private secretary, a policy advisor, a legal advisor and the Secretary to the Commissioner for Bonaire, Saint Eustatius and Saba. The Dutch government coordinators, BOPEC's General Manager and the Naval Commander from HMS Zuiderkruis also joined the meeting.

36 How many 200-litre drums were brought in by the tug from Curacao is not known.

Figure 5: Escalation of the fire[37]

Thursday 9 September
The disaster management committee met at BOPEC between 1.30 a.m. and 2 a.m. The committee discussed a number of resulting scenarios and decided not to meet again as the full group because this incident did not qualify as a disaster. The police checked the area around the BOPEC site to see whether the local population needed to be evacuated, but that was not the case.
Some of the members of the disaster management committee met again during the afternoon of Thursday 9 September. At that meeting the Lieutenant Governor officially transferred overall management of the fire fighting operation to the commander of the PDVSA fire service team. The attempt to extinguish the fire in the naphtha tank was discontinued at that point, but spraying of the tank continued in order to keep it as cool as possible. Cooling of the surrounding tanks also continued. The fire fighters from the island fire service went home during the night to rest. The island fire service had no personnel available to relieve this team (who had been on site continuously up to that point).

The first load of foaming agent arrived at BOPEC from PDVSA Venezuela at 3 p.m.

Friday 10 September
On the morning of Friday 10 September at around 4.30 a.m. the fire in the naphtha tank began to recede. The responsibility for completing the extinguishing of the fire had just been transferred from the PDVSA team to the island fire service. More foaming agent from PDVSA Venezuela arrived at 5 a.m. At 6 a.m., the Lieutenant Governor received advice from the BOT-mi team to the effect that the operation to extinguish the fire should stop to let the fire burn itself out. Then let the tank cool down for 24 hours. However, the Lieutenant Governor had noticed that the wind had changed direction and there was a danger that the local population would be affected by smoke and soot, so the advice given by the BOT-mi team was not implemented. BOPEC and the island fire service renewed their efforts to use foam to extinguish the fire from 10 a.m. onwards. The outside wall was kept cool at the same time. By 12 p.m., the fire in the naphtha tank seemed to have been extinguished, but it flared up once again during the afternoon. At 7 p.m. the chief of the island fire

37 Source: Royal Netherlands Navy.

service gave the signal that the fire was under control. The fire service continued cooling down the tank until 10 p.m.

Saturday 11 September
On Saturday 11 September, however, the fire broke out again at a number of points in the tank. The fire in the naphtha tank (1931) was completely extinguished in the course of Saturday afternoon.

3 ANALYSIS

This chapter analyses the facts that were presented in the previous chapter. The first section describes the cause of the fires. The second section describes what BOPEC and the authorities have done to prevent fire as a result of a lightning strike (prevention). The third section analyses how BOPEC and the island fire service had prepared for a fire and how the firefighting operation was implemented (preparation and response). The sections on prevention, preparation and response set out the frame of reference and analyse the circumstances based on this frame of reference.

3.1 Cause of the fires

The two fires at BOPEC broke out at multiple points along the seal between the floating roof and the wall of the storage tanks in question immediately after a lightning strike on 8 September 2010. A lightning strike is a discharge of electricity from the sky to the earth that sometimes passes through a good conductor if one is present at the location concerned. Steel storage tanks are good conductors.

Figure 6: The fire in tank 1931 on 8 September 2010 at 5.22 p.m.[38]

38 Source: Coastguard for the Netherlands Antilles and Aruba

The Safety Board was unable to determine the precise point where the lightning struck. A strike in the immediate vicinity of a tank can also cause a fire in the tank.[39] The fact that lightning did strike in tank 1931 was proven by traces of soot found on the tank wall that were caused by the spark discharge[40]. The electric charge caused by the lightning strike jumped across from the tank wall to a nearby electricity cable, causing the cable to become hot because it was not intended to carry the amount of electricity discharged by a lightning strike. The coating of the electricity cable melted because of the heat and become stuck on an earthing cable coming from the tank (see Figure 7). The Safety Board considers it plausible that both fires were caused by a lightning strike, probably as a result of two different electrical discharges. A lightning strike in or immediately adjacent to the tank will produce arcs at the seal between the tank wall and the floating roof in particular. The next section describes how the seal works. The arcs are created at the seal because it is an interruption between the steel of the roof and the wall which both conduct the electrical current. The electric charge forms an arc from one conductor to the other, both above the seal and in the vapour space below it.[41]

Figure 7: The outside of the wall of tank 1931 with fresh soot marks caused by spark discharge on the left-hand side, the earthing cable and the melted electricity cable

In 1997, a project was launched by 16 major oil companies[42] to identify the dangers involved with floating roof storage tanks with a diameter larger than 40 metres. The project studied a total of 2,420 floating roof storage tanks with a combined total of 33,909 years in service between 1981 and 1995 at 164 locations in 36 different countries. The results revealed that 62 tank fires were reported; 55 were rim seal fires and 52 of those were caused by lightning. Enquires also revealed that another rim seal fire occurred at BOPEC in 2004.

39 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, lighting protection of floating roof storage tanks, June 1997, page 2.
40 Spark discharge typically leaves a hand-shaped soot mark behind as shown in the photo.
41 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, lightning protection of floating roof storage tanks, June 1997, figure 8.
42 Agrip Petrol, BP, Conoco, DEA, Elf, Exxon, MOL, Mobil, OMV, Petrofina, Repsol, Saudi Aramco, Shell, Total, Veba and WRG.

3.2 Fire prevention

A fire is an undesirable situation from a safety, environmental and economic point of view. BOPEC therefore has to take certain measures to prevent this situation from occurring.
Rim seal fires are the most likely fire scenario in the case of floating roof storage tanks, with a lightning strike as the most frequent source of ignition.[43] The next section describes the frame of reference for the measures to prevent fires as a consequence of lightning. This is followed by a comparison between the actual circumstances at BOPEC and the frame of reference and then by the conclusions from the comparison drawn by the Safety Board.

3.2.1 Frame of reference

There are no rules applicable to BOPEC under public law because the Governing Council of Bonaire has not built on the statutory framework provided by the Nuisance Ordinance and the Island Ordinance on the Fire Service to prescribe specific rules, nor has it set conditions for exemption from these rules. BOPEC uses the Standards and Recommended Practices published by the American Petroleum Institute (API). Those documents are also referred to in the agreement between BOPEC, the Netherlands Antilles and Bonaire. The Safety Board therefore used the API documents as the frame of reference. The following API documents are relevant to this investigation:

- *API 650 Standard: Welded Tanks for Oil Storage, July 1973 and June 2007;*
- *API 653 Standard: Tank Inspection, Repair, Alteration and Reconstruction, August 2010;*
- *API 2003 Recommended Practice: Protection Against Ignitions Arising out of Static, Lightning and Stray Currents, September 1998;*
- *API 545 Recommended Practice: Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids, October 2009;*
- *API 2001 Recommended Practice: Fire Protection in Refineries, May 2005;*
- API 2021 Recommended Practice: Management of Atmospheric Storage Tank Fires, May 2001, reaffirmed June 2006.

The Safety Board checked whether BOPEC complies with the requirements laid down in the API documents. This investigation used both the currently applicable version of API 650 – the tank construction standard – and the version that applied in 1974 when the tanks were built.

3.2.2 Fire prevention at BOPEC

The design of the storage tanks
The design of a storage tank depends on the properties of the liquid that will be stored in the tank. According to a statement provided by BOPEC, tank 1901 contained 'napo crude'. Napo crude oil has a flash point[44] of 15.6°C and a variable boiling range[45]. Tank 1931 contained 'catalytic naphtha', which has a flash point lower than -40°C and a boiling range of 30°C to 202°C. This means that both substances give off sufficient flammable vapour to ignite at an average ambient temperature of 30°C – as on Bonaire – when they are in the presence of sparks and mixed with outside air.

BOPEC built the storage tanks in 1974. As far as the Safety Board could determine, they were built in accordance with API 650: Welded steel tanks for oil storage, July 1973. In order to prevent the flammable vapour from collecting above the liquid, BOPEC stores these substances in floating roof tanks. There is little vapour space between the liquid and the roof because the roof floats on the flammable liquid, which means that the danger of a fire or an explosion is reduced compared to a tank with a fixed roof.

Space is needed between the seal and the tank wall because the floating roof must move freely along the tank wall during emptying or filling of the tank. As a result, a certain amount of vapour is always lost from the tank.

43 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, June 1997, page 12.
44 The flash point of a substance is the lowest liquid temperature at which the substance still gives off sufficient vapour to ignite when the vapour-air mixture comes into contact with an ignition source.
45 The boiling range is the temperature range within which a liquid *mixture* transforms into its gaseous state.

There are three ways in which flammable vapour can be released from floating roof storage tanks:
1. evaporation along the seal;
2. evaporation of the layer of liquid that remains on the tank wall when the tank is emptied;
3. evaporation of naphtha or crude oil that ends up on the roof or on the seal because the tank is filled too quickly or overfilled.

Because the two substances involved in the incident under investigation both evaporate quickly, it is very unlikely that the second or third way mentioned above was a factor in the fires breaking out on 8 September 2010. The last activity involving each tank before the fire was when they were emptied, so liquid product on the roof or the seal as a result of filling the tank too quickly or overfilling can be ruled out. The last time that naphtha was pumped from tank 1931 to a ship was between 3 and 5 September 2010. The fire broke out on 8 September.
An analysis of the design and maintenance of the seal would prove whether the remaining possibility as regards the release of flammable vapour did occur.
This analysis is described in the following sections.

The design of the seal
The purpose of the seal is to minimise the amount of vapour lost from crude oil or naphtha tanks by sealing the gap between the roof and the wall of the tank. However, because the roof must be able to move, seals are never made fully vapour-tight. The Safety Board calculated the amount of vapour lost[46] for both tanks (see Table 1) in order to give an idea of the amount of flammable vapour that can be released with a properly functioning seal. The type of seal used is decisive as regards the result of this calculation. BOPEC drawings and documents showed that both tanks were equipped with a mechanical shoe fitted with a primary seal. In addition to the primary seal, the crude oil tank (1901) also had a rim-mounted secondary seal.

46 'Diffuse emissions and storage and transhipment emissions, handbook of emission factors', series of *MilieuMonitor* reports, issue 14, March 2004.

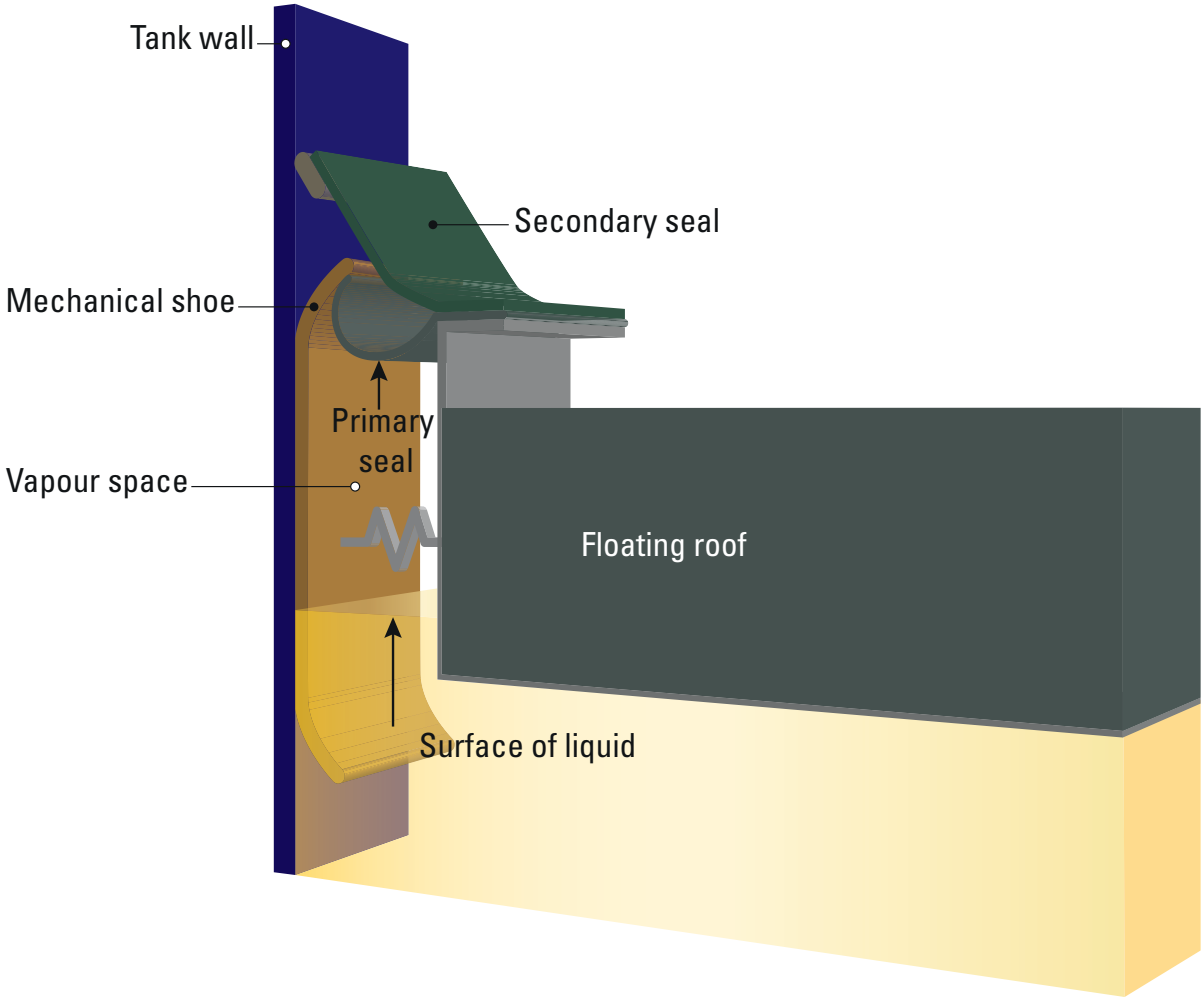


Figure 8: Simplified diagram of a mechanical shoe seal with a primary and a secondary seal (tank 1901). Tank 1931 only had a primary seal.

In the mechanical shoe seal, a metal plate (the "shoe") is pressed against the tank wall by an open mechanical structure connected to the floating roof. The bottom end of the shoe is in the liquid that is stored in the tank. The shoe and the floating roof are connected to each other by a large flexible rubber flap[47]; the shoe and the flap together form the primary seal. The rubber flap seals off the opening above the mechanical structure, between the *shoe* and the floating roof. The rubber flap is large (there is often some slack) in order to ensure that the roof can move.

There was a second rubber flap[48] – the secondary seal – above the primary seal in the crude oil tank so that vapour allowed through by the primary seal would still be kept within the tank by the secondary seal. The secondary seal is connected to the roof and leans against the wall. The rubber of the secondary seal lies on a metal ridge that holds the flap in place. The secondary seal plays a decisive role as regards reducing the amount of vapour lost, because it covers the entire space between the roof and the tank wall. This can be seen in Appendix 5 in the results of the calculation of the amount of vapour lost (see also the table below). In this theoretical model, a secondary seal means 79% less flammable vapour. Tanks with both a primary and a secondary seal give off less vapour.

47 2008 Buna-N.
48 2008 Buna-N.

Tank	With/without a secondary seal	Vapour lost through the seal[49]
Naphtha (1931)	With (rim-mounted secondary seal)	12,874 kg per year
	Without (primary seal only)[50]	163,114 kg per year
Crude oil (1901)	With (rim-mounted secondary seal)[51]	1,807 kg per year
	Without (primary seal only)	22,899 kg per year

Table 1: Vapour lost through a properly working seal

The precise design of a seal is custom-made for each tank to take into account welds in the tank wall and the fact that the tank wall is not entirely circular. The choice of material for the rubber seal also depends on the application in question. BOPEC used Buna-N on all its tanks. Buna-N is a material that is reasonably resistant to hydrocarbons such as naphtha and crude oil, has poor resistance to UV light, and has no fire-retardant properties at all. The currently applicable API 650 standard does not prescribe any specific seal material, but it does give examples of frequently used materials for crude oil, refinery products and petrol. Buna-N is one of the examples given for refinery products (e.g. naphtha)[52], but not for crude oil.

The API 650 Standard applicable when the tanks were built does not set any specific requirements as regards the type of seal or the vapour tightness of the *seals*. The most recent version of the API 650 Standard[53] refers to local laws and regulations for the vapour tightness of the seals.[54] Bonaire did not have these laws and regulations.

The vapour tightness of the four types of seals[55] on the market varies greatly. The vapour tightness of the mechanical shoe with a primary seal (which BOPEC had on the naphtha tank (1931)) is poor. Whenever a secondary seal is fitted, as BOPEC did on the crude oil tank (1901), the vapour tightness is good compared to the other types of seals available. Little maintenance is needed if seals are custom-made for the tank and well mounted. However, if maintenance is overdue, there are a number of possible scenarios with the BOPEC type of seal in which vapour can escape:

- if corrosion has created holes in the metal shoe;
- if the metal shoe is not in the proper position against the tank wall because:
  a. the mechanical structure is not working or not working properly;
  b. parts of the tank wall are uneven, possibly because there is dirt on the wall;
  c. the tank wall is no longer round and a space has been created between the round roof and the oval tank wall that the mechanical structure can no longer bridge;
  d. waste material or rainwater is accumulating in the loose-hanging rubber flap of the primary seal, therefore increasing the weight of the flap such that it pulls the shoe away from the tank wall;
- if a rubber flap is worn out or broken.

The faults described above can be seen with the naked eye in an inspection from the outside. API 653, Tank inspection, repair, alteration, and reconstruction[56], requires such an inspection to be carried out at least once a month[57] with the results documented in an inspection report.[58] BOPEC stated that the staff from their operations department performed the outside inspections. These inspections were not documented. During their two visits to BOPEC (in September 2010 and

49 This calculation does not include the amount of vapour lost when the tank is filled.
50 Tank 1931 had a mechanical shoe seal – vapour stop seal with a primary seal.
51 Tank 1901 had a mechanical shoe seal – pantograph with counterweights, a primary and a rim-mounted secondary seal.
52 API Standard 650: Welded steel tanks for oil storage, American Petroleum Institute, eleventh edition, June 2007, addendum 1 & 2, effective date May 1, 2010. Appendix H 4.4.2.
53 API Standard 650, eleventh edition, June 2007, addendum 1 & 2, effective date May 1, 2010.
54 API 650, eleventh edition, C.3.13.3.
55 Mechanical shoe seal, liquid mounted resilient seal, vapour mounted resilient seal and the wiper seal.
56 API 653, Tank inspection, repair, alteration, and reconstruction, fourth edition, April 2009 and addendum 1, August 2010.
57 API 653, fourth edition, April 2009 and addendum 1, August 2010. 6.3.1.2.
58 API 653, fourth edition, April 2009 and addendum 1, August 2010, 6.3.1.3.

February 2011), Safety Board investigators observed that the metal shoes of the seals on various tanks were not properly flush with the tank wall at several points and that the tank walls were dirty. There were also open manholes and various items lying around on the roof (see Appendix 4). Based on the lack of inspection reports showing that monthly preventive inspections took place as prescribed in API 653 as well as on the observations made during the visits, the Safety Board concluded that monthly inspections of the seals had not been carried out. An investigation conducted by representatives of the sector revealed that a lightning strike can also cause a fire if the seals are well maintained. Secondary seals and fire-retardant rubber materials can slow down the spread of the fire.[59]

Lightning conductor and earthing

The BOPEC tanks were equipped with the following facilities in order to conduct the electricity from a lightning strike down to the ground (low resistance) in the best possible controlled manner:

- a conductor between the floating roof and the tank wall[60]:
  - a cable acting as a conductor between the roof and the tank wall (a "bypass conductor"):
    - cables from the floating roof to the staircase leading to the roof;
    - cables from the staircase to the tank wall;
  - so-called "shunts" above the seals[61];
- earthing cables from the tank wall to earthing pins in the ground.

BOPEC had fitted a scaffolding pipe to the crude oil tank (1901) (see Figure 9), which can attract lightning.[62] [63]

59 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, June 1997, escalation mechanisms, page 3.

60 API 545, Recommended Practice for Lightning Protection of Above-Ground Storage Tanks for Flammable or Combustible Liquids, first edition, October 2009, 4.2.1.

61 API 545, first edition, October 2009, 4.2.1.1.

62 The expression "attract lightning" is in popular usage, but "conducting lightning" is actually what is meant.

63 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, June 1997, risk reduction options, page 27.

Figure 9: Scaffolding pipe on tank 1901

Conductive cable between the roof and the tank wall

Conductive cables are used to conduct the medium-length and long-lasting components of a lightning strike.[64] The floating roof must be connected to the tank wall directly by means of an appropriate number of cables that will conduct electricity.[65] These conductive cables must be evenly spaced, no more than 30 m apart, around the circumference of the roof.[66] In BOPEC's case, therefore, there should be eight conductive cables per tank. These requirements are laid down in API 545, which was adopted in 2009. The tanks have not yet been modified in line with this recent new development.

Shunts

BOPEC has used so-called "shunts" above the seals to connect the roof to the wall in order to conduct (static) electricity in the floating roof to the tank wall. Shunts are strips of metal (see Figure 10). API 2003 states: *'The most effective defence against ignition by lightning is a tight seal and properly designed shunts'.*[67] Shunts had been fitted approximately 3 m apart on tank 1901. The

64 API 545, first edition, October 2009, 4.2.1.2.1.
65 API 545, first edition, October 2009, 4.2.1.2.2.
66 API 545, first edition, October 2009, 4.2.1.2.2.
67 API 2003, Recommended Practice 2003, 5.4.2.2., page 28, Open Floating-Roof Tanks

American Petroleum Institute assumes a space of no more than 3 m between shunts.[68] According to the latest Recommended Practice published in 2009, the contact point between the shunt and the tank wall must be at least 30 cm below the surface of the liquid in the tank.[69] The investigators from the Safety Board saw that the shunts on tank 1901 were above the seal (Figure 10). The file on tank 1931 does not contain any information stating that the floating roof in tank 1931 was fitted with shunts.

Figure 10: The floating roof in tank 1901 with shunts above the seal

Earthing cables from the tank wall to earthing pins in the ground
Both BOPEC tanks were fitted with four earthing cables connected to earthing pins in the ground. The pins were 60 m apart. The American Petroleum Institute recommends one earthing pin every 30 m around the circumference of the tank wall for storage tanks of this size.[70] BOPEC should therefore have eight instead of the four earthing pins per tank that are currently in place. The earthing cables and the connection points between the cables and the tank were extremely corroded, which can have an impact on the effectiveness of the cables. The Safety Board had one of the earthing cables tested by Stork FDO Inoteq B.V. (see Appendix 6) to determine the level of effectiveness of the earthing cables. Stork ran tests to determine *"whether the copper used for the lightning conductor was suitable for that purpose and whether the copper wire became hot as a result of the high levels of current passing through it"*. The tests showed that this cable was suitable for use as an earthing cable and had carried out that function (i.e. it was effective).

68 API 545, first edition, October 2009, 4.2.1.1.2 and API 2003, Recommended Practice 2003, 5.4.2.2, page 28, Open Floating-Roof Tanks.
69 API 545, first edition, October 2009, 4.2.1.1.2.
70 API 2003, 5.4.1. NFPA 780, edition 2008, 7.4.1.7.2.

The total resistance of all the earthing pins combined should in any event be less than 25 Ohm[71]. The latest standards are even based on less than 10 Ohm. BOPEC measured the resistance of the earthing pins after the fires and neither tank met the 25 Ohm requirement. The resistance measured for the earthing pins of the crude oil tank was 8.09, 12.60, 36.80 and 64.40 Ohm, respectively, while the earthing pins of the naphtha tank gave results of 2.94, 3.07, 27.40 and 8.00 Ohm, respectively. The conductivity of the subsoil is a factor in these measurements. The coral debris in the lower terrace (on which the BOPEC site is built) extends down to 25 m below sea level. This coral debris is porous and contains salty seawater, which makes the lower terrace a good protective earth in principle, but is also means that the earthing pins corrode easily underground and therefore create resistance.[72] The API prescribes an inspection of the earthing pins every five years.[73] The tank files did not contain any inspection reports stating that BOPEC had carried out these preventive inspections. In 2006, BOPEC carried out maintenance on tank 1931, for which a "scope of work" document was drawn up. The earthing pins and the earthing cables from the wall to the pins were not included in the scope of work. A scope of work document from the year 2000 describing repairs to the roof of tank 1901 was also found.

Inspection and maintenance by BOPEC

American Petroleum Institute Standard 653, 'Tank Inspection, Repair, Alteration, and Reconstruction' describes external and internal inspection of a tank. The tank can remain in operation while an external inspection is performed. The API distinguishes between two different types of external inspections: an external inspection at least once a month carried out by an operator[74] and an external inspection every 5 years carried out by an authorised inspector. The operator's monthly inspection covers possible distortion in the surface of the tank wall, leaks or traces of a leak, whether the tank has sank to a tilting position, corrosion, the condition of the tank's foundations, the condition of the coat of paint on the tank, the insulation (if any) and the tank's accessories.[75] The operator is required to document the results of these monthly inspections so that an authorised inspector can follow up on the points described in the inspection report during the five-yearly inspection.[76] BOPEC says that the operators carried out the monthly inspections; the results were not documented, however. In the five-yearly external inspection, the authorised inspector must in any event carry out a visual check of the components of the earthing system such as the shunts and the mechanical cable connections.[77] BOPEC has not shown that the five-yearly preventive inspections were carried out.

In addition to the external inspections, the API 653 Standard also prescribes an internal inspection which the authorised inspector carries out every ten years.[78] API 653 provides a complete checklist for this inspection (API 653, Appendix C). BOPEC has maintenance plans showing that BOPEC carries out these inspections every ten or twelve years. The authorised inspector must write a report on the inspection.[79] However, BOPEC has been unable to provide the Safety Board with any reports on these inspections.

According to the API, BOPEC should keep a file containing the inspection reports, information on the design of the tank and the tank's history of repairs/modifications.[80] No inspection reports were found in the tank files obtained from BOPEC.

71 Ohm is the unit of electrical resistance.
72 Buisonjé, P.H. de, *Neogene and Quarternary Geology of Aruba, Curacao and Bonaire*, Utrecht, 1974.
73 API 653, 6.3.2.3.
74 An 'operator' is a member of staff from the operations department, which is the department that loads and unloads ships.
75 API 653, 6.3.1.3.
76 API 653, 6.3.1.3.
77 API 653, 6.3.2.3.
78 API 653, 6.4.2.1.
79 API 653, 6.9.1.
80 API 653, 6.8.1.

BOPEC knew the fire risks and chose the standards published by the American Petroleum Institute (API) as its company standards to ensure the safety and operational security of the tanks. However, BOPEC then failed to comply with the API rules. The required installation components did not undergo preventive inspections and maintenance or were missing altogether.

The fires in two storage tanks at BOPEC started separately from each other as a result of lightning during severe weather conditions. Flammable vapour at the rim seal of the floating roofs on both tanks ignited at various points.

Because the seals were not properly tight, there was enough flammable vapour for ignition to take place. The vapour was ignited by an electric charge as a result of a lightning strike. The tanks were not earthed in accordance with the Recommended Practice published by the American Petroleum Institute (API). There were not enough earthing pins and not all of them were working properly.

Fire alarm system
BOPEC has installed an automatic fire alarm system on the storage tanks. The system consists of a wire along the inside of the tank wall which sends an electrical signal to the fire control panel in the control room in the event of a fire. An alarm then sounds and lights come on to indicate the tank in which the fire is located. The system only raised the alarm in the case of the fire in the crude oil tank (1901). The investigation revealed that the fire alarm system in several tanks was not working. However, this had no further impact on the firefighting operation because the fires broke out in broad daylight and the smoke was also visible.

BOPEC fire-extinguishing system, fixed and mobile
BOPEC has fixed (i.e. stationary) and mobile fire-extinguishing facilities. The following diagram shows the fixed system. According to BOPEC's emergency manual, it was possible to use the fixed system remotely. In reality, however, this was not the case, because the remote-control system had broken down. The fire-extinguishing system therefore had to be activated manually.

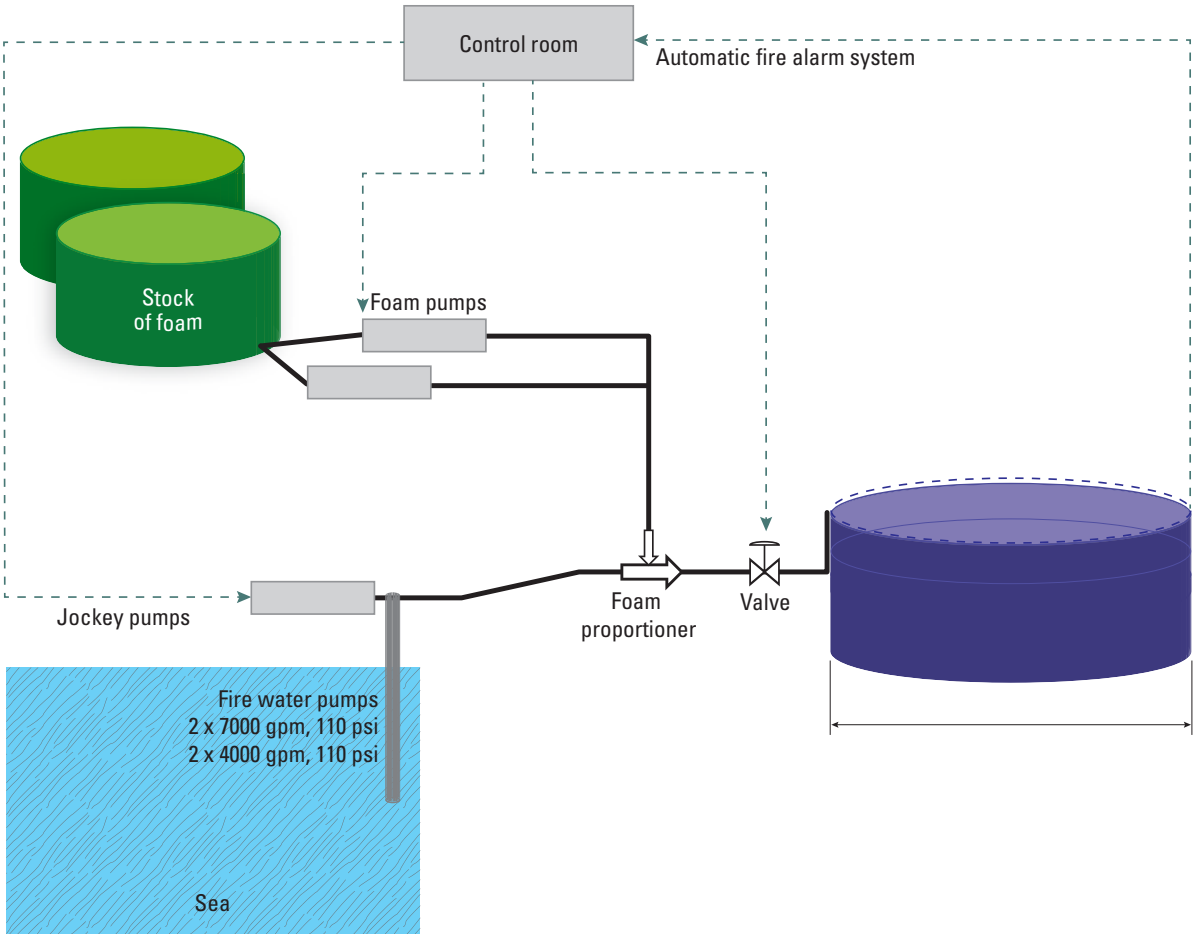


Figure 11: Diagram of the fixed fire alarm and fire-extinguishing system[81] for a seal fire

The fixed fire-extinguishing system consisted of:

- a network of pipes;
- six pumps;
- three foam proportioners;
- two storage tanks containing foaming agent.

The network of pipes was filled with seawater up to the foamproportioners and was permanently pressurised. Two so-called "jockey pumps" maintained the required level of water pressure in the pipes. The fire-extinguishing pumps on the jetty were engaged in the event of a fire.[82] BOPEC had four of these pumps with a combined capacity of 22,000 GPM[83] (82,278 litres/minute), which BOPEC said was sufficient to extinguish a tank full surface fire and to cool down the surrounding tanks. The Safety Board calculated (see Appendix 7) that this amount of water is indeed more than enough to extinguish two rim seal fires using the fixed extinguishing system, but it is not enough to both extinguish a full surface fire and cool down the surrounding tanks if the assumptions used in BOPEC's calculations are maintained.

BOPEC had three foam proportioners (one at each tank pit with the exception of the utilities pit). The foaming agent added to the water in the foam proportioners was stored in two closed supply tanks close to the central foam proportioners. The seawater was pumped to the mixing stations where it was mixed with the foaming agent. The pipes ran from the mixing stations to the storage tanks.

81 Page 47, BOPEC emergency manual.
82 API 2001, 5.10.3.
83 GPM stands for gallons per minute (source: BOPEC emergency manual).

The foam supply tanks combined could hold approximately 76 m^3 of foaming agent, which BOPEC said should be enough to extinguish a tank full-surface fire. The Safety Board established that BOPEC's calculation was wrong (see Appendix 7). The correct calculation shows that BOPEC needed at least 122 m^3 of foaming agent.

BOPEC's emergency manual states that its calculation is based on NFPA 11[84]. However, extinguishing a full-surface fire using mobile fire-extinguishing equipment is not covered by NFPA 11.[85] Based on information provided by specialists in tank firefighting, at least 120 m^3 of foaming agent should be sufficient to fight a full-surface fire. According to the calculations, approximately 3 m^3 of foaming agent should have been enough to extinguish both rim seal fires.

BOPEC assumes that the pressure on the fire-extinguishing water will reduce because of the length of the pipes and the roughness on the inside of the pipes and because the BOPEC site is on a slope and the water ultimately has to go upwards to the top part of the tank. According to information provided by BOPEC, any calculations must allow for a reduction in the extinguishing water pressure by 2 bar if the water is stationary by 4.6 bar if a fire-extinguishing operation is in progress. At the BOPEC site, a 2.9 bar reduction (from 7.5 bar to 4.6 bar) was feasible at the outlet opening. Regardless of the type of opening, pressure of between 5 bar and 7 bar is necessary for optimum mixing of the foam and water. If all four pumps had been available, this pressure requirement would have been met.

The pipe split into two branches when it reached the tank. The two branches ran to the left and right round the tank wall for a quarter of the circumference of the tank before then running up the tank (vertical discharge pipe). Once on top of the tank, the two pipes ran half way round the circumference of the tank so that together they formed a circle.
There were approximately 22 branches leading off from the pipe to merlons containing openings for discharging the foam. The foam was formed the moment the water and foaming agent pass through the opening. Spatter plates in front of the openings ensured that the foam flowed along the wall downwards and ended up on the seal.

BOPEC's mobile fire-extinguishing equipment included three booster pumps[86] and three water cannons (top guns*).* BOPEC also had two tugs available which acted as fire-floats. The fire-floats had a special pump that could generate high water pressure.

Maintenance of the fixed and mobile fire-extinguishing equipment
BOPEC had not carried out any preventive maintenance on the fire-extinguishing system since 2007. According to BOPEC, it tested the system continuously for leak tightness because the system was filled with seawater and pressurised from the water pumps on the jetty up to the foam proportioners . The foam proportioner itself and the dry pipes from the station to the outlets on the tank were neither tested nor maintained. Because no actual tests were carried out any longer, the seawater was permanently stationary and pressurised and the tropical climate on Bonaire accelerated the formation of deposits. As a result, fouling developed in the foam proportioners' pipes.

The two largest of the four fire-extinguishing pumps were not available on 8 September 2010 as they had been disassembled some time previously because they were not generating enough water pressure. Since these two pumps were unavailable, the total amount of water provided by the pumps on the jetty was not 22,000 GPM, but 8,000 GPM (29,920 litres/minute). This was enough to extinguish one rim seal fire (for which approximately 1,550 litres/minute were needed for 20 minutes)[87], but the end pressure of 10.3 bar (150 psi) was not available. The maximum achievable pressure from the two working pumps was 7.5 bar (110 psi).

84 NFPA 11, Standard for Low-, Medium-, and High-Expansion Foam (NFPA = National Fire Protection Association).
85 The system design is usually based on the rim-seal fire scenario.
86 A booster pump is an extra pump connected to the fire-extinguishing system that is used to increase the height or distance reached by the jet of water.
87 API 2001, page 21, table 1: NFPA 11, Standard for Low-, Medium-, and High-Expansion Foam, 2010 edition.

The fixed fire-extinguishing installation was in a poor state of maintance on both tanks, which is why it was not immediately possible to use these installations to fight the fires.
The water was not sufficiently pressurised to fight the fires because the four water pumps were unable to generate sufficient pressure. The two largest of the four pumps had been withdrawn from service, which reduced the water pressure available on 8 September 2010 even further.

- The proportioner for tank 1931 was not working properly, which meant that a foam mix did not form immediately. Furthermore, no foam mix was sprayed out of some of the discharge openings from the fixed fire-extinguishing installation on tank 1931.
- Of the three available booster pumps (mobile fire-extinguishing equipment), one had broken down before the fire and a second broke down during the fire on 8 September 2010.
- There was also a shortage of foaming agent for several hours, probably because BOPEC did not have much foaming agent among its stored supplies.

Supervision by the authorities
One of the tasks of the Bonaire island fire service is to carry out preventive inspections and give advice on fire safety. The Bonaire fire service has a fire prevention department which is responsible, among other things, for issuing fire-safe construction permits. The fire service issues the permits in cooperation with the Spatial Development and Management Department (DROB) and domain management in the construction committee. When BOPEC originally built the tanks in 1974, Bonaire did not yet have a fire service (the fire service was not founded until 1999). A permit was therefore not issued and no inspection was carried out by the fire service in 1974. Up to 2007, the island fire service had an overview of the operational readiness of the BOPEC fire-extinguishing installation thanks to the joint exercises. Any faults were immediately repaired. No reports were compiled to document these tests. The Bonaire fire service also conducts inspections at corporate premises to check them against fire-safety requirements.

However, as far as the Safety Board was able to determine, a fire-safety inspection has never been carried out at BOPEC. It is not clear why these inspections had not been carried out, even though it was known that BOPEC stored flammable substances on site. The annual report for 2009 states that the fire service inspected 68 'premises requiring a permit' in that year. The main focus of the fire service inspections is on the hotel and catering industry. The fire service annual report 2009 also says that two legislative proposals were drafted on Bonaire regarding fire-safe construction and fire-safe occupation. However, these proposals never came into effect because they were never adopted and the absence of these laws makes it difficult for the fire service to perform its preventive duties properly. The Safety Board also got the impression that the fire service has insufficient capacity to conduct fire-safety inspections. There is one person at the fire service who is responsible for fire prevention.

Inquiries revealed that the local authorities have not set any requirements for and do not supervise BOPEC's operations. According to the Lieutenant Governor, there is currently not enough capacity and knowledge available for supervision and enforcement activities at a company like BOPEC.

BOPEC's understanding of the risks
BOPEC has an emergency manual[88] describing the procedures and actions that must be implemented in the event of an emergency. The emergency manual distinguishes between four different types of emergency situation, namely a tank fire, oil pollution on land, oil pollution at sea, and a storm or hurricane. The Safety Board did not find any separate BOPEC risk inventory during the investigation apart from the emergency manual. The emergency manual describes in sub-manuals how the different types of emergencies can be tackled and brought under control.

The Bonaire public authorities' understanding of the risks
The island authority and the fire service on Bonaire have no overview on paper of all of the high-risk companies on the island.

88 The emergency manual is described in detail in section 3.3.

In interviews with the Safety Board as part of this investigation, the fire service stated that a risk inventory for Bonaire had been drawn up in the past by the Apeldoorn fire service. The Safety Board did not receive a copy of this document. The interviews revealed that both the fire service and the island authority do know which companies and organisations present the greatest risks on Bonaire. Those companies and organisations include BOPEC, the airport, the hospital, the care home for senior citizens, the large hotels and the storage tank in the middle of the residential neighbourhood of Hato in Kralendijk.

Based on this information, the Safety Board concluded that the authorities are well aware of all the possible risks on the island. However, neither the fire service nor the island authority has taken any action to tackle or control these risks. In the case of BOPEC, the Governing Council of Bonaire had the option of designating BOPEC as a company that must have its own fire service in accordance with Article 11 of the Island Ordinance on the Fire Service. The Council did not exercise this option, but BOPEC did have its own fire service. Nevertheless, designating BOPEC as a company required by law to have its own fire service would have allowed the Governing Council to set fire-safety requirements for BOPEC and to check for compliance with those requirements. BOPEC would have been obliged to report to the Governing Council annually, for example, regarding the state of the company fire service and how the requirements applicable to the fire service were being met.

In its capacity as an administrative authority, the Office of the Lieutenant Governor of Bonaire is itself responsible for risk management and disaster response. According to the Lieutenant Governor, there is insufficient capacity and expertise on the island to draw up a risk inventory and disaster response plans independently. The Lieutenant Governor has therefore asked the Netherlands to assist Bonaire in this regard by providing people and resources. In 2008, the external safety department of the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) performed a quick scan of external safety on the BES Islands as part of the run-up to the change in constitutional status.[89] BOPEC was one of companies described as high-risk. According to the report, explosions, soil pollution, water pollution and damage to the aquatic environment are the biggest risks at BOPEC.

VROM subsequently commissioned a "BOPEC Bonaire terminal (landside) exploratory mission"[90]. The report on this exploratory mission states that, given the nature and quantity of the flammable liquids stored by BOPEC at the time (80% fuel oil and 20% crude oil), the external safety rules in the Netherlands would have required BOPEC to comply with the Major Accidents (Risks) Decree 1999 (BRZO'99). If the company only stored fuel oil, it would not have to comply with BRZO'99 as regards fire and explosion risks, but possibly with regard to environmental risks (serious pollution of the ocean). The island authority and BOPEC were contacted following this exploratory mission. It became clear that BOPEC was not complying with the requirements that would apply to similar companies in the Netherlands.

It was subsequently agreed that BOPEC would be given three years to bring itself up to 'the Dutch level'. It is not known when this agreement was made or whether arrangements were also made about the programme of changes in order to achieve the Dutch level.

In 2008, the Lieutenant Governor asked the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) for help in gaining an insight into the foreseeable disaster situations on Bonaire. A fire in the rim seal of the floating roof on a storage tank was a recognised risk for BOPEC. However, a rapid and adequate response to the fire – as described in BOPEC's emergency manual – was not possible.

89 Quick Scan of External Safety on Bonaire, Saint Eustatius and Saba (BES), commissioned by the external safety department of the Ministry of Housing, Spatial Planning and the Environment, January 2008.

90 DCMR Environmental Protection Agency Rijnmond , BOPEC Bonaire terminal (landside) exploratory mission), commissioned by the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM), 8-9 October 2008.

3.3 Preparation for firefighting

How BOPEC and the Bonaire authorities had prepared for firefighting was assessed based on the available manuals and plans, the Island Ordinance on Disaster Response and the Island Ordinance on the Fire Service. The Safety Board looked at the question of whether the availability of people and resources at the island fire service was suitable for fighting a tank fire. The Safety Board also examined whether and, if so, how the personnel at the island fire service and at BOPEC were trained and how they practised for fighting tank fires.

3.3.1 Manuals and plans

There are three types of manuals/plans regarding preparations for fighting fires, namely the disaster plan and disaster response plans drawn up by the Bonaire authorities and BOPEC's emergency manual.

Disaster plan for the island territory of Bonaire
The Bonaire island authority adopted a disaster plan for the island territory of Bonaire in 1997. The disaster plan is intended to help provide a structured and coordinated approach to tackling serious, major accidents and disasters. Bonaire's disaster plan distinguishes between nine specific sub-plans.[91] Further details have been laid down in relation to four of the nine sub-plans[92]: (1) providing information to the population, (2) warning the population, (3) evacuation, shelter and care, (4) recuperation/after-care. The Safety Board requested copies of the 'Public Safety', 'Dangerous Substances and Rescue' and 'Administrative Affairs' sub-plans as part of this investigation. The details of these plans have not been worked out, however. The four sub-plans worked out in detail describe the work to be performed for the organisations involved in disaster response. According to the disaster plan, small specialist teams – so-called 'ESF Groups' (ESF = Emergency Support Functions) – were set up to draw up and maintain the sub-plans.
In addition to maintaining the sub-plans, the disaster plan states that the ESF Groups are also responsible for exercises to practise implementation of the plans, including in disaster response. The disaster plan prescribes the composition of and duties of the various officials in the ESF groups.

The disaster plan distinguishes between three different levels in the organisation of disaster response: strategic, tactical and operational. The highest of these levels – the strategic level – consists of the island's disaster management committee which is chaired by the Lieutenant Governor and has as members the Island Disasters Coordinator (the chief of the fire service), coordinators from the ESF Groups and other advisors and representatives of the various agencies appointed to the committee by the Lieutenant Governor. The joint ESF Groups are the tactical level. At the operational level there is the Incident Location Command Team (CoPI), which is composed of (at least) representatives of the fire service, the police, the health & hygiene department and the information department. The CoPI team manages the disaster response unit(s) directly on site. The standby officer from the fire service acts as leader of the CoPI team.

The disaster plan also describes the escalation structure within the organisation of disaster response and the alert system. As soon as an incident is classified as 'affecting the surrounding area', the incident is escalated to a higher alert level (GRIP II[93]), which is the level at which the administrators who have a seat on the island disaster management committee are also alerted.
The disaster plan also describes the subjects that should be included in the island's basic operational plan. However, Bonaire does not have a basic operational plan.
The island's basic operational plan should include the location, nature and consequences of a possible disaster or accident, giving the specific details (personnel and resources) for the effective deployment of the operational agencies in order to minimise the consequences of a disaster or accident.

91 The disaster plan of the island territory of Bonaire describes the following sub-plans: water and power, telecommunications, public works and transport, public safety, dangerous substances and rescue, public order, medical assistance and health care, evacuation and shelter, public information, administrative affairs.
92 Other names are used.
93 GRIP = Coordinated Disasters Incident Response Procedure.

The disaster plan for the island territory of Bonaire describes in particular how the disaster response system is organised on Bonaire, including escalation and the accompanying tasks and powers. The Safety Board believes that Bonaire's disaster plan is a good starting point for responding to emergency situations. However, Article 3 of the Island Ordinance on Disaster Response states that the disaster plan must also include a list of the types of disasters that could strike the island territory. The disaster plan for the island territory of Bonaire does not contain a list of potential disasters (nor therefore of the risks) facing Bonaire. The Safety Board finds this surprising since the possible disasters form the basis for the approach and the deployment of the organisations involved in disaster response (such as the fire service).

Taking the Security Regions Act as an example, the Safety Board believes that the Island Ordinance on Disaster Response and the Island Ordinance on the Fire Service provide a basis for shaping and tackling disaster response on Bonaire. However, detailed disaster response plans have not been produced based on the Ordinances, largely because more information is needed about the types of disasters that might occur on the island. One reason for not fully developing plans based on the Island Ordinance on the Fire Service was also a lack of time: the priority for the fire service in the time not needed for day-to-day activities was to build up a service and develop the accompanying training programmes for fire service officers.

Disaster response plans
Under Article 4 of the Island Ordinance on Disaster Response, the Lieutenant Governor must adopt a disaster response plan by Order for each type of foreseeable disaster. For this purpose, the Lieutenant Governor can designate organisations that must draw up a disaster response plan.[94] A disaster response plan describes the procedures in the event of a serious accident in order to ensure that the response to the accident is well prepared. The plan is agreed with the government and the other parties involved. The basic premise is that the plan must be anchored in the day-to-day reality of each component of the island's organisational structure. The organisations are themselves responsible for preparing for the tasks assigned to them in the plan. The Governing Council ensures that the organisations carry out their responsibilities. The Safety Board did not find a disaster response plan kept by the government for BOPEC.

- The Island Council of Bonaire adopted the Island Ordinance on Disaster Response (2002). However, the Lieutenant Governor did not adopt a disaster response plan for BOPEC under this Island Ordinance.

BOPEC's emergency manual

BOPEC's emergency manual consists of four parts:
1. *Emergency plan;*
2. *Contingency plan for oil fires;*
3. *Contingency plan for oil spills;*
4. *Contingency plan for storms and hurricanes.*

The relevant parts (one and two) are explained below.

The emergency plan, which was drawn up in 2009, describes the tasks and responsibilities of all members of the emergency reaction team as well as the activities of the personnel during an emergency. The plan also contains alert schedules and the names and telephone numbers of both the internal employees and the external agencies who may be involved in the response to an emergency situation. The plan includes a list of the emergency equipment based on possible scenarios. This list indicates the locations of the various fire-extinguishing installations and their capacity, once again based on the possible scenarios. As described in section 3.2.2., the calculation of capacity in the emergency manual is not correct (see also Appendix 7).

94 Bonaire has two disaster response plans: the Disaster Response Plan for Aviation Accidents and the Maritime Disaster Response Plan of the Coastguard for the Netherlands Antilles and Aruba.

The 'Contingency plan for an oil fire on BOPEC premises' was developed for fighting a fire at BOPEC and for working with the Bonaire authorities in that event.[95] However, the plan does not say anything about working with the island fire service. The plan also describes the different types of fire that can break out as well as the procedures for each location if the fire alarm sounds. The plan contains the actions that must be taken in the event of a 'minor tank (seal) fire' (see Appendix 8). The emergency manual is based on using the fixed fire-extinguishing system to fight the seal fire. The plan also contains the actions that must be taken in the event of a 'major tank (seal) fire' (see Appendix 8).

3.3.2 Bonaire fire service

The Bonaire fire service consists of three departments: response, engineering and prevention. The departments are accountable to the chief and the deputy chief. The deputy chief is also head of fire prevention. Under the law, the fire service has tasks in terms of response, prevention and preparation, including preventing, limiting and responding to fires, danger and disasters. To carry out these tasks, the fire service has 46 professional fire officers, of which 39 work shifts (13 people to a shift). The Bonaire fire service is also the fire service for Flamingo Airport. The International Civil Aviation Organisation requires every airport to have its own fire station. There is also a fire station in Rincon.

In line with the requirements of the International Civil Aviation Organisation, the Bonaire fire service has the following vehicles:

Vehicles	Volume of the water tank	Volume of foaming agent
Crash tender 1	6,000 litres	795 litres
Crash tender 2	6,000 litres	795 litres
Crash tender 3	12,000 litres	795 litres
Water tender 1	7,000 litres	159 litres
Water tender 2	4,000 litres	159 litres
Water tender (Rincon)	3,785 litres	--

Table 2: Vehicles belonging to the Bonaire fire service and the volume of water and foaming agent on board

The fire service also has a container of disaster response equipment (emergency aid) and an immersion pump unit.[96] The total amount of foaming agent available is based on the size of the aircraft that land at Bonaire's airport. The airport has a stock of approximately 2,080 litres of foaming agent.

3.3.3 Training and exercises

Bonaire fire service

Training for the Bonaire fire service is often provided in cooperation with the fire service in the Netherlands. One of the reasons given for doing so is that the island authority has few people and resources to allocate to the fire service. The Bonaire fire service therefore uses twinning agreements (including with the fire services in the municipalities of Apeldoorn and The Hague) so that they can still take part in training and exercises.

All training courses for fire service personnel on Bonaire are given by instructors from the Netherlands. The Bonaire training system is based on the Dutch system. Five members of the Bonaire fire service have passed the course to become crew managers (Netherlands Bureau of Fire Services Exams (NBBe) examination) in the Netherlands. The teaching material used by the Netherlands Institute for Safety (NIFV) (assistant crew manager/crew manager, choice of response measures) includes a chapter on fighting fires on industrial sites (including in the petrochemical

95 Section 2, Introduction to the emergency manual.

96 The immersion pump unit is used whenever a lot of water is needed. There are no fire hydrants on Bonaire.

industry, although fighting tank fires is not specifically addressed). The teaching material emphasises that the company in question knows about fire fighting and the dangers of its products. There is also a separate module covering assistant crew managers in the petrochemical industry and tank incidents. The chief of the Bonaire fire service trained as a deputy watch manager in the Netherlands. The chief also trained in a number of specialist areas in the United States. The training completed by the fire service personnel is recorded and the record is kept in a system called 'AG5'. The Bonaire fire service conducts exercises per team[97]led by fellow employees of the Bonaire fire service. The fire service exercises are based on the exercise guidelines. The service keeps an electronic record of participation in the exercises. The head of response draws up an exercise programme every year and each team takes the same programme. The Safety Board asked for a copy of the general exercise programme during the investigation but did not see or receive a copy. As they themselves state, the Bonaire fire service does not practice specifically for fighting tank fires.[98] They do practice using foam to extinguish fires, but not often because foam is extremely expensive. The fire service primarily practises its response to aviation accidents using a specially equipped training site at the airport.

The Safety Board found that the fire service on Bonaire was very poorly prepared for fighting a tank fire. The fire officers had received only limited training and had not practised fighting tank fires. Responding to aviation accidents was and still is the priority of the fire service because of the requirements laid down in aviation legislation. The Board does not consider this to be a strange situation, given the fact that the Bonaire fire service in its current size and form is a product of international aviation legislation (ICAO), which states, for example, that a fire station at airports like Bonaire's Flamingo Airport is mandatory. It is therefore logical that the fire service's main priority will be preparing for and responding to aviation accidents, but that does not alter the fact that the fire service must also prepare for other potential risks on the island. The Bonaire fire service annual report for 2009 states that the fire service was deployed twice to an aviation incident and 190 times to fight fires (161 of which were outside) during the year. These figures provide a good overview of the deployment of the fire service.
The figures also show that the fire service hardly ever has to tackle a complex (multidisciplinary) deployment. The Board is aware that the fire service on Bonaire has insufficient capacity and resources to prepare for all possible scenarios. However, the Board does expect the fire service to make a well-considered decision about the types of deployment (risks) to prepare for on Bonaire, in spite of the shortage of people and resources.
The Board established during the investigation that the fire service chose to give priority to its response to aviation incidents.

BOPEC
The investigation revealed that all BOPEC employees had had basic training in how to operate the fire-extinguishing system.[99] Third parties working on site temporarily (e.g. contractors) are also trained to fight fires. The employees from the operations department are fully trained to operate the fixed fire-extinguishing system and they are also the ones who are responsible for activating the system in the event of a fire. The operations and engineering departments combined make up BOPEC's fire service. They have had special training for this firefighting role – including in Venezuela and on Curacao – in which they practised tackling a variety of scenarios.
BOPEC conducts a major incident exercise twice a year (first-aid accidents, tank fire and fire on a boat) as part of the activities required to maintain ISO certification. The Safety Board requested copies of BOPEC documentation, certificates and training or exercise plans.[100] In addition to the emergency manual, BOPEC has had a schedule of disaster response exercises since March 2008.

97 As well as the fire service exercises, there were also multidisciplinary and administrative exercises. The exercises conducted by the ESF Groups included table-top and partial exercises. Larger exercises were also organised to practise coordination with the other agencies at COPI and disaster management committee level.
98 Now that the Bonaire fire service falls directly under the Dutch national structure (after 10-10-10) a programme has started for practising how to fight tank fires. The fire service personnel will soon start a course, part of which will be theory. The course as a whole will end with an exercise. The course will be taught by someone from the Netherlands.
99 API 2001, 9.5 and API 2021, 7.5.
100 API 2001, 10.1.

According to this schedule, exercises are organised to practise responding to eleven different types of emergencies, including a scenario called 'fire at the terminal'. An exercise is organised twice a year. A report is available on each exercise, including 'lessons learned'. The 'fire at the terminal scenario' was practised in April and November 2008.
The emergency manual describes the tasks to be carried out by the head of operations and the head of maintenance in preparation for a potential emergency situation. In addition to training for the personnel, these tasks also include maintenance of fire-extinguishing equipment. BOPEC did not explain how these tasks are carried out.

Joint exercises
In the past (until 2007) the Bonaire fire service also organised joint exercises with the BOPEC fire service,[101] although there was no set schedule for these exercises. The fixed fire-extinguishing installations were also used during these exercises. Agreements were made about how to improve fire fighting facilities where necessary. In 2007, however, the management at BOPEC decided to stop these exercises for reasons that are not clear to the Board. The BOPEC personnel did continue to carry out their own exercises after the joint exercises stopped.[102]

The Lieutenant Governor – who has overall command in the event of fire and emergency assistance – and the fire service were not prepared to fight tank fires.
- The island fire service was organised for fire fighting in the event of aviation accidents, not tank fires. Until 2007, the island fire service took part in joint exercises with BOPEC; BOPEC decided to stop the joint exercises from 2007 onwards.

3.4 Firefighting (response measures)

This section describes the fire fighting operation and compares it with the approach described in BOPEC's emergency manual.

The fixed fire extinguishing system
The emergency manual assumes that a minor tank seal fire will be fully extinguished automatically using the fixed extinguishing system (see section 3.3). However, both in the case of tank 1901 and tank 1931, the system did not work automatically and had to be activated manually. The sudden increase in water pressure caused holes to develop at weak points in the extinguishing pipes. There were also holes in the pipes from the foam proportioner to the crude oil tank (1901).

101 API 2001, 5.5.3.
102 "Given the relations between Venezuela and the Netherlands, it was no longer desirable politically for an initiative to resume the exercises to come from Bonaire".

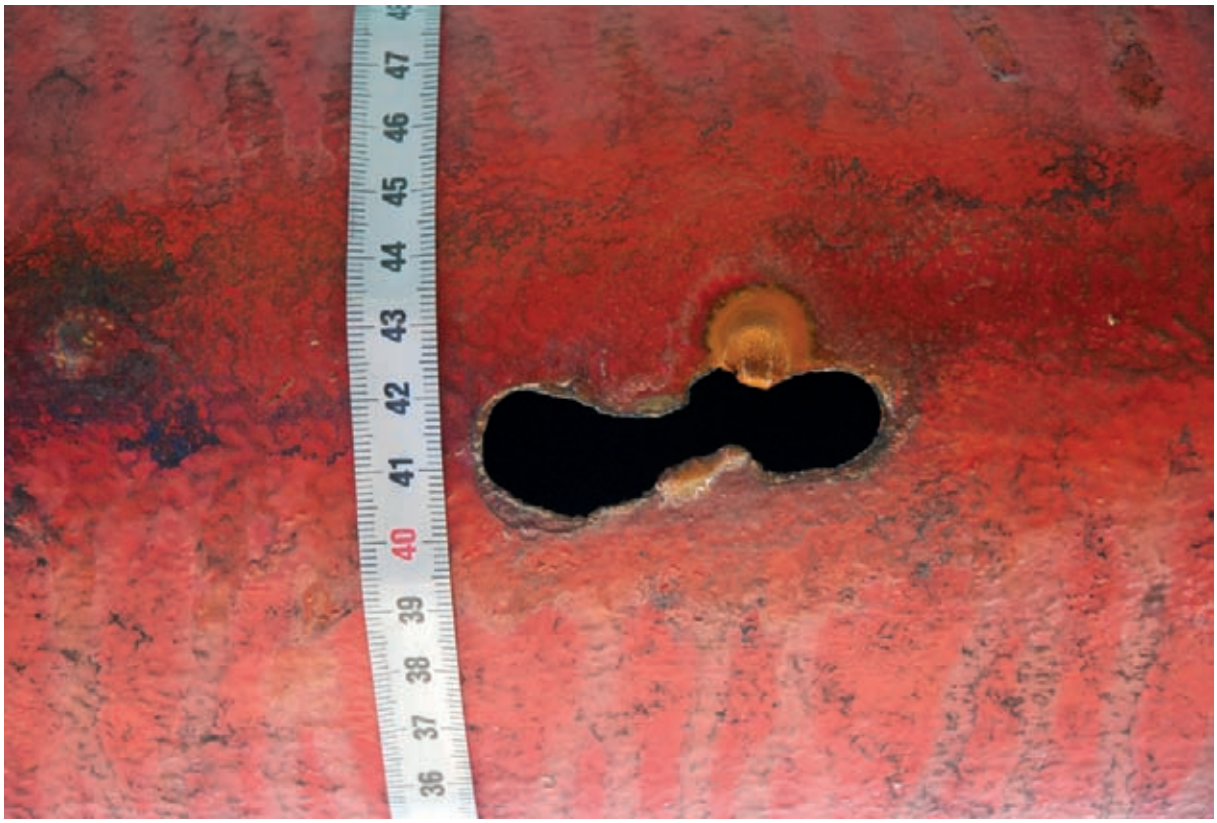


Figure 12: Hole in the underside of the pipe to tank 1901

There was a blockage in the foam proportioner that should have supplied foam to the naphtha tank (1931), which meant that no foaming agent was added to the water. BOPEC employees tried to divert the flow to go around the blockage, but without success. Foaming agent may have been lost in the attempt. The pipe from the foam storage tank was connected directly to the fire-extinguishing pipe, but the Board believes it unlikely that the supply of foam was used up more quickly as a result, given the fact that there was more pressure on the fire-extinguishing water than on the foaming agent. A mobile tank containing foaming agent was then brought in. Efforts to divert the flow using a flexible pipe were finally successful and a mixture of water and foaming agent (with an unknown mixing ratio) was delivered to the naphtha tank (1931). The firefighting operation at the naphtha tank (1931) was still not adequate, however, because some of the discharge openings were blocked, resulting in only part of the seal being covered with foam.

The openings were probably blocked by bits of rust that had come loose from the inside of the pipes. The fire continued to burn under the blocked openings.

The fixed extinguishing system failed to put the fire out in either of the tanks. The Board believes that it was impossible to extinguish the rim seal fires quickly because the fixed extinguishing system was not working properly as a result of poor maintenance.

Water for fire suppression

Water pumps are needed to pump enough sufficiently pressurised fire-extinguishing water into the system's pipes. Two of the four pumps were not in service when the fires broke out on 8 September, but the remaining pumping capacity supplied enough water to extinguish a rim seal fire. Unfortunately, because two of the four pumps were not available, insufficient water pressure was built up to pump the water from the ocean through the fixed extinguishing system, which meant that there was also insufficient water pressure to pump the water and foaming agent via the vertical discharge pipe, out through the openings and onto the seal. One of the two remaining working pumps also broke down on Friday 10 September.

Foaming agent
BOPEC had two tanks of foaming agent, each with a capacity of approximately 38 m^3. The resulting total amount of approximately 76 m^3 should have been enough to extinguish two rim seal fires. BOPEC stated that the tanks of foaming agent were full before the fires started. The investigation revealed, however, that there was not enough foaming agent left after the fire in tank 1901 had been extinguished. The investigation also showed that the BOPEC senior management asked for extra foaming agent from various sources as soon as the fires broke out. Some of BOPEC's foaming agent may have been lost because of the leaks in the pipes in the fixed system and the problems with the foam proportioner. Foaming agent was also used to fight the fire in tank 1931. The Board has calculated (see Appendix 7) that approximately 3 m^3 of foaming agent should have been enough to extinguish both rim seal fires. The Board considers it unlikely that 76 m^3 of foaming agent were used for this purpose and finds it more likely that the two tanks were almost empty.

The Bonaire fire service arrived with a water tender and a crash tender and these vehicles also had a supply of foaming agent. Around 5 p.m., after the fire in the first tank had been extinguished, a shortage of foaming agent was reported. Extra foaming agent arrived in the course of the evening from HMS Zuiderkruis as well as from Curacao and Venezuela.

Tackling the fires
The procedure for tackling a minor tank seal fire is described in the BOPEC emergency manual. As stated in the manual, BOPEC's emergency reaction team was alerted when fire broke out on 8 September. In addition to the emergency reaction team, the island fire service, experts from PDVSA in Venezuela and crew from HMS Zuiderkruis were also deployed, although their deployment is not specified in the emergency manual. Two rim seal fires were still burning when the experts from both the fire service and PDVSA arrived. The emergency manual does not say anything about tackling two rim seal fires at the same time.[103] Furthermore, BOPEC's emergency manual is based on an oil fire, but the properties of the oil are not specified. On 8 September, one of the fires was in a tank containing crude oil and the other in a tank containing naphtha.

In spite of the faulty fixed extinguishing system, the fire in tank 1901 was extinguished thanks to the efforts of the BOPEC employees and the island fire service.

The fixed extinguishing system only partly worked in the case of tank 1931. One problem with this tank was that the fire continued to burn at the level of the tank's outside staircase in particular. Because of the heat from the fire it was impossible to walk on the staircase leading up to the top of the tank wall, which meant that manually fighting the fire from positions along the tank wall – as had been done with the fire in the crude oil tank (1901) – was not possible on the naphtha tank (1931). In the meantime, the apparently already extinguished parts of the rim fire in tank 1931 flared up again (the faulty fixed installation had not fully extinguished the fires).

At approximately 9.35 p.m., in an attempt to get onto the naphtha tank, a mobile crane was used to lift a BOPEC employee standing in a bucket with a foam jet pipe towards the rim of the tank wall. However, the bucket was swaying too much because of the pressure in the foam jet pipe, so the man climbed onto the rim running along the tank wall for increased stability. He did not manage to extinguish the fire. The extinguishing capacity of a single hand-operated foam jet pipe was not sufficient. The crane was needed at 10 p.m. to unload foaming agent from a ship that had just arrived, so it was no longer possible to use the crane to lift fire officers with hand-operated foam jet pipes above the fire. The man was brought down from the tank.

103 API 2021, 8.5.4.

Figure 13: BOPEC's mobile crane

The fire in the naphtha tank escalated at around 11.15 p.m.[104] According to BOPEC's emergency manual, the escalation of the fire turned it into a 'major tank fire' and the manual stated that fighting such a fire was partly the role of the fixed extinguishing installation. The manual also describes how a major tank fire should be fought using water cannons with booster pumps and states precisely how the cannons and pumps should be positioned. This approach was not used on 8 September.
One of the reasons for not following the instructions in the emergency manual was the fact that three booster pumps (15,000 litres per minute at a pressure of 150 psi) and three water cannons (15,000 litres per minute at a pressure of 100 psi) would be needed for the firefighting operation. When the fire escalated, BOPEC only had one working booster pump and water cannon.

Escalation of the fire
Witnesses have stated that they thought the roof had given way just before they saw an enormous sea of fire on top of the tank. This sea of fire was visible from approximately six kilometres away in Kralendijk. The Board was unable to determine how the fire in naphtha tank 1931 could escalate into a fire of uncontrollable proportions. The investigation revealed two possible explanations for the fact that the roof sank. How the Safety Board arrived at these two explanations is set out below.

No one who was in the vicinity of the tank and saw the escalation saw any liquid naphtha hurled out of the tank, which would have been a sign indicating any one of three possible escalation mechanisms.[105] Furthermore, a sample was taken of the fire-extinguishing water in the tank pit around tank 1931 after the fire, but no naphtha was found in the sample. Because no naphtha was thrown out of the tank, the Safety Board considers it a reasonable assumption that none of the three aforementioned escalation mechanisms – slopover, frothover and boilover – occurred.

104 The exact time is not known.
105 Risinger, J.L. (1985): How Oil Reacts When It Burns. In: Fire Protection Manual for Hydrocarbon Processing Plants. Vervalin (ed.), pages 137-148. Houston: Gulf Publishing Company.

Furthermore, a boilover can also be ruled out because a boilover usually involves crude oil (one possible explanation is that crude oil naturally contains water).

It can be assumed from the witness statements that the roof sank, for which there were two possible reasons. Firstly, the pontoons under the floating roof may have sprung a leak, resulting in the roof sinking completely or partially. If the pontoons keeping the roof afloat spring a leak, they fill up with liquid, which therefore impairs the roof's capacity to float. If a pontoon springs a leak and product enters the pontoon, flammable vapour will be created which may explode. The second possible reason why the roof sank is that it may have become weighed down by fire-extinguishing water. Photos show that water was being sprayed into the tank and therefore onto the roof at 15,000 litres/minute from a single water cannon with a booster pump before the fire escalated. On 13 September 2010, investigators from the Safety Board discovered that the water drainage system from the roof of tank 1931 was blocked. On 14 September 2011, RIVM collected a sample of an oil-like substance near tank 1931. Upon analysis, the sample was found not to contain naphtha. The naphtha apparently came from an open water drain after the roof sank. The Board is not aware of any statements to the effect that the water drain was either still open or was shut after the fire started or during the firefighting operation. Based on the above, the Safety Board concludes that the water drain was shut during the fire and the escalation. However, the API says that the water drain must be open because of the danger that excess weight on the roof will cause it to sink and/or tilt.[106] The method used to fight a rim seal fire in this case is considered poor practice because the weight on the roof can cause the fire to escalate to a full surface fire.[107]
The American Petroleum Institute warns about this danger,[108] emphasising that it is mainly present when municipal fire officers with no experience of fighting tank fires are in charge.[109] A combination of the first two scenarios is also possible. In all three cases, the size of the burning surface area increases, which explains the sudden fierceness of the fire and its further development after that point.
A survey conducted by the sector showed that one out of the fifty-five rim seal fires investigated escalated from a rim seal fire into a full surface fire.[110]

106 API 2021, page 33.
107 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, June 1997, risk reduction options, page 84, API 2001, page 11 and API 2021, Appendix F.
108 API 2021 Management of Atmospheric Storage Tank Fires, API Recommended Practice 2021, fourth edition, May 2001, page 53.
109 API 2021, page 53.
110 Lastfire project, large atmospheric storage tank fires, a joint oil industry project, June 1997, escalation mechanisms, page 16.

Figure 14: Fighting the fire with a water cannon and a booster pump[111]

Command of the operation

The Bonaire island fire service came to assist at BOPEC's request. The BOPEC employees were in control of the firefighting operation.[112] When the island fire service is deployed, the Lieutenant Governor is in overall command.[113] In addition to the island fire service and the BOPEC employees, there were also two Dutch government coordinators and a number of fire experts present during the fires at the request of the Lieutenant Governor and BOPEC respectively. The Board has the impression that these different groups were working at cross-purposes and one group did not always know what the other group was doing. It was not clear to the Board, for example, which member of the BOPEC staff was in charge. The advice from the BOT-mi team is another example. At the request of the Lieutenant Governor, one of the Dutch government coordinators asked the BOT-mi team for advice about fighting the fires and cooling down the tanks. The information given to BOT-mi was so general – two tanks are on fire – that the BOT-mi team could only give very general advice, pending more detailed information. It is also not clear whether the advice given to the Lieutenant Governor by the BOT-mi team was communicated to the BOPEC employees. The chief of the island fire service only heard about the existence of this advice much later.

The Safety Board is aware of the fact that there were two tank fires at the same time and that this affected the way in which the two fires were handled because of the limited human and other resources on Bonaire. The Board believes that a decision was taken to prioritise fighting the fire in tank 1901 by first using all mobile resources there. Only afterwards was it possible to focus completely on fighting the fire in tank 1931.

111 Source: Royal Netherlands Navy.
112 API 2021, 7.4.10.
113 Article 5 Island Ordinance on the Fire Service.

The Board concludes that a lack of maintenance and inspections caused the fixed extinguishing system not to work properly where disaster response was concerned. Efforts were made to extinguish the fire in the crude oil tank (1901) using a hand-operated foam jet pipe from the rim of the tank wall.

It was not possible to use the same method to extinguish the second fire in the naphtha tank (1931). The tank wall rim was inaccessible because the staircase was too hot to walk on. Furthermore, the foaming agent was used up and before sufficient foaming agent to fight the fire was available, the fire escalated and the fire fighting operation stopped.

The roof on the naphtha tank very probably sank due to the load on the roof, including a large quantity of extinguishing water sprayed onto the roof by the fire service that could go nowhere. This water combined with the weakening of the roof's pontoons caused the roof to sink. As a result of the roof sinking, the fire escalated to become a full tank surface fire.

4 CONCLUSIONS

On 8 September 2010, a fire started in two storage tanks belonging to the company BOPEC on Bonaire. The two tanks stood approximately 800 m away from each other. The tanks contained liquids classified as highly inflammable: crude oil in tank 1901 and naphtha in tank 1931. The fire in the naphtha storage tank escalated on the evening of 8 September and this tank subsequently burnt out completely. The fire in the naphtha tank was put out on 11 September. No one was injured in these fires, but there was damage to property.

Thanks to the efforts of the island's and BOPEC's own fire officers, the fire in the crude oil tank was extinguished the same afternoon and it was possible to save the tank. The naval vessel HMS Zuiderkruis also came to offer assistance and provided fire-extinguishing water pumps, foaming agent and two fire fighting teams after the fire in the crude oil storage tank had been extinguished.

The fires in two storage tanks at BOPEC started separately from each other as a result of lightning during severe weather conditions. Flammable vapour at the rim seal of the floating roofs on both tanks ignited at various points. Fire caused by lightning is always a risk when products such as crude oil and naphtha are stored in floating-roof tanks, which is why it is extremely important that tank terminals such as BOPEC's minimise the chance of a fire and limit any consequences if a fire does occur.

The Dutch Safety Board has investigated the tank fires at BOPEC on Bonaire and has reached the following conclusions:

BOPEC

- BOPEC knew the fire risks and chose the standards published by the American Petroleum Institute (API) as its company standards to ensure safety and the operational security of the tanks. However, the company then failed to comply with the API rules. The required installation components did not undergo preventive inspections and maintenance or were missing altogether.

- Because the seals were not properly tight, there was enough flammable vapour[114] for ignition to take place. The vapour was ignited by an electric charge from a lightning strike. The tanks were not earthed in accordance with the requirements of the American Petroleum Institute (API). There were not enough earthing pins and not all of them were working properly.

- A fire in the rim seal of the floating roof on a storage tank ('rim seal fire') was a recognised risk for BOPEC. However, a rapid and adequate response to the fire – as described in BOPEC's emergency manual – was not possible. The water was not sufficiently pressurised to extinguish these fires. The four fire-extinguishing water pumps were unable to generate sufficient pressure. In addition, the two largest of the four pumps had been withdrawn from service, which reduced the water pressure on 8 September 2010 even further.

- The foam proportioner for tank 1931 was not working properly, which meant that a foam mix did not form immediately. Furthermore, no foam mix was sprayed out of some of the discharge openings from the fixed fire-extinguishing installation on tank 1931.

- Of the three available booster pumps (mobile fire-extinguishing equipment), one had broken down before the fire and a second broke down during the fire on 8 September 2010.

- There was also a shortage of foaming agent for several hours, which was probably because BOPEC had not stored much foaming agent in its storage tanks.

114 The correct mix of vapour and air.

AUTHORITIES ON BONAIRE

It is the role of the authorities on Bonaire to protect people and the environment by imposing rules on BOPEC and supervising the company's compliance with those rules. The Governing Council neglected to set requirements and supervise the activities and company fire service of BOPEC. The Lieutenant Governor – who has overall command in the event of fire and emergency assistance – and the fire service were also not prepared to fight tank fires. The Safety Board concludes as follows:

- The Island Council of Bonaire had drawn up the legal framework for fighting and preventing fires at BOPEC. The Island Council adopted the Bonaire Nuisance Ordinance (1995) and the Island Ordinance on the Fire Service (1999).
  - In 2009, the Governing Council of Bonaire decided that BOPEC's activities required a permit under the Nuisance Ordinance of 1995;
  - In June 2010, the Governing Council gave BOPEC permission to conduct activities without a permit until 31 December 2010 and attached no conditions to that permission;
  - The Governing Council did not designate BOPEC as a company that must establish its own fire service under the Island Ordinance on the Fire Service and therefore failed to apply this local law.

- The Island Council of Bonaire adopted the Island Ordinance on Disaster Response (2002). However, the Lieutenant Governor did not adopt a disaster response plan for BOPEC under this Island Ordinance. In 2008, the Lieutenant Governor asked the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) for help in gaining an insight into the foreseeable emergency situations on Bonaire.

- The island fire service was organised for firefighting in the event of aviation accidents, not tank fires. Until 2007, the island fire service practised with BOPEC; BOPEC decided to stop these joint exercises from 2007 onwards.

- The roof on the naphtha tank very probably sank because of the load on the roof, including a large quantity of water sprayed onto the roof by the fire service that could go nowhere. This water, combined with the weakening of the roof's pontoons, caused the roof to sink. As a result of the roof sinking, the fire escalated until the entire surface of the tank was on fire (a 'full surface fire').

It was possible for the fires to start and escalate because BOPEC had not fulfilled its responsibility to minimise the chance of a fire in the storage tanks and to limit the consequences if a fire started. The authorities on Bonaire had not imposed any rules on BOPEC as regards fighting and preventing fires in storage tanks.

5 RECOMMENDATIONS

The Safety Board is aware of the developments on Bonaire after the fires (see Appendix 9). As the Lieutenant Governor felt it was important to assess the extent to which the BOPEC site could resume work after operations had been suspended on 10 September 2010, a group was established to advise on the matter. Based on the advisory group's findings, Bonaire's Lieutenant Governor gave BOPEC permission to resume operations – subject to strict conditions – on 7 October 2010. One of the conditions stipulates that only fuel oil shall be stored on the site, as it has a higher flash point than naphtha and crude oil and is therefore less flammable.

The Ministry of Infrastructure and the Environment is now processing BOPEC's environmental permit, which the Minister will grant under the Housing, Spatial Planning and Environmental Management (BES Islands) Act. The bill for this Act was passed by the Lower House of Dutch Parliament on 8 February 2011. The preliminary inquiry by the Upper House Committee for Kingdom Relations is not yet complete. The Plants and Activities (BES Islands Environmental Management) Decree that will ensue from the Act is currently expected to enter into force on 1 January 2012. The Minister will then be able to grant a permit to BOPEC.

However, in order to prevent any repeat of the subject of this investigation, the Safety Board considers it extremely important in the interests of fire safety that the following recommendations are implemented as soon as possible:

1. BOPEC
   Give verifiable priority to safety. Ensure in any event that the conductivity and earthing of the tanks and the maintenance and inspections of the installations and firefighting equipment meet BOPEC's own corporate standards, e.g. the Standards and Recommended Practices of the American Petroleum Institute and the National Fire Protection Association.

2. Governing Council of Bonaire
   Ensure that fire safety at BOPEC is and remains guaranteed by setting clear conditions. In this regard, the Safety Board believes it should be mandatory for BOPEC to have its own company fire service including joint exercises under the Island Ordinance on the Fire Service and its supervision.

Administrative bodies that are the subject of a recommendation are required to inform the Minister concerned of their standpoint with respect to implementing this recommendation within six months of the publication of this report. Non-administrative bodies or persons that are the subject of a recommendation are required to inform the Minister concerned of their standpoint with respect to implementation of the recommendation within one year. A copy of this reaction must be sent at the same time to the Chairman of the Dutch Safety Board and the Dutch Minister of Security and Justice.

APPENDIX 1 JUSTIFICATION OF INVESTIGATION

Initial phase of the investigation

On 10 September 2010, the Lieutenant Governor of Bonaire, in agreement with the Prime Minister of the Netherlands Antilles, asked the Governor of the Netherlands Antilles to ask the Dutch Safety Board to initiate an investigation into the tank fire at BOPEC.[115]

In that request, the Lieutenant Governor of Bonaire asked for an investigation covering:
- *The circumstances surrounding the incident*
- *An analysis and assessment of the action taken by the involved parties*
- *Recommendations for the future*[116]*.*

Investigation objective

The objective of the Safety Board's investigations is to limit the impact of future incidents, and wherever possible, prevent them altogether. The Safety Board is tasked with investigating and pinpointing the causes or probable causes of types of incidents or the incidents themselves, as well as of the extent of the impact and, where necessary, with making recommendations to limit that impact.

The Safety Board set the following questions for the investigation into this incident to answer:
- How was it possible for the fires to start?
- How was it possible for the fire in naphtha tank 1931 to develop into a fire of uncontrollable proportions?

In its search for answers, the Safety Board first examined the facts as reported and deduced the direct causes. It then investigated the underlying causes to come up with recommendations in support of structural improvements to physical safety on Bonaire.

Other investigations

At the orders of the Ministry of Housing, Spatial Planning and the Environment (VROM) Inspectorate, the National Institute for Public Health and the Environment (RIVM) also conducted a study into the impact of the tank fire on the human population and the natural environment, in addition to the Dutch Safety Board investigation.

Investigation methods

On 13 September 2010, the investigation began on Bonaire, led by a team consisting of an investigation manager and two investigators. The investigation manager was on-site for three days, while the two investigators stayed for fived days. During the team's stay, it went several times to BOPEC and once to the main island fire station. The team also conducted ten interviews and gathered documentation.

115 Until 10 October 2010, the Dutch Safety Board was authorised, under Article 4(1)(b) of the Kingdom Act concerning Safety Investigation Board (*Rijkswet Onderzoeksraad voor veiligheid*), to respond to such a request by initiating an investigation into an incident on the Netherlands Antilles, including Bonaire. Since 10 October 2010, Bonaire has been a public body of the Netherlands and the Dutch Safety Board is authorised to initiate an investigation with or without a request accordingly.

116 Letter from the Lieutenant Governor of the Island Territory of Bonaire, dated 10 September 2010.

Upon returning to the Netherlands, two more investigators and a project manager were added to the investigation team. Since the Bonaire visit, all of the new information has been processed and analysed. Additional information also came to light in the Netherlands.

During the second visit, the Board asked permission to discuss several matters with the general manager of BOPEC. Unfortunately, this request was denied.

The Safety Board outsourced part of the investigation to external parties, to determine the functionality of one of the earth cables from the naphtha tank (1931). This inspection was carried out by Stork FDO Inoteq B.V.

Analysis

Three instruments were used in the analysis: Sequentially Timed Events Plotting (STEP) for timeline analysis, the Systems-Theoretic Accident Model and Process (STAMP) and Tripod. These instruments are explained in detail below.

Timeline analysis
An analysis was carried out on the basis of a timeline and a reconstruction of the incident, generated using Sequentially Timed Events Plotting (STEP). In this procedure, the events are plotted sequentially and two-dimensionally. Time is plotted along the horizontal axis and the actors corresponding to the events are plotted on the vertical axis. This timeline helps illustrate the chain of events starting from the moment lightning struck. The events in the timeline were reconstructed from various sources, such as photographs taken on the ground and from the air, emails, logbooks and assessment reports by the involved aid workers and interview reports.

Systems-Theoretic Accident Model and Process (STAMP)
STAMP is based on the assumption that accidents result from a disruption in various interacting elements of in a system. Accidents occur when there is insufficient control over or enforcement of safety-related constraints on the development, design and execution of the system. Safety is considered be a 'control problem', with accidents occurring when those in charge fail to manage malfunctioning components, disruptive outside influences and/or dysfunctional interaction between system components properly.

The STAMP analysis is a four-step procedure. First, the system is assessed for risks. Next, the system's control measures are identified. The third step involves identifying the structure designed to ensure that the control measures are actually taken. Lastly, the malfunctioning components or interactive relationships between the disrupted components are assessed.

Tripod BETA
The Tripod BETA analysis method was used in this investigation. A practical instrument based on the Tripod theory that plays a supporting role in accident investigations, the method is a tool that enables structured investigation and analysis of accidents and incidents. This investigation's Tripod diagram has been included in a separate appendix (Appendix 10).

Safety management assessment framework

The ability to demonstrate control over safety and continue to improve it, are largely dependent upon the structure and individual parts of the safety management system. This is true not only for all organisations actively involved in activities with potential risks for Dutch citizens, but also for those that involved more peripherally. These organisations can differ in size and type and assume a variety of roles and responsibilities in society, including ministries, provinces, municipalities and private companies. The requirements of the various individual parts of the safety management system for a particular investigative area are directly dependent upon the context. The context, in turn, is determined by the type, size and responsibilities of the involved parties, as well as the phase in the life cycle (the focus on design, execution, control, etc.). Based on national and international legislation and regulations and a large body of widely accepted and implemented standards, the

Safety Board has identified particular safety focus areas, which the involved organisations are expected to address in more detail in their own safety management systems. These are:

A safety strategy based on an understanding of the risks
The basis for achieving an acceptable safety level is:
i. a system survey, followed by
ii. an assessment of the associated risks. On this basis, it can be determined which risks must be controlled and preventive and repressive measures required to do so.

A testable, realistic safety strategy
A realistic, practical safety strategy/policy, plus the related points of departure, must be established in order to prevent and manage undesirable situations. This safety strategy must be adopted and supervised at management level. This safety strategy is based on:
i. relevant and applicable legislation and regulations
ii. the available standards, guidelines and industry best practices, as well as the organisation's own insight and experiences, plus safety objectives drafted specifically for the organisation.

Implementing and enforcing the safety strategy
To implement and enforce the safety strategy and mitigate the acknowledged risks, the following steps are taken:
i. the method of implementation of the chosen safety strategy is described, with a view to concrete objectives and including the plans plus the associated preventive and repressive measures.
ii. the responsibilities in the workplace for implementing and enforcing safety plans and measures are assigned in manner that is transparent, unambiguous and accessible for everyone.
iii. the staff complement and expertise required for the various duties is clearly laid out.
iv. safety activities are clearly, actively and centrally coordinated.

Tightening the safety strategy
A stricter safety strategy must be an ongoing goal, to be achieved through:
i. risk and other analyses, observations, inspections and audits (proactive approach) to be carried out periodically, or, at the vey least, each time the points of departure change.
ii. development of a system to monitor and investigate and expert analysis of incidents, near accidents and accidents (reactive approach). On this basis, evaluations are carried out and, if necessary, the management modifies the safety strategy. Areas for improvement are also raised, which can be actively addressed.

Management supervision, commitment and communication
The management of the involved parties/organisations is responsible for:
i. taking steps internally to ensure expectations regarding safety objectives are clear and realistic, that there is a spirit of ongoing safety improvement in the workplace, in any event by setting a good example and, finally, that there are enough staff and resources to do so.
ii. communicating clearly to the outside world regarding the general working methods and their assessment and the procedures in exceptional circumstances, by reaching and specifying clear agreements with the community.

Verification

From 14 to 18 February 2011, an investigation team, consisting of the project manager and one investigator, visited Bonaire to definitively verify several matters before drafting the report. Together, the team conducted six interviews and gathered documentation. On 16 February, a second investigator was sent to join the team to provide technical support.

Project team

The project team consisted of the following members:	
R. Smits	Investigation Manager
A.P. Nelis	Investigation Manager
M.C.F. Konijn	Project Manager
R. Lagendijk	Project Assistant
A. van Roosmalen	Investigator
S. van Rossenberg	Investigator
L.P. Sluijs	Investigator
P.J.J.M. Verhallen (until 15-01-2011)	Investigator
E.M. de Croon	Analyst

The following individuals made important contributions to the investigation:	
W.F. Furster	Investigator

APPENDIX 2 RESPONSES TO THE REPORT

Inspection of the draft report
Under Safety Board Kingdom Act anyone directly involved in an incident must have the opportunity to respond to findings in a draft report by the Safety Board for a period of 30 days. Those parties can then point out if any of the facts have been misrepresented and where necessary, the Safety Board can correct any errors in the final report.

Once approved by the guidance committee and Board, the draft report (without any comments or recommendations) was submitted to the involved parties for assessment. The following parties received a copy of the draft report:

- BOPEC N.V.
- Lieutenant Governor of Bonaire
- Bonaire Head of the Fire Service and Disaster Response
- Bonaire Police Force
- Harbour and Pilotage Service
- Flag Officer Netherlands Forces Caribbean
- Ministry of Defence
- Ministry of the Interior and Kingdom Relations
- Ministry of Infrastructure and the Environment
- Ministry of Security and Justice
- Ministry of Social Affairs and Employment

Where relevant, the Safety Board integrated the feedback into the final report. Any responses not included are mentioned below. In each case, the Safety Board explains why it chose not to change its report in response to the comment.

The feedback is divided into three categories: first, there were comments on the text itself and factual errors. The majority of these comments were accounted for in the final version. Second, some comments related to unclear descriptions of the facts. The writing in those parts of the final report was clarified or tightened in response to those comments. Finally, there were comments which were not accounted for at all in the final report. See below for an overview of these comments and the reasons for not accounting for them. The comments are listed by party.

Party	Section	Comment (quoted)	Reason comment was not accounted for
1 BOPEC	1.3	*The introduction suggests that, in relation to the second question raised in the investigation, the fire was of "uncontrollable proportions". According to the facts, the contents of tank 1931 burned in a controlled manner that did not pose a risk to people or the surroundings.*	In fire fighting, a fire is termed 'uncontrollable' if protecting the surrounding area is the only measure that can be taken. That was not true in this case: the tank could have collapsed, but it did not.
2 BOPEC	2.3	*"BOPEC immediately requested foaming agent from sister companies." This statement suggests that this measure was taken because there was no foaming agent available. This measure is normal if a long logistical procedure for delivery is involved. This was a proactive measure.*	No fact has been disputed by BOPEC.

Party	Section	Comment (quoted)	Reason comment was not accounted for
3 BOPEC	2.3	*It is untrue that "A replacement was found, but it was not in working order". The first booster pump used to cool the wall of the tank did, in fact, break down at 12:50 p.m. The second booster pump that was brought in for use on Tk-1931 functioned satisfactorily. The photos show that this pump continued to work for several days.*	It was inferred from information that the Safety Board received from BOPEC that BOPEC had three booster pumps. One of them was not working before the incident occurred. One was used in tank 1901. The pump in tank 1931 broke down. Various sources have stated that the next pump that was brought in did not work.
4 BOPEC	2.3	*The last sentence: The amount of foaming agent that leaked out of the electrical foam pump and was therefore unusable, was not significant.*	No fact has been disputed by BOPEC.
5 BOPEC	3.2.2	*The inspections were, in fact, carried out. There are files with all inspection reports for each tank.*	The tank files were sent by BOPEC to the Safety Board at the latter's request. There were no inspection reports in those tank files.
6 BOPEC	3.2.2	*The last sentence: BOPEC does have reports on these inspections.*	In response to this reaction from BOPEC, the Safety Board requested the tank files (including the inspection reports). BOPEC sent information, but it did not include any inspection reports.
7 BOPEC	3.2.2	*"Only with the fire… 1901, did the system's alarm go off". This statement is false.*	This response prompted the Safety Board to request a copy of BOPEC's own investigation. There were no new facts in that investigation requiring changes in the report.
8 BOPEC	3.2.1	*"The investigation demonstrated that the fire detection system in several different tanks was not working". However, this was not shown to be the case in our own investigation.*	The Safety Board requested a copy of BOPEC's own investigation. It states that a report came in, but does not say whether the report came from the fire detection system.
9 BOPEC	3.2.2	*110 psi should have read 250 psi.*	BOPEC previously supplied information indicating that 110 psi was the correct figure.
10 BOPEC	3.2.2	*The calculation is based on NFPA 11, Williams Fire and the Rotterdam Joint Fire Service. This combination is not an internationally recognised calculation method (Williams Fire is not a standard). It is also unclear whether the surfaces that had absorbed radiation were the only ones used to calculate which surfaces had to be cooled.*	The report states (p.35) that Williams Fire is a specialist in tank fire fighting, and therefore is not standard. BOPEC's own calculation served as the basis for the calculation. In this calculation, BOPEC calculated a cooling capacity. The cooling capacity calculated by BOPEC was checked, to establish whether it was feasible. This proved not to be the case.
11 BOPEC	3.2.2	*BOPEC complies with the NFPA 11c code, the prevailing international standard prescribing a 65-minute extinguishing time.*	NFPA 11c was withdrawn in 1999.

Party	Section	Comment (quoted)	Reason comment was not accounted for
12 BOPEC	3.3.1	*"Government authorities were not found by the Safety Board to have a disaster response plan for BOPEC". This sentence implies that there was no plan in place for the incidents that were investigated. However, it is inaccurate to refer to a "disaster" in this case. That is also indicated on page 20.*	No fact has been disputed by BOPEC.
13 BOPEC	3.3.1	*The last sentence in relation to the capacity calculation is incorrect. BOPEC does in fact comply with NFPA 11c. See the comment on page 32, paragraph 1.*	NFPA 11c was withdrawn in 1999.
14 BOPEC	3.4	*There are no nozzles on the ring line in tank 1931 that can become plugged with rust particles, as has been suggested.*	It is not possible to ascertain from the drawings of the outlet openings provided by BOPEC whether the outlet openings have features protecting against blockage. Sources have stated that the outlet openings were blocked with rust particles.
15 BOPEC	3.4	*"According to the Board, the notion that the two tanks with foaming agent were not completely full is plausible". There are no facts to back up this statement. The two foam tanks were full when the two fires broke out.*	In response to this comment, the Safety Board asked BOPEC to prove that the tanks were completely full. BOPEC sent out a checklist, on which one of its employees stated that the tanks were full. However, the Safety Board does not think that this represents incontrovertible evidence that the tanks were filled with foaming agent. Several sources have stated that, from time to time, there was not enough foaming agent available.
16 BOPEC	3.4	*The fire in tank 1931 never satisfied the definition of a "fire of uncontrollable proportions".*	In fire fighting, a fire is termed 'uncontrollable' if protecting the surrounding area is the only measure that can be taken. That was not true in this case: the tank could have collapsed, but it did not.
17 BOPEC	3.4	*"Furthermore, the foaming agent was used up. Before there was enough… and they stopped fighting the fire". These sentences are factually incorrect.*	In response to this comment, the Safety Board asked BOPEC to prove that the tanks were completely full. BOPEC sent out a checklist, on which one of its employees stated that the tanks were full. However, the Safety Board does not think that this represents incontrovertible evidence that the tanks were filled with foaming agent. Several sources have stated that, from time to time, there was not enough foaming agent available.

Party	Section	Comment (quoted)	Reason comment was not accounted for
18 BOPEC	3.4	*The notion that "The fire escalated… was sprayed on the roof." is highly unlikely. The roof drains were open and the roof was not sprayed with the booster pump until just after the fire had escalated.*	On 13 September 2010, investigators from the Safety Board discovered that the water drainage system of tank 1931 was blocked. On 14 September 2011, RIVM collected a sample of an oil-like substance near tank 1931. Upon analysis, the sample was not found to contain naphtha. The naphtha apparently came out of an open water drainage system after the roof had sunk. No statements have been made to suggest that the water drainage system had either been opened or shut off after the fire started, or during the extinguishing process. Based on the above, the Safety Board concludes that the water drainage system was shut off during the fire and as it escalated.
19 BOPEC	4	*GENERAL CONCLUSIONS: BOPEC disputes the first sentence of this conclusion. Most of the facts mentioned have been refuted and have proven incorrect. The investigation of the background information and the circumstances surrounding the established shortcomings in the fire fighting efforts have not been sufficiently substantiated and do not justify this statement.*	The first sentence reads as follows: "Two tank fires broke out and one of them was able to escalate because BOPEC had not taken responsibility for fighting and preventing fires in the storage tanks". The Safety Board believes that this sentence is adequately substantiated by the facts described in the report.
20 BOPEC	4	*Fourth dash: BOPEC had enough foaming agent.*	In response to this comment, the Safety Board asked BOPEC to prove that the tanks were completely full. BOPEC sent out a checklist, on which one of its employees stated that the tanks were full. However, the Safety Board does not think that this represents incontrovertible evidence that the tanks were filled with foaming agent. Several sources have stated that, from time to time, there was not enough foaming agent available.

Party	Section	Comment (quoted)	Reason comment was not accounted for
21 Lieutenant Governor of Bonaire	3.2.1	*Within the context of political changes, the Governing Council of Bonaire granted pro-forma approval to all businesses requiring permits to carry out activities without a permit until 31 December 2010 on the condition that they would submit requests for a permit some time after being granted this approval. In early 2010, it looked as if the Netherlands would draft an act from the Ministry of Housing, Spatial Planning and the Environment (VROM) for the BES islands. Pending the new act, aforementioned 'exemptions' were granted. The fact that the Harbour Master periodically monitors safety at BOPEC was not taken into account.*	This paragraph was moved to Chapter 2, Section 2.1.2. The supervisory tasks performed by the Harbour Master related to regulations to preserve the underwater ecology and were aimed at activities performed at BOPEC's jetties.
22 Lieutenant Governor of Bonaire	3.2.1	*Despite the fact that a company fire service was not formally required by the Governing Council, BOPEC had set up its own company fire service, of which the Governing Council was also aware. Later, during the fire, the company fire service proved to be below par. Immediately after the incident, the Lieutenant Governor imposed requirements on BOPEC, including that the calibre of the BOPEC company fire service had to be raised to conform to current standards. BOPEC accepted these requirements in writing.*	The events following the fire are outlined in the appendix of the report.
23 Bonaire Fire Service	3.2.2	*The drawing unfairly oversimplifies the situation because it does not show the sectioning of the floating roof.*	It is intended to be a schematic drawing of the seal, which is clearly indicated in the text. The caption has been changed.
24 Bonaire Fire Service	3.2.2	*The water pressure of the fixed fire-extinguishing installation was found to be too low, contrary to the conclusion (page 33, first item of interest and page 48, last sentence), which states that "the fire escalated because the fire in the naphtha tank was very likely caused by the fact that the fire service sprayed a great deal of water on the roof, thus increasing the load of the roof". If the water pressure was not high enough, this is physically impossible. Furthermore, the passage on page 42, first paragraph in relation to the water pressure also undermines the aforementioned conclusions (on pages 33 and 48).*	The water pressure of BOPEC's installation was not high enough to put out the rim-seal fire with the fixed system. The photos show that water was sprayed on the roof with mobile extinguishing equipment, with the aid of an additional pump.
25 Bonaire Fire Service	3.4	*The second scenario, which may have been assumed, is physically impossible, because, as previously stated, the water pressure was not high enough.*	The water pressure of BOPEC's installation was not high enough to put out the rim-seal fire with the fixed system. The photos show that water was sprayed on the roof with mobile extinguishing equipment, with the aid of an additional pump.

APPENDIX 3 BONAIRE GOVERNMENT STRUCTURE

General information

Until 10 October 2010, 3 countries belonged to the Kingdom of the Netherlands: the Netherlands, the Netherlands Antilles and Aruba. On 10 October 2010, the number increased to 4: the Netherlands Antilles no longer exist as such, and Curaçao and Saint Martin are two 'new' countries in the Kingdom.

In 1986, Aruba was granted country status within the Kingdom, which it retained after 10 October 2010.

Like Aruba, Curaçao and Saint Martin are now sovereign countries within the Kingdom of the Netherlands with an independent government and are therefore no longer dependent upon the Netherlands. On Curaçao and Saint Martin, a governor represents the government of the Kingdom of the Netherlands.

Bonaire, Saint Eustatius and Saba, which are all part of the Dutch Caribbean became 'special' municipalities (i.e. public bodies) of the Netherlands, and will have this status under Dutch law from now on.

Government and legislation

Like Aruba and the Netherlands Antilles (until 10 October 2010), Curaçao and Saint Martin both have their own government and parliament. The government and parliament share the power of passing legislation each in their own designated areas.

Gradually, the previous Antillean legislation is making way for 'BES legislation' on Bonaire, Saint Eustatius and Saba (derived wherever possible from Dutch legislation). In the process, the unique situation on the individual island is also carefully factored in.

Two governments on the Dutch Caribbean islands

Bonaire, Saint Eustatius and Saba have 2 governments: the local government and the Dutch National Government. To a large degree, the Dutch National Government has taken over the previous national duties of the Netherlands Antilles. The local government was previously and continues to be controlled by the islands' own parliamentarians and the Island Council. The Island Council is chaired by the Lieutenant Governor, who is appointed by Royal Decree. The Lieutenant Governor also presides over the Governing Council. In addition taking over responsibilities from the former Dutch Antilles, the Dutch National Government has also assumed duties previously performed by the individual islands, such as managing the Fire Service.

Foreign interests following constitutional reorganisation

The constitutional reorganisation did not affect the promotion of foreign interests

- the Kingdom's external borders have not changed
- foreign affairs, as well as defence, remain the responsibility of the Kingdom
- the Minister of Foreign Affairs still has authority over the entire Kingdom
- the Ministry of Foreign Affairs and the embassies still act on behalf of the entire Kingdom and all of its parts
- as of 10 October 2010, the Caribbean countries of the Kingdom of the Netherlands (Aruba, Curaçao and Saint Martin) have each had their own Foreign Relations Department (DBB). The

Dutch name of this agency is slightly different on Saint Martin: 'Beleidsafdeling Buitenlandse Betrekkingen' (BBB).
- International treaties can apply either to the all parts of the Kingdom, or to individual parts, in any possible combination. For the time being, EU regulations do not apply on the BES islands or on Aruba, Curaçao or Saint Martin.

Bonaire, Saint Eustatius and Saba

Special municipalities
The new status of these islands as 'special municipalities' means that they are recognised as official 'public bodies' of the Netherlands, as laid down in the Bonaire, Saint Eustatius and Saba (Public Bodies) Act. The national government, municipalities, provinces and water boards are examples of other public bodies.

Dutch and Antillean legislation
The Antillean legislation remained in force after 10 October 2010, except in cases where BES legislation replaced Antillean laws or filled a gap in the Antillean legislation. It would be impossible to simply impose Dutch legislation 'straight away'. It would cause a great deal of turmoil on the islands, because the legislation is designed specifically for the Netherlands. Therefore, Dutch legislation is being introduced gradually, while carefully monitoring the situation on each island.

Changes for inhabitants
Since 10 October 2010, the inhabitants of Caribbean Netherlands have enjoyed the same rights as the Dutch because the islands became Dutch municipalities on that date. It goes without saying the local populations on the islands have retained their own culture. Additionally, facilities have improved, or improvements are planned for the future.

Examples:
- universal health care
- better care facilities (specialised hospitals, more ambulances)
- better education facilities (programmes to eliminate learning disadvantages, refresher courses for teachers, new teaching methods, new school buildings)
- subsidised rented housing for lower income groups
- clean drinking water
- new police force, fire service and ambulances plus a central control room
- the dollar became the new currency on 1 January 2011
- better airport and harbour security
- right to vote in elections to the Lower House

Effect on government and legislation
- The Antillean legislation will gradually be replaced by the Dutch legislation on Bonaire, Saint Eustatius and Saba.
- The National Office for the Caribbean Netherlands represents all Dutch ministries on Bonaire, Saint Eustatius and Saba.
- Curaçao and Saint Martin are responsible for their own national government and legislation.

APPENDIX 4 OVERALL IMPRESSION OF BOPEC INSTALLATIONS

Photo 1: Leak in a water pipe (source: Dutch Safety Board, dated 13 September 2010)

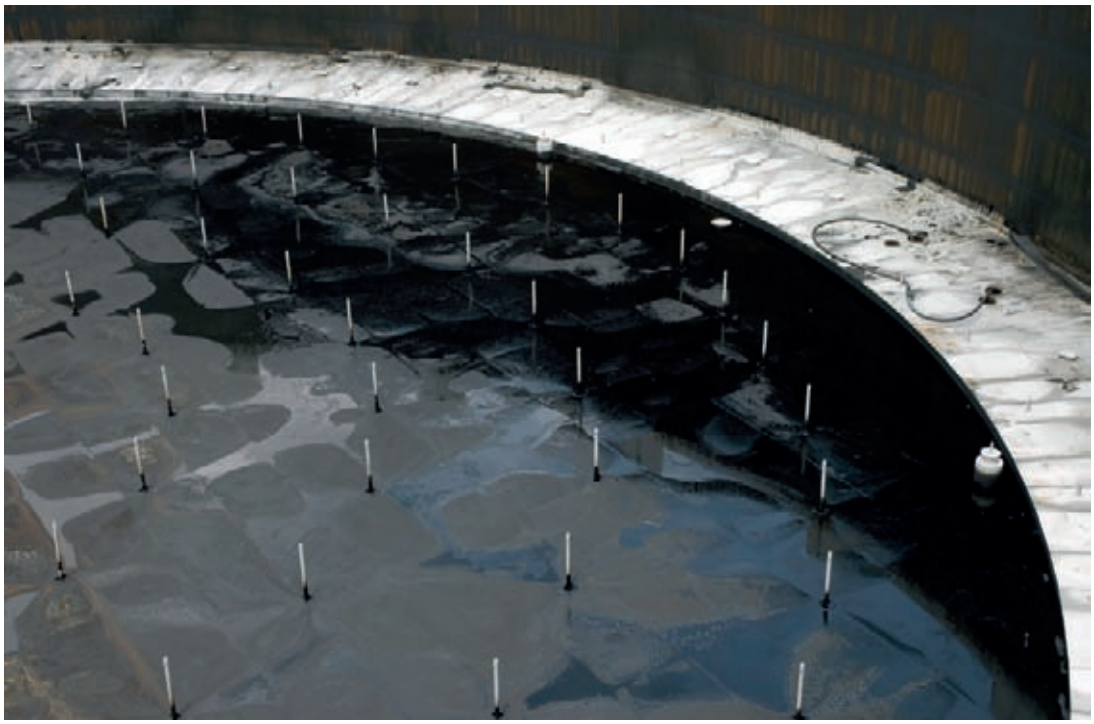


Photo 2: Roof 1901 with open manholes and a dirty roof and walls (source: Dutch Safety Board, dated 13 September 2010)

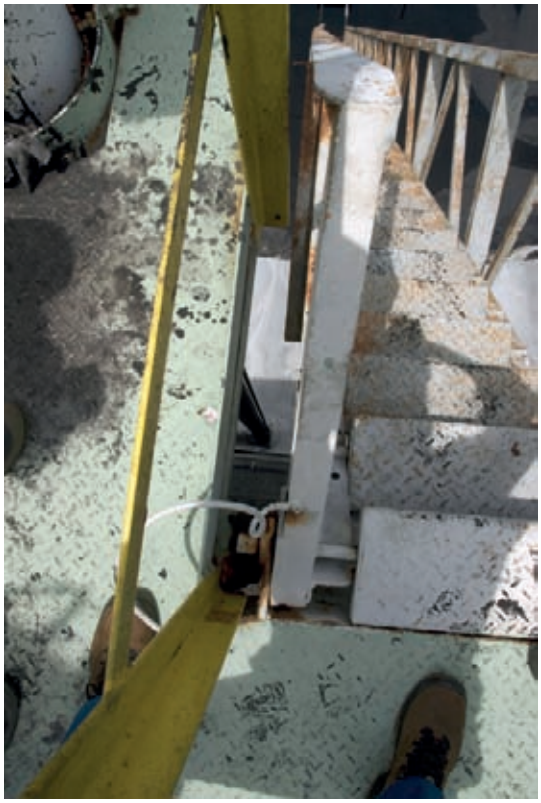


Photo 3: Tank 1901, loop in connecting cable, stairway/wall (source: Dutch Safety Board, dated 13 September 2010)

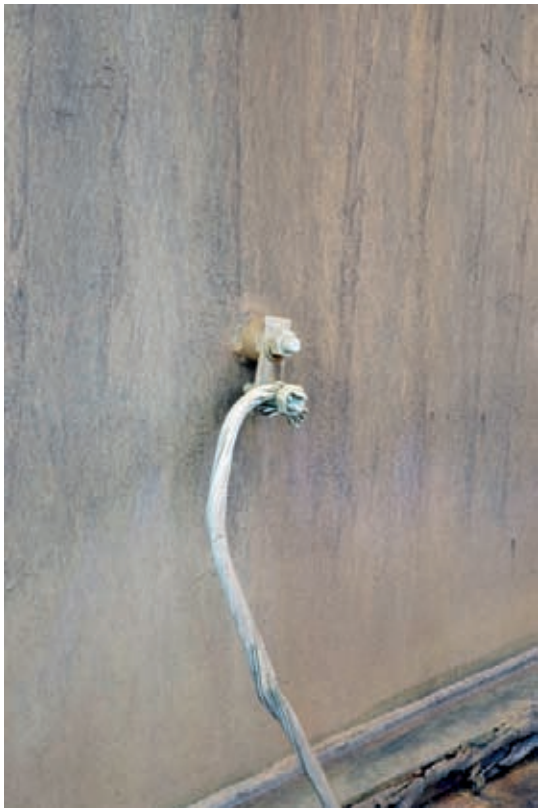


Photo 4: Tank 1931, earth connection, covered with paint (source: Dutch Safety Board, dated 13 September 2010)

Photos 5 and 6: Both fire-extinguishing pumps (blue) and a pallet (source: Dutch Safety Board, dated 13 September 2010)

Photos 7 and 8: Overall impression (source: Dutch Safety Board, dated 13 September 2010)

Photo 9: Tank 1906, pallets and water on the tank roof (source: Dutch Safety Board, dated 16 February 2011)

Photo 10: Storage tank with foaming agent in the pool (September 2010)

Photo 11: Tank 1934, corroded earthing pins (source: Dutch Safety Board, dated 16 February 2011)

APPENDIX 5 CALCULATION OF EVAPORATIVE LOSS

Points of departure

Calculation method: RIVM/Netherlands Environmental Assessment Agency (MNP) report "Diffuse emissions and emissions in storage and transfer – Emissions Factors Manual" ["Environmental Monitor"report series, Number 14, March 2004 (+ 2006 correction)]

Parameter Tank contents (substance)		**T1901** Crude petroleum	**T1931** naphtha	**unit**
Reid vapour pressure*	RVP	41.4	80	kPa
tank diameter	D	82.9	83.8	m
product temperature	T	30.3	29.9	°C
product factor	Kc	0.4	1	-
wind velocity	v	6	6	m/s
atmospheric pressure	Pa	101.3	101.3	kPa

* The mean of the RVP range (between 60 and 100 kPa) was chosen for naphtha, as referred to in the RIVM/MNP report. The value referred to on the Napo Crude MSDS (available at BOPEC) was used for crude petroleum.

Sealing factors – welded tank; metallic shoe seal; rim mounted secondary seal			
- zero-wind-speed rim-seal loss factor	K_{ra}	0.6	lb-mole/(ft x yr)
- wind-dependent rim-seal loss factor *	K_{rb}	0.4	lb-mole/((miles/hr)^n x ft x yr)
- wind-dependent rim-seal loss exponent	n	1	-
Sealing factors – welded tank; metallic shoe seal; primary seal only			
- zero-wind-speed rim-seal loss factor	K_{ra}	5.8	lb-mole/(ft x yr)
- wind-dependent rim-seal loss factor *	K_{rb}	0.3	lb-mole/((miles/hr)^n x ft x yr)
- wind-dependent rim-seal loss exponent	n	2.1	-

Molecular weight and vapour pressure calculation

	T1901	**T1931**
Molecular weight of the vapour [g/mol]: $M = -0.0023 \cdot RVP^2 + 0.1758 \cdot RVP + 64.942$	60*	64.3
Vapour pressure [kPa]: $P = RVP \cdot 10^{(7{,}047 \cdot 10^{-6} \cdot RVP \cdot T + 0{,}01392 \cdot T + 2{,}311 \cdot 10^{-4} \cdot RVP - 0{,}5236)}$	28.7	67.8
Measure for relative vapour pressure [-]: $P^* = \frac{P/P_a}{\left(1+\sqrt{\left(1-\frac{P}{P_a}\right)}\right)^2}$	0.083	0.27

* The value was not calculated for T1901 with crude petroleum, but taken from the RIVM/MNP report (page 41).

CALCULATIONS FOR THE WELDED TANK WITH MECHANICAL SHOE SEAL

Tank	With/without secondary seal	Weight loss from evaporation between floating-roof and tank wall [kg/yr] *: $L_u = 1{,}489 \cdot (K_{ra} + K_{rb} (2{,}23 \cdot v)^n) \cdot D \cdot P^* \cdot M \cdot K_c$
T1901	With (rim mounted secondary seal)	1807
	Without (primary seal only)	22899
T1931	With (rim mounted secondary seal)	12874
	Without (primary seal only)	163114

* Zero-wind-speed factor K_{ra} was accounted for in this calculation. In the RIVM/MNP report, this value is considered negligible for a tank with an external roof.

APPENDIX 6 ASSESSMENT OF THE LIGHTNING CONDUCTOR COPPER WIRE

STORK

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ONDERZOEK AAN EEN KOPERDRAAD VAN EEN BLIKSEMAFLEIDER

Rapport

Opdrachtgever	: Onderzoeksraad voor Veiligheid Postbus 95404 2509 CK Den Haag
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1 INLEIDING

Op 13 oktober 2010 ontving Stork FDO Inoteq B.V. van Onderzoeksraad voor Veiligheid een stukje koperdraad afkomstig van de aardleiding van de bliksemafleider van een tank voor olieoverslag op Bonaire voor onderzoek. Het doel van het onderzoek is omschreven als het vaststellen of het koper dat gebruikt is voor de bliksemafleider daar geschikt voor was en of de koperdraad heet geweest is als gevolg van een hoge stroomdoorgang. Een hoge stroomdoorgang zou een gevolg zijn van het afvoeren van een blikseminslag.
De ontvangen koperdraad betreft een enkele draad met een lengte van circa 130 mm en een nominale doorsnede van 2 mm. De aardleiding zelf heeft een totale dikte van circa 15 mm (geschat aan hand van een foto).
Het onderzoek is uitgevoerd in de maand november van 2010 in het laboratorium van Stork FDO Inoteq B.V. te Amsterdam en in het laboratorium van Stork Materials Testing & Inspection te Huntington Beach, USA.
Alle resultaten en de conclusies vermeld in dit rapport hebben alleen betrekking op de onderzochte koperdraad en zijn mede gebaseerd op informatie verstrekt door Onderzoeksraad voor Veiligheid.
Dit rapport bevat 1 bijlage.

2 WERKWIJZE

Om de doelstelling van het onderzoek te behalen zijn de volgende onderzoeken uitgevoerd:

- Visueel onderzoek van de koperdraad;
- Bepaling van de weerstand van de koperdraad om de specifieke elektrische weerstand te berekenen;
- Kwalitatieve bepaling van de chemische samenstelling van het koper;
- Metallografisch onderzoek van een doorsnede over de koperdraad ter beoordeling van de microstructuur van het koper.

3 RESULTATEN

3.1 Visueel onderzoek

De figuren 1 en 2 tonen de koperdraad in ontvangen toestand. De lengte van de koperdraad is bepaald op 133 mm. De doorsnede, gemeten met een micrometer, is op drie positie bepaald. De gemeten waarden zijn 1,90 mm; 1,97 mm en 1,93 mm. Dit geeft een gemiddelde diameter van 1,93 mm.
Op het oppervlak zijn restanten van een coating aanwezig. Verder vertoont het oppervlak mechanische beschadigingen. Dit maakt de metingen over de diameter enigszins onbetrouwbaar. De coating is aan het uitwendige oppervlak groen van kleur. Daaronder is een witte laag zichtbaar. Op andere delen van de draad is een zwarte aanslag aanwezig.

3.2 Metalllografisch onderzoek

Op twee posities van de draad is een doorsnede vervaardigd. De eerste doorsnede is een langsdoorsnede over circa 10 mm lengte, direct aan een uiteinde van de draad, de tweede doorsnede is een dwarsdoorsnede op ongeveer 1 cm vanaf het uiteinde. Deze doorsneden zijn geprepareerd voor metallografisch onderzoek. In gepolijste toestand is zichtbaar dat in de draad

kleine oxiden aanwezig zijn. Deze oxiden liggen in langgerekte banen. De diameter van de afzonderlijke oxiden is kleiner dan 1,5 µm en de lengte is kleiner dan 4 µm. De verdeling van de oxiden is over de gehele diameter vergelijkbaar. De figuren 3 tot en met 7 tonen de doorsneden in ongeëtste toestand.
De figuren 8 en 9 tonen de microstructuur in geëtste toestand. De microstructuur bestaat uit uni-axiale korrels met tweelingvlakken. Deze microstructuur is over de gehele doorsnede aanwezig. Aanwijzingen dat de microstructuur aan het oppervlak afwijkt ten opzichte van de microstructuur in de kern zijn niet waargenomen.
Verder toont de dwarsdoorsnede aan dat onder de coating het oppervlak van de draad beschadigd is. Het oppervlak van de draad onder deze coating is bepaald op 2,755 mm^2.

3.3 Bepaling weerstand van de draad

Van de draad zoals ontvangen is de elektrische weerstand gemeten. Dit is uitgevoerd volgens het vierpuntsmeetprincipe met een milliohmmeter. Bij deze meetmethode wordt over de draad zowel de spanning als de stroom gemeten. Hierdoor worden de overgangsweerstanden van de klembekken op de te meten draad geëlimineerd zodat een nauwkeurige weerstandsbepaling uitgevoerd kan worden. Tijdens de meting is een weestand van 0,82 mOhm gemeten over een draadlengte van 129 mm.

3.4 Chemische samenstelling

Van de draad die overgebleven is, is de chemische samenstelling bepaald. De gemeten samenstelling wordt weergegeven in bijlage 1. Uit de chemische analyse blijkt dat het een kopersoort betreft met een zuiverheid van 99,96% koper. Het zuurstofpercentage is bepaald op 0,026%.

4 DISCUSSIE

Stork FDO Inoteq B.V. heeft op verzoek van Onderzoeksraad voor Veiligheid een onderzoek uitgevoerd aan een koperdraad afkomstig van de aarddraad van de bliksemafleider van een olieoverslagtank op Bonaire. Het onderzoek heeft als doel het bepalen of de koperdraad heet geweest is en om te bepalen of de koperdraad geschikt is als elektriciteitsdraad. Tijdens het onderzoek is gebleken dat in de microstructuur kleine oxiden voorkomen. De chemische samenstelling geeft aan dat het koperpercentage 99,96% bedraagt. Dit geeft aan dat het een nagenoeg zuiver kopersoort betreft, welke tijdens raffinage gereinigd is door middel van zuurstof. De verontreinigen die een negatieve invloed hebben op de elektrische eigenschappen van koper worden hierdoor geoxideerd en komen in de slakresten terecht. Dit verklaart de aanwezigheid van de koperoxiden in het koper en de zeer lage concentratie aan andere elementen.
De specifieke weerstand voor een dergelijk kopersoort bedraagt $1{,}724 \cdot 10^{-5}$ Ωm. De weerstand van de draad is dan te berekenen volgens de wet wet van Pouillet met de formule:

$$R = \frac{\rho \bullet l}{A} \qquad (1)$$

waarbij:
R = de weerstand van de draad in [Ohm];
ρ = de soortelijke weerstand van het materiaal in [Ohm•meter];
l = de lengte van de te meten draad in [m];
A = de dwarsdoorsnede van de draad in [m^2].

Als de theoretische soortelijke weerstand ingevuld wordt bij een lengte van 129 mm en een doorsnede van 2,936 mm^2 (gemiddelde diameter van 1,93 mm) dan levert dit een weerstand van 0,76 mOhm. De diameter is door de aanwezigheid van resten coating op het oppervlak en door de mechanische beschadiging van het oppervlak niet zuiver te bepalen. Ter plaatse van de doorsnede was voor de diameter 1,93 mm gemeten (gemeten langs de coating). Echter, tijdens het metallografisch onderzoek is vastgesteld dat onder de coating het oppervlak van de draad mechanisch beschadigd is. Deze oppervlakte beschadiging moet dus al aanwezig geweest zijn voor het aanbrengen van de coating. Het oppervlak van de doorsnede onder de coating bedraagt 2,755 mm^2. Dit komt overeen met een theoretische diameter van 1,873 mm (3% lager ten opzichte van de gemeten diameter). Als deze vermindering op de diameter wordt toegepast op de gemiddelde gemeten diameter levert dit een weerstand op van 0,81 mOhm. Dit geeft aan dat de gemeten weerstand van 0,82 mOhm overeenkomt met de theoretische weerstand welke voor het toegepaste kopersoort geldt. Hieruit kan geconcludeerd worden dat het kopersoort zoals gebruikt geschikt is voor elektriciteitsdoeleinden.
De koperoxiden zoals waargenomen in de doorsneden zijn klein van omvang, duidelijke georiënteerd in de lengterichting van de draad en zijn homogeen verdeeld over de draad. Dit geeft aan dat de koperoxiden al van oorsprong in het koper aanwezig zijn. Als koper heet wordt in een zuurstofrijke omgeving zal het aan het oppervlak oxideren. Hierdoor zou aan het oppervlak een verhoogde concentratie van koperoxiden aan het oppervlak optreden. Dit is niet waargenomen. Hieruit kan vastgesteld worden dat het onderzochte stukje koperdraad niet heet geweest is.

5 CONCLUSIE

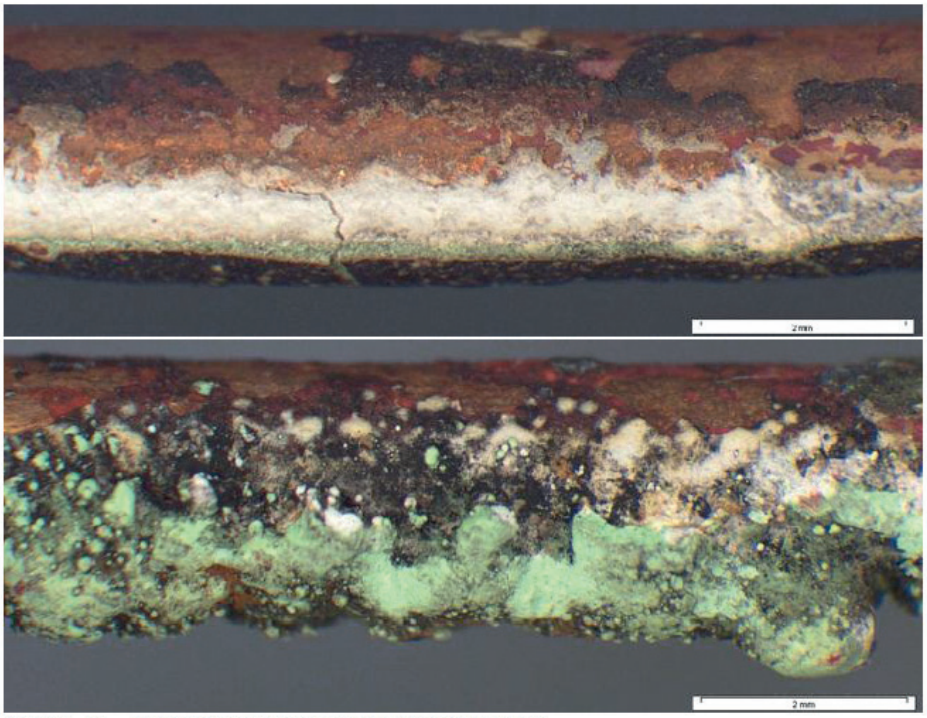
Stork FDO Inoteq B.V. heeft op verzoek van Onderzoeksraad voor Veiligheid een onderzoek uitgevoerd aan een koperdraad afkomstig van de aarddraad van de bliksemafleider van een olieoverslagtank op Bonaire met als doel het vaststellen of de koperdraad heet geweest is vaststellen of het toegepaste kopersoort geschikt was voor elektriciteitsdoeleinden. Uit het onderzoek is gebleken dat het onderzochte stukje koperdraad niet heet geweest is en dat het toegepaste kopersoort geschikt is voor elektriciteitsdoeleinden.

Stork FDO Inoteq B.V.

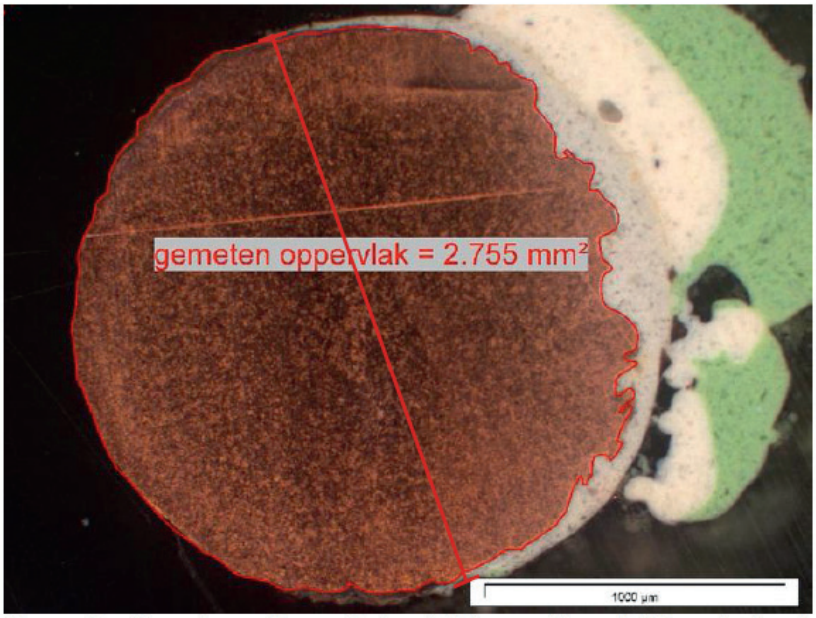
Autorisatie: G.W. Medendorp
BU Manager

Auteur: Ing. A. Bank

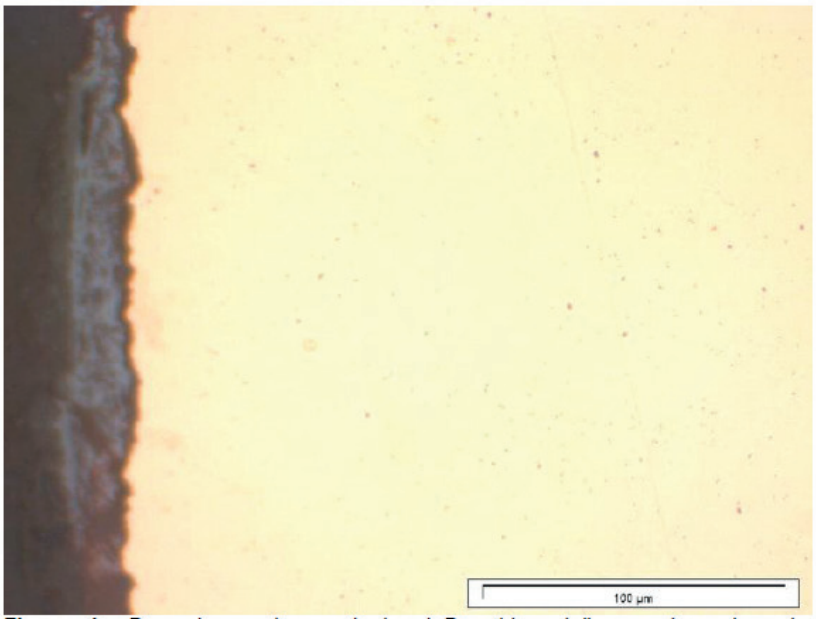
Figuur 1. Het stukje koperdraad zoals ontvangen.



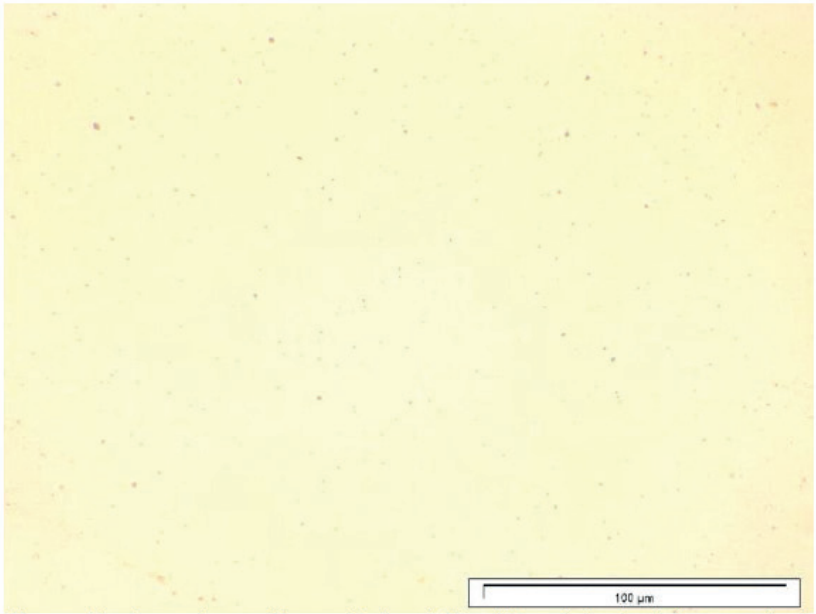
Figuur 2. Detail van het oppervlak van de koperdraad.



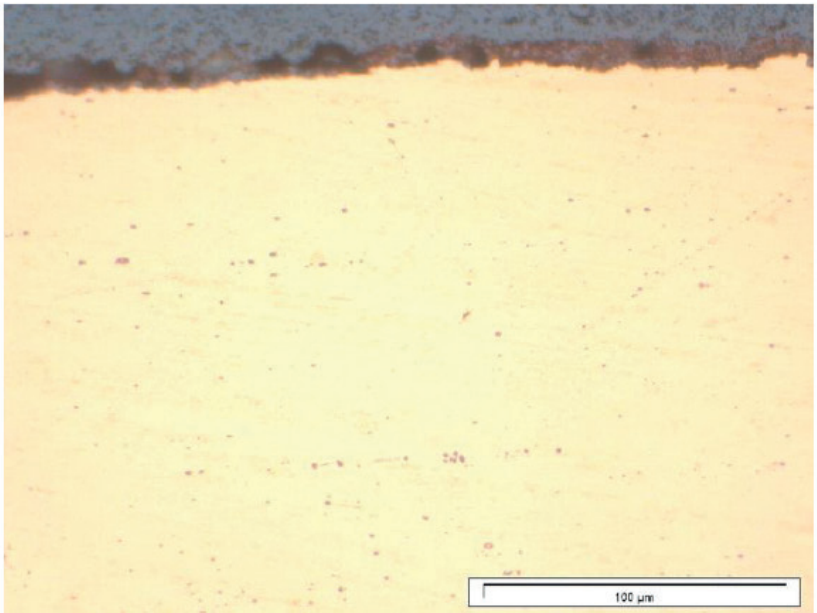
Figuur 3. Dwarsdoorsnede over de draad. Het oppervlak van het koper bedraagt 2,755 mm². De diameter was op deze positie bepaald op 1,93 mm.



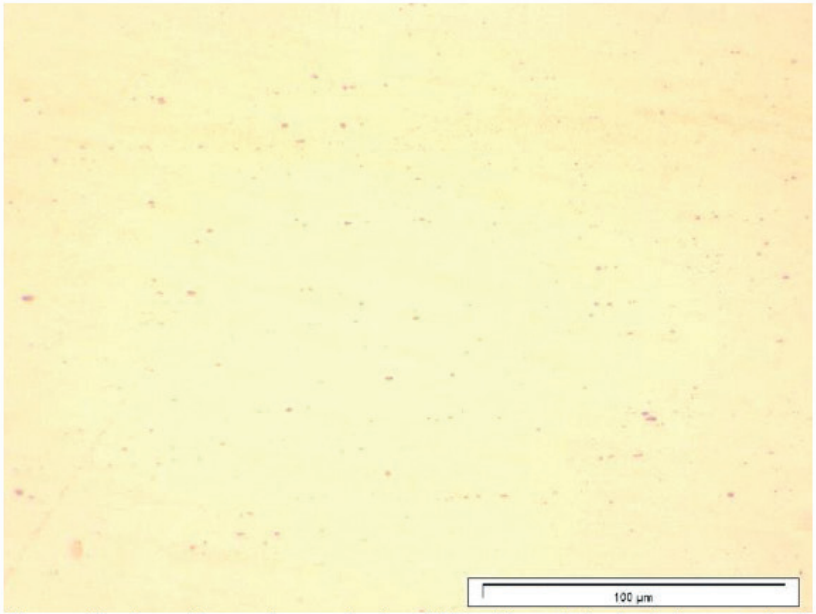
Figuur 4. Dwarsdoorsnede over de draad. De oxideverdeling aan de rand van de draad.



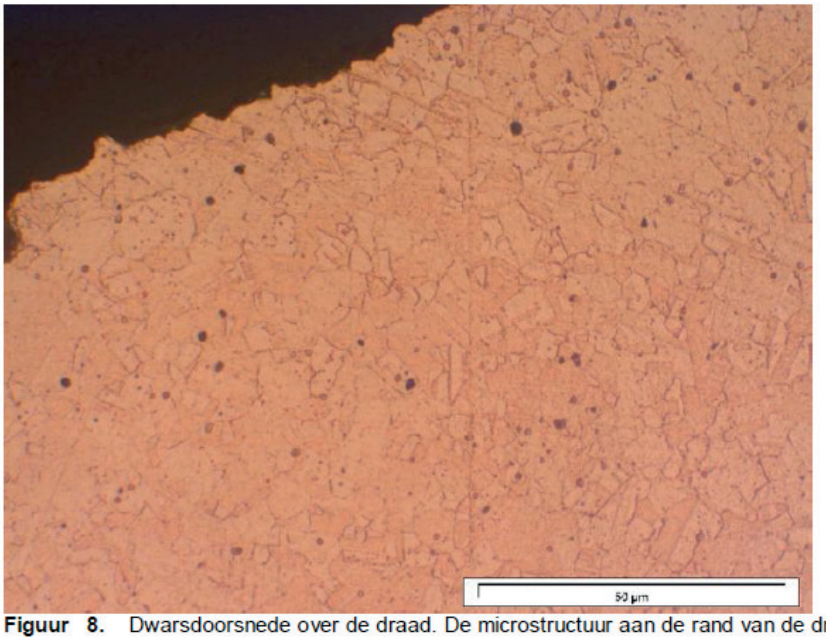
Figuur 5. Dwarsdoorsnede over de draad. De oxideverdeling in de kern van de draad.



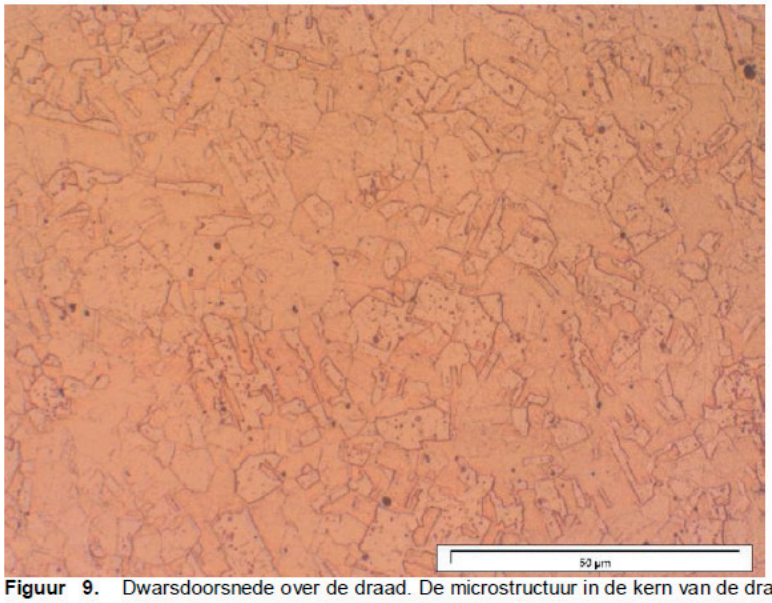
Figuur 6. Langsdoorsnede over de draad. De oxideverdeling aan de rand van de draad.



Figuur 7. Langsdoorsnede over de draad. De oxideverdeling in de kern van de draad.



Figuur 8. Dwarsdoorsnede over de draad. De microstructuur aan de rand van de draad.



Figuur 9. Dwarsdoorsnede over de draad. De microstructuur in de kern van de draad.

APPENDIX 7 CALCULATION OF FOAMING AGENT AND WATER FOR FIRE SUPPRESSION

Points of departure

Calculation method	NFPA 11, Standard for Low-, Medium-, and High-Expansion Foam (2010 edition); section 5.3 'Outdoor open-top floating roof tanks'.		
Extinguishing method	- top-of-seal method with foam dam - fixed foam discharge outlets.		
Extinguishing requirements*	minimum application rate – mechanical shoe seal (B)	12.2	l/min.m^2
	minimum discharge time – mechanical shoe seal (t)	20	min
Tank data	tank diameter (D)	83.8	m
	distance from foam dam to tank wall (a_{fm})	0.5	m
Foam data	Foam concentration (c)	3	%

* values taken from NFPA 11 - Table 5.3.5.3.1

Calculations

total rim-seal surface area (A) [formula: ¼π(D^2 – (D- 2xa_{fm})^2)]	130.8	m^2
minimum quantity of foam mix required per minute [formula: B x A]	1596	l/min
minimum quantity of fire-extinguishing water required per minute [formula: B x A x (100-c)/100]	1548	l/min
minimum quantity of foaming agent required per minute [formula: B x A x c/100]	48	l/min
total minimum quantity of fire-extinguishing water required (over 20 minutes) [formula: B x A x (100-c)/100 x t]	30969	l
total minimum quantity of foaming agent required (over 20 minutes) [formula: B x A x c/100 x t]	958	l

Formula	**V=A x R X t x %C / 100**		
Correct calculation based on data from Sections 2.4.6. and 2.4.7. of the BOPEC emergency manual			
Tank diameter		85.3	m
Liquid surface area	A	5,721	m^2
Application rate	R	11.0	l/m^2.min
Application time	t	65	min
Foaming agent mix percentage	%C	3	% foaming agent
Foaming agent volume	V	122,266	l foaming agent
Minimum application premix	A x R	62,701	l/min

Foam calculation footprint as indicated in Section 2.4.6 of the BOPEC emergency manual			
Tank diameter		83.8	m
Liquid surface area	A	5515.281873	m^2
Minimum application premix	A x R	30,283	l/min
Application time		65	min
Mix percentage		3	% foaming agent
Foaming agent volume		59,052	l foaming agent
Application rate	R	5.49	$l/m^2.min$

Foam calculation according to Section 2.4.7 of the BOPEC emergency manual			
BOPEC application rate – Section 2.4.7.1		7.33	$l/m^2.min$
Minimum application premix		41,956	l/min
Foaming agent volume		81,814	l

Calculations based on information from Williams Fire & Hazard Control Inc.			
Tank diameter		85.3	m
Liquid surface area	A	5,721	m^2
Application rate for tank diameters from 77 m to 91 m	R	9.0	$l/m^2.min$
Application time	t	65	min
Foaming agent mix percentage	%C	3	% foaming agent
Foaming agent volume	V	100,395	l foaming agent
Williams advises keeping a 50% reserve of foaming agent	V reserve	50,198	l foaming agent
Total according to Williams	V total	150,593	l foaming agent
Minimum application premix	A x R	51,485	l/min

Calculations based on experiences of Rotterdam Joint Fire Service			
Tank diameter		85.3	m
Liquid surface area	A	5,721	m^2
Application rate for tank diameters from 77 m to 91 m	R	9.0	$l/m^2.min$
Application time	t	65	min
Foaming agent mix percentage	%C	1 or 3	% foaming agent
Foaming agent volume	V	69,504	l foaming agent
Williams advises keeping a 50% reserve of foaming agent	V reserve	50,198	l foaming agent
Total	V total	119,702	l foaming agent
Minimum application premix	A x R	51,485	l/min

APPENDIX 8 BOPEC EMERGENCY MANUAL

Minor tank (seal) fire alarm procedures[117]*:*

1. *Determine that the tank is actually on fire and apply the contingency plan for minor tank seal fire;*
2. *Verify that the roof drain is closed;*
3. *Open the deluge access valve that corresponds with the tank;*
4. *Start one main fire water pump automatically;*
5. *Start the electromotor driven foam pump automatically;*
6. *Open the solenoid switch for foam supply via the proportioner at the pit manifold. The water stream to the tank will take the foam/water mix to the tank;*
7. *Alert BCO or stand-in and all required personnel;*
8. *Have a person with a hand radio standby at the fire pumps to increase fire water pressure if necessary; See pressure gauge in the control room panel; it should read ±7,5 bar;*
9. *Maintenance personnel have to relief the operator at the fire pumps;*
10. *Disconnect the electrical power only if this is necessary.*

NOTE: Water pressure = the pressure at which there is enough water supply to extinguish a fire.

Major tank fire alarm procedures[118]*:*

a. *If there is a fire on a floating roof tank, initiate the contingency plan for a minor tank fire including the application of foam on the roof via the deluge valve and foam shields. From the Control Room can be started:*
   - *A main firewater pump (by opening the deluge valve) and*
   - *The electromotor driven foam pump. The foam pump discharge valve has to be opened manually. This provision is to prevent waste of foam in case of false alarm or overreaction.*

b. *The fire becomes major, when the fire extends over the whole surface of the roof, meaning, that there must be an extensive hole in the center deck or that the floating roof has sunk.*

c. *A major fire is classified as a Class C fire and as such the fire water pumps, foam pumps have to be started, the booster pumps, foam nozzles and proportioners and 5" hoses shall be deployed. Orient on the indicated drawing for (see 2.4.9. "Equipment Placement at Oil tank with Major Fire" for the correct location to install the firefighting equipment.*

d. *The procedures of Fire Alarm also applies:*
   1. *Determine that there is actually fire on the tank;*
   2. *Alert BCO and BCI and all the required personnel.*
   3. *Move the large 4000 GPM nozzles (monitors) into position as shown in "C-plan"= "Contingency plan for major fire";*
   4. *Move the large 4000 GPM booster pumps into position as shown in "C-plan"*
   5. *Move foam proportioner into position for connection to the nozzles;*
   6. *Lay out and connect all hoses (5" and 2½")*
   7. *Start electrical motor/diesel driven foam pump;*
   8. *On arrival the maintenance mechanic will relief the operator at the fire pumps;*
   9. *Start the last main diesel pump manually.*
   10. *Apply shell cooling to the neighbouring tanks if necessary;*
   11. *Begin fire combat operation;*
   12. *Apply "Contingency plan for major tank fire"*

117 Section 2.3.2 of the emergency manual.
118 Section 2.4.2 of the emergency manual.

APPENDIX 9 DEVELOPMENTS SINCE THE FIRES

This section will first describe the Lieutenant Governor's measures in response to the fires. Next, the developments following the BOPEC fires that relate to the constitutional changes as of 10 October 2010 are described: the Minister of Infrastructure and the Environment granted BOPEC an environmental permit and changes occurred due to the Safety (Bonaire, Saint Eustatius and Saba) Act.

Steps taken by the Lieutenant Governor of Bonaire

The Lieutenant Governor responded to fires by:
- Requesting an investigation by the Safety Board
- Initiating an investigation into the impact on the environment and public health
- Suspending operations at BOPEC
- Instituting an advisory group to settle the BOPEC incident.

Request submitted to the Dutch Safety Board
On 10 September 2010, the Lieutenant Governor of Bonaire, in agreement with the Prime Minister of the Netherlands Antilles, asked the Governor of the Netherlands Antilles to ask the Dutch Safety Board to initiate an investigation into the tank fire at BOPEC. The following were requested:
- An investigation of the circumstances surrounding the incident
- An analysis and assessment of the involved parties' actions
- Recommendations for the future.[119]

Investigation of the impact on the environment and public health.
Following the fires, the Lieutenant Governor asked the National Institute for Public Health and the Environment (RIVM) to investigate the potential severity of the environmental and public health impact.

BOPEC operations suspended
On 10 September 2010, the Lieutenant Governor suspended operations at BOPEC until further notice[120] and ordered seizure of the installations for the Board's investigation.

Advisory group instituted to settle the BOPEC incident
In the Lieutenant Governor's view, an assessment of the extent to which operations could be reinstated at the plant was crucial. He therefore set up a group to issue advice on the subject. To take the pressure off the administrative organisation, staff was supplied for this advisory group by the Ministry of the Interior and Kingdom Relations and the Ministry of Housing, Spatial Planning and the Environment at the Lieutenant Governor's request. In addition, a consultancy was brought in to provide the necessary expertise, supplementing the advisory group.

The following steps were taken and reports were compiled to ensure the Lieutenant Governor could take an educated decision.

The advisory group assessed the function and status of the BOPEC installations, to gather the necessary data and subsequently identify the risk of reinstating operations. The advisory group focused on:
- The nature of BOPEC's activities, including the products stored and the blending method
- The condition of the installations and fire safety facilities
- The function of these facilities
- The capacity (in terms of people, resources, expertise and training level) for managing industrial incidents

119 Letter from the Lieutenant Governor of the Island Territory of Bonaire, dated 10 September 2010.
120 Letter from the Lieutenant Governor of the Island Territory of Bonaire, dated 10 September 2010.

- The availability and condition of environmental protection facilities at BOPEC.

The advisory group also estimated the risks of reinstating BOPEC's operations in terms of:
- On-the-job safety of BOPEC staff
- On-site fire safety
- Danger, damage and nuisance to the surrounding environment.

Finally, the available capacity of the fire and disaster response services on Bonaire was assessed. The advisory group also estimated the required capacity to effectively manage a BOPEC incident. The results of this assessment and estimate are described in a report.[121]

Based the advisory group's findings, the Lieutenant Governor of Bonaire grant BOPEC permission to resume operations, confirming this in writing on 9 October 2010.[122] An enclosure contained the *"general conditions that BOPEC needs to comply with in order to meet the necessary requirements".* One of the conditions was that only fuel oil could be stored on the site because fuel oil has a higher flash point than naphtha and crude oil and is therefore less inflammable.

- At the Lieutenant Governor's request, BOPEC was monitored between 28 November and 4 December 2010 in relation to the agreements and conditions to reinstate operations.[123] The consultancy engaged to support the advisory group established to settle the BOPEC incident with specialist knowledge performed these monitoring activities. The conclusions:
  - *"The BOPEC grounds underwent major renovation and generally leave a better impression"*
  - *There is still a lot of work scheduled*
  - *Education and training will be provided on location*
  - *An extra dam has been installed to keep out rain water on parts of the grounds at higher elevation*
  - *The list of activities and the schedule have been enclosed*
  - *The parts of the main fire pump will arrive at some point, after which the larger pumps can once again operate*
  - *BOPEC has company rules regarding the maximum storage capacity per burner, which is always considerably lower than the maximum capacity of the tank*
  - *There is more than enough foam available: over 33,000 gallons, of which 20,000 gallons are stored in the large foam tanks."*

Ministry of Infrastructure and the Environment permits

The Ministry of Infrastructure and the Environment is now processing BOPEC's environmental permit, which will be granted by the Minister under the Housing, Spatial Planning and the Environment (BES islands) Act. The bill was passed by the Lower House of the Dutch Parliament on 8 February 2011. The preliminary investigation by the Senate Committee for Kingdom Relations was conducted on 29 March 2011. The Industrial Premises and Activities (BES Islands Environmental Management) Decree that will ensue from the Act is currently expected to enter into force on 1 January 2012. The Minister will then be able to grant a permit to BOPEC.

The Ministry of Housing, Spatial Planning and the Environment (VROM, previously the Ministry of Infrastructure and the Environment) established the permit procedure in anticipation of the constitutional change. On 20 November 2008, the BES islands and the Netherlands agreed the following: *"From 2009 onwards, VROM shall arrange for new environmental permits for NuStar*[124] *and BOPEC. These permits are expected to enter into force on 1 January 2011".*[125]

121 'Advice for restarting BOPEC operations', advisory team of the Lieutenant Governor of Bonaire, October 2010.
122 Letter from the Lieutenant Governor of the Island Territory of Bonaire, dated 9 October 2010.
123 Follow-up report for: the Lieutenant Governor of Bonaire
124 NuStar operates a tank terminal on St. Eustatius.
125 List of resolutions, talks between BES and Dutch National Government bodies on 20 November 2008 in The Hague.

Further to this agreement, VROM wrote to the board of BOPEC on 5 July 2009 to arrange for the permit application.[126]

In response to this letter, BOPEC commented as follows in 2009: *"The Government of the Island Territory of Bonaire, represented by the DROB Environmental Service, is still the official entity to whom BOPEC accounts its ongoing operation. The Government of the Island Territory of Bonaire is therefore still the Competent Authority. In your letter, as well as in the meeting we had on August 13 with the Regional Service Center, you indicated that the Dutch Ministry of VROM will be the Competent Authority that will eventually issue the Environmental Permit for BOPEC's operations. We have never received any official information from the local government of this deferring authority yet you propose to start the permit application process. Surely you understand that we will require the existing authority to officially inform us of this upcoming transfer before we can start discussing a planning".*[127]

On 1 September 2010, just before the fire broke out, VROM paid a visit to BOPEC, during which VROM explained the permit application process. BOPEC later received a letter from VROM dated 3 September 2010, confirming its explanation of the process: *"To minimize risks and ensure the continuity of the business of the BOPEC terminal on Bonaire, it is of great importance to submit an environmental permit application as soon as possible, so that the environmental permit can be granted and BOPEC complies with the VROM Act BES".*[128]

In 2008, VROM concluded that few regulations, if any, were in place to ensure the safety of the surrounding area, in the face of risks for the environment and public health of a potentially large magnitude.[129] VROM therefore included a regulation in this act relating to the prevention of serious accidents. "The term 'serious accidents' refers to: *Incidents resulting from uncontrollable developments that occur in the course of business operations in a plant, which have grave consequences either immediately or in the long-term, for human health either inside of the plant or in its surroundings or for the environment and which involve one or more hazardous substances".*[130] The act imposes a duty of care on anyone operating a plant. Additionally, the Housing, Spatial Planning and the Environmental Management (Bonaire, Saint Eustatius and Saba) Act also incorporates the basis for a decree relating to serious accidents, abbreviated to Bzo-BES.

The Safety (Bonaire, Saint Eustatius and Saba) Act

Since, under the Dutch constitution, Bonaire has the status of public body, the Netherlands is responsible for ensuring Bonaire's fire service, police force and disaster response services perform effectively and efficiently.

No joint national Dutch-Antillean legislative framework existed for the fire, disaster response and crisis management services of the kind deemed necessary for Bonaire, Saba and Saint Eustatius. Given the islands' unique status, applying the prevailing Dutch regulations relating to the fire, disaster response and crisis management services without some adjustment was not an obvious choice. Developing special, customised regulations was the only solution, due to the unique features of island life, the small scale and less sophisticated facilities. Taking account of each island's unique conditions, the Safety (Bonaire, Saint Eustatius and Saba) Act (*Veiligheidswet BES*) seeks to optimise collaboration between the safety and incident response services on the individual islands and, if necessary, between the islands themselves.

126 Letter to BOPEC from VROM, dated 5 July 2009.
127 Letter to VROM from BOPEC, dated 14 August 2009.
128 Letter to BOPEC from VROM, dated 3 September 2010.
129 Explanatory Memorandum accompanying the Housing, Spatial Planning and the Environmental Management (Bonaire, Saint Eustatius and Saba) Act, Lower House of the Dutch Parliament, session year 2009-2010, 32 473, no. 3.
130 Explanatory Memorandum (accompanying the Housing, Spatial Planning and the Environmental Management (Bonaire, Saint Eustatius and Saba) Act Lower House of the Dutch Parliament, session year 2009-2010, 32 473, no. 3.

In addition to the existing Dutch legislation, which formed the basis, the Security Regions Act (Wet op de veiligheidsregio's), was also considered, although the Safety (Bonaire, Saint Eustatius and Saba) Act emphasises effective control and multidisciplinary collaboration in the public body in question more than authority structures above island level. The geographical distance between Bonaire, on the one hand, and Saint Eustatius and Saba, on the other, made this the obvious choice.

First and foremost, the Safety (Bonaire, Saint Eustatius and Saba) Act establishes the existence and availability of a multi-functional, inter-island control room. Second, the effective, efficient management of the fire, disaster response and crisis management service organisations is also embedded in the Act. Furthermore, the Act provides for a single fire service organisation with a single administrator for the three islands. The Minister of Safety and Justice bears[131] the administrative responsibility.

As a result, the three island authorities need not individually organise a management structure for a fully-fledged fire service. In daily practice, the Lieutenant Governors of the three islands exercise authority over the fire service. In case of fire, the local fire brigade commander receives the necessary orders and instructions from the Lieutenant Governor.

Plans ensuing from the Safety (Bonaire, Saint Eustatius and Saba) Act
Given the current level of the disaster response services on Bonaire, Saint Eustatius and Saba, the islands' unique status and the large distances between them, the planning structure for the disaster response and crisis management services must be adapted to the unique conditions and guarantee aid services of acceptable quality. More specifically, this means that the island authorities will be encouraged more explicitly to implement fire, disaster response and crisis management policy.

The Act identifies the following general planning concepts:
1. policy plan
2. disaster and crisis plan
3. police force and fire service control plan

Under the Act, the individual Governing Councils are obliged to adopt a policy plan and a disaster and crisis plan, consistent with the systemology in the Security Regions Act. As in that Act, it was decided not to apply the disaster response plan as a general planning concept. The control plans of the police force and the fire service are adopted by the administrator.

Division of administrative responsibilities according to the Safety (Bonaire, Saint Eustatius and Saba) Act

Lieutenant Governor
According to Article 175 of the Bonaire, Saint Eustatius and Saba (Public Bodies) Act, the Lieutenant Governor is the commander in chief in case of fire, as well as other accidents not associated with fires, but in which the fire service is involved. In the event of a fire or accident, the Lieutenant Governor is authorised to give the necessary orders to prevent, limit, or control the threat. The Safety (Bonaire, Saint Eustatius and Saba) Act adds to this, dictating that the Lieutenant Governor is the commander in chief in case of a disaster or strong suspicion that a disaster might occur (Article 53). The Lieutenant Governor answers to the Island Council in matters relating to the how he exercises his powers.

Governing Council
The Governing Council is charged with organising the disaster response and crisis management services, as well as the fire service.[132] It does so in part through the fire service. Additionally, the

131 As is the case with the administration of the police force on Bonaire, Saint Eustatius and Saba
132 According to Article 27, paragraph 3 of the Safety (Bonaire, Saint Eustatius and Saba) Act, this includes preventing, limiting and fighting fires, limiting the risk of fire, preventing and limiting the scope of fire-related accidents and all associated consequences, as well as limiting and controlling the risks to humans and animals in accidents other than fires.

Governing Council also adopts a policy plan for the fire, disaster response and crisis management services every four years based on a risk profile and a disaster and crisis plan. Moreover, the Governing Council ensures that the Minister of Safety and Justice, the National Representative, the general head of the fire service, the chief public prosecutor and the public are kept informed of disasters and crises that could affect the public body and of measures that have been taken in order to prevent, control or manage them.

Island Council
Generally speaking, the Island Council is tasked with framework development and verification. Under Article 39 of the Safety (Bonaire, Saint Eustatius and Saba) Act, the Island Council is also charged with formulating regulations to prevent, limit and fight fires, limit the risk of fire, prevent and limit the scope of fire-related accidents and all related events (Article 39). The Island Councils must also verify reports on the management of disasters and crises, and well as the yearly reports.

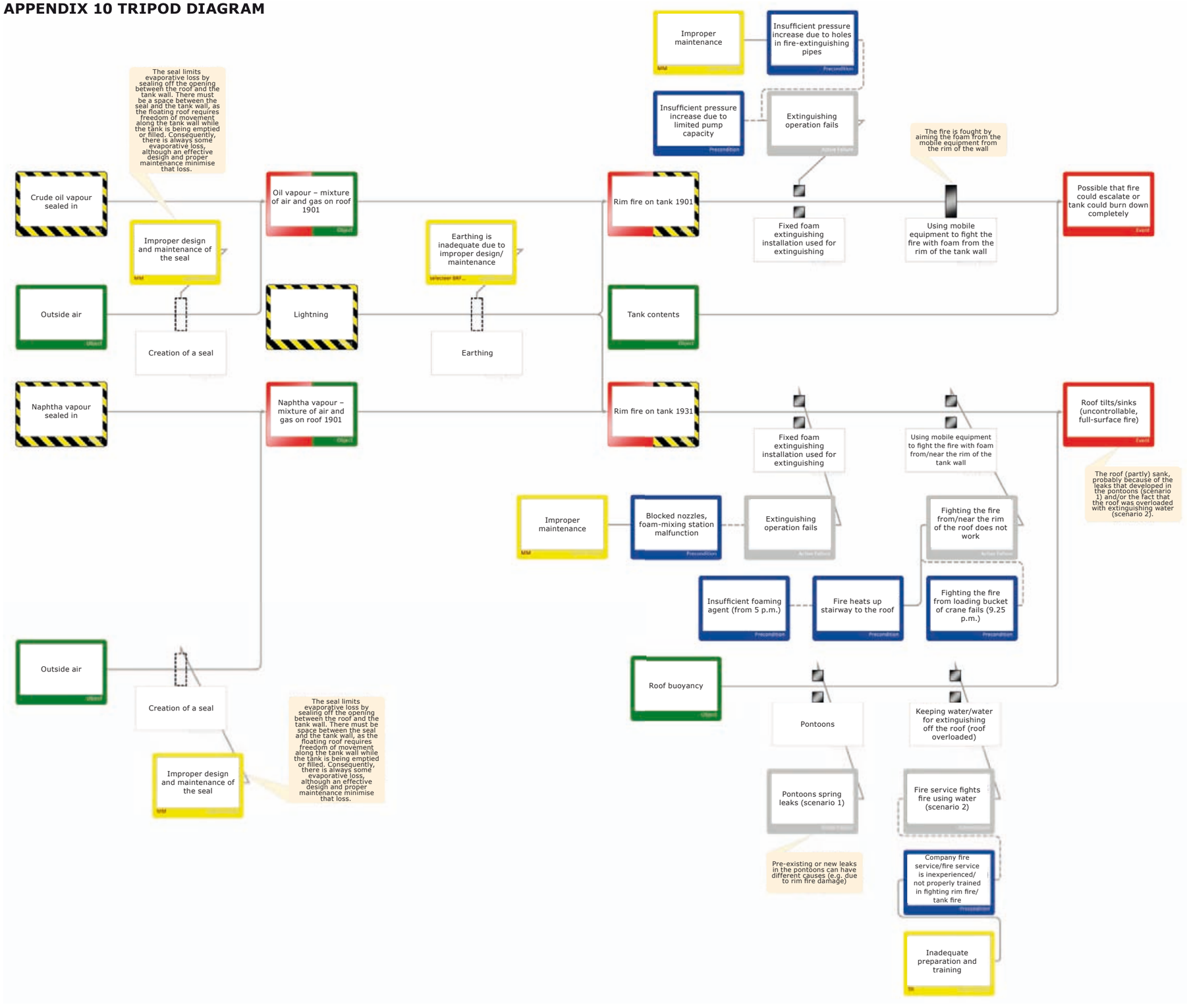
National Representative
The Bonaire, Saint Eustatius and Saba (Public Bodies) Act provides for the appointment of a National Representative for the public bodies. The National Representative, a completely new authority, is the administrative link between the Dutch national government and the three islands. His authority is administrative and falls under the national government. He has his own powers, which he exercises under the responsibility of the Minister of Safety and Justice and relate mainly to preventive measures aimed at ensuring the islands are properly governed. The National Representative does not fall under the public bodies' administration, nor is he part of a separate level of government between the national government and the public bodies. Under the Bonaire, Saint Eustatius and Saba (Public Bodies) Act, he answers to the Minister of Safety and Justice where his performance is concerned, but also answers to other ministers under acts that relate to their respective mandates. The Bonaire, Saint Eustatius and Saba (Public Bodies) Act serves as the legal basis for the National Representative's duties and powers, though the Safety (Bonaire, Saint Eustatius and Saba) Act also grants him certain powers. For instance, he has the power to order the Lieutenant Governor to take measures relating to the policy for disaster response or crisis management in the event of a disaster or crisis affecting more than one island, or a strong suspicion that such a disaster or crisis might occur (Article 59).
He is also charged with assessing the policy plan, disaster and crisis plan and disaster response plan adopted by the Governing Council (Article 42, paragraph 5, Article 44, paragraph 5 and Article 45, paragraph 3) and adopting a coordination plan for disaster response and crisis management. (Article 47). The National Representative is also involved in requests for disaster response and crisis management aid.

Ministry of Security and Justice as fire service manager
Under the Safety (Bonaire, Saint Eustatius and Saba) Act, the Minister of Safety and Justice is the manager of the fire service on Bonaire, Saint Eustatius and Saba. In practice, however, this authority is delegated to other parties. The fire service manager is also responsible for adopting the control plans. It is essential that the control plans are geared to the policy plans and disaster and crisis plans and vice versa. The legal regulations also provide for procedural coordination between the plans and the responsible administrators (e.g. Article 29).

Caribbean national examination
Due to the small surface area, the insular nature, the climate and the geographical location of the island, the fire service staff on Bonaire must fulfil different requirements than their Dutch counterparts. These factors mean that the relatively small fire service is also charged with fighting fires at the airport, for example, which would be somewhat exceptional in the Netherlands. It is therefore necessary to train several members of the Bonaire fire service in this specialist area. Conversely, fire fighters in the Netherlands are sometimes also required to learn specialist skills, which are irrelevant on Bonaire (such as working in freezing temperatures or with railway transport). The Safety (Bonaire, Saint Eustatius and Saba) Act provides for these differences with the introduction of a national examination. However, the qualifications still need to be similar enough, that a Bonaire fire fighter can qualify to practice his profession in the Netherlands by attending extra training and earning a supplementary diploma in addition to the one awarded on the basis of the Caribbean national examination, and vice versa.

The Netherlands Bureau of Fire Services Exams (NBBE) is responsible for the development, implementation, organisation and administration of the Caribbean national examinations. It also grants exemptions and certificates, assesses examinations and provides advice to the Minister of Safety and Justice about issuing diplomas. It is the job of the Minister of Safety and Justice to issue a diploma.

APPENDIX 10 TRIPOD DIAGRAM



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