STATENS HAVERIKOMMISSION (SHK)
BOARD OF ACCIDENT INVESTIGATION

Report S 1992:5e

Maritime Accident on 5th November 1991 10 nautical miles east of Teesport, England, U.K.

Case S-09/91

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Ärendebeteckning
S-09/91

Maritime Administration
National Rescue Services Board

Report S 1992:5

Board of Accident Investigation (SHK) has investigated a maritime accident which occurred on 5th November 1991 outside Teesport, England, U.K. with a ro-ro vessel, MS Stora Korsnäs Link I.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a report of the investigation.

Sven-Erik Sigfridsson Sölve Arvedson Erik Steneroth Börje Stenström

/L-O Skoglund

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Appendices

Note

Except where noted, all times given in the report are in Swedish standard time (SNT = UTC + 1 hr).

SUMMARY OF ACCIDENT INVESTIGATION REPORT S 1992:5

Vessel	MS Stora Korsnäs Link I, ro-ro carrier ("paper carrier"), gross tonnage 5018.21
Date of accident	5th November, 1991
Location	10 nautical miles east of Teesport, England, U.K., N54°40', W00°48'
Weather	5th Nov 1991, 01.00 hrs: north-westerly wind, force abt 15 m/s, wave height 4 m, good visibility
Number of persons on board	18
Injuries to personnel	None
Damage to vessel	Total loss
Damage to cargo	Total loss
Damage to the environment	Limited
Other damage	Limited damage to one tug
Master's age and time as captain	58 years, 23—24 years

Stora Korsnäs Link I sailed at 11.20 hrs on 31st October 1991 from Gävle for Hartlepool, England. On 5th November 1991 at 06.29 hrs a fire started in the vessel's engine room. The CO_2 fire extinguishing system was activated. At 07.55 hrs it was feared that the fire had spread to the cargo. CO_2 fire extinguishing was activated to the cargo spaces (holds 1 and 2) and again to the engine room.

At 08.35 hrs, seven crew members were evacuated by helicopter. The vessel lay at anchor from 09.15 to 11.20 hrs. At 09.40 hrs a further five crew members were evacuated by helicopter. The vessel was under tow from 11.20 to 15.10 hrs. Towards the end of this period it was noted that the fire had spread to the garage deck.

At 15.10 hrs the vessel was again anchored. At 15.50 hrs the remaining crew members were evacuated by helicopter.

During the following four days the vessel was on fire, first on the garage deck, later in the accommodation spaces. Since the vessel was carrying dangerous cargo (sodium chlorate) she was not permitted to enter port. She was kept under observation and was sprayed with water for cooling from 6th November at 06.55 hrs by the contracted salvage company. On 10th November at about 04.05 hrs a number of violent explosions took place in the vessel, which immediately started to sink.

Investigation Results

- There is no suspicion that the officers and crew were not physically and mentally fit.
- The fire is assumed to have been started by oil igniting in the machinery spaces.
- Remote activation of the CO_2 installation did not function, causing the fire-fighting to be delayed and proper control of the release of CO_2 to be lost.
- The failure of the emergency generator and hence the emergency fire pump made it impossible for the crew to initiate other fire-fighting measures. This, however, most likely did not affect the further course of events.
- The weather with strong winds and heavy seas — in particular during the initial phase — rendered intervention by fire-fighting personnel from the shore difficult or impossible.
- Towing towards port was, due to the weather and lack of ocean-going tugs, virtually without effect. This, however, did not affect further developments.
- During the final phase of the fire, explosions caused the vessel to founder.
- A diver's investigation has revealed that, during the final phase, explosions occurred in the auxiliary engine room, causing two large holes to be blown in the ship´s side below the waterline.
- The dangerous goods documentation and the handling of this information was inadequate, resulting in the crew initially not being aware of the presence of dangerous goods.
- The stowage of the sodium chlorate and tall oil rosin ester partly above the non-insulated machinery spaces inside the vessel offered conditions for the formation of explosive mixtures.

The foundering was caused by flooding of the vessel. The flooding was made possible by holes in the hull below the waterline. These holes were created as a result of explosions following ignition of a mixture of molten sodium chlorate and molten tall oil rosin ester — possibly in combination with oil residues. These conditions were in turn generated by heating of the sodium chlorate and the rosin ester during a lengthy and extensive fire in the vessel. The fire had continued for several days and most likely started as a fire in the engine room that had spread to the cargo.

Recommendations

Board of Accident Investigation (SHK) recommends:

1. that the Maritime Administration should initiate a change in the transportation requirements for sodium chlorate in the IMDG Code to the effect that this and other substances with similar characteristics should be stowed on open deck.

2. that the National Rescue Services Board and the Maritime Administration should investigate whether any discrepancies exist in the formal responsibilities of cargo shipper, forwarder, brokers and other parties involved in the transportation chain to inform those involved about the existence of dangerous goods and should seek to introduce safer routines.

3. that the Maritime Administration should consider the need for more reliable fire-extinguishing systems in large open cargo spaces where cargoes that may develop glowing fire may be carried.

INTRODUCTION

The ro-ro vessel Stora Korsnäs Link I foundered on 10th November 1991 in Tees Bay off the east coast of England after a fire that started on 5th November.

The accident was investigated by the Board of Accident Investigation (SHK), represented by Sven-Erik Sigfridsson, chairman, Sölve Arvedson, operational investigator, Erik Steneroth (up to 30th June 1992) and Börje Stenström (from 30th June 1992), technical investigators. The Board was assisted by Jan Billvik, fire prevention expert, Leif Wannholt, chemical expert, Stefan Lamnevik, explosives research manager and Lars-Olof Skoglund, acting secretary. The investigation was followed by Sten Andersson on behalf of the Maritime Administration. Erik Steneroth participated as expert from 1st July 1992.

The Board of Accident Investigation met

Date	Location	Participants
26th Nov 1991	On board Stora Korsnäs Link II	Sölve Arvedson, Erik Steneroth, Jan Billvik, L-O Skoglund, Göran Borud, Maritime Administration Lennart Graff, Sea-Link AB Leif Wigö, Sea-Link AB
4th Dec 1991	SHK offices	S-E Sigfridsson, Sölve Arvedson Erik Steneroth, Jan Billvik, Sten Andersson, L-O Skoglund, Lennart Graff, Leif Wigö, Representatives of parties concerned and the crew
17th Dec 1991	Department of Transport, Hull	S-E Sigfridsson, Sölve Arvedson, Erik Steneroth, Jan Billvik, Sten Andersson, L-O Skoglund, T A Llewellyn Edwards, DOT
17th Dec 1991	United Salvage Ltd, Hull	S-E Sigfridsson, Sölve Arvedson, Erik Steneroth, Jan Billvik, Sten Andersson, L-O Skoglund, Eric Johnson, United Salvage Ltd Barry Weissenborn, Humberside Fire Brigade
18th Dec 1991	Cory Towage (Tees) Ltd Teesside	S-E Sigfridsson, Sölve Arvedson, Erik Steneroth, Jan Billvik, Sten Andersson, L-O Skoglund, Allan M Keer, Cory Towage Ltd
5th Febr 1992	On board Stora Korsnäs Link II	S-E Sigfridsson, Sölve Arvedson, Erik Steneroth, Jan Billvik, Sten Andersson, L-O Skoglund, Representatives of parties concerned

10th March 1992	Local Fire Brigade, Helsingborg	S-E Sigfridsson, Sölve Arvedson, Erik Steneroth, Jan Billvik, Sten Andersson, L-O Skoglund, Leif Wannholt
15th May 1992	Local Fire Brigade, Gothenburg	Sölve Arvedson, L-O Skoglund, Jan Billvik, Sten Andersson
25th May 1992	Malmö	Sölve Arvedson, L-O Skoglund, Jan Billvik, Sten Andersson
31st July 1992	Rotterdam	S-E Sigfridsson, Sölve Arvedson, Sten Andersson, Kees van Essen, Smit Tak BV Jaco Sluijmer, Smit Tak BV
6th Aug 1992	SHK offices	S-E Sigfridsson, Sölve Arvedson, Sten Andersson, Stefan Lamnevik
15th Oct 1992	Gothenburg	Sölve Arvedson, Erik Steneroth, Börje Stenström, Jan Billvik, Stefan Lamnevik, Sten Andersson, Leif Wannholt, L-O Skoglund
6th Nov 1992	SHK offices	S-E Sigfridsson, Sölve Arvedson, Erik Steneroth, Börje Stenström, Jan Billvik, Stefan Lamnevik, Sten Andersson, L-O Skoglund Bertil Lindberg, National Board of Explosives, Representatives of parties involved

1. FACTUAL INFORMATION

1.1 The Course of Events

1.1.1 The period prior to abandoning of the vessel

The Swedish ro-ro vessel Stora Korsnäs Link I was on 5th November 1991 en route from Gävle to Hartlepool with a cargo consisting mainly of forest products. At 06.29 hrs indication was given by the fire alarm system that a fire had started in the engine room. This was confirmed shortly afterwards. After the crew had been mustered attempts were made to release CO_2 fire-fighting agent to the engine room from the navigation bridge. As this was unsuccessful, CO_2 was released manually from the starboard CO_2 storage space in the aft part of the vessel. The distress signal MAYDAY was transmitted at 06.35 hrs from a position about N 54°40' W 00°48', about 10 nautical miles on bearing 95° from the Tees Fairway Buoy. In conjunction with the release of CO_2, the fuel oil supply to the engines was shut and the shaft generator stopped as a consequence. The emergency generator started automatically.

The vessel drifted in the strong north-westerly wind (20—30 knots) towards the coast and was at the closest point 2.5 nautical miles from the shore. The emergency generator stopped at 07.50 hrs. Shortly after 07.50 hrs it was feared that fire had spread to the cargo hold on the main deck. CO_2 was therefore released at 08.15 hrs to the cargo holds and — simultaneously — again to the engine room. At 08.30 hrs a rescue boat arrived for assistance and at 09.05 hrs another one, bringing two firemen. These could, however, not board the vessel. Between 08.35 and 09.07 hrs, seven crew members were evacuated by helicopter (R 131).

At 09.15 hrs the port anchor was lowered with six shackles in the water.

Between 09.25 and 09.40 hrs, five more crew members were evacuated by helicopter (R 128). The two firemen from the rescue vessel were brought on board by helicopter at 10.15 hrs. The firemen together with the captain judged that the fire, at that time only emitting white smoke, was under some control. It was therefore decided to attempt to tow the vessel to Tees Fairway Buoy.

At 10.52 hrs an agreement was reached about salvage. The agreement was in accordance with the Lloyds Open Form. At 11.15 hrs the tug Cleveland Cross was connected at the forward panama hawse and five minutes later the port anchor chain was disconnected from the chain locker and the tug started pulling. At 12.10 hrs the tug Roseberry Cross was also connected and towing started. This took place at a speed of about 1.5 knots.

At 12.40 hrs Cleveland Cross experienced problems with her tow winch and was forced to give up the tow. New attempts were made to attach a 9" cable between the vessel and Cleveland Cross. The attempts were, however, unsuccessful.

The naval vessel HMS Orkney arrived at 13.01 hrs and at 13.40—14.00 hrs offered the assistance of six firemen from her crew. As the fire-fighting resources on SKL I were out of operation and Orkney's resources were considered insufficient, the captain was advised by the two firemen on board not to accept the offer.

Around 14.45 hrs fire appeared on the garage deck. Black smoke was belching out of the hull and preparations were made to abandon the vessel. Helicopters were called, the tug pulled the vessel into the wind and the ship's documents were handed over to one of the rescue boats. The vessel was anchored with the starboard anchor in position N 54°37',50 W 00°53',35. The remaining personnel (six crew members and the two firemen) gathered on the forecastle, being the only smoke-free part of the vessel, and were lifted off at 15.40—15.50 hrs by helicopter.

1.1.2 The period after abandoning of the vessel

After the vessel had been abandoned it became evident from a telephone conversation between the chief officer and the cargo superintendent of the shipping company that two containers on board contained sodium chlorate (UN Number 1495), being rated as dangerous cargo. The Teesport port authorities and the Cleveland Fire Brigade were informed and the facts caused the Coast Guard to declare a safety zone of 1 nautical mile around the vessel on account of the explosion hazard.

Two tugs which had been contracted for the salvage arrived at the scene in the morning of 6th November. One commenced water spraying to cool the ship's sides. The vessel had, according to the captain, a metacentric height of about 0.85 m on departure from Gävle. The metacentric height as estimated by the Department of Transport representative at the time of the accident was 0.60 m and it was therefore considered impracticable to spray the garage deck with water even though this was on fire. The arrangement of the garage deck is described further under paragraph 1.6.2 below. The fire centres were identified and were kept under observation with a heat-sensing camera. At 10.15 hrs two representatives of the salvage company, one a fire-fighting officer, boarded the vessel to assess more closely the extent of the fire and to plan the further salvage work.

It was thereafter decided to let the burning cargo on the garage deck burn out under continuous checking and water spraying of the ship's sides. The intention was, after the fire had been put out, to tow the vessel to Teesport. It was estimated that the fire could go on for several days before the cargo was burnt out. Fire continued throughout the 7th November with some further spreading forward.

On 8th November the accommodation spaces were on fire. This fire was combatted with water but as a list to starboard of 3—5° developed the action was discontinued and the operation reverted to spraying the ship's sides.

During the 9th November the fire seemed to be less intense. Large parts of the cargo on the garage deck appeared to have burned out. The heat camera showed that the ship's sides in the vicinity of the accommodation area, the garage deck and the stern ramp had cooled off. Only a limited part of the aft part of the hull was hot. Towards midnight on 9th November it seemed that the fire had decreased further and at 01.30 hrs the ship's sides were again checked with the heat camera. No new hot spots were observed.

At 04.00 hrs a further check was made and at that time a new hot area was discovered on the starboard side aft, level with the forward end of the engine casing and at main deck level. The tug carrying the heat camera was manoeuvred around the stern of the vessel to check the port side. When the tug was about 30 metres aft

of the stern ramp and towards the port side, a series of violent explosions took place, between 04.05 and 04.14 hrs, (the tug's clock stopped at 03.07 hrs UTC) and the tug was hit by large amounts of splinters. The fire thereafter spread quickly over the entire vessel, which capsized to starboard and sank in position N 54°37',50 W 00°53',35 at a water depth of about 31 metres (see Appendix 1).

At 08.05 hrs the vessel had sunk by the stern so that the forward part of the underwater hull was visible for about 1/4 to 1/3 of its length and the bulb was above the water surface.

1.2 Injuries

No injuries occurred on board Stora Korsnäs Link I. According to information received from the tug that was attending about 30 metres aft and to the port side of the vessel at the time of the explosion, one man was slightly injured by a blow to the nose from a camera.

1.3 Damage to the Vessel and the Cargo

Total losses.

1.4 Other Damage

1.4.1 Damage to a tug

A tug sustained superficial damage in conjunction with the explosion. The windows of the navigation bridge were shattered, equipment and doors on the forecastle were damaged. The deck and the superstructure were covered by splinters, mostly twisted metal parts, and pellets of rosin ester.

1.4.2 Damage to the environment

After the foundering a limited oil spill was noticed. During the morning of 10th November airborne surveillance spotted two oil slicks at the site of the accident. The slicks were about 425 m long and 100 m wide.

During the afternoon of the same day only one slick remained. On 11th November no slicks could be observed as reported by a ship. The vessel carried at the time of the accident about 133 tons of heavy fuel oil, about 50 tons of diesel oil and about 12 tons of lubricating oil.

1.5 The Crew

The complement on board consisted of 17 crew members; captain, chief officer, two deck officers, chief engineer, two engineers, cook/steward, messman, four able seamen, repair man, motorman and two apprentices; all Swedish citizens. Additionally one passenger was on board.

Position	Qualification
Captain	Master mariner/K/, dangerous goods, IMDG code
Chief Officer	Master mariner/K/,dangerous goods, IMDG code
Deck Officer	Mate A/SA/, General operator´s cert
Deck Officer	Mate B 18 months /SB A 1 B2/
Chief Engineer	Marine engineer (diesel) /I/
First Engineer	Marine engineer (diesel) /I/
Second Engineer	Engineer B (12 months coastal, diesel) /TB C1 D2/
one Able Seaman	Certificate of proficiency in survival craft
one Motorman	Certificate of proficiency in survival craft
two Apprentices	Certificate of proficiency in survival craft

All except the two apprentices had signed on the vessel during October 1991 but the captain, chief officer, chief engineer and motorman had two to four years of previous duty on the sister vessels, Stora Korsnäs Link I and II.

1.6 The Vessel

1.6.1 General

The Stora Korsnäs Link I was owned by Rederi AB Sea Link at Nacka, Sweden, and sailed mainly with forest products between Gävle and U.K./The Netherlands. She was specially designed for rapid and rational handling of such products and was designated as "paper carrier" (see Appendix 3).

1.6.2 Data

The vessel was built in 1972 by A/S Framnaes Mek Verkstad at Sandefjord, Norway. She was lengthened in 1977 at Rijn-Schelde-Verlome. She was rebuilt in 1987 by Wärtsilä Marine at Turku, Finland, when a garage superstructure in lightweight steel construction with expansion joints covered by rubber seals was erected over the original weather deck, forming one additional cargo hold.

The vessel had cargo holds on three decks, namely on the tank top (hold number 1) 6,740 m^3, deck surface 1,191 m2, on main deck (hold number 2) 16,675 m^3, deck surface 2,670 m^2, and on the garage deck (the original weather deck) 10,766 m^3, deck surface 1,923 m^2. This hold had slots along the sides at deck level and additionally at the time an open pilot's entry gate on the port side.

Two side gates with elevator shafts and elevating mechanisms positioned on the starboard side. Additionally, one elevator with a capacity of 50 tons went from the main deck to the tank top deck and one with a capacity of 48 tons from the main deck to the garage deck. The main deck also had a stern ramp. The engine room was aft of the cargo hold on the tank top, separated from it by a flume stabilizing tank (empty). The engine room was not heat-insulated towards the cargo hold. The emergency generator room was on the garage deck in the starboard side engine casing and was not heat-insulated towards the engine spaces or the garage deck. The accommodation was sited forward on the original weather deck and was partly bounded aft by a stabilizing tank. These spaces were not fire insulated towards the cargo spaces. Unprotected portholes in the aft bulkhead of the accommodation faced the garage deck.

Call sign	SLVW
Class	Lloyds' Register *100A1 EO ICE 1A
Length	*o.a.* 163.47 m, *betw pp* 145.92 m
Breadth	20.60 m
Draft	*winter* 6.955 m, *summer* 7.103 m
Tonnage	*gross* 5,018.21, *net* 2,737.74
Deadweight	9,387 tons
Speed	14.0 knots
Main engines	Two Lindholmen SEMT Pielstick engines type 12 pc2v, developing 4,500 bhp each at 514 rpm
Auxiliary engines	Three HV Pielstick diesel engines, type V6 A/12GC, developing 600 bhp each at 1,200 rpm, each connected to an ASEA generator type GF 450 m, 3x450V, 525 kVA
Shaft generator	One generator coupled to the port side main engine, type DKBN 80/580-4, 600 kVA at 1800 rpm
Steering gear	Svendborg type 180/13 LD
Propellers	Two four-bladed controllable-pitch KaMeWa propellers type 86S 1/4, diameter 2,800 mm
Bow thruster	One KaMeWa four-bladed bow thruster, diameter 2,800 mm, 800 hp at 880 rpm, electrically driven
Ventilation	All fans were of make Nordisk Ventilator A/S, Norway *Tank top* Ten fans type ADH 900 ps, 36,000 m^3/h each, three inlet and seven inlet or exhaust Two fans type MNMX-110-26 1/1R inlet 40,000 m^3/h or exhaust 60,000 m^3/h *Main deck* Four fans type ADH 1 120 P5, 61,000 m^3/h each, two inlet and two exhaust Two fans type MNMX-110-26 1/1 R, one inlet 40,000 m^3/h or exhaust 60,000 m^3/h, one inlet 60,000 m3/h or exhaust 40,000 m^3/h All fan ducts terminated on weather deck except one, which terminated on garage deck, forward end, port side

Garage deck
Two fans type MNMX-110-26 R exhaust 60,000 m^3/h

Engine room
One fan type ADA 1000 S 6 inlet 37,000 m^3/h
One fan type ADA 1000 P 3 inlet 55,000 m^3/h
One fan type CM 630/R exhaust 15,000 m^3/h

Separator & auxiliary engine room
One fan type CNA 630/R exhaust 10,600 m^3/h

Emergency generator room
Natural ventilation to garage deck

Deck equipment — Two watertight loading gates on main deck, starboard side, 13 x 8.6 m with two doors

Stern ramp

Miscellaneous — Radio transmitter type Commander, Marconi
Radio receiver type Apollo, Marconi
VHF type Argonaut, Marconi
One radar type Raytheon 1020-6S
One radar type FR 805 DA, Furuno
Gyro compass type Brown, Mark 10
Direction finder, type Marconi
Depth sounder type Simrad Skipper
Speed log type Jungner 8 Al 24

1.6.3 Certificates, inspections

The vessel had the following valid certificates and conditions

- Certificate of Registry, endorsed for North Sea operations with the following limitation. In the upper hold only unseasoned timber and other non-inflammable cargoes or cargoes having low fire hazard according to evaluation by the Maritime Administration may be carried.
- Safety Equipment Certificate with Appendix
- Safety Construction Certificate with Appendix
- Safety Radiotelephony Certificate
- Safety Radiotelegraphy Certificate
- Exemption Certificate
- International Tonnage Certificate
- International Loadline Certificate
- International Oil Pollution Prevention Certificate
- Minimum Crewing Decision

Port State Control inspection was performed without comments in Rotterdam on 30th May 1991.

During a seaworthiness inspection carried out at Gävle on 23—24 April 1991, a list of discrepancies was filed. The list covered 37 items of which 12 were related to fire safety. The discrepancies were ordered to be corrected before 31 July 1991. The shipping company has claimed that the discrepancies were corrected before the accident. This has been verified by the chief engineer. Two gas tubes containing oxygen and acetylene had, however, not been moved out of the engine room.

1.6.4 Fire-fighting equipment

The vessel's fire-fighting equipment is shown on its safety plan and includes two fire stations, one at the aft end of the superstructure and one aft on the starboard side of the garage deck, both with approved equipment including a total of five breathing apparatuses.

Fixed installation for fire detection

The vessel was equipped with smoke detectors in the machinery spaces and cargo spaces and heat detectors in the accommodation spaces; connected to alarm panels on the bridge.

The detectors were divided into the following zones.

Engine room

Zone 1 (five sensors)	Auxiliary engine room, steering gear room
Zone 2 (five sensors)	Engine control room, separator room and boiler space
Zone 3 (four sensors)	Main engine room, port side
Zone 4 (five sensors)	Main engine room, starboard side
Zone 5 (four sensors)	Below platform deck, below port side engine casing and main engine room on starboard side aft.

Cargo hold on tank top (hold 1)

Two zones, one forward with four sensors and one aft with eight sensors.

Cargo hold on main deck (hold 2)

Three zones, one forward with six sensors, one amidships with eleven sensors and one aft with four sensors.

Accommodation spaces and bridge

Six zones with sensors in each space, cabin etc.

Fixed fire-fighting system

A low-pressure CO_2 fire extinguishing system was installed in the starboard engine casing with connection to the engine room, and the cargo holds on the tank top (hold 1) and the main deck (hold 2).

Release arrangements were provided on the bridge, at the fire-fighting station on the garage deck and in the CO_2 storage space. The CO_2 storage tank contained 16,000 kgs.

A fixed light foam fire extinguishing system was in the process of being installed on the garage deck. Only some wiring remained to be completed.

Two fire pumps were sited in the engine room, each with a capacity of 83 m^3/h, electrically driven from the shaft generator or the generator units. An emergency fire pump was sited in the bow thruster room, with a capacity of 50 m^3/h.

The emergency fire pump was powered by the emergency generator installed in a separate space on the garage deck, aft end to starboard.

1.7 The Cargo

The cargo consisted mainly of paper, pulp and timber. In total a cargo of 8,108 tons was carried.

The cargo hold on the tank top (hold 1) contained 2,580 tons of forest products, mostly pulp, and one mafi loaded with board.

The main-deck cargo hold (hold 2) contained 3,724 tons of forest products. Aftmost on the deck were five trailers and one mafi with two loaded containers and one mafi with board. The five trailers contained 112.4 tons of rosin ester in the shape of pellets, in total 3,653 x 25-kg paper bags on pallets, wrapped in polythene foil, 43 x 25-kg plastic bags and 40 x 500- kg big bags. The two loaded containers each contained 20 tons of sodium chlorate (IMDG class 5.1, UN Number 1495, page 5178), packed in 40 x 1000-kg big bags. See also Appendix 4.

The garage-deck cargo hold contained 1,650 tons (2500 m^3) of timber and a number of empty containers on mafis.

The cargo stowage plan and cargo summary are shown in Appendix 2.

1.8 Tugs

The two harbour tugs of 290 GRT each which were used for the towing had an engine power of 2,540 kW and a pulling power of 37 tons each. The tugs were ordered from Teesport and alerted by the Marine Rescue Sub-Centre. Lloyds Underwriters in London have stated that no other tugs were available.

1.9 Weather

Weather information was obtained from the British Meteorological Office for the period 4 to 10 November 1991. The information is summarized below.

	Wind	*Visibility*	*Weather*	*Wave height*
4 Nov 1991				
0000 GMT	W 10 m/s	Good	-	1.5 m
1200 GMT	NW 12 m/s	Good-moderate	Occasional rain	1.5 m
5 Nov 1991				
0000 GMT	NW 15 m/s	Good-moderate	Showers	4 m
1200 GMT	NW 12 m/s	Good-moderate	Showers	3.5 m
6 Nov 1991				
0000 GMT	NW 12 m/s	Good	-	3 m
1200 GMT	W-SW 10 m/s	Good moderate	-	2.5 m
7 Nov 1991				
0000 GMT	W 12 m/s	Good	Occasional rain	2 m
1200 GMT	W 10 m/s	Good-moderate	Occasional rain	2 m
8 Nov 1991				
0000 GMT	W-NW 12 m/s	Good	-	2 m
1200 GMT	W 12 m/s	Good	-	2 m
9 Nov 1991				
0000GMT	NW 12 m/s	Good	-	2 m
1200 GMT	NW 10 m/s	Good	Occasional showers	2.5 m
10 Nov 1991				
0000 GMT	W-NW 10 m/s	Good	-	1.5 m
1200 GMT	SW 12 m/s	Moderate	Occasional rain	1.5 m

1.10 Other Information given to SHK

1.10.1 Reports from the crew

The sequence of events

From information given to SHK by the crew the following emerges — over and above the facts stated above.

The vessel was scheduled to arrive to Hartlepool around midnight during the night of 4th November 1991. Prior to arrival, the change-over from heavy fuel oil to diesel oil was made. At 23.00 hrs the first engineer visited the engine room for inspection. Due to the bad weather it was decided to await more suitable conditions and tide level off the Tees Fairway Buoy. The vessel headed into wind and waves at

low speed following the coastline. At 04 hrs on 5th November the master was on the bridge to turn the vessel around. The wind was then 7 Beaufort. A second mate was on duty between 04.00 and 08.00 hrs. He was on the bridge together with the helmsman of the watch when at 06.29 hrs the fire alarm for the engine spaces was sounded. The alarm indicated smoke in zone 1 and/or zone 2. Immediately thereafter smoke was also indicated in zones 3 and 4. The chief engineer, having woken at the first alarm, came to the bridge after one or a few minutes. After checking the alarm panel he ran, together with the first engineer, to the engine room via the garage deck. It proved impossible to enter the engine room despite attempts from starboard as well as port entrances. The chief engineer saw a strip-light on the platform deck inside the door to the engine room glowing faintly in the black smoke and heard a hissing sound as when an indicator cock is opened. Also the motorman attempted to enter the engine room wearing a smoke suit. He did not manage to do so. All flaps and vents were ordered closed by the chief engineer. Emergency closing of the oil supply from the day tank and settling tank was executed. Whilst this was being done the main engines stopped and there was a blackout. The emergency generator started automatically. The engineer and the motorman returned to the bridge. After the crew had been mustered it was decided to activate the CO_2 fire-fighting system in the engine room from the control panel on the bridge. The system had been tested on the previous day and had worked properly. At this time it did not work, however, and the first engineer and the motorman went to the CO_2 space via the garage deck and activated the system locally. Due to unclear radio communication, the order to release CO_2 was given twice, giving a release time double the recommended one (about 3 minutes). It was observed that CO_2 escaped through the system as the pressure gauge reading dropped, the valve armature got frosty on the outside and a hissing sound was heard. The black smoke was dampened. At the time the main engines were stopped, an emergency radio call was broadcast.

About one and a half hours after the first release of CO_2 a smell of burnt wood was observed coming from the main deck. It was therefore decided to activate the CO_2 system to the cargo holds as well. At the same time a new release was made to the engine room. Due to the smoke and heat, the smoke diver (the first engineer) could not remain long in the CO_2 space. The CO_2 release valves were left open.

At about 07.50 hrs the emergency generator on the garage deck stopped. Attempts were made to restart it despite intense heat and smoke but were unsuccessful.

After all the CO_2 had been released the emerging smoke was white, giving the impression that the fire had been dampened. The officers were not sure of assessing the situation themselves and requested firemen from the shore. Two firemen came on board at 10.15 hrs. The first engineer and the two firemen were able, without protective gear, to inspect the garage deck for possible spread of fire. Their opinion and that of the master was that the fire was under control as long as the enclosed spaces were not opened up.

During towing, which started at 11.20 hrs with some difficulty due to the heavy seas, a towline parted around 14.00—14.30 hrs. At the same time black smoke started to belch out from the garage deck and a fire developed quickly on this deck. Helicopters were requested, the vessel was anchored and was finally abandoned at 15.50 hrs.

The dangerous goods cargo

One mafi with two containers, one mafi with board and five trailers had been loaded last. The units were strapped by the stevedores with chains as normal. The officers responsible have stated that they were not informed of the contents of the trailers and containers. They had not observed whether the containers were labelled as containing dangerous cargo. The trailers and containers were stowed aft on the main deck (hold no 2), immediately inside the stern ramp. The chief mate could not recall the order in which the units were placed on deck.

From the documents brought ashore by the chief mate when the vessel was abandoned, it emerged that one cargo shipper was Eka Nobel. This prompted the mate to call the cargo superintendent at Gävle, when it was learned that the containers contained sodium chlorate.

Containers with sodium chlorate had been transported with the same stowage arrangements on a number of earlier occasions.

1.10.2 Information from cargo shipper and brokers

SHK has collected information from the manufacturers about the sodium chlorate and the tall oil rosin ester.

Sodium chlorate

Sodium chlorate is a white crystalline powder. It is hazardous to health and an oxidizing agent. Its melting point is 248°C. Within the range from melting point up to about 300°C, the chlorate will fractionate, sodium chloride and free oxygen being formed. In the temperature range around and above the melting point both solid and liquid and fractionated chlorate may appear. During continued heating the pressure will increase if the chlorate is hermetically enclosed.

The ability of the chlorate to generate oxygen makes it form very inflammable mixtures together with organic substances. Together with oils, combustion sequences may develop which are very rapid and release energy at a rate equivalent to that of explosives.

The sodium chlorate was delivered by Eka Nobel. The firm's Alby factory (as cargo shipper) and the Stockholm office (Eka Nobel Elektrokemi) had filed a Dangerous Goods Declaration on 24 October 1991 .

The cargo was transported by rail in two containers from the Alby factory to the port of Gävle and was accompanied, as stated by the stevedoring company at Gävle, by a consignment note. The stevedoring company had not received any transportation card or other documents. The railway wagon was unloaded in the port of Gävle and the containers were stored for three to four days in the open in the area designated for dangerous goods.

The receiver for the land transportation was the forwarder at Gävle who also, via Combi Shipping, made up the shipping documents which were placed on board the vessel as ship's mail. The cargo superintendent of the shipping company made up

the vessel's loading plan, in which the sodium chlorate was noted as "1 mafi/2 cont load" without stating the contents. In the cargo summary statement accompanying the cargo plan it was noted: "Shipper Eka Nobel Product 2 x 20' cont 40,080 kg".

During the period from 1988 to October 1991 sodium chlorate had been shipped on 15 voyages on board Stora Korsnäs Link I and on 68 voyages on board Stora Korsnäs Link II. The vessels had on 12 of these voyages had the same captain as on the current voyage. The stevedoring company has stated that the containers with sodium chlorate had carried dangerous goods labels in about half the cases.

Tall oil rosin ester

Tall oil rosin ester is an entirely organic substance (produced by esterification of tall rosin by pentaerytriol or glycerol). The melting point is 85—135°C and the flammability point >200°C. At temperatures above 300°C the rosin ester fractionates, forming hydrocarbons and carbon dioxide.

Bergvik Kemi AB delivered 112.4 tons of tall oil rosin ester of three different types in a total of 3,653 paper bags, 43 plastic bags and 40 big bags, loaded in five trailers. The transportation to Gävle was done by truck. Tall oil rosin ester does not come under the IMDG Code.

Product information had been provided by Bergvik Kemi AB. It was included in the ship's mail, see Appendix 5.

1.11 Fire-fighting after Abandoning the Vessel

A salvage contract was signed between the vessel and Cory Towage (Tees) Ltd. A sub-contract was signed between this company and United Salvage Ltd, having fire fighting capacity. A tug with water monitors, the Lady Josephine, arrived on the scene of the accident on 6 November at 06.55 hrs after having picked up a salvage master and a fire-fighting officer. Up to that point, the vessel had been kept under observation from another tug. Heavy fire was noted, primarily on the garage deck. Open fire with flames was clearly visible through an open gate on the port side. Cooling of the ship's sides by water spraying was initiated immediately.

Around 11.30 hrs the salvage master and the fire-fighting officer boarded the vessel. They noted that the bridge and the accommodation spaces were somewhat warm and smoky and that the top of the garage deck had collapsed. There was intense fire on the garage deck. The two officers closed as many openings as possible in the accommodation area but left the bridge wing doors open to expel the heat.

The intention was to let the garage-deck cargo burn out, which could take several days, and thereafter tow the vessel to Teesport.

During the following days cooling of the ship´s sides continued. The heat radiation was checked at intervals with a heat camera. The checks showed initially that the garage deck was hot but the aft parts and the accommodation were less hot. The accommodation spaces were on fire on the morning of 8 November. On the following morning the bridge was burned out and the heat camera indicated that the accommodation spaces were cool, as were large parts of the hull. Open fire was.

however, visible on the starboard side of the garage deck. The stern ramp was not hot but limited parts of the aft part of the vessel indicated heat.

At midnight on 9th November the intensity of the fire seemed to decrease. A check with the heat camera at 01.30 hrs showed no new hot spots.

At 04.00 hrs a new check unexpectedly revealed a new hot spot aft on the starboard side, forward of the engine casing and at main deck level. As the tug moved around the aft part of the vessel to continue the examination at least three very heavy explosions took place in the vessel, which subsequently sank.

1.12 Diver's Investigation of the Wreck

SHK, together with the insurance companies, commissioned Smit Tak BV to carry out a diver's investigation of the wreck. The observations made can be summarized as follows.

- The wreck was lying on the seabed at an inclination of 100—105°. Due to the shape of the underwater body of the hull and because the wreck was lying on an elevation on the seabed, only the aft part of the starboard side could be inspected.
- The auxiliary engine room was heavily burnt and showed a chaos of distorted metal parts.
- The main engine room did not seem to be much affected by fire.
- On the starboard side below the waterline at frame 30 a 3ft x 4 ft hole was created. The bulkhead between the auxiliary engine room and the main engine room was bent heavily forward and the steel door was missing. A rupture of 7ft by 1ft had formed between frames 35 and 40, with outward-bent edges.
- The port side had no holes at or below the waterline. Parts of the port structure at the level of the garage deck were, however, missing.
- The garage roof had disappeared except for a collapsed part on the starboard side between the accommodation forward and the engine casing.
- The aft bulkhead of the garage deck had disappeared.
- The garage deck (the original weather deck) had disappeared from the accommodation area forward to the engine casings aft.
- There was a hole about 10 m in diameter in the garage deck on the starboard side, half of it forward and half of it aft of the aft garage deck bulkhead.
- The side plating on the port side of the garage deck between the accommodation forward and the engine casing aft had partly disappeared.
- The stern ramp had gone. The port side hinge had sheared and the starboard one was bent outwards.

- The mafi with two containers of sodium chlorate was found hanging in its lashings on the port side at the level of the driving ramp for the aft elevator (about 10 m from the stern ramp). Only the bottom frame remained of one of the containers. The other container was almost undamaged, but empty.

- The trailers had gathered in an unidentifiable pile on top of the starboard engine casing.

- The main deck on the starboard side was covered with solidified rosin ester.

- Cargo was missing from the main deck aft, below the garage deck that was blown away. Portions of the paper cargo were found around the wreck.

- All doors in the accommodation spaces were open and the windows and port-holes were smashed.

A sketch made during the divers´ inspection is shown in Appendices 6a and 6b.

2. ANALYSIS

2.1 The Vessel's Load and Loading

The vessel was loaded with forest products (timber, pulp rolls, pulp bales, hard-board, soft board) in accordance with a loading plan and cargo summary made up by the cargo superintendent of the shipping company (Appendix 2). Additionally the vessel had on board a number of empty containers and mafis and aftmost on main deck five loaded trailers, one mafi with board and one mafi with two 20-foot containers.

These trailers and containers, which were ascertained only after the abandoning of the vessel to contain sodium chlorate and rosin ester, were taken on board during the final stage of the loading and were placed where this type of cargo is normally stowed and as had been the case on at least 15 earlier occasions.

The stevedoring company collected the two containers with sodium chlorate placed on a mafi from the part of the port area where dangerous cargo is normally stored. It has not been possible to ascertain whether the containers were labelled as danger-ous goods.

In the cargo documentation given directly to the master/chief mate — a loading plan and a cargo summary — there was no mention of dangerous goods. The ship's mail, however, contained a Dangerous Goods Declaration made out by Eka Nobel (Alby) to the forwarder at Gävle (see Appendix 8) as well as a Bill of Lading issued by Combi Shipping (broker). The part of the ship's mail that is intended for the cargo receiver is not normally opened on board.

In accordance with current routines, Combi Shipping shall deliver to the mas-ter/chief mate an envelope containing a copy of the Bill of Lading, Dangerous Goods Declaration and the transportation/stowage requirements for the dangerous

goods. The forwarder shall additionally submit by telefax to Combi Shipping the dangerous goods declaration for the land transportation for further information to the stevedoring company and the shipping company.

Due to conflicting information it has not been possible to ascertain whether current routines were followed with regard to the distribution of cargo documentation for the dangerous goods. SHK has, however, noted that the handling of this documentation was not satisfactory.

The rules of the IMDG Code do not prevent stowage of sodium chlorate in a vessel in the manner that was applied.

Tall oil rosin ester is not subject to any loading or stowage restrictions.

2.2 The Diver's Investigation

A written diver's report and accompanying discussions with the diver superintendent show that the vessel is a total wreck.

A violent explosion blew away the stern ramp, among other things. The hinges show that the ramp separated on the port side first and left the starboard side hinge deformed but in one piece located on the seabed 200 to 300 metres from the main wreck.

A hole in the garage deck aft, about 10 metres in diameter, with upward-bent edges indicates an upward-directed explosion force from the area where the chlorate and the rosin ester had been stowed.

The remaining half of the collapsed garage deck indicated high temperature. The garage deck had blown away over the entire observable area (sidewards of the collapsed garage roof). The side plating along the port side, above the garage deck, was partly torn away between the accommodation area and the engine casing. A fairly deep rupture had developed in the hull plating on the port side amidships. All the damage taken together shows that one or several heavy explosions had taken place inside the vessel.

Information from the diver who had been inside the engine room and moved parallel to the grating aft of the main engines and immediately forward of the control room indicates no significant signs of fire, soot or oil residues which would prove that a direct fire had taken place in that space. The diver stated, however, that only the cylinder tops themselves in the aftmost positions could be observed. Their light green paint was still intact.

The complete destruction in the auxiliary engine room, the 3ft x 4ft hole in the starboard side at frame 30, the heavily distorted bulkhead towards the engine room, the blown away door and the 7ft x 1 ft rupture between frames 35 and 40 in the engine room indicate on the other hand that a violent explosion had taken place in that region. The combined area of the holes in the side shell below the waterline would permit rapid water flooding of the vessel, and its subsequent turning over and foundering.

According to the diver's information, the holes in the shell plating within the engine room spaces could be seen also from the outside as that part of the hull was not resting on the seabed.

2.3 The Origin, the Combatting and Spreading of the Fire and the Events Leading to the Final Explosions

2.3.1 The origin of the fire

The fire started in the engine room spaces shortly before 06.29 hrs. The main engines were running at normal speed but at low load. The engines were run on diesel oil after change-over the preceding evening. The shaft generator was providing electrical power to the vessel. No auxiliary generator set was running. At least one separator was in operation.

Smoke alarm was first given from loops 1 and 2, monitoring the auxiliary engine room, the separator room and the engine control room. These spaces were most likely in direct communication with the main engine room through open doors. Shortly thereafter indication was also given from loops 3 and 4, monitoring the main engine room itself.

The smoke sensors may have had some individual delays. The direction of the air flow in the engine room spaces may also have affected the sequence in which the loops gave alarm.

The auxiliary engine room was, according to the diver's report, completely demolished and burnt out. It is not possible from this information to judge whether the damage was caused solely by the final explosion in this space (an explosion that was most likely not directly initiated from the original fire) or in part by the original fire.

This indicates that the original fire was intense, considering the heat that was emitted, and a substantial amount of oil must have been available for the fire, e.g. a fractured oil pipe under pressure, or something abnormal having happened around the engine fuel service tanks. Ruptured fuel oil lines on engines are a rather common cause of engine room fires. It cannot be excluded that this was also the cause in this case. The hissing sound that the chief engineer heard on his first attempt to enter the engine room also supports this theory. The hiss may alternatively have come from a broken indicator cock.

The limited information available about the conditions in the wreck makes it impossible to determine whether the initial fire started because of a fractured fuel pipe on the running main engines or because of a malfunction in the separator room or in the pump and piping systems in the separator room which connect the engine fuel service tanks to the main engines.

It is normally possible to extinguish a fire of this kind with the fixed fire-fighting system. Most likely this was also the case here, but the extinguishing did not prevent the spreading of the fire to the cargo spaces.

Several facts may have contributed to this development. The additional delay before carbon dioxide could be released allowed the fire to develop intense heat and caused, among other things, extensive heating of the engine room casings. A more readily accessible emergency release and/or a more durable installation of the electric cabling and safeguarded power supply would have eased rapid fire extinguishing.

2.3.2 The spreading and fighting of the fire

The fire in the engine room caused a fire on the main deck. It has not been possible to ascertain how the spreading occurred. The most likely cause is that the main-deck cargo above the engine room was ignited by the deck plating hot from the fire in the engine room. A contributory cause may have been flames or hot gases reaching the main-deck cargo through the gap developing around the maintenance hatch above the engine room after the rubber seal had burnt.

Soot marks observable on a photograph taken at an early stage and showing the open door to the elevator machinery space between the main deck and the garage deck, show that smoke from the incomplete burning of cargo on the main deck had escaped this way. During a second phase, fresh air may have entered through the same passages.

After all flaps had been closed and carbon dioxide had been released to the engine room spaces, the fire in the engine room was most likely extinguished. The time from the start of the fire to the carbon dioxide release was 11 to 16 minutes. The remotely-controlled valves in the oil lines to the engines and the boiler were closed at the same time. The main engines stopped at that moment. The emergency generator started correctly.

It has not been possible to determine why the release of carbon dioxide from the bridge did not work. There may have been an electrical fault in the installation. It is also possible that the electrical cables between the control panel and the carbon dioxide installation in the engine room casing on the starboard side had already been damaged by the fire. It is also possible that the system lacked power due to the blackout. It has not been possible to ascertain whether the carbon dioxide release control from the bridge was connected to the power supply from the emergency generator.

The emergency generator stopped at 07.50 hrs, possibly due to short-circuiting in burnt cables. The generator starter battery was probably run down during repeated automatic restart attempts, followed by cut-outs due to overloading. When the first engineer later tried to restart the generator locally, the starter battery was flat. On the sister vessel, the cabling from the emergency generator passes through the engine casing down into the engine room, and it may be assumed that this was also the case in this vessel.

About one hour after the engine-room fire was put out, smoke from burnt wood was noted. Carbon dioxide was released to cargo holds 1 and 2 and again to the engine room, whereafter the carbon dioxide tank was probably empty. During the period prior to this release the garage deck had been visited at least twice. From all evidence the fire had at that time not spread to the cargo on the garage deck. It was, however, very warm in the entrance casings to the main deck, used e.g. when

entering the carbon dioxide storage space for the second release of carbon dioxide. It was also very hot in the emergency generator room on the garage deck.

After the second release of carbon dioxide, the smoke emission from the aft part of the vessel diminished and the opinion, including that of the firemen from the shore, was that the fire was under control if it could be kept enclosed. After the CO_2 release, fire development on the main deck was dampened. It is likely that the fire had been extinguished except for some glowing centres which could not be reached by the carbon dioxide. These may have been supported by air contained in porous materials.

The glowing fire in the timber cargo on the main deck may have continued for the hours following and accounted for the smoke that was being continuously emitted from the area. Unburnt gases from a glowing fire in the main-deck cargo may — with fresh air added from spaces outside the CO_2-filled cargo hold — have ignited and resulted in heating of the garage deck aft, e.g. near the elevator installation. The open door to the elevator machinery and the open slots around the guide system for the elevator to the main deck allowed fresh air access to the unburnt gases. The observations by the heat camera showing that the aft part of the vessel was generally warmer than the rest of the hull supports this assumption. The fire on the garage deck thereafter spread unchecked. After the heavy fire had broken out on the garage deck it became necessary to abandon the vessel.

The possibility of a fire starting on the garage deck may also have existed in the spreading of hot gases through the vertical casing shafts from the engine room and the elevator installation.

Three trailers containing tall oil rosin ester were stowed aftmost on the main deck. The space underneath was used for water ballast tanks. Immediately forward of the trailers were one mafi with two containers with sodium chlorate, probably close to the port side engine casing, plus one mafi with board and two trailers with rosin ester. One of these was most likely parked close to the starboard side engine casing. (see Appendix 9). The forward ends of these trailers and mafis reached almost to the forward end of the engine casings. The spaces underneath these units were occupied by water ballast tanks, diesel oil fuel tanks and the auxiliary engine room. The forward parts of these cargo units thus extended above the engine spaces. The space immediately forward of the units was, according to the loading plan, used for timber and board cargo.

Tall oil rosin ester melts at 85—135°C and has a flash point >200°C. At the prevailing temperature it is likely that rosin ester had already melted and flowed over the deck during the initial phase, emitting inflammable gases.

Ignition sources within the likely temperature range existed through direct contact with hot deck surfaces, possibly supported by remnants of paint, oil spill and other contamination. Alternatively a gas passage may have existed between the engine room and the main deck.

The carbon dioxide fire extinguishing on main deck was unsuccessful, partly because the carbon dioxide as released under the emergency release conditions did not give the required nominal dosage on the main deck and partly because carbon dioxide in limited concentration cannot spontaneously extinguish a glowing fire in timber and

paper. This would require additional cooling of the spaces. The conditions for successfully injecting carbon dioxide into a large space, filled with bulky, easily inflammable and porous cargo, were inadequate, also taking into account the fact there was not enough CO_2 for additional injection. It is likely that a glowing fire in a hot environment existed for a long time.

The carbon dioxide supply on board, about 16 tons, allowed 50% filling of the spaces into which it was injected, taking into account that carbon dioxide was released twice to the engine room. Assuming that the engine room had been completely filled during the first, extended, release, almost half of the total supply would have been consumed for the machinery space. Taking into account the volume of the cargo in the cargo holds the remainder would have been sufficient to fill the two cargo spaces to 35—40%. This is normally sufficient for extinguishing a fire with naked flame but most likely not for a glowing fire in a hot environment. The CO_2 concentration was gradually reduced in the cargo hold by leakage and insufficient sealing of the cargo hold. There was then a risk of reignition due to high temperatures in the hull and to remaining glowing spots in the cargo.

2.3.3 The development of the fire and the final explosions

Heat from the burning cargo on the garage deck eventually caused the fire on the main deck to increase in intensity. The heat in time melted more rosin ester. The vessel had at this stage a few degrees' list to starboard and a somewhat forward trim. A little later the heat also caused the sodium chlorate to melt. The molten chlorate and rosin esters had flowed together on the deck, creating a very inflammable and explosive mixture which most likely exploded spontaneously and blew away the aft ramp as well as causing the big hole in the garage deck. The fire in the molten mixture that probably preceded the explosion was indicated by the heat camera in the fire-fighting tug in the final stage as an unexpected and intense heat development in this region. It is assumed that a hole through the main deck into the auxiliary engine room was also caused by this explosion.

Chlorate and rosin ester was then able to flow into the auxiliary engine room where — possibly in combination with oil residues or oil from the tanks in the area — it caused a further explosion of such intensity that the shell plating was penetrated.

It is known that sodium chlorate together with diesel oil creates an easily ignitable mixture with an explosive power equivalent to or stronger than that of commercial explosives. The high temperature in the entire area is assumed to have been sufficient to trigger such an explosion.

It cannot be ascertained whether the fire from its start on 5th November up to the explosions was supported by oxygen emitted from heating of the sodium chlorate. This is, however, less likely because of the relatively small quantity (40 tons) of sodium chlorate and the actual development of the fire during the final stage. During the last days the fire decreased in intensity and developed black smoke, whereupon it unexpectedly gathered intensity on the aft part of the main deck.

Diminishing fire and black smoke indicate the beginning of quenching of a fire through lack of oxygen. After five days of fire it must be assumed that the interior of the hull was well heated. When the fire had decreased under such circumstances

it is likely that pyrolysis of organic material continued locally, producing inflammable gases that spread throughout the vessel. The rapid spreading of fire over the entire vessel after the initial explosions indicates that the inflammable pyrolysis gases had been mixed with oxygen from fresh air admitted through the damage to the hull and superstructure.

Mapping the conditions for development of explosive mixtures shows the following facts about the cargoes and substances involved.

Pulp and timber	Inflammable, develop inflammable pyrolysis gases products when heated. Pyrolysis gases developing during fire or intense heating of organic substances, e.g. wood or paper, form in the presence of oxygen an inflammable mixture that may explode.
Sodium chlorate	Sodium chlorate is a white crystalline powder, dangerous to health. It oxidizes. Instable when heated, develops free oxygen in the temperature range 240—300°C and melts at 248°C. (Sodium chlorate mixed with fuel oil has been used as an explosive, "Imatrex").
Tall oil rosin ester	The tall oil rosin esters were of six different kinds and had different melting points, the lowest 85°C and the highest 135°C. Rosin ester is inflammable and develops inflammable pyrolysis gases when heated. The flammability limit is >200°C.
Oils	Different types of oil were present in the engine spaces.

The fire on board eventually involved the cargo on the aft part of the main deck where the containers with sodium chlorate and tall oil rosin ester were stowed. The heat caused the rosin ester to melt and flow onto the deck. During the melting phase the temperature in the rosin ester may locally be rather constant at 135°C as the available heat is used for melting the ester. The heat required to melt the entire cargo of rosin ester is about 10 GJ which corresponds to the burning of about 500 kgs of pulp. The volume of the molten rosin ester was about 140 m^3.

Melting of the rosin ester may thus temporarily have stabilized the temperature in the area to some extent. Eventually the sodium chlorate would, however, start to melt, initially on the surface (sodium chlorate is a poor heat conductor) and at a temperature of 248°C. Molten sodium chlorate flowed down and got mixed on the starboard side with the rosin ester, melted previously. Photographs taken on 7th to 9th November show that the vessel had a 3—4° list to starboard and a forward trim, promoting the flow of the two molten substances to the same area. It is likely that the mixture ignited relatively early, before all the sodium chlorate had melted.

After ignition, about 5 MJ energy per kg of mixture would have been released, the temperature in the direct reaction zone perhaps reaching 3000°C. The burning surface and the released energy would have increased gradually as more chlorate melted and mixed with the molten ester. About 10 m^3 of gases would be formed per kg of burnt chlorate/ester mixture. This means that even when the burning surface was only 10 m^2, about 2000 m^3 of gases would have been released per second.

After a minute or more, it is likely that the burning surface of the chlorate mixture on the main deck had increased so much that the pressure in the cargo hold increased at an accelerating rate despite the openings to the outside. The pressure itself would further increase the reaction speed and thereby the size of the burning surface. A pressure of perhaps a few hundred atmospheres could be generated this way.

It is likely that the first explosion ruptured the garage deck and the main deck in the area of the storage of the chlorate and rosin ester cargoes, and blew out the stern ramp. It is also likely that chlorate (both solid and molten) and rosin ester was ejected, and mixed, through the holes in the garage deck and the main deck and caused the ensuing explosions. During each of these later explosions the burning surface was probably larger than during the first one (due to more efficient mixing and spreading mechanisms). Explosions in gases are not considered capable of creating sufficient pressure to rupture hull plating below the waterline.

The sequence of events may have been a deflagration of an explosive mixture. A deflagration may where there are large burning surfaces in explosive substances penetrable by gases and under a certain physical containment develop into a detonation, a process where the energy is transmitted by a pressure wave. The pressure wave so generated may be in the range of 200,000 atmospheres. The second series of explosions may have been detonations, but not necessarily so.

The auxiliary engine room contained on the starboard side two tanks for lubricating oil. Aft of this room were diesel oil tanks (22.4 m^3) and fuel oil tanks (113 m^3) located. An approximately 1m^2 access hatch, midships by frames 28-30, from the main deck to the auxiliary engine room had seals which were most likely destroyed by the fire. (see Appendix 7).

A more extensive gas explosion took place on the main deck some minutes after the first explosions. It lifted away large parts of the garage deck and blew away parts of the port side plating. This was most likely an explosion in the pyrolysis gases together with fresh air that had gained access after the first explosions. The intensity of this explosion indicates that the timber and paper cargoes had become extensively charred by the intense heat from above. The presence of carbon dioxide had probably prevented an earlier outburst of open fire.

The damage below the waterline caused water to flow into the engine room and the auxiliary engine room. This made the vessel sink sufficiently to allow water to enter through the opening left by the missing stern ramp as well. The original list to starboard then increased rapidly whilst the vessel lost stability and buoyancy and started to sink by the stern. This happened about five minutes after the third explosion.

2.4 Summary of the Course of the Fire

The evaluation by SHK of the course of events leading up to the foundering of the vessel and the reasons therefor is based on statements made by the crew, rescue personnel and others, on extensive collection and analysis of facts concerning the vessel, the cargo and the handling thereof, on expert statements concerning fire and explosion developments and on studies of the sister vessel. Detailed information

from the wreck has not been available as it has not been possible to investigate the vessel by other means than the diver's inspection.

SHK judges that the initial fire most likely started in the main engine room due to a fault in the fuel system that released an considerable amount of oil which finally ignited. This fire was most probably extinguished by the first release of carbon dioxide. It has not been possible to determine the exact sequence of events in the engine room spaces due to lack of information about the conditions in the area after the accident.

The intensity of the fire in the engine room spaces and the delay in releasing the carbon dioxide seem to have caused ignition of easily-ignitable materials on the main deck. It has not been determined exactly how this fire spread. It was most likely not extinguished by the subsequent release of carbon dioxide to the main deck, and a glowing fire developed locally into an open fire that later during the first day caused ignition of the timber cargo on the garage deck via hot gases or heat transmission.

During the following days the main-deck fire was kept limited to a glowing fire in the relatively oxygen-depleted atmosphere. Due to continued intense heat dissipation from the fire on the garage deck and some ingress of air through the elevator slots and the open door to the elevator machinery, the fire on the main deck gathered increasing intensity towards the final phase. This caused the sodium chlorate and the rosin ester to melt and flow out over the deck.

The sodium chlorate and rosin ester mixture, which burned with an intense release of energy, subsequently exploded at least twice, partly in combination with explosions in the pyrolysis gases together with oxygen released from the chlorate. The explosive force went in all directions and blew away the stern ramp, blew the hole in the garage deck and blew or melted a hole in the main deck down to the auxiliary engine room below. A mixture of chlorate and rosin ester deposited in the auxiliary engine room exploded again with a heavy explosive effect towards the hull plating, causing it to rupture below the waterline. Water entering through these openings was the direct cause of the foundering. During the second stage, extensive explosions also took place on the main deck in the pyrolysis gases that had collected during the course of the fire, reacting with fresh air entering as a result of the damage after the primary explosions and with oxygen released from the chlorate. In this way large parts of the garage deck and parts of the port side plating were blown away.

The diver's observations confirm that the aft part of the main deck was covered with molten and re-solidified rosin ester. The damage to the sodium chlorate containers indicate that chlorate may have melted and flowed out before an explosion occurred (the most forward-stowed container was empty but little damaged) and also taken part in a violent explosion (the aftmost container had completely disintegrated and the metal splinters found on the tug most likely come from the sides of this container).

The temperature needed to ignite a mixture of molten rosin ester, chlorate and oil residues was present. This burning mixture causes very high temperatures, and may melt steel. It develops into a violent explosion or deflagration.

It is also possible that at least one of the final explosions was caused by oxygen from fractionated chlorate, mixed with pyrolysis gases.

Photographs taken from the shore indicate one initial heavy explosion which among other effects blew away the stern ramp, followed by another one after a minute or so and finally at least one more. The last explosion was followed by fire engulfing the entire vessel, which by now was listing heavily.

SHK has not been able to determine why the release of carbon dioxide from the bridge did not work. At this point the vessel had its electrical power supply available from the emergency generator. The fault in the carbon dioxide release function may have been caused by the electrical cables already being damaged by the fire or possibly the system did not receive power from the emergency generator. This delay may have had a crucial effect on the possibility for the fire to spread to the cargo.

Placing easily ignitable materials such as rosin ester and strong oxidizing agents like sodium chlorate in close connection with the engine spaces may have been a contributory factor in the initial spread of the fire. The stowage of these substances is also judged to have been a contributory factor in the final destructive explosions.

The possibility of entirely extinguishing a glowing fire in a large cargo hold containing wood and paper cargoes must be regarded as very small. This further contributed to the failure to prevent the fire from spreading to the upper deck.

The salvage party's judgement that the cargo on the garage deck could be allowed to burn out, whereupon the vessel could be towed to safety, seems optimistic in view of the enormous amount of heat released and largely transmitted downwards by conduction and radiation to the inflammable cargo inside the vessel.

2.5 On-board Arrangements Affecting Fire Safety

The heat spread rapidly from the engine room because the vessel did not have, and did not need, fire-retardant type A-60 bulkheads and deck insulation. In addition, there were unprotected portholes between the garage deck and the accommodation area.

The siting of the emergency generator with its diesel engine and fuel tank in close connection with the engine casing on the garage deck proved to be less suitable. The electrical cables from the emergency generator most probably passed through the engine room. Long and vulnerable cables may be affected by fire in the cargo or by other fires and may render the emergency fire pump unusable. In this case the emergency fire pump was located forward below deck.

One ventilation trunk from the main deck opened on the garage deck at the port side and enabled hot gases to spread.

The 1987 enclosure of the original weather deck affected the spread of the fire, making access to the cargo for fire-fighting more difficult.

The burning cargo could not be reached for water spraying. The heat generated from the fire remained enclosed in the vessel and could therefore generate high temperatures even though the ship's sides were being sprayed with water.

The vessel lacked arrangements for refilling the carbon dioxide storage tank as there was no external connection. The weather conditions on 5 November would, in any case, have prevented such refilling.

2.6 Salvage Operations

2.6.1 Saving of lives

After the first (08.35—09.07 hrs) and second (09.40 hrs) evacuations of crew members only six crew members remained on board. The captain´s judgement that he and part of the crew should stay on board after the second evacuation and assist as required was correct. It should be noted that it is very demanding to handle heavy towing cables, to drop anchor and to unshackle anchor chain in a vessel without electrical power.

At 13.05 hrs, HMS Orkney arrived at the scene. This vessel is intended for assisting drilling rigs and fishing vessels when required. The vessel has a length of 53.7 m, a breadth of 11.0 m, a draft of 4.5 m and a displacement of 1260 tons. The equipment includes two "Searider" boats with 85-hp engines and portable fire pumps.

It appears that HMS Orkney's offer to provide fire-fighting assistance should have been accepted even though weather conditions were unfavourable for boarding and there were some doubts about the resources.

The life-saving operations continued up to 15.50 hrs on 5 November.

The helicopter evacuation operations were very skilfully conducted.

SHK considers that the decision to abandon the vessel during the afternoon of 5 November was correct. The situation on board was then:

- heavy fire and spreading of smoke,
- risk that remaining personnel could be trapped by the fire,
- no electrical power,
- no operable fire-fighting installations on board,
- no fire-fighting assistance could be expected from the shore,
- no further towing could be carried out,
- the vessel was not allowed to be towed into port,
- the vessel was safely anchored.

2.6.2 The salvage

When the vessel transmitted the MAYDAY distress signal at 06.35 hrs on 5 November,it was about 2.5 nautical miles from the shore with a north-westerly wind of 24 to 30 knots and a westerly tide current (Appendix 1). There was a risk that the vessel would drift ashore and the captain's decision to anchor her was necessary. The tugs which could be made available were insufficient in view of the prevailing

wind and sea conditions. Other tugs than these — intended for port service — were not available within reach. The towing towards the Tees Fairway Buoy was further hampered by the failure of the tow winch on one of the tugs. The vessel was only moved about one nautical mile during the towing.

After the final anchoring and after the last members of the crew had left the vessel, the salvage operation was taken over by the salvage company. Their intention was to let the fire on the garage deck and in the accommodation burn out, whereupon the vessel was to be towed to Teesport.

As it became evident that the vessel contained dangerous cargo, no permission to enter port could be obtained. For the same reason the Coast Guard ordered a safety zone around the vessel with a radius of 1 nautical mile, later reduced to 0.5 nautical mile.

The Humberside Fire Brigade and the Coast Guard considered it dangerous to place personnel on board the vessel.

On 9th November the salvage management considered that the danger for the vessel was over and that the salvage operation would be successful. It was believed that the sodium chlorate had been consumed.

The tug that was spraying water and monitoring the heat escaped devastating damage thanks to its position in a sheltered sector aft and to port of the vessel.

3 CONCLUSIONS

3.1 Investigation Results

- There is no suspicion that the officers and crew were not physically and mentally fit.
- The fire is assumed to have been started by oil igniting in the machinery spaces.
- Remote activation of the CO_2 installation did not function, causing the fire-fighting to be delayed and proper control of the release of CO_2 to be lost.
- The failure of the emergency generator and hence the emergency fire pump made it impossible for the crew to initiate other fire-fighting measures. This, however, most likely did not affect the further course of events.
- The weather with strong winds and heavy seas — in particular during the initial phase — rendered intervention by fire-fighting personnel from the shore difficult or impossible.
- Towing towards port was, due to the weather and lack of ocean-going tugs, virtually without effect. This, however, did not affect further developments.
- During the final phase of the fire, explosions caused the vessel to founder.

- A diver's investigation has revealed that, during the final phase, explosions occurred in the auxiliary engine room, causing two large holes to be blown in the ship's side below the waterline.

- The dangerous goods documentation and the handling of this information was inadequate, resulting in the crew initially not being aware of the presence of dangerous goods.

- The stowage of the sodium chlorate and tall oil rosin ester partly above the non-insulated machinery spaces inside the vessel offered conditions for the formation of explosive mixtures.

3.2 Causes of the Accident

The foundering was caused by flooding of the vessel. The flooding was made possible by holes in the hull below the waterline. These holes were created as a result of explosions following ignition of a mixture of molten sodium chlorate and molten tall oil rosin ester — possibly in combination with oil residues. These conditions were in turn generated by heating of the sodium chlorate and the rosin ester during a lengthy and extensive fire in the vessel. The fire had continued for several days and most likely started as a fire in the engine room that had spread to the cargo.

4 RECOMMENDATIONS

The Board of Accident Investigation (SHK) recommends:

1. that the Maritime Administration should initiate a change in the transportation requirements for sodium chlorate in the IMDG Code to the effect that this and other substances with similar characteristics should be stowed on open deck.

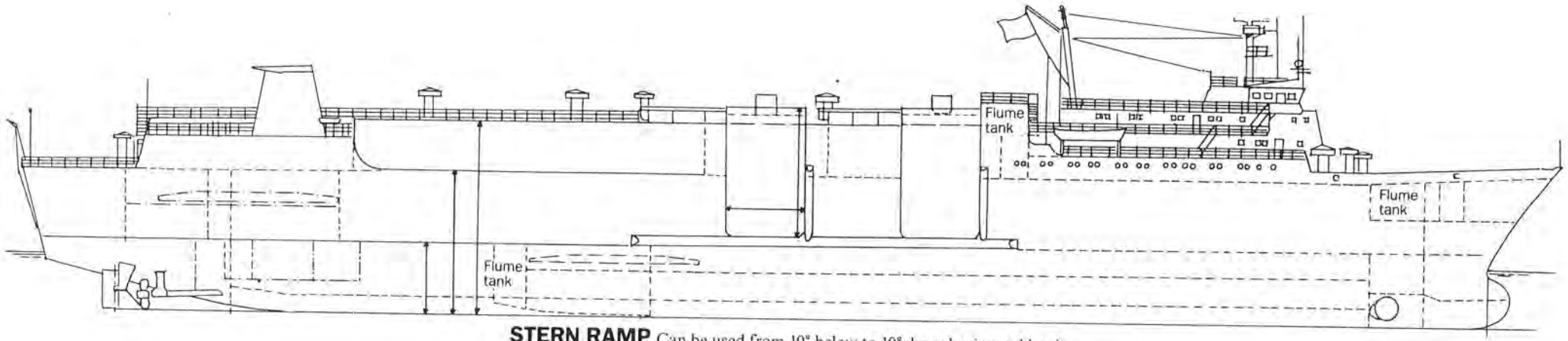
2. that the National Rescue Services Board and the Maritime Administration should investigate whether any discrepancies exist in the formal responsibilities of cargo shipper, forwarder, brokers and other parties involved in the transportation chain to inform those involved about the existence of dangerous goods and should seek to introduce safer routines.

3. that the Maritime Administration should consider the need for more reliable fire-extinguishing systems in large open cargo spaces where cargoes that may develop glowing fire may be carried.

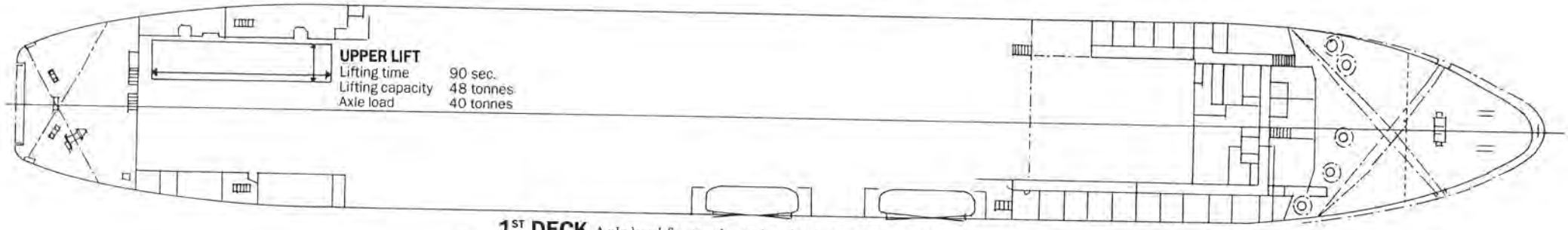
M/S STORA KORSNÄS LINK I

Flag: Swedish
Built: 1972, by A/S Framnæs Mek. Værkstad, Sandefjord, Norway.
Lengthened: 1977, by Rijn–Schelde–Verolme, Rotterdam, Holland.

Converted: 1987, by Wärtsilä Marine, Turku Shipyard, Finland.
Class: Lloyd's register ★ 100 A1 E0 ICE 1A, "Paper carrier".
Signal letters: S.L.V.W.



STERN RAMP Can be used from 10° below to 10°above horizontal level.
Total load 65 tonnes divided in two axles with an axle base of 5 m.
Max. axle load 45 tonnes. Preventer chain 35 tonnes at 6.0 m from free edge.



1ST DECK Axle load for trucks-twin wheel air pressure 10 kg/cm², 40 tonne
Uniformly distributed load 1.5 t/m²
Total load 410 tonne

MS STORA KORSNÄS LINK I
General arrangement

Appendix 3
(4 pages)

S (UK) LTD

GODSSAMMANDRAG
STORA/KORSNÄS LINK 1

AVLASTARE	PRODUKT	HARTLEPOOL	TERNEUZEN	
KORSNÄS	RULLMASSA	393.966	447.561	
KORSNÄS	PAPPER	1850.236	1159.601	
KORSNÄS	TRÄ	878.427 m3		
STORA CELL	RULLMASSA	288.153	215.462	
STORA CELL	BALMASSA	204.800	1367.424	
STORA SANDARNE	BALMASSA	9.792	48.960	
NORRSUNDETS BRUK	BALMASSA	160.962		
STORA TIMBER ALA	TRÄ	1198.330 m3		
STORA TIMBER LINGHED	TRÄ	16.460 m3		
STORA TIMBER KOPPARFORS	TRÄ	189.820 m3		
KARLIT	HARDBOARD	182.935		
LJUSNE BOARD	PORÖS BOARD	18.480		
JÄMTLAMELL	TRÄ	264.532 m3		
HEDIN-SKINNSKATTEBERG	TRÄ	48.975 m3		
BERGQVIST-INSJÖN	TRÄ	49.896 m3		
MÄLARSKOG	TRÄ	198.744 m3		
FREIGHT MASTER	5 TRAILER	112.404		(Bergvik Kemi)
EKA NOBEL	2x20' CONT.	40.080		
CERESTAR SCANDINAVIA A/S	7x20' CONT.	17.780		(Tomma)
COMBI SHIPPING AB	14x40' MAFIS	84.000		(Ägda och inhyrda)

MS STORA KORSNÄS LINK I
Loading plan and cargo summary

SEA-LINK

STORA KORSNÄS LINK 1

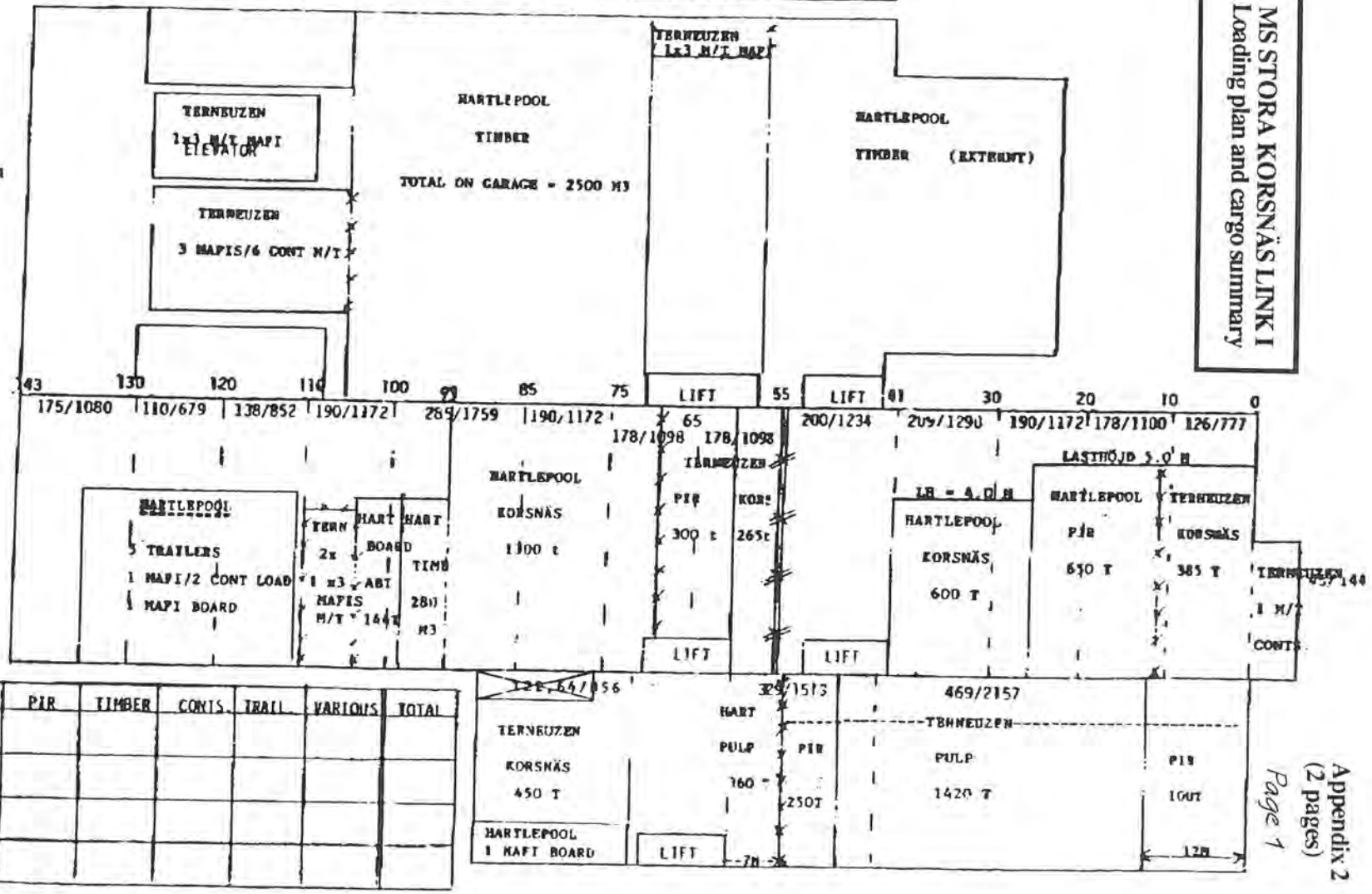
LOADED GRANUDDEN 911029/31

VOY 91-22

	LOWER HOLD	GARAGE	1ND. LIFT	TWD. RAMP	TOTAL
GRANUDDEN					
HALMSTAD					
HARTLEPOOL					
CHATHAM					
TERNEUZEN					

REMARKS

LÄGG TÄCK. FÖR UNDER PIR OCH BALKASSA

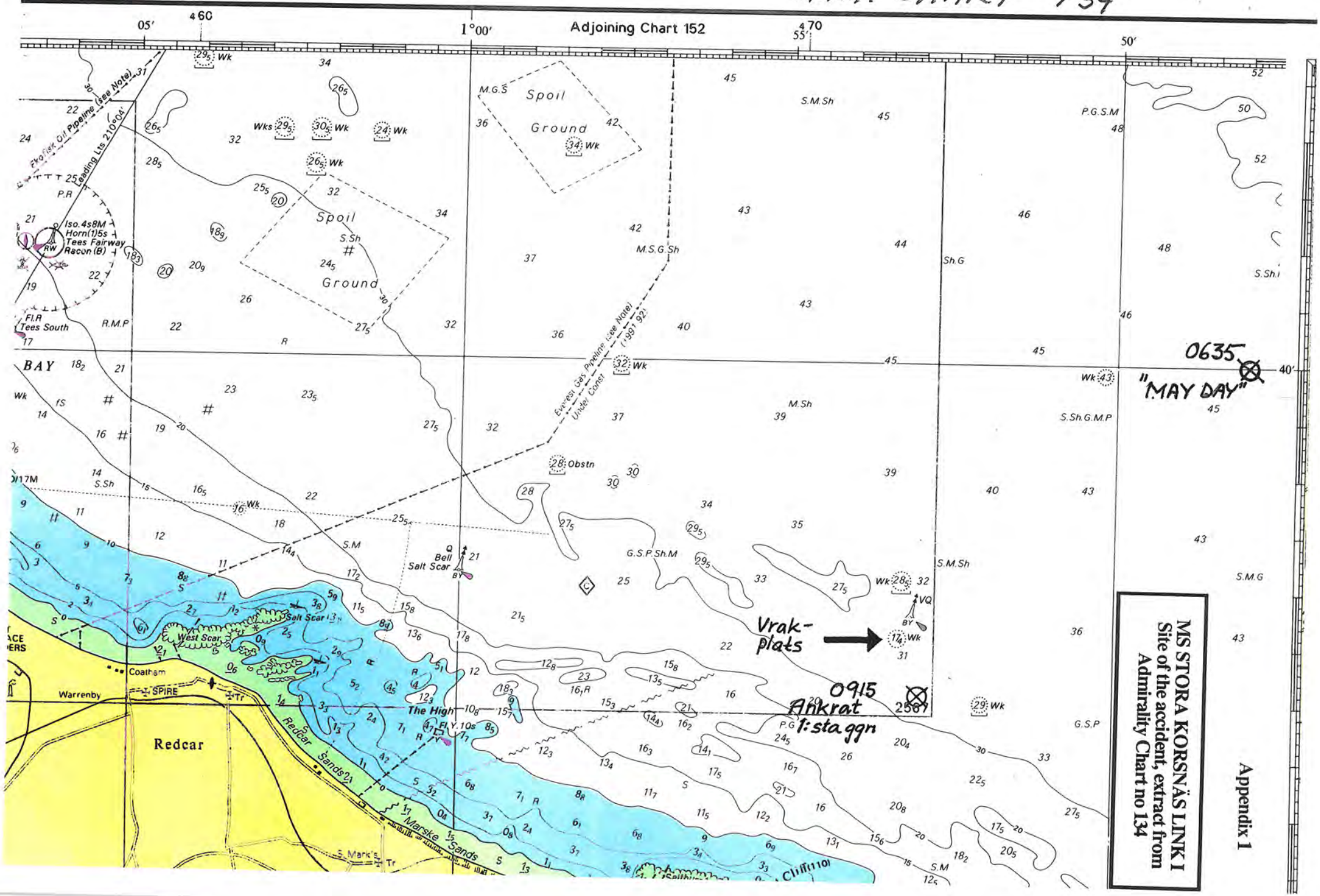


	PAPER	PULP	PIR	TIMBER	CONTS.	TRAIL.	VARIOUS	TOTAL
HARTLEPOOL								
CHATHAM								
TERNEUZEN								
TOTAL								

Appendix 2
(2 pages)
Page 1

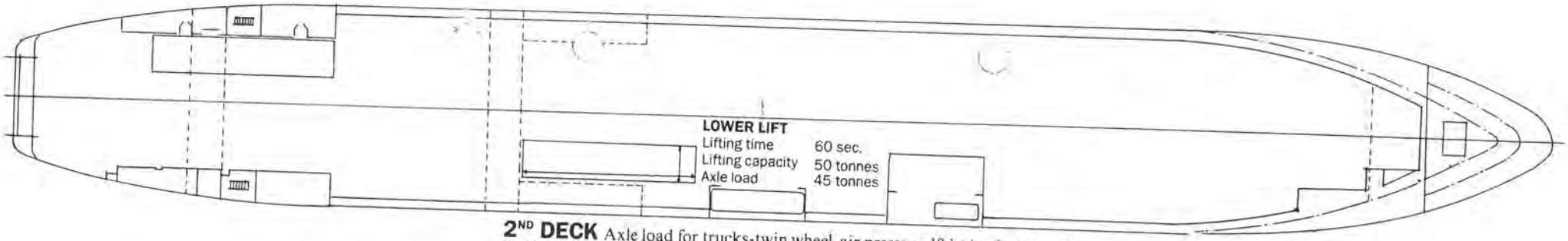
IETRES

Adm. CHART 134



MS STORA KORSNÄS LINK I
Site of the accident, extract from Admirality Chart no 134

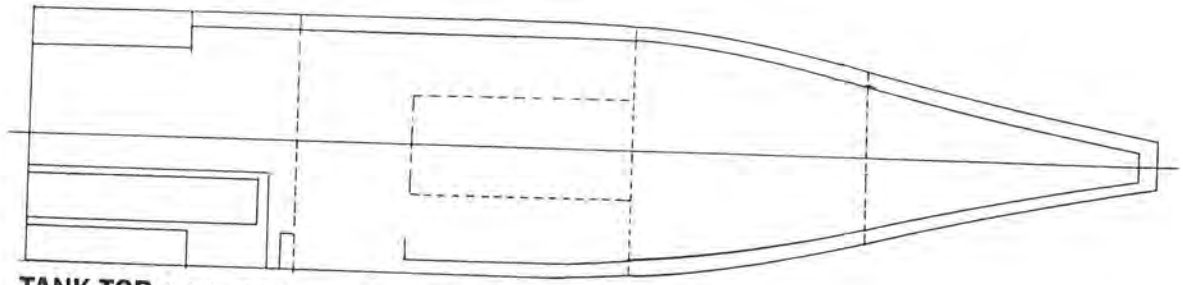
Appendix 1



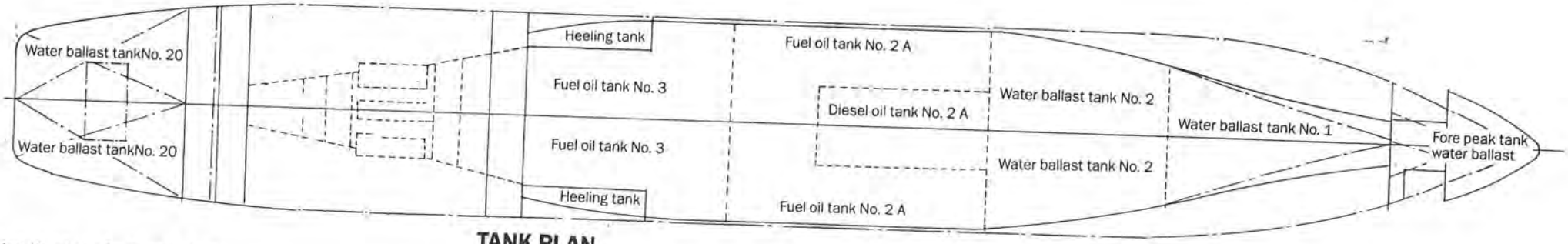
2ND DECK Axle load for trucks-twin wheel air pressure 10 kg/cm² 45 tonne
Uniformly distributed load 3.0 t/m²
Trailers (40') 55 tonne

CARGO CAPACITIES

Compartment	Location	Capacities		Cargo	LCG	VCG
	(Frame No)	Bale (m3)	Grain (m3)	Area (m2)	From ap (m)	(m)
Between Tank top and 2nd deck	64–150	about 5594	about 6740	about 1191	84.9	4.8
Between 2nd and 1st deck	0–158	about 14306	about 16675	about 2670	50.4	11.1
Between 1st and carage deck	5–123		about 10766	about 1923		

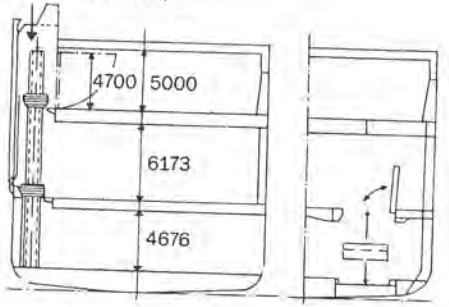


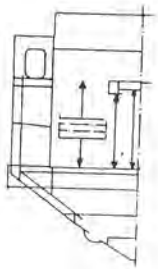
TANK TOP Axle load for trucks-twin wheel air pressure 10 kg/cm² 45 tonne
Uniformly distributed load 3.0 t/m²

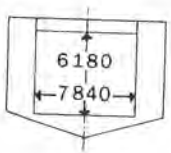


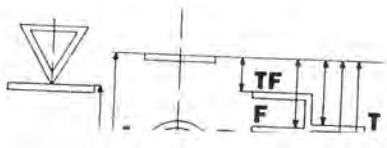
TANK PLAN

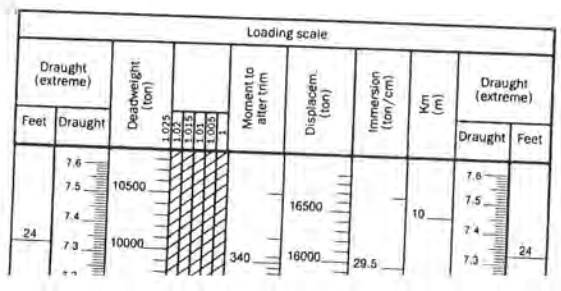
Sideshifter hoist 2 pcs/each door
Lifting capacity 10 tonnes
Speed ABT 30 m/min











MAIN ENGINES

Two 4 stroke 12 cyl. v-eng. single acting non-reversible turbo- charged trunk diesel motors, type 12 pc 2 v.
Make: Lindholmen S.E.M.T. pielstick.
Max. cont. output per motor 4500 mhp at 514 rpm.
The motors are intended for fuel oil of 180 est. Redwood No. 1 at 100°F.

Auxiliary engines
Three HV pielstick diesel engines, type V6 A/12GC, each of 600 BHP at 1200 rpm, each coupled to an 'ASEA' alternator of type CF 500 m, 3 × 400 V, 60 Hz, 520 KVA, cos PHI 0.8.

Steering gear
One of Svendborg type 180/13LD, serving to rudders.

Shaft alternator
One shaft alternator coupled via step-up gear to port main engine, type DKBN 80/580-4, power: 600 kVA at 1800 rpm. Make: A. van Kaick.

Propellers
Two controllable pitch propellers plant, type 86 S 1/4.
Diameter of propellers: 2800 mm, each of 4 blade. Make: Kamewa.

Steering propeller:
One steering propeller plant, electrically driven. Type 800/200/AS-CP. Diameter of propellers 2800 mm, 4 blades, drive motor output 800 HP at 880 rpm. Make: Kamewa.

VENTILATION

Make: Nordisk Ventilator A/S.

Cargo hold No. 1.
Ten axial fans, type adh 900 ps, each capacity of 36000 m³/h three fans for supply, seven fans for both exhaust and supply. Two axial fans, type defor MNMX-110-26 1/1R (reversible), supply 40000 m³/h, exhaust 60000 m³/h.

Cargo hold No. 2.
Four axial fans, type ADH 1120 P5, each capacity of 61000 m³/h two fans for supply, two fans for both exhaust and supply. Two axial fans, type defor MNMX-110-26 1/1R (reversible).
One for supply 60000 m³/h, exhaust 40000 m³/h.
One for exhaust 60000 m³/h, supply 40000 m³/h.
Air changes in holds No:s 1 & 2 at sea 10 times/h, at quayside during loading and unloading 20 times/h.

Garage space.
Two axial fans type defor MNMX-110-26 1/1R for exhaust 60000 m³/h each.

Accomodation
HI-pres. RE-heat. Ventilation plant with electrical reheaters in the room units. Central type Z915, capacity 13900/9250 m³/h. HI-pres. exhaust fan, type CNA-400 for sanitary room.
Low pressure exhaust fan, type CNA 315 for galley and provision store. Low pressure supply fan type ADH 315 for galley and provision store.

TANK CAPACITIES

COMPARTMENT	FRAME NO:S	CUBIC METRES	TONNES
WATER BALLAST S.G. 1.025 t/m³			
Fore peak tank	160-forw.	333.6	341.9
WB tank No. 1	120-152	265.8	272.4
WB tank No. 2 stb	94-120	219.2	224.7
WB Tank No. 2 port.	94-120	219.2	224.7
WB Tank No. 20 stb.	-2-14	237.9	243.9
WB TankNo. 20 port.	-2-14	257.4	263.8
HeelingTank stb.	64-82	233.9	239.7
HeelingTank port.	64-82	233.9	239.7
Total water ballast		2000.9	2050.8
FUEL OIL S.G. 0.952 t/m³			
FO Tank No. 2A stb.	92/2-94	265.9	253.1
FO Tank No. 2Aport.	92/2-94	265.9	253.1
FO Tank No. 3 stb.	64-92/2	282.1	268.6
FO Tank No. 3 port.	64-92/2	333.9	317.9
FO serviceTK No. 15 port.	20-24	60.7	57.8
FO settlingTK No. 18 stb.	20-24	57.0	54.3
FO overflowTank No. 12 stb.	40-51	21.8	20.8
Total fuel oil		1287.3	1225.6
DIESEL OIL S.G. 0.865 t/m³			
DO Tank No. 2A	92/14-94	208.0	179.9
DO Tank No. 4	51-55	44.5	38.5
DO Tank No. 13	24-35	42.2	36.5
DO serviceTK No. 16 port.	20-24	11.2	9.7
DO settlingTK No. 17 stb.	20-24	11.2	9.7
Total diesel oil		317.1	274.1
LUBRICATING OIL S.G. 0.905 t/m³			
LUB. OIL SystemTK No. 5 stb.	40-50	9.8	8.9
LUB. OIL SystemTK No. 5 port.	40-50	9.8	8.9
LUB. OIL StoreTK No. 6 stb.	44-50	9.5	8.6
LUB. OIL Drain.TK No. 7 port.	40-50	14.4	13.0
LUB. OIL Drain.TK No. 8 stb.	40-44	4.9	4.4
LUB. OIL for Kamewa No. 11 stb.	33-34	0.8	0.8
LUB. OIL for Kamewa No. 11 port.	33-34	0.9	0.8
LUB. OIL Tank No. 14 sbt.	26-28	1.6	1.4
LUB. OIL Tank No. 14A stb.	28-30	1.8	1.6
Total of Lubricating Oil		53.6	48.4
FRESH WATER S.G. 1.000 t/m³			
FreshWaterTK No. 19 stb.	14-20	90.7	90.7
FreshWaterTK No. 19 port.	14-20	98.8	98.8
Total of FreshWater	-	189.5	189.5
OTHER TANKS			
Sewage Tank stb.	154-160	15.5	15.5
Sewage Tank port.	152-160	25.7	25.7
Sludge Oil Tank No. 9	35-39	26.3	23.9
Flume Tank I	59-64	401.8	411.8
Flume Tank II	152-160	300.8	308.3
Flume Tank III	95-104	279.4	286.4
Total		1049.5	1071.6

Engine room.
One axial fan, type ADA 1000J6 for supply, capacity 37000 m³/h.
One axial fan, type ADA 1120 P3 for supply capacity 55000 m³/h.
One centrifugal fan, type CM 630/R for comfort plant, capacity 15000 m³/h.
One centrifugal fan, type CNA 630/R for exhaust in separator and auxiliary room, capacity 10600 m³/h.

DECK EQUIPMENT

Watertight side doors.
Two PCS on the SB side, length 8600 mm, height 13000 mm, operation time ABT. 2 min.

Side shifter hoists.
Two PCS on SB side, each door, each hoist has lifting capacity of 10 tonnes, speed ABT. 30 m/min, swinging time 12 s.

Folding doors.
Two PCS, one each opening on the 1st deck.
Clear opening 7,48 × 4,60 m, opening/closing time ABT. 1 min.

Power pack unit (to supply side loading system).
Consist of 4 main pumps, max. working pressure 25 MPa.

EQUIPMENT

Radio: Transmitter-commander,
Receiver-Appollo
Make: Marconi

V.H.F.: Type argounat,
Make: Marconi

Radars: Raython 1020-6S,
Make: Raython
Fr 805 DA,
Make: Furuno

Gyro: Type: Mark 10,
Make: S.G. Brown Ltd.

Radio Direction Finder: Marconi Loadstar 11D.

Echo sounder: Simrad skipper sounder es.

Engine telegraph: Chadburn Press Button Telegraph.

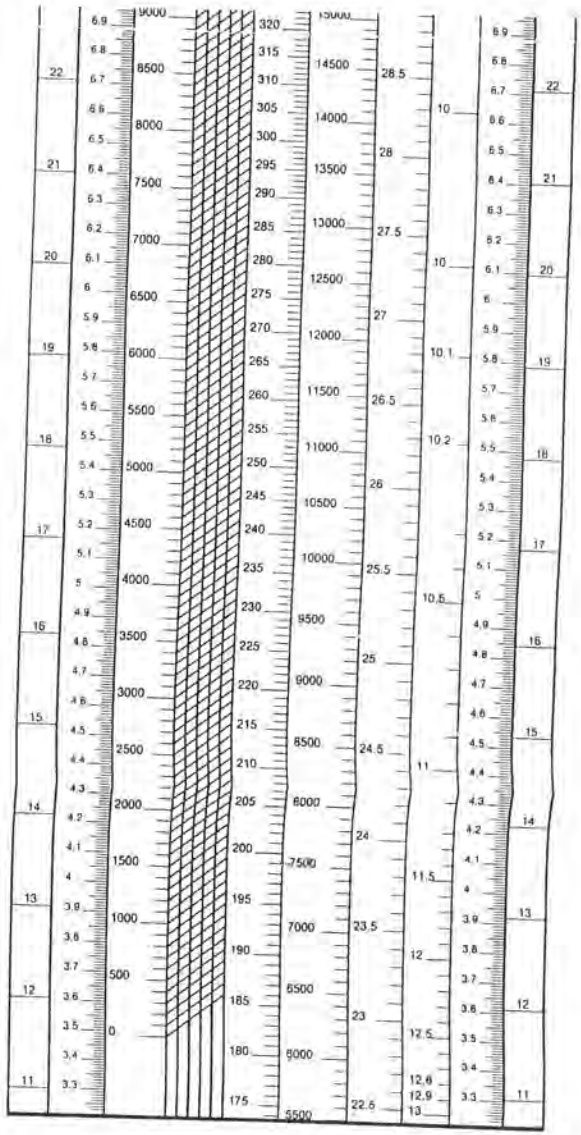
Standard compass: Krohn's Reflector compass mod. 35

Log: Type 8AL24,

Make: Jugner Instrument AB.
Particulars in this drawing are believed to be correct, but are not guaranteed.

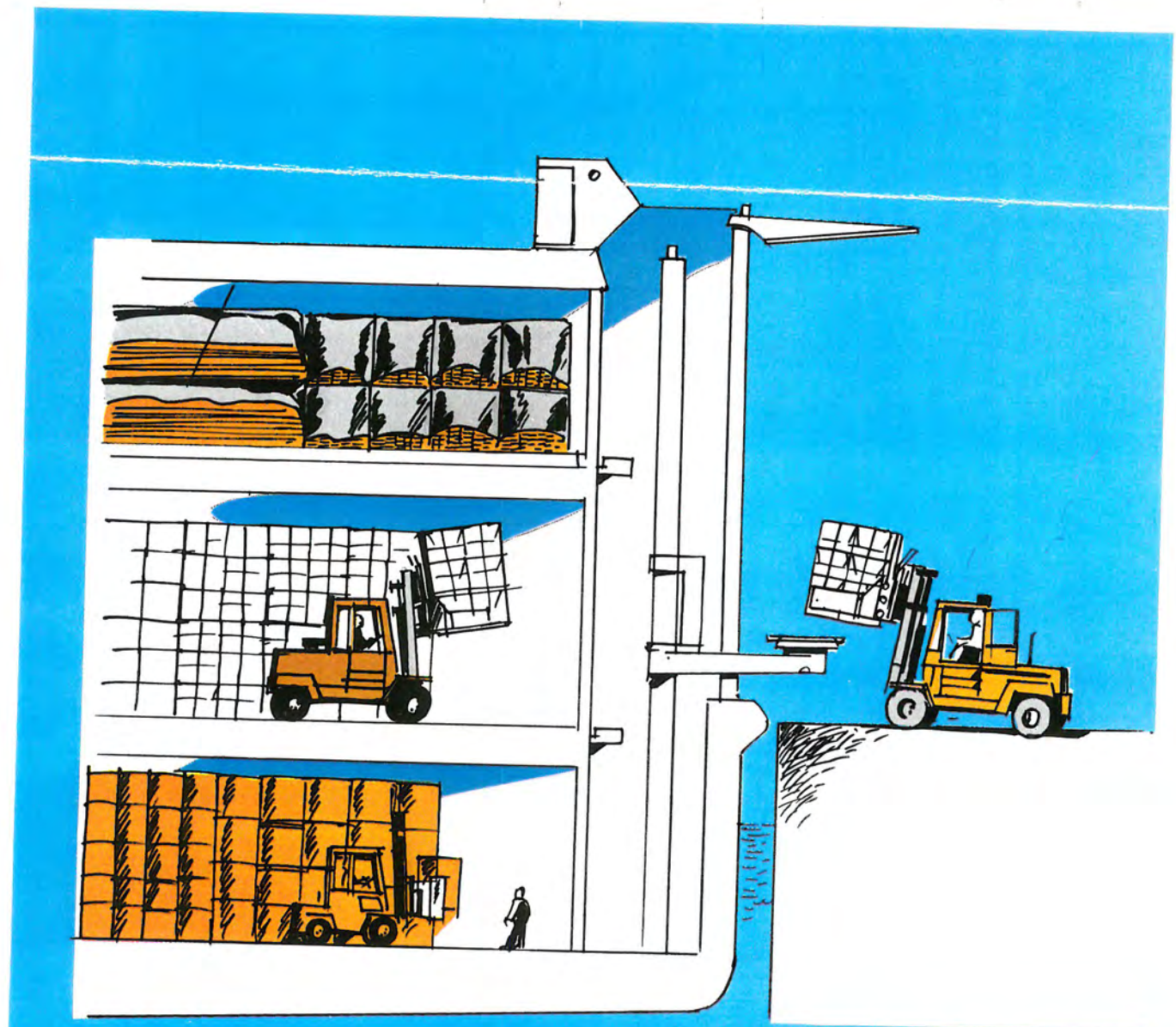
MAIN DIMENSION

Length over all	163.47 m	= 536'-4 3/4"
Length between perps.	145.92 m	= 478'-10"
Breadth moulded	20.60 m	= 67'- 7'
Depth mld to 1st deck	14.70 m	= 48'-2 3/4"
Depth mld to 2nd deck	7.50 m	= 24'-7 1/4"
Deadweight at7 103 mm	9387 t	

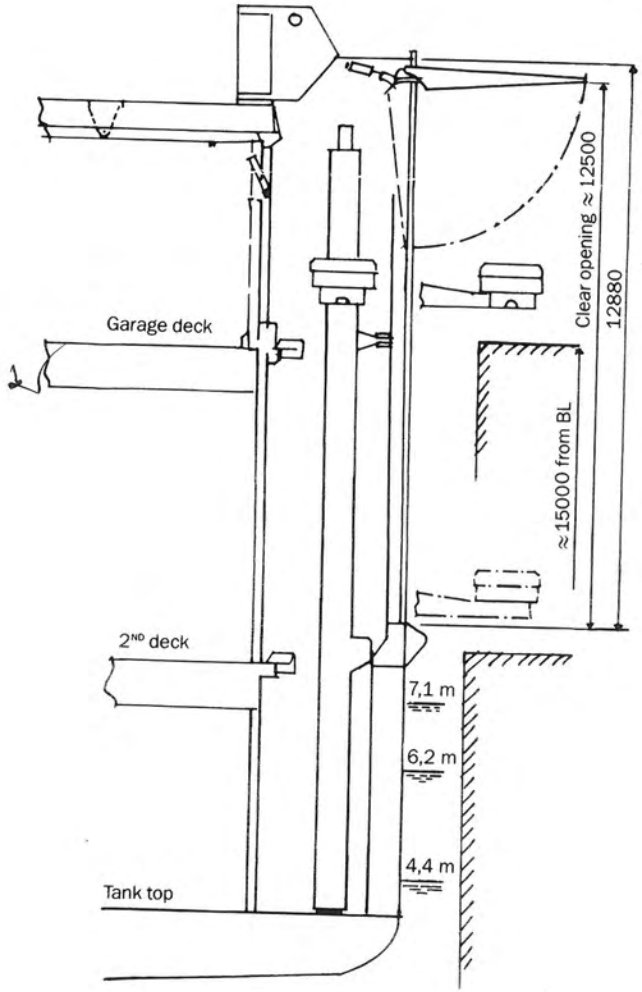


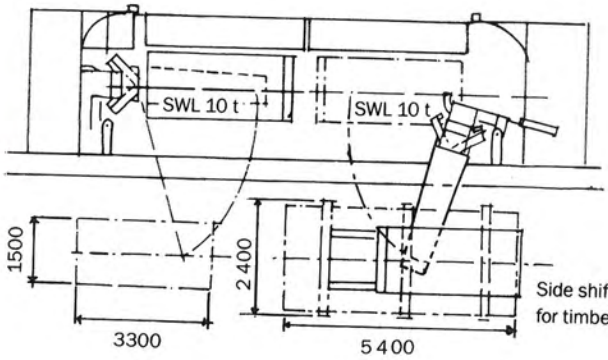
	DRAUGHT		FREEBOARD		DEADWEIGHT	
	mm	feet	mm	feet	tonnes of 1000 kg	S.G.
TF	7384	24.23	146	0.48	9817	1.00
F	7236	23.74	294	0.96	9390	1.00
T	7251	23.79	279	0.92	9821	1.025
S	7103	23.30	427	1.40	9387	1.025
W	6955	22.82	575	1.89	8958	1.025

TONNAGE	INTERNATIO NAL
GROSS	5018.21
NET	2737.74



SIDE LOADING SYSTEM





Side shifter rigged for timber handling

MS STORA KORSNÄS LINK I
IMDG information about sodium chlorate

CLASS 5.1 – Oxidizing substances

SODIUM BROMATE

UN No. 1494 **Formula** $NaBrO_3$

Properties
White deliquescent crystals. Soluble in water.
Reacts vigorously with sulphuric acid.
Reacts fiercely with cyanides when heated or by friction.
May form explosive mixtures with combustible material, powdered metals or ammonium compounds. These mixtures are sensitive to friction and are liable to ignite.
When involved in a fire may cause an explosion.

Packaging group: II

Observations

Label

Packing
See table 2.4 in the introduction to this class.
Bags 5H3, 5H4, 5L3 and 5M2 allowed only in closed cargo transport units.

Stowage
Category A.
"Separated from" powdered metals, ammonium compounds and cyanides.

Packing, Stowage & Segregation
See also General Introduction and introduction to this class

SODIUM CHLORATE

UN No. 1495 **Formula** $NaClO_3$

Properties
Colourless deliquescent crystals. Soluble in water.
Reacts vigorously with sulphuric acid..
Reacts fiercely with cyanides when heated or by friction.
May form explosive mixtures with combustible material, powdered metals or ammonium compounds. These mixtures are sensitive to friction and are liable to ignite.
When involved in a fire may cause an explosion.

Packaging group: II

Observations

Label

Packing
1. See table 2.4 in the introduction to this class. Bags 5H3, 5H4, 5L3 and 5M2 allowed only in closed cargo transport units.

2. Four-ply paper bags with plastics inner bag which are shrink- or stretch- wrapped on to pallets and loaded in a closed freight container (FCL/FCL)*.

For IBCs see section 26 of the General Introduction.
May be carried in bulk in a closed freight container (FCL/FCL)*, see section 25 of the General Introduction.

* Full container load/full container load (door-to-door).

Stowage
Category A.
"Separated from" powdered metals, ammonium compounds and cyanides.

Packing, Stowage & Segregation
See also General Introduction and introduction to this class

CLASS 5.1 – Oxidizing substances

OXIDIZING SUBSTANCES (AGENTS)

CLASS 5.1 – Oxidizing substances

1. PROPERTIES

1.1 Substances of class 5.1 in certain circumstances directly or indirectly evolve oxygen. For this reason oxidizing substances increase the risk and intensity of fire in combustible material with which they come into contact.

1.2 Mixtures of oxidizing substances with combustible material and even with material such as sugar, flour, edible oils, mineral oils, etc., are dangerous. These mixtures are readily ignited, in some cases by friction or impact. They may burn violently and may lead to explosion.

1.3 There will be a violent reaction between most oxidizing substances and liquid acids, evolving toxic gases. Toxic gases may also be evolved when certain oxidizing substances are involved in a fire.

1.4 Some oxidizing substances have toxic or corrosive properties, or have been identified as harmful to the marine environment (MARINE POLLUTANT). This has been indicated in the individual schedules where appropriate.

1.5 The above-mentioned properties are, in general, common to all substances in this class. Additionally, some substances possess specific properties, which should be taken into account in transport. These properties are shown in the individual schedules.

2. PACKING

2.1 Classification and grouping criteria

2.1.1 Oxidizing substances have for packing purposes been apportioned among three categories (packaging groups) according to the degree of danger they present: great danger (packaging group I), medium danger (packaging group II) and minor danger (packaging group III). The packaging group to which a substance has been assigned is given in its individual schedule.

2.1.2 In assigning the packaging group to an oxidizing substance for which no specific packaging group is given in its individual schedule, due account should be taken of the criteria described in chapter 11 of the *United Nations Recommendations on the Transport of Dangerous Goods*. The packaging group of a substance or mixture possessing more than one hazard should be assigned in accordance with subsection 5.2 of the General Introduction.

2.2 Packing – general requirements

2.2.1 Packages of solid oxidizing substances should be at least "effectively closed". Hermetically sealed packages are required for oxidizing substances in packaging group I and for those substances where this is mentioned in their individual schedules.

2.2.2 Parts of packagings which are in direct contact with oxidizing substances should not be affected by chemical or other reaction with these substances. Where necessary, packagings should be provided with a suitable inner liner, coating or treatment. Such parts of packagings should not incorporate constituents liable to react dangerously with the contents so as to form hazardous products, or to weaken the packagings significantly.

2.2.3 Where significant internal pressure may develop in a package by the evolution of gas from the contents (arising from temperature increase or other causes), a vent may be fitted provided the gas emitted will not cause danger, taking into account toxicity, flammability and the quantity evolved. The venting device should be so constructed that liquid will not escape when the package is in an upright position. The outer packaging should be so arranged as not to interfere with the operation of the venting device.

2.2.4 As the vapour pressure of such a liquid with a low boiling point is usually high, the strength of packagings for liquids should be sufficient to withstand, with an ample factor of safety, the internal pressures likely to be generated.

2.2.5 When filling packagings with liquids*, sufficient ullage should be left to ensure that neither leakage nor permanent distortion of the packagings occurs as a result of an expansion of the liquid caused by temperatures likely to occur during transport. Unless specific provisions are prescribed in national or international rules, agreements, or recommendations, liquids should not competely fill a packaging at a temperature of 55°C.

2.2.6 Unless otherwise indicated in the individual schedules, where a percentage of a substance, or of its active ingredient, is stipulated, this refers to the percentage by mass in relation to the total mass of the substance in the state in which it is to be transported.

2.3 **Packing – packaging types and limits**

2.3.1 Except where there are special packing provisions in the individual schedules, the packagings indicated in the table in 2.4 of this introduction should be used.

2.3.1.1 *Glass receptacles* packaged in an outer packaging should be surrounded by inert cushioning material so arranged as to prevent breakage and leakage from the package. For liquids, this cushioning material should also be absorbent. This is not necessary if close-fitting parts of expanded plastics are used as cushioning material and the provisions of the second sentence of 2.3.1.5 are met.

2.3.1.2 Where *glass* is permitted, it should be understood to include earthenware, porcelain and other comparable materials.

2.3.1.3 Where *glass or plastics bottles* are permitted, it should be understood that glass or plastics jars are included.

2.3.1.4 Where *wooden boxes* are permitted as outer packagings, it should be understood that boxes of natural wood (4C), plywood boxes (4D) and reconstituted wood boxes (4F) are included.

2.3.1.5 *Moulded expanded plastics boxes (4H1)* should be constructed of a fire-resistant grade of material. When the contents are not compatible with the outer packaging, each glass bottle should be enclosed in a bag made of plastics material compatible with the contents and the bag should be effectively closed.

2.3.2 A *cylinder* of the kind normally used for compressed gas, approved by the competent authority of the country concerned and with suitable valve protection, may be used to contain an oxidizing substance, provided that the substance is compatible with the material of construction.

2.3.3 *Removable head packagings* should not be used for liquids. However, they may be used for suitable liquids in packaging groups II and III with the approval of the competent authority of the country concerned.

* Viscous substances with an outflow time via a DIN-cup with a 4 mm diameter outlet exceeding 10 minutes at 20°C (corresponding to an outflow time via a Ford cup 4 of more than 690 seconds at 20°C, or to a viscosity of more than 2,680 centistokes at 20°C) should be subject to the provisions applicable for packagings destined for solid subtances.

CLASS 5.1 – Oxidizing substances

2.4 **Packaging specifications for SOLIDS only**

TABLE

Inner packaging	Outer packaging	Packaging code – Annex I –	Maximum gross mass	
			Packaging group	
			II	III
Bottles, glass, maximum contents 10 litres	Wooden box Fibreboard box Moulded expanded plastics box Solid plastics box	4C, 4D, 4F 4G 4H1 4H2	75 kg 40 kg 40 kg 75 kg	75 kg 55 kg 55 kg 75 kg
Bottles, plastics or rubber, maximum contents 30 kg	Wooden box Fibreboard box Moulded expanded plastics box Solid plastics box	4C, 4D, 4F 4G 4H1 4H2	225 kg 40 kg 40 kg 75 kg	225 kg 55 kg 55 kg 75 kg
Cans, metal, maximum contents 40 kg	Wooden box Fibreboard box	4C, 4D, 4F 4G	225 kg 40 kg	225 kg 55 kg
Bags, plastics, maximum contents 5 kg*	Wooden box Fibreboard box	4C, 4D, 4F 4G	225 kg 40 kg	225 kg 55 kg
Plastics receptacle in a:	steel drum steel crate or box aluminium drum aluminium crate or box wooden box plywood drum plywood box fibre drum fibreboard box plastics drum	6HA1 6HA2 6HB1 6HB2 6HC 6HD1 6HD2 6HG1 6HG2 6HH1	400 kg 75 kg 400 kg 75 kg 75 kg 250 kg 75 kg 250 kg 55 kg 400 kg	400 kg 75 kg 400 kg 75 kg 75 kg 250 kg 75 kg 250 kg 55 kg 400 kg
Drum, steel Drum, aluminium Drum, plywood* Drum, fibre* Drum, plastics		1A2 1B2 1D 1G 1H2	400 kg 400 kg 250 kg 250 kg 400 kg	400 kg 400 kg 250 kg 250 kg 400 kg
Barrel, wooden, slack type*		2C2	300 kg	300 kg
Box, natural wood, with sift-proof walls* Box, plywood* Box, reconstituted wood* Box, fibreboard*		4C2 4D 4F 4G	225 kg 225 kg 225 kg 55 kg	225 kg 225 kg 225 kg 55 kg
Bag, woven plastics, water resistant* Bag, plastics film* Bag, textile, water resistant* Bag, paper, multiwall, water resistant*		5H3 5H4 5L3 5M2	55 kg 55 kg 55 kg 55 kg	55 kg 55 kg 55 kg 55 kg

* These packagings should not be used when the contents are likely to melt during the intended voyage.

CLASS 5.1 – Oxidizing substances

3. STOWAGE

3.1 Class 5.1 oxidizing substances should be stowed as indicated in the individual schedules in accordance with one of the categories specified below.

3.1.1 *Stowage category A*

Cargo ships or passenger ships carrying a number of passengers limited to not more than 25, or to 1 passenger per 3 metres of overall length whichever is the greater number	ON DECK OR UNDER DECK
Other passenger ships in which the limiting number of passengers carried is exceeded	ON DECK OR UNDER DECK

3.1.2 *Stowage category B*

Cargo ships or passenger ships carrying a number of passengers limited to not more than 25, or to 1 passenger per 3 metres of overall length whichever is the greater number	ON DECK OR UNDER DECK
Other passenger ships in which the limiting number of passengers carried is exceeded	ON DECK ONLY

3.1.3 *Stowage category C*

Cargo ships or passenger ships carrying a number of passengers limited to not more than 25, or to 1 passenger per 3 metres of overall length whichever is the greater number	ON DECK ONLY
Other passenger ships in which the limiting number of passengers carried is exceeded	ON DECK ONLY

3.1.4 *Stowage category D*

Cargo ships or passenger ships carrying a number of passengers limited to not more than 25, or to 1 passenger per 3 metres of overall length whichever is the greater number	ON DECK ONLY
Other passenger ships in which the limiting number of passengers carried is exceeded	PROHIBITED

3.1.5 *Stowage category E*

Cargo ships or passenger ships carrying a number of passengers limited to not more than 25, or to 1 passenger per 3 metres of overall length whichever is the greater number	ON DECK OR UNDER DECK
Other passenger ships in which the limiting number of passengers carried is exceeded	PROHIBITED

CLASS 5.1 – Oxidizing substances

3.2 **General stowage precautions**

3.2.1 Before loading oxidizing substances, attention should be paid to the proper cleaning of the cargo spaces into which they will be loaded. Particular attention should be paid to the removal of all combustible material which is not necessary for the stowage of such cargoes.

3.2.2 As far as reasonably practicable, non-combustible securing and protecting materials, and only a minimum of clean dry wooden dunnage, should be used.

3.2.3 Precautions should be taken to avoid the penetration of oxidizing substances into other cargo spaces, bilges, etc. which may contain combustible material.

3.2.4 After discharge, cargo spaces used for the transport of oxidizing substances should be inspected for contamination. A space which has been contaminated should be properly cleaned and examined before being used for other cargoes, especially foodstuffs.

3.2.5 Where it is deemed necessary for an oxidizing substance to be stowed "clear of living quarters", this is included in its individual schedule.

3.2.6 For stowage in relation to foodstuffs, see subsection 14.18 of the General Introduction and the individual schedules.

3.2.7 Packages from which there is apparent leakage or spillage should be refused for shipment.

3.2.8 Fibreboard boxes should be stowed under deck or, if they are stowed on deck, should be so protected that at no time are they exposed to the weather or to seawater.

3.3 **General stowage precautions for substances harmful to the marine environment (MARINE POLLUTANTS)**

3.3.1 Where stowage is permitted "on deck or under deck", under deck stowage is preferred except when a weather deck provides equivalent protection.

3.3.2 Where stowage "on deck only" is required, preference should be given to stowage on well-protected decks or to stowage inboard in sheltered areas of exposed decks.

4. SEGREGATION

4.1 **Segregation from other dangerous goods**

4.1.1 Requirements in this respect will be found in section 15 of the General Introduction.

(Pages 5106 to 5119 have be reserved for future amendmen

COMBI SHIPPING AB

B/L NO	REF	RECEIVER	PRODUCT	UNITS	QTY
91081001	FM 1058	FRANS MAAS	BEVILINE 200 RA	921 PAPERBAGS	23.025
	FM 5001		BEVILITE 62-85	450 PAPERBAGS	11.250
			BEVITACK 2000	435 PAPERBAGS	10.875
	~~FM 9000~~ 1268		BEVILITE 62-107	900 PAPERBAGS	22.500
	FM 1189		BEVITACK 125/15	225 PAPERBAGS	5.625
			BEVILITE 62-107	632 PAPERBAGS	15.800
			BEVILINE M 95 RA	43 PLASTIC BAGS	1.075
			30 SAMPLE	1 BOX	0.004
	FM 7084		BEVILINE 200 RA	90 PAPERBAGS	2.250
			BEVILINE 200 RA	40 BIG BAGS	20.000

112.404

SHIPPER: FREIGHT MASTERS TRSP & SHIPPING AB

M A N I F E S T

VESSEL: S/K LINK 1

VOY: 91081

PORT: HARTLEPOOL

DEPART: 1991-10-29

MS STORA KORSNÄS LINK I
Product information for
rosin ester

Appendix 5
(7 pages)
1 (7)

PRODUCT INFORMATION

Classification, Composition and Properties

Date of issue: 1991-06-20

Manufacturer/Supplier: BERGVIK KEMI AB

Address: P.O. Box 66
S-820 22 SANDARNE
Sweden

Trade name: ~~DEVIPALE 100~~ BEVILINE 200 RA

Chemical or technical name: Rosin ester

Information issued by/contact person/department: Product Regulatory Affairs

Phone No.: +46 2706 1350

CLASSIFICATION ACCORDING TO SWEDISH LEGISLATION

Product hazardous to health
☐ Poison ☐ Hazardous other than poison ☒ No

Pesticide
☐ Class 1 ☐ Class 2 ☐ Class 3 Reg. No. ☒ No

Labelling sub-class(es)—Product hazardous to health
☐ Very toxic ☐ Toxic ☐ Highly corrosive ☐ Corrosive ☐ Irritant ☐ Harmful ☐ May be harmful

Inflammable product
☐ 1 ☐ 2a ☐ 2b ☐ 3 ☐ Inflammable gas ☒ No

Explosive product
Transp. class ☐ A ☐ B ☐ C ☐ D ☐ E ☒ No

☐ Extremely/highly inflammable ☐ Inflammable ☐ Explosive ☐ Oxidizing

TRANSPORTATION CLASSIFICATION

UN	IMDG (sea)				ADR/RID (road, rail)		DGR (air)
Packaging group UN No.	Class	Page	EmS No	MFAG No	Class	Item	Class

INFORMATION ON COMPOSITION

A. Substances which give the product its health-risk properties, if any.-State if possible CAS No.

	Contents	TLV	Remarks

B. Other substances

Ester of tall oil rosin	100 %		

PHYSICO-CHEMICAL PROPERTIES

General description (form, colour, smell, viscosity etc)
Solid yellowish-brown material with weak odour.

Boiling point °C	Solidif./melt. point 100 °C	Density 1070 kg/m³	Rel. vap. dens. (air = 1)
Flash point >200 °C	Auto-ignition temp. °C	Explosive limits in air vol %	Solubility in organic solvents: Good
Vapour pressure at °C mmHg kPa	pH in concentrate	Rel. evaporation rate Ether = 1: BuAc = 100:	
Specific properties or risks	pH in dilution as used (%)		Solubility in water at °C weight %: Not soluble

BIOLOGICAL PROPERTIES

OTHER INFORMATION

Kemikontorets Förlag, Stockholm 1984

This form has been prepared by Kemikontoret (The Association of Swedish Chemical Industries) and PKL (The Swedish Plastics and Chemicals Suppliers Association) in collaboration with LO (The Swedish Trade Union Confederation), SAF (The Swedish Employers' Confederation), KTF (Cosmetic, Toiletry and Household Products Association), SPI (Swedish Petroleum Institute) and SVEFF (Swedish Paint Association) after consultation with the National Board of Occupational Safety and Health. The form and instructions on how to fill it in can be ordered from Kemikontorets Förlag AB, Box 5501, 11485 Stockholm, or PKL, Box 5512, 11485 Stockholm.

PRODUCT INFORMATION

Classification, Composition and Properties

Date of issue: 1990-01-24

Manufacturer/Supplier: Bergvik Kemi AB

Address: Box 66
S-820 22 SANDARNE
Sweden

Trade name: BEVILITE 62-85

Chemical or technical name: Rosin ester

Information issued by/contact person/department: Research and Development

Phone No.: +46 27061350

CLASSIFICATION ACCORDING TO SWEDISH LEGISLATION

Product hazardous to health
☐ Poison ☐ Hazardous other than poison ☒ No

Pesticide
☐ Class 1 ☐ Class 2 ☐ Class 3 Reg. No. ☒ No

Labelling sub-class(es)–Product hazardous to health
☐ Very toxic ☐ Toxic ☐ Highly corrosive ☐ Corrosive ☐ Irritant ☐ Harmful ☐ May be harmful

Inflammable product
☐ 1 ☐ 2a ☐ 2b ☐ 3 ☐ Inflammable gas ☒ No

Explosive product
Transp. class ☐ A ☐ B ☐ C ☐ D ☐ E ☒ No

☐ Extremely/highly inflammable ☐ Inflammable ☐ Explosive ☐ Oxidizing

TRANSPORTATION CLASSIFICATION

UN		IMDG (sea)				ADR/RID (road, rail)		DGR (air)
Packaging group	UN No.	Class	Page	EmS No	MFAG No	Class	Item	Class

INFORMATION ON COMPOSITION

A. Substances which give the product its health-risk properties, if any.-State if possible CAS No.

	Contents	TLV	Remarks

B. Other substances

Rosin ester	100 %		

PHYSICO-CHEMICAL PROPERTIES

General description (form, colour, smell, viscosity etc)
Very pale brittle pastilles, neutral in odour.

Boiling point °C	Solidif./melt. point ~ 85 °C	Density ~ 1070 kg/m³	Rel. vap. dens. (air = 1)
Flash point > 200 °C	Auto-ignition temp. - °C	Explosive limits in air - vol %	Solubility in organic solvents most common solvents
Vapour pressure at - °C mmHg kPa	pH in concentrate - pH in dilution as used (%)	Rel. evaporation rate Ether = 1: BuAc = 100:	

Specific properties or risks
Acid value: 5-10. Colour (Gardner 1:1 in Toluen): 2-3

Solubility in water at °C weight %
insoluble

BIOLOGICAL PROPERTIES

Biodegradable

OTHER INFORMATION

The product has received a Certificate of Conformity (Unbedenklichkeitserklärung) by ISEGA after testing according to Bundesgesundheitsamt (BGA) for use in contact with food and meets the requirements of the code of Federal Regulations Title 21, 175.105 (Adhesives).

This form has been prepared by Kemikontoret (The Association of Swedish Chemical Industries) and PKL (The Swedish Plastics and Chemicals Suppliers Association) in collaboration with LO (The Swedish Trade Union Confederation), SAF (The Swedish Employers' Confederation), KTF (Cosmetic, Toiletry and Household Products Association), SPI (Swedish Petroleum Institute) and SVEFF (Swedish Paint Association) after consultation with the National Board of Occupational Safety and Health. The form and instructions on how to fill it in can be ordered from Kemikontorets Förlag AB, Box 5501, 11485 Stockholm, or PKL, Box 5512, 11485 Stockholm.

PRODUCT INFORMATION

Classification, Composition and Properties

Date of issue	
1987-01-22	

Manufacturer/Supplier	Trade name
Bergvik Kemi AB	BEVITACK 2000
Address	**Chemical or technical name**
Box 66 S-820 22 SANDARNE Sweden	Rosin Ester
	Information issued by/contact person/department — Phone No.
	Technical Department — +46 270 61350

CLASSIFICATION ACCORDING TO SWEDISH LEGISLATION

Product hazardous to health

☐ Poison ☐ Hazardous other than poison ☒ No

Pesticide

☐ Class 1 ☐ Class 2 ☐ Class 3 Reg. No. ☒ No

Labelling sub-class(es)–Product hazardous to health

☐ Very toxic ☐ Toxic ☐ Highly corrosive ☐ Corrosive ☐ Irritant ☐ Harmful ☐ May be harmful

Inflammable product

☐ 1 ☐ 2a ☐ 2b ☐ 3 ☐ Inflammable gas ☒ No

Explosive product

Transp. class ☐ A ☐ B ☐ C ☐ D ☐ E ☒ No

☐ Extremely/highly inflammable ☐ Inflammable ☐ Explosive ☐ Oxidizing

TRANSPORTATION CLASSIFICATION

UN	IMDG (sea)				ADR/RID (road, rail)		DGR (air)
Packaging group UN No.	Class	Page	EmS No	MFAG No	Class	Item	Class

INFORMATION ON COMPOSITION

A. Substances which give the product its health-risk properties, if any.-State if possible CAS No.	Contents	TLV	Remarks
B. Other substances			
Pentaerythritol Ester of Tall Oil Rosin CAS-No 8050-26-8	100 %		

PHYSICO-CHEMICAL PROPERTIES

General description (form, colour, smell, viscosity etc)

Yellowish-brown, solid material with weak odour.

Boiling point °C	Solidif./melt. point 97 °C	Density 1070 kg/m³	Rel. vap. dens. (air = 1)		
Flash point >200 °C	Auto-ignition temp. °C	Explosive limits in air vol %	Solubility in organic solvents		
Vapour pressure at °C	pH in concentrate	Rel. evaporation rate	Good		
mmHg kPa	pH in dilution as used (%)	Ether = 1: BuAc = 100:			
Specific properties or risks			Solubility in water at °C weight%		
			Non-soluble		

BIOLOGICAL PROPERTIES

The product is biodegradable.

OTHER INFORMATION

The product meets the requirements in the Code of Federal Regulations, Title 21, No: 175.105, 175.300, 176.210, 177.1210, 177.2600.

This form has been prepared by Kemikontoret (The Association of Swedish Chemical Industries) and PKL (The Swedish Plastics and Chemicals Suppliers Association) in collaboration with LO (The Swedish Trade Union Confederation), SAF (The Swedish Employers' Confederation), KTF (Cosmetic, Toiletry and Household Products Association), SPI (Swedish Petroleum Institute) and SVEFF (Swedish Paint Association) after consultation with the National Board of Occupational Safety and Health. The form and instructions on how to fill it in can be ordered from Kemikontorets Förlag AB, Box 5501, 11485 Stockholm, or PKL, Box 5512, 11485 Stockholm.

PRODUCT INFORMATION

Classification, Composition and Properties

Date of issue: 1989-10-11

Manufacturer/Supplier: Bergvik Kemi AB

Address: Box 66, S-820 22 SANDARNE, Sweden

Trade name: BEVILITE 62-107

Chemical or technical name: Rosin ester

Information issued by/contact person/department: Research and Development — Phone No.: +4627061350

CLASSIFICATION ACCORDING TO SWEDISH LEGISLATION

Product hazardous to health: ☐ Poison ☐ Hazardous other than poison ☒ No

Pesticide: ☐ Class 1 ☐ Class 2 ☐ Class 3 Reg. No. ☒ No

Labelling sub-class(es)–Product hazardous to health: ☐ Very toxic ☐ Toxic ☐ Highly corrosive ☐ Corrosive ☐ Irritant ☐ Harmful ☐ May be harmful

Inflammable product: ☐ 1 ☐ 2a ☐ 2b ☐ 3 ☐ Inflammable gas ☒ No

Explosive product: Transp. class ☐ A ☐ B ☐ C ☐ D ☐ E ☒ No

☐ Extremely/highly inflammable ☐ Inflammable ☐ Explosive ☐ Oxidizing

TRANSPORTATION CLASSIFICATION

UN	IMDG (see)					ADR/RID (road, rail)		DGR (air)
Packaging group UN No.	Class	Page	EmS No	MFAG No		Class	Item	Class

INFORMATION ON COMPOSITION

A. Substances which give the product its health-risk properties, if any. State if possible CAS No.	Contents	TLV	Remarks
B. Other substances			
Ester of Tall Oil Rosin	100 %		

PHYSICO-CHEMICAL PROPERTIES

General description (form, colour, smell, viscosity etc): Very pale and neutral in odour, at room temperature solid pastilles in paper bags.

Boiling point °C	Solidif./melt. point ~105 °C	Density ~ 1080 kg/m³	Rel. vap. dens. (air = 1)
Flash point > 200 °C	Auto-ignition temp. – °C	Explosive limits in air – vol %	Solubility in organic solvents: Good
Vapour pressure at – °C: – mmHg – kPa	pH in concentrate –	Rel. evaporation rate: Ether = 1: BuAc = 100:	
	pH in dilution as used (%)		

Specific properties or risks: Acid value: 4-9, Colour (Gardner) 1:1 in Toluen: 2-3

Solubility in water at °C weight%: Not soluble

BIOLOGICAL PROPERTIES

The product is biodegradable

OTHER INFORMATION

Acidity: about 6 mg KOH/g
The product meets the requirements in the Code of Federal Regulations, Title 21, No: 175.105, 175.300, 176.210, 177.1210, 177.2600

This form has been prepared by Kemikontoret (The Association of Swedish Chemical Industries) and PKL (The Swedish Plastics and Chemicals Suppliers Association) in collaboration with LO (The Swedish Trade Union Confederation), SAF (The Swedish Employers' Confederation), KTF (Cosmetic, Toiletry and Household Products Association), SPI (Swedish Petroleum Institute) and SVEFF (Swedish Paint Association) after consultation with the National Board of Occupational Safety and Health. The form and instructions on how to fill it in can be ordered from Kemikontorets Förlag AB, Box 5501, 114 85 Stockholm, or PKL, Box 5512, 114 85 Stockholm.

PRODUCT INFORMATION

Classification, Composition and Properties

Date of issue: 1987-01-22	
Manufacturer/Supplier: Bergvik Kemi AB	Trade name: BEVITACK 125/15
Address: Box 66 S-820 22 SANDARNE Sweden	Chemical or technical name: Rosin.Ester
	Information issued by/contact person/department: Technical Department — Phone No. +46 270 61350

CLASSIFICATION ACCORDING TO SWEDISH LEGISLATION

Product hazardous to health: [ ] Poison [ ] Hazardous other than poison [X] No	Inflammable product: [ ] 1 [ ] 2a [ ] 2b [ ] 3 [ ] Inflammable gas [X] No
Pesticide: [ ] Class 1 [ ] Class 2 [ ] Class 3 Reg. No. [X] No	Explosive product: Transp. class [ ] A [ ] B [ ] C [ ] D [ ] E [X] No
Labelling sub-class(es)—Product hazardous to health: [ ] Very toxic [ ] Toxic [ ] Highly corrosive [ ] Corrosive [ ] Irritant [ ] Harmful [ ] May be harmful	[ ] Extremely/highly inflammable [ ] Inflammable [ ] Explosive [ ] Oxidizing

TRANSPORTATION CLASSIFICATION

UN Packaging group	UN No.	IMDG (sea) Class	Page	EmS No	MFAG No	ADR/RID (road, rail) Class	Item	DGR (air) Class

INFORMATION ON COMPOSITION

A. Substances which give the product its health-risk properties, if any.-State if possible CAS No.	Contents	TLV	Remarks
B. Other substances			
Pentaerythritol Ester of Tall Oil Rosin CAS No 65997-12-8	100 %		

PHYSICO-CHEMICAL PROPERTIES

General description (form, colour, smell, viscosity etc)

Yellowish-brown, solid material with weak odour.

Boiling point °C	Solidif./melt. point 125 °C	Density 1070 kg/m³	Rel. vap. dens. (air = 1)
Flash point > 200 °C	Auto-ignition temp. °C	Explosive limits in air vol %	Solubility in organic solvents: Good
Vapour pressure at °C mmHg kPa	pH in concentrate pH in dilution as used (%)	Rel. evaporation rate Ether = 1: BuAc = 100:	
Specific properties or risks			Solubility in water at °C weight%: Non-soluble

BIOLOGICAL PROPERTIES

The product is biodegradable.

OTHER INFORMATION

The product meets the requirements in the Code of Federal Regulations, Title 21, No: 175.105, 175.300, 176.210, 177.1210, 177.2600.

VARUINFORMATION

om klassificering, sammansättning och egenskaper

Utfärdandedatum	
1986-11-10	

Tillverkare/Leverantör	Handelsnamn
Bergvik Kemi AB	BEVILINE M 95 RA
Adress	**Kemisk eller teknisk produktbenämning**
Box 66 820 22 SANDARNE	Maleinatharts
	Utfärdare/kontaktperson/avdelning — **tel nr**
	Forskning och Utveckling — 0270/61350

KLASSIFICERING ENLIGT SVENSK LAGSTIFTNING

Hälsofarlig vara

☐ Gift ☐ Vådligt ☒ Nej

Bekämpningsmedel

☐ Klass 1 ☐ Klass 2 ☐ Klass 3 Reg nr: ☒ Nej

Märkningskategori(er) – Hälsofarlig vara

☐ Mycket giftig ☐ Giftig ☐ Starkt frätande ☐ Frätande ☐ Irriterande ☐ Hälsoskadlig ☐ Övr hälsofarlig

Brandfarlig vara

☐ 1 ☐ 2a ☐ 2b ☐ 3 ☐ Brandfarlig gas ☒ Nej

Explosiv vara

Transportklass ☐ A ☐ B ☐ C ☐ D ☐ E ☒ Nej

☐ Mycket brandfarlig ☐ Brandfarlig ☐ Explosiv ☐ Oxiderande

TRANSPORTKLASSIFICERING

FN		IMDG (sjö)				ADR/RID/ADR-S/RID-S (väg)		DGR (flyg)
Förp.grupp	FN nr	Class	Page	EmS No	MFAG No	Klass	Varunr	Class

SAMMANSÄTTNINGSUPPGIFTER

A Ämnen som ger varan dess av hälsofarlighet – ange om möjligt CAS-nr	Halt	Hyg. gränsv.	Anm.
B Andra ämnen			
Ester av maleinsyra-hartssyra-addukt från tallharts	100 %		

FYSIKALISKA/KEMISKA EGENSKAPER

Varubeskrivning (form, färg, lukt, viskositet etc)

Sprött, flingformat, gulbrunt harts med svag lukt.

Kokpunkt	C°	Stelp-/smältp	135 C°	Densitet	1086 kg/m³	Rel. gasdens. (luft = 1)	
Flampunkt	>200 C°	Tändtemp	C°	Expl.omr.	vol %	Lösl. i org. lösn.medel	
Ångtryck vid	C°	pH i koncentrat		Rel. avdunstningshastighet			
mmHg	kPa	pH i brukslösn. (%)		Eter = 1:	BuAc = 100:	Ja	

Spec. egenskaper eller risker

Lösl. i vatten vid C° vikt%

Nej

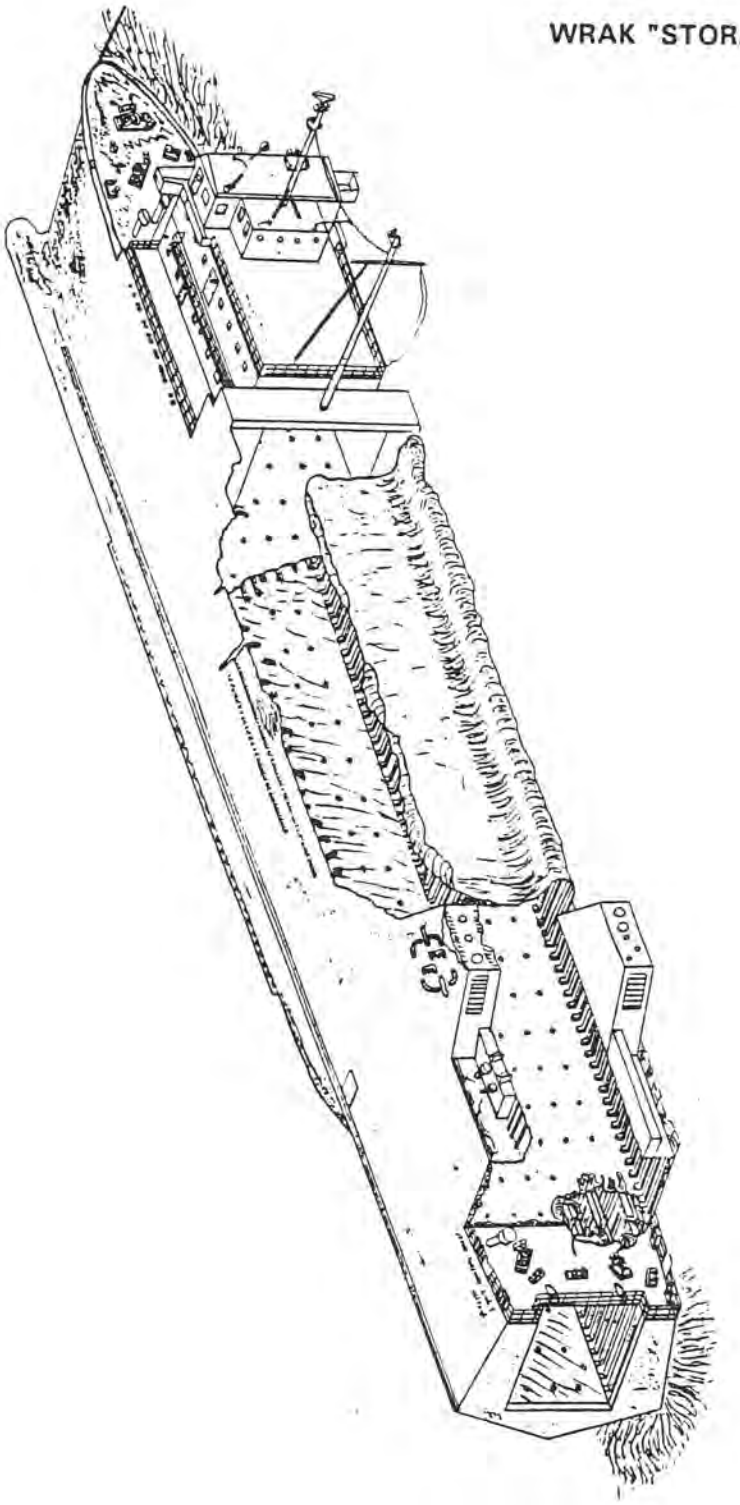
BIOLOGISKA EGENSKAPER

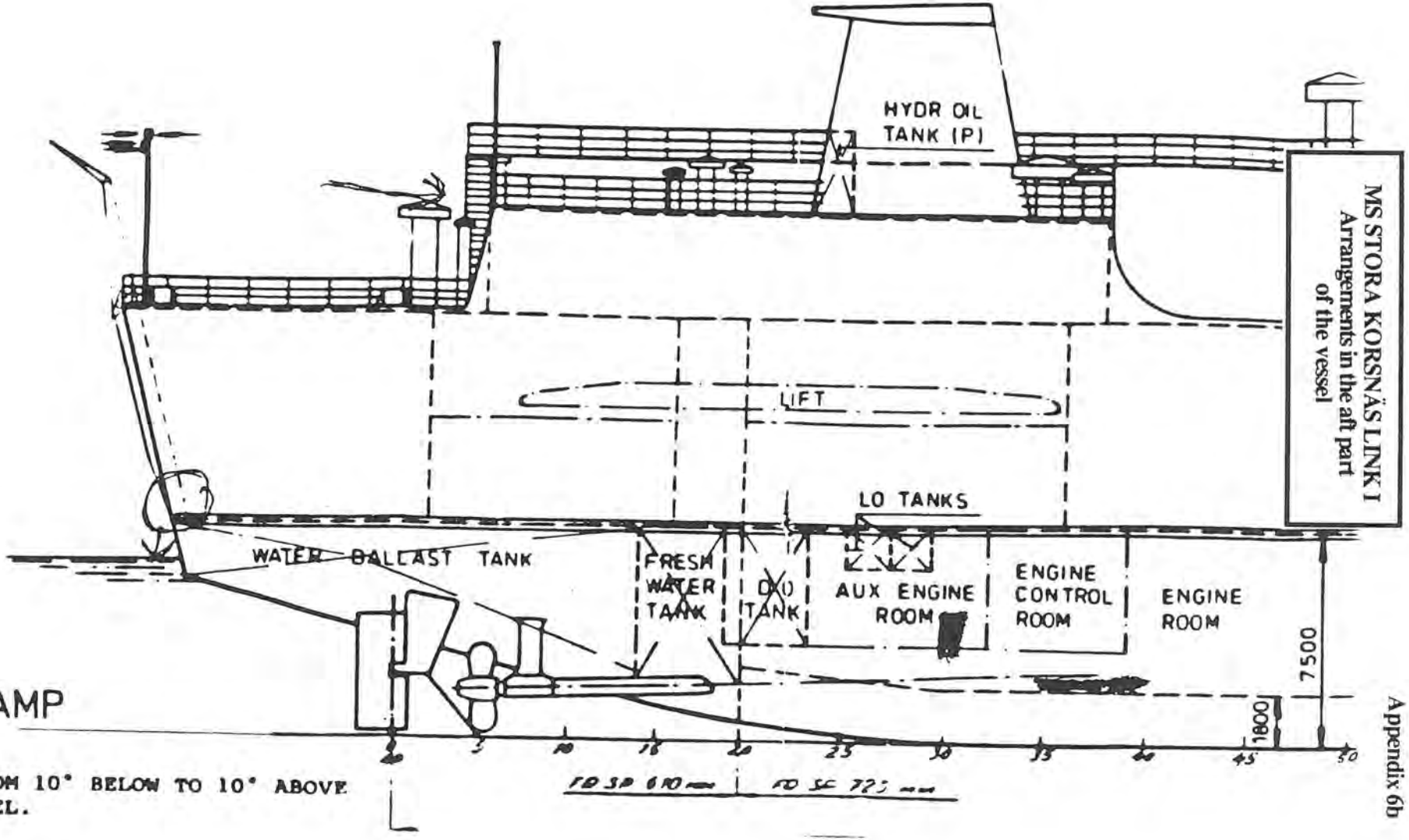
Hartset är biologiskt nedbrytbart. Har låg akut och subakut toxicitet.

ÖVRIG INFORMATION

Denna blanken har utarbetats av Kemikontoret och PKL i samarbete med LO och SAF samt KTF, SPI och SVEFF, efter samråd med Arbetarskydd styrelsen. Beställning av blanketter med anvisningar kan göras hos Kemikontorets Förlag AB, Box 5501, 11485 Stockholm, eller PKL, Box 551 11485 Stockholm.

MS STORA KORSNÄS LINK I
Sketch of the sunken vessel



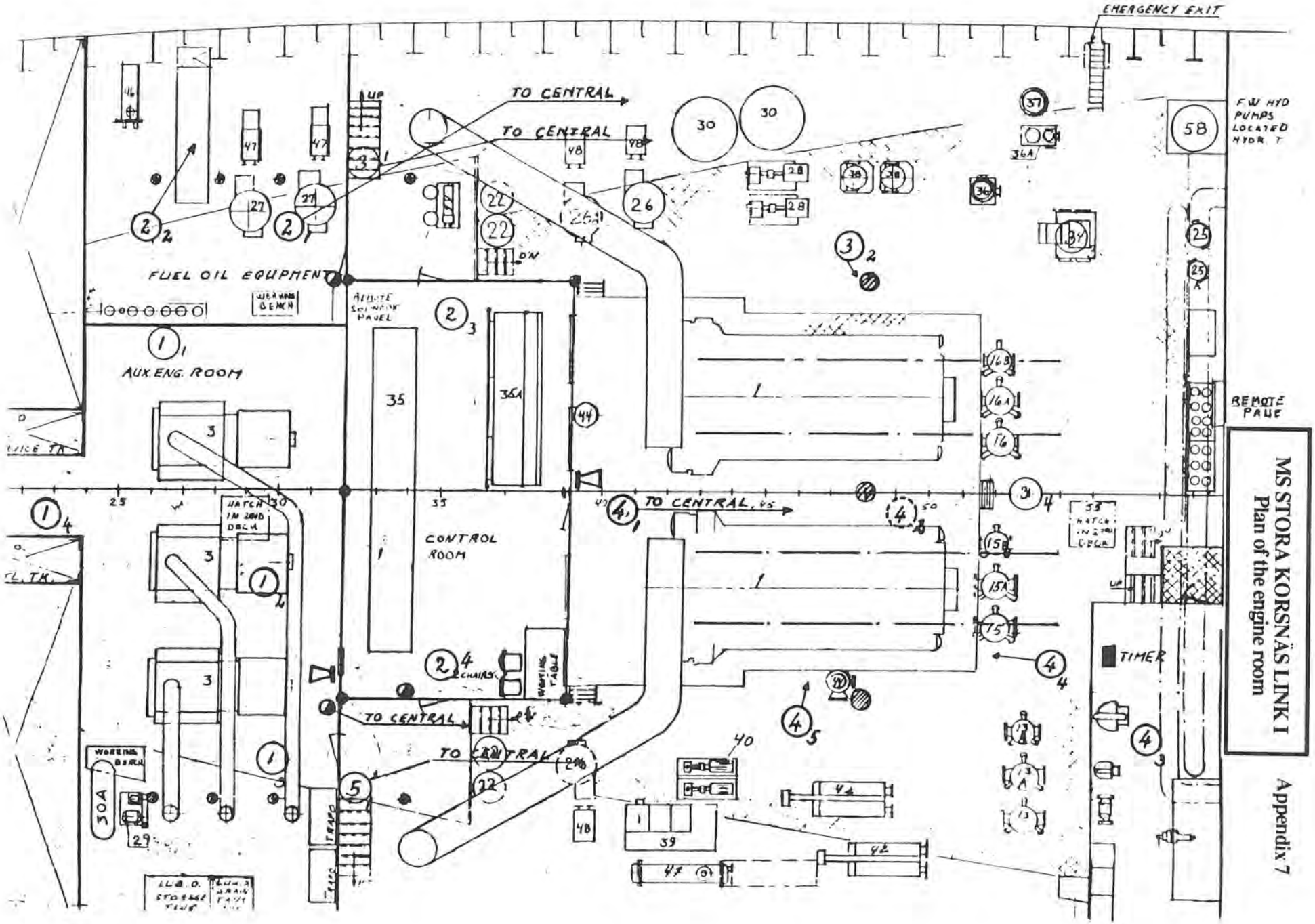


MS STORA KORSNÄS LINK I
Arrangements in the aft part of the vessel

Appendix 6b

STERN RAMP

CAN BE USED FROM 10° BELOW TO 10° ABOVE HORIZONTAL LEVEL.


EMERGENCY EXIT
TO CENTRAL
TO CENTRAL
FUEL OIL EQUIPMENT
AUX. ENG. ROOM
CONTROL ROOM
TO CENTRAL
TO CENTRAL
TO CENTRAL
TO CENTRAL
REMOTE PANEL
TIMER
F.W. HYD PUMPS LOCATED HYDR. T
MS STORA KORSNÄS LINK I
Plan of the engine room
Appendix 7

MS STORA KORSNÄS LINK I
Dangeroud goods declaration
for sodium chlorate

Appendix 8
(4 pages)

BID 1 (4)

Field	Content
Godsavsändare (namn och postadress)	Eka Nobel Elektrokemi AB, Albyfabriken, 840 22 ALBY
Avsändningsort -station	Alby
Telefon	0690-402 00
Kod	116
Datum	1991-10-24
Fraktsedel nr	730 620 949 0
Godsavsändarens referenser	Bokn nr
Godsmottagarens referenser	Warrington
Godsmottagare (namn och adress)	AB P J Haegerstrand, Terminal Granudden, Gävle
Godsadress	55.623
Fraktbetalning	Avsändaren 1 betalar / Mottagaren 3 betalar
Avtal nr, uppdrag nr	175144
Bestämmelseort -station	Gävle Granudden
Leveransanvisning	Lista 1 Nr. 8

Avsändarens godsadressnummer (streckkod)

Fraktmedel (sändning) nummer (streckkod)

Vagnsnummer	Kolliantal, -slag	Varuslag	Varunummer (transport)	Bruttovikt, kg	Volym
3900256-7	1 vgn	Natriumklorat	3771 3		
		Cont CSU 44		20 040	
		" 820089-9		20 040	

Fara-nr	Gods-nr	Ämnesnamn enligt RID-S/RID
50	1495	Natriumklorat

RID-S/RID klass	Ämnesnummer i klassen	Regelverk (RID-S / RID)	IMDG klass	IMDG sida	Nettovikt/Enhet	Fareparkt/Enhet
5.1	4a					

Tomvikt — För tömd, ej rengjord statartankvagn/tankcontainer, används text

Utan ansvar för transportföretaget

Upplysningar för godsmottagaren

Detta uppdrag utförs i enlighet med transportföretagets vid varje tidpunkt gällande ansvarsbestämmelser

För transportföretagets redovisning | Transportföretagets anteckningar | Transportföretagets avsändningsstämpel, av vägningsstämpel

FARLIGT GODS

CONTAINERPACKNINGSCERTIFIKAT
FORDONSDEKLARATION

Den som ansvarar för packning/lastning av farligt gods i en enhet, t ex container, flak, trailer eller andra fordon avsedda för sjötransport, skall lämna detta certificat.

DANGEROUS GOODS

CONTAINER PACKING CERTIFICATE
VEHICLE DECLARATION

Those responsible for the packing of dangerous goods into a unit e.g. a container, flat, trailer or other vehicle intended for sea transport should provide this Certificate.

Unit number/Enhet nummer: CSU 44[illegible]

Type of unit (container, trailer, tank container, etc)/ Typ av enhet: Container

LIST OF DANGEROUS GOODS packed in this unit:

FÖRTECKNING ÖVER FARLIGT GODS, som packats/lastats i denna enhet:

No & Type of packages / Antal & typ av förpackning	Proper shipping name/correct technical name / Tekniskt riktig benämning	IMO Class	UN Number	IMDG Code page/sida	Gross Weight, kg / Brutto vikt, kg
20 bags a 1000 kg	Sodium Chlorate	5.1	1495	5178	20 040

Härmed intygas att vid packning/lastning i ovanstående enhet

- enheten var ren, torr och uppenbart lämplig för avsett gods.
- Innehåller skeppningen gods av klass 1 avdelning 1.1 eller 1.2 skall enheten vara av den standard som specificeras i punkt 5.5.1 i Inledningen till klass 1.
- Inga oförenliga varor enligt IMDG-kodens anvisningar packats/lastats i enheten.
- alla kollin har inspekterats med avseende på yttre skador och endast intakta, oskadade förpackningar har packats/lastats.
- alla kollin har packats/lastats och säkrats på ett tillförlitligt sätt i enheten.
- enheten och varje förpackning har vederbörligen markts med rätta etiketter och texter.
- När fast koldioxid (torr-is) används för kyländamål, enheten utvändigt är märkt eller etiketterad på väl synlig plats på dörrgaveln med följande text: "FARA. INNEHÅLLER CO_2 — GAS (TORRIS), VENTILERA NOGGRANT FÖRE INTRÄDE."
- det intyg som fordras i paragraf 9.4 i IMDG-koden* har erhållits för varje parti, som packats/lastats i enheten.

It is hereby certified that when packing above unit

- the unit was clean, dry and apparently fit to recive goods.
- if the consignments include goods of Class 1, Division 1.1 or 1.2, the unit is structurally serviceable as defined in paragraph 5.5.1 of the introduction to Class 1.
- no incompatible substances have been packed into the unit.
- all packages have been externally inspected for damages and only sound packages packed.
- all packages have been properly packed in the unit and secured.
- the unit and packages are properly marked and labelled.
- when solid carbon dioxide (dry ice) is used for cooling purposes, the unit is externally marked or labelled in a conspicuous place at the door end, reading: "DANGEROUS CO_2 — GAS (DRY ICE) INSIDE, VENTILATE THOROUGHLY BEFORE ENTERING".
- the Dangerous Gods Declaration required in subsection 9.4* of the International Maritime Dangerous Goods Code has been received for each dangerous goods consignment packed in the unit.

* Avsändaren skall intyga antingen i skeppshandlingarna eller i en särskild förklaring att det gods, som han lämnar till transport är riktigt förpackat och märkt samt i behörigt skick för transport (Dangerous Goods Declaration).

* The shipper should certify, either on the shipping papers or in a separate declaration, that the goods which he offers for shipment have been properly packaged, marked, labelled and are in proper condition for carriage (Dangerous Goods Declaration).

Stuvage ombord/Stuvning ombord

Place and date of issue/Plats och datum: Alby 911025

Name and signature/Namn och signatur

EKA NOBEL ELEKTROKEMI AB
Albytabruken

Rolf [illegible]

FARLIGT GODS

CONTAINERPACKNINGSCERTIFIKAT
FORDONSDEKLARATION

Den som ansvarar för packning/lastning av farligt gods i en enhet, t ex container, flak, trailer eller andra fordon avsedda för sjotransport, skall lämna detta certificat.

DANGEROUS GOODS

CONTAINER PACKING CERTIFICATE
VEHICLE DECLARATION

Those responsible for the packing of dangerous goods into a unit e.g. a container, flat, trailer or other vehicle intended for sea transport should provide this Certificate.

Unit number/Enhet nummer: 82088179

Type of unit (container, trailer, tank container, etc)/ Typ av enhet: Container

LIST OF DANGEROUS GOODS
packed in this unit:

FÖRTECKNING ÖVER FARLIGT GODS,
som packats/lastats i denna enhet:

No. & Type of packages Antal & typ av förpackning	Proper shipping name/correct technical name Tekniskt riktig benämning	IMO Class	UN Number	IMDG Code page/side	Gross Weight, kg Brutto vikt, kg
20 bags a 1000 kg	Sodium Chlorate	5.1	1495	5178	20 040

Härmed intygas att vid packning/lastning i ovanstående enhet

- enheten var ren, torr och uppenbart lämplig för avsett gods.
- innehåller skeppningen gods av klass 1 avdelning 1.1 eller 1.2 skall enheten vara av den standard som specificeras i punkt 5.5.1 i inledningen till klass 1.
- inga oförenliga varor enligt IMDG-kodens anvisningar packats/lastats i enheten.
- alla kolli har inspekterats med avseende på yttre skador och endast intakta, oskadade förpackningar har packats/lastats.
- alla kolli har packats/lastats och säkrats på ett tillförlitligt satt i enheten.
- enheten och varje förpackning har vederbörligen märkts med rätta etiketter och texter.
- När fast koldioxid (torr-is) används för kylandamål, enheten utvändigt är märkt eller etiketterad på väl synlig plats på dörrgaveln med följande text:
"FARA, INNEHÅLLER CO_2 — GAS (TORRIS), VENTILERA NOGGRANT FÖRE INTRÄDE."
- det intyg som fordras i paragraf 9.4 i IMDG-koden* har erhållits för varje parti, som packats/lastats i enheten.

It is hereby certified that when packing above unit

- the unit was clean, dry and apparently fit to recive goods.
- if the consignments include goods of Class 1, Division 1.1 or 1.2, the unit is structurally serviceable as defined in paragraph 5.5.1 of the introduction to Class 1.
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- all packages have been properly packed in the unit and secured.
- the unit and packages are properly marked and labelled.
- when solid carbon dioxide (dry ice) is used for cooling purposes, the unit is externally marked or labelled in a conspicuous place at the door end, reading:
"DANGEROUS CO_2 — GAS (DRY ICE) INSIDE, VENTILATE THOROUGHLY BEFORE ENTERING".
- the Dangerous Goods Declaration required in subsection 9.4* of the International Maritime Dangerous Goods Code has been received for each dangerous goods consignment packed in the unit.

* Avsändaren skall intyga antingen i skeppshandlingarna eller i en särskild förklaring att det gods, som han lämnar till transport är riktigt förpackat och märkt samt i behörigt skick för transport (Dangerous Goods Declaration)

* The shipper should certify, either on the shipping papers or in a separate declaration, that the goods which he offers for shipment have been properly packaged, marked, labelled and are in proper condition for carriage (Dangerous Goods Declaration)

Stuvaga ombord/Stuvning ombord

Place and date of issue/Plats och datum
Alby 911025
Name and signature/Namn och signatur

EKA NOBEL ELEKTROKEMI AB
Albyfabriken

DANGEROUS GOODS DECLARATION

Shipper
Eka Nobel Elektrokemi
Box 11553
S-100 61 Stockholm

Booking reference No.

Shipment reference No.
3912

Consignee
Trafford Chemicals Ltd
Clayton Road, Birchwood
Warrington Cheshire
England

Carrier name

Notify party

Domestic carriage by

From
Alby

Main transport
SKL I
1991-10-28

From
Gävle

Shipment approved by (name of line or agent)

Signature of authorized person

Stowage instructions

Port of discharge
Hartlepool

Place of delivery
Warrington

Unit No(s)., Marks and Nos.	Number and type of packages, Proper shipping name, UN No [3], IMDG code page No., and Flash point (if any) in °C	IMO class and sub class No. [2]	Net weight, kg [4]
	Sodium Chlorate 40 Big-Bags loaded in 2 x 20' containers		40.000
	Each container 20 MT net, 20,040 MT gross weight		Gross weight, kg 40080 Cube, m3
	IMCO 5.1 UN 1495 CP 5178		

1) Trade names only must not be used
2) For class 1 Explosives) also: Division Compatibility group and Storage Category
3) For class 7 (Radioactive substances): Schedule No. (1-12)
4) For class 1 also: Net quantity of explosives

EMERGENCY INSTRUCTIONS according to the General Index of the IMDG-code (amdt.)

EmS No(s):	MFAG Table No:
5.1 - 06	745

Goods to be delivered

[ ] as break bulk cargo [X] as unitized cargo

Type of unit (container, trailer, tank container etc)
20' Dry [ ] open [X] closed

Documents required when applicable

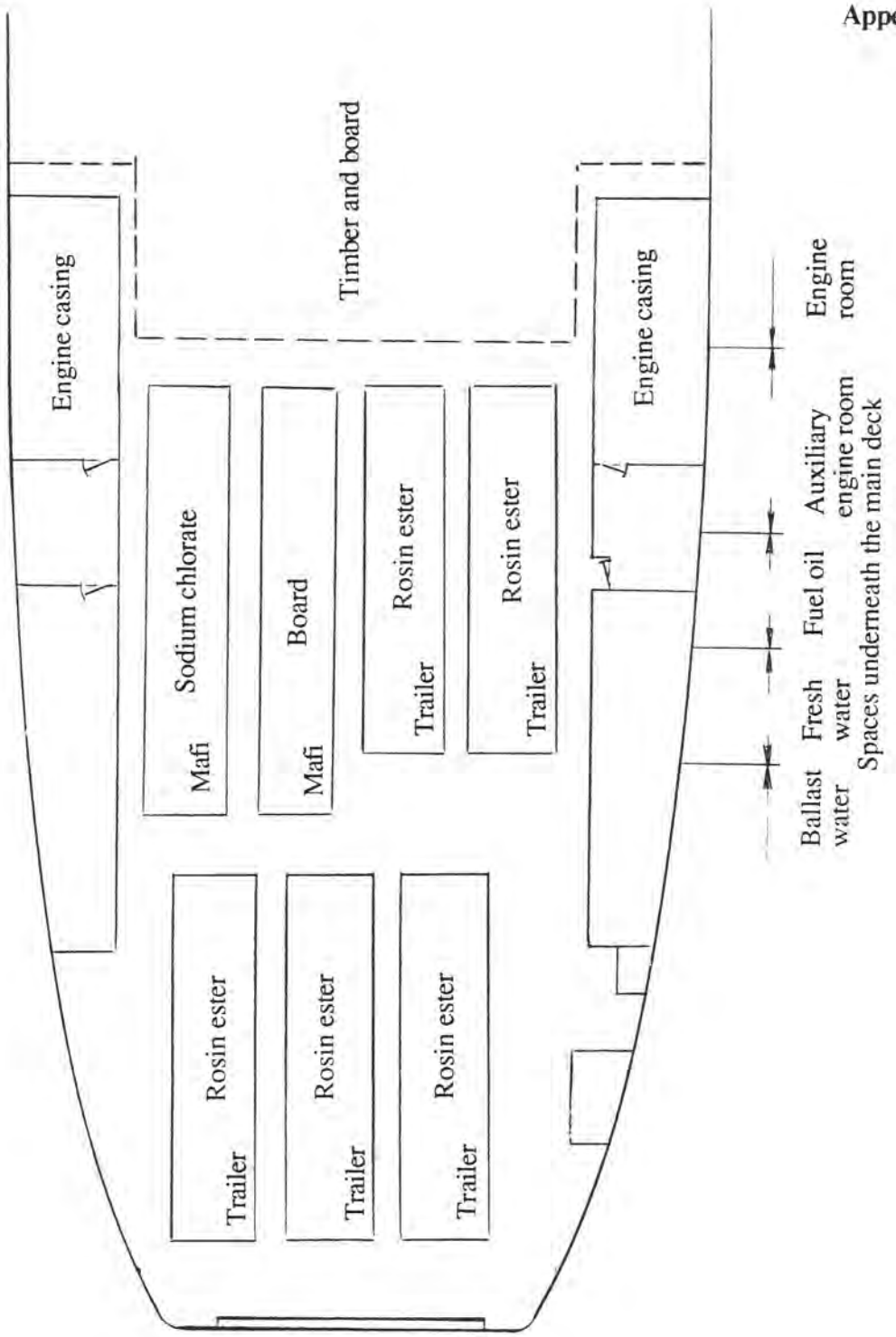
[X] Transport emergency instructions [X] Container packing certificate/ Vehicle declaration [ ] Additional information on Radioactive substances [ ] Weathering certificate, etc.

DECLARATION: I hereby declare

That the contents of this consignment are fully and accurately described above by the proper shipping name(s) and are classified, packaged, marked and labelled, and are in all respects in proper condition for transport by sea according to the IMDG code. That the packaging used is sound and of an approved type.

Place and date of issue
Stockholm 1991-10-24
Name and signature

Eka Nobel Elektrokemi



MS STORA KORSNÄS LINK I
Likely stowage of sodium chlorate and rosin ester cargoes