Statens haverikommission
Swedish Accident Investigation Authority

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Final Report RS 2013:01e

Cargo Shift on board M/V Phantom

on 15 February 2012

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SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring again, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

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This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

Statens haverikommission (SHK) Swedish Accident Investigation Authority

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Statens haverikommission
Swedish Accident Investigation Authority

1. Swedish Transport Agency, Civil Aviation and Maritime Department (Transportstyrelsen, Sjö- och luftfartsavdelningen)
2. Shipping company: Interscan Schiffahrtsgesellschaft mbH
3. Flag state: Gibraltar
4. Swedish Forest Industries Federation (Sveriges Skogsindustrier)

Final Report RS 2013:01e

The Swedish Accident Investigation Authority (Statens haverikommission, SHK) has investigated an accident that occurred on 15 February 2012 on board M/V Phantom.

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

The Swedish Accident Investigation Authority respectfully requests to receive, by 25 September 2013 at the latest, information regarding measures taken in response to the recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Jonas Bäckstrand Patrik Dahlberg

General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring again, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Accidents and incidents are, therefore, neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies. The task of SHK does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post-crisis management, are not a subject of the investigation.

The investigation

On 16 February 2012 at 08.30 hours, SHK was informed that an accident had occurred on 15 February at 21.40 hours on board M/V Phantom off the north cape of the Baltic island of Öland.

The accident has been investigated by SHK represented by Mr Jonas Bäckstrand, Chairman, and – until 3 May 2013 – Captain Richard Blomstrand, Investigator in Charge. The rescue operation has been investigated by Patrik Dahlberg.

SHK has been assisted by MariTerm AB as an expert specializing in cargo securing and the stability of vessels.

The work of the investigation team has been followed by Captain Jörgen Zachau of the Swedish Transport Agency.

Contents

1 SUMMARY

The cargo ship Phantom, sailing under a Gibraltar flag, was being loaded with a shipment of sawn timber at the port of Oskarshamn between 13 February and 15 February 2012. Before loading started, the chief officer on board had calculated that only a small proportion of the cargo would have to be stowed up on the hatch, but since less cargo had been stowed inside the cargo hold than expected, the deck cargo was loaded two timber packages high on the entire hatch area.

There had been light snowfall throughout the entire loading period. However, on the night of the 14^{th} and the 15^{th}, the snowfall had been heavier and when the loading of the second layer was about to start in the morning, there was about 15 cm of snow covering the first layer of the deck cargo. The vessel was fully loaded by about 14.00 hours and after covering and lashing of the deck cargo Phantom left Oskarshamn at 18.05 hours on 15 February for its destination Casablanca, Morocco, without a pilot on board.

At 20.00 hours, the master had observed in the ship's journal that there was a NNW wind blowing with a strength of 8 on the Beaufort scale, which is equivalent to 17.2-20.7 m/s which, according to the same Beaufort scale, is likely to generate waves with a height of 4 – 5.5 m in the open sea.

At about 21.30 hours on the same evening, the master attempted to go around Ölands North cape and during the process, a wave caused the vessel to roll to starboard, and as she was righting herself she was again hit by a large wave. This caused the righting movement to the port side to stop abruptly while the cargo continued shifting to the port side as a result of the centrifugal force. The deck cargo was left hanging from its lashings with the vessel listing heavily as a result.

The master immediately sounded the alarm to abandon ship in order to wake any crew members who were lying asleep, and shortly afterwards he also alerted the Swedish search and rescue services.

By about 23.15 hours, all crew members had been evacuated from the vessel and transported by helicopter to Kalmar Airport.

The investigation into the cargo shifting on board Phantom has shown that the stability of the vessel had been unsatisfactory on its departure from Oskarshamn. The reasons for the shortfalls in stability were a combination of unsuitable ballast, insufficient bunker volume and too much deck cargo. Furthermore, the investigation has shown that the Cargo Securing Manual on board was deficient and that the general advice issued by the flag state concerning uprights to prevent the cargo from sliding had not been followed.

Recommendations:

The shipping company Interscan Schiffahrtsgesellschaft mbH is recommended to:

- Ensure that vessels follow established requirements for stability and requirements stipulated in the Cargo Securing Manual *(RS 2013:01 R1).*
- Consider a revision of the Cargo Securing Manual for the vessel with clear instructions on the type of cargoes that are normally carried by the vessel *(RS 2013:01 R2).*
- Consider implementation of the requirements for cargo securing in the shipping company's vessels in accordance with the revised Timber Cargo Code TDC 2011 *(RS 2013:01 R3).*
- Instruct vessels to carry out rolling tests before departure in connection with timber deck cargoes *(RS 2013:01 R4).*
- Consider the possibility of conducting refresher courses in stability and cargo securing, particularly for the officers on board vessels that carry timber deck cargoes *(RS 2013:01 R5).*

The Swedish Transport Agency (TS) is recommended to:

- Investigate the preconditions for introducing regulations in Sweden, as in Canada, imposing requirements that vessels are inspected, both before and after the loading of timber, to ensure that the vessels are seaworthy before departure from a Swedish port. *(RS 2013:01 R6).*

The flag state Gibraltar is recommended to:

- Improve the review and approval process of Cargo Securing Manuals so that the instructions in the manuals can be used by the crews on board the vessels *(RS 2013:01 R7).*

The Swedish Forest Industries Federation is recommended to:

- Ensure, as soon as possible, that the information required in line with SOLAS and TDC 2011 is provided by the Swedish Forest Industries Federation members to vessels in conjunction with loading timber in Swedish ports *(RS 2013:01 R8).*

2 FACTUAL INFORMATION

2.1 Ship particulars

Flag	Gibraltar
Identification	
IMO identification/ call sign	9226712/ZDEH5
Vessel data	
Type of ship	General Cargo
New building ship-yard/year	Peterswerft, Wewelsfleth/2000
Gross tonnage	2329
Length, over all	92.45 m
Beam	12.5 m
Draft, max	5.449 m/5.336 m
Deadweight at max draft	3 217/3 110 dwt
Main engine, output	MAN B&W Alpha Diesel/2 040 kW
Propulsion arrange-ment	1 propeller with adjustable propeller blades
Lateral thruster	Bow thruster
Rudder arrangement	Standard rudder
Service speed	11.5 knots
Ice class	E3, equivalent to Finnish-Swedish ice class A1
Ownership and operation	Interscan Schiffahrtsgesellschaft mbH
Classification society	Germanischer Lloyd
Minimum safe manning	6 persons
Certification	The vessel was certified in accordance with current conventions

2.2 Voyage particulars

Ports of call	Vejle-Oskarshamn-Casablanca
Type of voyage	International
Cargo information/ passengers	Approximately 2 180 MT/3 830 m^3 of sawn timber goods. No passengers
Manning	6 persons

2.3 Marine casualty or incident information

Type of marine casualty or incident	Shifted cargo
Date and time	15 February 2012 at approx. 21.40 hours local time
Position and location of the marine casualty or incident	N 57° 28.2 E 017° 05.60, Norra Kalmarsund (Northern part of Kalmar Sound)
Weather conditions	Wind direction, north about 11 m/s gusting to 15 m/s according to observations from the Swedish Meteorological and Hydrological Institute, SMHI
Other factors	
Consequences	
Personal injuries	None
Environment	None known
Cargo	Lashing around deck cargo cut at quay thereby jettisoning the deck cargo overboard
Vessel	Water damage to accommodation and bow thruster room

Figure 1. Phantom at quayside in Oskarshamn on 17 February 2012.

2.4 Emergency response

2.4.1 Rescue service

Rescue service in this context is understood to mean the emergency response for which the state or local authorities shall be responsible according to the Act (2003:778) on Protection against Accidents (LSO) relating to accidents and the imminent risk of accidents in order to prevent and restrict injuries to people, damage to property or damage to the environment.

Each municipality shall, on the basis of the local risk scenario, draw up an action plan which is to describe the goals of the operations of the municipality and the risks for accidents that exist within the municipality and which could warrant an emergency response. The action plan shall also specify the geographical area of responsibility for the municipal rescue service and the state rescue service. On this occasion, the emergency response activities were led by JRCC[1] in Gothenburg.

2.4.2 The County Administrative Board in connection with emergency response

The Act (2003:778) and the Ordinance (2003:789) on Protection against Accidents are regulating the responsibilities of the County Administrative Board in connection with an emergency response. SOS Alarm alerts or reports the occurrence of a serious accident to the emergency duty officer whose task it is, when necessary, to initiate introductory work to determine whether the incident could develop in a direction that could warrant the taking-over of responsibility.

When a report is received from SOS Alarm about a serious accident, the risk scenario is analysed and assessed on the basis of available information and the County Administrative Board's organization for rescue services and crises management is called in. Active information search and contact with the rescue service officer in charge gives an indication of the situation and whether it is necessary to build up an organization. At the County Administrative Board in Kalmar, there is a risk and vulnerability analysis model for the County of Kalmar that was drawn up in 2011.

2.4.3 Emergency alert

The distress call was received by JRCC from Phantom at 21.41 hours on 15 February 2012 with information that a timber-loaded vessel with 6 people on board was listing. The rescue base in Visby was called out and the rescue bases in Ronneby and Norrtälje were put on alert. A rescue helicopter from Norrtälje was flown to Kalmar to be on stand-by there. The airports in Ronneby and Kalmar were ordered to stay open if the rescue helicopters needed refuelling. The overall decision was taken to rescue those in distress as soon as possible and to bring them to safety and provide medical care. KBV[2] was put on the alert for environmental control.

At 21.55 hours, JRCC contacted SOS Alarm in Växjö who were informed of the accident and asked to alert the municipality and the medical care services. The TiB-function at municipality and at the County Council, as well as municipal crisis management groups, were alerted by SOS Alarm on the basis of alarm lists. The police were informed via LKC[3].

The Crisis Management Group within SOS Alarm then informed MSB[4], the County Administrative Board in Kalmar and the Swedish Transport Agency of the event at 22.26 hours.

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[1] Joint Rescue Coordination Centre
[2] The Swedish Coastguard
[3] County Communications Centre
[4] Swedish Civil Contingencies Agency

2.4.4 Sequence of the life-saving operation

At the Visby base, the alarm was received from JRCC at 21.41 hours with the information that the emergency involved a vessel with six persons on board that was listing heavily north of Öland's North Cape. A rescue helicopter was sent out from the base and the response team took with them a 20-man life raft for use if winching proved to be impossible.

The rescue helicopter arrived at the scene of the accident at 22.16 hours and noted that the vessel was listing approximately $40\text{-}45^{o}$ and was being driven by, at times, heavy seas. The helicopter crew discussed various solutions for winching up those in distress, and after due consideration decided to lower a rescue swimmer down to the vessel.

The rescue swimmer moved the crew members, who were on the boat deck, to a more suitable winching position and by 23.15 hours they were all safely on board the helicopter on their way to Kalmar Airport.

At the airport, they were given medical check-ups before being moved to Kalmar Hospital, where they arrived at 23.53 hours.

2.4.5 The Swedish Coast Guard

The Swedish Coast Guard, South West District, received the alarm and started to make an inventory of resources. The staff sought actively to build up a picture of the incident and the current situation, and to send an OSC[5] to the scene of the accident. Contact was made with the helicopter on the scene, and information was received on the current state of events.

During the night, calculations were made to assess the risk zone and where the vessel was likely to run aground or where and when it was likely to sink.

Information was transmitted to the units on alert regarding the situation and the fact that the highest level of safety should be observed for the personnel and that the action taken should be set in proportion to possible environmental consequences.

At 01.37 hours, a first decision was formulated on preventing oil from leaking into the water and that if the vessel were to sink, to order divers to inspect the hull and seal any leaks.

At 02.03 hours, the first unit, KBV 285, was in place at the scene of the accident, by which time Phantom was judged to be listing 45^0 to port with its railings under water. The vessel was drifting in the heavy seas and the rescue team managed to attach a thick cable to the bow pending the arrival of a tug. The coast guard staff contacted the oil-spill duty unit to find out what the natural environment was like in the area, at the same time as information was received that tugs were available within a 5-hour sailing distance. The decision was then taken to try to tow Phantom using the attached unit in order to prevent the vessel from running aground.

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[5] On-scene coordinator

During the course of the day, various possibilities were considered, such as allowing the vessel to sink, pulling her up on land or, if possible, towing her to Oskarshamn. In the afternoon, the next decision was formulated which entailed KBV 003 towing the vessel to Oskarshamn in stages, with towing operations starting at 17.12 hours. The intention was to follow a course near shallow waters in order, if necessary, to run the vessel aground if she began to sink.

On the night of 17 February, the listing of Phantom had increased while towing and the risk of the vessel capsizing had thus also increased. It was decided that if there was a tendency for the vessel to capsize, it should be run aground south of Furö.

The rescue services in Oskarshamn and the emergency duty officer at the County Administrative Board in Kalmar were contacted and informed of the risk that the vessel could sink. In Kalmar the work started under a higher state of alert and various contingency plans were drawn up for alternative courses of environmental action.

Towing operations continued throughout the night and at 06.58 hours in the morning the vessel and the towing unit arrived at Oskarshamn, where Phantom was tied up and handed over to the representative of the vessel's owner.

2.5 The crew

The crew of Phantom consisted of:

The Master, who at the time was 47 years old and held a Russian master certificate, had worked as a master since 2000 and been employed on board Phantom on some 5-6 contracts, each four months long.

The Chief Officer, who at the time was 39 years old and held Ukrainian chief officer certificate and had some 20 years' experience of working at sea.

The Chief Engineer was at the time 61 years old and held Latvian chief engineer certificate.

Other operational crew members consisted of one able-bodied seaman and two ordinary seamen, one of whom also served as the cook on board.

The vessel was manned according to the flag state's minimum manning certificate and the officers qualifications were recognised and approved by the flag state. This meant that the crew was directly qualified to operate the vessel in accordance with the flag state's requirements.

2.6 The shipping company

The shipping company, Interscan Schiffahrtsgesellschaft mbH, was founded in 1973 and has its registered offices in Hamburg, Germany. The company is active in freighting with container and multipurpose vessels and with the transport of forestry products and other dry cargoes in northern Europe, primarily with smaller gross tonnages of up to 5 500. It also has three other, somewhat larger vessels that are operated globally. All the company's vessels sail under either Gibraltar, Cyprus or Antiguan flags and are ISM/ISPS[6] certified.

Phantom was manned by Marlow Navigation Co. Ltd, which has its head office in Limassol, Cyprus.

2.7 Fact collection and limitations

SHK paid a visit to the vessel on 17 February 2012 and held interviews with the master and the other crew members. On another occasion, on 21 February 2012, interviews were held with the chief officer and the master. MariTerm AB was also present during these interviews. SHK has also interviewed the boat man, some of the stevedores and the ship's agent in Oskarshamn.

SHK has chosen to limit the investigation to cover the relevant events that preceded the loading, the loading itself and the stability calculations that influenced the sequence of events. This means that SHK has not investigated the vessel's or the shipping company's entire safety system, but has only reviewed the aspects considered to be important to cargo handling.

[6] International Safety Management Code/International Ship and Port Facility Security Code.

3 COURSE OF EVENTS

3.1 Voyage to Oskarshamn

The vessel had taken on steel in St Petersburg, Russia, for discharging in Norway and Denmark. When the vessel arrived at the first port of call – Fredrikstad in Norway – the master received information that the vessel was to take on approximately 3 900 m^3 of sawn timber in Oskarshamn bound for Casablanca, Morocco. During final discharging in Vejle, Denmark, the master decided to fill all the vessel's double-bottom tanks in order to bring the bow thruster and propeller lower down in the water and thereby improve the vessel's manoeuvring capability.

In the meantime, they experienced problems in filling the ballast as a result of either faulty valves or ice plugs blocking the pipe system, whereby they filled Bottom Tanks 1 and 2 (port and starboard sides) using the fire pump and fire hose via the air pipes on the tanks after the automatic closing devices had been dismounted (see Figure 2). These sealing devices were not remounted.

Figure 2. Air pipe for Double-bottom Tank No 1.

Phantom arrived on 12 February at Oskarshamn and at 09.25 hours the vessel dropped anchor to await berthing at the quay.

Just under 3 hours later, at 12.15 hours, the anchor was heaved and at 13.45 hours she tied up at quay 50 in Oskarshamn with port side alongside. On arrival, the vessel's agent came on board and the master handed over the NOR[7], which was valid from 07.00 hours the same day.

[7] Notice of Readiness, the point in time at which the master of the vessel considers the vessel to have reached its destination and is ready to be loaded/discharged in compliance with the freight agreement.

Loading of the timber cargo started the following day, on 13 February at 07.00 hours with two gangs of stevedores and two cranes.

3.2 Loading and cargo intake

A total of 1 039 timber packages were loaded on board the vessel. According to the master and the chief officer, the cargo was distributed as follows:

Position	**No of packages**	**Timber volume**	**Weight***
On deck	231 pcs	670 m^3	380 tons
In the cargo hold	808 pcs	3 160 m^3	1 800 tons
Total	**1 039 pcs**	**3 830 m^3**	**2 180 tons**

Table 1. Cargo distribution according to the master and chief officer.

**The weight is calculated on the basis of a weight factor of 0.56 – 0.57 tons per loaded timber volume according to information given by the master*

The only information the master or chief officer received about the cargo was the number of packages and their total volume. This information was received immediately before loading (see Appendix 1). No information was received concerning weights, stowing factors, racking strength or friction.

Both the ship's agent and the stevedore foreman have subsequently stated that there was an unusually large proportion of truck packages[8] (TP) compared with length packages (LP). The distribution was approximately 50% TP and 50% LP.

The dimensions of the vessel's cargo hatch were as follows: length 55.80 m and breadth 10.20 m. According to information received from the master and the chief officer, 9 packages were stowed in breadth in a first layer and 8 packages in breadth in a second layer on the hatch. They also stated that the entire hatch was covered with two layers of timber packages, that the total length of the deck cargo was estimated to be about 50 m and that the distance between the outboard edge on the hatch and the outermost packages in the lower layer was approximately 20-30 cm on both the port and starboard sides. The master rejected about 20 packages that were not taken on board because he did not want to load more than two layers high on deck.

According to the vessel's capacity plan, the hold, which was basically boxed[9], had a vertical clearance beneath the cargo hatches of 8.24 m and the volumetric centres of gravity for "bale"[10] cargo were:

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[8] Truck package = a package consisting of timber of different lengths and packaged so that one end was even.
[9] The length and breadth of the hatch frame and the hold are the same.
[10] Bale specifies the volume of bales, boxes, containers, etc. that can be stowed on board.

LCG[11] 42.24 m and VCG[12] 5.01 m. According to information received from the stevedore, the hold was almost completely full all the way up to the underside of the hatch cover since, among other things, half packages were used to “top up” the cargo.

The cargo consisted of several batches from different shippers. The sizes of the individual packages varied considerably, partly between the different batches but also between the packages in the different batches. According to information from the stevedore company, the package width was approximately 1.1 m and the package height 1.05 – 1.1 m, and the packages that were stowed in the hold and on the deck were of the same size. In order to calculate the total volume, the stevedores in Oskarshamn normally use a volume factor of 3.68 m^3 per timber package. With the aid of this volume factor, and the previously mentioned stowage factor from the master, the following volumes and weights can be calculated to be the cargo intake:

Position	**No of packages**	**Timber volume**	**Weight***
On deck	231 pcs	850 m^3	480 tons
In the cargo hold	808 pcs	2 973 m^3	1 680 tons
Total	**1 039 pcs**	**3 823 m^3**	**2 160 tons**

Table 2. Calculated cargo distribution according to information from the stevedore company.

A number of the packages that were loaded on board were damaged. The damage was described as handling damage at the lower edge of the package. On some of the packages, plastic packaging tapes were missing so that in practice it was the vessel’s own sling that held together the package. The master signed all the cargo lists with the comment:

“Cargo loaded from open storage. Packages covered with snow and ice. Half packages are not straight. Broken!”

During loading of both the hold and the deck cargo it was snowing. The timber packages were collected from open storage areas and were covered with snow. According to information received from the master, the deck hatches were clear of snow prior to loading, but he was not certain whether they were dry.

Loading of the bottom layer of the deck cargo took place on the afternoon of 14 February. The stevedore foreman has in an interview stated that the master asked whether they could assist with a stability test after the first layer had been loaded on to the hatch. However, the master did not repeat this request when the first layer had been loaded so no test was carried out.

[11] LCG = Longitudinal centre of gravity.
[12] VCG = Vertical centre of gravity.

Loading of the upper layer took place on the morning of 15 February and during the night there had been a heavy snowfall, which meant that in the morning the first layer of deck cargo was covered with about 15 cm of snow, which had partly melted down between the packages. The master has stated that he had asked the stevedore to clear the snow before the top layer was loaded, but that this had not been done. The stevedore, in their turn, has stated that they helped the crew to clear the snow from the two outer packages on either side, despite the fact that they did not consider it to be their responsibility.

Phantom's hatch covers were completely smooth and the container fittings on top of the hatch covers were fully recessed (see Figure 3).

Figure 3. Phantom's cargo hatch with recessed container fittings.

3.3 Securing of the cargo

3.3.1 According to information from the vessel

Before loading of the deck cargo started, the crew spread out tarpaulins along the outside edges of the hatch covers on which the outer packages later were placed.

When loading, every effort was made to avoid empty gaps and voids in the cargo. Half-high packages were turned on their side and used as filling in the transverse direction. However, there were a number of cavities in, above all, the longitudinal direction and in the upper layer – partly as a consequence of varying package lengths and partly because certain packages contained timber of different lengths.

The deck cargo was centred laterally on the cargo hatches in two layers, 9 packages wide in the lower layer and 8 packages wide in the upper layer. There were detachable uprights available on board, but they were not used. The reason given was that these were only used for round timber and that in the event of a cargo shift they would make it impossible to jettison the cargo overboard.

The detachable uprights (see Figure 4) each weighed approximately 30 kg and consisted of square profiles 110 x 110 mm in size with a material thickness of 5 mm. The uprights were 1.85 m high and were stored in front of the forward cargo hatch.

Figure 4. Detachable uprights that were available on board.

The cargo was secured using the synthetic fibre webb lashings that are specified in the vessel's Cargo Securing Manual and which are specially intended for timber deck cargoes. A total of 20 lashings were used. The deck cargo lashings were applied in the form of top-over lashings and attached with the aid of shackles to D rings positioned along the hatch frame. The tensioning devices were positioned on top of the cargo. Pelican hooks that permit quick loosening of the lashings were not used. The distance in the longitudinal direction between the lashings was approximately 2.5 – 3.0 m.

Figure 5. ***D-ring on hatch frame positioned about 1.1 m beneath the top of the cargo hatch***

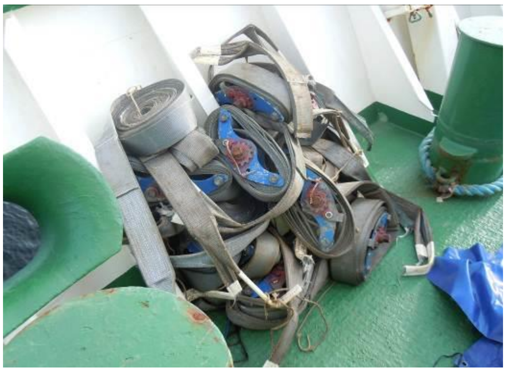


Figure 6. ***Webb lashing equipment.***

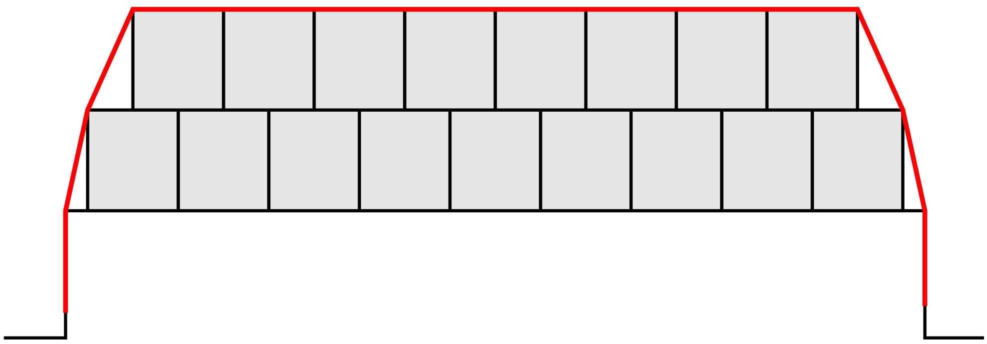


Figure 7. ***Diagram showing the loading and securing of deck cargo.***

3.3.2 Contents of the Cargo Securing Manual

The Cargo Securing Manual was issued in 2004 and was approved by Germanischer Lloyd on behalf of the flag state.

The Cargo Securing Manual contained a separate chapter on the securing of timber cargoes which contained a specification of equipment for timber cargoes and drawings indicating where fixed cargo securing equipment was located. No information was given on how much equipment should be used or how the equipment should be applied. Neither did the manual contain any information on stowing patterns for timber cargoes, either in the hold or on deck. However, the manual did include a sketch showing a cargo securing arrangement for a section of timber packages on deck loaded in one layer. According to the sketch, the cargo should be secured with top-over lashings, edge protection and short uprights to prevent the cargo from sliding against the hatch.

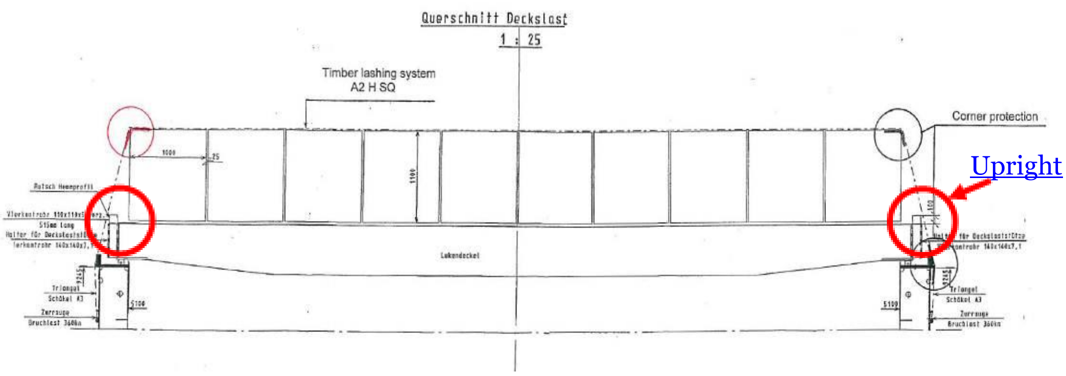


Figure 8. ***Cargo securing arrangement.***

The top-over lashings consisted of webb lashings which, according to the specification in the manual, had the following properties:

- MSL[13] for system: 6.65 tons (breaking strength 133 kN or approximately 13.3 tons)
- Width of webbing: 65 mm
- Thickness of webbing: 6 mm

[13] Maximum Securing Load (maximum permissible loading of cargo securing equipment).

The pre-tensioning for which the equipment was designed was not specified in the manual.

The lashings were to be attached to D-rings along the sides of the hatch frame. According to information in the manual the D-rings had the following properties:

- MSL: 18 tons
- Quantity: 56 pcs

The distance between the D-rings is 2.4 m except for the fore and aft edges of the hatch covers, where the distance is 1.2 m.

The short uprights that are described in the manual consisted of square profiles of steel measuring 110 x 110 x 5 mm. Their length was 515 mm but their strength was not specified in the manual. The uprights were inserted in the fixing points that were positioned on either side of the hatch covers. There were 22 fixing points for uprights on either side of the cargo hatches and the average distance between them was 2.6 m. The illustration in the Cargo Securing Manual showed a cargo that had been loaded centrally on the cover and not out against the uprights.

There was no specification in the manual as to how many lashings or uprights were to be used.

In an annex to the separate chapter on the securing of timber cargoes described above, the Timber Cargo Code from 1991 was included in its entirety as an appendix to the manual, including all the appendices that are to be found in IMO's printed version of the code.

Nowhere in the Cargo Securing Manual could any reference be found to the appendix with the Timber Cargo Code. Certain information was not given in the principal language English but instead in German or Swedish.

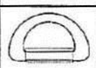
Extract from the vessel's Cargo Securing Manual:

5 SECURING DEVICES AND ARRANGEMENTS FOR TIMBER DECK CARGOS

Please note: The actual strength data of all securing devices only according to the certificates / proof test! The drawings are symbols only and not necessarily in total compliance with the real pieces.

5.1 Specification of fixed cargo securing devices

5.1.1 On-deck

Type designation	Manu-facturer	Identifi-cation marking	Symbol	SWL [kN]	BL [kN]	PL [kN]	Quan-tity	Certi-ficate no.	Sketch no.
D-RING	Conver / Ozean-Service+ Reperatur GmbH	E2		Tension: 180	Tension: 360	Tension: 225	56	---	HNA-E-104

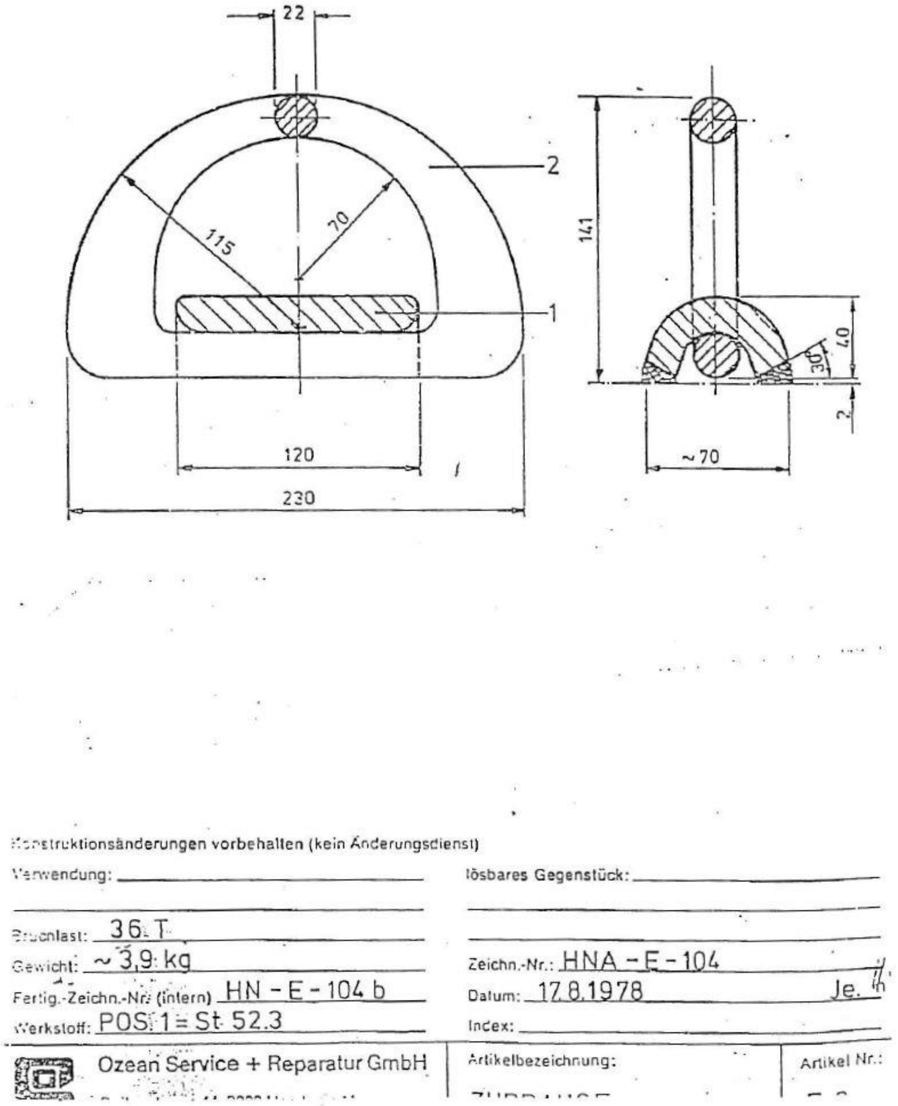
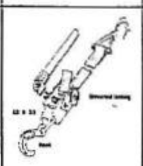
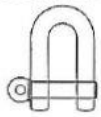
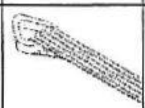


Figure 9. Specification of fixed cargo securing equipment for timber deck cargoes.

MEC | Shipyard: PETERS SCHIFFBAU AG | Hull No.: 669
Owner: INTERSCAN BEREEDERUNGEN GmbH&Co | GL Reg. No.: 94059
Vessel: MULTIPURPOSE VESSEL | Delivered: 2000

5.2 Specification of portable cargo securing devices

5.2.1 On-deck

Type designation	Manu-facturer	Identifi-cation marking	Symbol	SWL [kN]	BL [kN]	Quan-tity	Certi-ficate no.	Sketch no.
TIMBER LASHING SYSTEM A2 H SQ	Pfeifer Seil-und Hebetechnik	A2 H SQ		Tension: 66.5	Tension: 133	25	---	31314, 28-1029-DL, 28-3046, CARGO SAFE, SPARR-NYCKEL 1040 mm, RITN SAFE,
SHACKLE	Pfeifer Seil-und Hebetechnik	5/8 INCH HIGH TENSILE		32	159	50	---	---
POLYESTER WEB	Pfeifer Seil-und Hebetechnik	65 mm wide		66.5	133	20 x PS, 20x SB	---	---
CORNER PROTECTION	Pfeifer Seil-und Hebetechnik					40		

REMARK: ALL SECURING PARTS MUST HAVE A MINIMUM BREAKING LOAD OF 133 kN. (see IMO-Reg.)

STRENGTH VALUES OF WEB LASHINGS HAVE TO BE TESTED REGULARLY, LATEST EVERY TWO YEARS.

Test certificates of all securing devices have to be on bord.

Figure 10. Specification of loose cargo securing equipment for timber deck cargoes.

3.4 Stability details for the vessel

3.4.1 According to information from the master and the chief officer

During both the interviews with the master and the chief officer, it was stated that the vessel had the following draught and stability on its departure from Oskarshamn:

- Draught fore: 4.97 m
- Draught aft: 5.58 m
- Mean draught: 5.27 m
- Metacentric height G'M approx. 0.40 m

They also stated that the vessel's draught had increased by approximately 0.5 m from the time when stowing in the hold had been completed and the time when the vessel was ready for departure. In the chief officer's assessment, 1 800 – 1 900 tons of cargo had been stowed in the vessel's hold after receiving information that 808 timber packages had been loaded. He has also stated that he had conducted a draught survey[14] after the hold had been loaded, and he had been surprised by the fact that there was still so much cargo to load. According to his pre-plan and calculations, only a small proportion of the cargo should have had to be placed on the hatches.

The information and calculations from the chief officer's draught survey were, according to him, lost when water found its way into his cabin via the toilet in conjunction with the accident.

According to the chief officer the vessel was, at the time of its departure, at its winter (5.336 m in salt water and 5.454 in fresh water according to the capacity plan, with a corresponding displacement of 4 383 tons).The vessel was due to bunker in the Kiel Canal before its continued voyage to Casablanca.

Prior to departure, the master had noted in the deck log book that the draught fore was 5.00 m and aft 5.70 m. In a supplement to the above information on draught and stability, the following extracts from the vessel's trim and stability calculation program (WSCV "TRIFESTAB") for the voyage in question were presented.

[14] A calculation of the load taken on board based on the difference between the draught on arrival and the current draught, including bunker, ballast handling and stores.

TRIM AND STABILITY MV 'PHANTOM' - PROGRAMME 'TRIFESTAB'

NOMINATION	P (t)	LCG (m)	TCG (m)	VCG (m)	FS (mt)
ICE on DECK	20.00	80.85	0.00	11.71	0.0
CARGO	2200.00	42.36	0.00	5.23	0.0
WATER/ICE in DECK CARGO	2.00	42.90	0.00	11.15	0.0
GRAIN BULKHEAD	0.00	0.00	0.00	0.00	0.0
GAS OIL	21.99	18.90	2.83	4.24	0.0
LUB OIL	6.00	9.65	-4.92	3.94	0.0
POTABLE WATER	41.00	3.40	0.00	4.38	46.4
SUNDRY TANKS	3.50	9.84	-0.46	1.68	0.0
BALLAST WATER BOTTOM	296.10	47.45	0.00	0.47	0.0
BALLAST WATER NON-BOTTOM	350.00	42.68	-0.48	3.59	0.0
CREW & EFFECTES	1.00	6.90	0.00	10.00	0.0
PROVISIONS	1.00	13.50	-3.50	6.50	0.0
STORES	0.00	0.00	0.00	0.00	0.0
LIGHT SHIP	1272.96	34.30	0.00	5.40	0.0
DISPLACEMENT	4215.55	39.90	-0.03	4.84	46.4

Figure 11. Schedule of weights and centres of gravity of cargo, ballast and bunker fuel.

TRIM AND STABILITY MV 'PHANTOM' - PROGRAMME 'TRIFESTAB'

DISPLACEMENT D = 4215.55 t
LONG. CENTRE OF GRAV. LCG = 39.90 m AP
CORR. VERT. CENTRE OF GRAV. KG' = 4.84 m above base

RESERVE IN DEADWEIGHT = 167.45 t

Spec. gravity of the water = 1.015 t/cbm

Mean DRAUGHT = 5.20 m
TRIM by stern = 0.07 m

DRAUGHT forward = 5.17 m
DRAUGHT aft = 5.24 m

Figure 12. Trim and draught.

TRIM AND STABILITY MV 'PHANTOM' - PROGRAMME 'TRIFESTAB'

DISPLACEMENT D = 4215.55 t
LONG. CENTRE OF GRAV. LCG = 39.90 m AP
CORR. VERT. CENTRE OF GRAV. KG' = 4.84 m above base

RESERVE IN DEADWEIGHT = 167.45 t

Spec. gravity of the water = 1.015 t/cbm

Mean DRAUGHT = 5.20 m
TRIM by stern = 0.07 m

DRAUGHT forward = 5.17 m
DRAUGHT aft = 5.24 m

Figure 13. Stability and list.

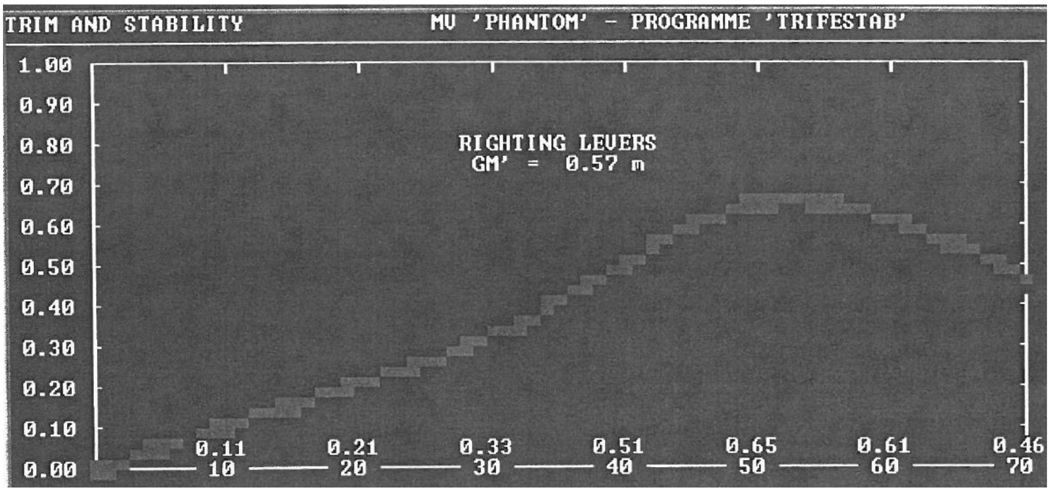


Figure 14. Righting lever curve.

BALLAST BOTTOM TANKS MV 'PHANTOM' - PROGRAMME 'TRIFESTAB'

No.	TANK NOMINATION	P (t)	%	LCG	TCG	VCG	FS
18	DB 1 P	53.57	99	62.51	-2.83	0.47	0.0
19	DB 1 S	53.57	99	62.51	2.83	0.47	0.0
20	DB 2 P	73.24	99	44.40	-4.23	0.47	0.0
21	DB 2 S	73.24	99	44.40	4.23	0.47	0.0
22	DB 3 P	21.24	99	19.97	-3.90	0.50	0.0
23	DB 3 S	21.24	99	19.97	3.90	0.50	0.0
TOTAL		296.10		47.45	0.00	0.47	0.0

Figure 15. Ballast in bottom tanks.

BALLAST NON-BOTTOM TANKS MV 'PHANTOM' - PROGRAMME 'TRIFESTAB'

No.	TANK NOMINATION	P (t)	%	LCG	TCG	VCG	FS
24	Fore Peak Tank	0.00	0	76.09	0.00	0.39	0.0
25	Wing Tank 1 P	0.00	0	62.27	-5.11	0.96	0.0
26	Wing Tank 1 S	0.00	0	62.27	5.11	0.96	0.0
27	Wing Tank 2 P	160.00	98	44.40	-5.67	3.76	0.0
28	Wing Tank 2 S	160.00	98	44.40	5.67	3.76	0.0
29	Wing Tank 3 P	30.00	25	24.33	-5.65	1.77	0.0
30	Wing Tank 3 S	0.00	0	25.72	5.63	0.93	0.0
TOTAL		350.00		42.68	-0.48	3.59	0.0

Figure 16. Ballast in other non-bottom tanks.

GAS OIL MV 'PHANTOM' - PROGRAMME 'TRIFESTAB'

No.	TANK NOMINATION	P (t)	%	LCG	TCG	VCG	FS
1	DB 1 P	5.00	14	44.40	-1.57	0.06	0.0
2	DB 1 S	0.00	0	44.40	1.57	0.00	0.0
3	DB 2 P	0.00	0	25.71	-2.53	0.00	0.0
4	DB 2 S	0.00	0	25.71	2.53	0.00	0.0
5	Settling tank S	8.00	75	8.41	4.88	4.41	0.0
6	Daily service tank 1	4.65	100	13.99	2.65	6.40	0.0
7	Daily service tank 2	4.33	100	14.10	4.32	6.40	0.0
8	Overflow tank S	0.00	0	12.97	5.21	2.48	0.0
9	Leakage oil tank S	0.00	0	11.55	2.20	0.51	0.0
10	Sludge tank P	0.00	0	11.46	-2.21	0.55	0.0
TOTAL		21.99		18.90	2.83	4.24	0.0

Figure 17. Bunker

3.4.2 Stability according to the Trim and Stability Booklet

Load cases 4a and 4b in the vessel's Trim and Stability Booklet show the vessel loaded with packaged timber on its departure and its arrival, respectively. The timber in the load cases has a weight of 0.65 tons per m^3. In the load cases, it has been assumed that the cargo in the hold weighs 2 009 tons and that the centres of gravity of the hold cargo are LCG 42.24 m and VCG 5.01 m. These centres of gravity concur with those specified in the capacity plan for "bale" cargo in the hold.

The deck cargo, which in the load cases only consists of one layer, are assumed to weigh 261 tons and to have their centres of gravity at LCG 42.90 m and VCG 10.32. According to the capacity plan, the upper edge of the cargo hatch cover is on a level of 9.275 + 0.500 = 9.775 m over the vessel's base line (see the following amidships section). With the timber package that has a height of 1.10 m, the centre of gravity lies on a level of 1.10/2 = 0.550 above the upper edge of the cover and thereby 9.775+ 0.550 = 10.325 above the vessel's base line (BL).

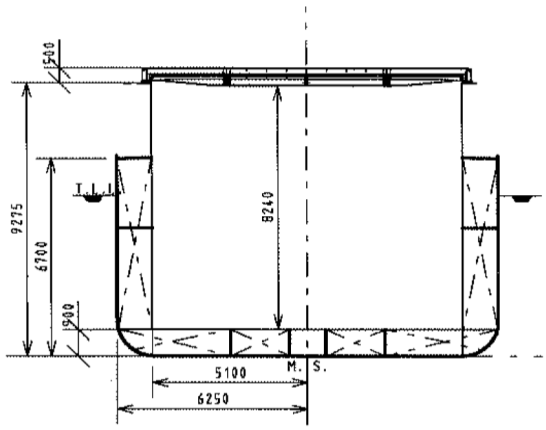


Figure 18. Transverse cross-section

The common centres of gravity of the cargo used in the Trim and Stability Booklet calculations are: LCG 42.32 m and VCG 5.62 m.

In the stability calculations, a 10% weight increase in the deck cargo has also been added owing to the water absorption in both the departure and the arrival condition.

The stability of the vessel is 0.38 m on departure and 0.41 m on arrival.

Displacement on departure is 4 178 tons and on arrival 4 490 tons, and the corresponding mean draughts in salt water is 5.12 m and 5.45 m respectively. It should be noted that the vessel is only at its international summer load line, 5.45 m, in its arrival condition.

In its departure condition, the vessel had 310 tons of bunker and stores and all water ballast tanks in the double bottom filled with 299 tons of ballast while the forepeak and port and starboard Wing Tanks 1-3, which are intended for water ballast, were empty.

According to information in the vessel's hydrostats, the minimum allowable metacentric height needed to meet the intractability requirements for a departure draught is 0.34 m and for an arrival draught is 0.41 m, which can also be seen from the following table taken from the vessel's hydrostatic data.

Draught (m)	KM (m)	Max KG' (m)	Min G'M (m)
5,00	5,392	5,072	0,32
5,05	5,396	5,064	0,33
5,10	5,401	5,059	0,34
5,15	5,405	5,052	0,35
5,20	5,411	5,048	0,36
5,25	5,416	5,045	0,37
5,30	5,422	5,042	0,38
5,35	5,429	5,038	0,39
5,40	5,436	5,036	0,40
5,45	5,444	5,036	0,41
5,50	5,451	5,034	0,42

Table 3. Max allowable KG and min G'M for different draughts.

In order to meet the stability requirements in the arrival condition when the quantity of bunker and stores decreased to 88 tons, in addition to 299 tons of ballast in the double bottomed tanks, the port and starboard wing tanks 2 were filled to 100% and the port and starboard wing tanks 3 were filled to 88% with totally 534 tons of ballast. This is the reason why displacement and draught are greater in the arrival than in the departure condition.

3.4.3 Stability details for previous timber cargoes carried by Phantom

The shipping company has provided the stability calculations for a number of earlier timber cargoes carried by Phantom that have been compiled in the table below together with the stability data according to the vessel.

Compilation of load cases for Phantom

Sammanställning av lastfall för M/S Phantom

	Ballast		Gas Oil		Rumslast		Däckslast Lager 1			Däckslast Lager 2			Däckslast Totalt			Hela lasten		Deplacement		Draft			
Resa	Vikt	VCG	Vikt	VCG	Vikt	VCG	Vikt	%	VCG	Vikt	%	VCG	Vikt	%	VCG	Vikt	VCG	Vikt	VCG	SW	FS	G'M	G'MR
06/07 6/3 2007 DEP	680	1,6	57	1,52	1870	4,74	263	54	10,32	228	46	11,50	491	21	10,87	2361	6,01	4435	4,99	5,39	0,06	0,38	0,40
06/07 13/3 2007 ARR	640	1,54	70	1,29	1870	4,74	263	54	10,32	228	46	11,50	491	21	10,87	2361	6,01	4411	5,00	5,37	0,06	0,36	0,39
11/07 26/4 2007 DEP	697	1,63	80	1,45	1817	4,72	283	56	10,32	223	44	11,43	506	22	10,81	2323	6,05	4434	4,95	5,39	0,06	0,39	0,40
15/07 24/5 2007 DEP	678	1,64	95	1,22	1830	4,72	291	57	10,32	224	43	11,43	515	22	10,80	2345	6,06	4428	4,97	5,38	0,06	0,39	0,40
17/07 26/6 2007 DEP	684	1,62	43	2,12	1878	4,72	275	62	10,32	171	38	11,43	446	19	10,75	2324	5,88	4336	4,92	5,28	0,05	0,47	0,38
31/07 25/10 2007 DEP	697	1,65	74	1,01	1800	4,72	290	60	10,32	190	40	11,43	480	21	10,76	2280	5,99	4347	5,03	5,30	0,01	0,41	0,38
37/07 9/11 2007 DEP	755	1,8	69	1,51	1792	4,72	325	66	10,32	170	34	11,43	495	22	10,70	2287	6,01	4403	4,93	5,36	0,04	0,46	0,39
27/08 10/6 2008 DEP	792	1,91	69	1,35	1796	4,77	316	78	10,31	90	22	11,38	406	18	10,55	2202	5,84	4392	4,79	5,34	0,05	0,6	0,39
Olycksresan enligt fartygets beräkningar	646	2,16	22	4,23	1800								380	21		2200	5,23	4216	4,84	5,20	0,01	0,57	0,36

Table 4. Compilation of load cases for Phantom

3.5 Preparedness for sea and departure from Oskarshamn

As the stevedores gradually stowed the second layer from the stern forwards, everyone in the crew – including the master – began to cover and lash the cargo in order not to lose any time after the loading had been completed. The loading was completed at about 14.00 hours and the crew members were ready with the covering and lashing of the timber packages by about 16.45 hours.

When they had finished lashing, the master went up to the bridge in order to prepare for departure while the remainder of the crew made the vessel seaworthy.

When he considered that the vessel was ready for departure, the master called and ordered a boat man for 18.00 hours. At 17.50 the main engines were started by the chief engineer. In the deck log book it was noted that the laminated checklist for departure (see Appendix 3) was followed and completed in compliance with the vessel's safety handbook at 18.00 hours.

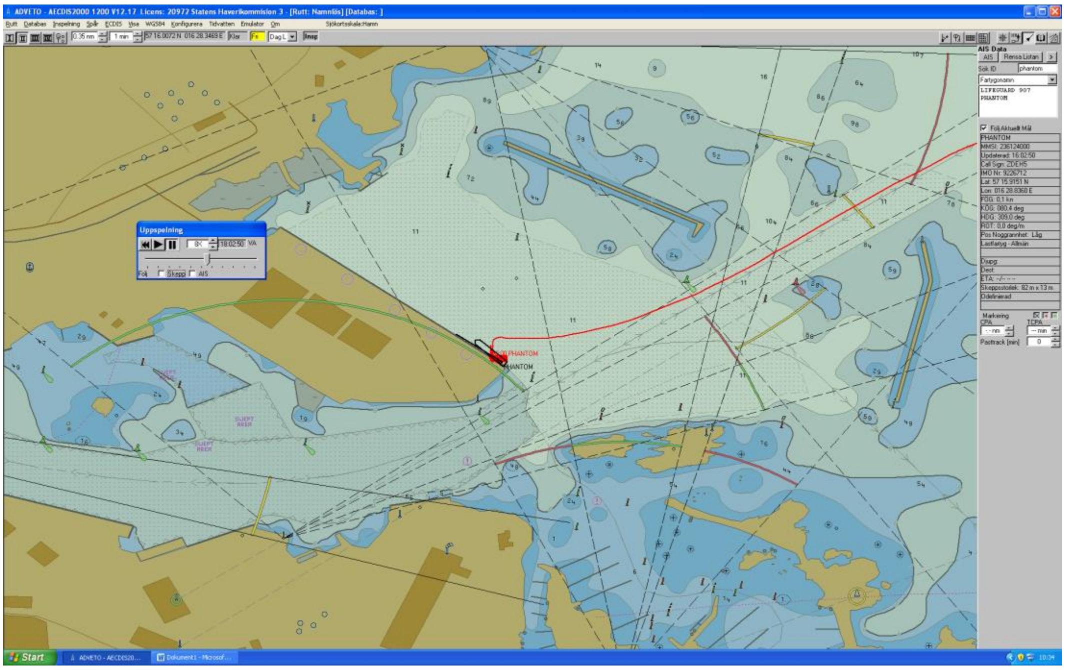


Figure 19. Phantom at the quay in Oskarshamn immediately before departure. © Sjöfartsverket, nr 10-01518.

The vessel departed at 18.05 without a pilot, as this was not a requirement for a vessel of this size. The master felt safe about not using a pilot for the departure since he had been to Oskarshamn a number of times before, both as a chief officer and master, and had never taken on a pilot.

All the crew members have in the course of their interviews stated that the vessel felt completely "normal", somewhat soft when rolling but that this was normal when carrying timber. According to both the chief officer and the master, they had measured rolling periods of about 15 seconds on the journey out from the harbour when the vessel altered course.

When the master, who throughout the entire evening was alone on the bridge altered course towards WP 11 (see Figures 20 and 21), the ship was hit by waves on the port bow at an angle of approximately 40°. The risk that the ship would begin to roll made him decide to alter the course further to port, at about 19.30 hours, to a more northerly course (about 025^{o}) in order to take the waves more directly on the bow.

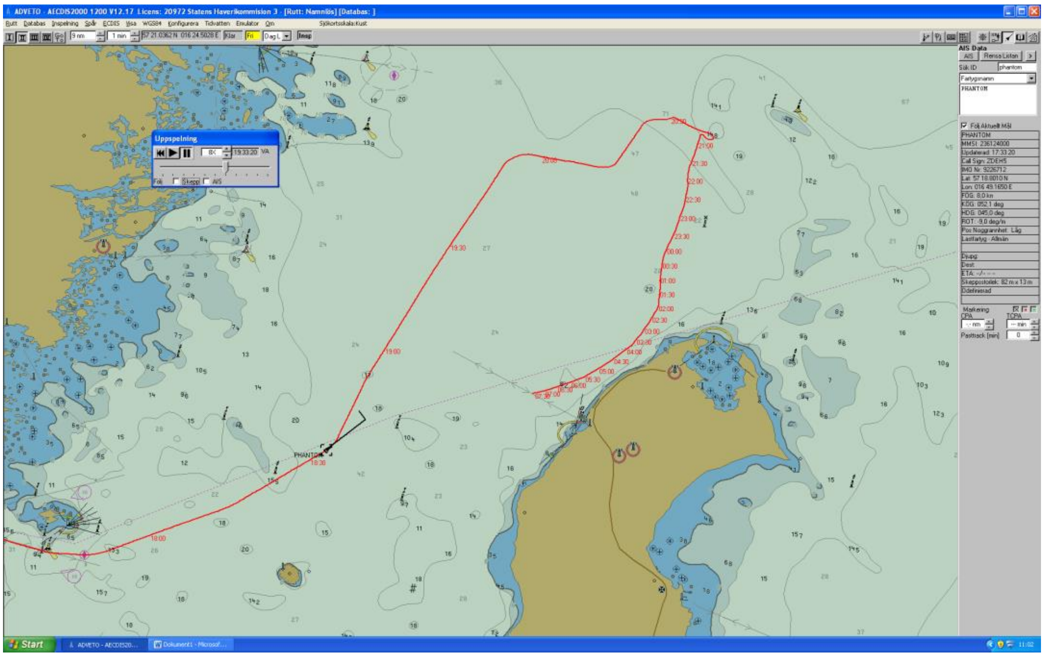


Figure 20. Phantom's position at 19.33 hours. © Sjöfartsverket, nr 10-01518.

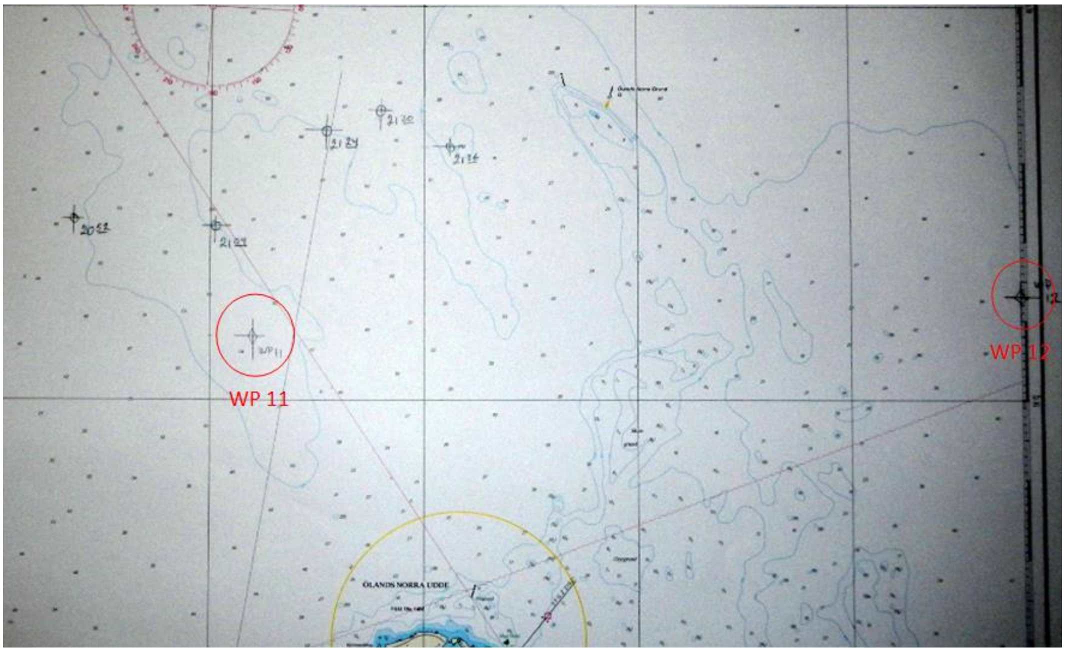


Figure 21. The turning points and positions from 20.52 hours inserted by SHK on Swedish Sea Chart No. 624.

At about 20.50 hours, the master attempted to alter course to 095^{o} towards WP 12 (see Figures 21 and 22). After about 20 minutes on the new course he changed his mind because the vessel was beginning to roll. He therefore altered back on to the original course in order to come more northwards and gain a better angle down to the planned waypoint north-east (WP 12) of Öland's North Cape. This would mean that the vessel would take the waves more from the stern, which would also increase its speed (see Figures 22 and 23).

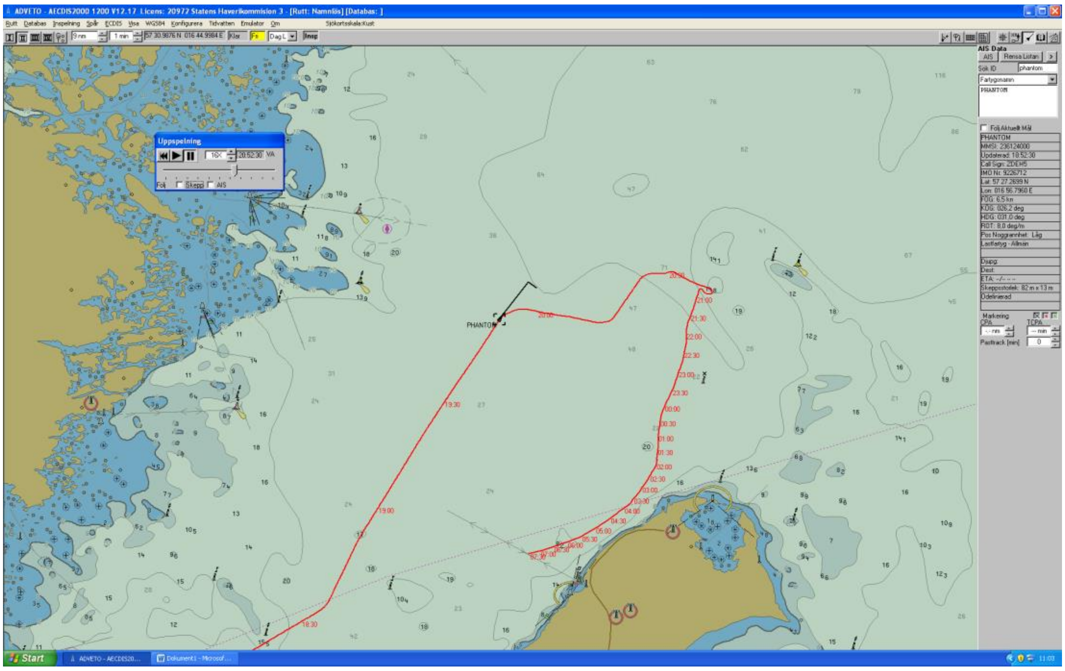


Figure 22. Phantom’s position at 20.52 hours. © Sjöfartsverket, nr 10-01518.

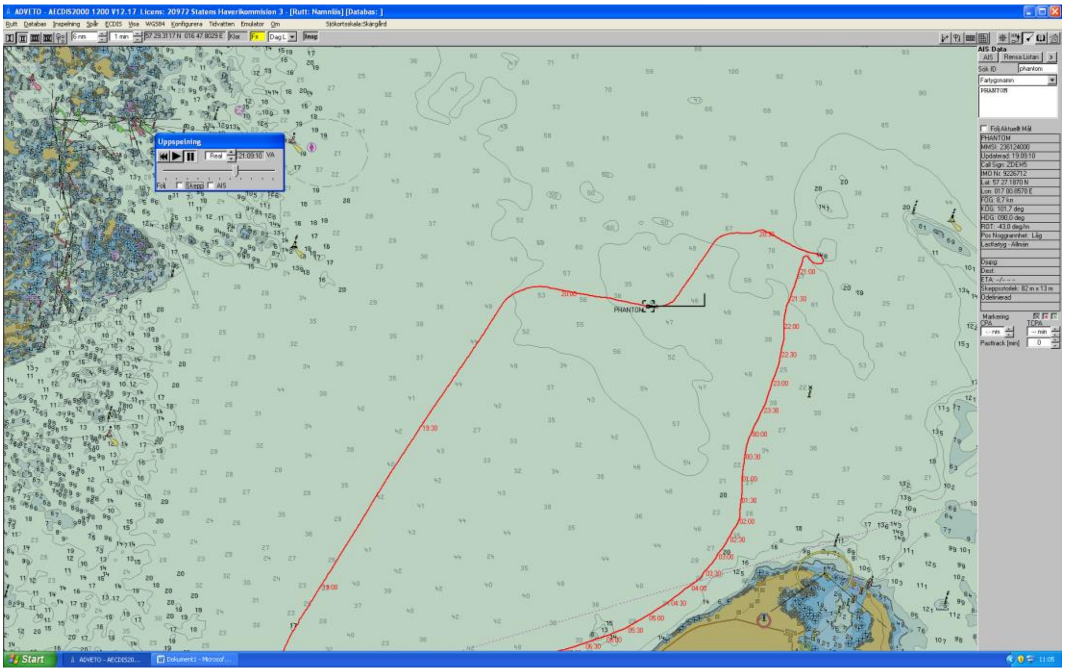


Figure 23. Phantom’s position at 21.09 hours. © Sjöfartsverket, nr 10-01518.

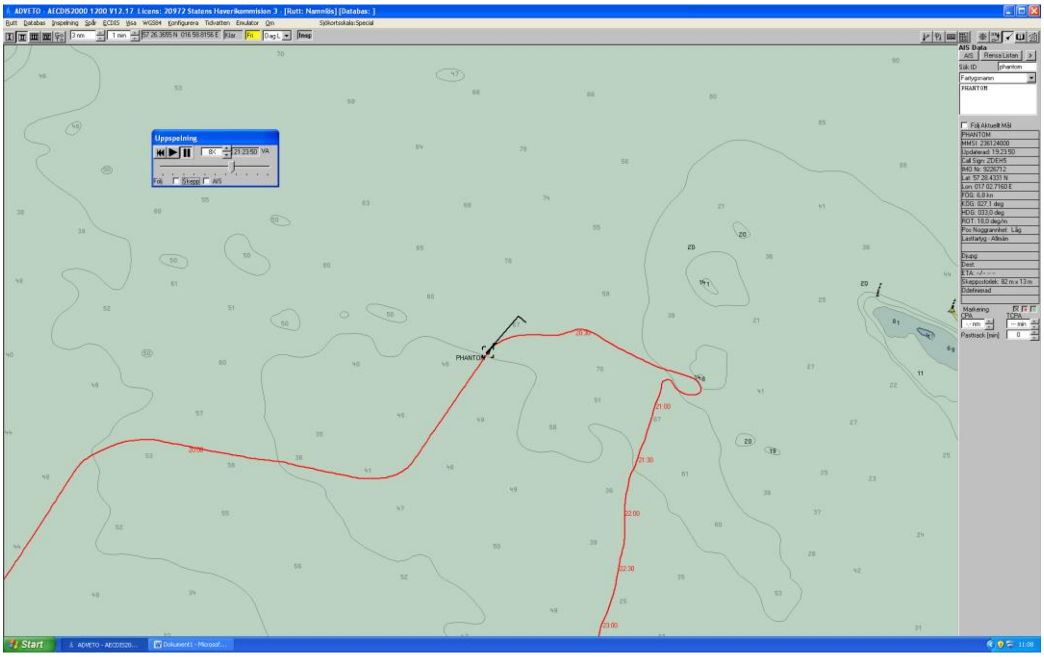


Figure 24. Phantom's position at 21.24 hours. © Sjöfartsverket, nr 10-01518.

At 21.30 hours, approximately 1.9 nm[15] north-east of the first attempt to alter course, the master tried once again to change course to starboard but shortly afterwards the vessel was hit on its port side by a large wave, which he estimated to be about 4 m high.

The wave caused Phantom to roll over to starboard, and as she was righting herself she was again hit by a large wave. This caused the righting movement to port to stop abruptly while the cargo continued shifting to port as a result of the centrifugal force. The deck cargo was left hanging from its lashings with the vessel listing heavily as a result.

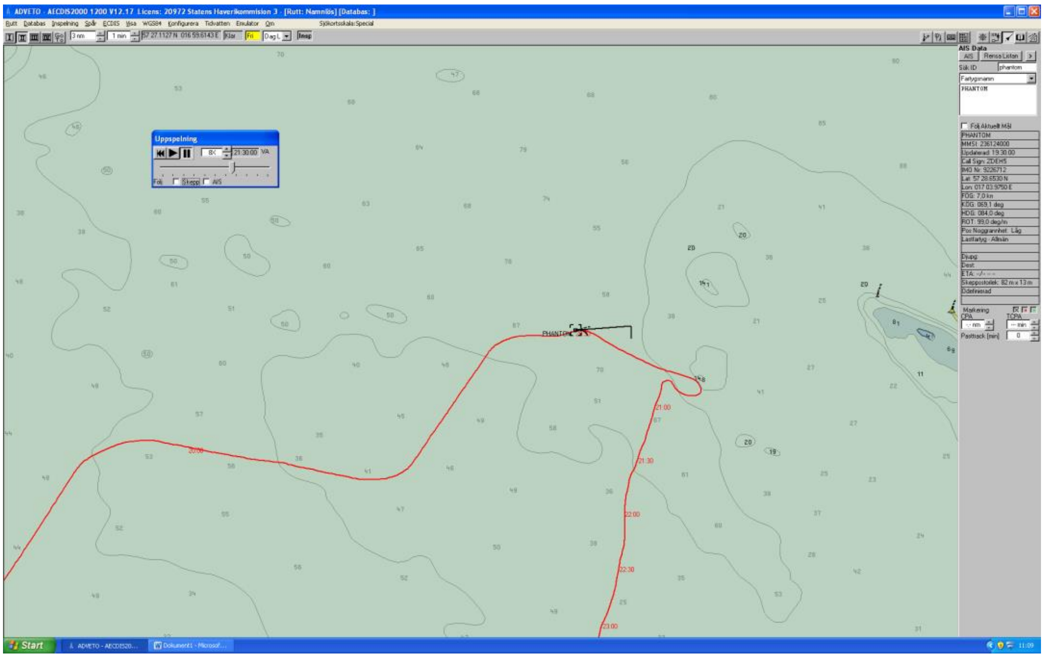


Figure 25. Phantom's position at 21.30 hours. © Sjöfartsverket, nr 10-01518.

[15] 1 nm = 1 852 m.

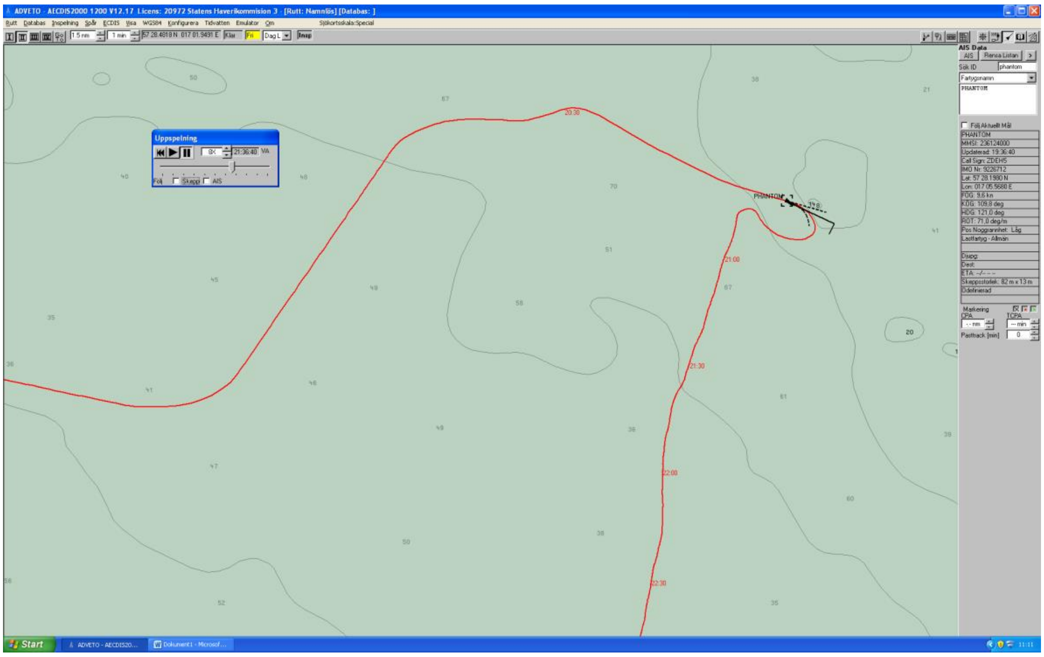


Figure 26. Phantom's position at 21.37 hours. © Sjöfartsverket, nr 10-01518.

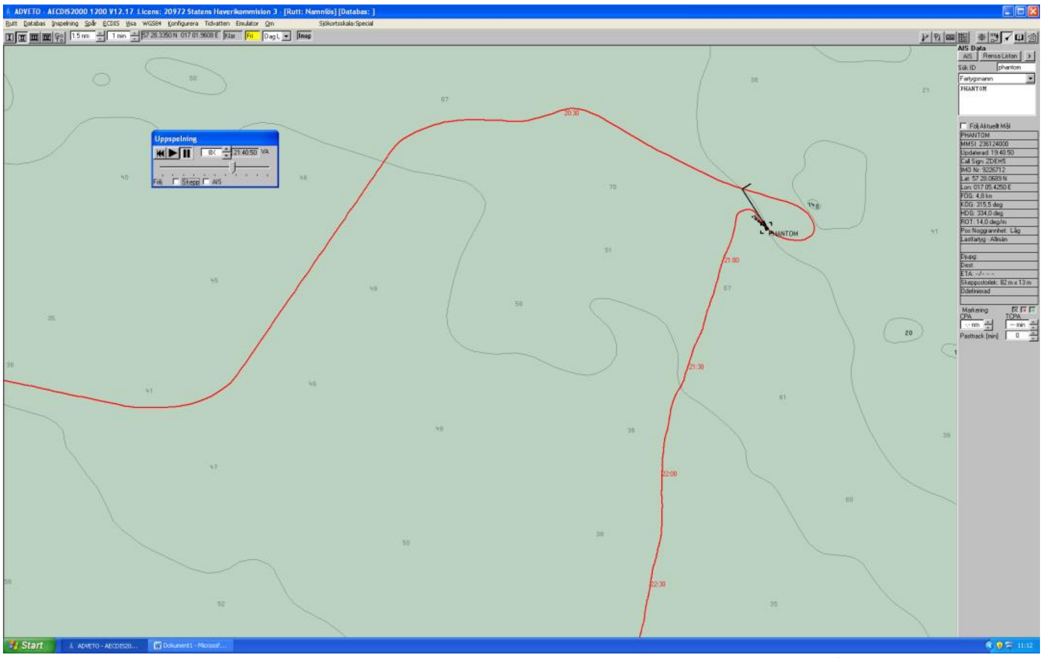


Figure 27. The vessel's position at 21.41 hours when the alarm was received at JRCC. © Sjöfartsverket, nr 10-01518.

The master has stated that he was surprised by the fact that he had no indication that the cargo was about to shift since he had experienced a cargo shift previously on board another vessel. On that occasion, the cargo had emitted a "creaking" sound before the lashings had broken.

After the vessel began listing, the master became worried that the crew members were sleeping. They were exhausted after lashing the deck cargo and there was therefore a risk of them remaining inside their cabins if there was a power failure owing to the heavy list. He therefore immediately sounded the alarm to abandon ship in order to wake the crew as quickly as possible.

The master deliberately refrained from stopping the main engine because the vessel was supplied with electricity via the shaft generator that was driven by the main engine. He thought that there was a risk of black out and was not certain whether the auxiliary engines/emergency generator would start owing to the heavy list.

When the listing became even worse shortly afterwards, he pressed the emergency alarm button on the VHF-DSC [16] and MF[17]and at the same time called out “Mayday” on VHF Channel 16, which JRCC answered immediately. JRCC asked the master about the vessel’s position, how many people there were on board, what had happened and what the situation looked like.

The chief officer then arrived on the bridge and asked for orders. The master told him that everyone was to put on their survival suits in order to be able to abandon the ship later on. After putting on their suits they were to gather at the mustering station which was located on the starboard side of the boat deck. For about 5-10 minutes the master continued to communicate with JRCC, after which he tried to put on his survival suit as he was afraid that the ship would capsize.

On the bridge there was a box of emergency equipment in a cabinet on the starboard side, the key to which was on the port side. The master succeeded in finding the key but since the floor plates were slippery and the vessel was listing badly he could not reach the equipment in question.

Once the master had succeeded in putting on his survival suit he decided to leave the bridge in order to check on the crew. They had gathered on the boat deck as the chief officer had informed him when he had come on to the bridge for the second time. Before they left the bridge together the master switched on the deck lights so that the helicopter could locate the vessel in the dark. They also took a portable VHF and EPIRB[18] with them, which they immediately activated. Once he was off the bridge, the master was contacted by JRCC who informed him that the rescue helicopter was on its way and that it would be arriving in about ten minutes’ time and that other vessels, which were in the vicinity, were also on their way. The master passed on this information to the crew.

When the search and rescue helicopter arrived on the scene, it circled round the vessel one or two times and hovered over the vessel’s hatches, and a rescue swimmer was lowered down on to the vessel’s starboard deck just in front of the bridge. The master instructed the crew to approach the rescue swimmer one at a time in order to be winched up into the helicopter. The first to be lifted were the able-bodied seaman and the ordinary seaman followed by the cook in the second lift. The next pair to be lifted was the chief officer and the chief engineer. The last to leave Phantom were the master and the rescue swimmer.

Once inside the helicopter the master counted the crew and at the same time noted that the time was 23.15 hours. Before the helicopter left the scene for Kalmar, the master could also see that the Phantom’s port-side bridge wing was on the same level as the sea surface.

[16] Very High Frequency-Digital Sell Call radio.
[17] Medium Frequency radio.
[18] Emergency Position Indicating Radio Beacon.

The alternative of cutting the lashings and jettisoning the cargo overboard had been considered by the master, but he considered it too risky for someone to be on deck performing this operation.

3.5.1 According to information from the boat man

According to information from the boat man, who laid off Phantom's ropes from the bollards on the quay when the vessel departed, Phantom seemed "weak"[19] since she listed noticeably at the smallest manoeuvring. He estimated that she was listing 10-15 degrees when manoeuvring with the bow thruster and rudder inside the harbour basin.

3.5.2 According to information from the stevedore´s tallyman [20]

The stevedore´s tallyman, who had been present throughout the entire loading, had counted off the cargo inside the storage area after the vessel was fully loaded. When he was about to return to the foreman who was standing on the quay beside the vessel, he noted that it was listing to starboard (seawards). He could not estimate by how much, but in his opinion it was too much for the vessel to be considered seaworthy. While walking to the vessel, a distance of some 2-300 m, the vessel had instead heeled over to port with the same amount of list. Since he was worried that the cargo could slide off on to the quay, he warned the foreman not to stand too close to the side of the vessel.

3.5.3 The weather

The master has stated that he was well aware of the weather situation at the time of departure but that the forecasts he had received indicated that the weather would improve during the voyage. The weather during the day and the evening had been characterized by blustery winds about NNW 14-16 m/s in strength, and out at sea the wave height had been from 2–2.5 m.

At 20.00 hours, the master noted in the deck log book that there was a NNW wind blowing with force 8 on the Beaufort scale, which is equivalent to 17.2-20.7 m/s and which, according to the same Beaufort scale, is likely to generate waves 4 – 5.5 m high in the open sea.

3.5.4 Miscellaneous

The master has stated that during a telephone call with the agent, two days before his arrival in Oskarshamn, he had been advised not to pass through Kalmar Strait due to the prevailing ice situation.

[19] Had poor stability.
[20] The loading company's cargo counter.

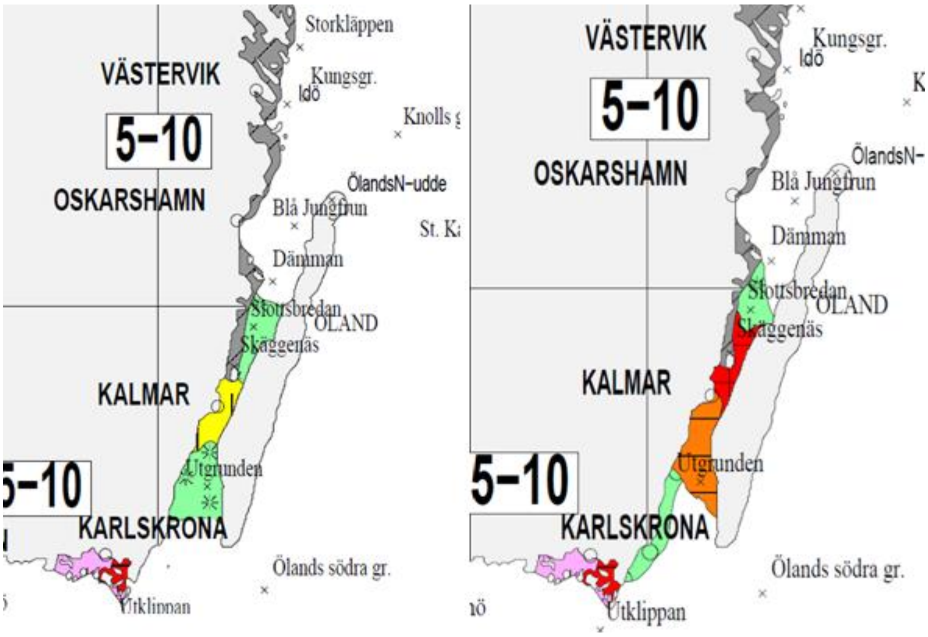


Figure 28. The ice situation in Kalmar Strait on 10 and 15 February 2012 respectively. The area shaded red for 15 February marks compact or very dense drift ice with a thickness of 5-10 cm. Photo: SMHI.

SMHI's information on the ice situation also contained a recommendation not to pass through Kalmar Strait on 15 February (see Figure 29).

SWEDISH RESTRICTIONS TO NAVIGATION

Harbour	Valid from	Min.tonnage, ice class
KARLSBORG–SKELLEFTEHAMN	2012–02–08	2000 dwt, ice class 1A
HOLMSUND	2012–02–08	2000 dwt, ice class 1B
RUNDVIK–ÅNGERMANÄLVEN	2012–02–08	2000 dwt, ice class 1C
HÄRNÖSAND–SKUTSKÄR	2012–02–05	2000 dwt, ice class 2
MÄLAREN	2012–02–08	2000 dwt, ice class 1C
VÄNERN	2012–02–06	1300 dwt, ice class 1C 2000 dwt, ice class 2
KARLSBORG–LULEÅ	2012–02–18	4000 dwt, ice class 1A
TRANSIT TRAFFIC WEST OF HOLMÖARNA IS PROHIBITED		
TRANSIT TRAFFIC THROUGH KALMARSUND IS NOT RECOMMENDED		
INFORMATION: ICE MAY OCCUR AT SEA IN KATTEGAT. LESS POWERFUL VESSELS CAN HAVE PROBLEMS WITH NAVIGATION.		

Figure 29. SMHI's recommendation on 15 February.

Canada's national regulations

In Canada, there is a current national regulation (SOR 2007-128 Cargo, Fumigation and Tackle Regulation) which requires that vessels shall first be inspected by the administration (TC[21]) and then be granted a certificate before being allowed to commence loading timber cargo. Once the loading has been completed, the vessel shall be inspected again and, provided the vessel is judged to be seaworthy, a certificate is granted allowing it to depart from the port of loading to its destination.

Certificates of Readiness to Load

140. (1) This section applies in respect of vessels in Canadian waters that load timber for export to a place that is not within the limits of an inland voyage.

(2) No vessel in Canadian waters shall load timber except in accordance with a Certificate of Readiness to Load issued to the vessel by the Minister or, in the case of a vessel in the Port of Quebec, by the Port Warden of the Harbor of Quebec.

(3) On application, the Minister shall issue a Certificate of Readiness to Load to a vessel if

(*a*) the applicable requirements of sections 132 to 139 are met;

(*b*) the Timber Code is on board the vessel; and

(*c*) the vessel is in fit condition to carry timber on the uncovered part of the freeboard or superstructure deck on which the timber is to be loaded.

(4) The Minister may, for the purpose of ensuring compliance with sections 132 to 139, specify the following terms and conditions in a Certificate of Readiness to Load:

(*a*) the type of timber that may be loaded;

(*b*) the freeboard or superstructure deck on which the timber may be loaded;

(*c*) the manner in which the timber is to be distributed;

(*d*) the ballast that is to be used; and

(*e*) the uprights that are required.

(5) If the Minister inspects a vessel for the purpose of establishing whether the requirements for the issuance of a Certificate of Readiness to Load have been met and establishes that some requirements have not been met, he or she shall give the vessel's master a written statement setting out those requirements.

Fitness to Proceed Certificates

141. (1) No vessel that is carrying timber for export to a place that is not within the limits of an inland voyage shall depart from a Canadian port unless it holds a Fitness to Proceed Certificate issued under subsection (2).

(2) On application, the Minister shall issue a Fitness to Proceed Certificate to a vessel loaded with timber if

(*a*) the applicable requirements of sections 132 to 139 are met;

(*b*) if a Certificate of Readiness to Load was issued under subsection 140(3), the vessel was loaded in accordance with the Certificate; and

(*c*) the vessel is fit to proceed to sea.

Water density in Oskarshamn

In a principal study report from the municipality of Oskarshamn (Rapport O-hamn 2004:21, Sanering av hamnbassängen i Oskarshamn (*Cleaning of harbour basin in Oskarshamn*)), which was published in March 2005, it is mentioned that the density of the water in the harbour is 1.006[22] to 1.007, partly as a result of the runoff of fresh water from the town and partly due to runoff from Döderhultsbäcken, which flows into the inner harbour basin. The deck officers of the vessel had calculated with a density of 1.015.

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[21] Transport Canada (Canada's equivalent to the Swedish Transport Agency).
[22] The normal density of saltwater is 1.025 kg/litre of water.

Measurements conducted by SMHI over the period 1990-2010 show the same results as in the above study for the Oskarshamn area (Source: http://vattenwebb.smhi.se/modelarea/#).

3.6 Cargo shift and listing

During an interview with the chief officer, he stated that the deck cargo had shifted approximately 1.5 m to port. According to information from the salvage company Svitzer, which was responsible for discharging the cargo, the deck cargo had shifted about 1.2 m.

When the cargo hatches were opened after the deck cargo was discharged in Oskarshamn, it was observed that the cargo in the hold had packed itself to port so that in the upper part of the hold there was about 30 cm clearance on the starboard side. At the bottom, the cargo did not appear to have shifted to any great extent.

When the vessel was berthed alongside in Oskarshamn before the discharge of the deck cargo started and before the water was pumped out of the vessel, Phantom was listing approximately 40^{o} to port, which has been possible to measure with considerable accuracy on the photograph of the vessel taken from the stern in calm water.

Figure 30. The vessel listing approximately 40^{o} at the quay in Oskarshamn. Photo: Swedish Coast Guard.

3.6.1 According to information from the salvage company

From the salvage company Svitzers' day reports from the salvage operations, the following aspects are of interest regarding the vessel's stability and trim:

- On her return to Oskarshamn, the accommodation was found to be partially filled with water and the bow thruster room contained approximately 20 tons of water.
- After the deck cargo had been discharged and the water in the accommodation and bow thruster room had been pumped out, the remaining list was about 16^{o}.

- The water quantity in WT 3 PS had increased from 30 tons on departure to about 50 tons. After this water had been pumped out, the list was approximately 11^{o}.
- It was impossible to pump the water out from WT 1 PS and there was no information available about how much water this tank held. On the other hand, Svitzer states that they had pumped out WT 2 PS until the list had decreased to approximately 1.5^{o}.
- The hold contained no water, despite the fact that the hatch frame had been submerged for a long time.

3.7 Current regulations for cargo securing and stability

3.7.1 SOLAS Chapter VI – Transport of cargo

A description is given below of the provisions for cargo securing that are presented in SOLAS Chapter VI – Transport of cargo – Part A:

From Rule 1, Paragraph 2, it can be concluded that it is the task of the administration to make sure that relevant information on the cargo and its stowing and securing is available for the vessel under its flag.

> *”To supplement the provisions of parts A and B of this chapter, each Contracting Government shall ensure that appropriate information on cargo and its stowage and securing is provided, specifying, in particular, precautions necessary for the safe carriage of such cargoes*.”*

In a footnote to the above paragraph, reference is made to the Code of Safe Practice for Ships Carrying Timber Deck Cargoes.

From Rule 2, Paragraphs 1 and 2, it can be concluded that it is the responsibility of the cargo owner to provide the vessel or its representative (normally the agent at the port) with relevant information on the cargo:

> *“1. The shipper shall provide the master or his representative with appropriate information on the cargo sufficiently in advance of loading to enable the precautions which may be necessary for proper stowage and safe carriage of the cargo to be put into effect. Such information shall be confirmed in writing and by appropriate shipping documents prior to loading the cargo on the ship.”*
>
> *2. The cargo information shall include:*
>
> *1. in the case of general cargo, and of cargo carried in cargo units, a general description of the cargo, the gross mass of the cargo or of the cargo units, and any relevant special properties of the cargo. For the purpose of this regulation the cargo information required in sub-chapter 1.9 of the Code of Safe Practice for Cargo Stowage and Securing, adopted by the Organization by resolution A.714(17), as may be amended, shall be provided. Any such amendment to sub-chapter 1.9 shall be adopted, brought into force and take effect in accordance with the provisions of article VIII of the present Conven-*

tion concerning the amendment procedures applicable to the Annex other than chapter I.“

Regulation 5, Paragraph 1, specifies the purpose of adequate cargo securing:

”Cargo, cargo units and cargo transport units carried on or under deck shall be so loaded, stowed and secured as to prevent as far as is practicable, throughout the voyage, damage or hazard to the ship and the persons on board, and loss of cargo overboard.”

The fact that all cargo shall be secured in compliance with the Cargo Securing Manual is apparent from Regulation 5, Paragraph 6:

”All cargoes, other than solid and liquid bulk cargoes, cargo units and cargo transport units shall be loaded, stowed and secured throughout the voyage in accordance with the Cargo Securing Manual approved by the Administration. [---] The Cargo Securing Manual shall be drawn up to a standard at least equivalent to relevant guidelines developed by the Organization.”

It is thus clear from SOLAS that cargo shall be secured in accordance with the instructions provided in the Cargo Securing Manual and that this manual shall be drawn up in compliance with the guidelines worked out by IMO. It is also evident that the manual shall be reviewed and approved by the flag state administration.

3.7.2 Cargo securing according to TDC 1991

The instructions on stowing and securing of timber cargoes from the IMO Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (TDC 1991) which are applicable in this case, are presented below.

It should be noted that for packages of sawn timber, TDC only contains instructions for when they are carried as deck cargo. As regards to the part of the cargo that is stowed below deck, instructions must be looked for in the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS).

In *TDC 1991, Appendix A – Advice on stowage practices*, the following primary causes are specified for the shifting of timber deck cargoes:

1.4 The shifting of timber deck cargo is due mainly to the following causes which may occur singly or together:

- **.1** lashings becoming slack due to compaction of the cargo during the voyage, unsuitable devices for tightening the lashing systems and/or inadequate strength of the lashings;
- **.2** movement of the cargo across the hatch covers due to insufficient friction, particularly in ice and snow;
- **.3** inadequate strength of the uprights due to poor material properties and/or excessive forces;
- **.4** heavy rolling or pitching of the ship;
- **.5** impact from heavy seas.

The instructions in TDC 1991 have been formulated with due consideration to these points in order to prevent cargo shifting.

Before loading is started, and if necessary also during loading, accumulations of ice and snow shall be removed. This can be seen from Paragraphs 3.1.1 and 3.1.3 respectively.

3.1.1 Before timber deck cargo is loaded on any area of the weather deck:

.3 accumulations of ice and snow on such area should be removed; and

3.1.3 During loading, the timber deck cargo should be kept free of any accumulations of ice and snow.

The loading and stowage of timber packages shall be carried out in such a way that as compact a cargo as possible is obtained, as far as possible without large voids. The following general instructions are to be found in Appendix A– Advice on stowage practices.

2.9 The timber should be loaded to produce a compact stow with a surface as level as practicable. Throughout the loading, a level and firm stowage surface should be prepared on each working tier. Rough dunnage, if used, should be spread over at least three adjacent packages to produce a binding effect within the stow, particularly in the wings.

2.10 Any gaps occurring around packages in which the cargo may work at sea, such as in the vicinity of hatch coamings and deck obstructions, should be filled with loose timber, efficiently chocked off or effectively bridged over. For this purpose a supply of timber chocking material should be made available to the ship.

2.11 Packages at the outboard edges of the stow should be positioned so that they do not extend over the padeyes and obstruct the vertical load of the athwartship lashings. The end of each deck stow should be flush in order to minimize overhangs to resist the influence of green seas and to avoid the ingress of water.

2.12 Large heavy boards and squares of timber, when loaded on deck in combination with packages, should preferably be stowed separately. When placed in upper tiers, heavy pieces of timber tend to work loose at sea and cause some breaking of packages. In the event that boards and squares are stowed on top of packages they should be efficiently restrained from movement.

2.13 When the final tier is loaded on a large number of tiers, it may be stepped in from the outer edge of the stow about 0.5–0.8 m (a half package).

From Paragraph 4.1.1 to 4.1.5 it can be seen that lashings shall be applied over the cargo, from one side to the other. The lashings shall have a breaking strength lot less than 133 kN (13.3 tons) and be fitted with tensioning devices capable of producing a pre-tensioning strength of 27 kN (2.7 tons) in the horizontal part and 16 kN (1.6 tons) in the vertical parts. It shall also be possible for the lashings to be post-tensioned.

4.1.1 Every lashing should pass over the timber deck cargo and be shackled to eyeplates suitable and adequate for the intended purpose and efficiently attached to the deck stringer plate or other strengthened points. They should be installed in such a manner as to be, as far as practicable, in contact with the timber deck cargo throughout its full height.

4.1.2 All lashings and components used for securing should:

.1 possess a breaking strength of not less than 133 kN;

.2 after initial stressing, show an elongation of not more than 5% at 80% of their breaking strength; and

.3 show no permanent deformation after having been subjected to a proof load of not less than 40% of their original breaking strength.

4.1.3 Every lashing should be provided with a tightening device or system so placed that it can safely and efficiently operate when required. The load to be produced by the tightening device or system should not be less than:

.1 27 kN in the horizontal part; and

.2 16 kN in the vertical part.

4.1.4 Upon completion and after the initial securing, the tightening device or system should be left with not less than half the threaded length of screw or of tightening capacity available for future use.

4.1.5 Every lashing should be provided with a device or an installation to permit the length of the lashing to be adjusted.

4.1.6 The spacing of the lashings should be such that the two lashings at each end of each length of continuous deck stow are positioned as close as practicable to the extreme end of the timber deck cargo.

According to Paragraph 4.2.1 of the code, uprights shall be used if the cargo properties so require.

4.2 Uprights

4.2.1 Uprights should be fitted when required by the nature, height or character of the timber deck cargo.

4.2.2 When uprights are fitted, they should:

.1 be made of steel or other suitable material of adequate strength, taking into account the breadth of the deck cargo;

.2 be spaced at intervals not exceeding 3 m;

.3 be fixed to the deck by angles, metal sockets or equally efficient means; and

.4 if deemed necessary, be further secured by a metal bracket to a strengthened point, i.e. bulwark, hatch coaming.

Section 4.3 specifies the required number of lashings. For deck cargo, the height of which does not exceed 4 m, the longitudinal distance between the lashings shall be max. 3 m. However, each of the outboard packages shall be covered by at least 2 lashings.

4.3 Loose or packaged sawn timber

4.3.1 The timber deck cargo should be secured throughout its length by independent lashings.

4.3.2 Subject to 4.3.3, the maximum spacing of the lashings referred to above should be determined by the maximum height of the timber deck cargo in the vicinity of the lashings:

- **.1** for a height of 4 m and below, the spacing should be 3 m;
- **.2** for heights of above 4 m, the spacing should be 1.5 m.

4.3.3 The packages stowed at the upper outboard edge of the stow should be secured by at least two lashings each.

4.3.4 When the outboard stow of the timber deck cargo is in lengths of less than 3.6 m, the spacing of the lashings should be reduced as necessary or other suitable provisions made to suit the length of timber.

4.3.5 Rounded angle pieces of suitable material and design should be used along the upper outboard edge of the stow to bear the stress and permit free reeving of the lashings.

At the fore and aft edges of the cargo, two lashings shall be positioned as close to the outboard ends as possible, as can be seen from § 4.1.6.

In TDC 1991, demands are only made for uprights if the nature of the cargo so requires. In a general advice issued by the maritime authority in the vessel's flag state Gibraltar in September 2006, the following interpretation of this requirement is given (see Appendix 4):

> *" The nature of timber deck cargoes is such, that uprights are required. They should meet the requirements of paragraph 4.2 of the Timber Code."*

Furthermore, it can be observed that if uprights are used, the cargo should be loaded all the way out to them. Any voids that are formed in the middle of the stow should be filled.

3.7.3 Cargo securing according to TDC 2011

The Timber Cargo Code was revised in 2011. It has been approved by the governing body of IMO, the Assembly, as Resolution A.1048(27). No reference to the new code has as yet been made in the Swedish regulations and thereby put into effect, but a revision of TSFS 2010:174 is under preparation. When this comes into force, the cargo securing manuals for new builds or revised manuals for existing vessels that have been submitted to the administration for approval will be reviewed in line with the new code, but existing approved manuals are not affected.

Paragraph 2.2.1 of TDC 2011 specifies as follows:

> *2.2.1 Prior to loading of the vessel, relevant cargo information as defined in chapter 4 of this Code, should be provided by the shipper, according to the custom of the trade.*

The information on cargo that is specified in Chapter 4 to the code includes the following:

- Stowage factors
- Friction coefficients
- Marking of timber packages, including approximate weight (with reference to ILO Convention No. 27, Marking of weight (packages transported by vessels), 1929)
- Racking strength (form stability) of timber packages.

The new code contains two parts with alternative principles for the securing of timber deck cargoes. The first part contains prescriptive methods for cargo securing that are based on the content of TDC 1991. The methods are identical for all vessels irrespective of their trade route and size. The other part contains function-based methods for cargo securing, with design criteria for various cargo securing arrangements.

If the prescriptive methods had been applied, the requirements for cargo securing for the deck cargo on board Phantom would be largely the same as those specified in TDC1991, but with the addition that cargo which is only loaded up on the hatch covers shall always be prevented from sliding in the transverse direction with the aid of uprights.

If the function-based regulations had been applied, one of the following alternative cargo securing arrangements would have had to be applied:

- Only top-over lashings
- Top-over lashings in combination with uprights
- Loop lashings

For these methods, design criteria have been specified in TDC 2011 that take into consideration the cargo and the vessel’s characteristics, as well as the anticipated weather conditions.

In those cases in which only top-over lashings are used, the required number of lashings is calculated by using the following formula:

$$n = \frac{m \cdot (a_t - g_0 \cdot \mu_{static}) + PW + PS}{2 \cdot PT_V \cdot \sin\alpha \cdot \mu_{static}}$$

Where:

n	= Number of top-over lashings
m	= Weight of the deck cargo
g_o	= Acceleration due to gravity
PT_v	= Pre-tensioning in the vertical part of the lashings
a	= Angle between the deck and the lashings
u_{static}	= Static friction coefficient between the package and the cargo hatch
a_t	= Transversal acceleration acting on the cargo
PW	= Power from wind pressure acting on the cargo
PS	= Power of waves washing over the deck and acting on the cargo

3.7.4 Loading and cargo securing according to TSFS 2010:174

For Swedish vessels, irrespective of voyage, and for foreign vessels that are in Swedish territorial waters, there are provisions in the Swedish Transport Agency's Regulations that applies (*Transportstyrelsens föreskrifter och allmänna råd om transport av last på fartyg och terminaler som anlöps av fartyg som lastar eller lossar fast bulklast,* TSFS 2010:174).

According to § 3 and § 5 of this regulation, the following provisions apply with respect to cargo information:

Cargo information

§ 3 The master shall be able to ensure that:

1. different types of cargo are compatible with each other and sufficiently separated from each other,
2. the cargo is adapted to suit the vessel, and
3. the cargo can be loaded, stowed and secured in the requisite manner

The master shall therefore, in good time before loading, make sure that he has the necessary information on the cargo. In the case of vessels with a gross tonnage of 500 and more, the information shall be given on a cargo information form, which may be in an electronic format.

See Appendix 2 regarding the cargo information form.

§ 4 Cargo information that is to be provided on the form referred to in § 3 shall contain at least the following:

1. If it is a matter of general cargo or cargo that is to be transported in a cargo unit, a general description shall be given of the cargo, the total weight of the cargo or the cargo unit and any other relevant specific characteristics the cargo may have.

§ 5 The master shall, if practically possible, make sure prior to loading that the total weight of the cargo units concurs with the weight that is specified in the transport documentation.

Furthermore, the following provisions shall apply:

Stowing and securing of cargo

§ 6 Vessels shall be loaded and ballasted so that their seaworthiness is maintained throughout the entire voyage. Cargo that is transported above or below deck shall be loaded, stowed and secured so that:

- the vessel's stability or structural strength is not jeopardized,
- the cargo does not shift during the voyage, and
- the safety of the vessel or the people on board is not jeopardized in any other way.

As regards the Cargo Securing Manual, the following shall apply:

Cargo Securing Manual

§ 9 Vessels shall be equipped with a Cargo Securing Manual that is specific for the ship in question. The manual shall have been approved by the vessel's flag state administration and be kept updated. In the case of Swedish ships, the cargo Securing Manual and revisions to it shall be submitted to the Swedish Transport Agency for approval.

§ 12 When drawing up cargo securing manuals for Swedish ships, depending on the nature of the cargo and the vessel, and with the exception of the specifications in § 13, the provisions of Points 1-3 below shall be followed:

1. The CSS Code
2. The Timber Cargo Code, and
3. IMO Resolutions A.489 (XII)[27], A.533 (13)[28] and A.581 (14)[39], revised through MSC/Circ. 812[30].

3.7.5 Intact Stability Code

Phantom was built in 2000 and at that time the Intact Stability Code was applicable according to IMO Resolution A.749(18). It is also to this code that reference is made in the ship's Trim and Stability Booklet and hydrostatic data. When the vessel was built, the Intact Stability Code was not compulsory through SOLAS, but most authorities and classification societies had for a long time applied the requirements of the code. Since they were specified in the vessel's approved stability data, they applied also in the case of Phantom.

Through IMO Resolution MSC.267(85) and corresponding revisions in SOLAS Chapter II, the intact stability criteria in Part A of the Code have become compulsory for all passenger vessels regardless of length and for all cargo vessels with a length of over 24 m that were constructed after 1 July 2010.

The stability requirements that are nowadays compulsory are included in the stability data for Phantom and include the following requirements for the vessel's righting lever curve GZ :

2.2 Criteria regarding righting lever curve properties

2.2.1 The area under the righting lever curve (GZ curve) shall not be less than 0.055 metre-radians up to $\varphi = 30°$ angle of heel and not less than 0.09 metre-radians up to $\varphi = 40°$ or the angle of down-flooding φ_f[5] if this angle is less than 40°. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and φ_f, if this angle is less than 40°, shall not be less than 0.03 metre-radians.
2.2.2 The righting lever GZ shall be at least 0.2 m at an angle of heel equal to or greater than 30°.

[5] φ_f is an angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

2.2.3 The maximum righting lever shall occur at an angle of heel not less than 25°. If this is not practicable, alternative criteria, based on an equivalent level of safety[6], may be applied subject to the approval of the Administration.

2.2.4 The initial metacentric height GM_0 shall not be less than 0.15 m.

On the basis of these stability criteria, the maximum allowable vertical centre of gravity has been corrected for free liquid surfaces KG' and the minimum allowable metacentric height has similarly been corrected for free liquid surfaces G'M calculated for Phantom for different draughts.

In Part B of the Stability Code, it is stated that in arrival conditions, it shall be assumed that the weight of the deck cargo has increased by 10% as a consequence of water absorption.

3.8 TIMRA

On behalf of the Swedish Maritime Administration, a national project group, TIMRA, was set up in conjunction with the revision of the Timber Cargo Code. Under the management of TIMRA tests and investigations were conducted in order to study in detail the physical properties of timber deck cargoes and the effectiveness of various cargo securing arrangements.

In February 2008, a series of full-scale practical tests were carried out in Sundsvall, where the following aspects were established:

- The friction values for different timber deck cargoes under different weather conditions.
- The racking strength in ordinary timber packages.
- The effect of loop lashing arrangements with equipment of different materials.
- Required moments for uprights for round timber.

As a complement to the full-scale tests, the Institute of Higher Education on Åland conducted model tests over the period 2008 to 2010.

During friction testing, the following friction coefficients for different material combinations were established:

Cargo type, material combination	Condition	Static coefficient of friction
Sawn timber – Plywood	Dry	0.50
Sawn timber – Plywood	Snowy	0.25
Sawn timber – Painted Steel	Dry	0.45
Sawn timber – Painted Steel	Snowy	0.05
Sawn timber – Plastic Hood	Dry	0.40
Sawn timber – Plastic Hood	Snowy	0.25
Log (Round wood) – Painted steel sheet	Wet	0.38
Log (Round wood) – Plywood	Wet	0.62
Log (Round wood) – Log	Wet	0.78

Table 4. Friction coefficients for different material combinations in different weather conditions.

Particularly noticeable is the low friction for timber packages on painted steel plate when snow and ice has not been cleared from the underlying surface.

Figure 31. A timber package being loaded on to a surface of painted steel plate.

Figure 32. Angle of inclination where a timber package slides on a snowy surface of painted steel plate.

The tests that were carried out in Sundsvall served largely as a basis for the design principles that are specified in TDC 2011.

4 ANALYSIS

4.1 The rescue operation

The basic starting point for work in connection with accidents is that the activities are organized and have such resources, routines, methods and equipment, etc. that operations at the scenes of accidents can be conducted in such time and in such a way that lives can be saved and damage limited.

The resources that were used and the measures that were taken during the rescue operations corresponded well to the needs. The various phases of the work – life-saving, preparedness for emissions and towing to land – functioned extremely well. The same applies to the management of the operations by JRCC and KBV, and work on the analysis of different scenarios that could have arisen and cooperation with other bodies concerned, such as the County Administrative Board.

4.2 Information on the cargo

The only information on the cargo that was available to the vessel was the Cargo List, se Appendix 1. It stated the number of timber packages and the timber volume. No information was available on the weight of the cargo or on the division between truck packages (TP) and length packages (LP). Other information that could have been useful, such as weight factors, volume factors, friction values and racking strength, was also lacking.

It is for obvious reasons difficult to plan loading and make stability calculations based on the data made available to the vessel before loading was started. In order to make proper loading plans and necessary stability calculations, some form of information is required that at least gives an approximate value for the weight of the timber in relation to the volume. The only party that can provide such data, unless the timber is weighed in connection with loading, is the shipper.

It has been concluded that the chief officer had for some reason used different weight factors for the cargo on deck and the cargo stowed in the hold. No explanation has been given for this.

According to SOLAS, it is clearly stated that it is the shipper's obligation to provide the master or his representative with information on the cargo. Furthermore, TSFS 2010:174 specifies that the master has a responsibility to make sure that he is given this information.

According to TDC 2011, the shipper is required to provide relevant information on the cargo, which includes stowage factors, friction coefficients, marking including approximate weight and the racking strength for timber packages.

4.3 Stability

4.3.1 Comparison of the stability according to the T&S booklet and that presented by the vessel

The trim and stability calculations handed over by the vessel, which had been made on a PC program (WSCV “TRIFESTAB”) on board, were reviewed by SHK and the program appears to calculate accurately. However, it has not been possible to check this in detail because the program calculates with centres of gravity for the level of filling in question. The tanks with corresponding tables were not available for the evaluation.

In the vessel’s calculations, the hold and deck cargoes have not been separated. Instead, weights and centres of gravity have been specified for the entire cargo. In the Trim and Stability Booklet, the VCG is 5.62 m for cargoes with one layer of timber packages on the deck. In the ship’s calculations, a VCG of 5.23 m has been used as the centre of gravity with two layers of cargo packages on deck.

The chief officer has stated in interviews that he conducted a draught survey after the hold had been fully loaded and that the result of this was that they had loaded 1800 – 1900 tons in the hold. A draught survey is a way of finding out how much cargo a vessel is carrying at a given time, provided you know how much bunker, ballast and stores there are on board on the various occasions when the draught is read. The fact that, on a relatively small ship like Phantom, the cargo onboard cannot be specified with an accuracy greater than the nearest 100 tons, which is equivalent to about 10 cm of Mean Draught, could serve to indicate that no such survey had been carried out.

The master noted in the deck log book that the vessel, before departure, had a draught of 5.00 m fore and 5.70 m aft. During the interviews, both the chief officer and the master stated that the draught fore was 4.47 m and aft 5.58 m. The chief officer stated in the first interview that he could definitely recall the draught at the time of departure, despite the presence of ice in the harbour basin. Considering other information that the master and the chief officer has given to SHK as well as what is known about the cargo, SHK deems it reasonable to assume that the numbers mentioned in the interviews are the most correct. It cannot be ruled out that the master subconsciously specified a somewhat incorrect aft draught in the deck log book.

The shipping company has submitted stability calculations to SHK for seven previous voyages that the vessel has undertaken carrying cargoes of timber. In three of these the timber packages had been loaded in two full layers on deck, and in these cases the VCG for the entire timber cargo was 6.01-6.06 m.

According to the information from the vessel, the ship had a cargo intake of 1800 tons in the hold and 380 tons on deck. The vertical clearance in the hold from the tank top to the underside of the hatch cover was 8.24 m. The timber packages have had a mean height of approximately

(1.05 + 1.1) /2 = 1.075 m. With this height, almost exactly 7 whole packages and 1 half package have been accommodated vertically beneath the hatch covers. With a double-bottom height of 0.9 m, the VCG for the cargo in the hold will thus be: 0.90 + 7.5 x 1.075 / 2 ≈4.90 m. The VCG for the deck cargo with 9 packages in breadth in the first layer and 8 packages in breadth in the second layer has been about (9 x 1.075 / 2 + 8 x (1.075 + 1.075 / 2)) / (9 + 8) = 1.043 m above the top of the hatch cover. The centre of gravity over BL has therefore been 9.775 + 1.043 ≈ 10.80 m for the deck cargo.

With a cargo hold weight of 1 800 tons and a deck cargo weight of 380 tons, the centre of gravity for the entire cargo is: (1 800 x 4.90 + 380 x 10.80)/ (1 800 + 380) = 5.93 m, which is 0.70 m higher than in the stability calculations presented by the vessel.

Since the cargo constituted 51.7% (2 180 / 4 216) of the entire displacement, it means that a raising of the cargo by 0.70 m has increased the displacement centre of gravity by 51.7% of 0.70 m, or approximately 0.36 m. The metacentric height has decreased by the same value. If the correct centre of gravity for the cargo had been fed into the ship's stability program, it would have indicated a metacentric height G'M of 0.21 m instead of 0.57 m. The lowest allowable G'M according to the vessel's Trim and Stability Booklet was 0.36 m for the theoretically calculated draught 5.20 m.

In the vessel's calculations, 20 tons of "Ice on Deck" have been included on a VCG of 11.71 m. From what can be seen on photographs, there has probably not been ice in such large quantities on board the ship. An item of 2 tons had been included for "Water/Ice in Deck Cargo" on a VCG of 11.15 m. This item would appear to be realistic. However, it does not concur with the regulations, which specify that 10% of the cargo weight shall be included as a margin in the stability calculations for the water absorption of the timber on deck in the arrival case.

In all cargo cases in the ship's Trim and Stability Booklet, an item of 50 tons of stores has been included in the height of 7.30 m. This item is not included in the vessel's calculations. There is no indication as to what is hidden in the 50 tons, which is a high figure for a ship of Phantom's size. Even though the vessel is intended to carry containers, and for this reason requires a considerable amount of equipment, 50 tons is nevertheless a high figure. In the stability calculations presented by the shipping company for other voyages with timber cargoes, constants of varying sizes have been included. In one case there is a figure of 43 tons of stores quoted. For this reason, use has been made in this investigation of the figure of 50 tons that is specified in the vessel's Trim and Stability Booklet.

If the weight of 20 tons on the height of 11.71 m is removed from the calculations, G'M increases by approximately 0.035 m, and if 50 tons is added to the height of 7.30 m, G'M decreases by approximately 0.025m. These corrections are in other words marginal in relation to correction of the cargo's VCG.

4.3.2 Stability with a cargo intake in line with the stevedores volume factor

According to the tally report from the stevedores in Oskarshamn, a total of 1 039 timber packages were loaded on board: 808 in the hold and 231 on deck. The stevedores use the volume factor 3.68 m^3 of timber per package as an average value. This then gives a total timber volume of approximately 3 824 m^3: 2 973 m^3 in the hold and 850 m^3 on deck. With a weight factor of 0.565 tons per m^3 of timber, which the vessel uses, the weight of the cargo in the hold will be 1 680 tons and on deck 480 tons.

The volume factor of 3.68 m^3 per package is, of course, uncertain because the cargo contained packages from different shippers such as whole and half packages, but it should be the best approximate value that is based on long experience in the stowing of timber cargoes from different shippers in the Oskarshamn area. It has also been assumed that the proportion of half-packs was just as large in the hold as on deck since, among other things, half-packs are used to top up the cargo in the hold. It has not been possible to come up with any information as to why the vessel, according to information on the weights in the hold and on deck, respectively, has reckoned with a volume factor of 2.90 m^3 per package for the deck cargo and 3.91 m^3 per package for the hold cargo.

According to the chief officer, the draught of the vessel increased by approximately 0.5 m when the deck cargo was taken on board. With approximately 9.5 tons per cm immersion, this corresponds to 475 tons. A weight of 480 tons for the deck cargo would therefore appear to be likely. The corresponding weight of the deck cargo has also been used in previous voyages with double layers of timber packages on deck.

A stability calculation with a cargo of 1 680 tons in the hold and 480 tons on deck with the vertical centres of gravity as specified above, longitudinal centres of gravity as per the Trim and Stability Booklet, bunker and ballast as per the ship’s information, without 20 tons of ice on the deck and with 50 tons of stores, gives the following trim and stability:

- Displacement: 4 206 tons
- Mean draught: 5.19 m
- Draught fore: 5.05 m
- Draught aft: 5.33 m
- Trim: 0.28 by the stern
- Metacentric height G’M: 0.09m

In an interview, the chief officer has stated that the aft draught was 5.58 m and the fore draught 4.97 m. It can be assumed that the aft draught was read on the draft scale and that the draught at the aft perpendicular (AP) was a few centimetres less.

The forward reading was taken approximately at the forward perpendicular (FP). The chief officer had calculated with a water density of 1.015 ton/m^3. The reading would thus indicate a mean draught of approximately 5.26 m and a trim of approximately 0.60 m by the stern.

The hold tapers in its forward part, which means that the timber packages stow somewhat worse at the forward end than in the rest of the hold. It is therefore reasonable to assume that the centre of gravity of the cargo has been somewhat further to the stern in the cargo in question than that given by the “bale” centre of gravity for the hold. A reasonable longitudinal centre of gravity is approximately 0.5 m further to the aft than the “bale” centre of gravity, or about 41.75 m for the cargo in the hold.

The cargo hatch extends from frame 25 to frame 118. The vessel’s frame distance is 0.6 m. This gives a centre point for the cover at frame 71.5, which is situated 42.9 m forward of AP. This longitudinal centre of gravity for deck cargo has been used in the vessel’s Trim and Stability Booklet. It can be seen from the photo taken after the accident that the cargo forward ended at roughly at the forward edge of the hatch cover at frame 118. At aft, however, the cargo was loaded out on to the container supports and extended in principle to frame 20. This gives a longitudinal centre of gravity for the deck cargo of ((118 + 20) /2) x 0.6 = 41.4 m forward of AP.

Figure 33. Forward edge of deck cargo. Photo: Swedish Transport Agency.

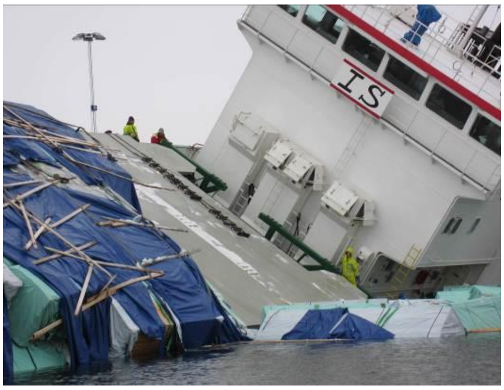

Figure 34. Aft showing the supports for containers. Photo: Swedish Transport Agency.

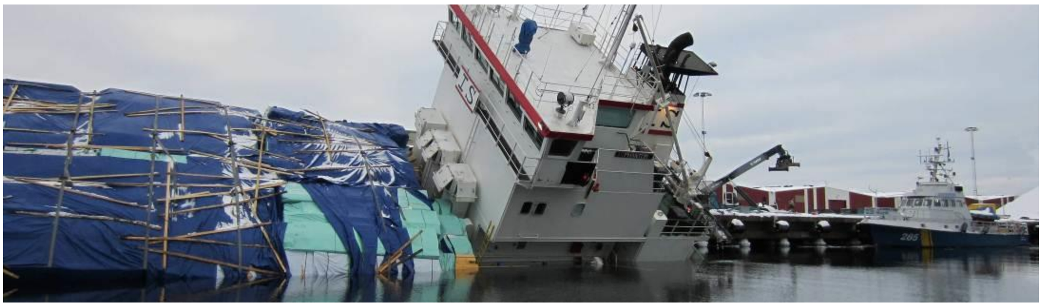

Figure 35. Photo showing that the deck cargo was stowed along the stern against the deckhouse. Photo: Swedish Coast Guard.

If these longitudinal centres of gravity are used for the cargo, the following trim and stability are obtained:

- Displacement: 4 206 tons
- Mean draught: 5.18 m
- Draught, fore: 4.90 m
- Draught, aft: 5.46 m
- Trim: 0.56 m by the stern
- Metacentric height G’M: 0.10 m

The difference of 8 cm in the mean draught between the calculations and the chief officer's reading is believed to be partly the result of uncertainty in the reading as a consequence of ice and partly because the water did not have a density of 1.015. If the density of 1.006 had been taken into account, the draught according to the calculations would have increased by approximately 4 cm.

4.3.3 Heeling moments of the cargo shift

According to information received from the master and the chief officer, the distance between the lower layer of the deck cargo and the edge of the hatch cover was approximately 0.2 - 0.3 m on either side. However, a calculation based on 9 timber packages in the lower layer and an average breadth of 1.1 m per package, indicates a distance of 0.15 m per side, which must be regarded as the most likely figure.

According to the master's information, the shifting of the deck cargo was 1.2 – 1.5 m. If the cargo shift in the following photo is compared with the width of the bridge beneath the window, which is 11.2 m, it can be concluded that the distance between the cargo and the outboard edge of the hatch cover on the starboard side is approximately 1.35 m. Since the cargo was stowed about 0.15 m in from the edge of the cover, it can be assumed that the deck cargo had shifted about 1.2 m, which corresponds to the cargo shift reported by the salvage company.

Figure 36. Displacement of the deck cargo. Photo: Swedish Coast Guard.

According to information received, the cargo in the hold had been packed to port so that a clearance of about 30 cm had been formed on the starboard side. At the bottom, the cargo had not shifted to any great extent. The total cargo in the cargo hold is therefore assumed to have shifted about 15 cm.

The total heeling moment from the cargo will thus be 1 680 x 0.15 +480 x 1.2=828 ton-metres. With a displacement of 4206, the heeling leverage will be 828 /4206 = 0.197 m.

If the heeling leverage multiplied by the cosine for the heeling angle is inserted in the vessel's righting lever curve, the curves intersect at approximately 37 degrees. Thus, this was Phantom's list after the cargo had shifted.

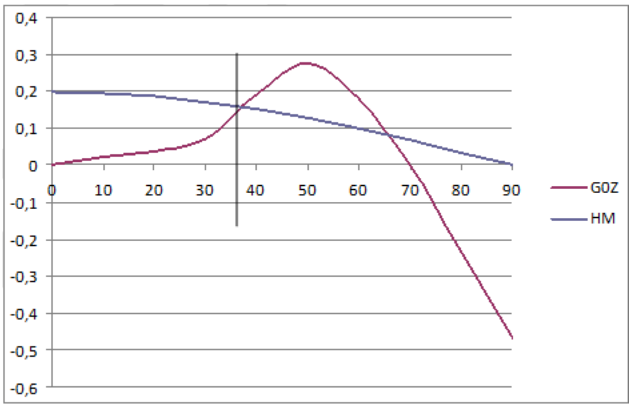

Figure 37. Shifting of the deck cargo.

In these calculations, the displacement effect of the deck cargo has not been included.

4.3.4 Trim after the cargo shift and water intrusion

The heavy listing has also meant that the air pipes on the vessel's port side became submerged. Even though they were fitted with automatic closing devices, the water is thought to have been able to enter during the long period they were submerged. All tanks with air pipes on the port side were full apart from WT 1 and 3 P. On departure, WT 3 P held 30 tons of water according to information from the vessel. According to information from Svitzer, the tank contained about 50 tons of water when the ship was righted in Oskarshamn. This means that approximately 20 tons of water had entered the tank during the time in which the air pipes were under the water.

Svitzer also states that the vessel's remaining list after the deck cargo had been discharged and water pumped out from the bow thruster room and the accommodation was approximately 16 degrees. In order to be able to explain such a heavy list, about 70 tons of water must have entered WT 1 P.

If about 70 tons of water are assumed to have entered the ship via WT 1 P, the stability would have increased somewhat, but the heeling moment would at the same time have increased and the list would have been about 38 degrees, see the graph below.

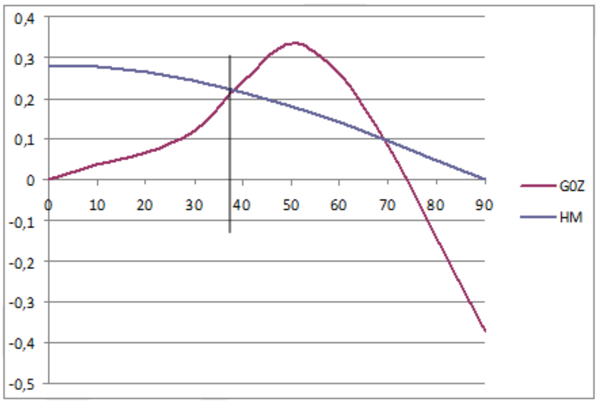

Figure 38. The vessel's approximate 38 degree list after the cargo shift and water intrusion.

This corresponds well with the list the vessel had after towing to Oskarshamn before discharging of the cargo and emptying of the flooded spaces, see photo in Section 3.6. In the calculations above, the water in the bow thruster room has not been included.

This water is not believed to have influenced the list to any great extent. In the calculations, the water in the accommodation areas, which is believed to have influenced the list somewhat, has not been included either. In the calculations, however, a lifting force from the deck cargo of 45 tons on a vertical centre of gravity of 9.80 m and a transverse centre of gravity of 6.00 m has been included. This lifting force is based on a triangle of the deck cargo, measuring approximately 1.25 x 1.25 m with a length of 58.8 m, being submerged, which is in turn based on observations from Figure 39.

Figure 39. Displacing effect of the deck cargo. Photo: Swedish Coast Guard.

4.3.5 Probable stability on departure

In view of the calculated stability corresponding well to the listing that occurred and the observed cargo shifting, it can be concluded with a high level of probability that the stability of the vessel on its departure from Oskarshamn was very low, approximately 0.10 m, according to SHK:s calculations.

Stability as low as this must reasonably have been felt inside the vessel, and the information that the boat man gave that the ship listed noticeably at the smallest manoeuvre at the time of its departure from Oskarshamn would appear to concur with the conclusions. The information given by the master and the chief officer that the vessel's period of roll was 15 seconds cannot reasonably have been correct if the vessel had had a stability of about 0.10 m. The rolling period should instead have been somewhere in the region of 30 seconds since the rolling period T in seconds is calculated based on the formula: $0.8 \times B / \sqrt{G'M}$ where B is the width of the vessel (12.5 m). The statement of 15 seconds could possibly have been taken by mistake from the timber cargo case in the vessel's Trim and Stability Booklet.

If the vessel's rolling period had been approximately 15 seconds, G'M would have been about 0.45 m according to the above formula. With such stability, the angle of heel for the cargo shift observed would only have been 25 degrees.

It can therefore be concluded with a high level of certainty that the vessel's level of stability on its departure from Oskarshamn was approximately 0.10 m.

A comparison in the table below with the stability calculations provided by the shipping company for previous timber cargoes transported by Phantom indicate major differences between these voyages and the one in question. The table contains load cases from the ship's Trim and Stability Booklet for the purpose of comparison.

Compilation of cargo cases for Phantom

	Ballast		Gas Oil		Rumslast		Däckslast Lager 1			Däckslast Lager 2			Däckslast Totalt			Hela lasten		Deplace-ment		Draft			
Resa	Vikt	VCG	Vikt	VCG	Vikt	VCG	Vikt	%	VCG	Vikt	%	VCG	Vikt	%	VCG	Vikt	VCG	Vikt	VCG	SW	FS	G'M	G'MR
06/07 6/3 2007 DEP	680	1,6	57	1,52	1870	4,74	263	54	10,32	228	46	11,50	491	21	10,87	2361	6,01	4435	4,99	5,39	0,06	0,38	0,40
06/07 13/3 2007 ARR	640	1,54	70	1,29	1870	4,74	263	54	10,32	228	46	11,50	491	21	10,87	2361	6,01	4411	5,00	5,37	0,06	0,36	0,39
11/07 26/4 2007 DEP	697	1,63	80	1,45	1817	4,72	283	56	10,32	223	44	11,4	506	22	10,81	2323	6,05	4434	4,95	5,39	0,06	0,39	0,40
15/07 24/5 2007 DEP	678	1,64	95	1,22	1830	4,72	291	57	10,32	224	43	11,4	515	22	10,80	2345	6,06	4428	4,97	5,38	0,06	0,39	0,40
17/07 26/6 2007 DEP	684	1,62	43	2,12	1878	4,72	275	62	10,32	171	38	11,4	446	19	10,75	2324	5,88	4336	4,92	5,28	0,05	0,47	0,38
31/07 25/10 2007 DEP	697	1,65	74	1,01	1800	4,72	290	60	10,32	190	40	11,4	480	21	10,76	2280	5,99	4347	5,03	5,30	0,01	0,41	0,38
37/07 9/11 2007 DEP	755	1,8	69	1,51	1792	4,72	325	66	10,32	170	34	11,4	495	22	10,70	2287	6,01	4403	4,93	5,36	0,04	0,46	0,39
27/08 10/6 2008 DEP	792	1,91	69	1,35	1796	4,77	316	78	10,31	90	22	11,4	406	18	10,55	2202	5,84	4392	4,79	5,34	0,05	0,60	0,39
Olycksresan enligt fartygets beräkningar	646	2,16	22	4,23	1800								380	21		2200	5,23	4216	4,84	5,20	0,01	0,57	0,36
Olycksresan med intag enligt tallyt	646	2,16	22	4,23	1680	4,90	254	53	10,32	226	47	11,4	480	22	10,80	2160	6,21	4206	5,37	5,18	0,01	0,10	0,36
T&S DEP	299	0,47	184	0,99	2009	5,01	261		10,32				261	13	10,32	2270	5,62	4178	5,03	5,12	0,01	0,38	0,34
T&S ARR	833	2,55	18	5,45	2009	5,01	261		10,32				261	13	10,32	2270	5,62	4490	5,03	5,45	0,01	0,41	0,41

Figure 40 Compilation of cargo cases for Phantom

With 9 packages in width in the first layer and 8 in the second layer, the weight distribution will be approximately 53% / 47% between the two layers. The cargo intake shaded in green in the table above shows that on the voyages marked 06/07, 11/07 and 15/07, the vessel had in principle a full deck cargo in two full layers, but in these cases the G'M was 0.38 – 0.39. It has been possible to observe the following differences between these voyages and the one on which the accident occurred.

Despite the fact that the vessel on the accident voyage had, according to the calculations, a displacement that was 178 tons lower than the displacement on the winter mark, which is 4 383 tons, the ballast intake was lower than on previous voyages. The compilation also shows that the centre of gravity for the ballast was higher than on previous voyages. This is due to the fact that on the accident voyage only WT 2 P and S of the three pairs of wing tanks were filled, whereas on previous voyages all the wing tanks were filled to approximately 1/3. This lowers the centre of gravity without increasing the free water surface since the wing tanks are narrow and, according to the Trim and Stability Booklet, give zero in correction for free water surfaces.

If the ballast intake had been as in voyage 27/08, the stability would have been improved by 0.15 m. The reason why WT 1 and 3 P and S were not used during the accident voyage has not been definitely established. One possible reason could be that there were problems with the valves for WT 1, which is indicated by the fact that it was difficult for Svitzer to pump out the water from WT 1 P in conjunction with the righting of the vessel in Oskarshamn. With water only in WT 2 and 3, the result would have been an excessive aft trim.

The compilation shows that the vessel had unusually little bunker on an unusually high centre of gravity during the accident voyage in comparison with previous voyages. If the bunker had been as it was on voyage 27/08, the stability would have increased by about a further 0.06 m.

It also shows that the hold cargo on previous voyages was assumed to be on a level of 4.72 – 4.77 m, despite the fact that the hold cargo intake has been greater than on the voyage in question. One reason could be that half-packs had not been available on previous voyages to top up the hold space. If the calculation is based on7 packages in height with a height of approximately 1.1 m each, the VCG for the hold cargo will be about 4.75 m. This concurs with the centres of gravity for the hold cargoes that were used on previous voyages.

The difference in stability if the cargo is calculated to a height of 4.72 rather than 4.90 will thus be 0.07. The possibility cannot be discounted that the cargo on previous voyages should have been calculated with a higher centre of gravity and that the stability on these journeys has therefore been in practice approximately 0.07 m lower than the calculations showed.

All the above corrections with ballast water would have given an increase in stability of approximately 0.28 m, which shows that it would have been possible, with the cargo intake in question, to achieve roughly the same stability as on previous voyages.

From the compilation, it is clear that the centre of gravity applied by the deck officers for the entire cargo, 5.23 m, is remarkably different from those centres of gravity that were used on previous voyages with equivalent cargo intakes.

The compilation also shows that the vessel, on voyage 06/07, was overloaded by about 50 tons since this journey was made during the winter season when the vessel's maximum displacement is 4 383 tons. In the table, the stability values for a number of journeys have also been marked for which the calculated stability was below the required value.

Furthermore, it can be concluded from the calculations for voyage 06/07 that the prescribed increase in weight for the deck cargo has not been included.

4.3.6 Fulfilment of stability criteria

With a mean draught of approximately 5.18 m, the ship should have had a G'M of at least 0.36 m in order to meet the stability requirements. On departure, the vessel probably had a G'M of only 0.10 m. It can thus be concluded that the vessel, on its departure from Oskarshamn, had insufficient stability. This deficient stability is the result of a combination of unsuitable ballasting, not enough bunker and too much cargo on deck.

In Canada there are regulations that require the administration to approve the loading, the stability and the vessel before departure from the port of loading. It cannot be discounted that the accident on board Phantom could have been avoided if there had been similar regulations in Sweden.

4.4 Cargo securing

4.4.1 Design accelerations for different cargo securing arrangements

According to TDC 2011, and with the support of the research that has been conducted within the TIMRA Project, a requisite number of top-over lashings for winter packages on deck shall be determined by means of the following formula:

$$n = \frac{m \cdot \left(a_t - g_0 \cdot \mu_{static}\right) + PW + PS}{2 \cdot PT_V \cdot \sin\alpha \cdot \mu_{static}}$$

Where:

n	= *Number of top-over lashings*	
m	= *Deck cargo weight*	= *480 tons*
go	= *Gravity acceleration*	= *9.81 m/s*^{2}
PTv	= *Pre-tensioning in the vertical part of the webbing*	= *16 kN*
α	= *Angle between the deck and lashings*	= *77 degrees*
μ_{static}	= *Static friction coefficient between package and cargo hatch cover*	= *0.05*
α_t	= *Transverse acceleration acting on the cargo*	= *7.18 m/s*^{2}
PW	= *Power from wind pressure acting on the cargo*	= *105 kN*
PS	= *Power from sea washing over the deck and acting on the cargo*	=*100kN*

It is not apparent from the Cargo Securing Manual for Phantom or from the markings on the lashing equipment what pre-tensioning the tightening devices are designed to give, but since the equipment has been specially developed for timber deck cargoes it must be considered likely that it is capable of producing a pre-tensioning that meets the requirements of TDC 1991, i.e. that it generates at least 16 kN pre-tensioning in the vertical parts of the lashings.

The static friction coefficients are taken from Table 4.2 in TDC 2011. The values in this table have been taken from the practical tests that were carried out in Sundsvall in 2008 on behalf of the Swedish Maritime Administration. These tests clearly showed that an extremely low friction can be expected between timber packages and painted cargo hatches unless they are cleared from snow and ice before loading. The cargo hatches on Phantom were completely smooth and the container fasteners were recessed, which made it easier for the cargo to slide.

The values for acceleration and wind and water pressure have been taken from Annex 13 in the Code of Safe Practice for Cargo Stowage and Securing. The acceleration is based on the ship's dimensions and service speed, the position of the cargo on board and the current load condition. The specified acceleration in the transverse axis applies for unrestricted speed for a voyage in which the weather conditions cannot be foreseen on departure. The forces from wind and water pressure are determined by the exposed area. In the case of water pressure, however, the force is based only on the area up to 2 m above the cargo hatches.

With the values specified above, the following number of top-over lashings is needed at the voyage in question:

$$n = \frac{480 \cdot (7{,}18 - 9{,}81 \cdot 0{,}05) + 105 + 100}{2 \cdot 16 \cdot \sin 77° \cdot 0{,}05} = 2191\ st$$

The large number of required lashings clearly shows the limitations of this method of securing, especially when the underlying surface is covered with ice and/or snow and the friction is low.

If there had been more favourable weather conditions without snow and ice, a considerably higher friction coefficient of μ = 0.45 could have been used in designing the lashing arrangement, which gives the following required number of lashings:

$$n = \frac{480 \cdot (7{,}18 - 9{,}81 \cdot 0{,}45) + 105 + 100}{2 \cdot 16 \cdot \sin 77° \cdot 0{,}45} = 109\ st$$

If the entire deck surface had not been covered in snow and ice, the actual friction would have been somewhere between the extreme values quoted above. A probable friction coefficient is therefore approximately μ = 0.30, which gives the following requirement regarding the number of lashings:

$$n = \frac{480 \cdot (7{,}18 - 9{,}81 \cdot 0{,}30) + 105 + 100}{2 \cdot 16 \cdot \sin 77° \cdot 0{,}30} = 239\ st$$

TDC 2011 also provides the opportunity to design cargo securing arrangements on the basis of anticipated significant wave height during the voyage. With the aid of the formula above, the limiting transverse acceleration for the probable friction coefficient and the actual number of lashings, 20, can be calculated as follows:

$$a_t = \frac{(n \cdot 2 \cdot PT_V \cdot \sin\alpha \cdot \mu_{static} + m \cdot g_0) \cdot \mu_{static} - PW - PS}{m}$$

$$a_t = \frac{(20 \cdot 2 \cdot 16 \cdot \sin 77° + 480 \cdot 9{,}81) \cdot 0{,}30 - 105 - 100}{480} = 2{,}91\ m/s^2$$

The restricting transverse acceleration gives the maximum allowable significant wave height for the arrangement as follows:

$$HS = \left(\frac{a_{t\,\lim it}}{a_{t\,unrestricted}} \right)^3 \cdot 19{,}6 = \left(\frac{2{,}91}{7{,}18} \right)^3 \cdot 19{,}6 = 1{,}3\ m$$

If loading is carried out under such conditions that snow and ice can be discounted and the friction coefficient μ = 0.45 can be used, the design transverse acceleration will be 4.57 m/s^2 and the maximum allowable wave height 5.1 m for Phantom with metacentric heights lower than 0.9 m.

4.4.2 Fulfilment of provisions in the Cargo Securing Manual

In SOLAS, it is clearly apparent that it is the instructions in the Cargo Securing Manual that are to be followed for the securing of cargoes on board. In the manual, there is a separate chapter on timber cargoes and an appendix that contains the Timber Cargo Code from 1991 in its entirety, as well as the appendices that are to be found in IMO's printed version of the code. However, nowhere in the Cargo Securing Manual is any reference made to this appendix.

The deck cargo had been secured with top-over lashings in the form of web lashing equipment that concurred with the equipment that was referred to in the chapter in the manual on timber cargoes. Edge protection had also been used. However, it was not indicated in the manual how much lashing equipment should be used and there was no descriptive text on how the equipment was to be applied.

The shorter uprights that were described in the manual to prevent cargo sliding against the hatch cover were not available on board despite the fact that this was compulsory according to the Cargo Securing Manual approved by the flag state. Those longer uprights that were available on board had not been used.

The manual contained only a description of cargo securing arrangements for cargo packages in one layer. However, on the voyage in question, and on certain previous voyages, packages had been loaded in two layers.

The cargo had thus not been secured in compliance with the arrangement descframeed in the Cargo Securing Manual.

4.4.3 Fulfilment of provisions according to TDC 1991

The cargo appears to have been loaded as tightly and compactly as possible in accordance with the requirements of the Code. It can be concluded from the photographic material that lower packages had been stowed on their side in order to fill voids in the cargo. However, it can also be noted that snow and ice had not been cleared from the hatch covers or from between the layers in the cargo to the extent prescribed by TDC 1991.

Figure 41. From the photographic material it can be concluded that lower packages had been stowed on their side in order to fill voids in the cargo, and that significant amounts of snow had been left on the hatch covers and between the layers before loading.

It can be concluded that web lashing equipment with the necessary breaking strength has been used for the top-over lashings to secure the cargo.

According to TDC 1991, the distance between the lashings must not exceed 3 m for deck cargoes with a total height of 4 m or lower. Since the deck cargo extended from frame 20 to frame 118, the total length of the cargo was 58.8 m. Since, according to information received, a total of 20 top-over lashings were used, the mean distance between them was 2.9 m. Consequently, on this point the provisions of TDC 1991 were met. The distance between the D-rings was 2.4 m in most positions.However, TDC 1991, § 4.3.4 specifies that the outboard packages in the upper layer shall be covered by two lashings each. According to information received, the cargo was loaded with 9 packages in width in the lower layer and 8 packages in the upper layer. The 231 packages on deck should therefore have been loaded in 14 sections. With a total cargo length of 58.8 m, the average length of the packages is 4.2 m. In order to meet the requirement of 2 lashings per section, 28 lashings should have been used. Certain sections have thus probably only been covered by one lashing.

In TDC 1991, § 4.2.1, it is stipulated that uprights should be used if the properties of the deck cargo so require. As can be seen from Appendix 4, in 2006 the flag state issued a circular which clarifies that this requirement applies for all timber deck cargoes. Since no uprights had been used, and the number of lashings was insufficient, it can be concluded that the cargo had not been secured in accordance with the provisions of TDC 1991.

4.4.4 Fulfilment of provisions according to TDC 2011

The requirements for cargo securing according to the section with the prescriptive instructions in TDC 2011 concur largely with those specified for timber packages on deck in TDC 1991. However, the requirement for uprights is prescribed more clearly for timber packages that are loaded on the cargo hatch covers. These provisions have not been followed in this case.

TDC 2011 also provides the possibility to dimension the cargo securing with the help of function-based requirements by, for example, only top-over lashings.

If the provisions are based on winter conditions, the required number of top-over lashings, when used as the only cargo securing method for cargo stowed up on the cargo hatches, is incredibly large – approximately 2 200 lashings. Even if more favourable weather conditions were to prevail, without snow and ice, the required number of top-over lashings would still be considerable – over 100.

The unreasonable number of lashings required indicates clearly the limitations of this method of cargo securing, especially when the surface is covered in snow or ice and the friction is low. Under such circumstances, this method should be used in combination with uprights that prevent the cargo from sliding against the hatch covers.

The calculations in Section 4.4.1 show that the lashing arrangement used can be applied in significant wave heights of up to 1.3 m provided the conditions are comparatively good during loading. Under circumstances in which the possibility of snow and ice can be discounted, the design wave height will be 5.1 m. It is, however, unlikely that such favourable weather conditions could be foreseen with any degree of reliability during a voyage from Oskarshamn to Casablanca at the time of year in question.

It can be concluded that if the function-based requirements of TDC 2011 had been applied, the limitations of the lashing arrangement used would have been known and its application would have been excluded.

4.4.5 The ship's Cargo Securing Manual

The Cargo Securing Manual contained neither clear nor detailed instructions for the securing of timber deck cargoes. The fact that the manual contained on the one hand a separate chapter on timber cargoes and on the other an appendix containing TDC 1991 that is not referred to in the main section of the manual makes it difficult to gain an overview of and makes it unclear to the reader as to which instructions he or she should follow.

Some of the information in the manual is not written in the principal language English but instead in German or Swedish.

Since the instructions for timber cargoes have been inserted in a separate chapter, the manual does not follow the basic structure that was established by *IMO Guidelines for Preparation of Cargo Securing Manuals, MSC.1/Circ. 1353.* This chapter mainly contains certificates and drawings, but the following information is lacking:

- Descriptive text on the application of cargo securing equipment
- Minimum number of lashings
- Pre-tensioning in the intended lashing equipment
- Required number of uprights
- Strength of uprights
- Maximum distance between uprights and cargo
- Instructions for the securing of timber packages in several layers

5 CONCLUSIONS

The master and chief officer of the vessel stated during the course of interviews that the vessel's stability (G'M) on its departure from Oskarshamn was approximately 0.40 m whereas they at the same time handed over printouts from the ship's stability program indicating a stability of 0.57 m. This suggests considerable uncertainty as to the actual stability of the vessel and that the stability calculations were inadequate. Eye-witnesses stated that the vessel, on its departure, heeled over to an unusually great extent while manoeuvring in the harbour basin.

It has been possible to deduce, with the help of a reconstruction of the cargo case in question, that the stability of the ship on its departure from Oskarshamn was only about 0.10 m, which is to be compared with the required stability of at least 0.36 m. It can also be concluded that no form of rolling test was carried out, which would probably have established the fact that the stability of the vessel was considerably worse than assumed.

The conclusion is, therefore, that the stability of the ship was inadequate on its departure from Oskarshamn. Reasons for this and factors affecting the deficient stability have been a combination of unsuitable ballasting, not enough bunker and too much cargo on deck.

Stability calculations handed over concerning previous voyages indicate that the vessel was on one occasion overloaded on departure, that the regulated water absorption value had not been included in the calculations for the arrival case and that the stability was in certain cases somewhat worse than required.

With regard to cargo securing, the following conclusions can be drawn:

- The Cargo Securing Manual contained instructions on how timber deck cargo is to be secured. However, these instructions were unclear and scattered over different parts of the manual.
- The cargo was not secured in line with the Cargo Securing Manual. In particular, there were no uprights to prevent cargo sliding against the hatch covers, which is a clear requirement of the manual. This requirement had also been clarified by the flag state through the circular that is reproduced in Appendix 1.
- Neither was the cargo secured in accordance with TDC 1991, which is reproduced in the Cargo Securing Manual, as an insufficient number of lashings had been used.
- Without uprights, the chosen cargo securing method would have had a very limited effect on keeping the deck cargo in its original position because of the low friction between the hatch cover and the timber packages. If the function-based requirements of TDC 2011 had been applied, they would have excluded the use of the chosen cargo securing arrangement.

In interviews, the master and the chief officer stated that the reason why no uprights had been used was to allow the cargo to be jettisoned in the event of cargo shifting. Despite this, the crew left the ship without first attempting to cut the lashings securing the deck cargo, and in this way righting the vessel.

As a result of problems with the ballast valves, double-bottomed tanks 1 and 2 had been filled with water via air pipes on the weather deck after the automatic closing devices had been dismounted. These devices had not been remounted before departure from Oskarshamn.

It follows from the observations above that the vessel, on its departure from Oskarshamn, was not seaworthy as the stability was inadequate (0.10 m instead of the required stability of at least 0.36 m), as the deck cargo had not been secured in accordance with the Cargo Securing Manual, and finally as the closing devices for the air pipes had been dismantled.

6 RECOMMENDATIONS

The shipping company Interscan Schiffahrtsgesellschaft mbH is recommended to:

- Ensure that the company vessels follow established requirements for stability and requirements stipulated in the Cargo Securing Manual. *(RS 2013:01 R1).*
- Consider a revision of the Cargo Securing Manual for the vessel with clear instructions on the type of cargoes that are normally carried by the vessel *(RS 2013:01 R2).*
- Consider basing the requirements for cargo securing in the shipping company's vessels in accordance with the revised Timber Cargo Code TDC 2011 *(RS 2013:01 R3).*
- Instruct vessels to carry out rolling tests before departure in connection with timber deck cargoes (*RS 2013:01 R4).*
- Consider the possibility of conducting refresher courses in stability and cargo securing , particularly for the officers on board vessels that carry timber deck cargoes *(RS 2013:01 R5).*

The Swedish Transport Agency (TS) is recommended to:

- Investigate the preconditions for introducing regulations in Sweden, as in Canada, imposing requirements that vessels are inspected, both before and after the loading of timber, to ensure that the vessels are seaworthy before departure from a Swedish port. *(RS 2013:01 R6)*

The flag state Gibraltar is recommended to:

- Improve the review and approval process of Cargo Securing Manuals so that the instructions in the manuals can be used by the crews on board the vessels *(RS 2013:01 R7).*

The Swedish Forest Industries Federation is recommended to:

- Ensure, as soon as possible, that the information required in line with SOLAS and TDC 2011 is provided by Swedish Forest Industries Federation members to vessels in conjunction with loading timber in Swedish ports *(RS 2013:01 R8).*

7 APPENDICES

Appendix 1. The Cargo List that was given to the vessel after its arrival in Oskarshamn

ASKALA Shipping AB **CARGOLIST**

M/V PHANTOM DATE: 12-02-08 BERTH: 54 OSKARSHAMN-CASABLANCA

- 14 -

B/L	REF/MARKS	PCKGS	CBM	WEIGHT	SHIPPER	SUPPLIER	RECEIVER	REMARKS
			- CASABLANCA -					
	IFMA 7	385	1485,269		RÖRVIK	Rörvik, Linghem, Box		
	GHO 475	111	438,244		NORDLIGNUM	Bergs		
	YAN 479	80	238,417		NORDLIGNUM	Bergs		
	GHO 045	55	213,497		NORDLIGNUM	Bergs		
	GHO 074	51	147,280		NORDLIGNUM	Bergs		
	TOU 1	56	189,257		NORDLIGNUM	Bergs		
	GHO 075		37,000		NORDLIGNUM	INGARPS		EJ KLART!
	COM	13	55,000		UNI 4	SÖ, KINDA		
	SOCOB	206	748,000		UNI 4	SÖ, VIDA		ÖKNING!
	GHOLAMI	112	436,960		UNI 4	SÖDRA		
	Total :	~~850~~ 1069	3988,924					

Vid ankomst.

CASABLANCA PHANTOM FEBR 12

Appendix 2. The English version of the form for cargo information (TSFS 2010:174)

TSFS 2010:174
Bilaga 1

FORM FOR CARGO INFORMATION

Transport Document No. ....

Shipper:	Consignee:
Carrier:	
Name/Means of transport:	

Instructions or other matters:		
Port/Place of departure:		Port/Place of destination:
General description of the cargo (type of material/particle size):		
Gross mass (kg/tonnes):		
☐ General cargo		
☐ Load units		
☐ Bulk cargo	Specification of bulk cargo*	
	Stowage factor	
	Angle of repose	
	Trimming procedures	
	Chemical properties if potential hazard†	
	*If applicable	
	† For example IMO class, UN No. or bulk cargo shipping name in accordance with the Swedish Transport Agency's Regulations (TSFS 2010:166) on maritime transport of solid bulk cargoes (IMSBC).	
Special properties of importance of the cargo		
Additional certificate(s)*		
☐ Certificate of moisture content and transportable moisture limit		
☐ Weathering certificate		
☐ Exemption certificate		
☐ Other (specify)		
* If required		

DECLARATION

I hereby declare that the consignment is fully and accurately described and that the given test results and other specifications are correct to the best of my knowledge and belief and can be considered as representative for the cargo to be loaded.

Signature

Name/status: ....

Signature on behalf of the shipper ....

Company/organization: ....

Place and date: ....

Place and date: ....

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Appendix 3. Laminated checklist for departure

INTERSCAN Schiffahrtsgesellschaft MBH	Safety Management Manual Chapter 3 - Operation Procedures 3.2/3 - DEPARTURE CHECKLIST - DECK	Release No. : 3 Released : 01.04.2005 Created by : HanseSEAS Approved by : A. Fedorcov

M.V.: ________________________ Date: _____________ Port: ____________________

Responsibilities for the Officer preparing the bridge for departure:

☐ Passage plan and sea charts prepared (*in accordance with* ***3.2/1 - Passage Planning***)
The following bridge equipment has been checked and is in operation:
- ☐ Automatic Identification System (AIS) updated with relevant data
- ☐ Electronic navigational position fixing systems (*in operation and compared*)
- ☐ Radar(*s*) (*in operation and tuned*)
- ☐ Echo sounder (*if available*)
- ☐ Gyro/magnetic compass and repeaters (*in operation and synchronized*)
- ☐ Rudder and engine indicators *(if available)*
- ☐ Clocks (*compared and synchronized*)
- ☐ Navigation lights (*primary and secondary system*)
- ☐ Signalling equipment (*i.e. flags, lights, day signals, sound signals*)
- ☐ Communication equipment (*VHF, portable radios etc.*)
- ☐ Window wiper or clear view screen arrangements / heating system

☐ Weather details (*i.e. wind, current, tide etc.*) available, checked and assessed

Date / Time: __________________________ Signature of Officer: ___________________

Responsibilities for the Master:

☐ Draughts, stability and trim checked, recorded and in compliance with rules and regulations
☐ Cargo and crew data available
☐ Vessel in all respects secured for intended sea voyage, watertight integrity ensured
☐ All crew on board (*as per safe manning certificate*) and all shore personnel ashore
☐ Ship's certificates and other relevant documents valid and on board
☐ Required documents (*i.e. port clearance, DAGO manifests etc.*) available and on board
☐ Vessel sufficient equipped for intended voyage (*i.e. fuels, lubes, provision, freshwater etc.*)
☐ Fire fighting, lifesaving and oil pollution equipment complete and ready for use
☐ Steering gear test performed (*in accordance with* ***A2 - Steering gear test routine***)
☐ Anchors cleared away and ready for immediate use
☐ Pilot disembarkation equipment and pilot card prepared (***see Annexes, A3***) / available
☐ Engine department informed, engines tested and on stand-by
☐ Required crew for imminent operations on duty and/or stand by
☐ Drugs and / or Stowaway search performed *(if applicable)*
☐ Malfunction, deficiency or inefficiency in equipment and/or crew recorded (*if any*)
☐ **The use of this departure checklist has been recorded in the deck log**

Date / Time: __________________________ Signature of Master: ___________________

Page 1 of 1

Appendix 4. The flag state's SGN-013 for timber cargo on deck

GIBRALTAR MARITIME ADMINISTRATION
(Ministry of Maritime Affairs)

Watergate House
2/8 Casemates Square
Gibraltar

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shipregistry@gibtelecom.net
marinesurveyor@gibtelecom.net

Shipping Guidance Notice – 013

To: Ship Owners, Operators, Masters, Officers and Classification Societies

PULP WOOD TIMBER DECK CARGOES – SECURING

Certain Port State Control authorities have advised the Gibraltar Maritime Administration that they will detain any vessel with a timber deck cargo which is not stowed and secured in accordance with the **Code of Safe Practice for Ships Carrying Timber Deck Cargoes 1991 (The Timber Code)**

SOLAS 74 Chapter VI Regulation 5 require cargo to be secured to prevent *'as far as is practical, throughout the voyage, damage or hazard to the ship and the persons on board, and the loss of the cargo overboard.'*

The Gibraltar Maritime Administration considers that reliance on gravity to provide this requirement is unacceptable.

The nature of timber deck cargoes is such, that uprights are required. They should meet the requirements of paragraph 4.2 of the Timber Code.

Gibraltar Maritime Administration
September 2006
All notices are available through www.gibmaritime.com