Accident Investigation Board Norway

Federal Public Service Mobility and Transport Maritime transport

Issued May 2013

REPORT Sjø 2013/03

REPORT ON THE INVESTIGATION OF A MARINE ACCIDENT CLIPPER SUND LAIR6 OCCUPATIONAL ACCIDENT ANTWERP 6 SEPTEMBER 2011

AIBN has compiled this report for the sole purpose of improving safety at sea. The object of a safety investigation is to clarify the sequence of events and root cause factors, study matters of significance for the prevention of maritime accidents and improvement of safety at sea, and to publish a report with eventually safety recommendations. The Board shall not apportion any blame or liability. Use of this report for any other purpose than for improvements of the safety at sea shall be avoided.

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This report has been translated into English and published by the Accident Investigation Board Norway (AIBN) to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photo of ferry on the Norwegian west coast: Bente Amandussen

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NOTIFICATION OF THE ACCIDENT

On Tuesday 6 September 2011, the Accident Investigation Board Norway (AIBN) was notified by the Norwegian Maritime Directorate about an explosion on board the chemical tanker Clipper Sund at quay in Antwerp in Belgium at approx. 01.15 that same morning. One person was badly injured. The AIBN started collecting further information, and at 11.49, it was confirmed that the person had died as a result of the accident. The AIBN decided to initiate a safety investigation into the accident. On the morning of 7 September, two representatives of the AIBN travelled to Antwerp to interview involved personnel and carry out investigations on board. The investigation was initiated in collaboration with the Belgian authorities, and the accident inspectors were assisted by a local representative. In addition to the investigations on board, conversations were also held with the harbour police and the LBC Tank terminal, where the accident happened.

Figure 1: The vessel's position when the accident occurred is marked with a red cross.

SUMMARY

At 01.15 on Tuesday 6 September 2011, an explosion occurred on deck on board the Norwegian chemical tanker Clipper Sund at quay in Antwerp. One man died from injuries sustained in connection with the explosion.

The explosion occurred as the result of a reaction between two incompatible cargoes.

The vessel was loaded with mono nitrobenzene, nitric acid and aniline. After the discharging operations had finished, there was aniline in the vessel's port drip tray and nitric acid in the vessel's drainline, only separated by a single ball valve.

The investigation concludes that the factors that triggered the explosion were that the able seaman who was alone on deck at the time of the accident caused the opening of the ball valve separating the aniline and nitric acid. The incompatible cargoes reacted immediately and caused heat and gas generation. In all probability, the able seaman understood that something was wrong and reacted by

closing the valve in order to limit the extent of the damage. On the contrary, this made it impossible for the gases in the drainline to escape. The pressure in the pipe increased rapidly and caused an explosion.

The purpose of the investigation was to identify the underlying causes of how the opening of a single valve could lead to an accident of this kind. The investigation has focused on design, operational factors and regulations.

The applicable regulations, relevant industry standards and the classification society's interpretation of them permitted the vessel's drip tray to be directly connected to the vessel's drainline, only separated by a ball valve. In the case of the Clipper Sund, the drip trays were not just connected to the drainline, but, through them, also to cargo tank 5C. The AIBN submits a safety recommendation to Det Norske Veritas and the Norwegian Maritime Directorate in this connection, proposing a change in the current classification regulations and the interpretation of the IBC Code.

The shipping company had not carried out vessel-specific risk assessments of loading and discharging operations that should have formed the basis for the introduction of risk reduction measures, including the drawing up of necessary plans, procedures and instructions. The shipping company states that it has implemented a number of measures on four sister vessels in order to prevent similar accidents in future. The AIBN nevertheless submits a safety recommendation to the shipping company relating to the carrying out of risk assessments of loading and discharging operations and the establishment of necessary operational procedures based on such assessments.

The current regulations give the shipping company a great degree of freedom to choose how to conduct its risk management. No specific requirements apply to how risks on board are to be identified and how risk assessments are to be carried out. The regulations thereby provide the shipping company with little support for conducting satisfactory risk assessments that, in turn, put the shipping company in a position to implement relevant measures.

The AIBN is not aware of the quality of risk management work in other shipping companies, but, given that the same requirements for this work apply to small and simple shipping organisations as to large shipping organisations, the AIBN cannot exclude the possibility that the quality of this work can vary considerably. A safety recommendation is submitted to the Norwegian Maritime Directorate to the effect that it should map the status of the shipping companies' risk management work with a view to further targeting the work on guidelines/guides to help the shipping companies to establish satisfactory risk management.

1. FACTUAL INFORMATION

1.1 Details of the vessel and the accident

Vessel details

Name of vessel	:	Clipper Sund
Call sign	:	LAIR6
IMO number	:	9375977
Shipping company	:	BKR Carriers AS Smedasundet 97 B, NO-5525 Haugesund
Manager/ISM responsible	:	Brødrene Klovning Shipping AS
Home port	:	Haugesund
Flag state / register	:	Norway / NIS
Classification society	:	DNV
Vessel type	:	Chemical and oil product tanker
Build year	:	2008
Construction material	:	Steel
Length overall	:	89.00 metres
Breadth	:	13.32 metres
Depth	:	7.70 metres
Gross tonnage	:	2,613
Engine power	:	1,980 kW / 2,655 BHP

Figure 2: Clipper Sund. Photo: Brødrene Klovning Shipping

Details of the accident

Time and date	:	approx. 01.15, 6 September 2011
Site of accident	:	Antwerp, quay 275
Persons on board	:	10 crew members and a cargo inspector
Injured/dead	:	One of the ship's crew died
Damage	:	Damage to various structures in the area around the manifold.

1.2 Chain of events

The Clipper Sund left Aveiro in Portugal on the morning of 30 August 2011. The vessel was loaded with 856 scm of mono nitrobenzene, 1,095 scm of nitric acid and 858 scm of aniline. The cargo was to be discharged at two quays in Antwerp. The vessel arrived in Antwerp on 3 September. The cargo of mono nitrobenzene was discharged in the afternoon and evening on the same day. Routine safety meetings were held in connection with the discharging, and the actual discharging was carried out without event.

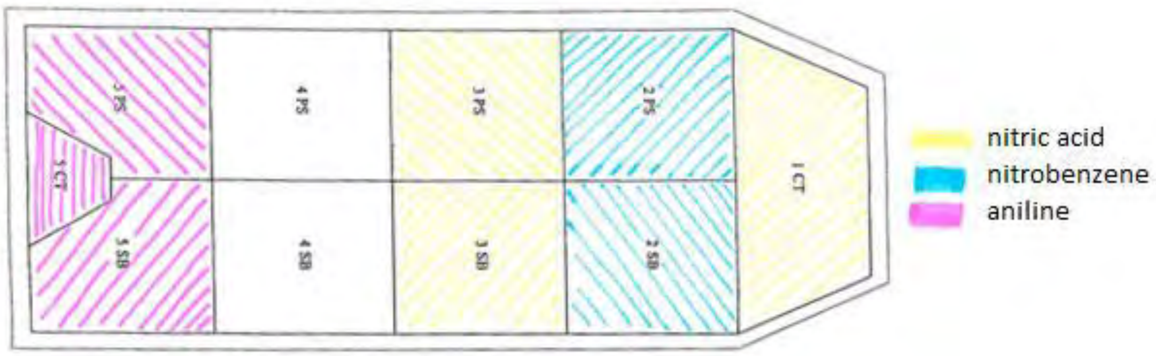

Figure 3: Tank arrangement and cargo distribution on arrival in Antwerp. Tanks 4 PS and 4 SB were empty. Illustration: Brødrene Klovning Shipping/AIBN

In the early hours of 4 September, the vessel moved to a waiting berth. A safety conference (pre-discharging conference) was held that day as part of the preparations for discharging the two remaining cargoes. Among other things, the conference covered safety information relating to the cargo, a review of the discharging and manifold plan and relevant checklists. According to the captain on board, the conference had focused on the incompatibility between the cargoes.

In the early hours of 5 September, the Clipper Sund moved to LBC's facility, where the discharging of the remaining cargo was planned to take place.

The vessel's chief officer was on duty from 06.00 that morning. According to the plan, the aniline cargo was to be discharged before the nitric acid. Cargo inspectors arrived in the morning and, together with the ship's crew, they carried out cargo calculations and took samples of both the aniline and nitric acid cargoes. The relevant checklist, the Terminal Safety Checklist, for the Clipper Sund and the tank facility, was reviewed and accepted by both parties. The same was done for the nitric acid cargo (ship-ship checklist), which was to be discharged to a barge. At 07.30, the barge moored on the Clipper Sund's starboard side to take delivery of the nitric acid.

The samples of the nitric acid were approved, but the samples of the aniline cargo contained too much water and did not pass the recipient's test.

Since the barge that was to take delivery of the nitric acid was already moored beside the Clipper Sund, it was decided that this discharging operation would be carried out first. The change in the discharging plan was approved by the captain. Preparations were made to discharge the nitric acid through the vessel's common cargo line on the starboard side, and discharging started at 10.10 a.m.

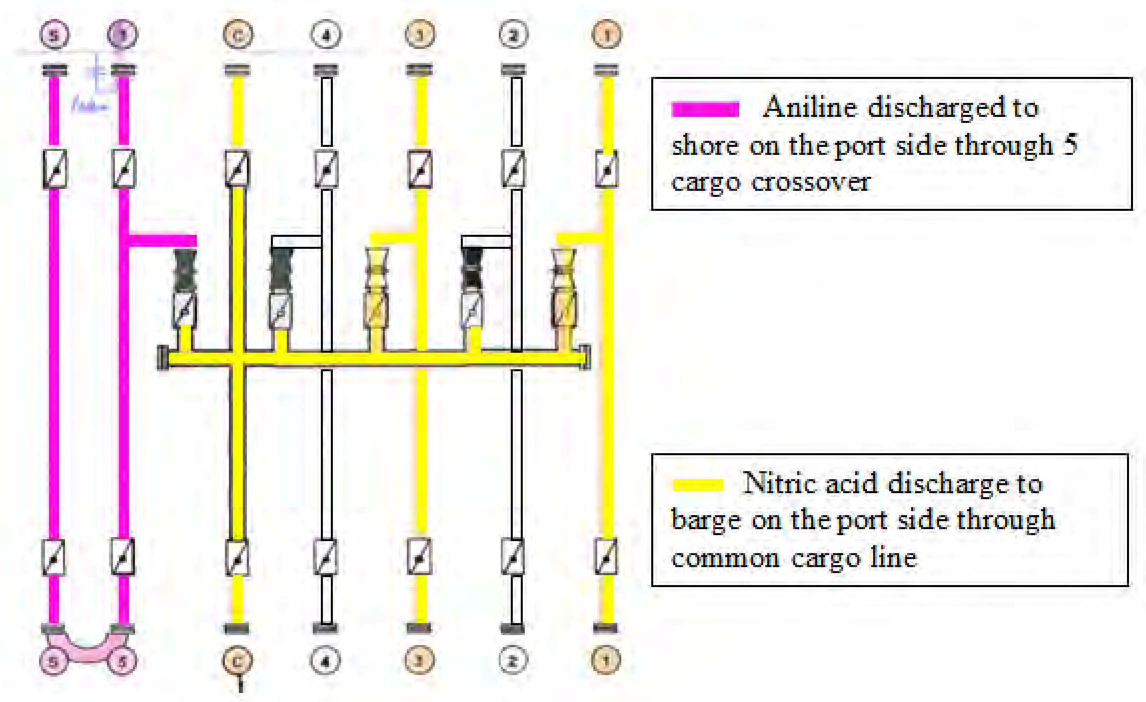

Figure 4: Overview of how the discharge lines were lined up, and of which lines were used to discharge the aniline and nitric acid. This manifold plan is a key part of the vessel's plan for carrying out loading and discharging. Illustration: Brødrene Klovning Shipping/AIBN

A cargo inspector from shore arrived at the vessel at approx. 10.15 to take new samples of the aniline cargo, this time from the manifold on the port side. The discharge pump in cargo tank 5P was started in order to pump the cargo to the manifold. At around 10.20, aniline suddenly and unexpectedly splashed out from the blind cover on the discharge line in question and caused spillage on both the drip tray and the deck area around the manifold on the port side. The cargo inspector who was on the grating on the drip tray threw himself to the side, but aniline spilled onto the lower part of his boiler suit. The inspector was wearing a boiler suit, helmet and gas mask. He threw off the boiler suit and went immediately to the vessel's emergency shower on deck. He later showered in the ship's superstructure and then went to the emergency room at the terminal and to hospital for a check-up.

The crew assessed the spillage of aniline as being a controlled spill and therefore did not implement the procedures in the vessel's SMPEP[1] manual. According to the material safety data sheet, minor spills shall be handled by diluting the chemical spillage with water and removing it. The area around the manifold was hosed down, but the aniline spillage in the drip tray was not dealt with. Meteorological data for the afternoon of 5 September 2011 in Antwerp show that there were some light rain showers. This may have meant that there was some water in the drip tray in addition to aniline.

The vessel's second officer and able seaman, who died later, came on duty at 12.00 and continued the discharging of the nitric acid. By 15.20, most if it had been discharged and stripping of the tanks was initiated. This was done by stripping the residual cargo from tanks 1C and 3P to cargo tank 3S. In this case, the nitric acid cargo was stripped through the stripping lines and the common drainline. The cargo residues were discharged to the barge from 3S and the discharging was concluded at 15.40. Air was then blown through

[1] SMPEP: Shipboard Marine Pollution Emergency Plan

the lines. The cargo inspector declared the tanks empty at 16.00. The discharge hoses were disconnected and the barge departed from alongside the vessel at 17.40.

At 16.40, new samples were taken of the aniline cargo through the Butterworth hatches for cargo tanks 5P, 5S and 5C. These samples passed the recipient's tests, the hoses were connected, see Figure 5, and the discharging of the aniline started at 20.05. The chief officer was the duty officer on deck from 18.00 until midnight. He had another of the vessel's able seamen with him on discharging duty. The aniline was discharged without event. Stripping of the tanks started at 23.30. A flexible hose from 5C to 5P on the manifold was used to strip 5C. The cargo residues were stripped to 5S via a cargo crossover. The stripping concluded at 23.55 and the vessel had an estimated aft trim of 3.5 metres.

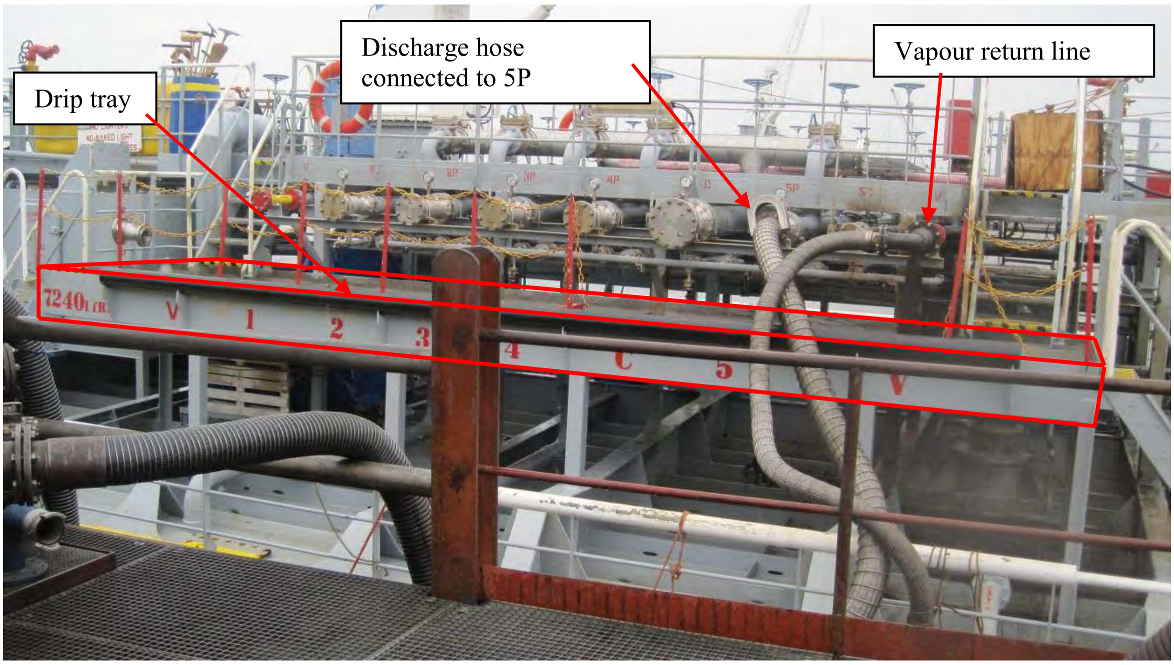

Figure 5: The photo shows how the discharge hose and the vapour return line were connected. The photo also shows the drip tray under the manifold. The drip tray's total capacity is 7,240 litres. Photo: LBC

A routine change of captains was planned during the stay in Antwerp. The captain who was to relieve the captain who had been on board arrived at 21.10. Both the captains then became busy with the normal handover procedures.

At 00.00, the vessel's second officer came on duty and relieved the chief officer. The able seaman who was later injured and died in the explosion relieved the able seaman who had been on duty during the last part of the discharging. The connections to land were still in place, but the discharging had concluded and they were waiting for the cargo inspector to inspect the tanks and declare them empty. Since no operations were taking place on deck, the second officer went to the bridge and carried out other work. The plan was that the Clipper Sund was to move to a waiting berth at 03.00, where cleaning and preparation for the next cargo was to start.

The cargo inspector arrived at the vessel at about 00.45. He checked the tanks together with the able seaman on duty. At 00.50, the cargo inspector went up to the bridge together with the chief officer to complete the paperwork.

At the time of the accident, the tank terminal, LBC, had camera surveillance of the area around the Clipper Sund's port manifold. The camera was located onshore in front of the vessel's manifold. In the final few minutes before the explosion, the duty seaman was the only man on deck. From the camera surveillance tapes at LBC's facility, it is possible to observe a person moving from the manifold area and proceeding aft on deck on the port side a little before 01.15. A few seconds later, smoke can be seen in the aft part of the manifold area on the port side, and the surveillance tapes show a person moving and re-entering the manifold area. The person moves in under the manifold area near valve VL-0258[2] at the drip tray on the port side. Shortly afterwards, this person again moves aft on deck on the port side.

Just before 01.15, there was a powerful explosion on deck. Those who were on the bridge ran to the windows and saw the duty seaman lying on deck near the aft ladder on the port side. They observed smoke out on deck, but could not see any flames. The duty officer sounded the vessel's general alarm. The crew members who were not on duty mustered after hearing the explosion and the general alarm. Both the departing captain and the new captain came to the bridge. The cargo inspector offered to notify the onshore facility and request it to notify local emergency services. This was cleared with the new captain who, on his part, notified the shipping company and the agent.

An ambulance arrived at 01.25, and the local fire service arrived two minutes later. The fire service started covering the deck with foam, and the injured seaman was brought down to the quay at 01.37. Ambulance personnel continued to treat the seaman and he was taken to hospital. The seaman had been hit by fragments of the pipe where the explosion occurred. The seaman died of his injuries.

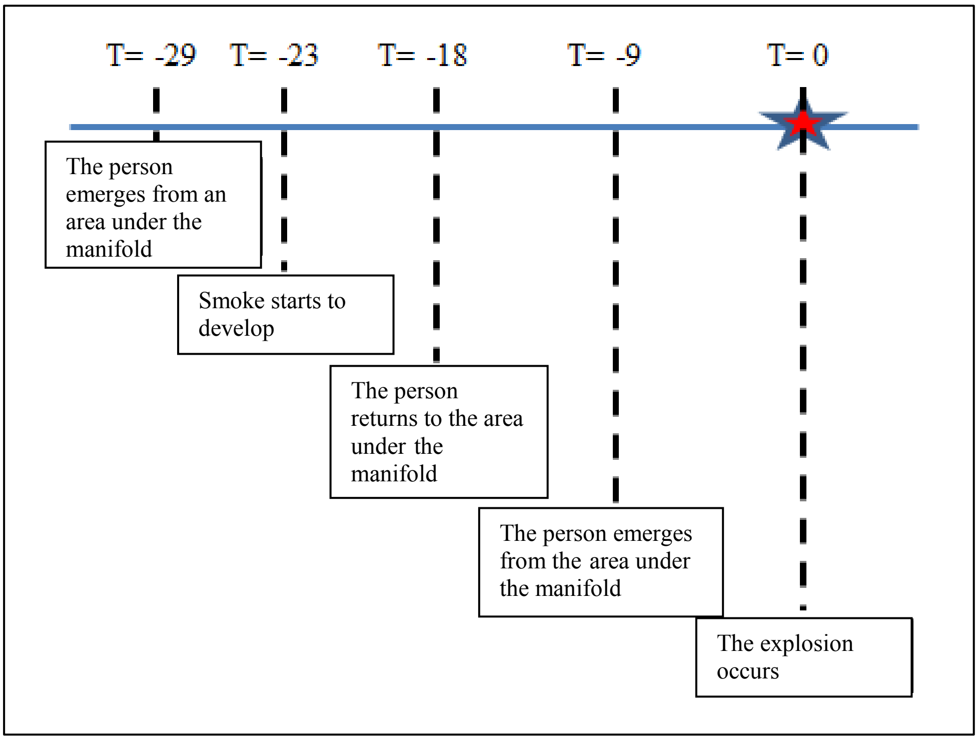

Figure 6: A timeline showing the movements of a person at the manifold just before the explosion occurred. T= -29 is 29 seconds before the explosion. Illustration: AIBN.

[2] A central valve in the investigation. It is discussed in more detail in Chapter 1.11.1.

Figure 7: The photo shows the area from the manifold and aft to tank 5 on the port side. The red circle marks the area the seaman moved in and out of under the manifold. The arrow indicates the area within which the seaman moved shortly before the explosion. The photo was taken the day after the accident and the persons shown have nothing to do with the accident. Photo: LBC

The explosion in the area under the manifold resulted in damage to different structures in the area; see Figure 8.

Figure 8: The photo on the left shows the drainline that was blown up. The photo on the right shows one of the cargo lines perforated by flying parts of the drainline. Photo: Capt. Hugo Vereckeen

In addition, parts of the drainline were found strewn over large parts of the Clipper Sund's deck. Parts of the pipe were also found in the onshore facility as far as 150 metres from the site of the explosion.

1.3 Shipping company and fleet

The Clipper Sund is owned by BKR Carriers AS and is operated by Brødrene Klovning Shipping AS. Brødrene Klovning was formed in 1970 and it owned and operated dry cargo vessels. The company acquired its first offshore vessel in 1975. Brødrene Klovning became a limited company in 1993 and started as a chemical carrier in 1996.

Today's Brødrene Klovning Shipping AS was formed in 1997. It currently operates a fleet of four chemical tankers (sister ships) that were built in the Netherlands and delivered during the period from 2006 to 2008. The vessels are registered in the Norwegian International Ship Register (NIS) and operate in European waters. The shipping company employs a total of 48 seafaring personnel. The senior officers are Scandinavians while the rest of the crew[3] come from the Philippines.

Brødrene Klovning Shipping AS was issued a 'Document of Compliance' (DOC) by Det Norske Veritas (DNV) on 16 June 2008. The document is valid until 27 March 2013.

1.4 The vessel and cargo systems

1.4.1 General information about the vessel

The chemical and oil product tanker Clipper Sund was built in 2008 by Volharding Shipyards Newbuilding BV in the Netherlands. Its length overall is 89.00 metres and it has a moulded depth of 7.70 metres. The vessel is registered in NIS and classed by DNV with class designation 1A1 ICE-1B Tanker for Chemicals and Oil Products ESP E0.

The vessel is one of a series of four vessels that were originally designed for a German shipping company. The German shipping company was unable to raise the necessary capital and the series of four vessels was put on the market. The shipyard was responsible for the fundamental design of the series, but it used Marine Service Noord BV (MSN) in the Netherlands as sub-supplier of the pipe systems.

Brødrene Klovning bought the series, but it wanted some changes to the design. The changes were agreed at design meetings between the shipping company and the shipyard, and the drawings were sent for class approval.

The vessel operates in European waters and typically carries 55 to 60 cargoes a year. The vessel primarily carries single-grade cargoes, [4] sometimes with two to three grades and, infrequently, with five grades. Since it was delivered, the Clipper Sund has not carried incompatible[5] cargoes or oil products.

All the vessel's certificates were valid at the time of the accident. Most of the certificates were issued in 2008 and are valid until 2013.

1.4.2 Tank arrangement and segregation

The Clipper Sund has ten cargo tanks, one of which (cargo tank 5C) is also the dedicated slop tank when carrying oil products. The tanks in a 'tank pair' (e.g. 2P/S) share a pipe system and can therefore not be individually segregated. On the other hand, all the tank pairs (2P/S, 3P/S, 4P/S and 5P/S), as well as tanks 1C and 5C, can be segregated from each other.

By segregation is meant keeping two cargoes physically isolated from each other in such a way that it is impossible for them to come into contact with each other. This can be solved in design terms by each tank having completely separate pipe and ventilation

[3] Employed through the crewing agency Net Ship Management Inc. Philippines.
[4] The same cargo in all tanks.
[5] Cargoes, cargo residues or mixtures of cargoes that react with other cargoes, cargo residues or mixtures of cargoes in a manner that can entail risk.

systems. It can also be solved operationally by physically removing parts of common pipe or ventilation systems. Incompatible cargoes must be segregated to safeguard against hazardous reactions. Toxic cargoes must also be segregated in order to safeguard against contamination of non-toxic substances. See Chapter 1.8.4 for the applicable regulations.

Cargo tank 5C is also the dedicated slop tank. According to the shipping company, the tank was very rarely used as a slop tank. Nor was this the case during the voyage on which the accident occurred, and it was not planned to be used as a slop tank on the next voyage either.

The vessel also had two one-cubic-metre plastic containers on deck that were used for temporary storage of cargo residues and residues from the drip trays. According to the shipping company, these containers are always empty when the vessel leaves port.

1.4.3 The pipe system for cargo handling

The pipe system for cargo handling includes the main cargo system (for loading and discharging) and the system for stripping and draining; see Figure 9.

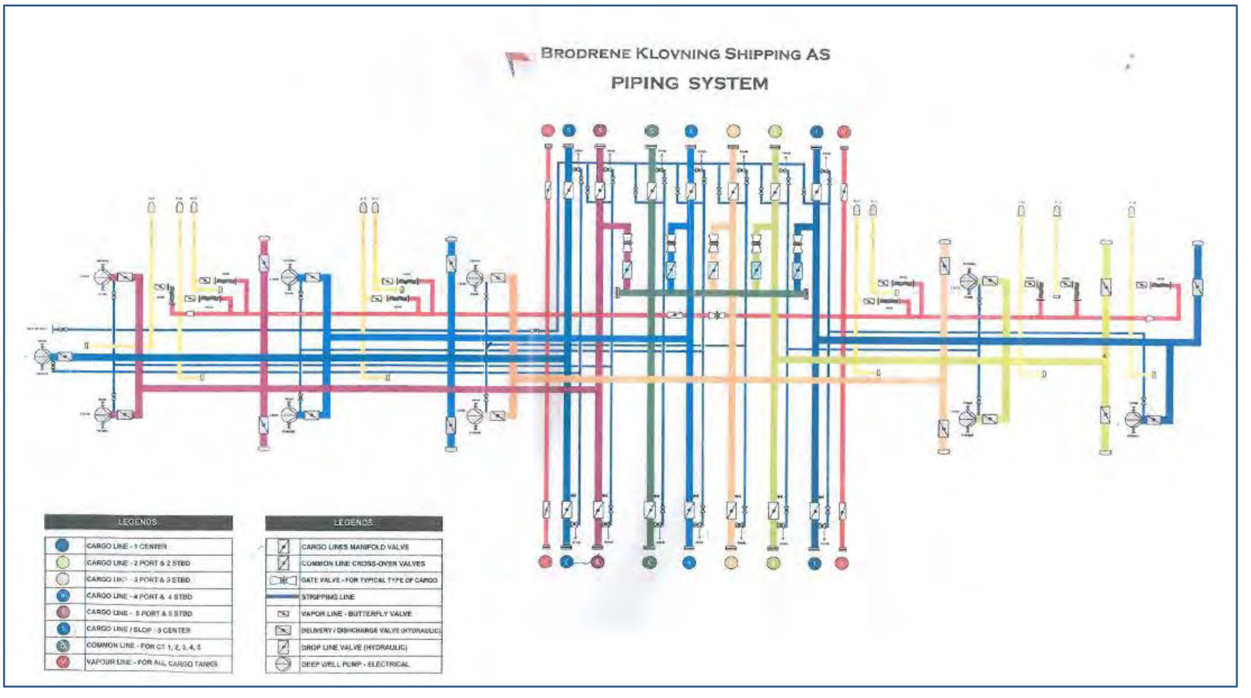

Figure 9: The figure shows the pipe system for cargo handling. The drip trays with pertaining pipe connections to the drainline are not shown here, but they are illustrated and described later in the report (see also Appendix E). Illustration: Brødrene Klovning Shipping

1.4.3.1 *The cargo system – the main pipe system for loading and discharging*

The pipelines from each tank are arranged as follows:

- Tanks 1C and 5C: A separate pipe section from each tank to crossover at the manifold
- The tank pairs 2P/S, 3P/S, 4P/S, 5P/S: A common pipe section from each tank pair to crossover at the manifold

Figure 10 shows a section of the manifold area with key elements marked and named for later reference purposes.

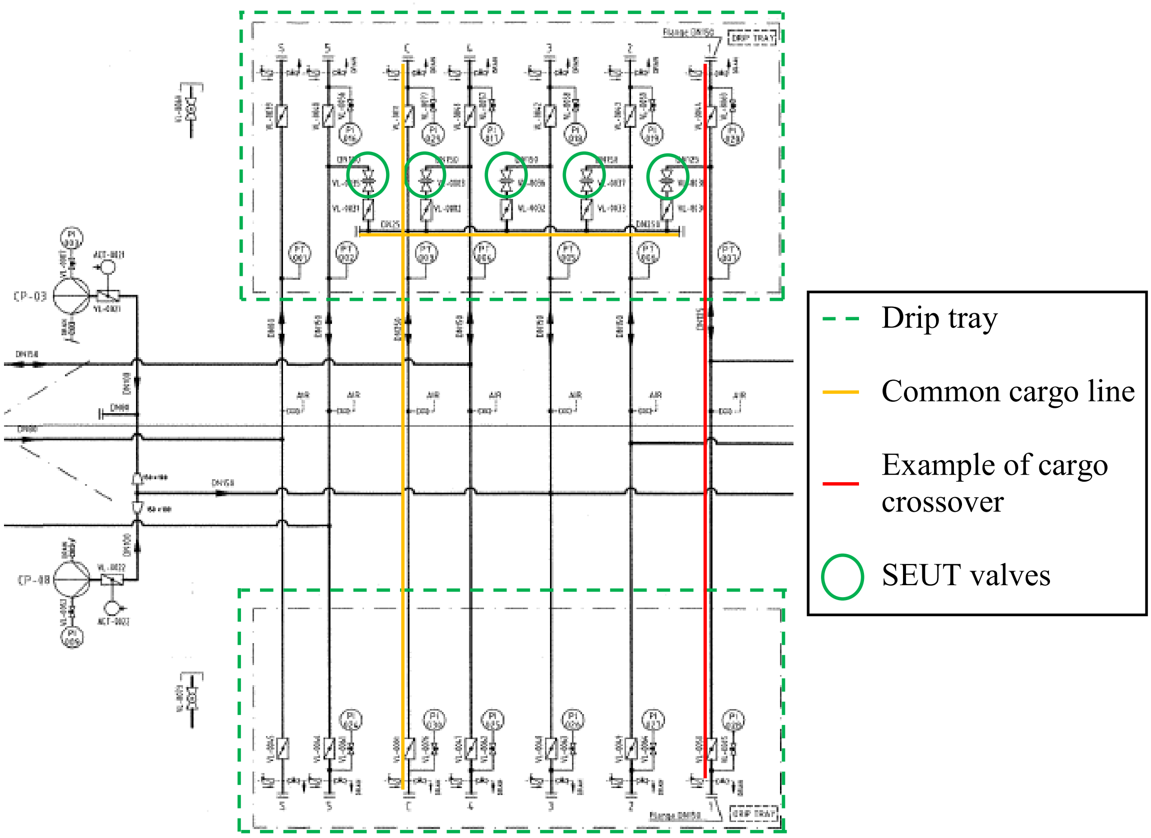

Figure 10: A section of the manifold area and the main loading and discharge lines. Illustration: Brødrene Klovning Shipping/AIBN

With the exception of cargo tank 5C, all the cargo tanks are connected to a common cargo line, as shown in Figure 10. The tanks can be segregated using blind flange valves, SEUT[6] valves, from the common cargo line.

The vessel is approved for carrying acid. The IBC Code states that, when a vessel is to carry acid as cargo, there must be a drip tray under the manifolds, something that the Clipper Sund is also equipped with. The drip trays were permanently connected to the drainline by pipes, see Figure 11, and they were equipped with draining valves (with snap couplings) at the aft end.

1.4.3.2 *The pipe system for stripping and draining*

The purpose of the stripping and drain system is to ensure the best possible emptying of the tanks. The stripping lines run from the pump in each individual tank, largely follow the cargo lines and end up at the manifold.

The Clipper Sund is equipped with a common drainline from the stripping lines to the slop tank (cargo tank 5C). Segregation is achieved by removing a spool piece (intermediate piece) between each individual stripping line and the drainline.

[6] SEUT: Norwegian manufacturer of blind flange valves.

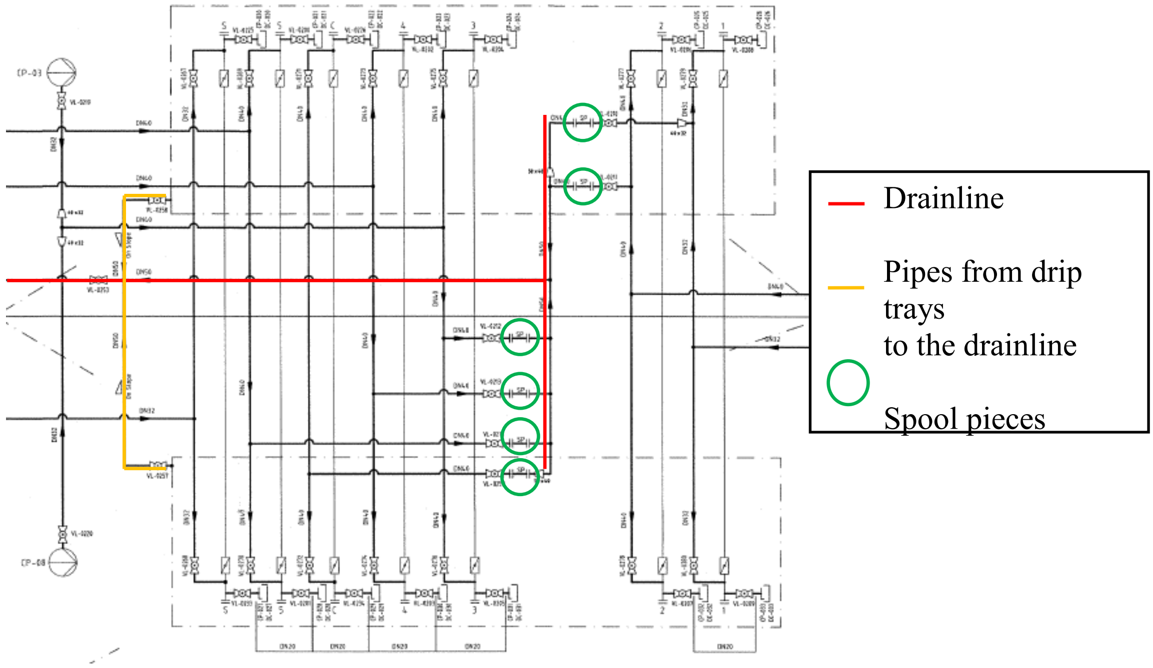

Figure 11: A section of the manifold area showing the stripping and drain system as well as the pipe connection between the drip trays and the drainline. Illustration: Brødrene Klovning Shipping/AIBN

When cargo residues come through the stripping lines to the manifold, there are four possibilities; see Figure 12:

- Discharge the cargo residues directly from the manifold
- Let the cargo residues into the main pipe system for loading and discharging, via the cargo crossover for the tank in question
- Let the cargo residues out through a ¾" ball valve with a snap coupling and cap for sample taking, draining and blowing through with air or nitrogen.
- Fit a spool piece between the stripping line and the drainline and let the cargo residues into the drainline for draining to the slop tank.

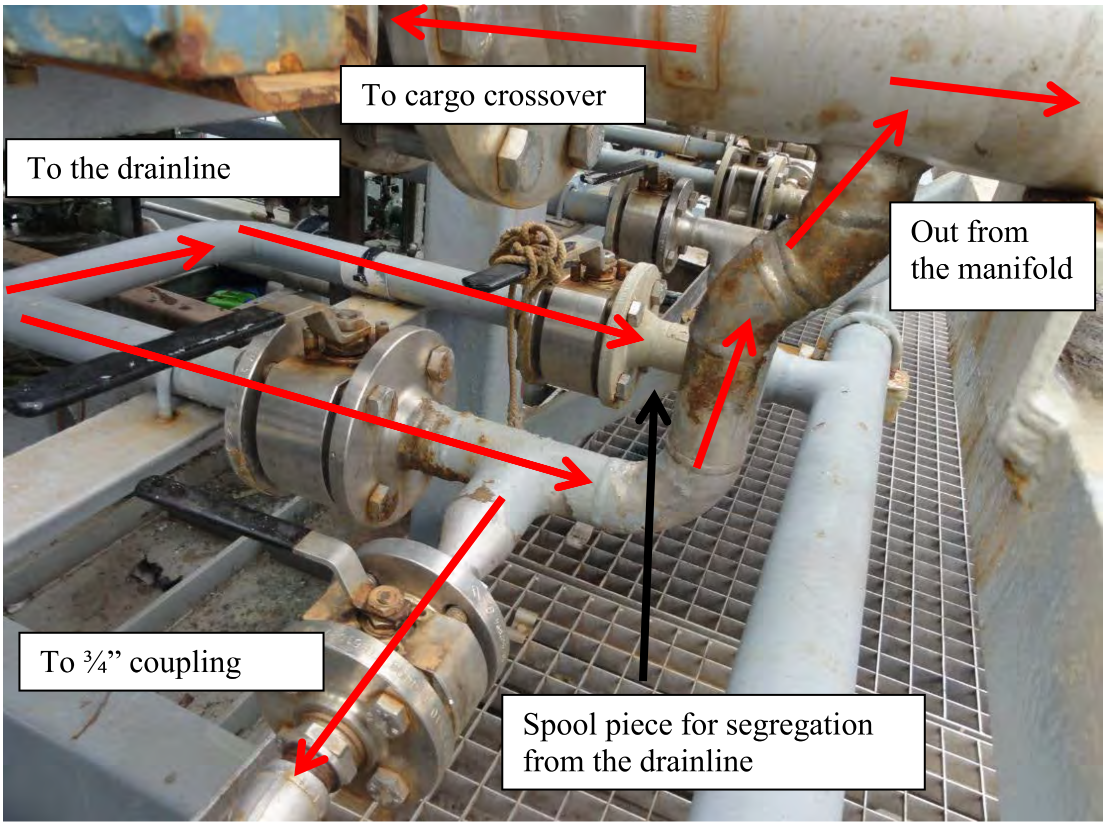

Figure 12: Alternative ways to lead cargo residues when they come through the stripping line from the individual cargo tanks. Photo: AIBN

1.4.4 The Clipper Sund’s design as a combined chemical and oil product tanker

As mentioned, the Clipper Sund is a combined chemical and oil product tanker. That means it is flexible with respect to which cargoes it can carry, but it also entails certain compromises and limitations. The purpose is to make it possible to carry both oil product cargoes in accordance with the provisions of Marpol Annex I and chemical products in accordance with the provisions of Marpol Annex II and the IBC Code.

No segregation requirement applies to oil product tankers. On the contrary, it is normal to have a common drainline from all the tanks to a dedicated slop tank for collecting oil residues and cleaning water.

A clean chemical tanker will normally have permanent design segregation of all tanks, pipes and ventilation systems. It does not normally need a permanent slop tank because stringent requirements apply as regards stripping (emptying) the tanks. Cargo residues and cleaning water are treated in accordance with the applicable regulations.

For the Clipper Sund, its combined design thus means that a cargo tank is dedicated as the slop tank (5C) when carrying oil products. A common drainline has also been established from the stripping system to this tank. In order to meet the segregation requirements when carrying chemicals, spool pieces[7] have been installed between each stripping line and the drainline as described above. SEUT valves have also been installed between the main cargo lines and the common cargo line in order to ensure segregation there.

[7] To be removed for segregation

As shown in Figure 11, there is also a permanent pipe connection between the drip trays and the drainline. This is normal for oil product tankers but not for chemical tankers, which are not usually equipped with a drainline.

1.5 Practice on board as regards stripping and segregation of the tanks

The Clipper Sund normally carries single-grade cargoes or two to three different grades (different cargoes). The vessel has never carried incompatible cargoes nor has it carried oil products so far. The shipping company believes it has had a strong focus on safety in relation to the cargo tanks and the loading and discharging lines, but that this focus has been considerably reduced in connection with what they deem to be 'secondary operations', including stripping, draining and cleaning.

1.5.1 Handling of single-grade cargoes

The shipping company has stated that it normally discharges single-grade cargoes via the common cargo line on the manifold. The subsequent stripping is normally carried out via the drainline to the common cargo line on the manifold. This is because it results in less backpressure in the pipes and thereby better emptying of the tanks. The vessel often carried single-grade cargoes and this stripping method was thus normal procedure.

When this method of stripping the tanks is used, cargo residues will be left standing in the drainline aft of the manifold. If cargo tank 5C had been used, the cargo residues were let back into it before the tanks and pipe systems were cleaned. If it had not been in use, air was blown forwards through the lines or the cargo residues were released into the drip tray before being returned to the cargo tank in question or to the containers on deck.

1.5.2 Handling of multi-grade cargoes

1.5.3 The shipping company has stated that, if it carries several types of cargo on board, and the same cargo in different tanks (over and above a given tank pair), it then discharges one cargo via the common cargo line and the others using a pipe bend on the manifold between the cargo crossover for the respective tanks with the same cargoes (as shown for the aniline cargo in Figure 4). In such cases, the shipping company states that it normally strips via the main pipe system by opening from the stripping lines to the respective main cargo pipes.

1.5.4 Handling of spool pieces

After the incident, it was observed that several spool pieces were fitted between the stripping system and the drainline. The shipping company states that the spool pieces have normally been fitted at all times, but that, when segregation is necessary, it has probably been normal to blind the pipes using thin, specially adapted stainless steel caps that have been fitted between the pipe flange and the spool piece. The AIBN does not know whether this was the case at the time of the accident. Such steel caps would not have been accepted as means of separation as per the IBC code

1.6 The cargo

1.6.1 The properties of the cargo

The discharging and stripping of nitrobenzene from tanks 2P and 2S was concluded two days before the accident and proceeded without incident. It is assumed with a high degree of certainty that this operation did not have anything to do with the accident. The properties of nitrobenzene will therefore not be further discussed in the investigation.

Nitric acid belongs to Hazard Class 8[8] (corrosives). The acid is characterised as an inorganic substance[9] and it is not flammable, but decomposes when heated and forms flammable/toxic/corrosive gases. The acid is stable under normal storage conditions, but it is strongly oxidising and can react strongly with many organic chemicals, and the reactions can be explosive. The acid must be stored separately from incompatible substances. Nitric acid will react with water and develop hot, toxic, corrosive and flammable gases.

Aniline belongs to Hazard Class 6 (toxic substances) and it is an organic colourless liquid. Aniline is stable under normal conditions, but it is specified that the chemical must be kept separate from acids and oxidising substances.[10]

According to the US Coast Guard compatibility chart,[11] nitric acid is incompatible with aniline.

1.6.2 Reactions between aniline and nitric acid

As previously mentioned, nitric acid is strongly oxidising and can react violently with many organic chemicals. According to a report commissioned from the Armed Forces' laboratory service, a reaction between nitric acid and aniline will have the following characteristics:

> *Mixing nitric acid and aniline will lead to the development of gases and heat. If it becomes sufficiently hot, aniline vapours and flammable gases will be formed. The gases could expand quickly and result in an explosion.*
>
> *The strength and speed of the reaction between aniline and nitric acid will depend on the amount of aniline and nitric acid and the concentration of the nitric acid.*

1.7 The crew

At the time of the accident, the Clipper Sund had a crew of nine in addition to the new captain who arrived on the same evening as the accident took place. The captain was Finnish, while the chief engineer and the new captain were Norwegians. The other members of the crew were from the Philippines.

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[8] Cf. Hazardous goods folder (the Norwegian Directorate for Civil Defence and Emergency Planning)
[9] CUF, Safety Data Sheet, Nitric Acid
[10] CUF, Safety Data Sheet, Aniline
[11] USCG Compatibility Chart. It is referred to in the industry standard Tanker Safety Guide Chemicals as a relevant reference work for deciding whether two cargoes are compatible.

The vessel's deck officers, including the captain, had the required certificates and had long experience on board chemical tankers. They all also had experience of the Clipper Sund or its sister ships.

The seaman who died in the accident was born in 1976. He had many years' experience at sea and had sailed for the shipping company on the sister ships Clipper Sira and Clipper Sund since 2008. He had a tankerman lowest grade certificate. During the seaman's periods on board the shipping company's vessels, none of the ships had carried incompatible cargoes simultaneously.

During the period prior to the accident, the seaman had worked sea watches from 00.00 to 04.00 and from 12.00 to 16.00. A list of working hours and periods of rest was not available for the first days of September. Based on information provided about the duty rota system in the period prior to the accident, this could indicate that the seaman who died had had an opportunity to get sufficient sleep and rest. Tiredness or sleepiness was probably not a contributory factor and will not be investigated further.

The shipping company's RIP manual[12]includes job instructions for the different positions on board. In connection with loading and discharging, the seaman's job instructions state that he is to carry out the work he is assigned by the pumpman. The seamen report directly to the chief officer and pumpman. During periods when there is no pumpman on board, the seamen are assigned work by and report directly to the chief officer. This was the case on the voyage when the accident happened. Because the pumpman signed off on 19 August, the vessel's three seamen worked an ordinary sea watch system with four hours on and eight hours off.

1.8 Regulations and industry standards

The building and operation of vessels like the Clipper Sund is regulated by a number of laws and regulations. The parts of the regulations that are relevant to the accident are discussed in this chapter.

1.8.1 The ISM Regulations – requirement for safety management

Pursuant to the ISM Regulations, shipping companies are required to have a safety management system.[13] Pursuant to Section 2 of the Regulations, all shipping companies shall have a safety management system that covers both the onshore organisation and each individual ship in accordance with the ISM Code. The international norm for the safe management and operation of ships and the prevention of pollution (the ISM Code) is appended to the Regulations. From the appendix, we mention in particular the requirement that *'The Company should establish procedures, plans and instructions, including checklists as appropriate, for key shipboard operations concerning the safety of the personnel, ship and protection of the environment.' The various tasks this involves should be defined and assigned to qualified personnel.*

Chapter 1.2.2 of the ISM Code originally stated that shipping companies should establish barriers against all identified risks. On 1 July 2010, amendments to the Code entered into force, requiring shipping companies, among other things, to carry out assessments of the

[12] This is discussed in more detail in Chapter 1.10 The shipping company's safety management system.
[13] Regulations No 306 of 14 March 2008 relating to safety management systems on Norwegian ships and mobile facilities.

risks relating to their vessels, crews and the environment, and, in light of these assessments, to establish relevant barriers.

1.8.2 The WEHS Regulations – requirement for risk assessments

Matters relating to personal safety are regulated by the WEHS Regulations.[14] The WEHS Regulations are intended to ensure that work and off-duty activities on board are arranged and organised in a manner that safeguards the physical and mental health of employees.

Section 2-2 of the WEHS Regulations sets out a requirement for risk assessments. This means that risks on board must be identified. The Regulations do not contain requirements for how such a process is to be carried out, but the Norwegian Maritime Directorate points out that there are several methods for this. In practice, the whole spectrum from discretionary judgement / expert assessments to structured methods will be acceptable. The Norwegian Maritime Directorate expects shipping companies to carry out a process in which factors that can have negative consequences for employees' safety and physical and mental health are identified. The Directorate expects this review process to cover the tasks that are part of the ordinary operation of the vessel.

Once a hazard has been identified, the WEHS Regulations require that the risk that it poses be assessed. The Regulations do not contain requirements as regards the method to be used in this context either. The Norwegian Maritime Directorate expects that the risks that have been identified will be assessed with respect to their consequences (for employees' safety and physical and mental health) and probability and/or uncertainty.

Pursuant to the Regulations, it is also a requirement that, if a risk to employees' safety and health is uncovered, necessary actions must be initiated to remove or reduce the risk. The WEHS Regulations do not have any defined criteria for what is meant by acceptable risk, but, according to the Norwegian Maritime Directorate, a discretionary risk acceptance criterion can be derived from section 1.1 of the Regulations, which states that *'the safety and physical and mental health of the workers is ensured in accordance with technological and social development of society'*.

The Regulations require that such risk assessments are carried out regularly, when new work equipment or technology is introduced, and in connection with other changes in how work is organised or planned that can have a bearing on employees' safety and health. The results of the risk assessment shall be documented in writing.

For ships that are required to have a safety management system, the shipping company shall ensure that the requirements that follow from the WEHS Regulations are complied with.

1.8.2.1 *Ongoing work by the authorities relating to guidelines/aids*

In connection with the WEHS Regulations, which entered into force on 4 August 2000, the Norwegian Maritime Directorate produced a guide to risk assessments on board vessels. This guide ceased to apply when the current WEHS Regulations were introduced. The AIBN has been informed that the Norwegian Maritime Directorate has started work on a new guide to the current regulations.

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[14] Regulations No 8 of 1 January 2005 relating to the working environment, safety and health of employees on board ships

The Norwegian Maritime Directorate is participating in a working group in ILO.[15] The working group is tasked with assisting the authorities with the implementation of MLC 2006 Maritime Occupational Safety and Health (OSH). Among other things, the working group is tasked with producing a manual that is intended to raise awareness and understanding of the conditions in MLC 2006. The draft manual deals, among other things, with risk assessments and their implementation in a maritime context. The need to establish a 'Shipowners' risk assessment tool/checklist' as an appendix to the manual is also discussed.

In collaboration with a number of players in the fisheries industry, the Norwegian Maritime Directorate established the website www.yrkesfisker.no in August 2010. The aim of the website was to make it easier for fishermen to keep up-to-date about important safety information and regulations and thereby prevent accidents. The topic of risk assessment has a central place on the website. Among other things, a tool called 'FiskRisk' has been developed in order to uncover hazards associated with the different tasks carried out on board vessels. The tool helps fishermen to assess risk and prepare action plans in a systematic way. Discussions have started in the Directorate about whether similar tools should be developed for use in other parts of the shipping industry.

1.8.3 The Qualification Regulations – qualification requirements for personnel on board Norwegian vessels

Qualification requirements and certificate rights for personnel on board Norwegian ships are set out in separate regulations relating to qualification requirements on Norwegian ships.[16] In addition to the general requirements that apply to individual seamen, the Regulations contain requirements for the training of personnel on certain types of ships, including tankers.

For chemical tankers in particular, it is a requirement that the crew on board have a practical and theoretical understanding of the vessel's special pipe, pump and tank arrangement, among other things. Moreover, the crew shall be sufficiently knowledgeable about cargoes' chemical properties to be able to handle the cargo in accordance with relevant 'Cargo safety guides'. The crew shall also have a practical and theoretical understanding of loading and discharging plans and procedures.

The seaman who died in the accident had a tankerman lowest grade certificate and should therefore have had the competence specified in the above.

1.8.4 The IBC Code

The IBC Code, which has been made mandatory through the reference to it in SOLAS, contains requirements for ship arrangements (Chapter 3), including the segregation of different cargoes, and operational requirements (Chapter 16), including information about the cargo, as well as procedures for handling cargo and the training of personnel.

[15] International Labour Organisation
[16] Regulations 2003-05-09-687 'Regulations concerning qualification requirements and certificate rights for personnel on board Norwegian ships, fishing vessels and mobile offshore units'. These Regulations were later replaced by 'Regulations 2011-12-22 concerning qualifications and certificates for seafarers'.

1.8.4.1 *Ship arrangements*

Among other things, Chapter 3 of the Code (Ship Arrangements 3.1.3/3.1.4)) contains provisions on the segregation of different cargoes. It states that incompatible cargoes[17] shall:

- be segregated from such cargoes by means of a coffer-dam, void space, cargo pump room, pump room, empty tank or a tank containing a mutually compatible cargo.
- have separate pumping and piping systems which shall not pass through other cargo tanks containing such cargoes, unless encased in a tunnel.
- have separate tank venting systems.

If the pipe or ventilation system is to be separate, this can be done using either design or operational methods[18]. Operational methods must not be used within a cargo tank. Operational methods shall be of the following types:

- removing spool-pieces or valves and blanking the pipe ends.
- arrangement of two spectacle flanges in series, with provisions for detecting leakage into the pipe between the two spectacle flanges.

1.8.4.2 *Operational requirements*

Among other things, Chapter 16 of the Code, which concerns operational requirements, contains provisions about what type of information shall accompany the cargo and about the training of personnel.

The provisions concerning the information that shall accompany the cargo state that such information shall be available on board and be accessible to all personnel involved in work on the cargo. Such information shall include a cargo plan that is to be stored easily available and include all the cargo on board. The following shall be available for each individual chemical on board:

- A full description of the cargo's physical and chemical properties, including its reactivity, necessary for the safe containment of the cargo.
- Action to be taken in the event of spills or leaks.
- Countermeasures against accidental personal contact.
- Fire procedures and fire-fighting media.
- Procedures for cargo transfer, tank cleaning, gas-freeing and ballasting.

The following provisions apply to the training of personnel:

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[17] Cargoes, cargo residues or mixtures of cargoes that react with other cargoes, cargo residues or mixtures of cargoes in a manner that can entail risk.
[18] For toxic cargoes the IBC code (15.12.3) do not specify any operational method for securing segregation of cargoes

- All personnel shall be adequately trained in the use of protective equipment and have basic training in the appropriate to their duties necessary under emergency conditions.

- Personnel involved in cargo operations shall be adequately trained in handling procedures.

- Officers shall be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo and a sufficient number of them shall be instructed and trained in essential first aid for cargoes carried based on guidelines developed by the IMO.

1.8.5 The class regulations

Clipper Sund is designed and built in accordance with Det Norske Veritas's regulations and it is classed by the same company. The class regulations are designed to meet the requirements in the IBC Code.

DNV interprets the IBC Code to mean that segregation shall be considered between 'closed systems'. The vessel's drip tray is deemed to be an 'open system' and is thus not addressed with a view to segregation.

1.8.6 Industry standards

There are several industry standards aimed at contributing to greater safety in connection with tanker operations. Of these, we mention the International Safety Guide for Oil Tankers and Terminals (ISGOTT[19]) and Tanker Safety Guide, Chemicals.[20] The shipping company has prepared its operational procedures in accordance with these standards, among others.

The most recent version of ISGOTT continues to set out best practice in connection with operations involving tankers and terminals, but it also focuses on risk-based control and risk understanding. The standard urges shipping companies and seafarers to identify the risk involved in the operations/work they carry out and thereby to implement appropriate risk reduction measures. This is in line with the intentions of the ISM Code.

Tanker Safety Guide, Chemicals (TSG) has been prepared by ICS. It contains a collection of experiences and best practice from the chemical tanker industry. The purpose of the publication is to give those who work on board chemical tankers updated information about best practice relating to safe operations. The recommendations in the publication do not cover all conceivable situations that can arise, but are intended to provide general guidelines for safe procedures and safe work practice for the handling and transport of bulk chemicals. The publication focuses on operational conditions and not on design and maintenance.

TSG discusses matters relating to unintended spills of chemicals and outlines some measures that should be implemented if such events occur and that should be part of the vessel's emergency response plan. TSG points out that the size of a spillage and its

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[19] Prepared by ICS (International Chamber of Shipping), OCIMF (Oil Companies International Marine Forum) and IAPH (International Association of Ports and Harbors).
[20] Prepared by ICS.

location should be considered in relation to whether all the measures should be implemented. In relation to unintended exposure of personnel to chemicals, it is pointed out that such incidents must always be treated as serious incidents.

1.9 Definitions of risk management, risk assessment and risk analysis

A review of the documentation and literature relating to risk concepts shows that the terminology is used interchangeably and can thus be understood in different ways. In subsequent discussions relating to risk assessments, risk analysis and risk management in the analysis of this accident, the AIBN has chosen to use the definitions and principles set out in the book Risikoanalyse – teori og metoder by Rausand & Utne[21] and Norwegian Standard NS 5814:2008.

Risk management can be defined as 'a management process whose aim is to identify, analyse and assess possible risk factors in a system or activity, and to find and implement measures that can reduce possible harmful effects'. (Rausand & Utne, p. 77)

Risk management starts by establishing which framework conditions and acceptance criteria apply to the work. According to NS 5814:2008, acceptance criteria can be expressed in words or be quantified, or be a combination of the two.

Risk management involves a continuous process that consists of the sub-processes planning, risk analysis, risk evaluation and risk control/reduction; see Figure 13. Stipulating when it is necessary to carry out or revise the risk assessments (indicators) is intended to ensure that the process is continuous.

Risk assessment is often used as a generic term for planning, risk analysis and risk evaluation. The objective of risk assessment is to uncover hazards and identify undesirable incidents, analyse and evaluate risk, establish an overview of all risks, assess them in relation to what is deemed to be acceptable (acceptance criteria), propose risk reduction measures and consider alternative solutions.

Planning refers to the part of the risk assessment in which the problem is described and the goal for the work defined. It also has to be planned how the assessment will be organised (including composition and competence) and which methods and data will be used.

By risk analysis is meant an analytical method identifying and assessing possible undesirable incidents that can lead to injury to persons, or harm to the environment and other assets. The risk analysis can be qualitative and/or quantitative and it can have a varying degree of detail. A risk analysis attempts to answer the following questions:

1. What undesirable incidents can occur?
2. How probable is it that the different undesirable incidents will occur?
3. What could the consequences be if the undesirable incidents should occur?

The answers to these questions can be visualised, for example, in a risk matrix by placing the possible undesirable incidents in a diagram with degree of probability and consequence, respectively, along each axis.

[21] Risikoanalyse – teori og metoder, Marvin Rausand and Ingrid Bouwer Utne, Tapir Akademiske Forlag, 2009

By risk evaluation is meant assessing the risk situation, as described in the risk analysis, in relation to the stipulated acceptance criteria, and proposing and assessing alternative risk reduction measures.

By risk control and risk reduction is meant making decisions to introduce risk reduction measures; implementing these measures and monitoring the risk with a view to implementing new measures if necessary; communicating risk to affected stakeholders and others.

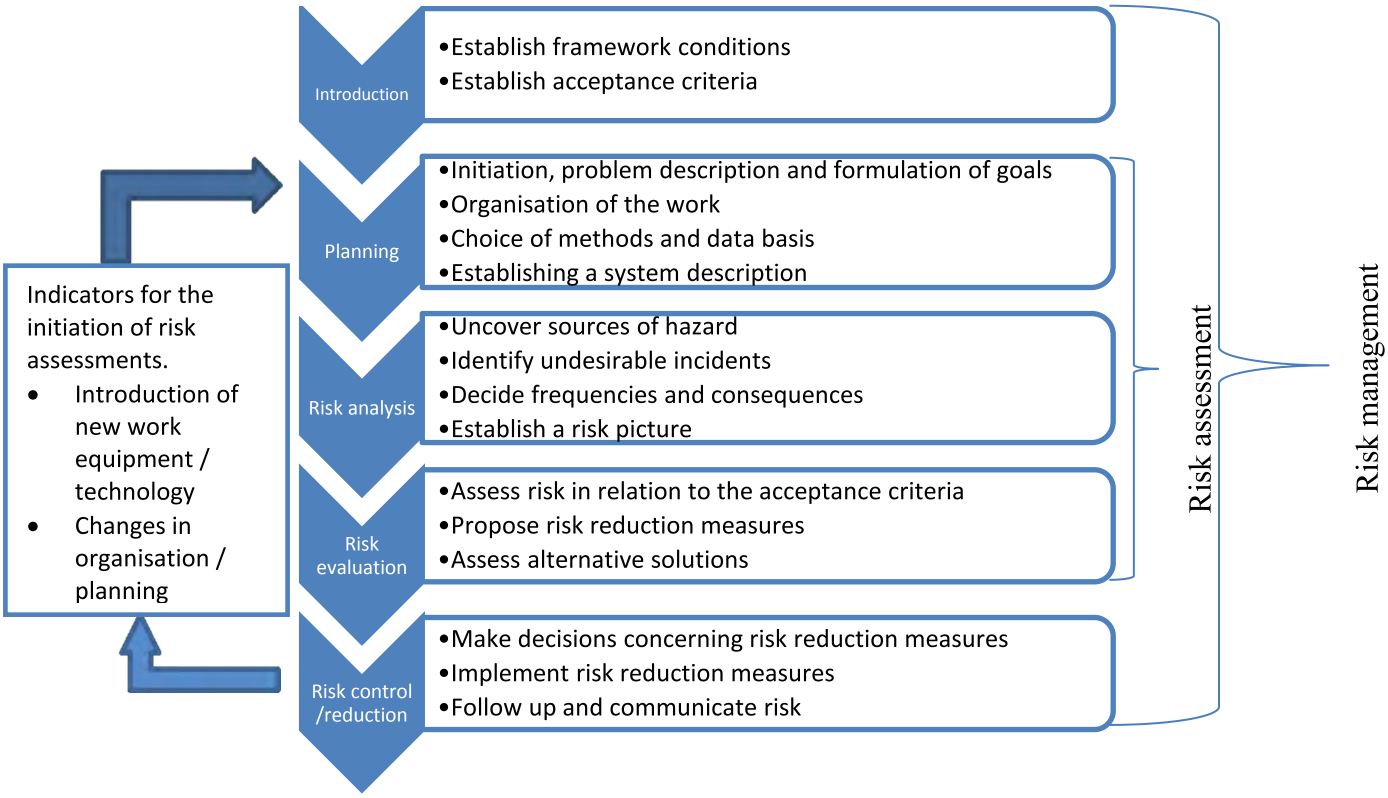


Figure 13: Simplified presentation of the connections between the individual elements in risk management. Illustration: AIBN

1.10 The shipping company's safety management system

The shipping company's quality and safety management system[22] has been established in accordance with the IMO's ISM Code.[23] The system has been established with four main levels as shown in Figure 14.

[22] Safety, Security and Quality Management System (SSQM System)
[23] International Safety Management Code, IMO Res. A 741 (18)

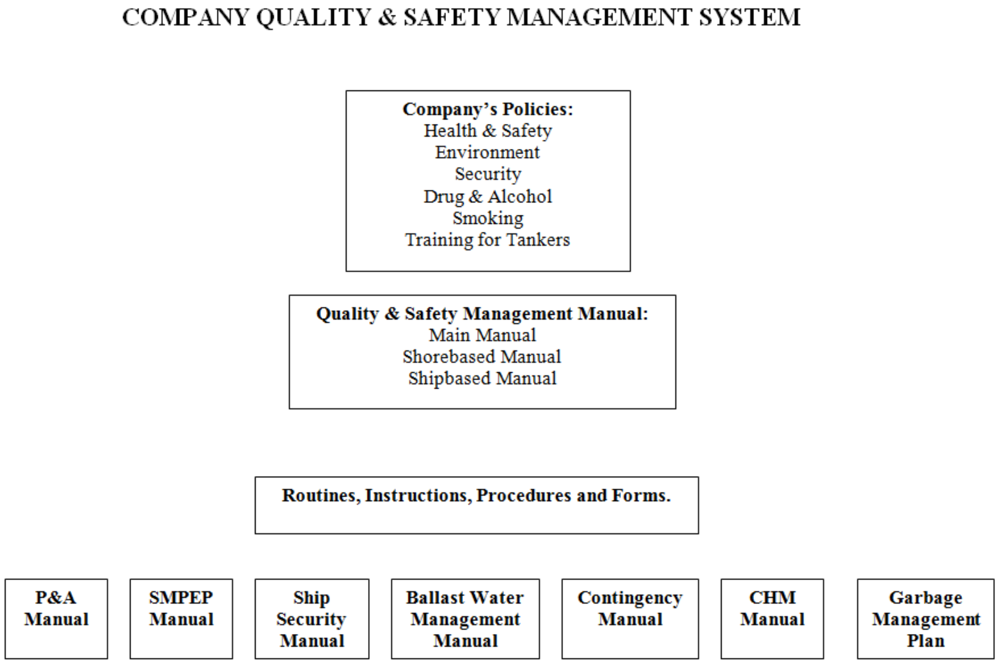


Figure 14: How the shipping company's quality and safety management system is designed. Illustration: Brødrene Klovning Shipping

The top level, 'Company's Policy', describes the shipping company's general policy in several areas.

The shipping company's Q&SMS System (Quality & Safety Management System) contains a main manual and separate manuals for the onshore organisation and for the vessels.

The manual deals with many topics, including the accident reporting system (SAFIR) and the shipping company's focus on learning and continuous improvement. It is also stated that the shipping company shall carry out risk assessments of its operations. The risk assessments are to be documented and evaluated, and necessary measures to reduce the risk are to be implemented.

The RIP (Routines, Instructions, Procedures and Forms) manual contains various routines, instructions, procedures and forms. The routines describe special activities that are carried out by the different departments in the organisation. The instructions describe activities for which the individual employees are responsible. The procedures describe how the activities are to be carried out. The forms contain some standard templates and checklists.

The lowest level contains sub-manuals relating to different topics. In the following, we look at the P&A (Procedures and Arrangements) manual, the CHM (Cargo Handling Manual) and SMPEP,[24] which are all related to cargoes and cargo handling.

[24] SMPEP: Shipboard Marine Pollution Emergency Plan

1.10.1 Risk assessments

1.10.1.1 *The management system's description of how risk assessments are to be carried out*

The shipping company's Quality & Safety Management Manual states that the shipping company shall carry out risk assessments of its operations. The risk assessments are to be documented and evaluated, and necessary measures to reduce the risk are to be implemented.

The shipping company has established procedures for carrying out risk assessments in the RIP manual's procedure 'Risk assessment and critical equipment identification'. Pursuant to this procedure, the shipping company's onshore organisation is required to carry out risk assessments of standard work/equipment/repairs, while the vessel's captain is required to carry out risk assessments of other work/equipment/repairs.

In order to carry out risk assessments, the shipping company has produced a risk assessment form that is to be used before the work commences; see Figure 15. The assessment starts by selecting hazards and existing controls that are relevant to the work. These hazards and controls are selected from a set of pre-defined hazards and controls in a dropdown menu. The pre-defined hazards in the risk assessment form do not include hazards associated with incompatible cargoes.

Based on the identified hazards and controls, the next step consists of defining probability and consequence. Probability is graded from 'highly unlikely', 'unlikely', 'likely' to 'highly likely'. Consequence is graded from 'not harmful', 'slightly harmful', 'harmful' to 'extremely harmful'.

The risk level is defined on the basis of the combination of probability and consequence. It is expressed as 'trivial', 'minor', 'tolerable', 'moderate', 'substantial' or 'intolerable'. Pursuant to the risk assessment procedure, work may be commenced if the highest risk is moderate (acceptance criterion). For risk above this level, the work shall not be started, and the shipping company shall be informed.

According to the flow chart attached to the RIP Manual, the highest risk level shall be 'minor'. If not, the job shall be postponed and the immediate superior contacted.

	Not Harmful	Slightly Harmful	Harmful	Extremely Harmful
Highly unlikely	Trivial	Minor	Tolerable	Moderate
Unlikely	Minor	Tolerable	Moderate	[illegible]
Likely	Tolerable	Moderate	[illegible]	[illegible]
Highly Likely	Moderate	[illegible]	[illegible]	[illegible]

Initial Assessment of Risk

Standard Hazards and Controls (Choose Harzard and Control from the ones listed)

Hazard	Existing Control	Likelihood	Consequence	Risk
Toxicity	PPE available	Likely	Extremely Harmful	Intolerable

Other Hazards and Controls (Write Hazards or Controls that are not listed)

Hazard	Existing Control	Likelihood	Consequence	Risk
HAZARDS OF POLYMERISATION AND FIRE		Unlikely	Extremely Harmful	Substantial
		Highest Risk Obtained		**Intolerable**

Additional Measures (to reduce the Risk that is Intolerable or Substantial)

	Measure	Likelihood	Consequence	Risk
	FULL CHEMICAL SUIT AND BA TO BE USED ON CONNECTION OF CARGO HOSES. FULL CHEMICAL SUIT WITH FILTER MASK WORN WHEN ON DECK.	Unlikely	Not Harmful	Minor
	INHIBITOR USED TO PREVENT POLYMERISATION			
	CARGO TANKS INERTED WITH N2			
	Highest Risk after additional controls			**Minor**

If the highest risk cannot be reduced below Substantial, do not start the work. Inform the office

Figure 15: Sketch showing an excerpt of the shipping company's risk assessment form. Illustration: Brødrene Klovning Shipping

1.10.1.2 *Risk assessments actually carried out by the shipping company*

In 2009, the shipping company carried out risk assessments of five standard operations: anchoring operations, mooring, lifting operations, work aloft and access to the vessel.

The shipping company has not carried out and documented formal risk assessments of, for example, loading and discharging operations. According to the shipping company, the vessel's operational procedures have not been established on the basis of concrete risk assessments, but they have been prepared in accordance with recognised industry standards such as ISGOTT and Tanker Safety Guide, Chemicals. The procedures are revised as a result of new international rules, inspections / comments from the oil companies, and experience of the non-conformity system.

1.10.1.3 *Risk assessments carried out on board*

Nine risk assessments were carried out on board the Clipper Sund in 2010, three of which were related to loading / discharging and tank cleaning of a particularly toxic cargo. A total of 12 risk assessments were carried out in 2011, two of which concerned loading and discharging of the same type of cargo for which a risk assessment was carried out in 2010. A risk assessment was also carried out relating to loading of the products that were on board on the voyage when the accident took place. The latter risk assessment was carried out on 26 August 2011 before loading in Aveiro. The risk assessment was carried out by the ship's captain. It identified the hazards relating to the cargo's toxicity and its corrosive properties, and thereby the hazards associated with inhalation and skin contact. The assessment resulted in several risk reduction measures that reduced the risk level to what was deemed to be an acceptable level. The assessment did not identify hazards relating to incompatible cargoes. As previously mentioned, hazards relating to incompatible cargoes are not pre-defined in the risk assessment form.

The shipping company expects risk assessments of deck-related factors to be carried out by the captain and chief officer. Risk assessments of engine-related factors are expected to be carried out by the captain and chief engineer.

The risk assessments shall be carried out using the shipping company's standard risk assessment forms, and they shall be stored on board and in the shipping company's office. The risk assessments that are carried out on board the individual vessel are sent to the shipping company's office, where the assessments are collected in a 'Risk Assessment Record' and made available to all the vessels. The purpose of this is to enable the individual vessels to make use of risk assessments that have already been carried out in their own assessments.

1.10.2 Plans for safe execution of loading and discharging operations

1.10.2.1 *Operations on board*

Pursuant to the ISM Code, shipping companies shall introduce procedures, plans, instructions, including checklists, that are necessary for key operations. The document[25] 'Shipboard operations', which deals with operations on board, forms part of the main section of the Q&SMS Manual. The document points out that necessary plans shall be prepared for the execution of shipboard operations.

The purpose of this document is to ensure that all the vessel's key operations that can affect quality and safety and prevent pollution are performed in a controlled and satisfactory manner. The above-mentioned document states that the ship's master is responsible for ensuring that the necessary routines, procedures and instructions, or other relevant manuals, are prepared and implemented on board the shipping company's vessels. It also states that the need for such plans shall be identified on board, and that the vessel's management shall assess whether existing plans are sufficient or whether new plans must be prepared.

1.10.2.2 *Cargo Handling Manual (CHM)*

CHM is of course a key document in relation to the vessel's handling of loading and discharging operations. The manual contains a set of routines, procedures, instructions, checklists and templates relating to loading / discharging and pertaining operations.

The document 'Cargo Handling Routines' is part of CHM. Among other things, it points out that checklists and procedures shall always be used in connection with loading and discharging in order to ensure that key operations are carried out in a safe manner and without accidents or stoppage of operations. The document contains guidelines for which

[25] Q&SMS Manual, main section, 11. Shipboard operations

plans shall be prepared in connection with loading and discharging operations, and it mentions that the chief officer is responsible for preparing loading / discharging plans in accordance with the applicable regulations and industry standards. The Code's requirements for the contents of such a cargo plan are set out in Chapter 1.8.4.2.

A number of checklists are included in CHM 2.1/2.2/2.3/2.4 and 2.5 as aids for the chief officer when preparing loading / discharging plans (see appendix). Among other things, the checklists ensure that manifold plans, the lining up of pipes and valves and cargo information are reviewed with respect to special safety factors. In relation to the requirements in the shipping company's safety management system, relevant plans for the discharging in Antwerp had been prepared, reviewed and made available to the personnel who were to take part in the discharging operation.

1.10.2.3 *Procedures & Arrangements Manual (PA Manual)*

In accordance with the requirements in Marpol Annex II, the vessel is equipped with a 'Procedures and Arrangements Manual' (P/A Manual) approved by the classification society. The manual deals with pollution of the marine environment in connection with the cleaning of tanks and the discharging of residues from the cleaning processes. The main purpose of this manual is to familiarise the vessel's officers with the ship's physical arrangements and all the operational procedures relating to cargo handling, tank cleaning, the handling of slops and the use of cargo tanks for ballast purposes that must be observed in order to satisfy the requirements in Annex II.

The manual begins by specifying that it is not a safety manual.

In addition to the CHM Manual, this manual is an important element in the vessel's handling of loading and discharging operations. Among other things, it describes the vessel's general arrangements and the cargo tanks, as well as the vessel's pump, pipe and stripping arrangements. The manual also deals with procedures relating to discharging and stripping tanks, and it contains relatively detailed guidelines for how operations are to be carried out, including requirements for how loading / discharging lines are to be lined up and how the discharge pumps are to be operated.

Moreover, it describes how the stripping of tanks is to be carried out with respect to the environmental aspect. On the other hand, the manual does not deal with safety-related factors in connection with stripping operations. Reference is made to the fact that the individual cargo tanks are equipped with a combined discharge and stripping pump with separate stripping lines to the cargo crossover at the manifold. The manual recommends stripping from tank to tank, but it does not go into detail about how the pipe system for stripping is designed or that the vessel is equipped with a common drainline. Nor is a drawing of the stripping system included as an appendix to the P/A Manual.

1.10.2.4 *Pre-cargo operation conference*

Holding pre-cargo operation conferences is an important part of the preparations for loading and discharging in addition to the written documentation and plans that have been prepared. These conferences are held with the captain, deck officers and deck crew present. Information is provided at the conferences about manifold plans, sample taking and the compatibility of different cargoes. A separate checklist, CHM Form 2.5, has been prepared as an aid to conducting these conferences. Copies of the manifold plan, stowage plan, the checklists and the material safety data sheets for the cargoes are posted in the mess and in the corridor outside the crew's cabins.

It is normally clarified what procedures are to be followed when stripping the tanks after the vessel has arrived at the discharge terminal and a meeting has been held between the vessel's chief officer and a representative of the recipient. In practice, this means after a pre-cargo operation conference has been held with other involved personnel present.

1.10.3 Procedures for taking samples of the cargo

Section 4.1.6 of the procedure describes how samples are taken. It mentions that the crew member who takes the samples shall use the personal protective equipment required for the cargo in question. Information about what this means is given by the chief officer at the pre-loading / discharging conference. This information is also listed in the checklist for the conference in question. The checklist for the pre-loading / discharging conference prior to discharging aniline and nitric acid stated that, in connection with the handling of aniline, chemical resistant gloves, a self-contained breathing apparatus and a chemical suit must be used as extra personal protective equipment (PPE) in addition to the standard equipment, consisting of protective footwear, a boiler suit, helmet, gloves and protective goggles.

It is the duty deck officer's job to ensure that the correct protective equipment is used during all phases of the sample taking.

It is not unusual for small quantities of the cargo to be spilled in the drip trays when taking samples from the manifold and when disconnecting and connecting hoses in connection with loading and discharging. According to the shipping company, this spillage is usually returned to the original tank before cleaning, or pumped to one of the two plastic containers on deck for intermediate storage until the tanks are cleaned and prepared.

1.10.4 Procedures and documents relating to training

1.10.4.1 *Familiarisation and training*

The shipping company's basis is that the personnel it employs have the formal training required by the regulations. In other words, it assumes that someone with a tankerman certificate has sufficient general knowledge. Vessel-specific knowledge is provided on board as described below:

The familiarisation process for crew on board is described in the document 'Familiarization/training' in the RIP Manual. The process is divided into three levels and starts with the shipboard safety system (the vessel, alarm plan and fire/rescue equipment), then continues with the crew member's own job function and familiarisation with the shipping company's Q&SMS system.

In addition to the familiarisation process, the crew have to undergo necessary training to ensure that each individual crew member has the competence required to handle emergency situations and the tasks described in his or her job description. Training is ensured by:

- following the items described in the 'training record'

- on-the-job training
- computer-based training (Seagull CBT), and
- overlapping with personnel who are being relieved.

Familiarisation of the captain and officers in connection with cargo handling includes reviewing the CHM and P/A Manuals.

Personnel who are to be part of the deck crew shall undergo training in accordance with the form 'Training record deck for ABs'. This checklist deals with topics relating to mooring and crane operations as well as several topics relating to cargo handling, including 'Cargo stripping operations' and 'Manual cargo valve operation'. The document does not contain further details about what the individual items entail, nor does it refer to other documents. During an annual audit of the shipping company's DOC on 15 June 2011, the classification society pointed out that the shipping company's description of the familiarisation of new crew members does not contain references to relevant points in STCW. The shipping company expects training relating to loading and discharging operations to be carried out by new crew members going on duty with experienced crew members before going on duty on their own. The chief officer who was on board on the voyage in question also accompanied new personnel on deck and explained how operations took place.

For the captain and chief officer, the overlap period comprises a sea voyage including a loading / discharging operation and tank cleaning. For the able seamen, it comprises one period of watch.

1.11 Authority and classification society – approval and supervision

1.11.1 Approval of the drain and stripping system

The original drawings for the drain and stripping system (P&ID Drain and Stripping Cargo System) were sent from Volharding Shipyards to DNV for approval on 7 February 2005. In these drawings, the vessel's drip trays were not permanently connected to the drain and stripping system.

DNV's comments on the original drain and stripping system were that, if the system was to be approved pursuant to the requirement for a separate pipe system, spool pieces would have to be introduced in the pipe systems where they connected the cargo tanks together.

The shipyard responded to this requirement and sent revised drawings (rev. A) in which spool pieces were introduced between the stripping lines and the common drainline.

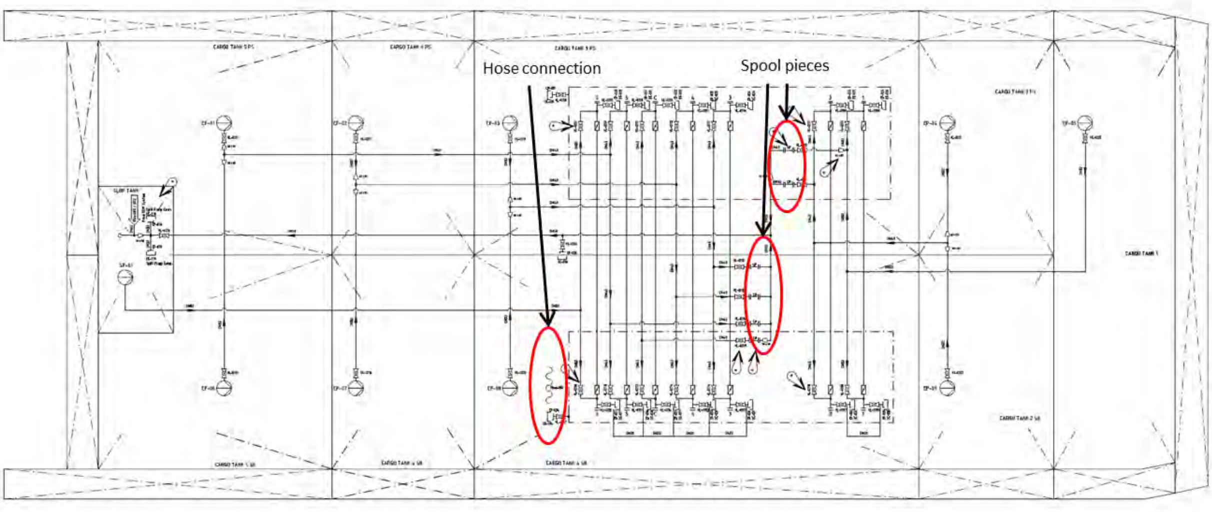


Figure 16: Revision A 'Drain and Stripping Cargo System' shows the introduction of a spool piece and hose connection from the drip tray (red circles). Illustration: Brødrene Klovning Shipping/AIBN

In a later version (rev. B) of the drain and stripping system (P&ID Drain and Stripping Cargo System), changes had been made based on the wishes of the shipping company. Among other things, these changes entailed a permanent pipe connection with separate valves (VL 0257/0258) from the drip trays on the port and starboard sides to a common drainline to the slop tank instead of a hose connection. The extra isolation valve, VL-0253, was also introduced here; see Figure 17.

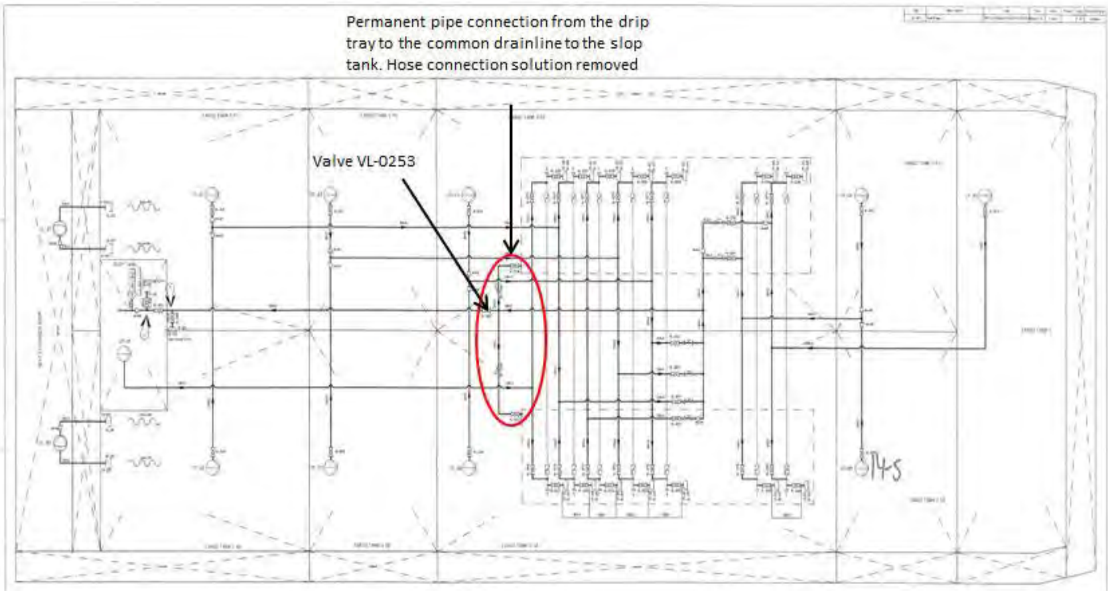


Figure 17: P&ID Drain and Stripping Cargo System revision C shows, among other things, the permanent pipe connection from the drip tray to the common drainline that was introduced in revision B (see the red circle). Illustration: Brødrene Klovning Shipping/AIBN

According to information from DNV, this was accepted by the local inspector from Veritas at the yard, and according to DNV, this is in accordance with the requirement for separation laid down in the IBC Code. This is based on the drip trays being treated as open systems and, as a result, segregation is not being required.

However, DNV points out that it is entirely possible to segregate the drip tray using operational measures, such as removing the ball valves vis-à-vis the drainline and fitting blind flanges.

1.11.2 Risk assessments in the construction, design and building phases

In 2008, the AIBN conducted an investigation into an occupational accident on board a Norwegian cargo vessel. In this investigation, the AIBN pointed out, among other things, that the regulations relating to cargo-handling appliances do not require risk assessments of crane operations to be conducted already in the design phase.

In 2009, the AIBN investigated an occupational accident on board another cargo vessel, in which it pointed out, among other things, that the chosen design appeared to solve the need for ventilation and drying of cargo, but without sufficient emphasis being given to the fact that the system was to be operated in a manner that ensures the safety of the crew.

In both these cases, the AIBN pointed to a failure to carry out risk assessments already in the design phase. In the AIBN's view, this resulted in effective safety barriers not being incorporated, and, hence, to personal safety being too dependent on organisational factors relating to the operation of the ship. In both the above-mentioned investigations, safety recommendations were submitted to the Norwegian Maritime Directorate.

The AIBN is aware that the Norwegian Maritime Directorate has started work on developing regulations in which these issues will be addressed.

In connection with the investigation into the accident on board the Clipper Sund, the AIBN has been in dialogue with DNV on risk assessments. In some general comments, the classification society points out that the risk assessments should also include the risks that vessels are exposed to during operations and the special factors that result from a special design or construction. In DNV's view, such analyses should be systematised and implemented at different stages of the construction/design/operating phase, and steps must be taken to ensure that risks and the need for actions identified in early phases (e.g. construction/design) are transferred over to the operating phase. These analyses must be carried out by specialists in the ship type and design in question.

DNV emphasises that, if risk analyses are to be used more efficiently as a tool in safety work, requirements must be specified for the method, goal, content, scope, documentation and specification of when and under what circumstances new assessments must be carried out.

DNV believes that, if more extensive guidelines were issued by the authorities, it would have more wide-ranging authority to demand more structured and better documented risk analyses than the documentation that normally is available for from the companies and on board.

1.11.3 Audit of the shipping company's safety management

The Norwegian authorities have delegated official control of vessels registered in NIS, including verification of the shipping companies' and the vessels' safety management systems, to seven approved classification societies. Through this supervisory role, DNV carries out verification of the shipping company's safety management system, both in the onshore organisation and on board the ships. System-oriented inspections are expected to be able to conclude as to whether instructions and work procedures have been adopted for the requisite areas. The classification society shall check that the company and shipboard management operate in accordance with the approved safety management system.

The vessel's SMC and the shipping company's DOC were valid at the time of the accident.

1.11.3.1 *The Norwegian Maritime Directorate*

The Norwegian Maritime Directorate carries out unannounced inspections of delegated ships, and it carried out an unannounced inspection on board the Clipper Sund in Sarpsborg on 10 March 2011. No instructions or orders were issued in connection with the inspection. The Directorate also carried out an unannounced inspection in connection with the accident in Antwerp.

1.11.3.2 *The classification society*

Det Norske Veritas issued an interim safety management certificate (SMC) for the Clipper Sund on 16 February 2008. It was valid until 16 August 2008. This was based on a provisional review on 16 February without any findings or observations being made.

The classification society carried out a verification of the system on 11 August 2008 and a short-term certificate was issued that was valid until 11 January 2009. The verification on 11 August resulted in five observations.

The current SMC was issued on 1 October 2008 with a period of validity until 11 August 2013 on condition that the shipping company's DOC is maintained and that the vessel passes intermediate audits. During the period after the SMC was issued, the classification society carried out an intermediate audit of the safety management system on board on 4 August 2011. The report from this audit showed two findings categorised as 'non-conformities' (NC).

The classification society points out that an ISM audit is based on spot checks. During the audit, all the general requirements in the Code must be covered by assessing a selection of processes and procedures and their implementation. A shipboard ISM audit normally takes one to two man-days (this is in accordance with IACS Recommendation 41). During such a brief visit, it is not possible to address all possible areas and rules in detail. In order for an auditor to discover that something is missing in the safety management system, the auditor must have planned to address precisely that topic.

The classification society also points out that the ISM auditor's core competence is the management system. In addition to looking at typical management system processes such as internal auditing, reporting of non-conformities (including follow-up of non-conformities identified, for example, in a port state control), a management review on board and onshore, the auditor will select topics to address during the audit.

The ISM Code gives companies great freedom to choose how to design their safety management systems. The same system applies in the Norwegian Ship Safety and Security Act.

The classification society carried out an ILO 178 inspection on 2 December 2011. The purpose of this inspection was to verify whether working and living conditions on board were in accordance with the Norwegian rules. The inspection was carried out using a checklist prepared by the Norwegian Maritime Directorate. One of the items on the checklist includes the working environment, safety and health relating to the WEHS Regulations. Risk assessments are one of the inspection areas under this item. It must be checked whether documentation exists that regular risk assessments are carried out, and the report from this inspection concluded that things were in order in this area.

The audits have uncovered some non-conformities, but none of material importance in relation to the accident on board the Clipper Sund and the factors the AIBN is examining in its investigation of whether risk assessments of loading /discharging operations were lacking or whether plans for the stripping of tanks were inadequate.

1.12 Implemented actions

1.12.1 The shipping company

After the accident on board the Clipper Sund on 6 September 2011, the shipping company sent a letter to all its vessels and introduced provisional actions. The actions included stopping the use of slop tanks as cargo tanks, that incompatible cargoes were not to be loaded / discharged at the same time, and that incompatible cargoes were not to be loaded into tanks without a compatible cargo having been in the tank in the intervening period. A prohibition was also introduced against loading two or more incompatible cargoes that required heating. Restrictions were also introduced as regards stripping between tank pairs.

The shipping company initiated an internal inquiry and issued a report on 29 September 2011. The report concludes that the explosion was caused by two incompatible cargoes coming into contact with each other. Aniline from the drip tray under the port manifold was drained into the vessel’s stripping and drainlines containing nitric acid.

Moreover, the internal inquiry showed that using the drainline instead of stripping the tanks via the cargo crossover line made incorrect operation possible in a manner that could result in contact between different chemicals during the stripping of the tanks.

The shipping company saw it as unfortunate that the drip trays under the manifold were connected to the drainline to the slop tank by a permanent pipe connection and that this made it possible to drain the contents of the trays to the slop tank.

The shipping company concludes that the direct cause of the accident was the unfortunate design of the pipe arrangement relating to draining / stripping, unfortunate operation during stripping of the nitric acid in combination with draining of aniline from the drip tray to the drainline.

The following actions were implemented in order to prevent similar accidents on all of the shipping company’s four sister vessels:

The common drainline that could be connected to the stripping lines has been removed. The permanent pipe connection from the drip trays to the drainline has also been removed.

The vessel's checklist for holding a 'pre-cargo operations' conference (CHM Form 2.5) has been revised, and matters such as stowage plans, compatibility and segregation are now stated more clearly than in the checklist that was in use when the accident happened. In the same checklist, a rule has also been included that those involved in loading and discharging operations must carry out simple risk assessments and not carry out operations if there is uncertainty. According to the shipping company, these revisions have seemed natural in relation to the company's own inquiry and the experience gained from the accident. The changes are not the result of a risk assessment of the whole loading and discharging process.

The shipping company has also drawn up a completely new procedure that deals with the loading of incompatible cargoes.

1.12.2 The classification society

Det Norske Veritas has informed the AIBN that it is working on a proposal to amend the regulations that is intended to introduce a requirement that open systems such as drip trays must also be designed to enable segregation in line with closed tank and pipe systems.

2. ANALYSIS

2.1 Introduction

The purpose of the analysis is to clarify the details surrounding the chain of events, circumstances that led up to the explosion and the underlying causes of the accident. The analysis will also shed light on any other safety-critical factors identified in the investigation.

The analysis is based on an assessment of the chain of events undertaken in order to determine the factors that triggered the event. Furthermore, it is based on a fault tree analysis of the explosion itself and the events that led up to the explosion in order to identify the underlying causes. Of these causes, the factors that can result in a general gain in terms of maritime safety will be discussed

2.2 Evaluation of the chain of events – immediate causes

The AIBN's assessment of the chain of events is based on conversations with the crew, observations made on board the Clipper Sund shortly after the accident, information collected from and conversations with, among others, the classification society, the Norwegian Maritime Directorate, the shipping company and the receiving facility for the cargo, as well as a review of surveillance tapes of the area where the accident occurred.

2.2.1 The content of the drainline before the explosion

As described in the description of the chain of events, the tanks were stripped from tanks 1C and 3P to 3S following the discharging of nitric acid. This stripping was carried out via the drainline and it resulted in parts of the latter being filled with nitric acid; see Figure 18. Valves VL-0257, VL-0258 and VL-0253 were closed during the stripping of the nitric acid and in connection with the subsequent blowing of air through the lines.

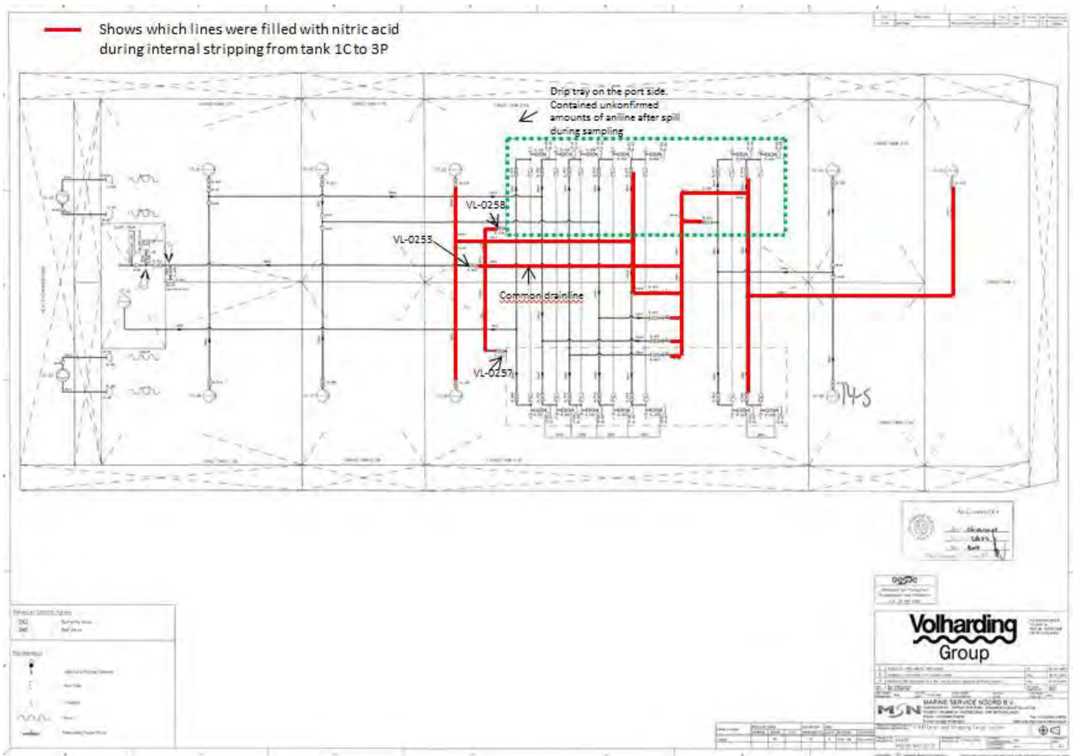


Figure 18: Illustration showing which lines were filled with nitric acid during internal stripping. Illustration: Brødrene Klovning Shipping/AIBN

After the stripping, the lines were blown clean, but as a result of the drainline being used for stripping and the way the system is designed with a difference in height on the drainline, it is very likely that nitric acid remained in the T-joint as shown in Figures 19 and 20.

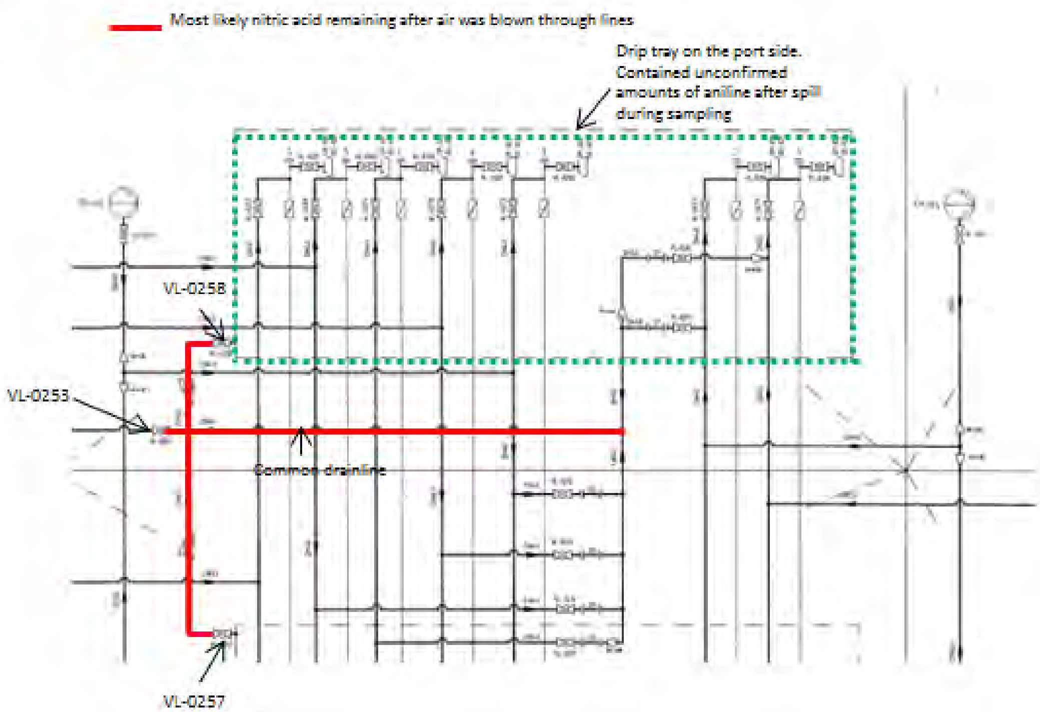


Figure 19: Illustration showing where the remaining nitric acid was most likely localised after air had been blown through the lines, and where aniline in the drip tray was localised. Illustration: Brødrene Klovning Shipping/AIBN

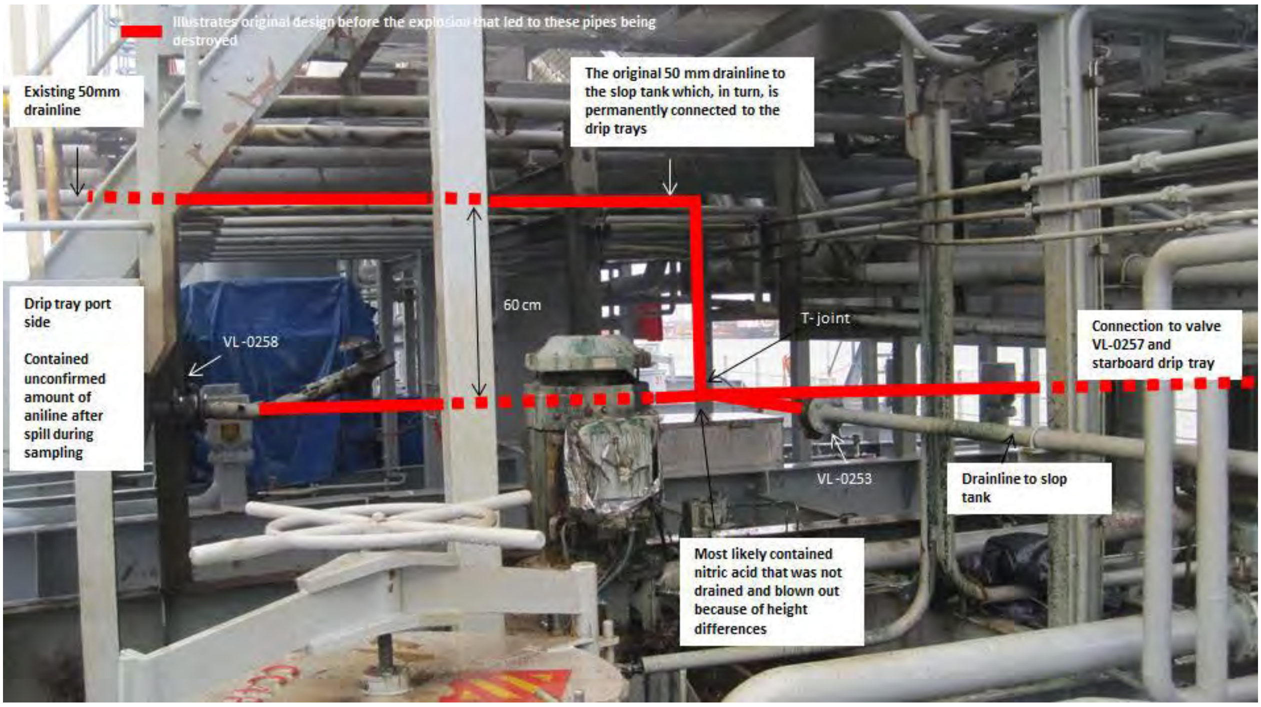


Figure 20: The figure illustrates the location of the drainline to the slop tank and where the drainline was connected to the drip tray. The figure also illustrates differences in height and the position of the pipe area, most likely containing residues of nitric acid after air had been blown through the lines. Photo: AIBN

2.2.2 The content of the port drip tray before the explosion

As mentioned in Chapter 1.2, aniline had been spilt on the port side, both in the drip tray and on the deck, during sampling on the same day. The crew removed the aniline spillage on deck, but chose not to remove the aniline from the drip tray. Meteorological data for the afternoon of 5 September 2011 in Antwerp show that there were some light rain showers. This could also have resulted in there being some water in the drip tray in addition to aniline. Following discharging, the vessel had an aft trim, which indicates that the residue in the drip tray was located in the aft part, where the pipe connection to the drainline was.

2.2.3 Assessment of the explosion and its immediate causes

Observations made at the site of the explosion shortly afterwards show that the whole drainline between the valves indicated in Figure 20 has been destroyed or is missing.

Figure 21: The figure shows the remains of the pipe section from the drip tray on the port side to the drainline after the explosion, cf. Figure 20. Photo: AIBN

We know that the drainline contained nitric acid residues and that the drip tray contained aniline residues, possibly mixed with some rainwater.

Video tapes from the terminal show a person moving around in the area around the port manifold, and that there was some smoke in the area immediately prior to the explosion.

The chemical reaction between nitric acid and aniline leads to the development of gases and heat, and in certain conditions it can lead to an explosion.

Based on the above-mentioned facts, the AIBN considers the chain of events immediately prior to the explosion to have been as follows:

The able seaman on duty on deck has caused valve VL-0258 to open, so that aniline from the drip tray has come into contact with the nitric acid in the drainline. The incompatible cargoes have reacted immediately and caused heat and gas generation. The gas has escaped through the opening to the drip tray and been visible as smoke. In all probability, the able seaman understood that something was wrong and reacted by closing the valve again as soon as possible in order to try to limit the extent of the damage. On the contrary, this has made it impossible for the gases to escape and led to a rapid increase in pressure in the pipe as a result of heat and gas generation on the inside of the now closed valve. The explosion was caused by the rapid increase in pressure in the pipe.

2.3 Factors with a bearing on the chain of events

The assessment of the chain of events has ascertained that the explosion was probably caused by a reaction between aniline and nitric acid in the drainline. It has also established that this reaction was directly caused by aniline in the drip tray coming into contact with nitric acid located in the drainline when the valve between the two was opened and then closed again.

A fault tree analysis has been carried out for the purpose of uncovering the underlying factors that contributed to the opening of a single valve causing such an accident, including why there was aniline in the drip tray and nitric acid in the drainline at the time in question, and why the valve was opened.

Appendix F shows a sketch of the fault tree analysis.

2.3.1 Handling of the aniline spillage

The aniline that splashed out from the manifold during sampling is toxic and it contaminated parts of the deck and the drip tray in addition to splashing onto the receiving facility's cargo inspector. The crew on board nonetheless assessed this as being a controlled and limited spillage and chose not to initiate the measures described in the vessel's SMPEP manual. The aniline spillage on deck was removed while the spillage in the drip tray was not.

Both the terminal's and the vessel's representatives signed the ship/shore checklist every four hours, acknowledging that the drip tray was in position and empty. It was also signed every four hours after the spill had occurred and there was aniline in the drip tray.

Considering that the spill splashed onto the cargo inspector, the AIBN is of the opinion that the crew's reaction to and classification of the event were inadequate. Furthermore, in the AIBN's view, the drip tray should have been cleaned immediately given aniline's toxic properties. In light of the above-mentioned ship/shore checklist, it is also clear that the drip tray should have been cleaned after the spillage and that both the ship and the terminal should have been reminded of this through the checklist that they signed regularly.

The AIBN has chosen not to further analyse circumstances that can have led to the crew choosing to handle the aniline spillage in the way they did.

2.3.2 Nitric acid in the drainline and breach of the segregation of the aniline cargo.

Chapter 1.2 describes how the vessel's drainline was used during the stripping operation in connection with the discharging of nitric acid. It led nitric acid to valve VL-0258. Due to the design of the pipe system, it was not possible to blow air through this part of the drainline without opening it to the drip tray or cargo tank 5C.

In the AIBN's opinion, this use of the drainline was a clear breach of the segregation of the aniline cargo in cargo tank 5C. Moreover, this segregation was never actually established since the spool pieces between the stripping lines and the drainline had not been removed. This prevented segregation of all the cargo tanks.

According to the shipping company, it has not had sufficient focus on safety in connection with what it considers 'secondary operations', including stripping. Nor had it carried incompatible cargoes before. Furthermore, it had established a practice on board of using the drainline for stripping when carrying single-grade cargoes because this simplified the operation and resulted in lower backpressure and hence a better effect.

A risk assessment was carried out for the voyage in question before loading in Aveiro. It focused on the loading operation, the cargoes' toxic and corrosive properties and the use of correct PPE. The risk assessment did not identify the risks associated with the fact that the cargoes were incompatible and therefore had to be segregated in all systems. A risk assessment was not carried out of the discharging operation.

In the AIBN's opinion, the combination of a lack of experience of incompatible cargoes and the established practice of using the drainline for stripping played a decisive role in the drainline also being used for stripping on the day in question despite the fact that the cargoes were incompatible. This is seen in conjunction with the shipping company's insufficient focus on incompatible cargoes, stripping of tanks, inadequate shipboard risk assessments of the discharging operation, and the fact that the shipping company had not carried out company-specific and vessel-specific risk assessments of the loading and discharging operation.

The AIBN sees factors relating to inadequate risk assessments as important and as an area that can result in a general gain in terms of maritime safety. Risk assessments will therefore be discussed in further detail in Chapter 2.4.

2.3.3 Opening of valve VL-0258

The surveillance tapes show a person moving around in the manifold area immediately prior to the explosion. The tapes indicate that the person is first in the area around valve VL-0258, then moves away from there, only to return quickly once smoke starts to develop in the area. He then moves aft just before the explosion.

It seems probable that the able seaman caused the opening of the valve and thereby the contact between the two incompatible cargoes. It cannot be ruled out that the valve suddenly started leaking, but it seems highly unlikely that such a sudden leak would happen by chance just as the able seaman was passing the area in question. The AIBN has therefore chosen to assume that the able seaman caused the opening of the valve.

The ensuing scenario is described in Chapter 2.2, whereby the reaction between the incompatible cargoes leads to the development of smoke, which the able seaman probably reacts to by closing the valve to try to limit the extent of the damage. This leads to the reaction continuing in a closed system where the increase in pressure quickly causes the fatal explosion.

The AIBN cannot say with certainty why the able seaman opened the valve to the drip tray. There is no reason to believe that the able seaman was aware of the consequences this would have. In the AIBN's view, there are three possible reasons why the able seaman opened the valve:

1. The drip tray contained aniline spillage. The drainline would lead this spillage to cargo tank 5C, which had contained aniline, had been discharged and was soon to be cleaned. It is possible that the able seaman wanted to lead the aniline spillage back to 5C, and that he was not aware of or had forgotten that there was nitric acid in the drainline just behind the valve he opened.

2. As mentioned, it was common to use the drainline during stripping when carrying single-grade cargoes. The AIBN has been told that, in such cases, it was not uncommon to release the cargo residues from the drainline into the drip tray as part of the preparation process before cleaning the system for the next cargo. The vessel had previously only carried compatible cargoes, and the able seaman had no experience of incompatible cargoes from the other vessel he had sailed on for the shipping

company. In other words, the able seaman may have wanted to release the nitric acid from the drainline into the drip tray, without being aware that it would react with the aniline spillage that was already there.

3. The able seaman may have been unlucky and caused the opening of the valve without intending to, for example by knocking against it or catching on it.

The AIBN does not have the information required to further assess which of the above-mentioned causes actually led to the opening of the valve.

2.4 Risk assessments and planning of critical operations

As mentioned, the vessel was built as a combined chemical and oil product tanker. The segregation of incompatible cargoes was only facilitated to a limited extent by the design solutions on board the Clipper Sund and it was therefore necessary to use operational solutions. In the AIBN's view, this increases the need for carrying out the vessel-specific risk assessments that should form the basis for the introduction of risk reduction measures, such as necessary plans, procedures and instructions for carrying out safe operations.

The AIBN believes that the circumstances described in Chapter 2.3.2 can be linked to a lack of awareness on the part of both the shipping company and the vessel of incompatible cargoes and inadequate risk assessments of discharging operations.

2.4.1.1 *Risk assessments on board*

The vessel had not carried incompatible cargoes since it was put into operation in 2008. This can partly explain the crew's lack of awareness of the risks associated with incompatible cargoes throughout the discharging operation.

As mentioned, the captain carried out a shipboard risk assessment before the loading of the vessel in Aveiro. The captain was aware that the cargoes were incompatible, but the assessment nonetheless failed to address the risks associated with the cargoes' incompatibility. Nor was incompatibility pre-defined as a risk on the shipping company's risk assessment form. This could have contributed to the captain focusing on the toxic and corrosive properties of the cargoes.

The risk assessment was not carried out in cooperation with other relevant crew on board. This meant that possible safety-critical input from the crew was not included. Nor did the risk assessment lead to the crew gaining insight into possible risks and what measures would have to be implemented to ensure safe operations.

The AIBN believes that this shortcoming in how the risk assessment was carried out could have been discovered if the shipping company had established a method for systematic, regular risk assessments that, among other things, stated who was to participate in such reviews.

Shipboard risk assessments should be carried out by personnel who, among other things, have knowledge and experience of such work and information about the subject of the assessment and relevant risks. A more comprehensive, structured approach to risk assessments could have resulted in greater focus on the incompatibility of the cargoes. An inadequate overall assessment of the loading and discharging operations on the part of the shipping company could also have contributed to the shipboard assessment not being comprehensive enough.

The AIBN has not evaluated the risk assessments that were carried out on board the Clipper Sund in detail, but it notes that the quality of the assessments that were carried out varies. As regards the carrying out of risk assessments on board, the AIBN is of the opinion that access to guidelines/guides to the general regulatory requirements would be useful for the crew in relation to carrying out more comprehensive and structured risk assessments.

According to the shipping company's Quality & Safety Management Manual, risk assessments shall be documented and evaluated. The risk assessments that are carried out on board the individual vessel are sent to the shipping company's office, where the assessments are collected in a 'Risk Assessment Record' and made available to all the vessels. In the AIBN's opinion, the shipping company has a potential for improvement in relation to the evaluation of completed risk assessments with regard to assuring the quality and content of the assessments. This is especially important because the assessments also form the basis for the other vessels' risk assessments.

2.4.1.2 *The shipping company's risk assessments*

As described in the shipping company's Quality & Safety Management Manual, risk assessments shall be carried out for shipboard operations. The manual also stipulates a method for this that is to be used both by the shipping company and on board. The method is largely in accordance with the sub-processes 'risk analysis' and 'risk evaluation', which are defined in NS 5814 and are described in Chapter 1.9. The shipping company had established procedures and guidelines for determining the probability and consequence of identified risks with the goal of ascertaining the level of risk. The shipping company had also defined acceptance criteria for risk.

In 2009, the shipping company carried out risk assessments of a few individual operations. In the AIBN's opinion, additional operations and hazards could and should have been identified for which risk assessments should have been carried out. This applies in particular to the fact that the shipping company had not carried out a risk assessment of the vessel's loading and discharging operations, which must clearly be regarded as a key operation.

The operational procedures for loading and discharging operations adopted by the shipping company were based on recognised industry standards such as ISGOTT and Tanker Safety Guide, Chemicals. The procedures were not based on risk assessments of the loading and discharging operations.

In the AIBN's view, the factors addressed by ISGOTT and Tanker Safety Guide, Chemicals are relevant to the safe operation of vessels, but it is nonetheless necessary to carry out risk assessments and implement necessary company and vessel-specific measures.

The shipping company's failure to carry out a risk assessment of a key operation such as loading and discharging indicates the absence of a systematic, planned approach to risk assessments. In the AIBN's view, such an approach is necessary, among other things to define which operations and risks should be assessed.

The shipping company's safety management system was certified by the supervisory authority pursuant to the requirements of the ISM Code. The AIBN does not rule out that this could have contributed to increasing the shipping company's faith in the management system meeting the expected quality requirements, and it could therefore have raised the threshold for considering whether it was necessary to make changes to the safety management system.

2.4.1.3 *The contribution of the applicable regulations to ensuring that the shipping company establishes satisfactory risk management.*

The WEHS Regulations require that risks on board be identified, without stipulating requirements for how such risk identification shall be carried out. Neither the ISM Code nor the WEHS Regulations stipulate requirements for the shipping company's planning of the risk assessment, cf. Chapter 1.9. Nor do they contain requirements for the establishment of framework conditions and acceptance criteria.

The WEHS Regulations also state that, when a hazard has been identified, the risk that it poses shall be assessed. Nor do they require the shipping company to choose a method for doing so.

Pursuant to NS 5814, the establishment of risk acceptance criteria is an important precondition for risk assessments. The WEHS Regulations do not require the shipping company to establish acceptance criteria. It is true that the WEHS Regulations state that *'the safety and physical and mental health of the workers is ensured in accordance with technological and social development of society'*, but, in the AIBN's view, this is too general to provide sufficient guidance for shipping companies.

The AIBN believes that the WEHS Regulations and the ISM Code's functional requirements, which only contain elements of what Standard Norway believes a risk assessment should contain, have hardly contributed to steering the shipping company towards a sufficiently structured approach to risk assessments, especially with regard to the critical planning phase.

Despite this, the Norwegian Maritime Directorate clearly expects the shipping company to establish acceptance criteria, carry out risk assessments of the tasks involved in their ordinary shipboard operations and identify circumstances that can have negative consequences for the safety and physical and mental health of the crew.

The AIBN is aware that the Norwegian Maritime Directorate is working on various guides relating to risk assessments in the shipping industry, both nationally (in relation to the WEHS Regulations) and internationally (ILO).

The AIBN believes that this investigation has shown that guidelines/guides to the regulations could have helped to steer the shipping company in the direction of more structured, comprehensive risk management that, in turn, could have contributed to greater safety for the crew.

The AIBN does not know the quality of risk management work in other shipping companies, but, given that the same requirements apply to small and simple shipping organisations as to large, professional shipping organisations, the AIBN cannot rule out that the quality of this work can vary considerably.

A safety recommendation is submitted to the Norwegian Maritime Directorate to the effect that it should map the status of the shipping companies' risk management work with a view to further targeting the work on guidelines/guides to help the shipping companies to establish satisfactory risk management.

2.4.1.4 *Inspections' ability to verify the quality of the shipping company's risk assessments*

The shipping company's and vessel's risk assessments have been checked in both unannounced inspections and audits, without these inspections/audits pointing out lacking or inadequate risk assessments.

The classification society points out that an ISM audit is carried out in the course of one to two working days and that it is based on spot checks. The classification society also points out that it is not possible, during such a brief visit, to address all possible areas and rules in detail. DNV also points out that, if risk assessments are to be used more efficiently as a tool in safety work, requirements must be specified for the method, goal, content, scope, documentation and specification of when and under what circumstances new assessments must be carried out. DNV believes that, if more extensive guidelines were published by the authorities, it would have the authority to demand more structured and better documented risk analyses than documentation is normally available for at the companies and on board.

In the AIBN's view, the development of clear guidelines / guides to the regulations would, in addition to steering the shipping companies towards structured and comprehensive risk management, also form a better basis for the supervisory authority's audits. This would in turn put the supervisory authority in a better position to uncover deficiencies in the shipping companies' and the vessels' risk management work.

2.4.2 Planning of key operations

The ISM Code requires the preparation of plans, instructions and/or checklists for the safe performance of key operations on board. How key operations are defined depends on many different factors and varies from one vessel to another. As regards the Clipper Sund, cargo handling will be an operation for which necessary plans are required. The investigation has uncovered shortcomings relating to the segregation of cargoes in the vessel's draining system in connection with stripping operations. In the AIBN's view, the preparation of plans and procedures will also be crucial in relation to the safe performance of this part of the discharging operation.

The shipping company has drawn up a number of plans for different operations in its safety management system. On the basis of the accident on board, this investigation focuses on the plans relating to cargo handling and stripping.

2.4.2.1 *Plan for cargo handling and stripping*

The chief officer's manifold plan and stowage plan show how the main loading and discharge lines are lined up and how the cargoes are segregated in the pipe system and the tanks. As regards safety aspects relating to loading and discharging operations, the shipping company and the crew on board believe that they have had focus on and control of the cargo tanks and the loading and discharging lines.

On the other hand, the manifold plan does not describe how the stripping and drainline shall be lined up and how necessary segregation shall be ensured. The shipping company has had focus on and control of the cargo tanks and the loading and discharging lines, but it has had considerably less focus on operations regarded as secondary operations. By secondary operations is meant stripping, draining and cleaning. This reduced focus can be explained by the fact that the shipping company's vessels largely carry single-grade cargoes and that compatibility issues are therefore not emphasised.

The vessel's P/A manual is also a key part of the cargo handling and stripping plan. The manual encourages stripping from tank to tank, but it does not describe the lining up of the stripping lines and how they are connected to the drainline. Nor are drawings of this system included as appendices to the manual, unlike drawings of the main loading and discharging lines.

Holding 'pre-cargo operations' conferences is another key part of the cargo handling plan. Operations relating to the stripping of the vessel's tanks are not a topic at these meetings.

The vessel's discharging, stripping and draining arrangement demanded that the crew had to find operational solutions to carrying out the stripping and draining of the tanks, without procedures having been established for this.

In the AIBN's view, the shipping company's overall cargo handling plan provides a relatively detailed description of how the actual loading and discharging operations are to be carried out in a safe manner, but the plan contains little or no information about safety-critical aspects relating to the stripping of the tanks with regard to the segregation of cargo residues. This could have been addressed through risk assessments that could have formed the basis for the preparation of necessary plans, procedures and instructions. A safety recommendation is submitted to the shipping company concerning this matter.

2.5 No requirement for segregation of the drip trays.

The drip trays were permanently connected to the drainline, only separated by a ball valve. In practice, this means that any substance whatsoever (including water) in a drip tray will only be separated by that one valve from any other substance in the vessel's drainline. In the case of the Clipper Sund, the drip trays were not just connected to the drainline, but, through the drainline, also to cargo tank 5C.

Drip trays on chemical tankers are described in the IBC Code, but it states that drip drays only need to be installed if the vessel is to carry acidic cargoes. As far as the AIBN knows, the status of the drip trays in relation to the rest of the cargo handling systems is not described in any applicable regulations or industrial standards.

The vessel's classification society, Det Norske Veritas, does not normally assess what it regards as 'open systems', including drip trays, when it assesses the segregation of the cargo systems. In the AIBN's view, this is a weakness.

DNV points out that the design of the Clipper Sund enables cargo tank 5C to be segregated from the drip trays using operational methods. By removing the valves between the drip trays and the drainline and replacing them with blind flanges, the cargo tank – and the drainline – would have been isolated from the drip trays.

In the AIBN's view, cargo tank 5C was not segregated in accordance with the intentions of the Code.

DNV has expressed agreement with this view, but it nonetheless maintains that the current regulations do not provide for such a stringent interpretation. It has informed the AIBN, however, that it is working on an amendment of the regulations whereby open systems will also be considered with regard to segregation.

Two safety recommendations are submitted in this connection; a safety recommendation to the classification society concerning an amendment of the regulations, and a safety recommendation to the Norwegian Maritime Directorate that it should work towards an interpretation of the IBC Code with a view to ensuring that open systems shall also be designed for segregation on a par with closed tank and pipe systems.

2.6 Other findings

2.6.1 Risk assessments in the design phase

Pursuant to the current regulations (the ISM Code and the WEHS Regulations), the requirement for risk assessments does not apply until the phase during which a ship is to be operated and only after hazards have been identified.

In DNV's comments on risk assessments, which are described in Chapter 1.11.2, it expresses the opinion that risk analyses should be systematised and carried out at different stages of the construction/design/operating phase, and that risks and the need for measures identified in earlier phases (e.g. construction/design) should be carried over into the operating phase. DNV believes that, if risk assessments are to be used more efficiently as a tool in safety work, requirements must be specified for the method, goal, content, scope, documentation and specification of when and under what circumstances new assessments must be carried out.

The AIBN has previously pointed out that it is a weakness that such assessments are not carried out at an earlier stage. In the AIBN's view, this results in effective safety barriers not being built-in and, hence, to personal safety being too dependent on organisational factors relating to the operation of the ship. In that respect, the AIBN agrees with DNV that such assessments should be carried out already during the engineering, design and building phase and that they must ensure that as few risks as possible follow the vessel into the operating phase. Procedures should also be established to ensure that the remaining risk is transferred over into and handled operationally during the operating phase.

2.6.2 Training and transfer of experience

The seaman who died had a tankerman lowest grade certificate. In such cases, the shipping company assumes that the person in question has the expertise prescribed in STCW.

According to the management system, the shipping company has procedures for ensuring that the crew acquires the expertise they require in relation to the roles they have on board.

The AIBN is not familiar with how well acquainted the seaman who died was with the details of the vessel's loading and stripping system, nor does it have any reasons for claiming that the seaman had too little know-how in relation to his duties. There is no information to indicate that the deceased had too little know-how in relation to his duties. This is based, among other things, on the fact that the seaman in question had several years' experience of work on board the shipping company's vessels and had completed the shipping company's training.

Training relating to loading and discharging operations takes place by new crew members going on duty together with experienced crew members before going on duty on their own.

In the AIBN's view, the training that is given is inadequately described and documented. This means that the training of crew on board is very dependent on individuals, and that it is difficult to ensure that the training is sufficient and uniform for each seaman.

In the AIBN's view, preparing and reviewing risk assessments is also an important element of training and the transfer of experience. The risk assessments are normally carried out by the captain/chief officer or the captain/chief engineer. It is not common practice to involve all affected crew members in these risk assessments. The AIBN believes that this is a weakness that acts as an obstacle to the transfer of experience.

2.6.3 The use of PPE during sampling

The cargo inspector who was to take samples of the aniline cargo together with a member of the ship's crew was only wearing a gas mask, a helmet and a boiler suit as personal protective equipment. He was thus not wearing personal protective equipment required by the material safety data sheet for the aniline cargo and what is described in the pre-discharging checklist. This was not pointed out by the crew, and the sampling was initiated.

During sampling by the vessel's manifold, aniline splashed out over the deck and onto the cargo inspector. The captain on board later pointed out in his non-conformity report that the outcome of the incident could have been completely different if it had been the acidic cargo that had splashed over the inspector.

The AIBN has not investigated why the cargo inspector's lack of PPE was not raised by the crew on board. It could be the case, however, that the threshold for raising such issues with someone who represents the onshore facility, and people who analyse and approve samples, is too high.

3. CONCLUSIONS

3.1 The chain of events – immediate causes

The explosion occurred as a result of a reaction between two incompatible cargoes, i.e. aniline and nitric acid, in the drainline. This reaction was directly caused by aniline in the drip tray coming into contact with nitric acid in the drainline when the valve between the two was opened and then closed again.

3.2 Factors that contributed to the explosion

3.2.1 Handling of the aniline spillage in the port drip tray

After an accident involving an aniline spillage on deck occurred, the aniline in the port drip tray was not removed. Both the terminal and the vessel should have made sure that the toxic cargo was completely removed before other operations were initiated.

3.2.2 Lack of experience of incompatible cargoes

The combination of lack of experience of incompatible cargoes and the established practice of using the drainline for stripping was decisive in relation to why the drainline was also used for stripping on the day in question despite the fact that the cargoes were incompatible. Good procedures, risk assessments of and plans for critical operations could possibly have prevented the situation.

3.2.3 The practice of using the drainline for stripping – segregation of the cargo

The vessel was in the habit of having the spool pieces between the stripping system and the drainline permanently installed. Nor were they removed on the voyage when the accident happened, which meant that the incompatible loads were never properly segregated.

Because the drainline was used for stripping the nitric acid cargo, there was nitric acid left in part of the drainline, namely at the crossover between the drip trays. In addition to leading the nitric acid into the ball valves to the drip trays, this meant that the nitric acid was also led much closer to cargo tank 5C, which also contained aniline. There were only two ball valves between them.

3.2.4 Opening of the valve between the port drip tray and the drainline

As a result of the above-mentioned circumstances, a single ball valve was the only barrier between the aniline in the drip tray and the nitric acid in the drainline before the accident. The accident occurred when the able seaman on deck opened and then quickly closed this valve.

3.3 Risk assessments and plans

3.3.1 Risk assessments on board

The shipboard risk assessments of the loading and discharging operations were carried out by the captain and the head of department. No other personnel involved in the operations took part in the assessments. This reduces the chance for learning, transfer of experience and the possibility of registering important safety-critical input.

3.3.2 The shipping company's risk assessments

The vessel's discharge and draining arrangement demanded that the crew had to find operational solutions to how the stripping and draining of the tanks could be carried out, without procedures having been established for this. No vessel-specific risk assessments were carried out that should have formed the basis for the introduction of risk reduction measures, including the drawing up of necessary plans, procedures and instructions. Insufficient risk assessment on the part of the shipping company of a key operation such as loading and discharging indicates the absence of a systematic, regular approach to risk assessments.

3.3.3 Applicable regulations and the supervisory authority's contribution to ensuring that the shipping company establishes satisfactory risk management.

The current regulations give the shipping company a great degree of freedom to choose how to conduct its risk management. The AIBN believes that the functional requirements in the WEHS Regulations and the ISM Code contribute little to ensuring that the shipping company has a sufficiently structured approach to risk assessment and risk management.

The preparation of guidelines/guides to the current regulations that can help to achieve a structured and comprehensive risk management in the shipping company and on board could contribute to:

- improving the shipping company's ability to carry out risk assessments, also relating to key operations, so that risks are identified and assessed and necessary risk reduction measures are implemented.
- improving the crews' possibilities of identifying hazards, carrying out risk assessments and incorporating barriers that are both vessel-specific and relevant to the vessel's operations.
- putting the supervisory authority in a better position to uncover deficiencies in the shipping company's and the vessel's risk management work.

The AIBN does not know the quality of risk management work in other shipping companies, but, given that the same requirements for this work apply to small and simple shipping organisations as to large, professional shipping organisations, the AIBN cannot rule out that the quality of this work can vary considerably.

A safety recommendation is submitted to the Norwegian Maritime Directorate to the effect that it should map the status of the shipping companies' risk management work with a view to further targeting the work on guidelines/guides to help the shipping companies to establish satisfactory risk management.

3.3.4 Planning of key operations

The shipping company's overall cargo handling plan contains a relatively detailed description of how the loading and discharging operations are to be carried out in a safe manner, but the plan contains little or no information about safety-critical aspects of the stripping of tanks with regard to the segregation of cargo residues. This could have been addressed through risk assessments of the whole operation relating to loading and discharging. The underlying safety problem was that the shipping company had not carried out or documented risk assessments of loading and discharging operations. A safety recommendation is submitted to the shipping company in this connection.

3.4 No requirement for segregation

The drip trays are not described in much detail in the existing regulations and are not assessed by DNV with regard to segregation. In the case of the Clipper Sund, the drip trays were not just connected to the drainline, but, through the drainline, also to cargo tank 5C. In the AIBN's view, this cargo tank was not segregated in accordance with the intentions of the Code.

DNV maintains that the current regulations do not provide for such a stringent interpretation. At the same time, DNV is working on an amendment of the regulations, whereby drip trays will also be included by the requirement for segregation.

The AIBN recommends DNV to carry out the above-mentioned amendment of the regulations, and it recommends the Norwegian Maritime Directorate to work to ensure that the same rule is adopted as an interpretation of the IBC Code through the IMO.

4. SAFETY RECOMMENDATIONS

The investigation of this marine accident has identified three areas in which the AIBN deems it necessary to submit safety recommendations for the purpose of improving safety at sea.[26]

Safety recommendation MARINE no 2013/10T

The shipping company had not carried out or documented risk assessments of the loading and discharging operations on board. This resulted in inadequate plans and a reduced focus on the safety aspect of stripping operations.

The AIBN recommends the shipping company, through a risk assessment of the overall cargo handling on board and on the basis of the uncovered risk, to assess existing plans, procedures and checklists and carry out necessary measures. This work should be carried out in close cooperation with the crews on board.

Safety recommendation MARINE no 2013/11T

The current national and international regulations do not set specific requirements for how risks on board are to be uncovered and how risk assessments are to be carried out. Guidelines to official requirements could have contributed to ensuring that the shipping company carried out risk assessments of the loading and discharging operation. The Norwegian Maritime Directorate is working both nationally and internationally on the preparation of guidelines to risk assessments.

The AIBN recommends the Norwegian Maritime Directorate to map the status of the shipping companies' risk management work with a view to further targeting the work on guidelines/guides to help the shipping companies to establish satisfactory risk management.

[26] The investigation report is submitted to the Ministry of Trade and Industry, which will take necessary action to ensure that due consideration is given to the safety recommendations.

Safety recommendation MARINE no 2013/12T

Drip trays are not described in much detail in the existing regulations and are not assessed by DNV with regard to segregation. In the case of the Clipper Sund, the drip trays were connected to the vessel's drainline. This led to the opening and closing of a ball valve, which resulted in an explosion in the vessel's drainline. The drip trays were connected to cargo tank 5C through the connection to the drainline, which meant that the tank was not segregated in accordance with the intentions of the Code and that it represented a latent risk.

The AIBN submits a safety recommendation to DNV that it amend its regulations and practice so that open systems, such as drip trays, must be designed for segregation on a par with closed tank and pipe systems.

Safety recommendation MARINE no 2013/13T

Drip trays are not described in much detail in the existing regulations. In the case of the Clipper Sund, the drip trays were connected to the vessel's drainline. This led to the opening and closing of a ball valve, which resulted in an explosion in the vessel's drainline. The drip trays were connected to cargo tank 5C through the connection to the drainline, which meant that the tank was not segregated in accordance with the intentions of the Code and that it represented a latent risk.

The AIBN submits a safety recommendation to the Norwegian Maritime Directorate that it work towards the adoption of an interpretation of the IBC code through the IMO to the effect that open systems, such as drip trays, must be designed for segregation on a par with closed tank and pipe systems.

Accident Investigation Board Norway
Lillestrøm, 21 May 2013

APPENDICES

APPENDIX A: RELEVANT ABBREVIATIONS

DNV	:	Det Norske Veritas
DOC	:	Document of Compliance
HSE	:	Health, safety and the environment
IACS	:	International Association of Classification Societies
ILO	:	International Labour Organization
IMO	:	International Maritime Organization
ISM	:	International Safety Management
NHD	:	Ministry of Trade and Industry
NIS	:	Norwegian International Ship Register
MLC	:	Maritime Labour Convention
MSDS	:	Material Safety Data Sheet
PPE	:	Personal Protective Equipment
SAFIR	:	Safety Improvement Report
AIBN	:	Accident Investigation Board Norway
SMC	:	Safety Management Certificate
SMS	:	Document Management System
WEHS Regulations	:	Working environment, health and safety

APPENDIX B The shipping company's cargo handling routines

1. CARGO HANDLING ROUTINES

1.1 Loading / Discharging

The deck and cargo checklists and procedures in this manual (CHM), shall always be used and complied with when preparing the vessel for loading and discharging. The Chief Officer is responsible for ensuring that all items are complied with.

1.2 Cargo Checklists and Procedures

The intention of the deck and cargo checklists and procedures is to secure that all critical operations in cargo handling are performed safely and without accident or malfunctions. The checklists and procedures in this chapter concern operation where failures or malfunctions can have serious consequences for personnel, ship, cargo, or the environment.

When cargo orders are received it is chief officer's responsibility to make a stowage plan in accordance with applicable legislation and industry Codes of Practise, e.g. IGC, BHC, IBC, ISGOTT. The stowage plan shall then be sent to the cargo operator and shore based management. Shore based management monitors and files the plans according to company filing system.

Before any cargo and/or ballast operation commence the chief officer must plan the sequence of the loading/discharging by documenting the stress, draft and trim for several stages of the operation ref. CHM form no. 6.12. Including in the plan there must be any limitations on the number and location of slack tanks. This documentation must be signed and filed according to the ship's filing system.

After chief officer has had the meeting with the shore representative about the cargo operation at hand, the mates have to be informed in writing about details of the following (but not restricted to): min/max load/discharging/initial rates, cargo information (hazards and personal protection shall be specified on the cargo information documentation), manifold plan, stowage plan, ullages, management of tank pressure/atmosphere, static precautions, clearing of shore line, port restrictions.

During cargo/ballast operation the stress, draft and trim must be constantly monitored and compared to the plan. If any deviation to the plan is observed, or if the limits set be the chief officer are exceeded, the cargo/ballast operation must be stopped and senior officer, hereunder captain or chief officer, called to the cargo control location to investigate the reason for the deviation. After thoroughly considering the reason for the deviation, a new plan must be made before the operation can resume.

As a general precaution the stress should always be monitored in ‘Sea mode’ on the loading computer and the stress must never exceed 100%.

Before leaving port a ‘Departure condition report’ of the vessel must be prepared, printed out, signed by chief officer and captain and filed according to the ship filing system. The same applies for Arrival condition.

Loading computer shall be tested against class approved test data once a month to ensure operational accuracy. Documentation to be filed on board the ship according to the filing system on board.

1.3 Cargo Handling Guidelines, Rules and Regulations

The Officer in charge of the cargo operations shall be familiar with the relevant parts of international cargo handling guidelines, rules, regulations and publications, (ref. Master list of controlled documentation, in RIP).

1.4 General Cargo Instructions

All requirements and procedures from port authorities and Charters concerning cargo shall be complied with unless such requirements conflict with the safety of the vessel.

1.5 Cargo Slop

It is the Captains responsibility to ensure disposal of cargo slop in accordance with existing rules and regulations.

1.6 Tank Cleaning

The tank cleaning procedures, ref. chapter 3, CHM, shall be fully complied with.

1.7 Gas Freeing

The gas freeing procedures, ref. chapter 3, CHM, shall be fully complied with.

1.8 Tank Entering

The tank entering procedures, ref. chapter 3, CHM, shall be fully complied with.

1.9 Sampling

The cargo sampling procedure, ref. chapter 4, CHM, shall be fully complied with.

1.10 Cargo Forms

The cargo forms are to be used for all the operations they have been prepared for.

1.11 Ship to Ship Transfer Operations

The Company procedures for Ship to Ship Transfer Operations are that ICS's 'Ship to Ship Transfer Guide' shall be fully complied with as appropriate.

The ICS's guidelines shall be fully complied with and Operation Safety CheckLists No.1-2-3-4-5 in Appendix 1 shall be copied and used before and during operation.

Always record Ship to Ship Transfer Operations in the Logbook.

Appendix C: Cargo checklists and procedures

CARGO CHECKLISTS AND PROCEDURES

The following cargo checklists and procedures shall be used for all cargo operations.

The checklists and procedures shall always be used together, and each procedure is included in the checklist as a checkpoint.

Pre Loading Checklist			Ref. Form no. 2.1
Procedure	01	Safety	Ref. Form no. 2.3
Procedure	02	Agreed with Shore	Ref. Form no. 2.3
Procedure	03	Lining up for loading	Ref. Form no. 2.3
Procedure	05	Loading Orders	Ref. Form no. 2.3
Procedure	06	After Loading	Ref. Form no. 2.3

Pre Discharging Checklist			Ref. Form no. 2.2
Procedure	01	Safety	Ref. Form no. 2.4
Procedure	02	Agreed with Shore	Ref. Form no. 2.4
Procedure	04	Lining up for discharging	Ref. Form no. 2.4

Brødrene Klovning Shipping AS	CHM	Vessel: All
Prep. By : LAS Appr. By : AB Date : 20.06.2011 Rev.: 9	Pre Discharging Checklist, Form No. 2.2	Page 1 of 1

PRE DISCHARGING CHECKLIST

Port: Antwerp Date: 05.09.2011

Item	Proc.	OK	Comments
Before Arrival			
Discharge plan and Manifold-plan prepared		✓	
Cargo information			
• Discharging conference with relevant crew		✓	
• MSDS placed in alleyway outside deck office		✓	
Crew informed about special safety requirements		✓	
Tank deck is clean, clear and presentable		✓	
After berthing			
AIS to be switched off during cargo operation		✓	
VHF sets to low power in harbour		✓	
Procedure "Safety", Ref. CHM 2.4	1	✓	
Before discharging			
P/V valves to be in correct position		✓	
Procedure "Agreed with shore", Ref. CHM 2.4	2	✓	
Procedure "Lining up for discharging", Ref. CHM 2.4	3	✓	
Ullage report calculated / signed by surveyor		✓	
Emergency shut-down system known		✓	
Terminal safety check-list received and signed		✓	
Port Contact List to be posted		✓	
Inform ER if the discharging will result in more than 3 cargo pumps on FULL load (2 generator needed)		✓	

Any comments to be explained in the logbook.

Officer in charge: [signature]

To be logged in the logbook and signed.

Brødrene Klovning Shipping AS	CHM	Vessel: All
Prep. By : LUR Appr. By: ESE Date : 08.10.2009 Rev.: 2	Pre Discharging Procedures, Form No. 2.4	Page 1 of 1

Pre Discharging Procedures

1 Safety

- [x] Fire / towing wire one metre above water, and turned on bollard.
- [x] All personnel on deck use personnel safety equipment.
- [x] Fire equipment prepared on deck
- [x] "Dangerous Area" sign placed at gangway.
- [x] Gangway-net prepared.
- [x] All scuppers plugged and bilge pumping arrangement prepared, (if overflow on deck).
- [x] Oil absorption products in strategic positions ready for use.
- [x] Light / flag signal in accordance with regulations.

2 Agreed with shore

- [x] Max rate [illegible]
- [x] Max manif.-press. [illegible]
- [x] Max cargo temp. [illegible]
- [x] Ship or shore stop
- [x] Emergency stop
- [x] Communication

3 Lining up for discharging

- [x] Stripping - valve closed
- [x] Drain – valve closed
- [x] Drop – valve closed
- [x] PV – valve in correct position
- [x] Manifold pressure gauge mounted
- [x] Discharging hose / arm correctly connected with the required number of bolts
- [x] Cargo – valve ready for opening when start pumping

04.04.2011

[illegible]

Brødrene Klovning Shipping AS	CHM	Vessel: All
Prep. By : LAS Appr. By : ESE Date : 25.08.2010 Rev.: 0	Pre-Cargo Operation Conference, Form No. 2.5	Page 1 of 1

PRE CARGO OPERATION CONFERANCE – LOAD__/DISCH__X_

Port: ANTWERP Voyage: 11033 Date: 03.09.2011

Information given about:	Comment	Check
Manifold plan and connection	See Manifold Plan	√
Side alongside at berth	To be advice	√
Mooring, Gangway, ISPS	Acc. To ISPS plan	√
Samples to be taken (as per charterers orders)	Manifold Samples	√
Fire protection and fire fighting agent	See MSDS info	√
Compatibility (if applicable)		√
Other cargo info: (Inhibitor, antidotes, freezing, heating, steam on deck, venting, etc)		
Actions taken in case of a spill	Per SMPEP manual	√
Emergency stop procedures	Acc. To CHM	√
Precautions against static generation	Ref. ISGOTT CH. 3.3 and 11.8	√

Minimum PPE (MPPE) is always: Safety shoes, Boiler Suit, Helmet, Gloves and Goggles

Cargo Name	Tanks	Quantity	CP	IMO	APPE
Aniline	5W+5C	870 MT	C,T	Y	CG, SS, BA CS
Nitric Acid	1C+3W	1530 MT	C	Y	CG, SS, BA, CS

Cargo properties (CP): Flammable (F), Corrosive (C), Toxic (T). **IMO Group**: X, Y, Z or OS.
Additional PPE (APPE): Chemical gloves (CG), Face Shield (FS), Splash Suit incl. boots (SS), Breathing Apparatus (BA), Chemical suit (CS), Gas Filter Mask (GF)

Other information:

READ MATERIAL SATEFY DATA SHEET (MSDS)

[redacted]

To be stamped in logbook and signed. To be filed for 3 months.

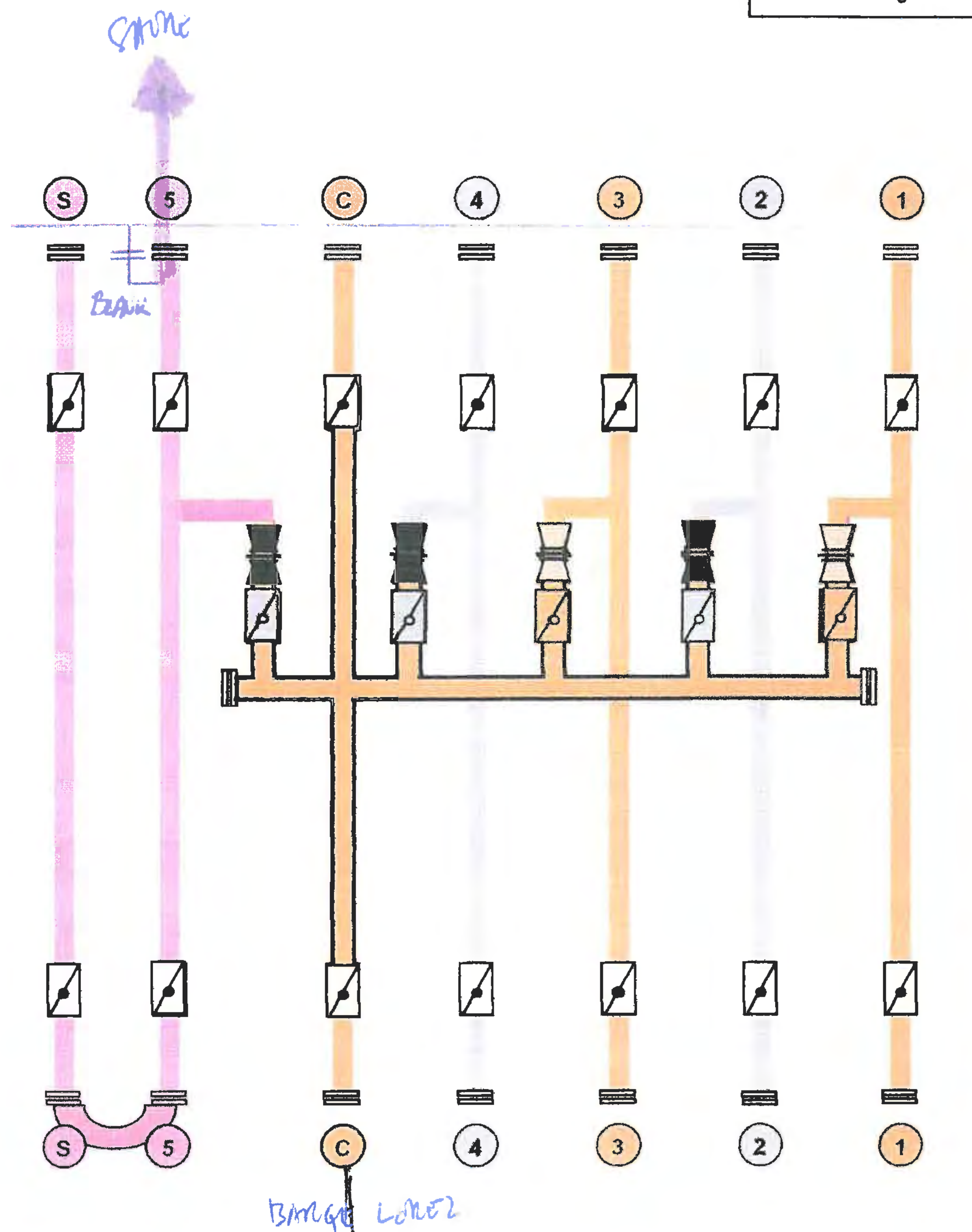
BRODRENE KLOVNING SHIPPING AS

M/T CLIPPER SUND

MANIFOLD PLAN

VOYAGE NO.	10033
LOAD PORT:	AVEIRO
DISCH. PORT	ANTWERP

CARGO
Aniline
Nitric Acid
0
0
0



NOTE: MANIFOLD CONNECTION/s DEPENDS ON WHICH SIDE THE SHIP LAY TO THE BERTH DISCHARGE.

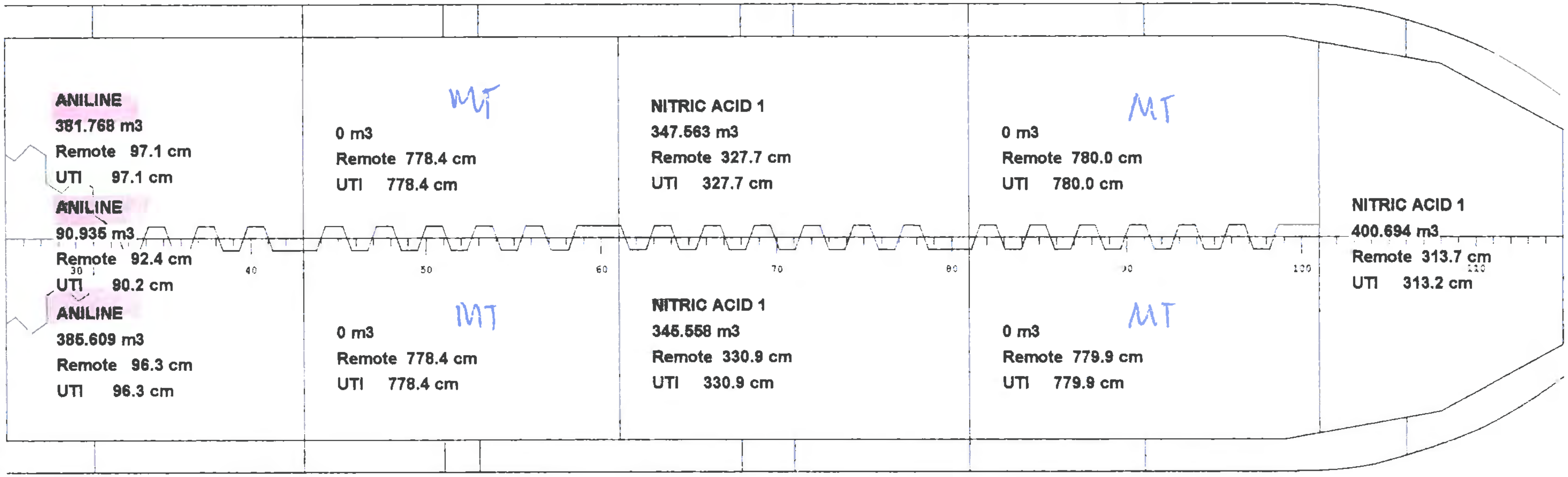
Remarks: ____

7202

Brodrene Klovning Shipping AS
CLIPPER SUND
Onboard-NAPA Version D

DISCHARGING PLAN
CLIPPER SUND

File Name:	SHIFTING-LAYBY	Voyage:	11033	Online Drafts	
		Port:	Antwerp	Draft fwd [m]:	4.18
Date:	03.08.2011	Terminal:	Oiltankning	Draft Aft [m]:	5.48
Time:	23:59	Jetty:	625a	Trim [m]:	A 1.28
				Heel [deg]:	0.00



Parcel	Density t/m3	Volume m3	Weight t
ANILINE	1.018	858	874
NITRIC ACID 1	1.396	1094	1527
TOTAL	1.230	1952	2401

~~MANUAL ULLAGING DONE IN MONO-NITRO BENZE~~

Chief Officer

Master

Shore Representative

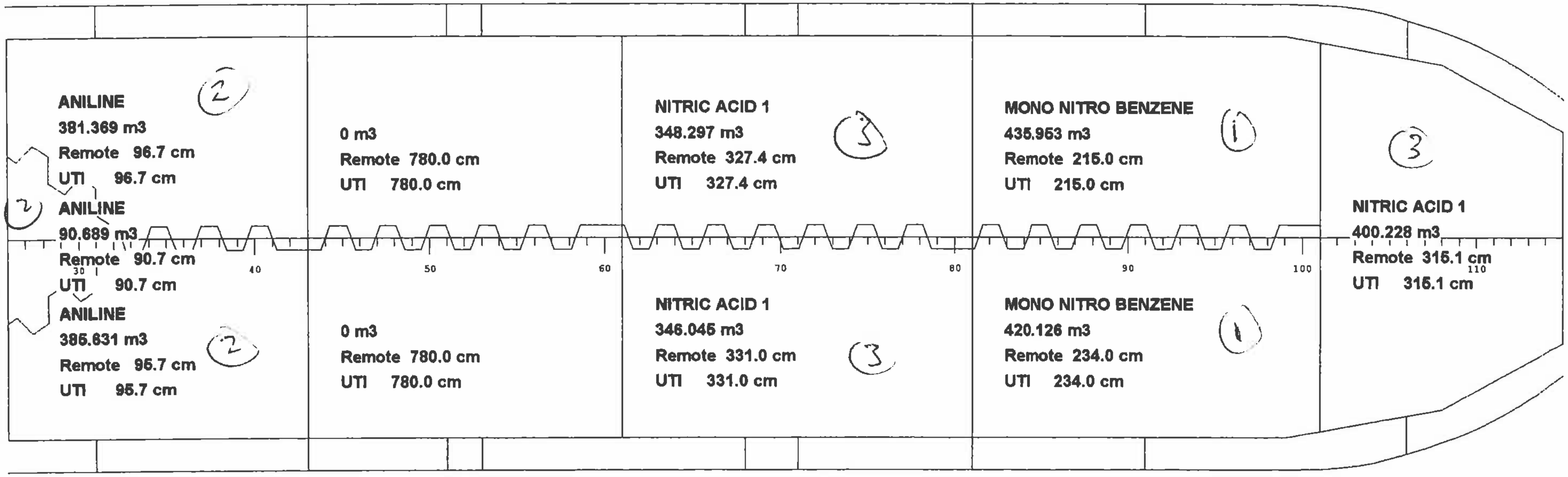
Brodrene Klovning Shipping AS
CLIPPER SUND
Onboard-NAPA Version D

DISCHARGING PLAN

CLIPPER SUND

7202

File Name:	DISCH-NITROBENZENE	**Voyage:**	11033	**Online Drafts**	
		Port:	ANTWERP	**Draft fwd [m]:**	5.51
Date:	03.09.2011	**Terminal:**	OILTANKING	**Draft Aft [m]:**	5.53
Time:	11:55	**Jetty:**	625A	**Trim [m]:**	A 0.02
				Heel [deg]:	0.00



Parcel	**Density t/m3**	**Volume m3**	**Weight t**
ANILINE	1.025	852	874
MONO NITRO BENZENE	1.205	850	1024
NITRIC ACID 1	1.389	1100	1528
TOTAL	1.223	2802	3426

MANUAL ULLAGING DONE IN MONO-NITRO BENZE

Chief Officer   Master   Shore Representative

CLIPPER SUND

CARGO INFORMATION

VOYAGE - 11033

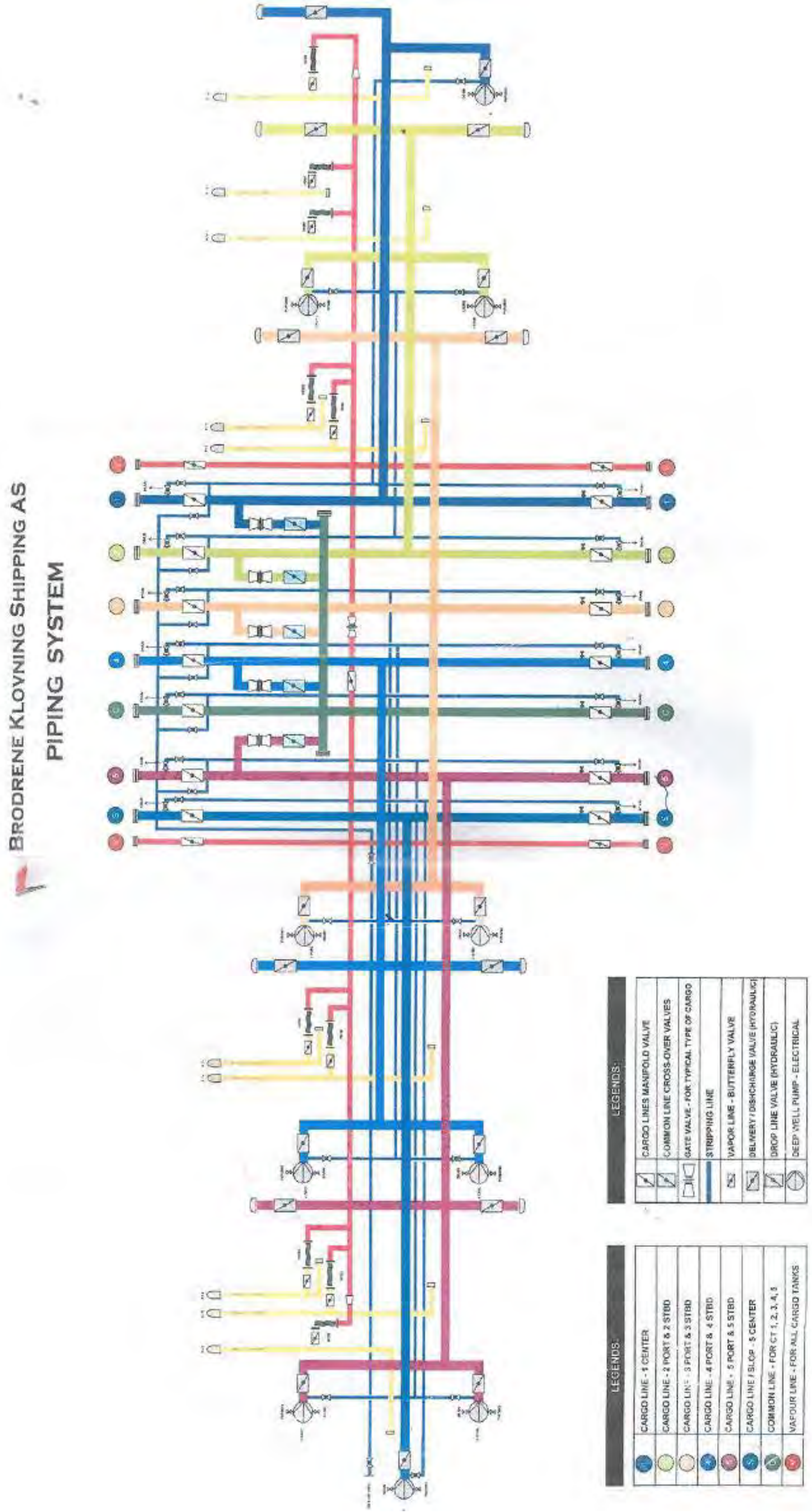
INDEX NAME	PRODUCT NAME	STOWAGE	DENSITY @ 15 C t/m3	VISCOSITY @ 20 C m Pa	QUANTITY	UN NO.
Aniline	Aniline	5W+5C	1,0253	4.35 mPa	Min/max 870 mt	1547
Nitric Acid	Nitric Acid	1C+3W	1,4111	0,75pka s @25degC	1530 mt	2031

POLL. CAT.	COF - FOOTNOTES	FLASH PT. DEGREE CELSIUS	BOILING PT. DEGREE CELSIUS	FREEZING/MELTING PT. DEGREE CELSIUS	IBC CODE CHAPTER	IMO HAZARD CLASS
Y	15.12, 15.17, 15.19	76deg C @ 1013 hPa	184.4degC@1013 hPha	6.2deg c (minus)	17	6.1, 8.0
Y	15.11, 15.19		356 K @ 1013 hPa	232 K @ 1013 hPa	17	5.1, 8.0

Note: Please refer to IBC Code, P & A Manual Material Safety Data Sheet, etc. For other Relevant Information regarding this cargo.

jnc11

Appendix E: Figure 9 in the report (large version)



Appendix F: Sketch of fault tree analysis