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OUTLINE OF INCIDENT

Shortly before noon on Thursday 14 August 1986 the Netherlands Antilles flag heavy lift cargo ship 'GABRIELLA' capsized and sank alongside No. 2 Products Berth in Port Kembla harbour New South Wales.

The ship capsized and sank on its side very rapidly while discharging a lift of 237.95 tonnes.

Two marine surveyors, Mr. David Brooke-Smith of Lloyds Register of Shipping and Mr. William Martin of Bureau Veritas, were unable to escape from the accommodation area of the ship and lost their lives. Apart from minor injuries to several persons there were no other casualties.

The ship was declared a constructive total loss. Subsequently both masts and the accommodation deck houses were cut off and the hull was re-floated upside down. It was towed out and sunk at sea on 10 December 1986 in Latitude 34° 34'.5 South, Longitude 151° 30'.8 East, about 29 nautical miles east of Port Kembla in a depth of water of about 2000 metres.

AUTHORITY TO CONDUCT INVESTIGATION

On 14 August 1986 John Michael Quinlan, Principal Marine Surveyor for New South Wales in the Federal Department of Transport, was appointed under Section 377A of the Navigation Act 1912 to make a Preliminary Investigation into the circumstances of the capsize of the Netherlands Antilles registered ship 'GABRIELLA' (call sign PJTQ) in Port Kembla harbour on 14 August 1986.

PERSONS INTERVIEWED

The following crew members were interviewed between the 15-18 August 1986 before their return to the Netherlands:

Peter BOMMELS	Master
Gerrit in 't VELT	Chief Engineer
Robert BOSKALJON	Chief Officer
Alfred Marinus van AARTSEN	Second Officer
Gerard Koenraad SCHOLTEN	Second Engineer
Pedro Tavares MONTEIRO	Able Seaman
Joao Francisco RAMOS	Able Seaman
Paul KUIKEN	Ordinary Seaman

Between 15 August and 29 January 1987 the following other persons were interviewed:

Alan Henry JONES	Foreman Stevedore, Port Waratah Stevedoring Company Limited, Port Kembla.
Arnold Frederik van der HEUL	Operations Manager, Kahn Shipping Rotterdam (operators of the ship).
Gustaaf Leendert KEESEN	Marine Surveyor, Port Kembla.
Grahame Dennis AULBURY	Operations Transport Manager, Brambles Heavy Haulage Division, Sydney.
Derek SIM	Stevedoring Superintendent, Port Waratah Stevedoring Company Limited, Port Kembla.
Paul James MICHELL	Leading hand boilermaker, construction department Australian Iron and Steel, Port Kembla.

Barry FLANAGAN	Proprietor, Illawarra Wire Ropes, Port Kembla.
Donald Barry MCGREGOR	Waterside worker. Port Kembla.
Barry Allan EDWARDS	Waterside worker. Port Kembla.
Kenneth Thomas MCBRIDE	Waterside worker. Port Kembla.
Rory SLADE	Waterside worker. Port Kembla.

BASIS OF INVESTIGATION

The scene of the incident was visited early on the morning of 15 August 1986 and the ship was observed lying on its port side on the harbour bottom alongside No. 2 Products Berth at Port Kembla. The heavy lift involved was lying where it fell onto a platform trailer on the wharf. Notes were made at the scene.

About an hour after the incident, Senior Constable Pieter Strik of the New South Wales Police Force Scientific Investigation Section took a series of photographs and recovered some pieces of broken wire strands on and near the platform trailer. Senior Constable Strik was investigating the incident as part of the routine police response.

During the salvage operation, sections of the wire runner on the forward derrick were recovered from the harbour. These sections of wire rope, together with one of the broken strands found by Senior Constable Strik, were submitted to Unisearch Limited at the University of New South Wales for scientific examination and tests. A summary of the examination and test reports is set out in Appendix 5.

Information about the ship was also provided by the Netherlands Scheepvaartinspectie (Shipping Inspectorate) and an inspection of cargo operations on the sister ship 'FAIRLOAD' was carried out at Brisbane on 16 September 1986.

The following report is based on the above information, interviews, inspections and tests and on copies of the ship's documents and records supplied by the operators of the ship, Kahn Scheepvaart (Kahn Shipping) B.V. of Rotterdam.

In view of the technical nature of the operation and the circumstances leading up to the capsize, this report is by necessity complex in parts. The majority of supporting material of this type is included in the Appendices, however some data of a technical nature has unavoidably been included in the narrative sections of the report.

PARTICULARS OF SHIP'S HEAVY LIFT OPERATIONS

CARGO HANDLING GEAR

'GABRIELLA' was fitted with two derricks serving its single cargo hold (see Appendix 2). Each derrick had a safe working load (SWL) of 160 tons at an angle to the horizontal of 47°. At an angle to the horizontal of 25° the SWL was 125 tons each. No SWL was assigned for derrick angles below 25° to the horizontal.

Certificate of Attestation No. 95/78 issued on 27 April 1978 by the Chief Representative of Bureau Veritas in the Netherlands declared that the ship was suitable to load and discharge weights up to 320 tons using the two derricks in tandem, provided the load on each derrick was no more than 160 tons. However, the lifting yoke supplied for use with the derricks in tandem had a SWL of only 240 tons, which together with the mass of the yoke of 30 tons indicated a maximum load in practice of 270 tons, when using the lifting yoke.

The lifting yoke consisted of two parallel beams 17.5 metres in length and 11.5 tons each supported at their ends by short transverse connections suspended from ramshorn type main lifting hooks. The transverse connections (2 tons each) fitted into inverted 'U' shape recesses in the ends of the parallel beams and after assembly on the ship were held in place by lightly welded plates. These plates were not designed to withstand any loads other than random light loads during assembly and deployment of the yoke prior to lifting. Assembly of the yoke was completed by fitting two transverse slinging beams across the parallel beams. The slinging beams were held in place by guides and their own mass (1.5 tons each).

A copy of the ship's Register of Cargo Gear and Certificates supplied by the operators, Kahn Shipping, indicated that the cargo gear was tested and periodically examined in accordance with laws in force in the Netherlands. The last quadrennial thorough examination of the forward derrick and associated gear was carried out at Rotterdam in June 1983 by A. Kwint B.V. Authorised Ship Riggers and Testers and noted by the Netherlands Inspectie Van de Havenarbeid (Dock Labour Inspectorate - government authority administering laws on ships cargo gear). The last quadrennial thorough examination of the aft derrick and associated gear was carried out in February 1982 by I. Roodenburg B.V. an engineering works at Krimpen a/d IJssel in the Netherlands. A visual inspection of all the cargo gear was made on 7 April 1986 by Inspectie van de Havenarbeid. The gear was found in good condition and an exemption from quadrennial thorough examination of the aft derrick and associated gear was granted until 1 March 1987 to enable the owners to synchronise surveys.

The master stated at interview that he kept the Register of Cargo Gear and that all entries were up to date. He also stated that he carried out the last annual examination of cargo gear at Higashi Harima Japan about 8 July 1986 and found it in good condition.

That examination, he said, included all the derrick runners and topping lift/slewing wire ropes. He went on to say that the wire ropes were checked "all the time" when discharging at Port Kembla and he had not noticed any broken strand wires. He last saw the Cargo Gear Register lying on top of the safe in his cabin.

The word 'tons' appearing in the cargo gear documents is not specifically defined except on one certificate relating to the construction of the derricks where the maximum compression load is shown in 'tons of 1000 kgs'. The derrick test certificates, issued on both Dutch and British statutory forms show identical SWLs in tons and it is assumed that these are tons of 2240 British Imperial pounds. However, the element of doubt on the matter is not significant in this investigation.

Documents provided by the owners and statements made by the master indicate that cargo gear testing and examination requirements of the Australian Navigation (Loading and Unloading-Safety Measures) Regulations were complied with at the time of the casualty. However, see Observations page 18, relating to the examination of wire ropes.

PONTOON STABILIZERS

'GABRIELLA', like her sister ship 'FAIRLOAD' and a number of other heavy lift ships operated by Kahn Scheepvaart, used pontoon stabilizers to improve the stability of the ship by increasing the initial metacentric height (GM), thus enabling use of the ship's own cargo gear for heavy cargoes.

'GABRIELLA' was provided with two pontoons. A set of curves in the ship's stability book gave the height of the metacentre (M) above the keel (K), referred to as KM, for various displacements using either one or two or no pontoons. For example, immediately before capsize the ship's displacement was 2767 tonnes, two pontoons were deployed and the KM from the appropriate curve was 10.16 metres. Without pontoons, the KM would have been 6.60 metres, a very significant reduction that would have resulted in a negative GM, the height of the ship's centre of gravity above the keel (KG) at that time being 7.58 metres. The terms GM, KM etc., are illustrated in Figures A, B, C in Appendix 3.

The principle of the system is to float a pontoon alongside on the side of the ship opposite to the'side over which heavy cargo is to be handled. By opening bottom valves in a flooding chamber the pontoon is allowed to sink until it floats on buoyancy chambers at a draught of about one metre, which is half the depth of the pontoon. The valves are then closed and the pontoon rigidly secured to the ship's side by special heavy duty locking and lashing arrangements. The securing arrangements were designed to withstand the stresses imposed when the pontoon is fully immersed or fully emerged, provided list and trim either way do not exceed 4° and 2° respectively and provided water flow parallel to the ship does not exceed 6 knots.

In effect, a secured pontoon is part of the ship's hull. It increases the area of the waterplane. The height of the transverse metacentre (M) above the centre of buoyancy (B) is directly proportional to the transverse moment of inertia of the waterplane so that the pontoon increases BM and hence KM and GM.

If the ship listed so that a pontoon began to immerse or emerge, thus decreasing the pontoon waterplane area, the ship would start to lose its increased GM. It was vital therefore that the list was controlled within limits to avoid this eventuality. The ship was fitted with anti-heeling tanks on each side, to or from which water ballast was pumped or transferred to control the list and maintain the pontoon waterplane area, while heavy cargo was being lifted over the ship's side. 'GABRIELLA' was also fitted with permanent cast iron ballast in the port lower anti-heeling tank so that heavy cargoes were normally handled over the starboard side, with the stabilizer pontoons being fitted on the port side. Detailed instructions on the use of the pontoons and controlling the list were set out in a ship's manual - "Loading and Discharging of Heavy Cargoes".

It must be emphasized that the stabilizer pontoons were not counterweights and that their function was solely to increase the ship's initial stability or metacentric height (GM). The pontoons and their securing arrangements were not designed to provide buoyancy, or to withstand capsizing forces in the event of a sudden loss of a load from the derrick when swung outboard.

STABILITY DATA

The Netherlands Shipping Inspectorate advised that it approved the stability data for 'GABRIELLA' in 1974. Kahn Scheepvaart supplied copies of the data for this investigation. Stability calculations for heavy cargoes are pre-planned for various stages of the operations on a computer in the office of Kahn Scheepvaart in Rotterdam. The operations manager, Mr. van der Heul, advised that such calculations were made for the 'GABRIELLA's' last voyage to ensure the cargo could be safely loaded in Japan, safely transported by sea and safely discharged in Port Kembla. The master advised that he also carried out such calculations on the ship.

An analysis of the ship's stability as it affects this investigation follows later in this report. (See Appendix 4)

SEQUENCE OF EVENTS

On 28 May 1986, at Geneva in Switzerland, a contract was entered into by Jumbo Navigation N.V. of Willemstad, Netherlands Antilles and the Broken Hill Proprietary Company Ltd., (BHP) of Melbourne Australia. The contract provided for the shipment and carriage of 1886.7 metric tonnes of slabcaster components on 'GABRIELLA' from Higashi Harima in Japan to discharge in Port Kembla Australia. Freight payable was $US 207,500.

The components were part of a new slab steel plant for BHP's Port Kembla steelworks. They were valued at 1.309 billion Japanese Yen and were insured by BHP for $A 15 million. Included in the consignment were two turning frames valued at about $A 1.7 million each.

The two turning frames were pre-calculated to weigh up to 240 tonnes each, depending on the number of sub-components built on. A stowage plan prepared by the Kobe branch of All Nippon Checkers Corporation shows the turning frames as 227.8 tonnes each and these were the weights marked on them. 227.8 tonnes was evidently the manufacturer's calculated weight. When the turning frames were weighed after discharge in Port Kembla, the first was found to be 235.6 tonnes and the other 237.95 tonnes. The variation between calculated and actual weight is not significant as far as this investigation is concerned.

Prior to signing the contract, the whole operation, from loading in Japan to discharge in Port Kembla, was planned in detail by Kahn Shipping and BHP to ensure that it was both feasible and safe at all stages. Taking into account the height of the wharf and the outreach of 'GABRIELLA's' derricks, it was determined that the two turning frames would have to be discharged after most of the other components and when the tide was close to high water. Otherwise, there would not.have been sufficient clearance under the turning frames to land them on the low loader on the wharf (the term "low loader" used in this report is a commonly used term describing what is technically a platform trailer).

A crane barge was used to load the two turning frames because of a load limit on the wharf at Higashi Harima. Seventy-five other components of up to 50 tonnes each were loaded by wharf cranes. In all, seventy seven items totalling 1799 tonnes were loaded.

Most of the cargo, including the two turning frames, was stowed in the lower hold on top of the five forward sections of tween deck hatch pontoons which had been stowed on the tank top. Other cargo was stowed in the aft end of the lower hold on the tank top. Sixteen items, totalling 80 tonnes, were stowed on the two aft sections of tween deck hatch pontoons, which were in place at tween deck level. Seven items totalling 233 tonnes were stowed on the upper deck hatches. Stowage details, including weights and dimensions, were shown in the stowage plan and associated packing list prepared by All Nippon Checkers Corporation.

'GABRIELLA' sailed for Port Kembla on 17 July 1986, manned with a crew of eleven persons including the master, two mates and three engineers, all of whom held the appropriate certificates of competency. Manning and qualifications were in accordance with the ship's Safe Manning Document, issued by the Netherlands Shipping Inspectorate. The ship was fully loaded to her summer loadline with a metacentric height (GM) of 0.54 M and a vertical centre.of gravity (KG) of 5.72 M. The maximum allowable KG in that departure condition is shown in the ship's stability data as 5.80M. On arrival at Port Kembla, the GM was 0.49M and the KG 5.76M. Maximum allowable KG in the arrival condition was 5.805M. The ship, therefore, met the stability requirements for the voyage as set out in the stability data approved by the Netherlands Shipping Inspectorate.

The voyage proceeded normally until very heavy weather was encountered on 5 August when the ship had almost reached its destination. It was forced to heave to off the coast near Port Kembla for several days during which some items of cargo shifted in heavy seas. The ship suffered a list which it was able to control and there was some comparatively minor damage to the ship's structure. This incident had no significant influence on the subsequent capsize and sinking in Port Kembla.

'GABRIELLA' berthed starboard side to No. 2 Products Berth in Port Kembla on 10 August and cargo discharge commenced the following day. Wharf cranes were used to discharge all lifts except the two turning frames. However, three lifts totalling 138 tonnes were left on the port side of the lower hold to assist ballast operations during discharge of the two turning frames using the ship's derricks.

On the afternoon of 13 August, the first turning frame was discharged using the two 160 tons SWL derricks in tandem with the lifting yoke. Discharge commenced at 1230 and was completed at 1700 hours. No problems were encountered. The length of time taken was normal for an operation of this type, mainly due to the necessity to swing the load outboard a little at a time and then ballast to keep the starboard list to a minimum and ensure the stabilizer pontoons did not emerge too far. (See page 9.)

For the discharge of the two turning frames, waterside workers were employed for slinging and unslinging only. On both occasions, the waterside workers were directed to leave the ship on completion of slinging and wait on the wharf for unslinging.

The discharging operation was under the direct control of the master who:

- controlled the movement of the load by hand signals to two seamen manning the winch controls of the forward and aft derricks

- controlled the transfer of water ballast from starboard to port anti-heeling tanks by radio orders to the second mate controlling the ballast pumps in the wheelhouse

- controlled the filling of other port side water ballast tanks by verbal orders to the second engineer standing by on deck

- received confirmation from the second mate and second engineer that ballast orders had been executed

- received radio advice from the second mate on the heel of the ship shown by a clinometer in the wheelhouse

- received radio advice from the first mate who was in the hold until the lift was about half way out of the hold and who later kept a visual check on the stabilizer pontoons to ensure they were properly immersed and secure at all times.

On 14 August, discharge of the second turning frame commenced. Waterside workers completed slinging at about 0830 hours and then left the ship. The three smaller lifts, totalling 138 tonnes, remained lashed on the port side of the hold. Shortly afterwards, on advice by radio from the first mate in the hold that all was ready there, the master, who was on the starboard side of the deck, signalled the winchmen to commence lifting.

Immediately prior to lifting, there was a small list to port of about ½°. When the lift was floated, about 0915 hours according to the master, the list was reported by the second mate to be ½° to starboard.

Discharge proceeded in the same manner as for the first turning frame. When the bottom of the load was above the top of the coaming, the master commenced to swing the derricks towards the wharf one at a time in small stages, making sure that the yoke was always horizontal and the runner wires always vertical. As soon as the second mate reported that the list to starboard had reached 1½°, the master stopped swinging out the derricks and ordered the second engineer to fill No. 3 Port Double Bottom water ballast tank. At the same time he ordered the second mate to commence transfer of water ballast from the starboard upper to the port lower anti-heeling tanks. When the list had been reduced to ½° to starboard, the derricks were swung out as before until the list again reached 1½° to starboard when further ballasting to port was ordered. This process was gradually repeated, until at about 1145 hours the turning frame was in position over the wharf with the ship listed about ½° to starboard.

At this stage, the turning frame was suspended 10.9 metres to starboard of the ship's centre line. Its weight, 237.95 tonnes, was counterbalanced by:

390 tonnes more fuel and water in port than in starboard side tanks

138 tonnes of cargo on the port side of the hold.

(See Appendix 4 for details.)

According to several witnesses, when the load was in position over the wharf it had to be lifted a little to allow the low loader to be positioned underneath. These witnesses stated that at approximately 1145 hours, while lifting, one strand in the forward runner wire broke between the top and bottom sheaves. Their attention was drawn to it by the noise it made. None of the ship's crew or the master referred to this reported break, although it was allegedly brought to the master's attention by a waterside worker. At this point, the load was high enough and the low loader was backed under it. The bottom of the load was about one metre above its intended position on the low loader and lowering then commenced. Almost immediately afterwards, the forward runner wire broke and the load fell about one metre onto the low loader. This happened, according to witnesses, at about 1150 hours, some five to fifteen minutes after the first strand broke, when that strand entered the top sheave.

When the load fell the ship rolled violently to port, away from the wharf. The lightly welded retaining plates parted at the connection between the lifting yoke and the aft derrick lifting purchase, freeing the ship from the load. In about two or three seconds, the ship had rolled about 45' to port when, according to witnesses, the roll slowed down or almost stopped. At about this point, water commenced flooding the large open hold and the ship continued its roll to port and sank very quickly on its side. It came to rest on the harbour bottom with its starboard side just clear of the water about ten to fifteen seconds after the load fell.

There were ten persons on board when the ship capsized:

- second mate in the wheelhouse at the ballast controls

- second engineer, on deck with his wife awaiting instructions from the master about ballasting

- two seamen at the derrick winch controls

- one seaman standing by on deck

- The ship's cook inside the accommodation near the galley/provision store area

- a male visitor to the ship on deck near the accomodation area

- two marine surveyors inside the accommodation in the vicinity of the master's cabin

  David Brooke-Smith of Lloyds Register of Shipping

  William Martin of Bureau Veritas

The latter two persons were on the ship in connection with damage sustained when some items of cargo shifted in heavy weather, prior to the ship's arrival in Port Kembla. They had inspected the damage with a local private marine surveyor, Gustaaf Keeson, and the Operations Manager of Kahn Shipping, Arnold van der Heul. The four were proceeding to the master's cabin at about 1145 hours but Gustaaf Keeson went ashore to photocopy some papers, intending to meet the others in the master's cabin about ten minutes later. Arnold van der Heul also went ashore briefly to speak to the master who was directing operations on the wharf. Very shortly after he did so the ship capsized.

The seven crew members, including the second engineer's wife and the male visitor, who were on the ship when it capsized managed to scramble to safety on the starboard side or were rescued by a passing fishing vessel or by persons on the wharf. The master and chief engineer jumped from the wharf into the water to assist.

Within a few minutes eight persons were accounted for. All, except for one seaman, were affected a little by immersion and some were taken to hospital for observation. There were apparently no significant injuries or after effects of immersion affecting those eight persons.

The master quickly realised that the two surveyors were unaccounted for and all possible efforts were made by him and other crew members on the capsized hull to locate them. They were soon joined by emergency rescue services from ashore, including divers, who arrived on the scene about 1210 hours. The ship's Safety Plan had been quickly recovered from its stowage position on deck and was used to assist the divers searching the accommodation for the two missing surveyors.

The body of David Brooke-Smith was found near the entrance to the master's cabin about 1600 hours, some four hours after the capsize. Divers continued the search for the other surveyor in very poor conditions caused by debris and escaping oil, but were forced to abandon their efforts at about 1900 hours. They resumed the search from about 0800 to 1600 hours the next day and again from about 0800 to 1300 hours on 16 August. The police in charge of search operations, considering that further searching was futile, then postponed the search for William Martin until conditions improved for the divers. His body was eventually found by the divers on 4 September in the first mate's cabin, where he was apparently trapped by the door becoming jammed shut, possibly due to movement of the door frame in the capsize.

Oil escaping from the ship was quickly contained within floating booms positioned by the Maritime Services Board. Salvage operations were under way by Monday 18 August, priority being given to sealing the fuel tanks to prevent further leakage and then removing the oil from the ship. Oil pollution effects on the harbour were minimal.

OBSERVATIONS

1. Documents produced show that GABRIELLA held current certificates in accordance with all international conventions applicable to ships of her class and tonnage. The ship was manned in accordance with the requirements of the Netherlands Administration.

2. GABRIELLA completed building at Waterhuizen in the Netherlands in January 1974 under special survey by Bureau Veritas and was assigned the Bureau's highest class notation. In addition the design of the ship for handling and carriage of heavy cargoes was specially studied and approved by the Bureau.

3. I examined three sections of the broken forward derrick lifting purchase runner wire with the following results:

WINCH END Apart from damage in the accident, the rope appeared in good condition. However, there were a number of small filler wires broken near the rope fracture. Closer examination showed these wires had corroded inside the rope, the broken ends having sprung out. These corroded ends ought to have been detected during the required statutory examination of the rope prior to the accident and should have led to internal examination. My internal examination of a short section 15 metres from the break revealed moderately heavy corrosion, some abrasion and a complete lack of internal lubrication.

FIXED END This section, 23.6 metres in length, was heavily damaged in the accident over a length of about 4 metres from the break. Clear of the damage, the rope appeared in good condition apart from a few broken filler wires as in the winch end.

INTERMEDIATE LENGTH This length of about one metre was found immediately after the accident by Senior Constable Strik. It consisted of three strands and the wire rope core which were on the low loader where the turning frame fell, and two separated strands found on the wharf alongside the low loader. It is understood that another four wires, apparently from the missing sixth strand, were recovered from the scene by Senior Constable Strik and sent to BHP for examination.

My examination revealed extensive lack of external lubrication and a complete lack of lubrication internally. Heavy external and internal corrosion was evident together with a large proportion of wire ends the appearance of which indicated they had corroded completely through some time prior to the accident. The master in his statement to me said he carried out the required annual examination of this rope on or about 8 July 1986 in Higashi Harima Japan and found it in good condition. In my opinion this defective intermediate length should have been detected then and should have led to replacement of the rope.

All three sections examined by me were of the same construction as the rope described in Test Certificate No. 9280 produced to me by Kahn Shipping and marked to indicate it was the certificate for the forward derrick runner wire.

4. The results of detailed metallurgical tests and examination of the three sections of the forward derrick runner wire by Unisearch Limited confirm my examination and opinion of the condition of the rope. In particular, Appendix 8 of the Unisearch Report shows beyond any reasonable doubt that the intermediate length recovered by Senior Constable Strik was part of the broken runner wire from GABRIELLA. A summary of the Unisearch Report at Appendix 5 of this Report shows the strength of the rope near the break had been reduced to about 37% of the original strength due to corrosion.

5. There is a conflict in evidence about one strand of the rope breaking shortly before the accident. Six eye witnesses interviewed by me made quite positive statements that one strand broke about five to fifteen minutes beforehand. Two of the eye witnesses stated their attention was drawn to the broken strand by a loud bang and a third referred to an unusual noise. A loud bang is typical of failure of a wire rope strand under heavy load. On the other hand the master of the ship denied any knowledge of a broken strand prior to the rope breaking. The statements of the six eye witnesses are considered reliable and consistent with one

strand breaking shortly before the accident.

6. Four of the six eye witnesses have stated that when the first strand broke the master looked up to the head of the forward derrick where the broken strand was located. Their impression was that the master seemed to be aware of the broken strand.

7. The eye witnesses stated that the rope parted when it entered the top block. Four of them indicated that the break occurred on the fourth sheave from the right of the top block (looking forward). This is consistent with the length of the fixed end from the break, 23.6 metres, and the calculated distance apart of the top and bottom blocks (see diagram on page 31). It is also consistent with the relatively minor damage to the winch end compared with the extensive damage to the fixed end of the broken rope. When the load fell the winch end unreeved through only one sheave whereas the fixed end unreeved through seven sheaves at a very rapidly accelerating velocity. Part of the fixed end apparently became caught up somewhere in the fallen load or gear resulting in the breaking off of the intermediate length found on the low loader by Senior Constable Strik. It is notable that one strand from this section of rope was not found, which supports the allegation that one strand had broken shortly before the accident. This strand would have partly unravelled from the rope, and did so according to one of the eye witnesses. Being unravelled it would have been more exposed to damage while the rope was rapidly unreeved through the blocks and probably broke up-into a number of small pieces. It is understood that a number of small pieces were picked up at the scene by onlookers.

8. Available information indicates that it has been an accepted risk with ships like 'GABRIELLA' to operate in conditions where capsize is inevitable in the event of sudden loss of derrick load. It is noted that the detailed instructions supplied by the owners and operators of 'GABRIELLA' for heavy lift operations make no reference to this. In such operating conditions it would be prudent to require special examination of all load bearing gear immediately before use and also to require evacuation of all non-essential personnel from the ship during the critical stages.

CONCLUSIONS

I find that:

1. 'GABRIELLA' capsized to port because the forward derrick runner wire broke when

   a load of 237.95 tonnes was suspended to starboard over the wharf

   and the ship was heavily ballasted to port to keep the ship upright

   : because of the need to keep the stabilizer pontoons immersed.

2. Capsize was inevitable in the circumstances as shown in the Stability Analysis in Appendix 4.

3. The ship sank because the cargo hold flooded

   the hatches being open, of necessity, for cargo discharge.

4. The runner wire broke due to considerable strength reduction caused by corrosion and abrasion of individual wires inside the rope.

5. (a) The corrosion and abrasion were caused by the protective lubricant not penetrating the rope. It is evident that the method of application was ineffective.

   (b) It is also evident that the examination of the rope prior to and during use in Port Kembla was ineffective. The intermediate length found by Senior Constable Strik was obviously defective externally and internally. Corroded filler wires in the winch and fixed ends of the rope near the break ought to have been detected. Their presence should have led to internal examination and discovery of the defective internal condition of the rope. In short, a proper examination of the rope ought to have resulted in it being discarded.

NOTE: Attention is drawn to the methods of rope lubrication and inspection described in Sections 10 and 11 of Australian Standard 2759 - 1985.

6. One strand of the runner apparently broke between five to fifteen minutes before the final break. It has been alleged that the master was aware of this, but he said he was not. It is difficult to understand why several casual observers stated that they noticed it, yet a person of the master's experience did not. However if the master was not aware of it, it would appear that he ought to have been.

7. Lowering with the runner after one strand had broken would have imposed additional stress on the weakened section as it was bent around the next sheave. The final break apparently occurred at that point, when the broken strand entered the top block in the sheave furthest from the fixed end.

8. On the assumption that one strand initially broke, the operation then would have become very dangerous. Capsize and sinking would have been inevitable if the rope broke completely. The following action should have been taken under these circumstances:

- cease all further winching (up or down) of the forward derrick runner

- order all persons from the ship and the danger area on the wharf immediately

- carefully monitor the partly broken section of rope for indications of further breaking

- assess options available for landing the load.

9. The following options then should have been considered:

- fill all empty double bottom water ballast tanks

  sinkage caused 0.14 M

  resultant starboard heel 1.39°, load drops 0.19 M

  metacentric height (GM) increases from 2.576 M to 3.075 M

. transfer water ballast from port upper to starboard lower anti-heeling tank

increased draught would allow an angle of heel of up to 5.2° before the stabilizer pontoon bottoms emerged

load would be lowered a further 0.96 M by heeling to about 5°

GM would also increase

. wait for falling tide, low water 2200 hours 14th August

fall of 0.5 M from noon.

10. The options in 8 above offered a potential load lowering, relative to the wharf, of 0.14 + 0.19 + 0.96 + 0.50 = 1.79 M, more than sufficient to land the turning frame on the low loader. It would have been necessary to re-position the low loader to take into account the extra derrick out-reach due to heeling.

11. Further options included:

. lowering the load by using the derrick topping lifts

as an alternative to waiting for the falling tide

. landing the load on the wharf

. supporting the load from underneath

for example, with heavy timber

. if possible without danger to persons.

APPENDIX 1

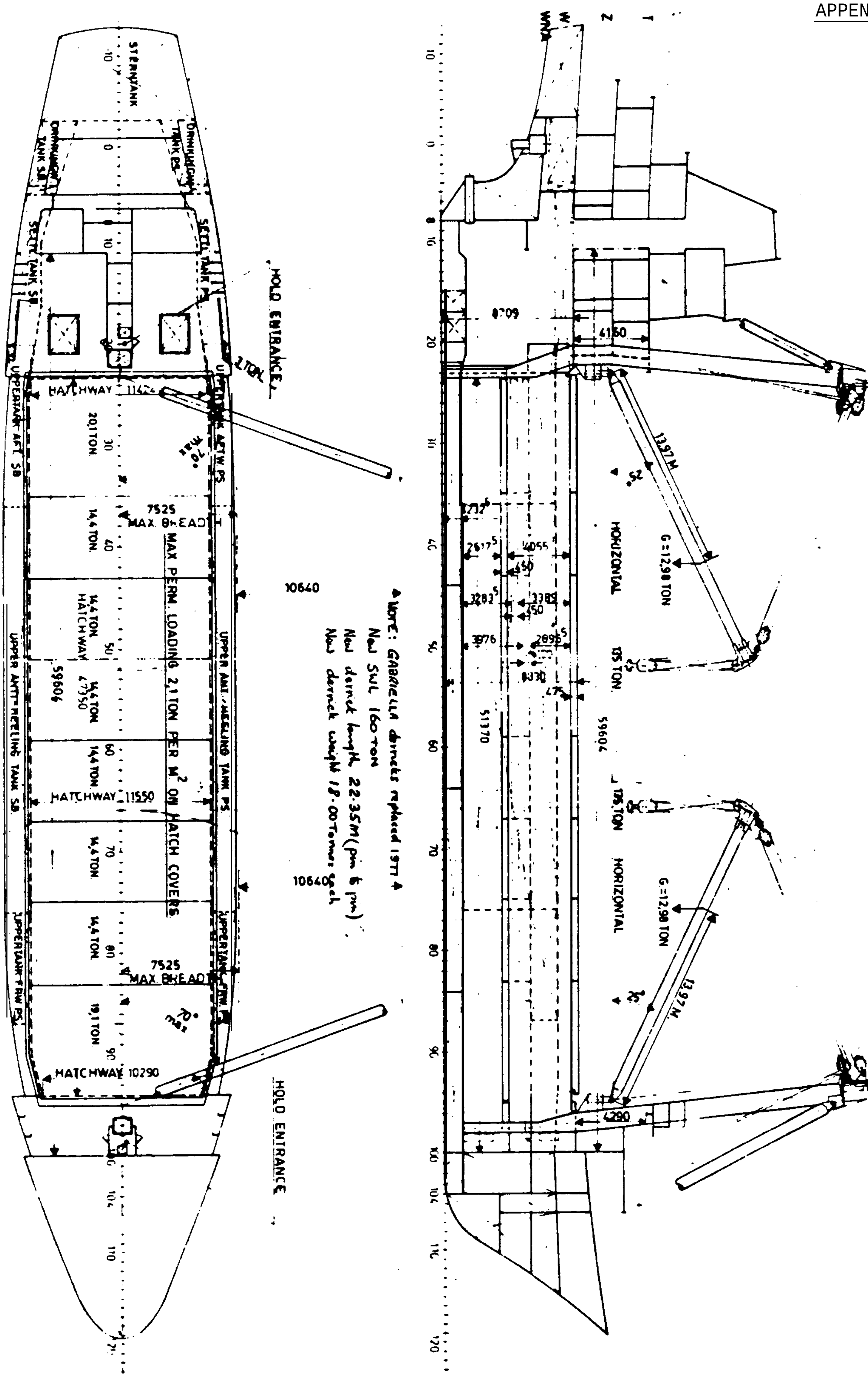
PARTICULARS OF SHIP

NAME	GABRIELLA
PORT OF REGISTRY	Willemstad, Curacao, Netherlands Antilles.
OWNERS	Jumbo Scheepvaart Maatschappij N.V. Curacao, Netherlands Antilles.
OPERATORS	Kahn Scheepvaart B.V. (Kahn Shipping Limited) Rotterdam.
TYPE	Cargo, specialized heavy lift cargoes.
CONSTRUCTION	Steel welded.
BUILT	Waterhuizen the Netherlands, completed January 1974.
TONNAGE	Gross 1327.33 register tons (International) Net 958.20 register tons (International). Deadweight 2558 tonnes capacity (to Summer Load Line).
DIMENSIONS (INTERNATIONAL TONNAGE CERTIFICATE)	Length 79.87 metres Breadth 14.98 metres Depth 6.32 metres, to upper deck.
PROPULSION MACHINERY	One, MAK-type 9 Mu 452 AK, supercharged diesel, 1692 kW.
CLASS	Bureau Veritas I 3/3 E + HEAVY CARGO DEEP SEA Last annual survey of hull and machinery 3 February 1986 Singapore.

INTERNATIONAL LOAD LINE CERTIFICATE	Issued by the Netherlands Scheepvaartinspectie (Shipping Inspectorate - Netherlands marine Administration) on 31 January 1984 and valid to 31 January 1989. Last annual survey 3 February 1986 Singapore.
SAFETY CONSTRUCTION CERTIFICATE	Issued by the Netherlands Scheepvaartinspectie on 31 January 1984 and valid to 31 January 1989. Last annual survey 3 February 1986 Singapore.
SAFETY EQUIPMENT CERIFICATE	Issued by the Netherlands Scheepvaartinspectie on 25 March 1986 and valid to 9 February 1988. Last survey 3 February 1986 Singapore.
SAFETY RADIOTELEPHONY CERTIFICATE	Issued by Government of Japan on 9 July 1985 and valid to 8 July 1986. Validity extended to 8 October 1986 by the Netherlands Scheepvaartinspectie on 13 June 1986.
INTERNATIONAL OIL POLLUTION PREVENTION CERTIFICATE	Issued by the Netherlands Scheepvaartinspectie on 16 February 1984 and valid to 30 September 1986. Last annual survey 3 February 1986 Singapore.
CERTIFICATE OF SEAWORTHINESS (ARTICLE 6 NETHERLANDS SHIPS ORDER 1965)	Issued by the Netherlands Scheepvaartinspectie on 5 June 1985 and valid to 1 July 1987. Validity extended to 1 July 1987 by the Netherlands Scheepvaartinspectie.
SAFE MANNING DOCUMENT	Issued by the Netherlands Scheepvaartinspectie on 5 June 1985 and with same period of validity as the above Certificate of Seaworthiness to which it belongs.
CERTIFICATE OF REGISTRY	Issued by the Governor of the Netherlands Antilles at Curacao on 23 January 1978.
INTERNATIONAL TONNAGE CERTIFICATE EXTRACT	Issued by the Netherlands Chief Inspector for Tonnage Measurement on 22 October 1974.

APPENDIX 2

M.V. GABRIELLA – GENERAL ARRANGEMENT



APPENDIX 3

STABILITY TERMINOLOGY

The centre of gravity of a body is the point through which the force of gravity is considered to act vertically downwards with a force equal to the weight of the body.

The centre of buoyancy is the point through which the force of buoyancy is considered to act vertically upwards with a force equal to the weight of water displaced. It is the centre of gravity of the underwater volume.

To float at rest in still water, a vessel must displace its own weight of water, and the centre of gravity must be in the same vertical line as the centre of buoyancy.

Figure A represents a ship floating upright in still water. The centres of gravity and buoyancy are at G and B respectively.

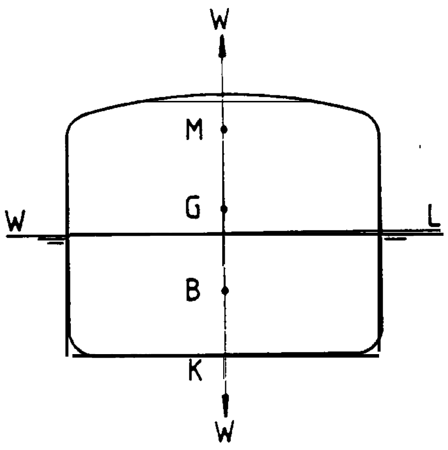


FIG. A

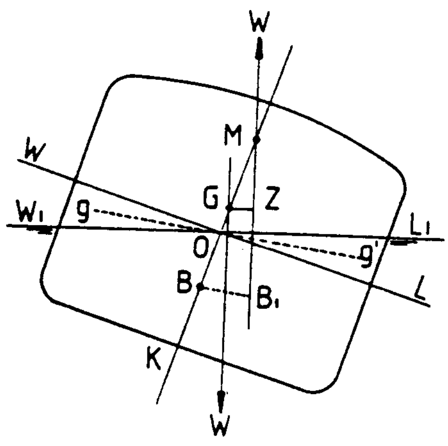


FIG. B

If the ship is inclined by an external force to a small angle as shown in Figure B the centre of gravity will remain at G and the weight of the ship (W) can be considered to act vertically downwards through this point. The centre of buoyancy shifts from B to B1 .

For angles of heel up to about 15° the vertical through the centre of buoyancy may be considered to cut the centre line at a fixed point called the initial metacentre (M in the figures). The height of the initial metacentre above the keel (KM) depends upon a ship's underwater form and the surface waterplane area.

The vertical distance between G and M is referred to as the metacentric height. If G is below M the ship has positive metacentric height, and if G is above M the metacentric height is negative.

A ship is in stable equilibrium if, when inclined, it tends to return to the initial position. For this to occur the centre of gravity must be below the metacentre. Figure A shows a ship in the upright position having a positive GM. Figure B shows the same ship inclined to a small angle. The centre of buoyancy moves from B to B1 to take up the new centre of gravity of the underwater volume, and the force of buoyancy is considered to act vertically upwards through B1 and the metacentre M. If moments are taken about G there is a moment to return the ship to the upright. This moment is referred to as the Moment of Statical Stability and is equal to the product of the force (W) and the length of the lever GZ.

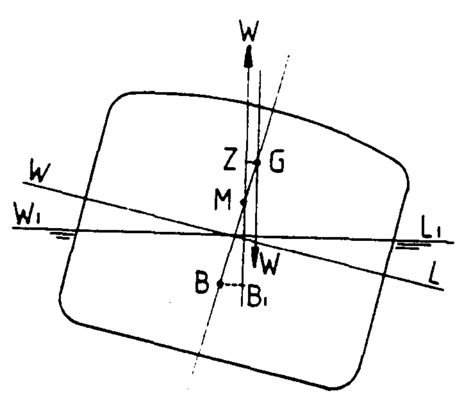


FIG C

When a ship which is inclined to a small angle tends to heel over still further, it is in unstable equilibrium. For this to occur the ship must have a negative GM.

Figure C shows a ship in unstable equilibrium which has been inclined to a small angle. The moment of statical stability, W x GZ, is clearly a capsizing moment which will tend to heel the ship still further.

APPENDIX 4

STABILITY ANALYSIS

The following calculations are based on:

.copies of the ship's stability data approved by the Netherlands Shipping Inspectorate and supplied by the ship's operators Kahn Shipping

.statements by the master and first mate and information on the ship's cargo plan relating to the cargo on board

.statements by the master, chief engineer and second mate relating to liquids in tanks

.information from Kahn Shipping and the master, based on operating experience, relating to the estimated quantities of unpumpable liquids in tanks

.information from BHP about the weight of the turning frames

.measurement of the distance from the wharf face to the centre of the turning frame where it dropped and hence the outreach of the derricks at the time of the accident

.a general arrangement plan of the ship supplied by Kahn Shipping.

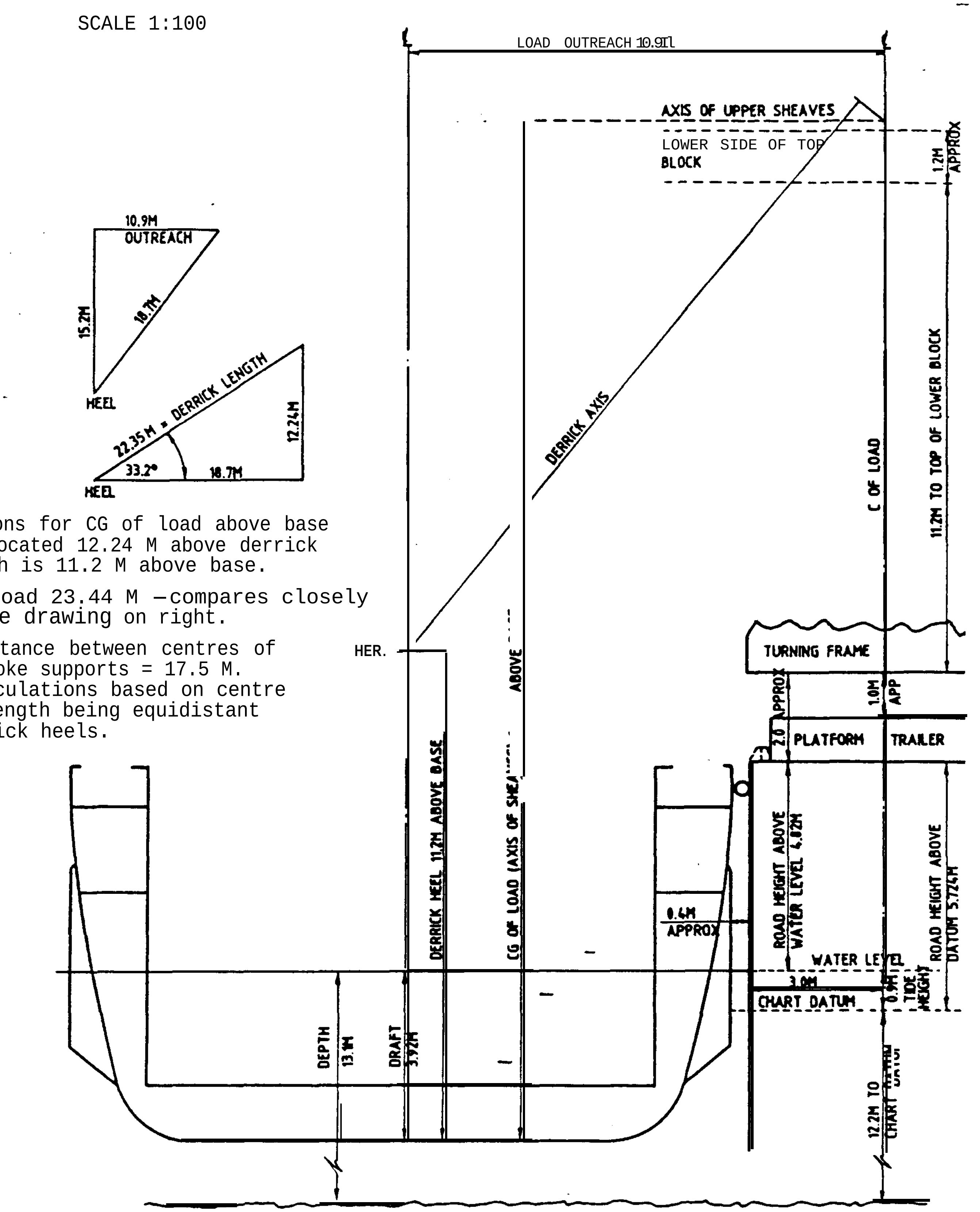
The analysis shows the stability conditions of the ship immediately before and after the turning frame dropped. Although some of the factors involved, notably the quantities of unpumpable liquids, are necessarily only estimates, they are considered sufficiently accurate for the purpose of this investigation. In the absence of information in the data relating to centre of gravity and free surface in the partly filled condition of some tanks, the partly filled centres of gravity have been estimated and the maximum free surface moments have been used. The ship's condition was, therefore, probably very slightly better than shown by the calculations. Any difference, however, is of no practical significance. The absence in the data supplied of the effect of trim of the ship is also considered to be of no practical effect on the results of these calculations. Certainly, the calculated angle of heel immediately prior to the accident accords with the master's statement that he ballasted the ship to keep the angle of heel very slightly to starboard of upright, about ½°.

The curve of righting levers (GZ) has been drawn past the angle of heel at which the hold would have commenced flooding. This illustrates that capsize was inevitable even if the hold was not open, as the capsizing levers are always greater than the righting levers. It is not suggested that the upper deck hatch covers should have been, or even could have been, secured in place by the wharf cranes when the turning frame was clear of the hold. Such a course of action, even if feasible, would have been undesirable for safety reasons.

This analysis shows that the stability was satisfactory for the discharge of the second turning frame. However, at the critical stage with the turning frame over the wharf, the amount of cargo and water ballast used to counter-balance the turning frame and keep the stabilizer pontoons immersed was such that capsize was inevitable if the load in the derricks were suddenly lost. With the cargo hold open for cargo discharge the consequence of capsize was sinking.

The analysis also shows that even if the turning frames could have been discharged before other cargo in the hold, the improved stability would not have been sufficient to prevent capsize and sinking.

CONDITION IMMEDIATELY BEFORE ACCIOENT



Calculations for CG of load above base show it located 12.24 M above derrick neel which is 11.2 M above base.

∴ KG of load 23.44 M — compares closely Jith scale drawing on right.

Note : Distance between centres of lifting yoke supports = 17.5 M. Above calculations based on centre of yoke length being equidistant from derrick heels.

ITEM	WEIGHT (tonnes)	KG (m)	V.MOM (t-m)	LCG (m)	L.MOM (t-m)	STBD+ TCG (m)	T.MOM (t-m)
Lightship excluding following	1546	7.13	11018	33.23	51374	-0.18	-278
Fore derrick	18	19.0	342	52.79	950	7.3	131
Aft derrick	18	19.0	342	32.17	579	7.3	131
Stabilizer beams	10	7.0	70	29.00	290	-8.0	- 80
Tween deck hatch No. 1	14.3	1.48	21	60.41	864	-	-
" " " " 2	11:4	1.48	17	52.45	598	-	-
" " " " 3	11.4	1.48	17	47.09	537	-	-
" " " " 4	11.4	1.48	17	41.73	476	-	-
" " " " 5	11.4	1.48	17	36.37	415	-	-
Stores		12.3	86	3.00	21		-
Lifting/Lashing gear	7:	7.0	525	50.00	3750	:	-
Sub-Total	1734		12472		59854		- 96
Less Nos. 3-7 upper deck hatches placed ashore	-72	8.65	-622	36.34	-2616	-	-
No. 8 upper deck hatch ashore	-20	8.65	-174	19.00	- 380	-	-
No. 2 hatch moved on top No. 1		+0.45	+ 6	+5.5	+ 79		- -
ADJUSTED LIGHTSHIP	1642		11682		56937		- 96

LIQUIDS		WEIGHT (tonnes)	KG (m)	V.MOM (t-m)	LCG (m)	L.MOM (t-m)	STBD +TCG (m)	T.TOM (t-m)	F.S. MOM (t-m)
2 DB Port	Fuel Oil	50	0.61	31	37.04	1852	-2.92	- 146	16
" " Stbd	" "	5	0.06		37.04	185	2.92	15	16
3 " Centre	" "	5	0.06		35.7	179			66
4 " "	" "	57	0.61	-35	21.6	1231			73
Settling Tank Port	" "	14	8.19	115	9.31	130	-5.82	- 81	0
Settling Tank Stbd	" "	3	7.6	22	9.31	28	5.82	17	8
Day Tank Stbd	" "	2	10.0	20	6.0	12	1.9	4	0
4 DB Port	Lub. "	3	0.8	2	11.99	36	-1.61	5	3
5 " "	" "	2	0.8	2	10.28	21	-1.29	3	0
" " Stbd	Leak "	1	0.8	1	10.28	10	1.29	1	1
4 " "	Dirty "	2	0.8	2	11.99	24	1.61	3	3
Fresh Water Tank Port		8	8.3	66	0.22	2	-4.08	- 33	5
" " " Stbd		2	8.0	16	0.22		4.08	8	5
Aft Peak - Fresh Water		30	5.0	150	3.3	99			95
Fore Peak Water Ballast		33	6.11	202	71.58	2362		-	
1 DB Centre	"	63	0.67	42	61.55	3878		-	
" " Port	"	32	0.67	21	54.4	1741	-3.5	- 112	0
" I, Stbd	"	8	0.17	1	54.4	435	3.5	28	43
" Upper Wing Tank Port	"	19	6.64	126	53.86	1023	-6.52	- 124	0
" Upper Wing Tank Stbd	"	2	6.0	12	53.86	108	6.52	13	33
2 DB Centre	"	5	0.05		49.09	245			66
" Lower Wing Tank Port	"	243	2.78	675	37.07	9008	-6.16	-1497	0
" Lower Wing Tank Stbd	"	30	0.35	11	37.07	1112	4.8	144	22
" Upper Wing Tank Port	"	30	6.05	182	37.05	1112	-6.6	- 197	9
2 Upper Wing Tank Stbd	"	2	5.6	11	37.05	74	6.6	13	8
3 DB Port	"	31	0.68	21	19.67	610	-3.46	- 107	
" " Stbd	"	8	0.17	1	19.67	157	3.46	28	39
" Upper Wing Tank Port	"	25	6.67	167	18.89	473	-6.44	- 161	
" Upper Wing Tank Stbd	"	2	6.0	12	18.89	38	6.44	13	3
TOTAL LIQUIDS		717		1946		26185		-2179	514

ITEM	WEIGHT (tonens)	KG (m)	V.MOM (t-m)	LCG (m)	L.MOM (t-m)	Stbd +TCG (m)	T.MOM (t-m)	F.S. MOM (t-m)
3 cargo items lower hold port	138	3.73	515	45.00	6210	-4.5	-621	-
Turning frame & lifting yoke	270		6328	39.22	10589	10.9	2943	-
TOTAL CARGO	408		6843		16799		2322	
TOTAL LIQUIDS	717		1946		26185		-2179	514
ADJUSTED LIGHTSHIP	1642		11682		56937		96	
CONDITION BEFORE ACCIDENT	2767	7.40	20471	36.11	99921	0.017	+ 47	514

IMMEDIATELY BEFORE ACCIDENT:
Displacement 2767 tonnes

KG	7.398 M
Free Surface Correction	0.186 M
KG (fluid)	7.584M
KM (2 Stabilizer pontoons)	10.16 M
(KM no pontoons 6.6 M)	
GM	2.576 M
LIST 0.38" STARBOARD	

Draft at LCF 3.92 M

LCB	37.4235 M
LCG	36.1117 M
Trim Lever	1.3118M
MCT 1CM	30.2
TRIM	1.2019
LCF	37.365 M
DRAFT	F. 3.33 M A. 4.53 M

ITEM	WEIGHT	KG	V.MOM	LCG	L.MOM	+TCG	T.MOM	F.S. MOM
BEFORE ACCIDENT	2767		20471		99921		+ 47	514
LESS TURNING FRAME/YOKE	-270		6328		-10589		-2943	-
AFTER ACCIDENT	2497	5.66	14143	35.78	89332	1.16	-2896	514

IMMEDIATELY AFTER ACCIDENT:
Displacement 2497 tonnes

KG	5.664 M
Free Surface Correction	0.206 M
KG (fluid)	5.870 M
KM(no stabilizer pontoons*)	6.850 M
GM	0.98 M

*Stabilizer pontoons do not augment KM when fully immersed. In any case they broke adrift due to capsizing forces.

Draft at LCF 3.585 M

LCB	37.4283 M
LCG	35.7757 M
Trim Lever	1.6526 M
MCT 1CM	29.33 MT
TRIM	1.4069 M
LCF	37.405 M
DRAFT	F. 2.89 M A.4.30 M

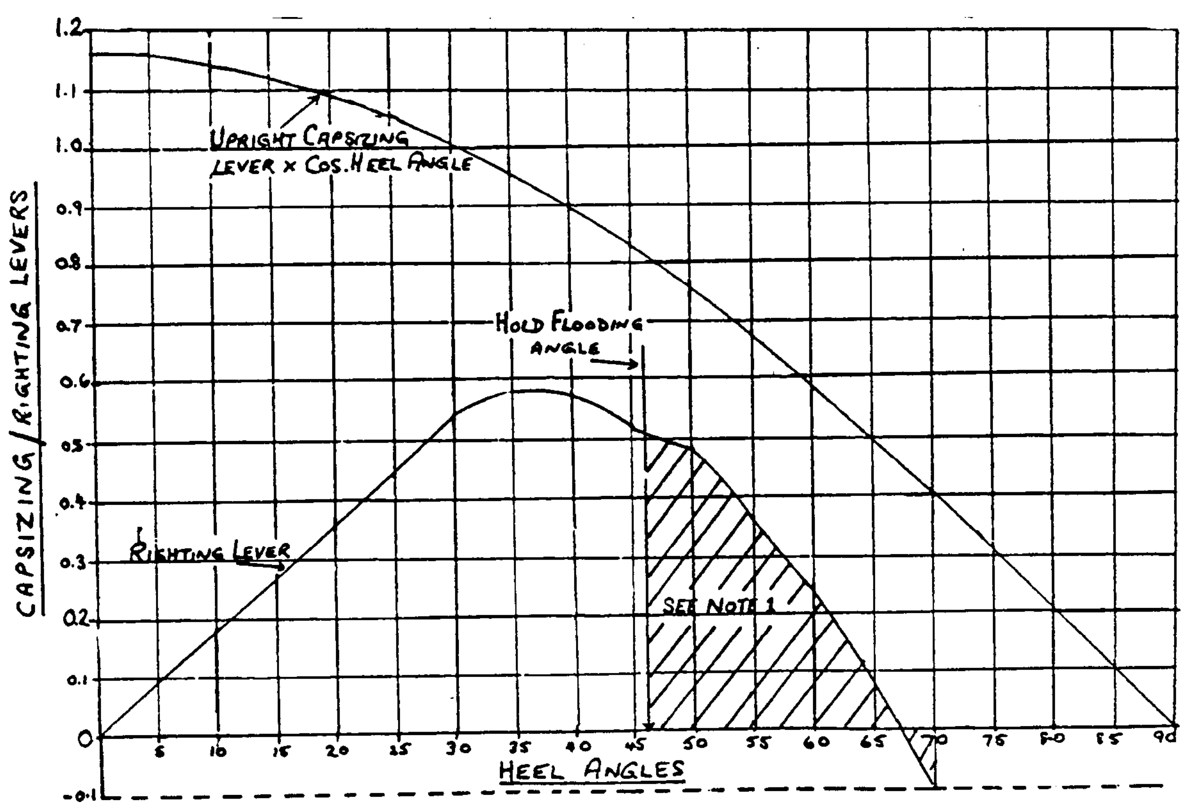
TABLE OF CAPSIZING LEVERS KG 5.87 DISPLACEMENT 2497

HEEL ANGLE	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
KN KG SIN HEEL ANGLE	0 0	0.60 0.51	1.20 1.02	1.79 1.52	2.37 2.01	2.92 2.48	3.475 2.935		4.34 3.77		4.98 4.50		5.325 5.085		5.4 5.5
RIGHTING LEVER	0	0.09	0.18	0.27	0.36	-0.4	0.54	0.58	0.57	0.52	0.48	0.36	0.24		-0.1
CAPSIZING LEVER	1.16	1.16	1.14	1.12	1.09	1.05	1.00	0.95	0.89	0.82	0.75	0.67	0.58	0.49	0.4
RESULTANT LEVER (CAPSIZING)	1.16	1.07	0.96	0.85	0.74	0.61	0.46	0.37	0.32	0.30	0.27	0.31	0.34		0.5

NOTE 1 GZ values are for intact hull. Vessel's cargo hold was open and angle of flooding for hold coaming was 46°. Although GZ values are not correct past 46° (they would be much less), the curves show the capsizing lever is always greater than the righting lever and capsize was inevitable, even if the hold was not open.

NOTE 2 There are no KN curves in the ship's data for 35° 45° 55° & 65°. GZ values at these angles have been extracted from GZ curves in the data for angles of heel 0° to 60°.

CURVES OF CAPSIZING & RIGHTING LEVERS



CONDITION IF TURNING FRAMES DISCHARGED BEFORE OTHER CARGO IN HOLD

ITEM	WEIGHT	KG	V.MOM	LCG	L.MOM	TCG	Stbd+ T.MOM	F.S. MOM
Turning frame & lifting yoke	270		6328					
4 x 45.7T items	183	3.73	682					
6 x 46.6 "	280	3.73	1043					
3 x 42.6 "	128	3.73	477					
4 x 34.8 "	139	3.22	448					
1 x 46.6 "	47	3.27	152					
1 x 32.2 "	32	2.95	95					
1 x 32.9 "	33	2.50	82					
2 x 10.3 "	21	2.05	42					
1 x 4.5 "	5	4.37	20					
30 items	27	3.20	86					
TOTAL CARGO	1165		9455				2322	-
TOTAL LIQUIDS	717		1946				-2179	514
ADJUSTED LIGHTSHIP	1642		11682				- 9 6	-
CONDITION BEFORE "ACCIDENT"	3524	6.55	23083				47	514
LESS TURNING FRAME/YOKE	-270		6328				-2943	-
AFTER "ACCIDENT"	3254	5.149	16755				-2896	514

Displacement	3254 tonnes	Draft at LCF	4.50M
KG	5.149M	Hold flooding angle	39°
Free Surface Correction	.158M	Righting lever at 35°	0.72M
KG (fluid)	5.307M	Capsizing lever at 35°	0.95M
KM (no stabilizer pontoons)	6.350M	Righting lever at 40°	0.78M
GM	1.043M	Capsizing lever at 40°	0.89M

NOTE 1 Trim is not significant and has been omitted

NOTE 2 3 cargo items totalling 138 tonnes have been 'discharged' from the starboard side of the hold first and are not included in the above calculations. This provides the required extra weight on the port side. The transverse moment (T.Mom) after the hypothetical accident above is therefore the same as after the actual accident (see page 34).

APPENDIX 5

SUMMARY OF RESULTS OF EXAMINATION AND TESTS BY UNISEARCH LTD, UNIVERSITY OF NEW SOUTH WALES

"Failure of the fore derrick running rope of MV 'GABRIELLA' at Port Kembla harbour on 14 August 1986 is attributed to the rope being so heavily internally corroded that the breaking load of the rope was exceeded by the combined forces of lifted load and the bending of the rope in the sheaves. On the basis of tensile tests on sections of the rope and individual wires, the breaking load of the rope had decreased from an initial value of 94.4 tonnes in 1981 to an estimated failure load at the break of 35 tonnes. While the contribution to the total lifted load of 265.6 tonnes from each of the 10 falls in the reeving system was only 13.28 tonnes, it is considered that the stiffness of the rope had been increased by corrosion and a force of at least 30 tonnes was developed in bending the rope around the sheaves. This was sufficient to cause failure of the rope.

Although formulated for marine conditions, the grease used to lubricate the rope did not penetrate the internal strands and, furthermore, was so badly deteriorated that 50 percent of the grease consisted of rust. Standard procedures for internal inspection of the rope would have identified the state of corrosion and lack of internal lubrication. In lowering after the alleged failure of one strand, appreciable additional bending forces would have been imposed on the weakened rope such that failure took place in the sheave."