Investigation report

B 4/2000 M

Mv. MARIA VG, incident at Sea of Bothnia off Pori, November 7, 2000

Onnettomuustutkintakeskus
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SUMMARY

On the 7th of November, 2000 the Finnish freighter Mv MARIA VG (two hatches – one hold) loaded, according to her weight capacity, a nearly full cargo of 2662 tonnes of ILMENITE CLAY in bulk, at the port of Pori / Tahkoluoto, Finland, for the destination of the port of Slite / Gotland, Sweden. At the time of the shipment, ilmenite clay was not classified in the BC Code. The officers of MARIA VG interpreted the cargo to be ilmenite, as per the BC Code. However, the shipper did not deliver any certificate of the moisture contents of the actual cargo for the carrying vessel. The shipper of the cargo delivered a document "Typical specification of ilmenite clay" to the master of the vessel. MARIA VG loaded the cargo.

On the 7th of November, 2000 at 15.45 local time, MARIA VG departed from the port of Pori/ Tahkoluoto. After about two hours of passage, in moderate swell from her port fore quarter she was rolling moderately. Suddenly she got a permanent list of about 20 degrees to starboard. The course of the vessel was altered against the swell in order to minimise her rolling. In immediate onboard investigations of the cargo holds, it was noted that the cargo had badly liquefied and shifted to starboard in the foremost and aftmost parts of the cargo space. All the officers and crew of the vessel were alerted and prepared for abandoning the vessel by ordering the personnel onto the Bridge of the vessel with their personal survival suits. The Master informed the Turku Maritime Rescue Co-ordination Centre of the incident. Under escort of the Finnish Coast Guard units (a helicopter and maritime units) the officers and the crew of MARIA VG brought the vessel to Port of Refuge at Rauma, Finland.

After the incident, the total quantity of the cargo of 2662 tonnes of ilmenite Clay of MARIA VG was discharged at the Port of Rauma under control of the cargo sampling system of the Maritime Accident Investigation Board, Finland.

The moisture content in the cargo was extremely high. It was concluded already during the preliminary investigation, that the moisture content cannot have increased during the voyage at sea, but that the cargo had been wet already prior to loading at Tahkoluoto. Cement had been used earlier to retain moisture in the cargo. This time no cement had been used although this was the general impression.

The cause for the incident and the permanent list of MARIA VG was the shifting of the liquefied cargo of ilmenite clay. The moisture content of the cargo clearly exceeded its TML value of 22,7%, which was determined during the investigations for this cargo parcel. The Shipper of the cargo had never determined the TML value for the cargo.

INDEX

1 GENERAL DESCRIPTION AND INVESTIGATION OF THE INCIDENT

1.1 Vessel

1.1.1 General data

Name	MARIA VG, (ex Pingo, Pingvin)
Home port	Naantali
Flagging state	Finland
IMO-Number	7211957
Registration	11105
Identification	OIKD
Type	Cargo vessel
Crew	8 persons
Owner	VG Maria Shipping Oy
Classification society	Det Norske Veritas
Classification	+1A1Is-B EO
Built	1972
Length	74,63 m
Breadth	13,75 m
Draught, summer	5,40 m
GT	1854
Dead weight	2802
NT	1156
Propulsion power	1464 kW
Speed	11,7 knots

Figure 1. Mv. MARIA VG

1.1.2 Vessel documents

According to the inspection performed by the Maritime Inspector soon after the vessel had berthed at Rauma, the documents of the vessel were found valid.

1.1.3 Crew and traffic limitations

At the time of the incident, the vessel had a qualified crew of 8, the master, two mates, the engineer, the repairman and three deck hands. This fulfilled the official requirement of crew for Near Coastal Traffic, 6 persons.

1.1.4 The Bridge

The vessel was fitted with standard navigation equipment.

1.1.5 Cargo

The vessel had 2662 tons of Ilmenite clay as bulk cargo.

Ilmenite clay is a by product in the process of producing titanium dioxide. The waste clay is stored temporary for loading outdoors in the factory area and at the port of Tahkoluoto. Various uses for ilmenite clay have been studied. The cargo of ilmenite clay loaded on board MARIA VG was intended for the cement industry.

Figure 2 Ilmenite clay storage area of Kemira Pigments Oy

1.1.6 Loading at Tahkoluoto

The Maria VG had transported similar cargo earlier without problems. At that time, the ilmenite clay had been pre carried from the plant to the quay storage at Tahkoluoto about 200 metres away from the loading quay.

During the loading cement was mixed with the cargo. The cement was spread to the face of the cargo on the quay by hanging a one tonne's sack with holes above the face of the cargo with a big wheel loader. After this, the cemented part of the cargo was transported to the loading area and loaded on board with a crane.

Regarding the loading of November 7, 2000, the shipper had notified the representative of the stevedoring company that the cement would be added to the ilmenite clay already at the factory. According to the representatives of the stevedoring company no agreement was made with the shipper concerning any adding of cement to this cargo or parts thereof. According to the foremen of the shift, the cargo appeared clearly more moist than the previous cargoes. According to the stevedoring foremen, some of the cargo had arrived from production to port for immediate loading whereas some was taken from an old stockpile at port.

According to the production report, a total of 2446 tons of cargo was taken from the stockpile during November 2.-7. 2000. A total of 216 tons of cargo was transported directly from production during November 4.-5. The cargo was delivered to the quay area a few days prior to loading. According to the memory of the stevedoring foreman, it was raining during those days. The production report of the ilmenite clay confirms the weather as having been rainy on all days of handling the cargo, between November 1.-7. 2000. The cargo stockpiles at port were not sheltered from the rain. On board the vessel, the edges of the lower parts of the hold (arc spans) were protected by walking boards made of plywood, in order to reduce the amount of manual labour at the port of discharge. The walking boards reached to the height of 1.2 metres from the bottom of the hold. According to the stevedoring foreman, the customary cargo sample for the shipper was taken in a bucket. The sample remained in the port office for several days. He has no knowledge of any analyses performed on the sample, but he estimated the purpose of the sample to be later verification of the constitution of the shipped ilmenite clay. The officers of the vessel had not requested any reports of the moisture contents of the cargo. According to the foremen, no representatives of the shipper or a cargo expert were present during the loading.

The loading commenced on November 7, 2000 at 08.00 and it lasted about 7 hours until 14.45.

The cargo was handled 3-4 times (drops) depending on whether it arrived directly to the loading site or was taken from the stockpile. A total of 2662 tonnes were loaded. An example:

Kemira; loading on truck -------; Tahkoluoto, drop onto pile -------; Loading from pile onto truck -------; drop on pier -----------; hoisted on board.

Due to the great specific gravity of the cargo, the dropping height from the crane's grab was low, it was estimated to be not more than 2 metres.

1.1.7 Stability of the vessel at departure from Tahkoluoto

At Tahkoluoto, MARIA VG loaded an almost full cargo of ilmenite clay, which has a relatively large specific gravity. In order to determine the quantity of cargo a survey was conducted prior to departure from port by an independent surveyor and the chief mate of the vessel (Draught Survey method) and this gave 2662 tons as the amount of cargo. At the same time, it was also noted that the draught of the vessel was 14 tons below the winter load line.

The density of the cargo was about 2 tonnes / cubic metre. The centre of gravity of the vessel lay very low because of the heavy cargo. The initial transverse metacentric height of the vessel, GM, was 2.28 metres. The intact stability of the vessel was excellent due to the heavy cargo, to the extent of the vessel being over stable.

One of the adverse effects of a large transverse metacentric height (over stability) is that in high waves the vessel rolls with quick jerking motions which is uncomfortable to those on board. Due to the violent motions in high waves, the cargo is affected by great inertial forces which increases the risk for a cargo shift.

1.2 Incident

1.2.1 Weather conditions

The weather forecast was south easterly winds of 16 m/s for Sea of Bothnia for the evening of November 7, 2000. Soon after departure, the wind in fact increased reaching the expected direction and strength.

1.2.2 Passage from Tahkoluoto and shifting of cargo

The vessel left port on November 7, 2000 at 15.45. According to the Master of the ship, once the ship entered open seas, heading of 224º towards Sea of Åland was taken. At this time, the ship was rolling a little more than five degrees. Because the ship was over stable (great transverse metacentric height) the rolling motion was quick. At the change of the watch at 18.00 it was noted that the rolling had somewhat increased. At about 18.20 a rather large wave hit the port side of the vessel and the ship immediately listed to starboard and listed about 20 degrees permanently. The Master of the ship suspected that the cargo had shifted and instructed the mate to turn gradually to port, against the sea. The ship was turned to heading 116 degrees. At 18.30 the position of the ship was taken by GPS: Lat. 61º21,8' N; Lon. 21º 08,2' E. The Master decided to seek a port of refuge. During the situation assessment and inspections on board, the cargo was seen to have badly slurred and shifted strongly to starboard in the aft part of the hold. It was not possible to inspect more closely the bow section of the hold because of the dangerous conditions. The Master estimated that the shift in the cargo had caused a permanent list to the vessel.

1.3 Rescue activity

1.3.1 Maritime rescue system

The Finnish waters of the Sea of Bothnia region form a part of the jurisdiction of the Maritime Rescue Co-ordination Centre of Turku (MRCC Turku). Maritime rescue units are stationed in Turku and at Marine Guard stations, for example in Pori and at Rauma.

1.3.2 Rescue of human lives

After the vessel had got a permanent list of about 20 degrees to starboard, the Master of the ship ordered the entire crew to be summoned to the bridge and to wear personal survival suits. At 18.33 the Master took contact on VHF radio (channel 16) to MRCC Turku, identified his ship, her position, informed of the list, of the number of crew and of his intention to seek a port of refuge at Rauma. After this, the ship maintained constant radio contact with the Maritime Rescue Co-ordination Centre. The crew of the ship prepared for possible evacuation. The port life boat was lowered to the railing and the life rafts were made ready for launching. The Maritime Rescue Co-ordination Centre dispatched a rescue helicopter from Turku and a patrol boat from Rauma to the scene. The helicopter reached the ship at about 19.15. Evacuation of some or all of the crew was considered but not deemed necessary since the state of the ship had stabilised. Later on, a pilot boat and a vessel of the Maritime Rescue Society arrived from Rauma as backup.

1.3.3 Rescue of vessel

The Master decided to steer to the nearest port of refuge within safe reach, Rauma. The port of Olkiluoto, which was closer, was not deep enough for the listed vessel. The permanent list to the vessel had stabilised to about 20 degrees. The vessel behaved stable in the waves. The Master decided not to attempt to use ballast for decreasing the list because of the potential dangers in the operation. The ship was proceeding at the speed of 9 knots. After reaching the shelter of the coastline, the heading was changed towards the entrance channels to Rauma. Due to the waves and the deeper draught caused by the list, the Master chose the deep channel of Rauma instead of the shorter but shallower Valkeakari entrance channel. Escorted by the helicopter and the rescue and escort vessels the ship berthed without tug assistance to Rauma at the Petäjäs quay on November 7, 2000 at 22.30.

1.3.4 Damage

The Maritime Inspector of the Finnish Maritime Administration and the crew of the ship inspected the ship immediately after arrival at Rauma. It was noted that the cargo was badly slurred and that it had shifted both in the bow and stern sections of the hold at a distance of 10 – 15 metres causing the vessel to list. All ballast tanks and bilges of the vessel were gauged. The ballast tanks and the port bilge (opposite the list) were empty. The bilge on the side of the list had about 1 metre of water, which equals the depth of the well. It was estimated that this water had separated from the liquefied cargo. No visible damage or leaks to the vessel herself were detected. The Maritime Inspector pronounced the liquefied cargo unfit for maritime transportation and detained the ship. The entire cargo was unloaded at Rauma on November 9, 2000.

Figure 3 Cargo under discharge at the Port of Rauma on November 9, 2000

1.4 Regulations

The International Maritime Organisation (IMO) has created the BC Code [1](Code of Safe Practice for Solid Bulk Cargoes) for regulating the safety of maritime transports of solid bulk cargo (for example ore, ore concentrate etc.). Both the solid cargo to be transported and the criteria for its safe maritime transport must be studied by the owner of the cargo and to be included in the BC Code. One of the criteria to be determined according to the code is the maximum Transportable Moisture Limit (TML), for maritime transportation of bulk cargo.

Ilmenite is included in the list of substances of the BC Code (Ilmenite, ”Dry” and ”Moist”). According to the particle size, the name for the substance is ilmenite sand. Out of these, ”Moist” is susceptible to liquefy. The code does not recognise a substance named Ilmenite Clay. These substances are markedly different from one another with regard to their physical properties. The particle size of the clay is considerably smaller than that of the sand.

Dry ilmenite sand (Dry) is classified in category C, non-hazardous – non-liquefying – materials. It is stated elsewhere in the code that moist ilmenite sand (Moist) belongs to category A, liquefying materials, if transported at moisture contents exceeding the TML. The same classification applies to all known metal concentrates. The relevant issue here is the fact that ilmenite clay becomes ”liquefied” if the moisture content exceeds the TML during transportation, thus causing a risk to the vessel transporting it.

[1] SOLAS 74 as amended, Chapter VI Regulation 2.2.2

Prior to loading bulk cargo, the shipper shall deliver on board and the vessel shall request a certificate from the shipper that the bulk cargo to be shipped fulfils the requirements of the BC Code.

1.5 Safety instructions of the company

The vessel and the shipping company have an audited and certified safety management system according to the ISM Code.

1.6 Investigation of the incident

The duty officer of the Accident Investigation Board was notified of the incident by MRCC Turku on November 7, 2000 at 21.25. The situation was monitored throughout the evening and the investigation was launched in the morning of November 8. In course of the investigation, it was decided to take a complete series of samples of the cargo during its discharge in order to analyse its moisture content and other physical properties affecting the transportation technology.

The Accident Investigation Board appointed an investigation commission for the incident by decision B 4/2000M. Maritime Accident Investigator, Captain Risto **Repo,** of the Accident Investigation Board, was appointed as Chairman of the investigation commission. Captain Sakari **Lehtinen,** Head of Maritime Management training Dpt. of Satakunta Polytechnic and Rainer **Laaksonen,** Research Scientist at VTT Bulding and Transport were invited as members.

The investigation is based on the Maritime Declaration by the Master of the ship, on interviews of the crew of the vessel and of the representatives of the stevedoring company, on cargo samples and laboratory tests on them, on documents of previous transportation of ilmenite clay, on a review of the stability of the MARIA VG, on an introduction to the production of the Pori factory of Kemira Pigments Oy and on research of the conditions of the port of Tahkoluoto.

1.7 Ilmenite

Ilmenite sand is an iron-titanium ore (FeTio3 + additional minerals characteristic of the place of origin). The international BC Code recognises and defines the required properties of ilmenite ore for international maritime bulk cargo transports.

Ilmenite clay is produced as process waste in the production process of titanium dioxide . About 35 000 tons of ilmenite clay are produced annually at the Kemira Pigments Oy, Meri-Pori factory. Titanium dioxide (TiO_2) is the basic pigment in paints and in nearly all other commonly used colourings (for example cosmetics). The waste clay is stored in the plant area and at the port of Tahkoluoto. Various uses for ilmenite clay have been studied.

After the incident, the surface of about half of the cargo of the MARIA VG, that was moored at the port of Rauma, was observed to be in the form of running slurry, which did not support human weight and had moved to the side. More solid cargo that had not shifted could be found in the ends of the hold and in midship, around the mast crossing the hold.

The cargo was sampled in connection with the unloading at Rauma. The sampling locations and levels are indicated in Figure 4. The general samples and the separate water content samples were analysed at the laboratory of VTT Communities and Infrastructure (since 2001 VTT Building and Transport). The water contents of the samples are presented in Table 1 according to location and level. (Separate water content sample and general sample from the same location are specified – the greater water content of the general sample is explained by the sampling method).

The maximum allowable moisture content as volume percentage, the TML value, for safe transportation of ilmenite clay on board a ship was determined at VTT. This value was determined at 22.7%.

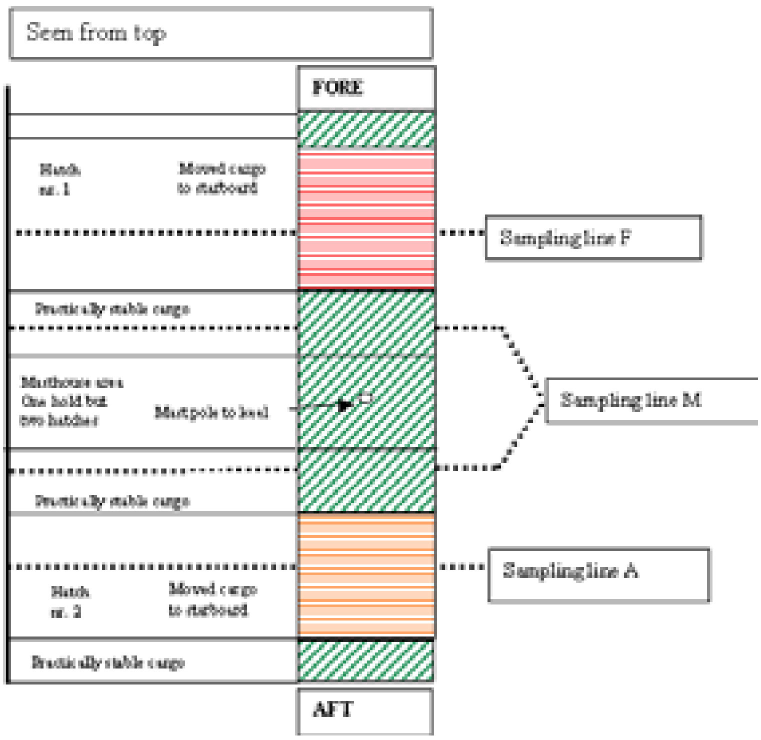


Figure 4. Sampling lines at the discharge of the cargo of the MARIA VG.

Table 1. Water contents of the cargo samples of the MARIA VG taken during unloading at the port of Rauma by location and level.

Sampling Line	Sampling level	Sample code (1)	Water content (%)	Sample code (2)	Water content (%)
F (Fore)	0 – 0.5 m from top of cargo	f1	46.5	F1	60.6
	Middle of cargo at about 1.5 m	f2	42.9	F2	46.0
	Bottom of cargo/hold	f3	38.9	F3	41.7
M (Mast House)	0 – 0.5 m from top of cargo	m1	39.0	M1	42.6
	Middle of cargo at about 1.5 m	m2	42.8	M2	44.7
	Bottom of cargo/hold	m3	39.8	M3	42.6
A (Aft)	0 – 0.5 m from top of cargo	a1	42.5	A1	50.3
	Middle of cargo at about 1.5 m	a2	42.6	A2	43.7
	Bottom of cargo/hold	a3	42.5	A3	45.4
		average	41.9		

(1) separate water content sample
(2) general sample

The composition of the cargo causing the incident was also analysed and any traces of cement mixed with it were looked for. The analysis was done at the Geological Survey of Finland in Espoo by x-ray diffraction. The analysis revealed the composition of the cargo but no traces of ordinary cement qualities were discovered.

The resolution of the x-ray diffraction method was further studied by analysing two samples of a sample batch taken on March 14, 2001. 2 percent of cement taken from the Tahkoluoto port at Pori was mixed with one of the samples.

The Geological Survey of Finland did not detect cement in either of the samples, so it can be stated that the method is not suitable for verifying whether there was cement in the cargo of the MARIA VG or not. According to the representative of the Geological Survey of Finland, the x-ray diffraction method is not well suited for identification of very small, less than 2 percent concentrations of cement.

Afterwards, a representative of Kemira Pigments Oy delivered to VTT an additional batch of the cargo that had caused the incident for further studies. This batch had been taken from the cargo transported to Tahkoluoto at Pori and stored under open skies. The average water content of the 6 sample containers was 45.2 % with a deviation of 0.86 % units. This value is likely to correspond well to the moisture balance of ilmenite clay exposed to the weather (see Table 1 above).

Ilmenite sand and clay. Ilmenite sand is an ore or an ore concentrate transported to the Kemira Pigments OY Pori factory by ship from Norway (crushed ore) or from Australia (ore concentrate). The imported quantity per year, at the present capacity of the factory, is about 250 000 tonnes. About 200 000 tonnes of this amount is shipped in from Norway. Correspondingly, the process produces about 50 000 tonnes of ilmenite clay annually. Until the present time, this waste has been stored at the factory waste dump. About 12 000 tonnes of the ilmenite clay can be reused whereas the rest is piled on the factory dumps.

At the factory, the ilmenite sand is ground and fed into the process with sulphuric acid. During the reaction at a high temperature,150 °C, titanium dissolves into the solution. Later in the process, the trivalent iron is reduced by adding scrap iron to the process. The ilmenite clay is removed from the process directly after this reduction phase. The removal takes place in press filters, where the accumulated solid particles are pressed semi-dry and dropped out of the process. The average moisture of this redundant ilmenite clay fluctuates between 25-32%, according to the report of the factory. The average water content of the sample batch taken by the investigators from the production on March 14, 2001 was 28.4%.

Ilmenite clay is suitable for raw material for the cement industry due to its high content of silicon oxide, titanium oxide and iron (ferro). For this reason, test transportation to the plant of Cementa Ab in Slite, Sweden, were started in 1999.

Properties of ilmenite clay. The grain size distribution of ilmenite clay according to the analyses of Kemira Pigments Oy is shown in Figure 5. According to the report of the producer, the transportation (wet) density of ilmenite clay is between 2.0-2.5 t/m^3 The solid density of the ilmenite clay examined by the analysis of VTT is 3.16 t/m^3 and the optimum values for the dry density and water content are 18.6 kN/m^3 (1.89 t/m^3) and 19.5 % . The corresponding wet density is 22.2 kN/m^3 and 2.26 t/m^3.

VTT determined the Transportable Moisture Limit = TML for the batch of samples taken on March 14, 2001 by the Proctor-C method (described in the IMO Code for Bulk Cargo, Appendix D). The value for the Transportable Moisture Limit (TML) was 22.7 % (mass). At this value, the dry density of the mass is about 1.56 t/m^3. The corresponding wet density (at 70 % saturation) is about 1.92t/m^3.

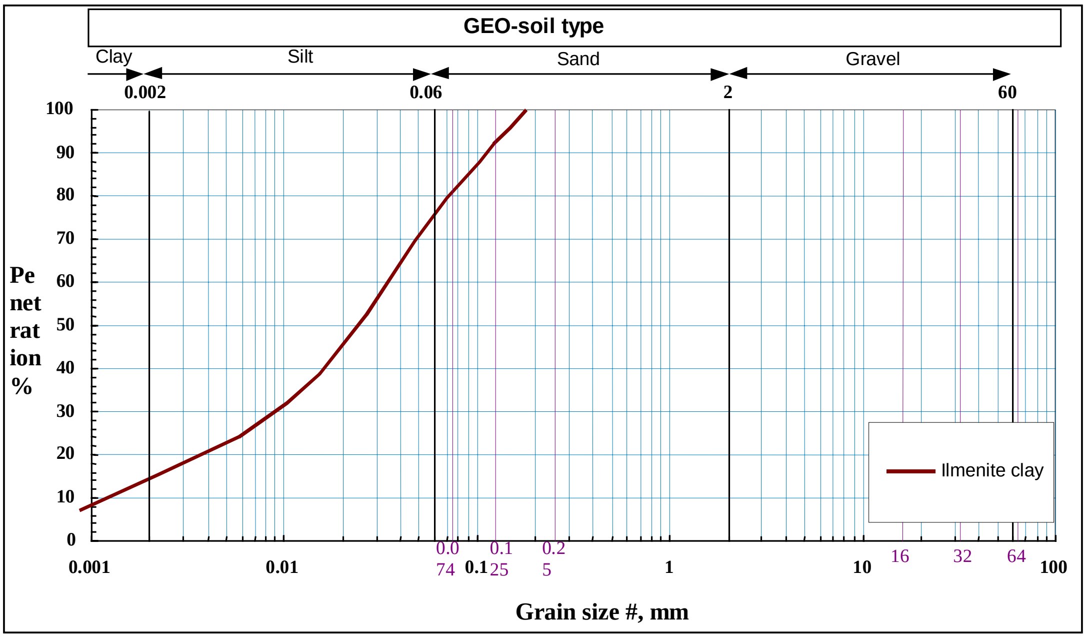


Figure 5 Grain size of ilmenite clay

Previous tests. Kemira Pigments Oy commissioned a determination of the plasticity limit for ilmenite clay at Geoinsinöörit Oy (Pori) in 1995. The test was made in order to define the fitness for transportation. According to the test, ilmenite clay becomes ”running” (liquefied) when it’s water content reaches about 34 %, if vigorously stirred. In vibrating tests of masses with different water contents (the water was added by spraying on the mass 64 hours before vibrating) a running state was achieved when the water content of the mass was about 40%.

Figure 6 Liquefied pile of ilmenite clay at Tahkoluoto, winter 2001

1.8 Investigation methods for bulk cargo (Dry Bulk)

Solid but ”liquefying” masses. Several methods have been developed for this purpose (Flow table, Proctor -C, Vibrating platform, Penetration method, ”Bucket method”). Some of these methods are approved by IMO as methods for determining the liquefying risk (described in the IMO BC Code, Appendix D). However, none of these methods is suitable for all solid bulk cargoes.

Flow table method. A cone made with a mould of the studied soil mass (material) is placed on a horizontal platform. The platform is dropped 25 times from a height of about 19 mm (3/4”) and the diameter of the collapsed cone is measured. The ”running” tendency of the material is determined from the change in the diameter. The Flow table method does not require electricity or expensive investments whereby it can be easily transported to the field.

Proctor C method. In this method, the studied mass is compacted into a Proctor mould at varying water contents using a lighter plunger than normally. The density, water contents and saturation degree of the pore space for the mass are determined from the results of each compaction. The water content resulting in a 70% saturation degree of the pore space of the mass is determined as its TML value.

Vibrating platform method. In this method, four table tennis balls are placed in a vessel installed on top a vibrating table. The studied mass is poured on top of these. The balls will rise to the top of the liquefying mass when it is vibrated.

Penetration rod method. In this method developed by the Japanese, a measuring rod is placed on top of the material placed in a vessel installed on top a vibrating table. The vessel itself is fixed onto the table. The tendency of the materials to liquefy is determined by how deep the measuring rod sinks during the vibration.

Bucket method. In this method, a bucket is filled with the studied material and the bottom of the bucket is knocked against a hard surface 25 times. If a layer of water escapes to the surface of the mass, the mass is likely to "liquefy" during transportation.

New studies. Kemira Pigments Oy is presently studying the transportation options for ilmenite clay from a new basis. Mere drying of the clay has been found uneconomical. Due to this, Kemira Pigments Oy is researching mixtures of ilmenite clay and hematite and ilmenite clay, hematite and cinder in order to ensure fitness for transportation.

Figure 7 A close look with a spoon, ilmenite clay storage at Tahkoluoto, winter 2001

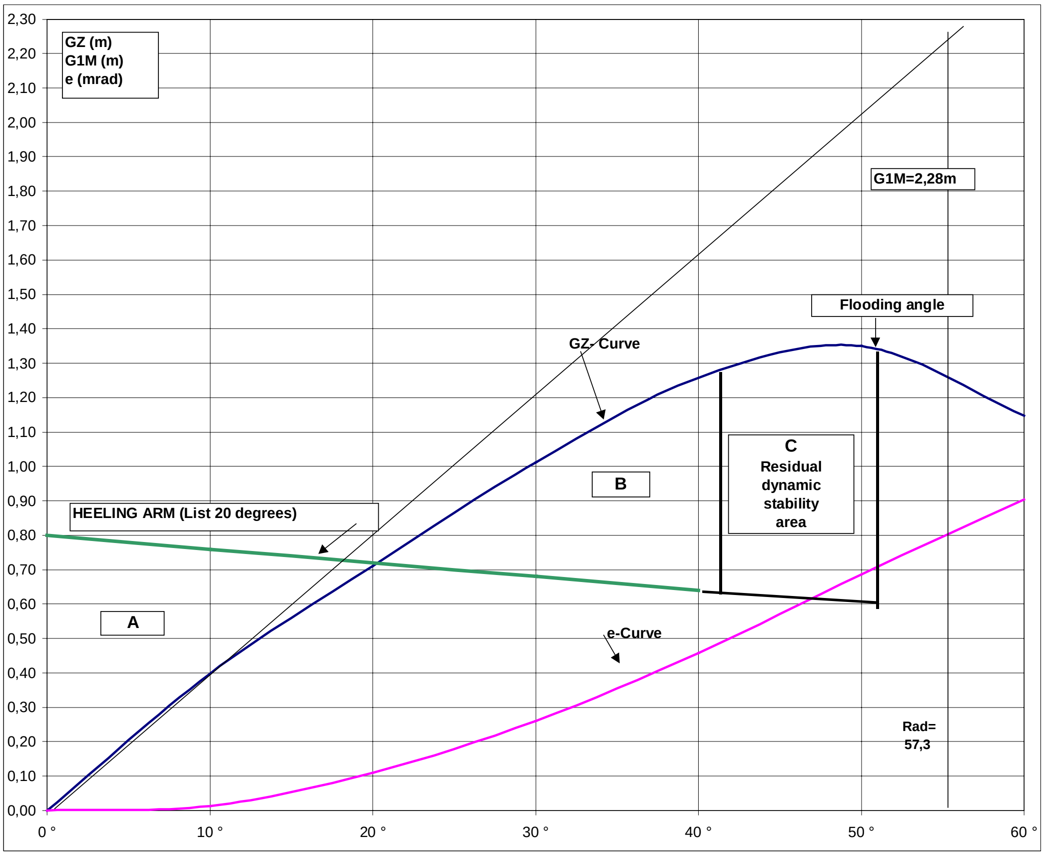
2 ANALYSIS

2.1 Shifting of cargo and stability of vessel after the shift

After the ship left Tahkoluoto, the cargo was subjected to hull vibration. Since the cargo was already initially too wet, having a water content of more than 40%, it liquefied. When the ship was hit by a big enough wave and simultaneously experienced a tilting dynamic force, the liquefied cargo shifted as one mass in the bow and stern of the hull. It was fortunate that the cargo did not shift in the centre section of the hold or near the bow and stern bulkheads. If the cargo had shifted also in these parts of the hold, in other words in its entire area, this would have very likely resulted in the ship capsizing quite quickly. The mast that runs across the hold from deck to keel helped for its part to hold the cargo around it. The faces at the ends of the hold conducted water and partially slurred cargo lower towards the ends which is why the cargo in the ends also remained stable.

After the ship had recovered her new listed balance, the waves outside caused a new risk, the dynamic heeling moment, which could have resulted in further shifts of the cargo and causing an increase in the list of the vessel. This would have changed the balance factors significantly. The centre of gravity of the displacement and the centre of gravity of the entire vessel would have moved laterally to the direction of the list in such a case. This, in turn, would have increased the width of the water line area until the deck on the side of the list would have sunk under. The stability improves until this point as the stability lever arm and the corrective moment increase. As the deck of the ship sinks under, the width of the water line area decreases markedly and the corrective moment starts to diminish. If the heeling moment does not decrease correspondingly, the ship will capsize.

As the vessel listed 20 degrees in a single instance, it was important to try to maintain the new balance and to prevent the rolling of the ship. This was done. If righting of the ship had been attempted, for example by pumping ballast into the port side tanks, this could have resulted in the liquefied cargo shifting immediately to port in its entirety. The shifted cargo and the ballast water together would have resulted in the vessel rapidly listing to port. This quick dynamic list would to opposite side with great probability have continued the listing process resulting in capsizing the ship.



The stability of MARIA VG with 20 degree list fully loaded with ilmenite clay

Corrected with the effect of free surfaces vessel's GM is 2,28 metres and she had a very good intact transverse stability. In high sea a too good GM causes heavy rolling with great g – forces affecting the cargo. The shift of the ilmenite cargo causing a permanent 20 degree list in the situation corresponds with the movement of the centre of gravity of the whole cargo of 2662 tonnes some 1,16 metres to the listed side (in reality, only the cargo in fore and aft part shifted).

In the GZ -curve it can be seen that if this movement of cargo had happened to the whole cargo in one sudden movement, the vessel would have listed dynamically to 42 degrees and after that back to a situation with a permanent 20 degree list (areas A and B of equal size). The vessel would have survived this as she had enough stability to cover this (area C shown only to flooding angle).

If the Master had decided to use ballast to correct the list by pumping water in to the tanks of opposite side, there would have been the danger that the liquefied cargo after some ballast intake could have moved in one movement to the side of ballast. It would have been probable that in this case the residual stability, (area C) would not have been large enough and the vessel would have capsized. This was not the case because the Master decided not to try to correct the list and steered her with course that caused minimum roll.

2.2 Rescue activity

2.2.1 Distress signal and initiation of rescue activities

The Master reported the situation to MRCC Turku but he did not give an actual distress signal. However, the MRCC immediately classified the situation as an emergency and promptly initiated rescue activity. A helicopter for possible evacuation was dispatched to the scene with surface vessels. When evaluating the operation of the MRCC it can be stated that the rescue organisation acted quickly and appropriately.

2.2.2 Voyage to port of refuge, measures on board the vessel

The Master decided to set course to the nearest port of refuge that was within safe reach, Rauma. The Master decided not to attempt to right the ship in the waves because of the dangers involved in the operation.

The crew was at readiness to abandon ship all the time, should something unexpected have occurred. Before the turn to the fairway leading to Rauma, the helicopter was requested to pick up four men from the ship, but when the helicopter approached the ship, the turn had already been executed successfully. The men were not lifted from the vessel.

When evaluating the activity of the Master it can be stated that he arrived at the right conclusions and performed the necessary measures for conducting the vessel safely to a port of refuge after the vessel had listed. By ordering the crew into their survival suits and in readiness to abandon ship, the Master ensured the safety of human lives. Co-operation with the rescue organisation was smooth and the Master kept the rescuers up to date about the situation on board. The activity of the Master can be considered as an example of good seamanship in managing a risky situation.

2.3 Other similar accidents and incidents

There have been previous incidents or accidents caused by shifts of cargo consisting of fine grain industrial raw material or side product bulk representing the grain size of clay, silt and fine sand (maximum grain size 2 mm).

In August 2000 the barge PARA DELTA loaded 3767 tons of ilmenite clay at Tahkoluoto for transport to Slite, Gotland. The barge was towed by the tug FRAM. The barge listed in the waves and some of the liquefied cargo was washed into the sea from the open deck barge. The combination deviated to Parainen, where the cargo was unloaded. The opinion of the independent surveyor was that the cargo was liquefied and not fit to be transported in an open barge. At the suggestion of the Kemira representative, 2% of cement was mixed with the cargo for retaining moisture. After this, the cargo was delivered to the recipient.

No further investigations were conducted but Kemira decided to switch to ship transportation instead of an open barge. The information about the listing of the barge was not actively distributed to commercial navigation or the authorities.

The most famous accident on Finnish territorial waters caused by a liquefied cargo is the capsize of the FINN-BALTIC pusher -barge combination outside Hanko on December 27, 1990. The barge was carrying iron concentrate on her way from Luleå to Koverhar. Eight lives were lost in this accident.

In the case of the FINN-BALTIC, the initially wet concentrate that had wetted further during the voyage started to shift on the deck of the level cargo space either as repeated collapses of the face (slope) or as one mass. The reason for the accident was the water in the cargo causing it to liquefy and the listing of the vessel caused by the waves.

In 1999 the PADANG HAWK listed in Australia in high waves. The vessel was carrying nickel concentrate. The reason was the liquefying of the cargo in four of the five holds of the vessel. The cargo liquefied due to the excess moisture of the concentrate at the loading. The vessel was able to reach port safely.

In the case of the PADANG HAWK as in the case of the MARIA VG currently under investigation, the cargo was already so wet at loading that the vibration and rolling caused by the waves at sea resulted in the cargo becoming liquid or at least in the water separating to the surface and creating a moving layer of slurry on top of the cargo. The separation of water to the surface also causes pore pressure in the cargo which contributes to the liquefying of the cargo. The latter mechanism is quite possible in these masses with a high specific density of the solid material.

The common factors for the incidents are the excess water content of the cargo and heavy rolling of the vessel caused by the waves.

3 CONCLUSIONS

3.1 Immediate cause of the incident

- Shifting of the liquefied cargo in high seas.

3.2 Factors leading to the incident

- The cargo was too wet, almost saturated (pore space filled with water). The measured moisture contents varied between 39%-46%. This clearly exceeds the assumed average moisture status of about 28 %. The estimate was based on post production reviews and it did not include the moisture increase caused by rain on the open storage field.

- The water content of the cargo clearly exceeded the TML value of 22,7%, determined for this investigation. The TML value had never been determined from the part of the shipper, although one transport had been aborted due to excess moisture. The practice in the shipping does not correspond to the spirit or the practices of the IMO BC Code.

- The Master of the ship did not for his part request a report of the actual moisture of the cargo or the TML value for the cargo.

- The cargo condensed during the loading and transportation – the water in the pores was pushed upward in the cargo – causing liquefying of the top part of the cargo into a mass fully saturated with water – which may have been affected further by the pore pressure caused by the water pushing upwards.

- The density of the waste concentrate contributed to the condensation process

- The liquefied pressurised slurry could shift in the hold almost like a liquid.

4 RECOMMENDATIONS

The Investigation commission does not issue any specific recommendations since the existing rules and regulations are already sufficient.

However, the commission wishes to emphasise the following safety relevant items in the maritime transport of ilmenite clay or mixtures of ilmenite clay and possible additives:

1. *The manufacturer/shipper of a new product transported as bulk cargo is responsible for ensuring that the cargo and it's transportation properties have been registered in the IMO BC Code.*

2. *The cargo shall fulfil the TML requirements of the IMO BC Code.*

3. *A certificate of the moisture content of the transported cargo and of the acceptable TML value shall accompany the cargo.*

4. *The Master of the ship is responsible for ensuring that he receives cargo certifiably fit for maritime transportation, i. e. he shall require a certificate of the moisture content of the cargo and of the fact that the TML value has been determined and that it is correct.*

5. *Liquefying cargoes should be stored and transported under conditions that prevent more water from seeping into the cargo as a result of rain or during the transportation.*

Helsinki,16/04/2002

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SOURCES

The following sources are on file at the Accident Investigation Board:

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8. Document, users safety in work; ilmenite sand, appended to a licence form for exporting waste, 1.11.2000

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11. Photographs