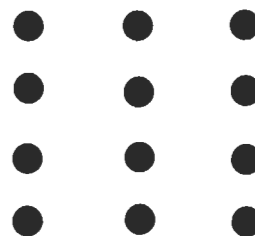


DEPARTMENTAL INVESTIGATION
INTO THE LOSS
OF THE BOW SECTION
OF THE GREEK REGISTERED
MOTOR TANKER

KIRKI



THE SUBSEQUENT FIRE,
EVACUATION OF THE CREW
AND SALVAGE OPERATION
FROM
20 JULY 1991 TO 23 AUGUST 1991

REPORT 33

NAVIGATION ACT 1912

Navigation (Marine Casualty) Regulations

**Investigation into the loss of the bow section
of the Greek registered motor tanker**

KIRKI

**the subsequent fire,
evacuation of the crew
and salvage operation
from**

20 July 1991 to 23 August 1991

No. 33

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Photograph 1 THE KIRKI, 5.8.91



PRELIMINARY

SECTION 1

Outline of incident

On the evening of 20 July 1991, the Greek registered oil tanker Kirki (call sign SVTW) was about 55 miles off the Western Australian coastal centre of Cervantes on passage from the Arabian Gulf to Kwinana with a cargo of approximately 82,660 tonnes of light crude oil. The weather was severe, with rough seas, heavy swell and southerly force 8 winds increasing in intensity.

At about 2000 Western Australia Standard Time, it was observed that the vessel had a pronounced trim by the head and the ship's speed was reduced and course altered to put the prevailing weather on a more comfortable quarter. On investigation it was established that the fore-peak ballast tank, which should have been effectively dry, had water in it, apparently to sea level. Attempts to pump the fore-peak did not succeed in lowering the water level and it became obvious that the fore-peak was open to the sea.

At about 0220 (UTC 1820) approximately 22 miles from the coast, in very rough seas and heavy swell, the bow was seen to break away from the ship just forward of No 1 oil cargo tanks. Simultaneously a fire erupted, from a rupture in the forward bulkhead of No 1 cargo tanks fuelled by highly volatile crude oil, and oil was lost to the sea. The engines were immediately stopped. Distress calls were broadcast and the crew was mustered at the port (leeward) lifeboat. After about 15 minutes the fire forward went out, extinguished by the action of the sea.

At 0302 (1902 UTC) Perth Marine Communications Station monitored a "Mayday" message followed by a two-tone alarm, from the Kirki. The Australian Maritime Safety Authority's Maritime Rescue Coordination Centre was alerted, and measures were put in place to evacuate the crew by helicopter. The off-shore support vessel Lady Kathleen responded by sailing for the casualty and the Western Australian Marine Emergency Operations Centre dispatched the State Department of Marine and Harbours vessel Vigilant. The National Plan to Combat Pollution of the Sea (the National Plan) was activated and the Marine Emergency Centre became the coordination headquarters for the State Committee of the National Plan.

During the ensuing hours the fire broke out from the Kirki's forward area on a further five occasions, each time being extinguished by the sea.

Helicopters arrived at first light and the evacuation of the crew, in relays to the nearest land, began at 0713 and was completed at 1156.

At 1040 the Lady Kathleen arrived at the casualty. At about 1430 the Lady Kathleen succeeded in securing a tow line to the Kirki's stern. The Kirki was then towed offshore while an assessment of the situation and decisions were taken as to the best course of action.

The Lady Kathleen was relieved of the tow by the offshore vessel Lady Elizabeth on 25 July and, over the next 14 days, the Kirki was towed to an area west-north-west of Dampier, where the remaining cargo was to be transferred to another tanker. On 25 July and again between 3 and 6 August, in high seas and heavy swell, two further quantities of oil were lost.

On 19 August, the remaining cargo and the bulk of the fuel oil was discharged in a ship-to-ship transfer in an area to seaward of the Monte Bello Islands and the Dampier Archipelago. A total of 64,372 tonnes of cargo and 1290 tonnes of heavy fuel oil were transferred, leaving approximately 600 tonnes of crude oil aboard the Kirki. The ship was subsequently towed to Singapore.

About 17,700 tonnes of crude oil was lost.

Note: *all times are given in Western Australian Standard Time (Universal Coordinated time + 8 hours), unless otherwise indicated.*

SECTION 2

Scope of the report

The Navigation (Marine Casualty) Regulations provide that the Inspector of Marine Accidents may investigate any incident for the purposes of identifying the circumstances in which it occurred and determining its cause.

The loss of the bow section, the fire and pollution from the Kirki on 21 July constitute an "incident" for the purposes of the Regulations.

Moreover, during the period 21 July to 23 August 1991, when the ship remained an operational unit under the care of the salvage team close to the Australian coast line, two further incidents occurred involving pollution of the sea by oil.

The Marine Incident Investigation Unit, assisted by Mr P. Wilkinson, a marine surveyor from the Australian Maritime Safety Authority who was also appointed as an investigator under Regulation 6, undertook an investigation into the incidents in accordance with the Regulations.

The investigation encompassed the structural failure of the ship and the action taken in response to that failure from the standpoint of minimising the risk to the safety of the ship's crew and salvage personnel and the threat of pollution of the sea.

The Master and crew of the Kirki gave every assistance to the investigation and the Inspector has received full cooperation from Mayamar Marine Enterprises Ltd (the ship's managers), Germanischer Lloyd (the classification society), and BP Australia Ltd (the ship's charterers and owners of the cargo).

SECTION 3

Sources of information

People Interviewed

From the Kirki:

Captain Efstathopolous	Master
Mr Hristidis Leonida	Chief Mate
Mr Haviaris Mihail	Second Mate
Mr Mendrinos Stamatio	Second Mate
Mr Vergiotis Dimitrio	Radio Officer
Mr Bijarakis Nikolas	Chief Engineer
Mr Dimopoulos Geogios	Second Engineer
Mr Koveos Stefanos	Boatswain
Mr Serifoglu Fezi	Able Seaman
Mr Kamarulas Vasilios	Able Seaman
Mr Sarados Xenofon	Able Seaman
Mr Labos Padelis	Able Seaman
Mr Dimos Konstandinos	Able Seaman

From the Lady Kathleen:

Captain Rolf Farstad	Master
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From the Department of Marine and Harbours, Western Australia:

Mr Lawrence Chapman	Master, Vigilant.
Mr Paul Nicholson	Senior Marine Officer

From United Salvage

Captain D. Hancox	Senior Salvage Master
Mr K. T. Cosh	Salvage Engineer

From Germanischer Lloyd

Mr Gunter Fodisch,	Regional Director, South East Asia
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Mr W. Stephens,	Principal Surveyor.
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Statements were provided by:

Mr G. Meagher	Seaman, Lady Kathleen
Mr and Mrs W. B. McCaughey	Perth
Captain Clive Mayo	Pilot, Police Airwing
Captain Derek Whitfield	Pilot, Police Airwing
Mr Rudy Ricercato	Crew man RAAF/ Bristow Helicopters
Mr I. C. Watson	Radio Officer, seconded to United Salvage

Information was also provided by:

The Australian Maritime Safety Authority
OTC, Perth and Sydney
The Civil Aviation Authority, Perth
RAN, HMAS Sterling, Fremantle
Mrs R. H. Burton, Perth
BP Australia Ltd
Mayamar Marine Enterprises Ltd
Bureau of Meteorology
Materials Research Laboratory, Department of Defence,
Melbourne

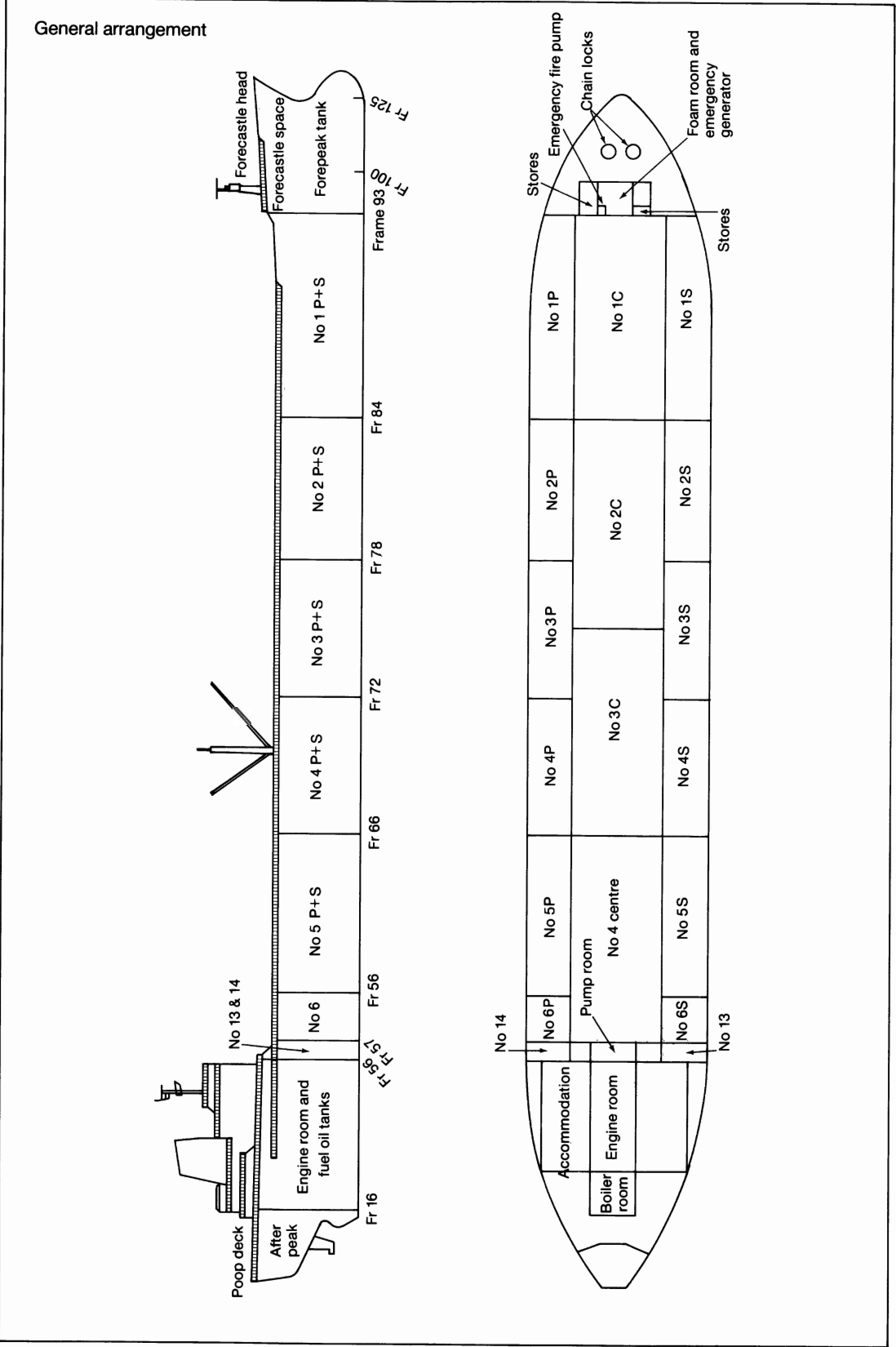
The Kirki's raised forecastle deck was forward of frame 93. Mooring machinery was serviced by steam pipes running along the main deck from the engine room. The supply and return lines to the windlass passed through the forecastle space, while pipes servicing the two steam-mooring winches passed outside the forecastle space, on the open deck. There was also a water supply to hydrants on the forecastle head deck and electric power supplies for lighting, flood lights, navigation signals and the Suez Canal search-light.

Inside the forecastle space, the port and starboard chain lockers were let into the fore-peak space either side of the centre line, between frames 105 and 110 to a depth of approximately 6m. Paint and rope stores, and the engine for the hydraulically-driven emergency fire pump were against the forecastle bulkhead. According to ship's staff, miscellaneous stores were also kept in the forecastle space, some of them against the after bulkhead. The fire pump was at the bottom of the ship in a casing constructed between frames 93 and 95 approximately 3m to port of the centre line.

Below the forecastle space was the fore-peak ballast tank with a capacity of about 7730 tonnes of sea water.

Mayamar Marine Enterprises issued a comprehensive operations manual to their ships, requiring inspection and maintenance of life-saving appliances, fire-fighting equipment and cargo systems, including the inert gas system.

There was also a company policy of alcohol prohibition extending to the Master and crew aboard the Kirki. A quantity of spirits was carried in the Master's bond.



Diagram

The crew

At the time of the incident the Master, Captain Efstathopolous, had 22 years sea-going experience, of which 20 years had been on tankers, with eight years as chief mate and five to six years in command. He was qualified as a master of a Greek ship and held an oil tank ship safety certificate. He had joined the Kirki in April at Fujairah, having also been on the vessel on one previous voyage - in 1990 as master.

The Chief Mate, Mr Hristidis, held a certificate as first officer and had about 18 years sea-going experience, seven years of which had been on tankers as chief mate. He apparently did not hold a tanker safety endorsement to his certificate of competency, but said he had participated at courses and seminars on tanker operations. He had sailed on the Kirki on two previous voyages - in 1987 and 1989.

The Chief Engineer, Mr Bijarakis, held a certificate as chief engineer. He had served on tankers since 1986 and had been promoted to chief engineer in 1989. He first served on the Kirki in August 1987 and since then had undertaken five tours of duty on the ship.

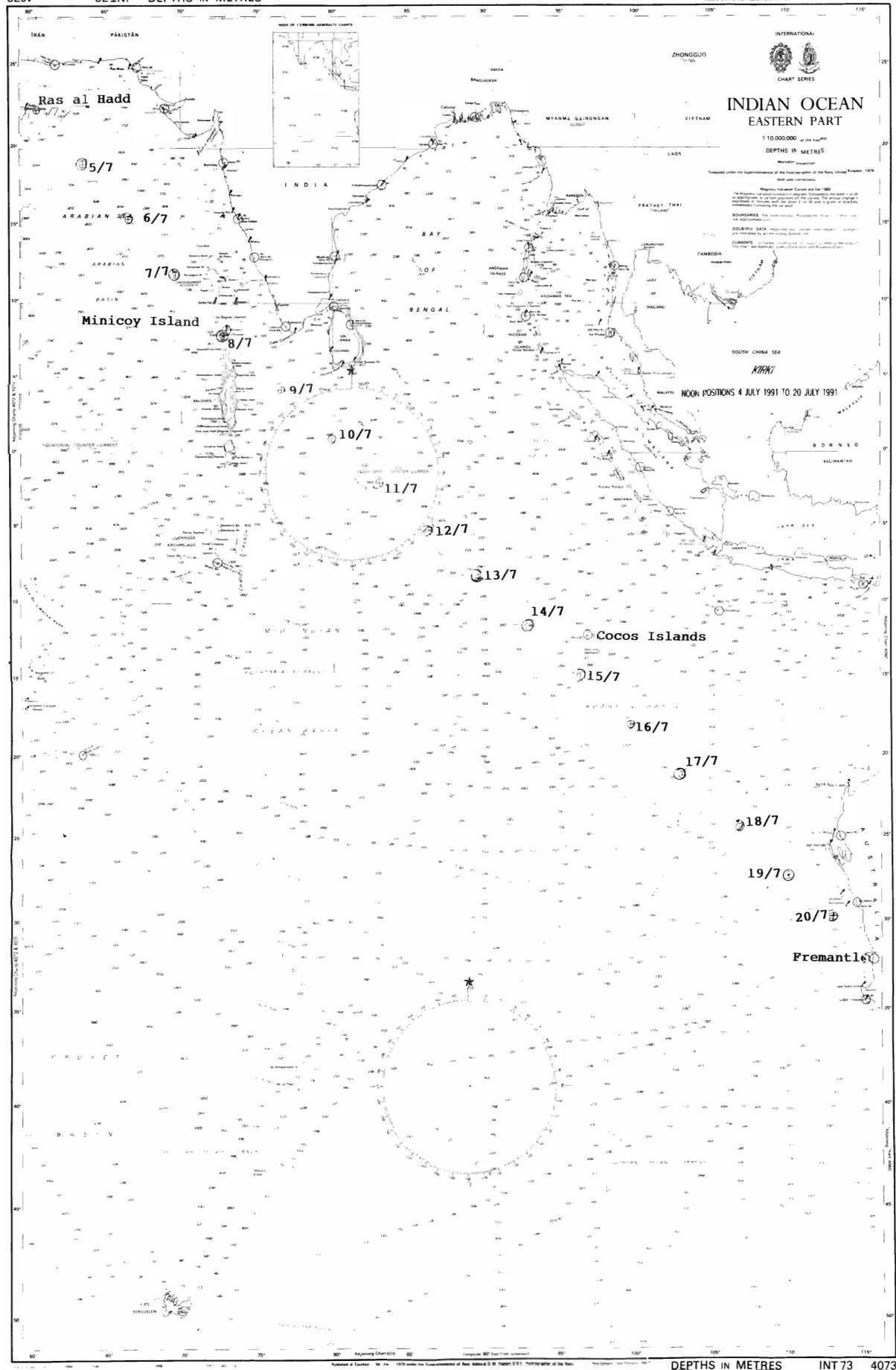
Of the other officers, the two Second Mates and the Second Engineer had spent limited time aboard the vessel.

Typically, it would seem that the crew served on board for between four and six months. With the exception of the Chief Engineer, none had served routinely on the vessel.

Mayamar Marine stated that the company had adopted a policy of sending a maintenance team to its vessels, particularly those trading to the Persian Gulf in summer, to undertake maintenance work. A team of five fitters was to join the ship in Kwinana for the return ballast voyage, to replace foundation supports of the pipelines on deck and to repair leaking heating coils and various pipes in the engine room.

Chart 1 - Route followed

4073 DEPTHS IN METRES INT 73



DESCRIPTION AND ANALYSIS

SECTION 5

The voyage to Australia (30 June to 1800 20 July)

On 9 June 1991, the Kirki arrived off Fujairah, on the east (Gulf of Oman) coast of the United Arab Emirates, from Yanbu on the Red Sea coast of Saudi Arabia, with a cargo of fuel oil. After completing a ship-to-ship transfer of the cargo between 9 and 13 June, the ship remained anchored off Fujairah until 28 June 1991. No record of any work or maintenance carried out between 13 and 28 June was entered into the bridge or engine room log books. However, all cargo tanks, except No 6 wing slop tanks, were water washed while at Fujairah and, according to the vessels Oil Record book, the slops were transferred to the lightering tanker on 25 June. Ballast was also taken on board into the fore-peak, No 3 wing and No 3 centre tanks. The ballast in the fore-peak was not pressed up, but, as was apparently normal practice on the ship, filled to within a few metres of the forecastle space deck.

On 28 June the Kirki proceeded to Jebel Dhanna on the north-west coast (Arabian Gulf) of the United Arab Emirates, to load a cargo of Abu Dhabi Land Export crude, a light crude oil, for the British Petroleum refinery, Kwinana, Western Australia.

The ship arrived at Jebel Dhanna at 0001 (local time) 30 June with all cargo tanks stated to be under inert gas pressure. Ballast was carried in the fore-peak, No 3 wing dedicated ballast tanks and No 3 centre cargo tank. Loading began after the discharge of ballast from No 3 centre and after the tanks had been inspected and passed to receive cargo by an independent surveyor, acting for the cargo interests. The cargo loaded had a specific gravity of 0.8274 at 15^o Celsius, in a temperature range of 42^o to 45^o Celsius, at an average loading rate of approximately 4160 tonnes an hour. A number of the ship's Whessoe gauges, for measuring the level of oil in the tanks, had not been operational for some time, and throughout loading operations, tanks were ullaged by portable sonic tapes (transferred from tank to tank to the appropriate metering/sampling point). The vessel completed loading at 1917 local time on 1 July.

According to the Bill of Lading the vessel sailed with 82,665 tonnes (629,689 US Barrels at 60^o (F)) of crude oil, 2770 tonnes of fuel oil and 330 tonnes of diesel oil. According to the independent surveyor, No 3 wings and the fore-peak were empty of ballast. However, according to the Chief Mate's records, 200 tonnes of

ballast remained in the fore-peak. Approximately 250 tonnes of ballast was retained in the after-peak.

The weather throughout the loading operation had been good with calm to light wind, slight seas and a swell of less than 0.6m.

At 2140 local time, 1 July 1991, the ship sailed for Kwinana via Fujairah, where five crew left the ship and eight, including Mr Haviaris (one of the two second mate's) joined. The vessel sailed from Fujairah in the forenoon of 3 July 1991, with 37 crew, including two wives, and 11 deck ratings, rather than the more usual complement of seven or eight ratings.

A voyage plan was prepared by one of the second mates and signed by the Master. The Master stated that the charter party required a passage speed of 12 knots "subject to weather" and he ordered between 95 and 100 revolutions per minute (rpm). This was calculated to give a speed of 12 knots and a voyage of 17.9 days, to Kwinana. The engine-room log book shows that the engine control lever was set at 5.8 giving approximately 95rpm. The estimated time of arrival (ETA) at Kwinana was given as 19 July. Throughout the voyage, until approximately 2000 20 July, an average of just under 96rpm was maintained.

In the Gulf of Oman the weather was fair, with winds recorded in the deck log book as north-east force 3. The Kirki passed Ras Al Hadd at about 0830 on 4 July and from a position logged as 23° 00' N, 60° 00' E a rhumb line course of 140°(T) was set for Minicoy Island. Off Ras Al Hadd, the vessel lost the protection of the Arabian Peninsula and came under the influence of the south-west monsoon. Four days later, at 0830 on 8 July, approximately 20 miles south-west of Minicoy Island, in position 08° 00' N, 072° 50' E, the course was altered to 135°(T), the rhumb line course for the pilot station off Rottnest Island, Western Australia.

According to the ship's deck log book and noon position reports, from the late morning of 4 July to some time in the morning of 6 July, the ship experienced force 7 to 8 winds from the south-east. The sea conditions were recorded as stormy, with very rough, heavy seas. However, the swell conditions were not specifically recorded. The vessel was noted as rolling, with water being shipped and breaking on deck. The weather forecasts issued from Bombay for that period were for winds of 35 to 40 knots from the south-west with swell heights of between 12 feet (3.7m) and 14 feet (4.3m). Thereafter the weather conditions slowly moderated, and from late on 6 July the winds were logged as force 5 or less until 13 July. From 13 July until the early morning of 19 July, south-east winds, force 5 or 6 were recorded.

The ship's average speed between 4 and 6 July was approximately 10.8 knots. Thereafter, from noon 6 July to noon 18 July, the daily average speed varied from a maximum of 12.87 knots to a minimum of 11.25 knots, with an overall average of 11.58 knots.

On 11 July, with a noon position of 02° 00'S 083° 06'E, the vessel entered the Australian Ship Reporting (AUSREP) area, the area for which the Australian Maritime Safety Authority's (AMSA) Maritime Rescue Coordination Centre (MRCC) is responsible for coordinating search and rescue operations. From 11 July the Kirki reported daily under the voluntary AUSREP system to MRCC.

On 17 July the Master advised the Kirki's Australian agents of an amended ETA of 2300 on 20 July 1991, a message which was repeated on 18 July.

From the morning of 19 July, when the Kirki was about 200 miles west of Shark Bay, the wind strength increased to force 7 under the influence of a low-pressure cell centred over Carnarvon, Western Australia, which moved slowly south-east, parallel to the Kirki's course, over the next day. The bridge log book contains no reference to swell height, or the movement of the vessel. The ETA was further amended to 0100 on 21 July, because of bad weather.

During the night of 19-20 July the ship's clocks were adjusted to Western Australian Standard Time, Universal Coordinated Time (UTC) + 8.

At noon on 20 July in position 30° 28'S 112° 58'E, the Kirki was approximately 65 miles south-west of the Abrolhos Islands, 200 miles from the pilot station and 100 miles from the nearest point on the Australian mainland. While the propeller speed remained at 95rpm the ship's speed had reduced to 10 knots in the prevailing wind, sea and swell conditions. The two second mates adopted a six-hours-on, six-hours-off watch routine before arriving at the discharge port. The wind force increased during the afternoon, but otherwise the ship's routine was followed normally and nothing out of the ordinary was noted. BP was advised of an amended ETA of 0900 on 21 July, due to bad weather.

Comment

The investigation's examination of the circumstances of the voyage sought to establish whether, either before or during the voyage, there were:

- Any indications, that should have been observed by the crew, of a structural fault in the forecastle area
- Any other factors which might have contributed to the structural failure.

Issues which are relevant to such consideration are:

- (i) The observed condition of the forecastle area
- (ii) The loading operation
- (iii) The weather conditions on passage.

In addition, having regard for the considerable public speculation at the time of the incident, the Inspector considers it appropriate to make some brief comment about the Kirki's route to Kwinana.

(i) The observed condition of the forecastle area

Mayamar Marine Enterprises own a subsidiary company situated in Fujairah, United Arab Emirates, Fujairah Marine Services, with premises and workshops in the port area, staffed by experienced ex seafarers, and fitters, welders and machinists. Fujairah was used by Mayamar Marine Enterprises as a convenient base. Survey documents show that considerable work was carried out there from time to time. Some routine maintenance work was undertaken on board the Kirki while at anchor off Fujairah between 9 and 28 June.

From the loading survey of 1 July, it is known that the main cargo tanks were water washed at Fujairah, following discharge of cargo in ship-to-ship transfer operations, and that the ship was ballasted. According to the stencilled notice on the inert gas deck water seal, it had been opened up and washed out. According to the owners, other routine maintenance was carried out, but of no relevance to the casualty. This maintenance included an inspection of the life saving appliances by the Second Officer.

The owners confirmed that nobody entered the fore-peak tank during this time and no internal examination could have been made while the space was ballasted. It would have contained water ballast for the greater part of the time at Fujairah and, for the time it was empty, it would not be usual for the ship's staff to undertake an internal inspection of the space, unless given special cause to do so.

According to the Master and other senior officers, inspections of the ship by ship's staff were carried out periodically. These were usually undertaken on an ad hoc basis, rather than a formal collective inspection and were not recorded in the log book. The ship had been inspected on the voyage to Kwinana, and the forecastle space had been entered by senior officers. According to the owners, inspections were carried out every eight to ten weeks by engineer superintendents.

According to the senior officers interviewed, there was nothing to suggest to them that the structure might have been flawed.

It cannot be determined from any documents whether any of the ballast spaces, particularly the fore-peak, were making water during the voyage. It was apparently not the practice aboard the Kirki to keep a written record of soundings of tanks forward of the engine room, although it may be considered normal practice on most ships. According to the pumpman, soundings of the fore-peak tank were taken daily and, other than residual ballast water amounting to 3 or 4cm, the tank remained "dry" throughout the voyage. He made no report of an increase in water to either the Chief Mate to whom he normally reported, or the Master.

From the engine room "working" log book, it has been established that the ballast pump was operated for periods during the voyage, on 7 July (2 hours), 12 July (3 hours 10 minutes), 15 July (2 hours

40 minutes), 18 July (3 hours 5 minutes) and on 20 July between 0840 and 1355 (4 hours 40 minutes). According to the Chief Engineer the ballast pump was run on these occasions to assist in testing the turbo charger of the B and W Holeby generator, which was under repair during the voyage. The log book records that the generator was also in operation at these times. There was no corresponding entry in the deck log book to suggest any other reason for the pump's operation. Ballast had been discharged at the loading port, and from engine room soundings (the only records of soundings that were made), the after-peak maintained a constant level of water.

Throughout the voyage up until the evening of 20 July, the engine revolutions, the fuel gauge readings and engine cylinder temperatures were relatively constant, indicating that no extra load was placed on the vessel by being trimmed by the bow. It may be concluded that the ship's staff were not aware of any significant structural defect in the forecastle area.

(ii) Cargo loading operations

The investigation also sought to establish whether or not any factor in the loading of the ship at Jebel Dhanna might have contributed to the loss of the bow section.

The loading operation at Jebel Dhanna appeared to have been routine and without incident. The loading rate seems to have been well within normal limits, as was the loading temperature of the cargo.

The weather and sea conditions throughout the loading operation were good.

There is no evidence that the loading operation at Jebel Dhanna contributed in any way to the incident.

(iii) Weather conditions on passage

During the voyage through the North Indian Ocean the officers, in entering the wind direction in the log book, consistently noted the wind at south-easterly, rather than the anticipated south-west direction. Otherwise the weather experienced by the Kirki was typical of weather for July in the Arabian Sea and Indian Ocean. July is the peak of the south-west monsoon season and coincides with the depth of winter in the southern hemisphere.

In the Southern Indian Ocean swells are generated by low pressure systems in the southern part of the area. North of 20°S the swell is typically moderate from the south-east or south, increasing to moderate to heavy from the south to south-west, south of the 20°S parallel of latitude.

The log-book entries after midnight 7 July refer only to choppy seas and give no indication of the ship labouring in heavy swell conditions. It would seem that an engine speed of 95rpm was maintained throughout the gales of 4 to 6 July, and thereafter there is nothing in the log book to suggest the vessel was unduly stressed by weather.

An analysis of the actual weather in the area through which the Kirki passed between 0800 on 19 July and 0800 on 22 July, commissioned from the Bureau of Meteorology, Perth, (Attachment 1) indicates that the ship would have experienced south to south-westerly winds, between 20 and 30 knots, with average sea and swell height of 2 to 5m, with the expectation of individual waves to 13m. The bridge log book entries for 19 and 20 July refer to overcast skies, very strong winds and rough seas breaking on deck, but do not refer to the rolling or pitching of the vessel. The Master and all crew interviewed rated the weather between 17 and 21 July as "bad". It is reasonable to assume that the vessel had been experiencing considerable ship motions, including pitching heavily, in the conditions of 4 to 6 July and 19 to 20 July. However, the Master did not order any reduction in revolutions from the 95rpm originally set until about 2000 on 20 July.

It is concluded that any stress to the ship's hull caused by maintaining propeller revolutions at 95rpm through the gales of 4 to 6 July and in the sea conditions of 18 to 20 July, was to an area already weakened structurally (see section 8). It would have been prudent for the Master to reduce the revolutions in such weather.

(iv) The ship's route

After the incident on 21 July, reports of possible sightings of the Kirki, off Shark Bay and off Geraldton, in the days preceding the casualty were received from members of the public by the Department of Marine and Harbours, Western Australia. To be in the positions reported, the Kirki would have been required to have made good an average speed of approximately 12.5 knots for the voyage.

As a result of interviewing the crew of a yacht, who reported a possible sighting north of Geraldton, the vessel observed was later positively identified as a dry bulk carrier. Other ships (that were sighted) were too distant for accurate descriptions, but ships known to be in the area of the reported sightings included bulk carriers and an Australian tanker en route from the North-West Shelf, all of which had accommodation aft, similar to the Kirki.

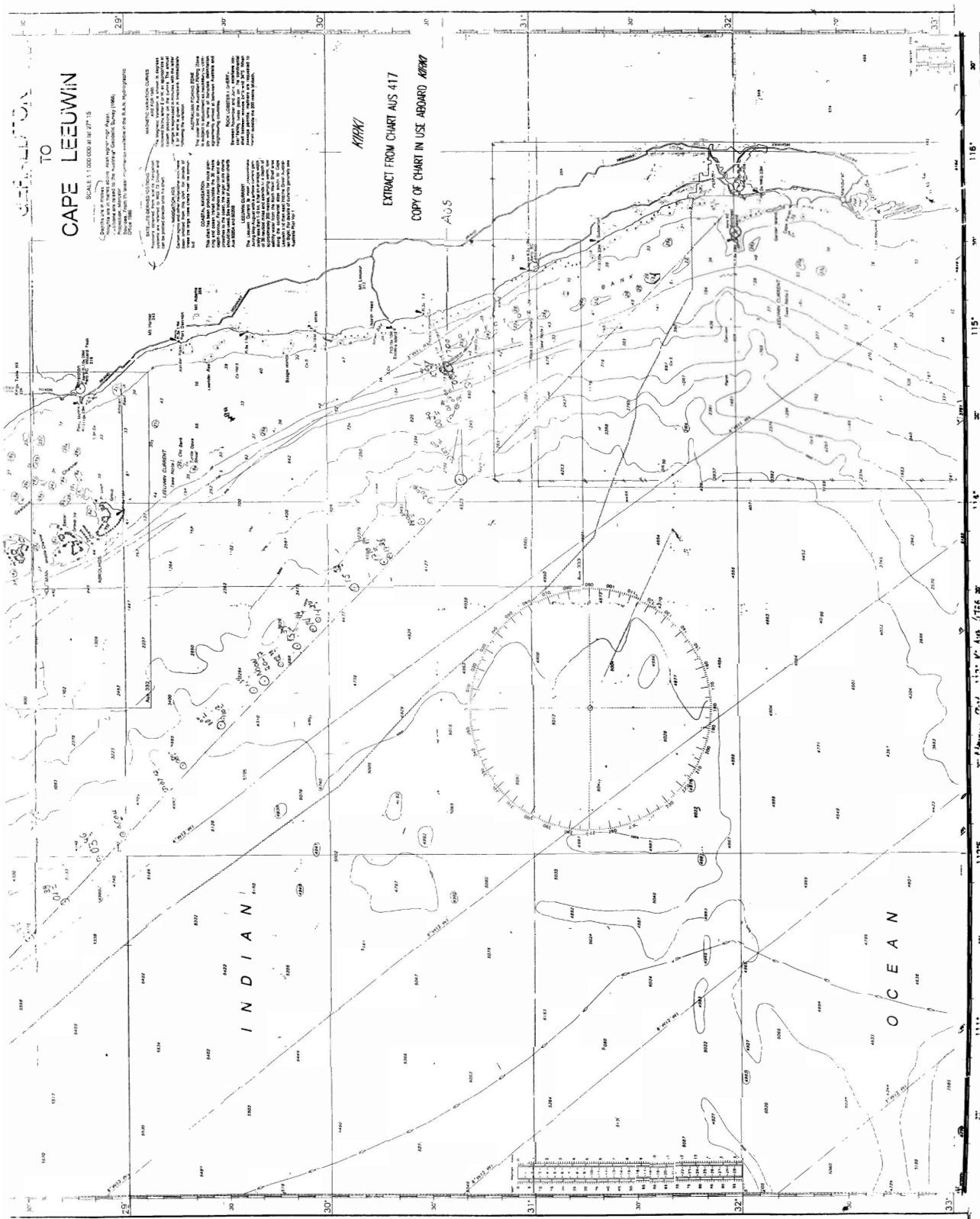
Further, in establishing the Kirki's route to Kwinana, the vessel's deck and engine room records were carefully examined. Among other navigation equipment the Kirki was equipped with a satellite navigator, and it is company policy that a ship's position be recorded in a "Satellite Navigator" log book at each pass of a satellite. This log book had been maintained by the various officers throughout the voyage and the positions recorded

(an average of 16 positions a day) are consistent with the deck log book, charted positions, and the engine setting and daily engine revolutions shown in the engine room log book.

The Kirki had also reported daily to MRCC since 11 July and all the positions given in the AUSREP reports were consistent with the ship's records.

The evidence, therefore, clearly suggests that, after clearing Ras Al Hadd on 4 July, the Kirki sailed a direct rhumb line to Minicoy and then towards Rottneest Island. The possibility of any of the reported vessels being the Kirki can be discounted.

Chart 2 - Part of chart in use aboard Kirki



SECTION 6

The events leading to evacuation and salvage

(1800 20 July to 1700 21 July)

At 1800 on 20 July 1991, Mr Haviaris, Second Mate, took over responsibility for the watch. He stated that the weather was very bad, with Beaufort force 8 winds.

At 1908 the ship's position was recorded as 30° 27.85'S 113° 53.3'E, making good a course of 135° true at a speed of 8.1 knots. The engine revolutions remained at about 95rpm. At about this time the Master telephoned Captain Chandras, a Port Captain from Mayamar Marine Enterprises, who had arrived in Fremantle and was to meet the ship in Kwinana.

According to the Chief Engineer, at about 1920, the Third Engineer in charge of the 1600 to 2000 engine room watch noted that the fuel load indicator gauge reading on the main engine had risen from a reading of 5.8 to 6.5, indicating that the engine was under heavy load. The Chief Engineer was called to the engine room where he checked the engine to ensure that all the cylinders were working correctly. When it was established that the engine and auxiliary machinery were apparently functioning normally he left the engine room and went to the poop deck, where he realised that the vessel was trimmed noticeably by the bow. He then went to the smoke room and reported to the Captain, before returning to the engine room to await further developments; the time was about 2000.

According to the deck log book, at 2000 the ship was steering 148° gyro, to make good 135° true. The wind was recorded as force 7 (28-33 knots), with overcast skies and passing rain squalls; the sea was rough and breaking on deck.

At about 2000 the Master instructed the Chief Mate to check the bow space. The Kirki was shipping heavy seas over the main deck, and it was necessary to reduce speed from 95 rpm to 60 rpm and alter course to approximately 090°(T), to facilitate safe access along the deck to the forecastle, to allow the inspection to be made. The Master stated that the vessel was extremely sluggish and took some 20 minutes to alter course 45 degrees.

The Chief Mate, Pumpman, Boatswain, Mr Mendrinos (the 12-4 Second Mate) and an apprentice were able to reach the forecastle space to inspect the fore-peak tank at about 2030. As the weather-tight doors to the forecastle were opened, a rush of air came from the space. The group forward was joined by the Chief Engineer, who stated that he could hear air through the vents and there was a wind generated inside the forecastle as the ship

rolled and pitched. It was quickly established that the fore-peak contained water to about sea level and the Master was informed.

The Chief Engineer returned to the engine room and the Master directed that the engine revolutions be reduced from 60 to between 55 and 50rpm. The Captain instructed the Chief Mate to pump the fore-peak space with the ballast pump. The ballast line was set and, at a time logged in the engine room "working log" as 2155, the ballast pump was brought into operation.

At 2147 the Master attempted to place a radiotelephone call with the Port Captain at his hotel in Fremantle, but the number did not answer. At 2158 (1358 UTC or 1558 Athens time) a radiotelephone call was placed to Athens to one of Mayamar Marine engineer superintendents.

At 2220 the last entry was made in the Satellite Navigator log book in position 30° 36'S 114° 15'E.

At 2232 the Master placed another radiotelephone call to the Port Captain in Fremantle and apparently explained the situation and gave the ship's position. According to Mayamar Marine Enterprises' records, the Master made contact with his owners at 2317 (1517 UTC, 1717 Athens Time). Between then and 0215 the Master made a further three radiotelephone calls: two to the Port Captain in Fremantle (0105 and 0142 21 July); and one to Singapore (0200 21 July), to the Company's port Captain based in the port.

At 0020 21 July the Kirki's position was plotted on the ship's chart as 30° 37'S 114° 28'E. While the Master had ordered minimum engine revolutions, consistent with maintaining steerage, the engine-room log book records that the engine turned 18,740 revolutions between 2000 and 2400 20 July, an average of 78rpm. In any event from the positions plotted on the chart it can be established that a forward speed of approximately 6 knots was maintained from 2220 to 0020 and a little over 2 knots from 0020 to 0206.

The level of water in the fore-peak tank remained constant and, with the ballast pump operating to full capacity, it became apparent that the fore-peak was open to the sea. The Master ordered the minimum revolutions to maintain steerage way and steered a general course of 110°(T).

To try and reduce the trim by the bow it was decided to transfer cargo from No 1 tanks to cargo tanks with sufficient ullage further aft, using the steam stripping pump in the after pumproom for this purpose. No record was made of the time this operation began, but according to the Second Mate it was before midnight and it lasted for about 45 minutes; the Pumpman recollected that the pump ran to approximately 0200.

A little after 0200 on 21 July, the Master, Chief Engineer, Second Mate and two deck ratings were on the bridge looking forward. The weather was severe with force 8 or more winds and a long, heavy swell. The Kirki's speed had dropped to less than 3 knots on a course of approximately 110°(T). The sky was cloudy to overcast, the ship was yawing wildly and rolling heavily with water breaking over the deck.

At a time put at 0220, when 25 miles from the nearest land, with the ship in approximate position 30° 39.5'S 114° 37'E, those on the bridge said they saw the foremast light apparently bend towards the bridge and then regain its vertical position. This was repeated and on a third occasion the foremast and forecastle head were seen to disappear into the sea. Almost simultaneously an intense fire broke out from the forward section.

The Captain ordered the engines to be stopped, the general alarm to be sounded and for all crew to muster on the leeward side of the accommodation. The port-side lifeboat and liferaft were made ready for abandoning ship and embarkation ladders rigged over the port side. At a time put at about 0230 by the Second Engineer, the engine room general-service pump was started to supply sea water to the fire main system. The Chief Engineer ordered that the power supplies to the forecastle should be isolated.

The Master also ordered the transmission of the distress call "MAYDAY". The Second Mate broadcast a "MAYDAY" call on Channel 16 VHF giving the ship's name and a position as 30° 41'S 114° 28'E, and stating that the ship was on fire. No response was heard and the Master ordered the Radio Officer to send a distress message from the ship's main radio station.

The crew of the Kirki did not prepare any portable fire-fighting equipment but prepared and relied on the main fire cannons for protection. The initial fire was extinguished, apparently by the action of the sea. According to all those interviewed, this was followed by a further outbreak of fire when oil from the forward end of No 1 cargo tanks re-ignited; that too was extinguished without intervention by the ship's crew.

At 0302 the Radio Officer transmitted a "MAYDAY" message followed by the automatic two-tone alarm signal and a repeat of the "MAYDAY" call by medium-frequency radiotelephone on 2182 kHz. The Radio Officer did not send the ship's position or indicate the nature of the emergency. The call was received by Perth Marine Communication Station (Perth Radio) and other Marine Communications Stations at Sydney, Townsville, Darwin and Singapore. None of these stations was able to establish contact with the Kirki.

The operators at Perth Radio recalled the radiotelephone connections to the Port Captain in Fremantle and contacted Captain Chandras, who was able to confirm that the ship had

reported being in heavy weather and was able to give an approximate position. Perth Radio alerted the Maritime Rescue Coordination Centre (MRCC), the organisation in Canberra operated by the Australian Maritime Safety Authority (AMSA), responsible for maritime search and rescue. Arrangements were made through the Civil Aviation Authority's Perth Rescue Coordination Centre, to initiate rescue by helicopter.

At 0320 the Radio Officer transmitted a general distress call to all stations by Morse Code on 500kHz, giving the ship's position as 30° 41' (S) 114° 40' (E), reporting that the vessel had a fire in the fore-peak and requesting helicopters be sent to his position. At 0335 Perth Radio attempted to contact the Kirki by radio telegraphy on 500 kHz. The Kirki did not reply immediately, but called on 500 kHz at 0340 giving an amended position of 30° 36'S 114° 28'E.

At 0330 the ship was stopped, lying headed in a south-easterly direction with the wind on the starboard side. The sky was overcast and the conditions were pitch black. The ship was rolling heavily in the gale-force winds and heavy seas, the swell and waves at times appeared to be higher than the deck.

At about that time the fire again erupted forward. On this occasion the fire ignited oil that had spread on the sea surface, down the windward side of the ship, past the cargo pipe manifold and threatened the accommodation area. The starboard side water cannon was used to try and create a water curtain to protect the after cargo deck and accommodation areas. A number of the crew stated that there appeared a very real danger that the sea and its surface of burning oil would break across the deck, putting at risk the after cargo tanks and accommodation.

At 0338 the Western Australian Marine Emergency Operations Centre was alerted to the incident by the Western Australian Police. The officer on duty established that the MRCC had coordination of the incident, called in the crew of the Department of Marine and Harbour's vessel Vigilant and alerted senior officers.

At about 0350 a commercial Boeing 747 airliner, Qantas QF8, en route from Learmonth to Perth, which had earlier been diverted to the area by the Civil Aviation Authority (CAA) Perth Rescue Coordination Centre, overflew the casualty. The pilot reported that the area was covered by fog, but the fire showed through to the point that he advised the CAA that it was a major fire and it appeared that "the ship would be destroyed". The pilot fixed the ship's position as 30° 35.1'S, 114° 40.9'E and the aircraft continued its flight to Perth. This fire also went out without intervention of those aboard.

At some time during the hours of darkness the Master ordered the crew to abandon the ship by the port lifeboat. It was stated that the lifeboat was lowered to near the water, but the waves and swell

made it impossible to launch the boat. The boat was hoisted back to the embarkation deck. With the rolling of the ship, the lifeboat, while being lowered and hoisted, swung heavily against the hull a number of times, slightly injuring one of the wives. In hoisting the boat, the wire falls became twisted and the life boat ladder became entangled in the boat.

A fourth, less intense, fire broke out which was also extinguished by the wave action.

At 0410, the Lady Kathleen, an off-shore support vessel on stand-by and anti-pollution duties, attending the drilling rig Southern Cross off Rottness Island, was alerted to the casualty by a MAYDAY relay from MRCC. At 0440 the Lady Kathleen's Master, having discussed the situation with the Marine Emergency Operations Centre, set course for the casualty some 92 miles to the north. At 0445 the Vigilant sailed from Fremantle for the Kirki's position.

At sometime between 0430 and 0500 the Kirki's Master said he had become concerned at the proximity of the land and shoal water about 18 miles to the east. With the Chief Engineer in the engine room, the engines were put astern to see if the stern would come up into the wind and the ship could at least be held off the coast until help arrived. Almost immediately, on putting the engines astern, a further fire broke out forward and the engines were stopped. This fire also went out after a short period.

Although a distress message had been sent by radiotelegraphy (Morse Code) at 0335, this was a general call to all stations, ship and shore, within range. The Kirki did not respond to voice communications until 0515, when Perth Radio made contact on 4125 kHz and the arrival of the helicopters was discussed, their carrying capacity and whether they would be able to land on deck or be required to winch crew from the ship. At that time Perth Radio was unaware that the helicopters were restricted from taking off by fog and reassured the Master that they would be at the ship "very soon".

At approximately 0530 the Master asked if a salvage tug was on its way to his ship. Perth Radio confirmed that the Lady Kathleen was on its way to the casualty, with an ETA of about 1100. At 0537 the Lady Kathleen made voice contact with the Kirki and attempted to explain the situation and to reassure Captain Efstathopolous that help was being mobilised.

At 0545 the Kirki's Master made a nine minute telephone call to the company's offices in Piraeus, this was followed by two further calls at 0620 (9 minutes) and 0640 (4 minutes) to the same number.

At 0601 Perth Radio informed the Kirki that the helicopters were delayed by fog, a message which the ship had difficulty in understanding.

At 0603 Captain Farstad, the Master of the Lady Kathleen, called the Kirki clarifying the situation regarding the helicopters and assuring Captain Efstathopolous that "we will be able to pick up people either from the water or will work out something ...we will be able to help you, assist you, to get people off the ship, if the helicopter hasn't arrived by then". Captain Farstad emphasised that once the helicopters had arrived they would be able to "shift you to shore pretty quickly".

Captain Farstad asked whether the fire was still burning, but the Kirki seemed not to have understood the message.

At 0635, MRCC established direct communications with the Kirki. The Master informed the Centre that the helicopter would be unable to land on the vessel. He also gave the ship's position as 30° 38.5'S 114° 41'E and that they were drifting in a north-north-easterly direction, with Thirsty Point bearing 070° by 20 miles. A further brief radiotelephone contact was made at 0705. No mention was made by the Master of the loss of the bow, or of any pollution.

The Marine Pollution Section of AMSA was alerted to the incident at 0440 (0640 EST, 2040 UTC) by MRCC. At this point AMSA's understanding of the situation was that a "MAYDAY" call had been received from a tanker and that it was on fire off Cervantes. Given the nature of the incident, under routine procedures, an officer of the section telephoned Captain K Ross, the Managing Director of United Salvage Ltd, at 0450. (United Salvage is recognised as the only Australian salvage company with the resources to undertake a major salvage operation at short notice.)

Captain Ross immediately made contact with the ship's leading insurance underwriters and owners' representatives through United Salvage's London agent. By 0615 WST on 21 July the owners and underwriters had agreed to the terms of Lloyd's Standard Form of Salvage Agreement 1990 (Lloyd's Open Form 1990) with United Salvage.

At 0700 Perth Radio queried the status of the ship and it was confirmed that the fire had been extinguished. No mention was made of pollution or the fact that the bow had broken away. Perth Radio passed this information to MRCC, which was the overall coordinator for search and rescue, stating that there was no further information and that the ship had requested a second helicopter.

At 0650 the first of two helicopters, an RAAF/Bristow helicopter, arrived at the Kirki. It was not possible for the helicopter to land on the vessel and, after a reconnaissance, the first crew members were winched from the after end at 0713. The winching operation was assisted by the Chief Engineer, Mr Bijarakis, who had experience in helicopter-transfer operations and instructed the crew in the use of the harness. At this time a police fixed-wing aircraft took off from Jandakot airport with droppable life-saving appliances in case such

equipment should be required. At 0719 the second helicopter, operated by the Western Australian Police Airwing, was overhead and further crew members were winched to safety. The evacuated crew were taken to the towns of Jurien Bay and Cervantes. The helicopters maintained a shuttle service, subject to fuel availability, until all the crew were evacuated.

At about 0815 United Salvage and Australian Offshore Services, the operators of the Lady Kathleen, agreed that the vessel should be contracted to United Salvage on an International Salvage Union subcontract. Captain Farstad was informed of the contractual arrangements by radio telephone at about 0830. A number of contacts were made between United Salvage and Captain Farstad regarding towing the vessel away from the coast and the use of dispersant. However, no plans could be finalised until the Lady Kathleen had arrived at the casualty and Captain Farstad had assessed the situation.

At 0817 MRCC received the first report that the bow had broken off. This was reported by a helicopter pilot through the CAA, Perth.

At some time during the morning, Captain Chandras went to the Marine Emergency Operations Centre, Fremantle, and spoke to the staff, including Captain Purkiss of the State Committee of the National Plan to Combat Pollution of the Sea by Oil. Captain Chandras informed the State Committee of the situation, including the fact that the bow had broken away and oil was leaking to the sea. The owners submit that Captain Chandras went to the Fremantle Centre at 0400, this is supported by the ship's agent. However according to Captain Purkiss, he (Purkiss) did not arrive at the centre until 0600, when he immediately met with others of the State Committee.

At approximately 0900 Perth Radio informed the Kirki that MRCC wanted to speak to the vessel's Master. While Perth Radio's log entries show that the Kirki changed to channel 404 to talk to MRCC, there is no record of the call actually connecting from either MRCC, OTC or Kirki records.

At 0908 MRCC sent a telex to Perth radio requesting that answers to the following six questions be obtained:

- A How many crew left on board vessel?
- B Please advise damage to vessel
- C Advise list and trim of vessel
- D What is extent of pollution - how many tanks ruptured?
- E What are the Masters intentions - is he going to abandon the vessel?
- F Please advise direction of oil slick
- D Any further details?

This message was relayed by Perth Radio at 0930. The Kirki's master replied by telex to the questions direct to MRCC at 1009 reporting:

- A 24
 - B cracked fore-peak
 - C N/A
 - D 500m - one tank No1 STBD
 - E No
 - F 140 degrees
 - D Nil
- Master M/T Kirki

At about 0945, at a time when four crew members were being evacuated from the stern of the ship by the police helicopter, a media helicopter flew close to the exposed bulkhead of No 1 cargo tanks and a sixth fire erupted. This was of relatively short duration and was reported by one of the rescue helicopters as being out at 1004. This fire illustrated the potential danger and the severity of the previous outbreaks, especially the major fire at about 0330.

The Kirki's crew had left two mooring lines over the stern, one from each quarter. Because of the rate of drift of the ship both these lines were lying close to and down the starboard (windward) side of the tanker, with the port quarter rope apparently fouling the top of the rudder. Also Captain Ross, of United Salvage, requested the owners, through their London agents and also through Captain Farstad, to leave one pilot ladder rigged on each side of the ship. It is not clear whether this message was received by the Kirki's Master.

At 1040 the Lady Kathleen arrived at the Kirki. Contact by VHF radio had been established between the Kirki, the Lady Kathleen and the Vigilant, which was about 40 minutes astern of the Lady Kathleen. The wind remained fresh to strong with a pronounced swell and rough sea.

Soon after the Lady Kathleen's arrival Captain Efstathopolous asked Captain Farstad whether or not he would come alongside the Kirki to pick up the remaining crew. Captain Farstad considered that, given the sea conditions, such a manoeuvre would have been most hazardous. As the Kirki's crew was relatively safe, he judged that it was better to wait until the helicopters returned. The only alternative, in his view, was for the crew to jump into the sea and be picked up by the Vigilant, which had a lower freeboard. The Master of the Vigilant, Lawrence Chapman, advised against such a method of escape unless in an extreme emergency.

By 1050, 29 of the crew had been evacuated leaving the Master and seven of the crew aboard. By this time both helicopters had exhausted their fuel supplies and the transfer of the crew to the shore was suspended until new fuel supplies arrived.

Captain Farstad assessed the situation and recorded the ship's draught as 49 feet at the stern (14.935m) with a 3° list to starboard. He estimated that the Kirki was drifting at the rate of about 1 knot to the north-east. This information was passed to MRCC at 1130, however, the angle of list was passed on as 10°.

Captain Efstathopolous asked whether the Lady Kathleen would be manoeuvred alongside the vessel to pick up the two mooring lines and take the Kirki in tow. Captain Farstad considered that the sea conditions were such that it would have been hazardous for the Lady Kathleen's crew to work on the exposed deck to clear pollution equipment and prepare the towing gear. Captain Efstathopolous then repeated the request that the Lady Kathleen should be put alongside to take off the remaining crew. Captain Farstad again advised the Master to await the return of the rescue helicopters.

At about 1130 Captain Farstad requested Mr Chapman to stand-by the Kirki with the Vigilant. The Vigilant took up a position about 500m from the Kirki's stern. Captain Farstad headed the Lady Kathleen into the wind and sea to allow access to the working deck, so that the anti-pollution equipment, which was welded to the deck, could be burnt off. Before the Lady Kathleen's working deck could be cleared, the helicopters returned to the casualty at 1150.

Attempts were made by those remaining on board to contact the media helicopters on channel 16, asking them to come to the ship and lift them off. There was some concern and anger that they did not receive any reply. The officers involved failed to appreciate that the helicopters were not equipped with marine-band VHF.

At 1156 the remaining crew, consisting of the Radio Officer, deck and engine-room officers and the Master, were evacuated. There was therefore nobody left on board the Kirki to pass a line or to secure a tow. At the time of the evacuation the ship's boiler had been closed down and the fires drawn. The B and W Holeby electrical generator was left running on fuel oil together with an associated lubricating oil purifier.

At 1250, with the pollution combat equipment restowed and the weather moderating, Captain Farstad backed the Lady Kathleen up to the starboard side of the vessel. Despite severe back wash from the swell deflecting from the side of the Kirki, the crew on deck were able to secure the starboard quarter rope. An attempt to secure the port quarter rope, which was lying alongside the ship, was unsuccessful. The weight of the tanker was taken on the single mooring rope; but at 1305 the line parted.

With further moderation in the weather conditions the Masters of the Lady Kathleen and Vigilant discussed the possibility of putting the Lady Kathleen alongside the main deck on the leeward side and putting some of the Lady Kathleen's crew aboard to take lines to secure a tow.

At 1350 the Lady Kathleen was manoeuvred alongside and three crew members were able to jump across to the main deck. They took a messenger rope, which they passed to the after end of the ship. This was passed around a suitable pair of mooring bitts and the end returned to the Lady Kathleen. Using the Lady Kathleen's winch a more substantial messenger was passed to the ship, around the bitts and back to the Lady Kathleen, after which the towing array was passed and secured on the ship at 1430.

At 1500, with Thirsty Point due East at a distance of 10 miles, the towing wire was streamed and the Lady Kathleen began to tow the Kirki, stern first, out to sea from a position $30^{\circ} 30.5'S$ $114^{\circ} 52'E$. The Kirki had drifted approximately 12 miles in an east-north-east direction, the wind drift possibly being modified by the south-going Leeuwin Current. However, by 1500 on 21 July the Kirki was probably on the eastern edge of the current where it had minimal strength. The tow began at a point where the Kirki was eight miles from shoal water. Although the wind force moderated from about 1400 to southerly 10 knots, on 23 July the weather veered to the west and increased to near gale, to gale force.

At about 1430, Captain David Hancox, the Salvage Master from United Salvage Pty Ltd, made an aerial survey of the ship. He returned to Cervantes and reported his assessment to his principals. He also requested that some senior officers should return to the Kirki that evening. He required particularly the assistance of the Chief and Second Engineers to operate engine-room machinery. According to Captain Hancox he had the impression that, after some reassurance, the Chief Engineer, Mr Bijarakis, was inclined to agree to the request. However, Captain Efstathopoulos, who was apparently under the impression that the vessel would sink, intervened and Mr Bijarakis then declined to return. The Chief Engineer and Chief Officer provided Captain Hancox with diagrams and basic instructions on the operation of essential services and the cargo distribution. With this limited information Captain Hancox was transferred to the Kirki by helicopter and took charge of the ship at about 1700 on 21 July.

The owners submit, however, that the Master specifically asked to return to the ship but was told by Captain Hancox that he only required engineers.

The Kirki's owners, Mayamar Marine Enterprises, confirmed its agreement with United Salvage, to the terms of Lloyds Open Salvage Form, by telex on 22 July. It was formally signed by Captain Efstathopolous at 1200 on 23 July 1991.

The Chief Engineer and Second Engineer returned to the ship on 23 July to assist the salvors (see page 46). Having done so, they did not remain on board but returned ashore, the Chief Engineer that evening and the Second Engineer the following morning.

Late on 27 July, United Salvage arranged for one of the two second mates and the Radio Officer to board the ship to secure valuable property and documents left behind by the crew when the ship was evacuated.

Comment

The description of the incident is based on the interview process, log books, records (including taped-voice records) and statements from others involved with the incident as it developed.

The considerations raised by the evidence relating to the period 1800 on 20 July to the evening of 21 July are:

- (i) The reliability of the description of the incident, particularly the times given
- (ii) The actions taken to protect the ship and its crew
- (iii) Measures taken to protect the environment
- (iv) The actions of the Master of the Lady Kathleen
- (v) Communications between the Kirki and Australian authorities
- (vi) The likelihood of the Kirki stranding on the Australian coast had it not been taken under tow.

(i) The reliability of the information

From about 2000 20 July, neither records nor relevant log-book entries were made on board the Kirki relating to the loss of the bow or to the fires, to allow the establishment of times of events. The only written record of any significance in any ship's document recorded after 2200 appeared in the engine room log book relating to the starting of the ballast pump and a brief note in the radio log recording the emergency message transmissions. Despite the fact that the flooding in the fore-peak was reported at about 2000 and almost six and a half hours elapsed before the bow fell off, no reference to any possible problem was recorded in either the bridge or engine room log book and no contemporaneous notes could be found.

At interview, allowing for some difficulties in translation, the Master and crew appeared to be open, frank and cooperative. However, there was some confusion as to the zone time which the ship was keeping, some of those interviewed seemed to be operating on Western Australian Standard time, which the ship had adopted at midnight on 19 July, while others including the Master, believed the zone time to be UTC +7. Other than those recorded in the engine room and radio log books, the times given are not reliable, except the time of the loss of the bow when a number of

witnesses put the time at between 0215 and 0220, based on a number of factors including a direct reading of a wrist watch.

Times relevant to the response to the incident by shore authorities have been taken from contemporaneous records.

(ii) Actions taken to protect the ship and its crew

Following the flooding of the fore-peak and then, later, following the loss of the bow section, the Master had certain responsibilities with respect to safeguarding the ship and its crew.

Action following the breach of the fore-peak tank.

With the initial breach of the fore-peak tank the Master had a duty to protect the ship and prevent further deterioration in the situation.

The Master's actions in turning the ship towards the coast, in order to place less stress upon the ship and particularly the bow area, was totally consistent with good seamanship. While, by about 2200 on 20 July, it was established that the fore-peak was open to the sea, there was, from the evidence given to the Inspector, no reason to believe that a massive structural failure and pollution would follow.

The Master had by this time slowed to the minimum speed at which steerage way could be maintained with the wind and swell direction abaft the starboard beam. But it would appear that in the conditions being experienced, the revolutions required to maintain steerage way were relatively high.

The average wind speed was 30 knots from the south with an average of 5m seas and 4 to 4.5m swells. While such weather conditions are not extreme, with the total darkness due to the overcast skies, wind gusts and occasional waves and swell well above the average, they might have seemed so. However the conditions were not so severe that the Master considered it necessary to inform MRCC of the initial flooding (communications are dealt with in (v) page 40).

Action following loss of bow section and resultant fire.

After the loss of the bow and resultant fire, the Master had a clear and paramount duty to protect the lives and safety of his crew, by organising the containment of the fire and, if necessary, by organising the safe evacuation of the ship.

The cargo carried by the Kirki was a highly volatile crude oil. It must be recognised that during the hours of darkness, in complete isolation, in the prevailing weather conditions and with the ship rolling heavily - so that at times burning oil threatened to break onto the decks to put at risk the cargo in the other tanks - the lives of the crew were in real danger and the desire to abandon the ship was overwhelming.

In the circumstances it was prudent to evacuate the majority of the crew, to minimise the number of people at risk.

No portable fire equipment such as hoses were prepared, instead the crew started the general service pump and relied upon the fixed water cannon on the poop and main deck. Access to the fire forward would have been extremely difficult and any attempt to use ship equipment to extinguish the fires from the vertical bulkhead would have been ineffectual and extremely dangerous. There was also the risk of explosion and the rupture of the main deck structure.

Source of Ignition

The Master and Chief Engineer assumed that the source of ignition for the first five fires was sparks from the mechanical action of rubbing of metal.

While it is possible that the initial fire at about 0220 was caused by sparks from the mechanical action of the bow breaking from the ship, there were, however, a number of electrical cables running along the deck supplying the forecastle lighting, the forward flood lights, the Suez Canal search-light, the forward whistle and navigation lights.

On examination of the broken ship's structure there was apparently no mechanical source of ignition at the forward end to account for the five subsequent outbreaks of fire. When examined, the broken ends of the wires were charred from external heat sources; fractures in the cable covering, about 2m from the end, showed a break down in the insulation from the inside suggesting that arcing had been taking place.

The owners consulted a fire and explosion expert, Dr J Bland. He, like the Chief Engineer, found it surprising that the sea water saturated cables should remain live and not blow the associated fuses.

Dr Bland stated that the video film did not show cables hanging down the bulkhead and that he could not see how they would cause ignition. He also stated that had the cables caused arcing there would have been globules of molten copper.

Dr Bland noted that a build up of static electricity can be caused by the sloshing action of an oily water mixture which can lead to an electrical discharge. While this is associated with the action of oily water inside a tank, he states there is a possibility of a similar mechanism outside the tank.

The Inspector accepts the possibility of a static charge being generated, however, in his opinion, the possibility of arcing from the live electric supply to the forward whistle cannot be discounted as being a source of ignition.

The Inspector accepts that the Chief engineer ordered the electrical supply to the forecastle be isolated. It would appear however that not all circuits were effectively isolated.

It is concluded that:

- The Master acted properly in putting the wind and sea on the starboard quarter, on the evening of 20 July, when it became apparent that the fore-peak tank was breached.
- The source of the ignition causing the original fire was either sparks caused by the mechanical action of the tearing of the steel work, or the arcing of broken electrical cables forward.
- The subsequent five fires were caused either by static electrical discharges or by the arcing of broken electrical cables.
- The Master acted properly and in the best interests of his crew in evacuating the bulk of the crew from the ship.

(iii) Measures taken to protect the environment

While the Master had a primary duty to safety of life, he also had a duty to protect the environment.

The discharge of oil or oily water into the sea by ships is prohibited under the International Convention for the Prevention of Pollution from Ships, 1973 as amended by the Protocol of 1978 (MARPOL 73/78), and it is a breach of the Convention to fail to report such a discharge. Discharge of oil from ships, and the failure to report any discharge in the Australian territorial sea are offences under the Protection of the Sea (Prevention of Pollution from Ships) Act 1983, which adopts MARPOL 73/78 into domestic legislation.

However, an offence is not committed when the discharge into the sea of oil or oily mixture is the result of damage to a ship or its equipment:

- "(i) Providing all reasonable precautions have been taken after the occurrence of the damage or discovery of the discharge for the purposes of preventing or minimising the discharge; and
- (ii) Except if the owner or Master acted either with intent to cause damage, or recklessly and with knowledge that damage would probably result".

The Master did not report the release of oil directly to the MRCC, but under the circumstances and having reported the fire, a possible pollution incident could be and was anticipated.

The owners submitted that Captain Chandras went to the Marine Emergency Operations Centre at 0400 on 21 July and that as soon as he arrived he informed Captain Purkiss that the bow had broken off, that oil was escaping into the sea and that there had been a fire. The ship's agent also recalled that Captain Chandras went to the Centre early, possibly at about 0400.

Captain Purkiss stated that he did not arrive at the Operations Centre until 0600 and went immediately into a meeting of the State Committee of the National Plan. The staff in the Operations Centre remember Captain Chandras arriving at some time during the morning and recall the time as between 0900 and 1000. They recall Captain Chandras telephoning Greece from the Operations Centre. He also talked to the Kirki by HF radio, as an intermediary and was able to give up-to-date information to the officers in the Operation Centre.

While it has not been possible to establish with certainty when Captain Chandras arrived at the Marine Emergency Operations Centre, by about 1000 all the essential information of the incident was known to the State Committee.

With the loss of the bow section, and the outbreak of fire and risk of explosion, the Kirki was dependent on outside (Coastal State) help to minimise the effects of pollution.

The Kirki had no suitable towing equipment in the after part of the ship and all the crew could have done was to take a towing wire from another vessel and ensure that the ship was in as safe a condition as possible. Under these circumstances the question is raised of whether the full crew should have been evacuated before the Kirki was taken in tow, or whether the Master and a minimum number of crew should have stayed on board until a proper tow line had been passed from the Lady Kathleen.

On one hand, as already stated, the Master had a responsibility for the safety of his crew. On the other, the Master had a duty under MARPOL 73/78 to minimise oil pollution.

Between about 0600 and 0945 and after 1004 until the time the Master evacuated the vessel, there had been no recurrence of the fire. The crew remaining at the after end of the ship had been secure there throughout the night and morning and, while it was difficult to assess the risk, they appeared to have been in little further danger.

The vessel posed a major pollution threat, and it was important, if possible, that sufficient crew remain to accept a towing line from the Lady Kathleen. Captain Efstathopoulos seemed to appreciate the need for salvage assistance in a radio exchange with Perth Radio between 0530 and 0537, when he asked whether a salvage tug had been dispatched. According to the owners he had also been in direct radio contact with them using a ship, the Tiger, which was

off Fujairah, as a relay station. He also made three radiotelephone calls to Greece at 0545, 0620 and 1040. It is fair to assume therefore that the Master knew of the salvage contract and that a salvage team was on the way.

The Kirki's crew prepared two mooring lines, one from each quarter. In open-sea conditions, and particularly the weather conditions prevailing at the time, such ropes could not, under any circumstances, be considered as an adequate towing arrangement. However the Kirki was not equipped with emergency towing equipment aft. All suitable towing equipment aboard the Kirki, anchor chain and heavy wire, would have been located in the forecabin space, which was lost.

After the Lady Kathleen's arrival at the Kirki, the possibility of using a rocket line to pass a towing array does not seem to have been considered. At the time the Lady Kathleen was not in a position to rig a tow, because of the equipment that had to be restowed on deck. On the Kirki the boiler had by this time been closed down. In the absence of power for the winches, the Kirki could have accepted a rope messenger, once the Lady Kathleen's deck had been cleared, and passed it back to the Lady Kathleen's winch to allow the towing array to be passed to the ship, the technique used when the Lady Kathleen's crew secured the tow that afternoon.

Under these circumstances it is hard to understand why, with daylight and rescue services in operation and two vessels standing by (one of which was a towing vessel), the Master together with a minimum number of crew, could not have remained on board, at least to secure a proper tow line when the Lady Kathleen had prepared the appropriate equipment. The Master had the option of remaining onboard, but despite the indication in the telex sent at 1009, he chose to evacuate the ship.

It was also stated that the Kirki's Master was asked to rig pilot ladders on the main deck to facilitate the salvors in boarding the ship from salvage vessels. This was not done, though liferaft and the port lifeboat ladders had been made ready aft from the raised quarter deck. However these ladders did not hang against the slab side of the ship, but in way of where the stern cut away at the after end of the ship. Any attempt to approach these ladders would have been most hazardous in the sea conditions because of the overhang of the stern section.

Captain Efstathopoulos stated that he wished to leave the Kirki and to transfer to the Lady Kathleen, so to be at hand to assist. It is difficult to understand what the nature of this assistance might have been other than to reboard the Kirki to secure a tow. He made no request to be transferred to the Lady Kathleen by helicopter, either as he left the ship or, according to the Captain Hancox, when offered the opportunity to return when he was ashore.

While the Master's decision to evacuate the ship when he did is open to criticism, the owners agreed to Lloyds Open Form 1990 very promptly.

At some time during the hours following the loss of the bow, the boiler was shut down and the fires drawn. Although this meant there was therefore no steam to operate the after-mooring winches, unattended operation of the boiler would have meant a risk of explosion and, in the circumstances of the evacuation of the ship, it was prudent to shut the boiler down. The B and W Holeby electrical generator was running throughout the emergency, together with an associated oil purifier, supplying power for the general-service pump, navigation equipment and other services.

Leaving the B and W Holeby generator running on fuel oil was not in itself a significant hazard, the engine room being a safe area and the likelihood of fire from such a source was minimal. These services were therefore available to Captain Hancox and the three crew members from the Lady Kathleen.

Although the officers declined Captain Hancox's request to return to the Kirki, he stated that the information supplied by Mr Bijarakis and the Chief Officer on engine room operation, including the generators, and cargo distribution was clear, detailed and accurate.

From the statements made at interview it was apparent that the Master received very little advice from his officers and the support that he was given was limited to people carrying out his directions.

The owners submitted that the Master does not seek advice from his subordinates. They also state that he was in frequent telephone contact with owner representatives who gave him continuous support and advice.

There is no evidence that the Master, or officers, or crew were in any way affected by alcohol or drugs and the Inspector is absolutely satisfied that alcohol or drugs did not contribute in any way to the decisions taken by the Master or the judgments made by the Master and his officers.

It is concluded that:

- After the evacuation of the bulk of the crew, the Master failed to make a realistic assessment of the situation. The risk to life would have been minimal had skeleton crew remained to secure a tow and assist the Salvage Master.
- In evacuating the ship the crew did not significantly increase the risk of fire by leaving the B and W Holeby generator operating. They were prudent in closing down the boilers.
- The use of alcohol and/or drugs was not a factor in the conduct of the Master or crew in responding to the fire and during evacuation of the ship.

- The discharge of oil into the sea was as a result of the damage to the ship. Mayamar Marine Enterprises responded immediately, by engaging United Salvage Ltd, to minimise the discharge and effects of possible pollution.

(iv) The response of the Lady Kathleen

The Master of the Lady Kathleen responded to the "MAYDAY RELAY" issued by MRCC through Perth Radio at 0440, in order to save the lives of the Kirki's crew. While the Lady Kathleen had been contracted by United Salvage at 0815, the saving of life remained the primary objective. Radio messages between the Kirki and the Lady Kathleen on 4125 kHz at 0537, confirmed that the Lady Kathleen was making best possible speed, and that the vessel had fire-fighting equipment and a towing capability.

The Owners made a number of submissions with regard to the situation at the casualty and the Lady Kathleen's response:

- that ladders were prepared to allow access to the vessel;
- the Lady Kathleen remained at a distance of one mile and therefore could not assess the conditions alongside;
- Captain Farstad could have taken off the remaining crew but refused to do so;
- Captain Farstad delayed in taking Kirki under tow until all crew had been evacuated.

Two ladders were available on the leeward (port) side of the Kirki. The liferaft ladder and boat ladder were both rigged from the raised quarter deck. While the lifeboat ladder was not immediately obvious, a video-tape recording shows the ladder caught in the port side lifeboat and the bottom treads of the ladder well clear of the water. To attempt to back the Lady Kathleen under these ladders would have run the real risk of the overhang of the Kirki's stern overwhelming the Lady Kathleen in the swell conditions. Also at that time it was not feasible to put the Lady Kathleen alongside the tanker's main deck without extreme hazard.

Given all the circumstances, the risk of transferring the Kirki's crew to the Lady Kathleen would not have been justified, given the helicopter operation in train. Captain Farstad stated that he approached to about 100 metres and, according to Mr Chapman, Master of the Vigilant, was about 200 metres off when Vigilant arrived at the casualty. This assessment is supported by video film taken from the Lady Kathleen. According to Mr Chapman both vessels stayed within a few hundred metres of the ship until about 1130 (page 30).

The Master of the Lady Kathleen was correct, in the circumstances, not to attempt to take crew off the Kirki. It would have been extremely hazardous and, given that the Kirki presented a relatively safe platform, it was sensible to await the transfer of the crew by helicopter.

Because of very rough seas and the exposed nature of the Lady Kathleen's working deck, crew members were unable to clear the pollution combat equipment and prepare to take the Kirki in tow until after the vessel had arrived at the casualty.

According to the Master of the Vigilant, Mr Chapman, the wind and sea conditions improved throughout the late morning and into the afternoon, although a 4 to 5 metre swell persisted. Mr Chapman stated that he raised the possibility of putting the Lady Kathleen alongside the Kirki and transferring some crew to the tanker, after the attempt to tow the tanker using the mooring rope failed. The two Masters discussed the situation and at 1350 three of the Lady Kathleen's crew boarded the Kirki on the port side of the main deck, just forward of the pipe manifold.

Having examined all the circumstances the Inspector is unable to accept that there was any unnecessary delay in taking the Kirki in tow.

The action of the Master and crew of the Lady Kathleen, in putting the vessel alongside the Kirki, boarding the ship in the existing sea conditions, and securing the tow, stabilised the emergency by preventing the Kirki from drifting closer to shoal water and stranding. In so doing they allayed immediate concern and displayed seamanship of a high degree.

It is concluded that the prompt action by the Master and crew of the Lady Kathleen stabilised the situation by preventing the tanker from drifting closer to the shore, where it would have stranded, and allayed immediate concern as to the damage that the ship and its cargo might cause.

(v) Communications with Australian authorities

A report from Mr I. C. Watson, the Radio Officer seconded to the ship during the salvage operation, states that the main and emergency transmitters were fully operational in telegraphy and upper sideband voice modes on medium and high frequencies, and that the lead acid batteries for the emergency transmitters were in good condition, topped up and fully operational.

Although the Kirki was an AUSREP participating ship, Captain Efstathopolous made no report of the damage to the bow or the deviation in the ship's course to MRCC. Under the scheme, which was voluntary for the Kirki, a Master is requested to file a "deviation report" when a vessel is in a position more than 2 hours steaming

from the position that would be predicted from its last reported position. The Kirki probably did not meet this condition until about 2300 on 20 July and then the Master was not strictly required to give the reason for the deviation. However, under the circumstances it would have been prudent, and in the best interest of the safety of those on board, to have alerted the Australian authorities to a possible emergency at the earliest opportunity.

The initial distress call, broadcast immediately after the outbreak of fire forward, was made on channel 16 VHF, which has a short range capability. However, no ship or other vessel was in VHF range of the Kirki, and Perth Radio, the nearest shore station, was well out VHF range. About 40 minutes passed before 2182 kHz medium-frequency radio was used.

According to information given to the owners by the Radio Officer, he transmitted distress messages on HF 2182 kHz immediately after the bow broke away. On checking the OTC multi-channel tape recorder monitoring SOLAS traffic, it has been established that the first MAYDAY message was received at 0302, a message to which five radio stations responded, but without any answer from the ship. The Inspector is satisfied that no message was sent by HF radio or morse telegraphy until 0302. The Kirki's radio log book records the distress phase between 0300 and 0330 on 21 July, in general terms with an entry "1900 to 1930 (UTC)(20 July) MAYDAY SOS and XXX QSL from Perth radio on 500kHz". The previous entry was made at 2220 on 20 July (1420 UTC) relating to the call the Master made to Piraeus. No entries were made after the reference to the distress messages.

After the loss of the bow at 0220 there was an effective delay of 42 minutes before a "MAYDAY" call was transmitted by medium-frequency radio on 2182 kHz. Even then, the message was incomplete, lacking the detail of the ship's position, the nature of the distress and the assistance required. It was not until 0320, one hour after the bow was lost, that some detail was provided on the nature of the incident and the position of the ship. Even then, there was no mention of pollution or the loss of the bow. The loss of the bow was reported to shore authorities by a helicopter pilot at about 0817.

The lack of detail and deficiencies in the voice transmission of the distress message and the failure to reply to the Marine Communication Centres (particularly Perth Radio) were probably caused by extreme anxiety.

Although there were three direct contacts with the ship from MRCC (0635, 0704 and 0859), little information of value was volunteered by the Master. The telex from the Kirki received at MRCC at 1009 indicated only a "cracked fore-peak", with no other details of the condition of the ship. In general, those responsible for coordinating the rescue and those responsible for combating the pollution experienced extreme difficulty in contacting the ship

directly to obtain a first-hand account of the emergency and the Master's requirements. The Salvors also reported that they could not contact the ship as the radio frequencies were dedicated to distress traffic.

There was also difficulty with language. The Master, Radio Officer and Mates spoke adequate or even good functional maritime English. However, under stress there seems to have been a failure of proper understanding on all sides.

From the start of the incident the Master's overriding priority, with regard to communications, was to maintain contact with his owners, rather than pass information to the coastal State authorities attempting to coordinate the rescue of ship's crew and exercise control over the developing pollution threat. The loss of the bow and, in particular, the recurring fires appear to have caused a level of anxiety aboard ship, whereby the obligation to pass basic information to the Australian authorities regarding the state of the ship was overlooked.

At no time did Captain Efstathopolous inform MRCC of the developing situation on board or indicate the condition of the ship, or the state of the fire. Effective contact between the ship and the Western Australian Marine Emergency Operations Centre was established through Captain Chandras. Until that time little reliable information on the situation at the casualty was volunteered by the Master.

It seems that the Master and the owners were confused as to the roles and responsibilities of the Operation Centre in Fremantle and the MRCC, in Canberra.

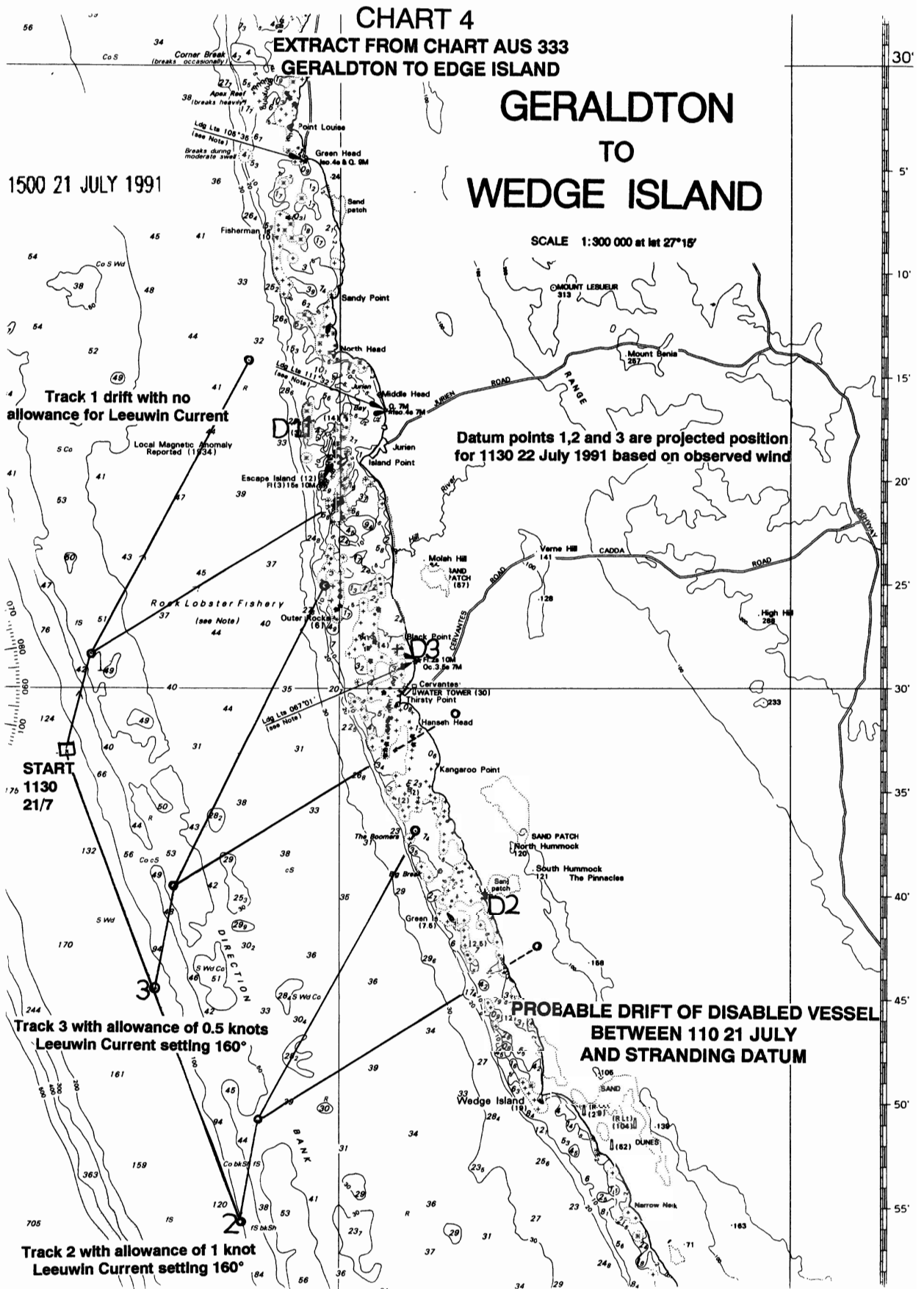
It is concluded that the Master did not initiate adequate direct communications with the shore authorities.

(vi) The likelihood of the Kirki stranding on the Australian coast.

During the course of the investigation the MRCC was requested to determine if the vessel would have drifted into shoal water and stranded, had it not been taken into tow, and if so an approximate time of the stranding.

Given the recorded weather conditions prevailing over the 36 hours following the evacuation of the Kirki (just before noon on 21 July), the drift characteristics of a tanker (based on the International Chamber of Shipping Companies International Marine Forum data for tanker drift modified for the loss of the bow) and wind-surface current and sea current, the MRCC produced three possible drift plans based on varying velocities for the Leeuwin current.

Chart 4 - Probable drift of disabled vessel



All three projections anticipated the vessel stranding in the morning of 22 July 1991 between Wedge Island and 30° 10'S, depending on the current.

It is concluded that, had a tow not been secured, the Kirki would have eventually grounded on the Australian coast, somewhere between Wedge Island and Jurien Bay, probably in the morning of 22 July.

The owners submit that there was no risk of the Kirki grounding, as the tug was able to attach a tow well before there was any danger of the ship taking the ground. They also submit that the main engine was available and that it could have been put astern to keep the vessel off the shore. This was the manoeuvre attempted by the Master just before dawn.

While the owners submission is noted, it remains a fact that had the tow not been secured or had the vessel remained unmanned, on the balance of probabilities the tanker would have grounded in the morning of 22 July.

SECTION 7

The salvage operation and transfer of oil

(1700 21 July to 23 August)

Following the initial oil pollution incident from the Kirki on 21 July, primarily from No 1 starboard and centre tanks, two further significant quantities of oil were released from the ship during the salvage operation. The purpose of this section is to address the circumstances of the oil pollution subsequent to the spill of 21 July, where it was lost, and the total quantity of oil spilt.

It is not intended to report in depth on the salvage operation by United Salvage Ltd, which was complex and conducted in conditions of extreme difficulty, or to examine the response to the incident under the National Plan to Combat Pollution of the Sea by Oil.

Under the National Plan responsibility for overseeing control of, and action on, any pollution from the Kirki rested with the Australian Maritime Safety Authority. Responsibility for beach, and inshore monitoring and clean up lay with the organisations represented on the State Pollution Combat Committee.

The west coast of Western Australia is exposed to the prevailing weather and ocean swell. There were no ports with sufficient water which could take the Kirki, even if it were acceptable on environmental grounds. Given the winter season, United Salvage in consultation with AMSA and the State Pollution Combat Committee, determined that the ship should be towed to the north-west coast to an area sheltered from the south-westerly swell, where a ship-to-ship transfer operation could be undertaken to remove the remaining oil from the Kirki. A successful ship-to-ship oil transfer operation had been completed off Dampier in 1975, when the Greek tanker Princess Anne Marie shed shell plating in the Indian Ocean, while on passage to Kwinana with a cargo of crude oil.

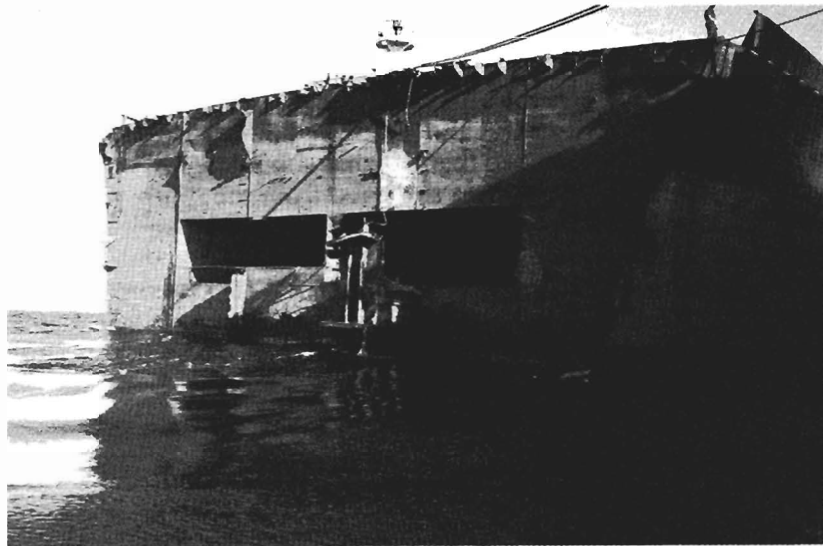
The area of Glomar Shoal (19° 31'S 116° 50'E) was initially identified as an area that would probably not be exposed to the South Indian Ocean swells, which was relatively shallow and could provide an anchorage.

The State Committee was concerned for the fishing grounds and environmentally sensitive areas inshore and requested that the ship should remain 100 miles from the coast during its passage north. After pointing out certain difficulties, including logistic problems, United Salvage with strong reservations, agreed that, after certain logistic requirements were met, the tow to the north would keep 100 miles from the coast.

The Kirki was progressively manned by personnel working for United Salvage from 1700 on 21 July, when Captain Hancox joined the vessel. The ship remained under tow by the Lady Kathleen, and the Fremantle tug Wambiri, which arrived at the casualty at 2230 on 21 July, acted as stand-by vessel.

On 23 July temporary repairs to plug the holes in No 1 centre forward bulkhead and a small leak in No 1 port-cargo tank were completed. The Kirki's Chief Engineer and Second Engineer, returned to the ship for the day to clarify the actual working pressure at which they operated the ship's boiler and to assist in translating various notices and operating instructions related to the ship's machinery and equipment.

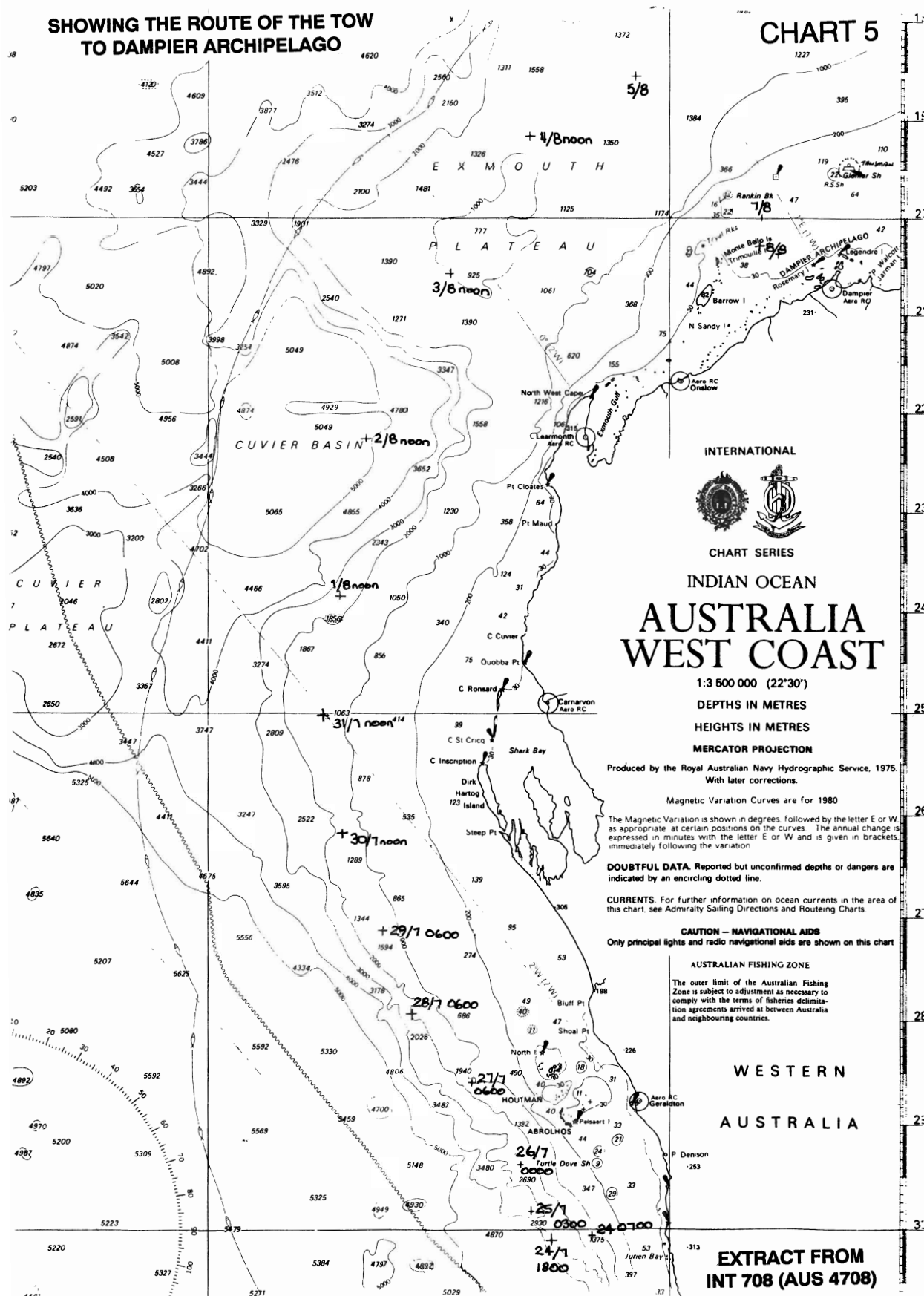
In the early morning of 25 July the Kirki was experiencing strong westerly winds with a pronounced swell, causing the vessel to slam heavily. At about 0130, in a position approximately 60 miles south-west of Pelsaert Island light (Abrolhos Islands) and 80 miles from the coast, a heavy banging was heard forward. At this time it seems that the welds of one or two large plates in No 1 cargo tank forward bulkhead failed. One plate was lost and the other was apparently "hinged" on residual weld metal at the top part of the plate. This plate was subsequently lost later in the tow. The remaining oil in the tank leaked to the sea. At 0910 it was confirmed that the remaining oil in No 1 centre was lost, amounting to about 6000 tonnes.



Photograph 2 - At frame 93, forward bulkhead No 1 cargo tanks at completion of 23 August discharge. Plates missing port and starboard of centre line were lost on or after 25 July, during tow northward.

Chart 5 - route of tow 25 July to 8 August

SHOWING THE ROUTE OF THE TOW TO DAMPIER ARCHIPELAGO



At 1250 on 25 July the Lady Kathleen relinquished the tow to the Lady Elizabeth. The Wambiri proceeded to Geraldton where, on 26 July, it embarked Mr Wilkinson (AMSA marine surveyor) and four salvage divers and transferred them to the Kirki. The Wambiri returned to Geraldton overnight and transferred further salvage personnel, two of the Kirki's crew to recover personal belongings, the ship's pumpman and a Mayamar Marine Engineer Superintendent. Rough weather prevented the transfer of equipment from the Wambiri to the Kirki. The Wambiri proceeded to Shark Bay, where the equipment was transferred to the larger, Panamanian registered offshore supply vessel, Pacific Chieftain.

The tow towards the north-west coast continued at about 100 miles from the land. The ship was experiencing consistent long high swells of 8 to 9m.

On 31 July, a further owners representative, Captain Chandras, was transferred to the Kirki, by the Pacific Chieftain.

On 1 August the Kirki was in position $23^{\circ} 43' S$ $111^{\circ} 25' E$ on a course of 014° making good a speed of about 2 knots. The Pacific Chieftain passed a towing array to the port quarter and both towing vessels proceeded at 50 per cent power. By this time the salvage crew had succeeded in purging all cargo tanks with inert gas and ensuring an oxygen level below 7 per cent.

At 0000 on 3 August the Kirki was 100 miles west of North West Cape. The swell conditions remained critical and at about 0645 a series of long steep and heavy swells impacted on No 1 port cargo tank and a small quantity of oil began to leak from the tank. Because of the swell conditions it was not possible for men to work forward, and over-deck transfer from this tank to No 3 centre tank and No 5 starboard tank, was not possible until the afternoon of 3 August.

At about 1815 on 4 August, the over-deck transfer from No 1 port cargo tank and all work on deck had to be abandoned. The weather deteriorated further with seas being shipped on deck, resulting in injury to one of the salvage crew. Throughout the night and next morning the vessel trimmed further by the head.

Significant quantities of oil continued to leak from No. 1 port cargo tank, and No. 2 centre cargo tank was found under hydrostatic pressure. This led to the conclusion that the bulkhead between No. 1 port centre, No. 1 centre and No. 2 centre cargo tanks had failed, although the cause was later established to be faulty valves in the cargo system.

By 1300 on 5 August, in position $19^{\circ} 04' S$ $114^{\circ} 47' E$ (about 145 miles north of Barrow Island), the decision was taken to detach and transfer all non-essential personnel to the Pacific Chieftain. A number of these personnel, including owners' representatives,

returned to the ship when the position was stabilised. The Kirki was in little immediate danger of sinking with reserve buoyancy of approximately 20,000 tonnes. However this buoyancy was predominantly in the after area of the ship. Had No 2 wing-cargo tanks also been breached, there would have been a danger that with the loss of the buoyancy of the oil (specific gravity of 0.8274), the ship would have gone down by the head due to a loss of longitudinal stability (a progressive loss of longitudinal metacentric height). It was therefore imperative to gain calmer water to allow reasonably safe access to the forward tanks, so work could be undertaken to raise the bow to allow the ship-to-ship transfer operation to take place. All cargo that could be accessed was moved aft and ballast was shipped into the after-peak to allow access to No 2 wing cargo tanks, so that that oil could be transferred to after tanks including No 7 wing tanks. No 7 wing tanks (tanks 13 and 14) were adapted for use for cargo by repairing the tank lid and introducing a temporary inert gas system.

On 7 August a representative from BP, London, boarded the vessel together with a representative from Marine Safety Services, UK, and members from AMSA's Pollution Prevention Section to assist in the preparation and transfer of cargo to the Flying Clipper, a ship chartered to take off the remaining cargo from Kirki.

The representative from Marine Safety Services was initially engaged by United Salvage to provide independent safety advice on the operation to transfer cargo. Responsibility for the representative was subsequently adopted by the cargo owners, BP Australia.

It was not until 8 August, in position $20^{\circ} 23' S$ $116^{\circ} 05' E$, off the Monte Bello Islands, that sufficiently calm water was reached to allow the transfer of oil within the ship and for compressed air to be introduced to No 1 port cargo tank.

On 9 August the situation was stabilised and the bow was raised to allow transfer operations to take place. At 0925 the transfer vessel, the Flying Clipper, arrived at Glomar Shoal and tendered "Notice of Readiness" to begin cargo operations and waited for preparations for the transfer to be completed.

The Flying Clipper arrived off the Kirki at 0600 on 10 August. At about this time, the salvors, after consultation with the Master of the Flying Clipper, decided that the Glomar Shoal was not sufficiently protected from the South Indian Ocean swells to allow a safe ship-to-ship transfer operation.

After attempts to moor the tankers alongside one another on 13 August, the Flying Clipper successfully came alongside the Kirki at 1142 on 14 August, in position $20^{\circ} 18.8' S$ $116^{\circ} 01' E$. The discharge of cargo and a quantity of bunker fuel from the Kirki to the Flying Clipper lasted until 0530 on 19 August.

The transfer was completed without any operational pollution. The Flying Clipper slipped from the Kirki at 0750 on 19 August in position 20° 32'S 116° 21'E, 64,372.43 tonnes of crude oil and 1289.85 tonnes of bunker fuel oil having been successfully transferred. However, 600 tonnes of crude oil remained aboard the Kirki as "unpumpable" oil.

Of the Kirki's original cargo of 82,665 tonnes of crude oil, about 17,700 tonnes were lost to the sea, about 6500 tonnes on 21 July, 6000 tonnes on 25 July and 5000 tonnes from 3 to 6 August.

The Kirki was delivered to her owners at 1015 20 August 1991 off the Monte Bello Islands. The owners contracted United Salvage to tow the vessel to Singapore and to provide a riding crew. The Kirki remained off the Monte Bello Islands while National Plan equipment was transferred to the shore and the vessel was prepared for the tow. The tow departed for Singapore on 23 August and was redelivered to her owners, off Singapore at noon on 8 September.

Comment

The loss of oil on 25 July resulted from the hull of the Kirki, and particularly the exposed bulkhead at frame 93, being subjected to the action of the sea and swell creating such stresses that the integrity of the already weakened structure failed. The loss of oil from No 2 centre cargo tank over the period 3 to 6 August, was due to faulty or fractured valves in the oil pipeline system.

No oil was lost as a result of any cargo transfer operation conducted by the salvors.

While it was unlikely that the Kirki would have sunk, in the sea conditions experienced between 21 July and 23 August, the heavy swell placed considerable stress on the exposed bulkhead of No 1 cargo tank and the forward end of the ship in general. These swells would have been experienced up to the 200m depth contour and would only have reduced in size in more shallow water close to the coast.

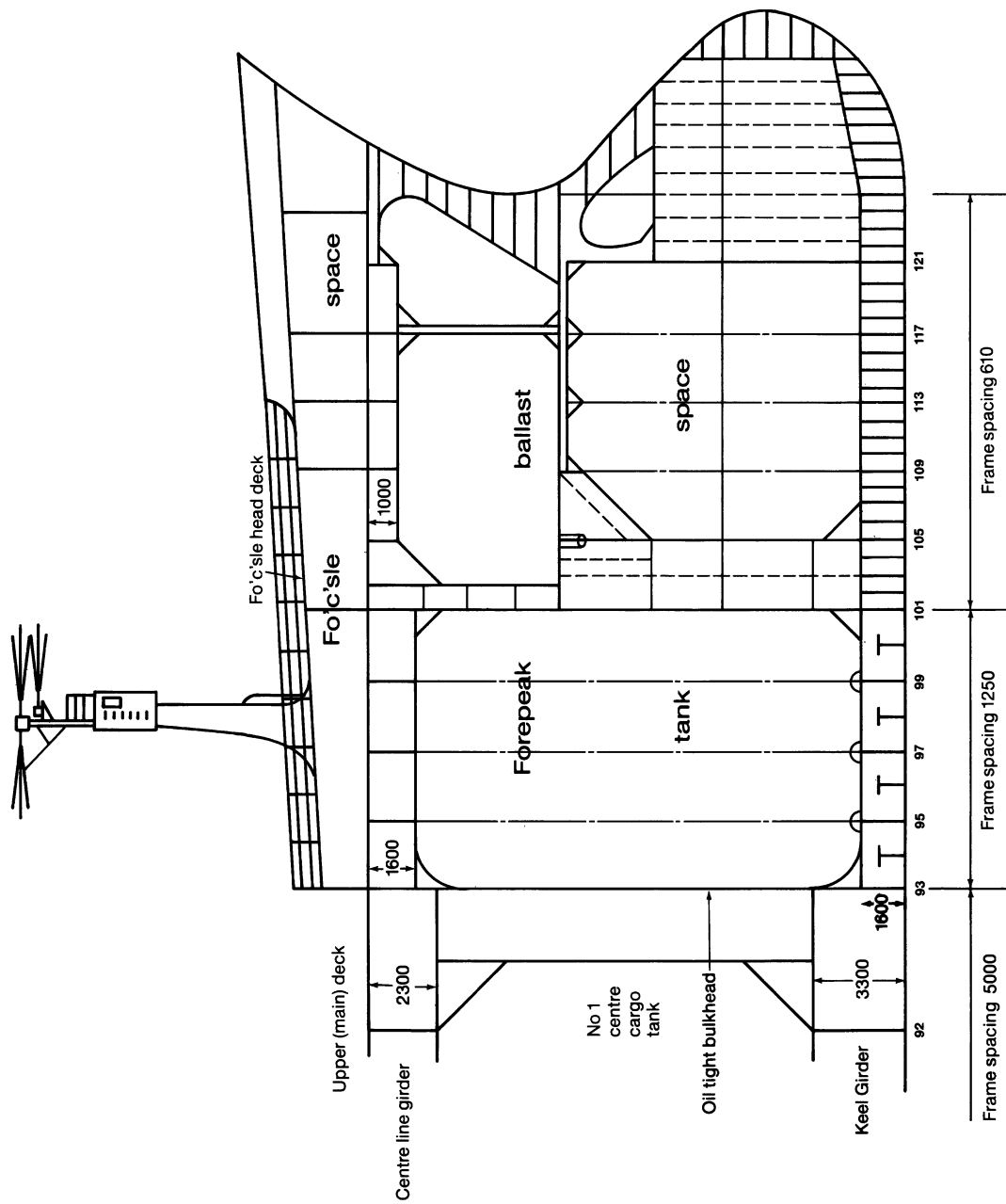
To avoid the large ocean swells the tow would have to have taken place well within 40 miles of the coast line, which was considered by the Western Australian authorities to pose an unacceptable pollution threat.

The requirement to keep the ship 100 miles off the coast on passage to the north-west added at least two days to the tow. The extra distance introduced a significant time factor in the working of the ship's weakened structure, and United Salvage are of the opinion that, had the tow been further inshore, time would have been saved and less oil would have been spilt.

There is no certainty that the tank bulkheads at the forward end of No 1 centre cargo tank would not have failed in the less heavy conditions which might have been expected within the 200m depth contour.

M.T. Kirki

All dimensions in millimetres



Diagram

SECTION 8

Comments on structural issues

In considering the possible causes for the failure of the bow section the existing condition and records of past maintenance of the ships hull are relevant. The condition of the ship's structure is considered in two areas:

- (i) The bow structure
- (ii) Tank spaces 13 and 14 (No 7 wing tanks)

(i) The bow structure

In the absence of written records of tank soundings and relying on the statements of the Master, Chief Officer and Pumpman, that the fore-peak tank had not experienced any leaks before the evening of 20 July, it is assumed that the tank contained no significant water until the evening of 20 July.

The steel work in the fore-peak tank was bare and the internal structure was not coated to protect the steel work. This is quite normal in a ship of the Kirki's age. The preservation of steel work, whether by coating with paint or some other substance, cathodic protection (the placing of sacrificial zinc anodes in tanks to reduce wastage), or whether the steel is replaced as necessary, is a matter for the owner. The Classification Society has no record of the renewal of anodes in the fore-peak or other ballast tanks from admission to class in January 1986 until the time of the casualty.

The initial flooding of the fore-peak on the evening of 20 July 1991 was most probably caused by a major failure in the Kirki's hull forward of frame 93, either where plates fractured or were lost, or where the sea ballast line sheared at the port side shell plating (shown in underwater video footage).

Inspection of the ship, examination of photographs and underwater video footage indicates that the initial breach to the cargo tanks, caused by the loss of the bow, was to No 1 starboard tank.

The deck and shell plating, and the forward bulkhead, had been torn open to a depth of about 1m at the extreme outboard forward end. In addition, three punctures, vertically disposed on the centre line, had apparently resulted when the centre-line girder carried away from the bulkhead. There was also one puncture on deck, to the starboard of the centre line, where some fitting had carried away.

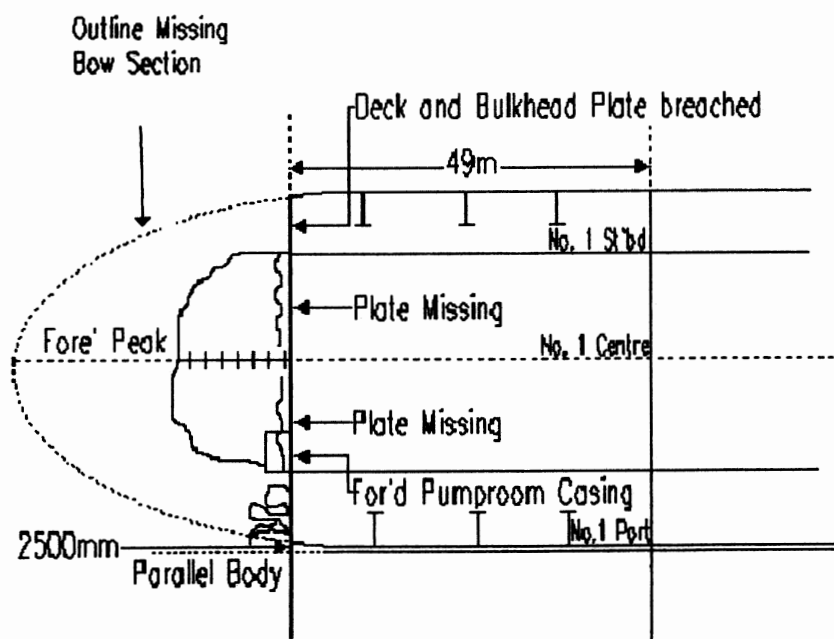
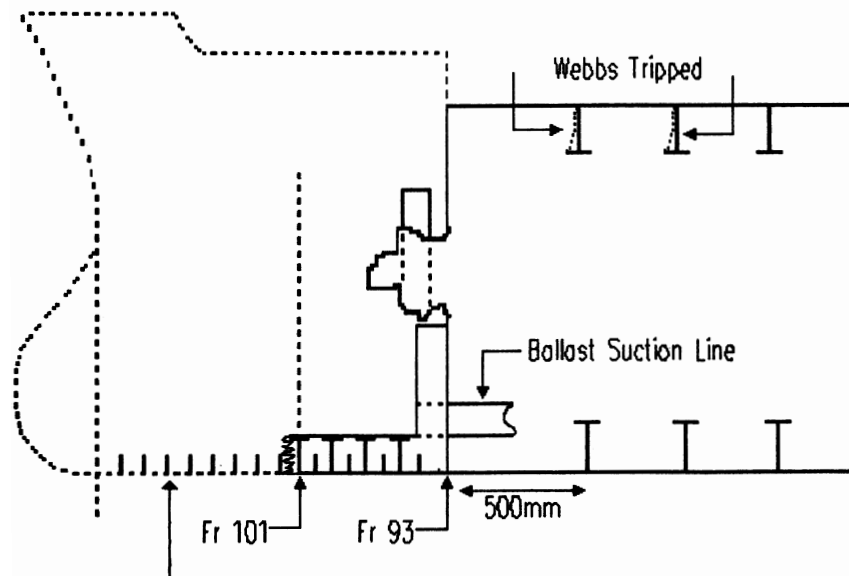
The loss of the bow section, including the raised forecastle section, was marked by a clean break transversely just forward of frame 93, (see photograph 2 page 46) which continued down the shell plating to the level of the floors. The bottom framing and shell plating remained intact forward to frame 101. The port side shell plating was less cleanly broken.

The whole of the fore part of the vessel forward of frame 93, (other than the floor area as outlined above), which included the forward mast, deck machinery and anchors, carried away.

Tankers are longitudinally framed ships, with main strength members (including deck plating) running fore and aft to counter bending moments. The fore and aft strength members are reduced in size outside the midships half length of the ship, the bending moment not being as pronounced as in the midships section.

diagram 3

SKETCH OF BOW AREA ADAPTED FROM DIVER'S SURVEY SKETCH AND VIDEO TAPE - 12TH AUGUST 1991



However, the forward end of the ship is strengthened to resist pounding damage. The Kirki was so designed and constructed, according to accepted class rules, that the sizes of deck plating frames and girders were all reduced forward of No 1 cargo tank forward bulkhead (frame 93). This created an area of transition from the deep strength members aft of frame 93 to the lighter members in the bow area, the longitudinal deck framing being connected by brackets at the oil tight bulkhead. The area of transition, where the raised forecastle begins, is compensated by fairing the forecastle sheer strake into the main sheer strake by fashion plates extending about 2m aft at frame 93. The port and starboard sheer strakes also spanned frame 93, contributing to the longitudinal strength.

The strength of the bow structure depended therefore on a number of components, including the fore and aft deck girders, that continued forward of frame 93, and the deck plating. The continuity of strength at frame 93 would depend upon the quality of the welds at the bulkhead.

According to classification society records, the Kirki was subject to extensive thickness testing in November 1986. Every deck plate was tested for indicative thickness in two places towards the ends of the plate. However, the deck plating just forward of frame 93 was immediately inside the forecastle, an area used for stores and keeping miscellaneous equipment. It is doubtful if any of the stores or equipment would have been moved to allow systematic thickness testing in the narrow band of plating immediately inside the forecastle space, forward of frame 93.

Repairs including the renewal of steel work in the fore-peak tank were carried out in Piraeus in 1986. These repairs involved the upper three strakes of plating in the oil tight bulkhead between the fore-peak and No 1 cargo tanks, and plates in the upper part of the port and starboard longitudinal wash bulkheads. Web frames, stringers, deck girders, brackets and side longitudinal frames were cropped and renewed "as found necessary". Repairs were also carried out in No 3 port and starboard permanent ballast wing tanks, involving the cropping and renewal of all deck girders, renewal of the upper metre section of the forward and after bulkheads, and renewal of other steel work as necessary.

On 22 February 1989 Germanischer Lloyd carried out a "heavy weather" damage survey at Fujairah (Survey Report "S 5"). According to classification society records, this was to survey damage in No 3 starboard tank. Temporary repairs were completed and the vessel's class confirmed for one voyage in ballast for repair.

The Kirki proceeded to Jebel Ali where extensive areas of steel between frames 73 and 77 were cropped and renewed in No 3 starboard tank and also some work was completed in No 3 port tank. On 10 April 1989 the Germanischer Lloyd survey report "S 6" was completed noting that all but some minor shell plate cracks had been repaired; these cracks were made good at Fujairah in June 1989 (Survey Report "S X").

According to an envelope found aboard the Kirki, marked "After repairs (Fore-Peak) at Jebel Ali - 18.02.89 to 05.04.89", repairs throughout the fore-peak tank, amounting to about 50 tonnes of steel work, had been completed. The document showed steel replacement in the area of transition at frame 93 as follows:

- The fore-peak centre line longitudinal deck girder and bracket in way of frames 93 to 98
- The port and starboard main longitudinal deck girders to frame 101
- Strakes 2,3,4,5 and 6 from deck level of the port longitudinal wash bulkhead (4875mm off the centreline) between frames 93 and 95
- Strakes at mid-depth in starboard longitudinal bulkhead (4875mm off the centreline) between frames 93 and 94
- Extensive areas to the top 4.2m of the transverse web frame in way of frame 95
- Some plating on the wind and water line.

The owners have provided details of steel renewals to the vessel between 1986 and 1991. There was no evidence of renewal of deck plating.

These repairs were apparently undertaken, with the vessel afloat, at the same time as the "heavy weather" damage was made good in No 3 starboard ballast tank, but were not noted in the "Entries related to surveys", appended to the Germanischer Lloyd Class Certificate. Documents retained by the Society confirm that steel work in the fore-peak was replaced although the grade of steel is not noted. It is understood from Germanischer Lloyd that not all the repairs could be completed before the vessel sailed for Fujairah in June 1989. Survey Report "S X" was completed at Fujairah on 23 June 1989 relating to repairs to cracks in the hull but made no mention of any work in the fore-peak tank.

Any repairs or steel renewals, particularly if carried out afloat, have the potential to set up new stresses within the structure in the area of the repair. It is therefore possible that some continuity of strength was lost at frame 93 as a result of repairs to the fore and aft members.

Suggestions were received by the Inspector that the Kirki had been involved in a missile attack during the Gulf war and had sustained damage. There is no record of the ship being involved in any casualty and it did not, according to class society records or Lloyds intelligence, sustain damage as a result of an attack in the Iran-Iraq conflict. The owners confirm that the Kirki's sister ship Dafni was involved in such an attack.

On 23 July 1991 the Inspector viewed the area of the break and, assisted by the Salvage Engineer, took a series of calliper readings across and immediately adjacent to the area of the break forward of frame 93 (Attachment 3). These readings were of the thickness of the deck plates (originally 13mm) and of some of the exposed brackets remaining in place on the forward bulkhead. A sample of deck plating was removed by bending the plate by hand, and submitted to the Materials Research Laboratories, Melbourne, for testing (Attachment 2).

Photograph 3 Calliper measurements taken of metal around the bow section near the break



Photograph 4 View of fracture looking towards centre line from the port side



The Materials Research Laboratory reported that the sample plate was found to be severely corroded, with up to 90 per cent of the plate thickness having been lost in some areas, the corrosion being of a general nature with some shallow pitting attack. The corrosive attack occurred mainly from the underside of the deck plating (the deck head of the fore-peak ballast tank), and it was considered that extensive corrosion of the weld had also occurred. A chemical analysis of the steel itself confirmed that the steel conformed to the chemical requirements of Lloyds Grade "A" specification. The analysis also concluded that the plate was subject to a ductile overload mechanism as a result of high loads on the sample plate.

On 17-18 September 1991, while the ship was off Singapore, a firm of engineers engaged by Mayamar Marine Enterprises took ultrasonic readings of:

- (a) The main deck plating between frames 92 and 93
- (b) The transverse belt between frames 92 and 93
- (c) The transverse bulkhead at frame 93
- (d) Deck brackets at bulkhead (frame 93 just aft of the break) (Attachment 4).

These two sets of measurements, together with the clean line of the break, suggested a major area of structural weakness between frames 93 and 94 transversely in a narrow band across the deck.

This band of relative weakness can be explained by water erosion in the fore-peak ballast tank and moisture within the fore-castle space. The intense water action within the fore-peak tank and the humidity would cause wastage on the underside of the deck plating, the most intense action affecting the structure adjacent to the bulkhead. Possible corrosion on the top of the plating just forward of the after fore-castle bulkhead and to the bulkhead itself would have resulted from residual moisture in the fore-castle space.

When inspected after the incident, the quality of the plating at the forward starboard side of No 1 starboard, and the plating of No 1 centre bulkhead (frame 93), all appeared to be reasonably sound. Subsequent ultrasonic thickness tests conducted on behalf of Mayamar Marine Enterprises confirmed little wastage, although readings of below 10mm were recorded at the upper level of the areas surveyed.

On the loaded passage, with the fore-peak ballast tank intact and empty, the upper structure in the area of frame 93, including the deck plating, would have been subject to a compressive stress. The breaching of the fore-peak tank and consequent loss of buoyancy would have resulted in a tensile stress. Such stresses would have been those normally experienced by a tanker's structure in loaded and ballast passages and should not, in themselves, result in structural failure.

This report cannot determine the sequence of the structural failure. This would seem to depend on whether shell plating was lost in the bow area and, if so, how much. A similar failure to the Atlas Pride off the South African coast in September 1991, where bow shell plating and framework below main deck level was stripped away in heavy seas, could explain the description of eye witnesses that the bow appeared to bend upwards before being lost. Examination of underwater video tape footage of the underwater damage showed distorted, bent and fractured steel work, including a collapsed wash bulkhead. Stresses were set up caused by either the action of the water in the fore-peak, on the night of 20 to 21 July, washing against the weakened structure between frames 93 and 94, or the loss of shell plating, or combination of both. These stresses acted on the severely corroded and weakened deck plating and the fore and aft longitudinal deck girders, particularly the centre line and two side fore and aft girders, causing a total failure of the ship's structure at this point.

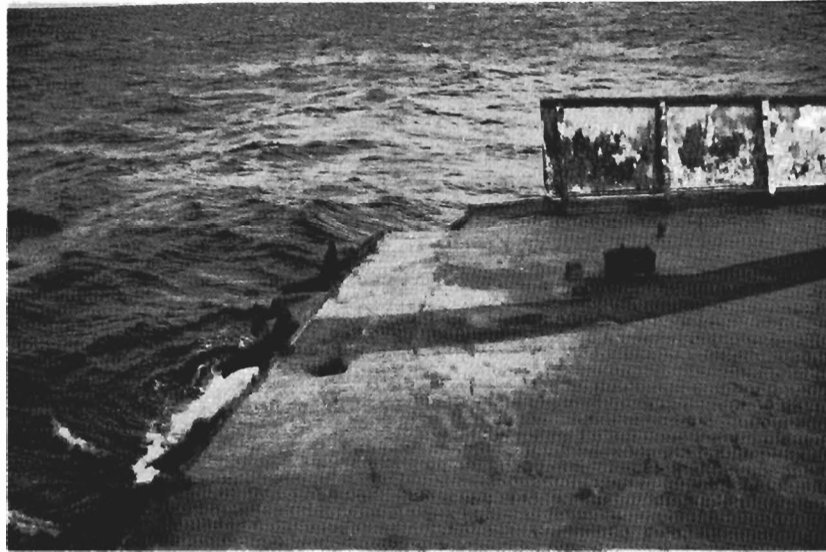
The deck plating and fore and aft girders sheared at or close to the bulkhead; the deck longitudinal frames sheared at the forward (reduced end) of the brackets secured to the oil tight bulkhead. While one such frame had apparently been cropped and renewed in 1989, apparently other longitudinals had not been renewed between frames 93 and 95. The failure of the girders at the bulkhead, steel work that had been renewed in March 1989, could indicate that the longitudinal continuity of strength had not been maintained subsequent to the repairs being made.

Therefore it would seem that the failure of the hull structure was caused by a combination of a number of factors triggered by the breaching of the fore-peak ballast tank.

However, what is established is that there was a narrow band of wastage immediately forward of frame 93. It is unlikely that this area would have failed had not the longitudinal strength members also failed at about the same time.

The main source of pollution on 21 July was from the breach in No 1 starboard tank. Sea water shipped through the breach at the top of the tank displaced the oil inside. Oil was also lost from the centre-line punctures in the upper part of No 1 centre tank.

*Photograph 5 Aft of frame 93 deck over No 1 starboard tank,
the initial source of pollution*



Photograph 6 Breach in No 1 starboard cargo tank



It is unlikely that any pollution occurred before the bow broke away. There is no evidence that oil had leaked into the fore-peak before the bow fell off; any oil and/or gas in that space would have been immediately detected by smell when the space was entered by the Chief Mate and others on the night of 20 July. Similarly, there is no evidence that any explosion or fire occurred before the bow was lost or any explosion, as such, at any other time.. It is probable that the initial fire was caused by the mechanical action of the structural failure, or by the parting of electric cables servicing the forward spaces and fore mast.

Consultants to the owners and underwriters consider that the initiating cause of the bow failure was a fracture in the starboard side shell plating below the water line, at first limited in size, which allowed the ingress of sea water. The weight of the sea water and the continual pounding of the structure in heavy seas caused the fracture to propagate, leading to eventual overload of the remaining structure.

The Inspector accepts the feasibility of this explanation. However, given the fact that the ballast line was sheared at the port shell plating, and recent examples of ships that have lost plating , these other possibilities can not be discounted.

It is concluded;

- that it is not possible to be precise as to the cause of the structural failure forward of frame 93 (the bow). It was either due to the action of sea water, which had flooded the fore-peak, impinging heavily in the area of frame 93, which led to an overload on the structure, or to a loss of bow plating. Either one or a combination of these factors led to excessive stress on an area of the ship's structure weakened by corrosion and the effects of repair work.
- the flooding of the fore-peak tank on the evening of 20 July was due either to a failure in the ship's shell plating forward of frame 93, or the shearing of the fore-peak ballast pipeline at the shellplating on the port side.

(ii) Tanks 13 and 14 (No 7 wings)

Numbers 13 and 14 ballast tanks were inspected in an attempt to gain some appreciation of the condition of the ship and particularly a ballast tank whose condition, through the filling and emptying of water, could approximate the condition of the fore peak.

Subsequent inquiries suggested that the tank was not regularly used for ballast. However, the condition of the tank did show extreme corrosion.

The two tanks were found to contain extensive areas of significantly wasted steel work with longitudinal strength members and framing badly corroded or split and wash plates also severely corroded.

There was evidence that work had been carried out in No 14 tank (No 7 port) to weld a crack into the engine room bunker tank and to replace a new section of pipeline from No 6 starboard slop tank. There was also evidence of a minor fire that had been extinguished by a portable extinguisher. Extinguisher powder in the area of the repaired weld was dry to the touch and had not been immersed in water.

There is no evidence that tanks 13 and 14 (No 7 wings) had been subject to steel renewal or had actually been physically inspected by a surveyor. While it would seem that the use of these tanks cannot be equated with the use of the fore-peak, the condition of the tanks does raise the question of the quality of survey by the Classification Society and inspection by the Mayamar Marine technical staff.

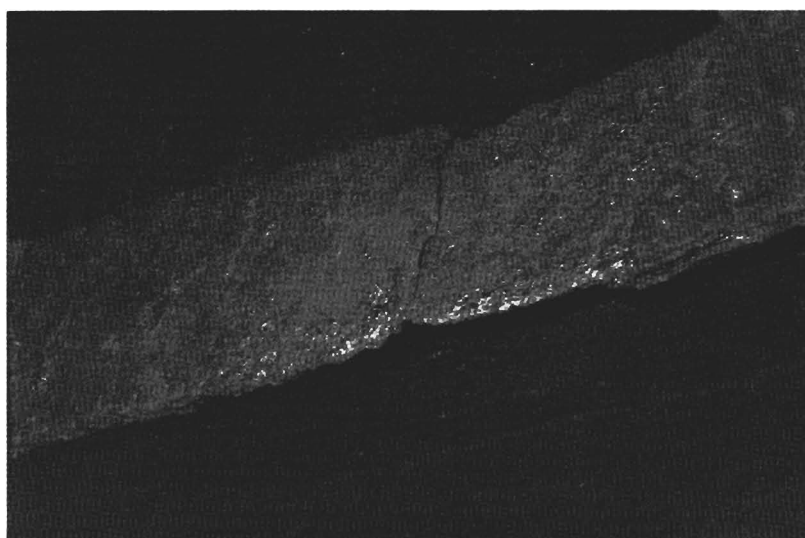
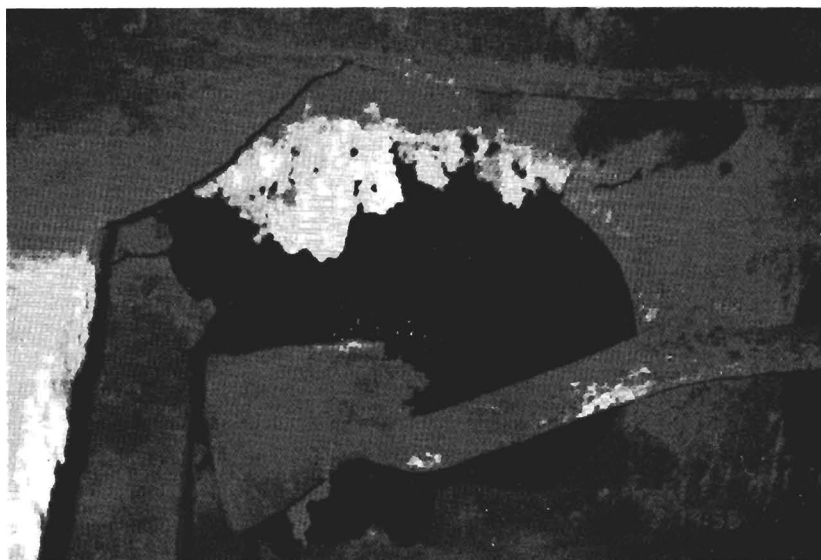
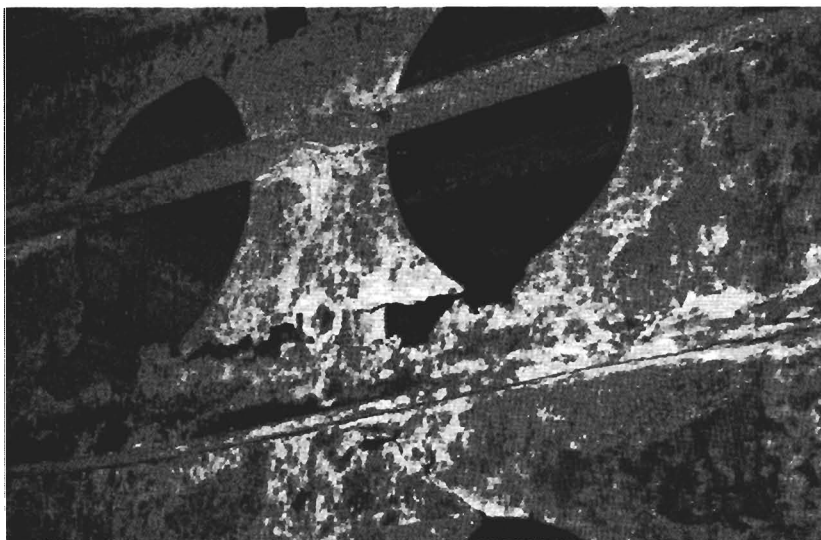
The condition of the tanks does suggest that the original steel work in the fore-peak would have been subject to significant wasting.

The owners submit that the condition of tanks 13 and 14 cannot be taken as a guide to the condition of the fore-peak, which had been subject to extensive repairs. The owners consider this section irrelevant to the cause of the casualty.

While the conditions of the tanks did not contribute to the casualty as such, the degree of corrosion observed does raise issues of the general standard of the ship and the effectiveness of inspection and inspection surveys.

It is therefore concluded that the procedures adopted by the Germanischer Lloyd during structural surveys failed to identify the area of localised corrosion. The condition of ballast tanks 13 and 14 together with the number and nature of deficiencies in safety equipment, indicates that a number of surveys over a period of time, including surveys that were conducted under international safety conventions, were not performed effectively.

Photographs 7, 8 and 9 Internal condition of dedicated ballast tanks 13 and 14 (No 7 wing tanks)



SECTION 9

Observed condition of the ship and its equipment

At about 1000 on 23 July 1991 the Inspector of Marine Accidents boarded the Kirki to view the area of structural failure, to secure log books, charts, relevant documentation and to familiarise himself with the vessel and its equipment, particularly the life-saving appliances.

The ship's deck area and engine room were well painted, with inspection dates clearly stencilled on the inert gas deck seal and the gas-venting pipes on the cargo-tank lids, giving the impression of being adequately maintained. However corrosion was evident around the deck, on the foundation supports of the cargo and service pipelines, and many of the pipelines showed extensive patching, all of which had been painted over.

(Note: the pipeline foundations were to be renewed by the fitters who were to join the Kirki in Kwinana.)

As a result of this inspection, Mr Philip Wilkinson, an AMSA marine surveyor and an investigator appointed under the Navigation (Marine Casualty) Regulations, was requested, under sub-regulation 8(2), to undertake a more detailed inspection of the ship. Mr Wilkinson boarded the vessel on 26 July and commenced his inspection.

On 11 August the Inspector returned to the Kirki to make a more detailed examination of the ship and its equipment with Mr Wilkinson. From this inspection it was apparent that the general impression of an old but reasonably maintained ship, created by the well painted deck and engine room, was misleading.

From documents viewed on 23 July it was evident that the ship had also been subject to a safety audit by a company representative in Singapore in February 1991 (see section 10). It also appeared that the vessel was stocked with an extensive range of stores and machinery spares.

Despite the requirements of the company's operations manual and the spare equipment on board the Kirki, a significant number of serious safety defects were found, which called into question the:

- Capability of the ship's crew to respond effectively to the fire
- Ability of the crew to abandon the vessel using ship's equipment

- Standard of survey in issuing statutory certificates under the requirements of the International Safety of Life at Sea Convention 1974, MARPOL 73/78 and the Load Line Convention 1966 (LL 66)
- Overall maintenance of the ship under the requirements of SOLAS 74 Regulation I/11, and MARPOL 73/78 Sub-regulation 4 (4)(a).

The defects identified related to:

- (i) Life-saving appliances
- (ii) Fire-fighting equipment
- (iii) The safety of the cargo system
- (iv) Pollution-control equipment
- (v) Engine-room safety
- (vi) International Load Line convention requirements.

In any ship, particularly a ship of more than 20 years old, some wear and tear of structure and machinery and break down of systems must be expected. Such deficiencies should not impair operational safety, invalidate the relevant statutory safety certificates, put lives in jeopardy, or put the environment at risk.

The Kirki's classification society was responsible for surveys and the issue of statutory certificates, on behalf of the Greek marine authorities, attesting to the operational effectiveness of the equipment on board. The Kirki's owner and Master had a responsibility to maintain the ship in a seaworthy condition at all times.

Germanischer Lloyd and the owners submitted that the defects noted had no influence on the casualty (see section 12). While the Inspector accepts that the state of the equipment had no influence on the structural failure, the deficiencies however, provide evidence of the ship's overall condition.

The condition of the Kirki's safety equipment on 21 July was such that, had outside help not been at hand or the incident occurred earlier in the passage, the ship's crew would have been put at considerably increased risk through inoperable life-saving appliances and fire-fighting equipment.

What is also of concern is that the crew, including past crews, had the means and opportunity to rectify many of the defects, particularly those defects that impinged upon their own safety, and had not done so.

(i) Life-saving equipment

An attempt had been made to evacuate the ship using the port lifeboat. When examined the hull of the lifeboat was cracked and the bilge grab rail had come away from the hull leaving open bolt holes. However, it appeared probable (this was corroborated by the owners), that this damage had been sustained when the boat was in the process of being lowered and hoisted on the morning of 21 July. The lifeboat falls were badly twisted, which suggested that the weight of the boat had come off the falls at some time, allowing the blocks to turn.

The interior of the boat was not well maintained; rotten canvas and rusted equipment were in evidence. The sea anchor and exposure cover were both rotten, much of the cordage was deficient and the embarkation ladder was in poor condition. In addition the engine was badly maintained with rusty exhaust pipes and a broken exhaust manifold. The engine mounting was also cracked. It is possible that the fracture at the exhaust manifold occurred on the morning of 21 July.

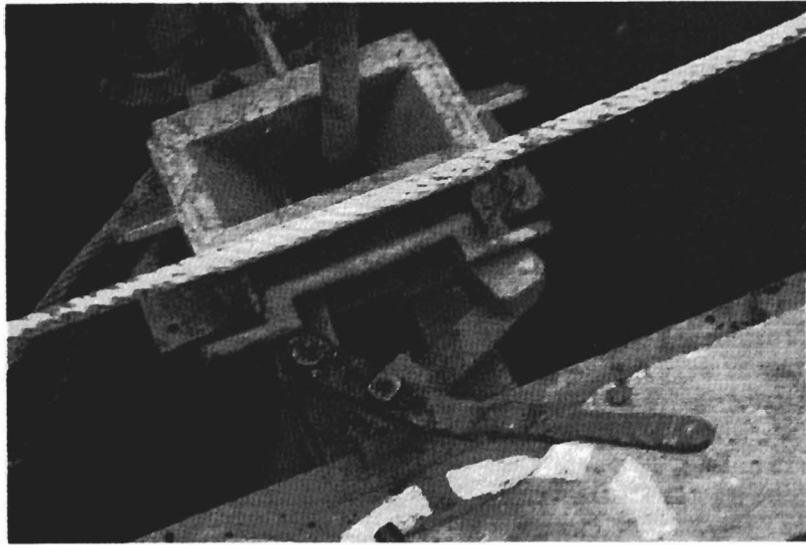
Despite the deficiencies noted, the port lifeboat may have provided an appliance which, in the short term, could have preserved the lives of those aboard, had it been capable of being launched.

However the port lifeboat could not be released from the forward fall and block using the patent release mechanism. The forward thwart, which had evidently been renewed some time in the past, did not permit full travel of the releasing handle, whereas the after thwart had been fashioned to allow proper operation of the release mechanism.



Photograph 10 Port lifeboat forward fall release gear in the open position with handle fouling thwart. Note oiled hinge pins.

Photograph 11 Port lifeboat aft fall release gear in the open position



The lifeboat was stated to have been used extensively at the anchorage at Fujairah in June and seen in the water by a company superintendent. It was submitted by the owners that the forward thwart had been repaired at Fujairah in June 1991. It was, according to the owners, immediately realised that the thwart was the wrong shape and it would have to be re-fashioned with a bit of elementary carpentry at the first opportunity. The owners went on to submit that the crew would not have used the release mechanism, and nobody would have drowned for this reason.

The Inspector, while accepting that the thwart may have been repaired as stated, rejects that there was no danger to the crew through this serious deficiency. It is totally unacceptable in a situation where the ship is abandoned in an emergency, in rough seas where simultaneous release of the falls is essential to prevent the boat being suspended by one fall, for the release mechanism to be inoperable. Moreover it was known to be in this condition for over 21 days. It was extremely fortunate that the after lifeboat fall was not released. Had it been, all those in the boat would have been thrown into the water and undoubtedly some, if not all, would have perished.

The deficiency in the release mechanism appeared, from the condition and apparent age of the wooden thwart, to have been of long standing and may have passed a number of surveys.

However, whether or not the repair was made in June, the problem must have been obvious to the crew and could easily have been rectified by shipboard staff immediately.

The starboard boat, being on the windward side, had not been made ready on 21 July, the harbour pins were found to be in place preventing the davits from operating. It was apparently the practice aboard the Kirki to leave the pins in during a sea passage. The hull of the boat appeared in good order, but the fittings and equipment appeared to be rusted and inadequately maintained. Despite the reported inspection by the Kirki's crew at Fujairah, who assessed the boat as being in good condition, the equipment in the boat was found to be in a poor condition, and it was reported that the engine was very hard to start. The exhaust pipe was secured by wire and the thwart to which the fuel tank was connected was rotten.

The general condition of the boats, including the corroded exhaust pipes, deficient cordage and equipment, should have been detectable to surveyors and at other relevant inspections. The defects must also have been apparent to the officers who purported to carry out routine inspections in accordance with the company instructions. All deficiencies could have been repaired by ship's staff.

One of the liferafts from the Kirki was recovered by HMAS Geraldton. It is assumed that this raft was stowed forward as required under SOLAS Chapter III Sub-Regulation 26 1.4. When recovered the two lower buoyancy tubes were inflated but the arch tube was not and pieces of the canister were fouled in the painter. Subsequently the liferaft, an "Autoflug" type 6MM Mark 4 (Serial No. 1221 of 3/73), was examined and tested by two surveyors from the Australian Maritime Safety Authority and the manager and serviceman from International Liferaft Services, Fremantle.

The examination found that the arch tube had been torn off the top buoyancy tube on one side and about half the canopy ripped loose from the upper buoyancy tube. The operating head and CO2 gas bottle were in good condition and had fired recently. Examination of the raft showed that it had been immersed in oil but that the fabric coating appeared to have been in good condition.

All four of those who inspected the raft agreed that the liferaft had been properly serviced and was in an acceptable condition before launching. They considered that the damage to the liferaft and in particular the pieces of liferaft canister fouled in the painter are consistent with wave-impact damage and being washed clear and then inflating.

The remaining two liferafts, stowed aft of the lifeboats, were launched by the ship's crew but, at some time before the arrival of the helicopters, broke loose and were not recovered.

(ii) Fire-fighting equipment

An inspection of the fire-fighting equipment on board found that a significant number of hoses, extinguishers and other equipment were defective. Of 32 portable fire hoses, eight out of 10 in the engine room leaked badly under pressure and five out of 22 hoses in the accommodation and on deck were also defective.

The ship was equipped with deck-foam monitors situated at intervals along the main tank deck and two water cannon on the poop deck just forward of the accommodation block. While apparently serviceable, there was evidence of marked corrosion on the supply side of these units.

Inspection of fire extinguishers in the engine room and ratings' accommodation showed a significant number were deficient through lack of reasonable maintenance and care. The extinguishers were 5kg dry-powder type with an internal CO₂ gas bottle acting as a propellant, activated by a trigger mechanism at the end of a short hose, and two 45kg dry-powder extinguishers, one at the boiler front and one on the lower plates at the fore part of the engine. All extinguishers carried labels showing an inspection date of November 1990 and a "due" date of November 1991.

There were nine extinguishers on the lower engine room platform, of which four were defective; two had been discharged, one had a damaged hose and trigger mechanism, and one had a broken internal pipe. The 45kg dry-powder extinguisher had a broken trigger, empty CO₂ cylinder, and the wheels on the trolley were seized.

The upper engine room had nine extinguishers of which one 5kg extinguisher was found to have an empty CO₂ cylinder, a broken trigger and to be half empty of powder. The 45kg extinguisher by the boiler front was half empty of powder.

Water to the fire mains could be provided by one of three pumps in the engine room, a dedicated fire pump, the general service pump, or the Butterworth tank-cleaning pump.

When Captain Hancox arrived on board on the afternoon of 21 July the general service pump was running supplying water to the fire main. On 22 July when the bulk of the salvage crew boarded the ship it was found that the fire pump and Butterworth pump* were not operational. Although the general service pump was found to have a badly worn bottom bearing, in the absence of an alternative, the pump had to be kept running as a safety precaution.

* The Butterworth pump is the pump used for supplying water to tank cleaning machines for water washing cargo tanks and can be interchanged to supply the fire main.

The general service pump was eventually rebuilt on 14 August after the other pumps had been made operational using the ship's equipment and from spares kept on board.

When started the main fire pump tripped the circuit breaker on the electrical distribution board. A spare overload relay was supplied from ashore and the pump was repaired by the salvage crew.

The Butterworth pump and fire pump also supplied water to the deck-foam smothering system. When tested the Butterworth pump was reported to have achieved a pressure of 3kg per square centimetre, giving an inadequate throw from the deck-foam monitors, and the pump itself was subject to excessive vibration. Inspection revealed the bearing to be completely devoid of white metal, and that the shaft was worn and misaligned by 4mm. The salvors located spare bearings on board and machined them to suit. The shaft was fitted with an oil distribution ring and improvised coupling sleeves. The pump was then fully operational.

The deck-foam system consisted of a 9 cubic metre tank situated in a dedicated space to the port side of the pumproom. The tank bore a stencil notice stating that it had been refilled in February 1990. The tank had been repaired in way of the top of the gauge glass, and this repair had carried away when examined by Mr Wilkinson, and further examination showed that it was in a generally rotten state.

An operational test of the system showed that the dosing pump and protein foam were satisfactory. The foam monitors on the cargo deck, however, although well painted, had numerous holes in the delivery pipe work.

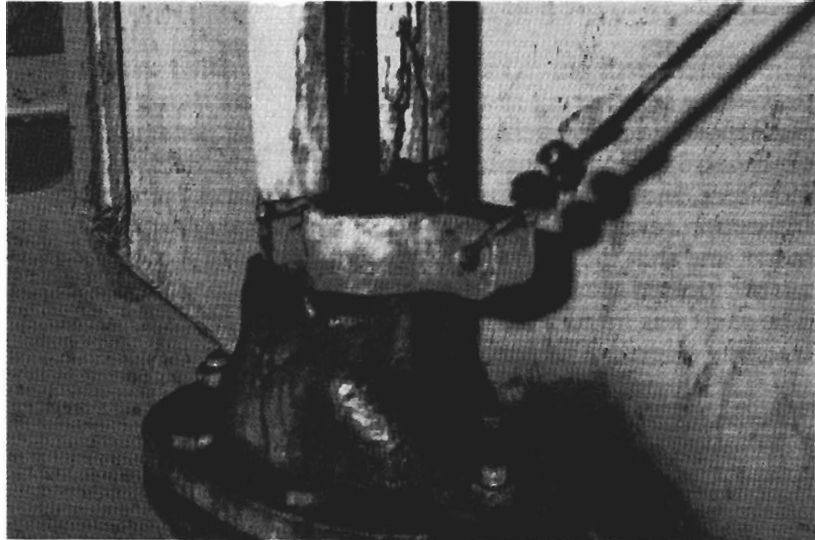
The Engine and Pumproom CO₂ smothering system carried an inspection label dated 17 November 1990. In the view of Mr Wilkinson and the Inspector, the level of rust found on the cylinders and the condition of the hoses were greater than would be expected under normal deterioration over an eight to nine month period.

The pumproom was also protected by the CO₂ smothering system. The control station for the pumproom CO₂, located to the starboard side of the pumproom, was not marked and had to be hammered open. When opened, the alarm switch did not activate and had to be operated by hand.

In the event of an emergency requiring the shut down of engine room machinery, engine room fuel tanks are so fitted that they can be closed from outside the engine room space. The Kirki was fitted with mechanical wire operated remote controls sited on the starboard funnel casing deck which, when operated, released bridge pieces holding the valves open. These bridge pieces were all found to have been lashed around the valve spindle with wire so that the trips could not be operated.

The number of turns and gauge of the wire would have made it impossible for the wire to be broken by the operation of the remote controls and for the valves to close remotely.

Photograph 12 & 13 Remote fuel shut offs and valve bridge pieces bound with wire.



Although the owners submitted the salvors bound the bridge pieces, the Inspector does not accept this. He is satisfied that the binding with wire of the remote fuel trip mechanism was done by crew members, not necessarily those onboard at the time of the incident. However, the bindings must have been obvious to all engineering staff. By rendering the system inoperable, the safety and lives of the whole crew were placed in jeopardy.

The engine room fire flaps, intended to seal the engine room funnel space and isolate the engine room in the event of fire to allow operation of the CO₂ smothering system, were seen to be corroded and wasted to a degree that they could not be effective.

The Inspector is unable to accept that certain of the basic safety features, such as the fire hoses, engine room fire flaps and the CO₂ control cabinet for the pumproom, had not been in that condition for some considerable time, or that the condition of the foam tank was not detectable at the last survey.

It was apparent that, of the hoses that failed pressure tests, a number had not been used or effectively inspected at survey for some considerable time, if at all.

The number of fire extinguishers that were found to be deficient is also of extreme concern. It is not possible to gauge their condition when the Safety Equipment Certificate was issued, or at their last inspection by Atlas Marine Services in November 1990, but the responsibility for ensuring that they are maintained in an operational condition rests with the ship's staff.

Again it is not possible to say for how long the fire and Butterworth pumps had been deficient. The Butterworth pump was probably used in Fujairah when the tanks were washed with water. The fact that, with the exception of the circuit breaker, both pumps were repaired from ship's stores suggests that these safety items in particular, and the engine room machinery and equipment in general were not maintained to a high standard.

(iii) Cargo and associated systems

In preparation for the proposed transfer of the crude and fuel oils remaining on board, the cargo system and related safety equipment was also examined. The Kirki was equipped with three steam turbine centrifugal pumps, situated in the engine room against the pumproom bulkhead, each capable of discharging 2670 cubic metres an hour at 1350rpm. All three pumps had evidently been used at the last discharge. The condition of the pumps was poor with a number of deficiencies.

Each of the three main cargo pumps had emulsified oil in the gear box and the gear teeth were rusted. Among other defects, control gauges were not working and basic safety mechanisms, such as the

over-speed striker pins, which were part of a system to close down the pumps in the event of the pump over-speeding, were so heavily painted that it was doubtful that they would operate. In addition, on the starboard pump, the over-speed trip link* arm was wedged with wood so that it could not operate. The grime and dirt covering the wedge, which prevented the over-speed operation, indicated that it had been in that condition for many months. Also the lubricating oil low pressure trip mechanism was disconnected. The over-speed trip on the port pump failed when the pump was run during the early stages of salvage operation.

The pumproom bilges were found to be 1.5m deep in crude oil, most probably the result of the leaking valve chests on the stripping pumps situated in the pumproom.

The pumproom bulkhead had corroded through at main deck level by way of an engine room tank vent where four such vents pierced the bulkhead. These vents were removed by the salvage crew before the transfer and the corroded area sealed. Close to this was an explosion-proof fluorescent tube light fitting which was broken. A number of light fittings in the pumproom were not working and their gas-tight fittings found to be insecure. All such fittings were made safe by the salvage crew.

The inert gas system components were found to be below a reasonable standard. The Kirki's "Inert Gas System Maintenance Record Book" records that inspections of the equipment had been undertaken at regular intervals, mostly monthly. The last inspection shown was 6 July 1991 when all components were recorded as satisfactory and signed by the Master, Chief Engineer and Chief Mate. This entry did not accord with the condition of the equipment on 23 July or 11 August.

Although the "deck water seal" had stencilled on it the legend "Inspected Washed 20.6.91", the dedicated water supply line was blocked for a significant length by silt and rust; the overflow line was blocked; the main non-return valve on the delivery side of the deck water seal was holed, allowing gas (including cargo vapour under certain circumstances) to flow back to the water seal and the water level in the deck vacuum breaker, close to the fore end of the main deck, was low. There were also a number of significant faults in the IG control system, with various warning signal transmitters inoperative.

* Basic safety mechanisms, such as the over-speed trip on the starboard pump, are designed to protect the cargo system in the event of the loss of suction by the pumps, resulting in over-speeding and cavitation. Over-speeding and cavitation can lead to overheating of the pumps with the subsequent risk of fire in the presence of a volatile cargo and to over pressurisation of the cargo pipeline system, leading to burst pipelines and hoses, with the attendant risk of explosion.

(iv) Pollution control equipment

The Kirki carried a current International Oil Pollution Prevention Certificate required under the provisions of MARPOL 73/78, issued by Germanischer Lloyd, following a survey in March 1988. The certificate was valid to 19th November 1991, and had been endorsed at annual surveys in September 1988 and August 1989 and an intermediate survey in September 1990. Under the terms of the certificate, no exemption from, or equivalent provisions to, MARPOL 73/78 had been granted or approved by the Greek Maritime Authorities.

Under MARPOL 73/78 tankers are required to retain oily water, both cargo slops and bilge water, on board. Discharge of water associated with the oil is required to be monitored.

Under Regulation 16 of Annex 1 to the MARPOL Convention "Oil Discharge and Control System and Oily-Water Separating and Oil Filtering Equipment", any ship of 10,000 tons gross and over must be fitted with an oily-water separating and monitoring equipment and a control system. If such a unit becomes defective, the unit shall be made operable before the vessel commences its next voyage.

The Kirki was equipped in accordance with the resolution. However, it was noted that the engine room oily-water separator had no three way motor valve. Such a valve was shown as part of the system in the makers manual (page 13), but was not fitted to the Kirki's system. Also the 15 ppm alarm monitor did not work according to the instruction manual and it was not possible to reset the zero point, hence calling into question the accuracy of the LED light display.

The owners submit that the system, a Poseidon PL-15, was designed to comply with MARPOL 73/78 and the system does not require a three way motor valve fitted in the system, but has a safety shut off system which automatically stops the pumping of oily waste of more than 15 ppm.

However when testing the equipment, Mr Wilkinson could not get the alarms to operate and consequently could not get the shut down mechanism to work. Neither was he able to reset the zero point as detailed at page 6 paragraph 6 of the makers manual.

The Kirki was fitted with a system to monitor discharge from the cargo tanks, specifically six wing slop tanks. From the ballast discharge oil content monitor record automatically printed on to a paper roll, this system was inoperative since March 1989. The sampling motor was missing and the pump had seized.

The owners confirmed that the system had been "out of use" since 1989, because they preferred to only discharge slops to barges and habitually did so. It is noted that according to the vessel's "Oil Record Book" the oily tank washings from tank cleaning operations off Fujairah, were transferred into a lightering tanker.

There would appear to be no provision in MARPOL 73/78 to permit a crude oil carrier on an international voyage to dispense with the oily-water monitoring/pumping requirements. No exemption or equivalent provisions were contained in the IOPP Certificate.

With the defects in the engine room oily-water separator system and the ballast discharge monitor, it is doubtful whether the Kirki complied with Convention requirements in the control of oily-water discharge to the sea.

(v) Engine-room safety

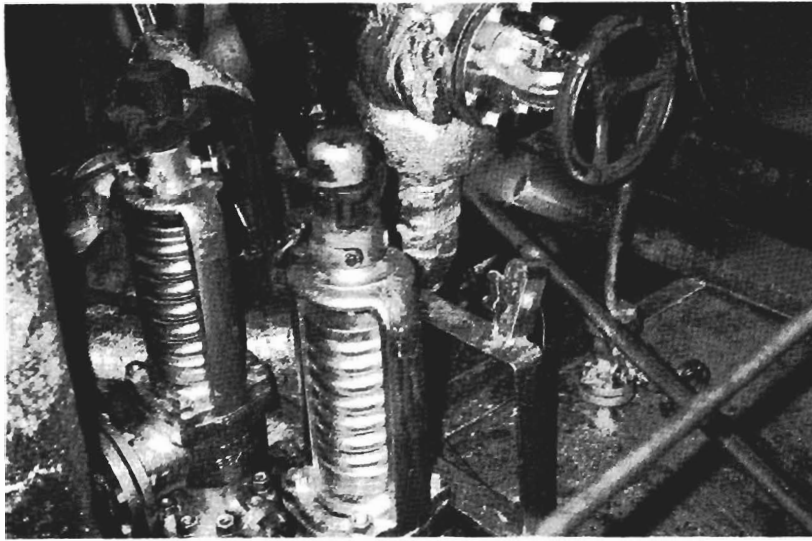
The engine room was not well maintained despite the facade of well painted machinery and steel work. While many of the deficiencies might not have affected, to any significant degree, the safety of individuals or their ability to respond to an emergency, three such deficiencies were serious.

There were no audible or visual alarms that operated outside the engine room control room, except the CO₂ alarm and fire alarm, to warn staff outside the control room, in the engine room space, of any malfunction of machinery or equipment, or other emergency.

The emergency generator, which was located at the after end of the accommodation in a space off the poop deck, was inoperable. The fuel tank was found to be empty with a 6mm hole in the bottom of the tank, apparently caused by corrosion. The bottom of the tank was covered in sludge and rust to a depth of 10 to 15mm, and the suction filter was blocked. The salvage crew rigged a temporary tank to allow operation of the generator.

The potentially most dangerous defect related to the boiler safety valves. On 19 August, Mr Wilkinson reported that the port boiler's secondary circuit-feed pump stopped and the water level was lost in the steam drum. At the time the lightering tanker was letting go and all the salvage and transfer crew were on deck assisting with the operation. No trips or alarms operated, the primary boiler fire remained in operation and the boiler secondary circuit safety valves did not lift, despite pressure in the boiler rising to at least 46 bar before being discovered. The boiler fire was tripped manually and the safety valves, which were rated to lift at 37 bar, had to be levered open with crow bars to prevent an explosion. It was reported that in resetting the valves the springs had to be eased about 4cm to reset the valves to lift at the correct pressure.

Photograph 14 Port boiler primary drum safety valve failed to operate at 46 bar. Note missing easing gear.



(vi) International Load Line Convention requirements

Load Line Convention requirements are that ventilators, air pipes and openings on exposed freeboard and raised quarter decks, and on exposed superstructure decks, including machinery space openings, should be in good condition and closing arrangements are required to be effective.

While the Kirki had undergone a load line survey in February 1991, vent pipes on the poop deck level, part of the load line requirement, were wasted, and it was noted that the engine room hatch, although secured closed, did not appear to be weather tight.

At some time in the past, defects in the tank lids to No 13 and No 14 (No 7 wings) ballast spaces had been deliberately hidden. Canvas patches were found, covered by paint, on the inside of both tank lids. When removed, the lids were found to be corroded through and the holes covered by canvas on the inside of the lid and covered both inside and outside with normal deck paint, so as to hide the lid's condition.

The owners made a number of submissions in respect of the deficiencies identified in this section of the report. Relying on statements from ship's officers and superintendents they state that the equipment was operational and in good condition. They went on to state that the condition and deficiencies in the engine room machinery resulted from the inexperience and neglect of the salvage team. Having regard to the nature and extent of defects observed during the investigation, the Inspector cannot accept the owners' submissions.

It is concluded that:

- The defects in the life-saving appliances, fire-fighting equipment, cargo equipment and the condition of engine room equipment were so numerous and of such a nature that the Inspector cannot accept that they all developed over a short period of time
- The patching with canvas and the camouflaging of No 7 tank lids was a deliberate attempt to mislead any person undertaking a load line survey. It is not possible to determine when the lids were patched, and it might not have been done with the knowledge of the owners or those on board the Kirki on 21 July 1991.

SECTION 10

Previous surveys and inspections

A ship owner has the prime duty and obligation to maintain a ship's condition and ensure that it is seaworthy. In turn, the owner and other interested parties place a degree of reliance on the survey carried out by the Class Society and the fact that such surveys are up to date, with no relevant outstanding recommendations or limitations.

The Kirki held valid certificates and had been subject to a number of non statutory inspections since June 1990. The failure of the bow structure, and the observed condition of the ship and its equipment, call into question the effectiveness of all the surveys and inspections undertaken.

Convention requirements

Ships are required to conform to basic standards of equipment, construction and pollution control under international marine conventions. To ensure compliance with these conventions ships must undergo periodical statutory surveys by, or on behalf of, the flag state.

Regulation 10 of Chapter 1 of SOLAS 74 applies to all ships and provides for the surveys of hull, machinery and equipment of cargo ships. It specifically provides that every ship will undergo an initial survey when built and thereafter periodic (special) surveys for hull, machinery and equipment (other than items surveyed under the Cargo Ship Safety Equipment, Radio Telegraphy and Radiotelephony Certificates) at intervals specified by the Flag State Administration, but not exceeding five years. Thus, in general terms, when a ship is 20 years old, the fifth special survey (including the special construction survey) is due, providing surveys are carried out routinely every five years.

In addition to the five-year periodic surveys, tankers must undergo at least one intermediate survey within six months of the half-way date of the certificate's period of validity. Also annual inspections for the endorsement of loadline, safety construction and safety equipment certificates must be undertaken.

Statutory surveys are conducted on behalf of the flag state which, under the provisions of Regulation 6(e) of Chapter 1 of SOLAS 74, are required to fully guarantee the completeness and efficiency of the inspection and survey, and to undertake to ensure the necessary arrangements to satisfy this obligation.

The SOLAS 74 requirements are similar to provisions under the MARPOL 73/78, contained in Annex 1, Regulation 4. There is also requirement under both conventions that a vessel and its equipment must be maintained to conform with the required standards, so that it is fit to proceed to sea without danger to the ship and the persons on board, and so that it does not present an unreasonable threat of harm to the environment.

Survey history

The Kirki completed its initial survey by Lloyds Register of Shipping, at the building yard, in December 1969.

Since early in 1986 the ship had been issued with statutory certificates on behalf of the Hellenic Republic of Greece, by Germanischer Lloyd.

The Kirki was first surveyed by Germanischer Lloyd in Singapore in January 1986, when classification and annual class surveys were carried out on behalf of the new owners, Kirki Shipping Corporation. Late in November 1986 the ship was surveyed in dry dock in Piraeus, when a new period of class covering hull and machinery was granted for five years to November 1991, having the effect that the vessel's five-year special survey, which theoretically would be due when the ship was 20-years-old, would not be undertaken until the ship was 22-years-old. This survey regime nevertheless conformed to convention requirements.

The International Safety Construction Certificate was issued at Hamburg in January 1987 and was valid to November 1991, subject to mandatory annual surveys; and the International Safety Equipment Certificate was issued in September 1989 and was valid to 30 August 1991.

The Kirki underwent annual surveys in October 1987 and September 1988 and further Class Society and statutory surveys were completed at the vessel's dry docking in Bahrain in August 1989 ("S 7") and afloat at Fujairah ("S 8") in February 1990. In September 1990 the Class Certificate was confirmed until November 1991 ("S 9"). In addition, statutory surveys were completed on behalf of the Greek Maritime Authorities and certificates endorsed, including the Cargo Ship Safety Construction Certificate mandatory annual survey.

The Kirki was surveyed by Germanischer Lloyd, on behalf of the Hellenic Republic, for the statutory International Oil Pollution Prevention Certificate (Intermediate survey) and the mandatory annual survey for the Cargo Ship Safety Equipment Certificate in September 1990. The Society also issued an International Load Line Certificate on 24 January 1991, valid, subject to periodical inspections, until 23 January 1996.

In issuing the full term Load Line Certificate on 25 February 1991, Germanischer Lloyd did not make any inspection to assess whether the strength of the ship's structure was consistent with the ship's assigned load line, and did not survey tanks 13 and 14. This was regarded as quite consistent with the regulations for determining load lines. Regulation 1 of Annex 1 to the International Load Line Convention 1966 requires:

"The Administration shall satisfy itself that the general structural strength of the hull is sufficient for the draught corresponding to the freeboard assignment.

Ships built and maintained in conformity with the requirements of a classification society recognised by the Administration may be considered to possess adequate strength."

(Emphasis is that of the investigator.)

On the basis that Germanischer Lloyd was satisfied that the ship had been maintained in accordance with its rules, there would have been no requirement upon the Society to undertake an inspection of the ship's structure.

Given the observed condition of the ship and the large number of serious deficiencies, some of apparently long standing, found in the engine room bulkhead, the boiler safety valves, life-saving appliances, fire-fighting equipment, inert gas system and the oily-water discharge system, it is difficult to understand how the ship passed survey inspections so regularly. The condition of the ship in general, calls into question the thoroughness of surveys, in particular of the hull and spaces aboard the ship.

Other inspections

The Kirki had relatively recently been subject to a number of inspections including:

- BP Vetting Services on behalf of the charterer
- Mayamar Marine Enterprises, as part of their management function
- the Australian Maritime Safety Authority under Port State Control as provided for in Regulation I/19 of SOLAS 74, and under the Australian Tanker Surveillance program.

In addition, tanker loading and discharging operations should be carried out in accordance with the International Safety Guide for Oil Tankers and Terminals (ISGOTT), the third edition of which was carried by the Kirki, a publication that all tankers arriving in Australia are expected to carry. Before each discharge or loading operation, an inspection of any tanker is carried out in accordance with ISGOTT. Therefore the officers aboard the Kirki were obliged to complete a check list, in conjunction with the shore installation, confirming the operational safety of the ship's cargo and safety equipment.

BP

BP Australia had used the Kirki on 10 occasions in the period since 1988, importing cargoes to the Australian ports of Brisbane and Kwinana. In the previous 12 months, the Kirki had also performed three voyages for another major oil company and one voyage on behalf of a foreign government.

BP Australia advised that as the ship was more than 20-years-old, BP Vetting Service inspected the ship on 8 June 1990 at Fujairah and found it to be satisfactory. The inspection covered the general outward condition and maintenance, manning, operation and observance of safe practices aboard the Kirki.

While on charter to BP, the ship had operated without any report of problems related to safety.

Port State Control and Tanker surveillance.

The Kirki had also been subject to a number of routine inspections by the Department of Transport and Communications (latterly the Australian Maritime Safety Authority).

Under Port State Control provisions, the Kirki was subject to an inspection directed towards verifying that SOLAS 74 and LL 66 certificates were valid. Under the "Control" Provisions of the conventions such certificates "shall be accepted unless there are clear grounds for believing that the condition of the ship or of its equipment do not correspond substantially with the particulars of any certificate...". Given the Kirki's appearance of being well maintained, and in the absence of any reported deficiencies, the surveyor had no grounds for a more detailed examination of the ship.

Tanker Surveillance Inspections are more extensive and are carried out to establish that the tanker's cargo and related operations are safe and conform to acceptable safety standards. The inspecting surveyor has a check list of relevant items selected from ISGOTT, principally relevant to ship-shore procedures, to confirm as satisfactory. The surveyor is required either to confirm these elements as satisfactory or advise the master or port authority of deficiencies.

The Kirki was inspected under the Australian Tanker Surveillance Program and under Port State Control Procedures in May 1988, January, July and November 1989. Under the Tanker Surveillance Program, deficiencies were noted on two occasions relating to the absence on board of the publication ISGOTT. The ship berthed at Kwinana on two occasions in 1990, in January and again in March; no inspections were undertaken on these visits.

The most recent inspections were conducted at Kwinana, when a Tanker Surveillance Inspection was conducted on 7 May and a Port State Control Inspection on 8 May 1991.

No deficiencies or comment accompanied either report.

Company inspections

Mayamar Marine Enterprises operated a system of ship inspections, whereby a Port Captain would from time to time inspect a ship and complete a "Ship Inspection Report". The most recent inspection to the Kirki was conducted at Singapore on 10 February 1991.

The owners state that this inspection was carried out in conjunction with a surveyor engaged on behalf of the Mobil Petroleum Company.

The items inspected included the life-saving appliances, fire-fighting equipment, the cargo system, inert gas, and pollution prevention system. The inspection is recorded in a pro forma booklet and the inspection of 10 February involved checking some 27 "A5" pages of items. The only negative comments recorded in the report related to the fact that the position of spare gas and oxygen bottles were not clearly marked, some of the Whessoe tank calibrating gauges were not working, there was some problem with the last link in the anchor chain ("the bitter end") and the cargo stripping pumps in the pumproom were leaking.

The number and type of inspections carried out by BP Vetting, Mayamar Marine Enterprises and AMSA, under the Port State and Tanker Surveillance regimes, when considered against the observed condition of the ship (Section 9), raises the issue of the effectiveness of such inspections.

Overall it is concluded:

The Kirki carried all necessary statutory safety certificates. Safety surveys had been carried out within the schedules required by the relevant international safety conventions. The scheduling of the Kirki's special five year survey at 22 years, rather than at 20 years, was consistent with the ship's survey program and within the rules covering the frequency of special surveys.

Having regard to the conclusions reached in Section 9 (Observed Condition of the Ship) that the defects in equipment were so numerous and of such a nature that the Inspector cannot accept that they all developed over a short period of time, significant deficiencies should have been observed during surveys by Germanischer Lloyd, inspections by BP Vetting and Mayamar Marine Enterprises, and under Port State inspections by the Australian Maritime Safety Authority.

Germanischer Lloyd were responsible for the issue of statutory certificates on behalf of the Hellenic Republic of Greece. The procedures adopted by the Society during structural surveys failed to identify the area of localised corrosion. The condition of ballast tanks 13 and 14 together with the number and nature of deficiencies in safety equipment, indicates that a number of surveys over a period of time, including surveys that were conducted under international safety conventions were not performed effectively.

SECTION 11

Conclusions

The Inspector concludes:

1. The flooding of the fore-peak tank on the evening of 20 July, was due either to a failure in the ship's shell plating forward of frame 93, or the shearing of the fore peak ballast pipeline at the shell plating on the port side.
2. It is not possible to be precise as to the cause of the structural failure forward of frame 93 (the bow). It was either due to the action of sea water, which had flooded the fore-peak, impinging heavily in the area of frame 93, which led to an overload on the structure, or to a loss of bow plating. Either one or a combination of these factors led to excessive stress on an area of the ship's structure already weakened by corrosion and the effects of repair work.
3. The source of the ignition causing the original fire was either sparks caused by the mechanical action of the tearing of the steel work, or the arcing of broken electrical cables forward.
4. The subsequent five fires were caused either by static electrical discharges or by the arcing of broken electrical cables.
5. There is no evidence that the loading operation at Jebel Dhanna contributed in any way to the incident.
6. Any stress to the ship's hull caused by maintaining propeller revolutions at 95 rpm through the gales of 4 to 6 July and in the sea conditions of 18 to 20 July was to an area already weakened structurally. It would have been prudent to reduce the revolutions in such weather.
7. The Master acted properly in putting the wind and sea on the starboard quarter, on the evening of 20 July, when it became apparent that the fore-peak tank was breached.
8. The Master acted properly and in the best interests of his crew in evacuating the bulk of the crew from the ship.
9. After the evacuation of the bulk of the crew, the Master failed to make a realistic assessment of the situation. The risk to life would have been minimal had a skeleton crew remained to secure a tow and assist the Salvage Master.
10. In evacuating the ship, the crew did not significantly increase the risk of fire by leaving the B and W Holeby generator operating. They were prudent in closing down the boilers.

11. The use of alcohol and/or drugs was not a factor in the conduct of the Master or crew in responding to the fire and during evacuation of the ship.

12. The Master did not initiate adequate direct communications with the shore authorities.

13. The discharge of oil into the sea was as a result of the damage to the ship. Mayamar Marine Enterprises responded immediately, in engaging United Salvage Ltd, to minimise the discharge and effects of possible pollution.

14. The Kirki carried all necessary statutory safety certificates. Safety surveys had been carried out within the schedules required by the relevant international safety conventions. The scheduling of the Kirki's special five-year survey at 22 years, rather than at 20 years, was consistent with the ship's survey program and within the rules covering the frequency of special surveys.

15. The defects in the life-saving appliances, fire-fighting equipment, cargo equipment and the condition of engine room equipment were so numerous and of such a nature that the Inspector cannot accept that they all developed over a short period of time.

16. The patching with canvas and the camouflaging of No7 tank lids was a deliberate attempt to mislead any person undertaking a load line survey. It is not possible to determine when the lids were patched, and it might not have been done with the knowledge of the owners or those on board the Kirki on 21 July 1991.

17. Significant defects should have been observed during surveys by Germanischer Lloyd; inspections by BP Vetting and Mayamar Marine Enterprises; and under Port State inspections by the Australian Maritime Safety Authority.

18. Germanischer Lloyd was responsible for the issue of statutory certificates on behalf of the Hellenic Republic of Greece. The procedures adopted by the Society during structural surveys failed to identify the areas of localised corrosion. The condition of ballast tanks 13 and 14 together with the number and nature of deficiencies in safety equipment, indicates that a number of surveys over a period of time, including surveys that were conducted under international safety conventions, were not performed effectively.

19. The prompt action by the Master and crew of the Lady Kathleen stabilised the situation by preventing the tanker from drifting closer to the shore, where it would have stranded, and allayed immediate concern as to the damage that it and its cargo might cause.

20. Had a tow not been secured, the Kirki would have eventually grounded on the Australian coast, somewhere between Wedge Island and Jurien Bay, probably late in the morning of 22 July.

21. The loss of oil from the Kirki on 25 July was due to a failure of the already weakened structure, compounded by the sea and swell conditions. The loss of oil on 5 August was due to faulty or fractured valves on the pipeline system. No oil pollution resulted as a consequence of cargo operations by the Salvors.

SECTION 12

Submissions received under regulation 16(3) & (4) of the Navigation (Marine Casualty) Regulations

Submissions were received from:

Kirki Shipping Corporation SA on their own behalf and that of the Mayamar Marine Enterprises, Captain Efstathopolous and the Crew, BP Australia Limited, Germanischer Lloyd.

Reference is made below to elements of any substantive submission that has not been incorporated into the text of the report.

Submission on behalf of the Owners, Managers, Master and Crew

In accordance with Regulation 16 of the Navigation (Marine Casualty) Regulations, the owners and managers have made a number of submissions, in their own interests and on behalf of the Master and crew.

Where appropriate these submissions have either been incorporated into the text of sections 1 to 11, or otherwise addressed in this section. In this section the Inspectors comments are in italics.

The owners and managers made substantive submissions relating to:

- (i) The record and background of the owners and managers
- (ii) The actions and competence of the salvors

1. The record and background of the owners and managers.

The owners submitted that more detail with regards to the ownership and management of the Kirki should form a new section following Section 4.

The Inspector considers that the essential details are contained in the existing text.

The following text is reproduced as submitted by the owners .

“The Owners and Managers

The vessel was purchased by the Kirki Shipping Corporation in 1986. She has since then been managed by Mayamar Marine Enterprises, of Greece. Mayamar is part of the group of companies owned by the Mavrakakis family, who are well known in the shipping world and have a first class reputation. Mayamar have managed vessels since 1972. They presently manage ten tankers. In the past they have had as many as 26 tankers under their management at any one time.

These vessels range in size from 9000 DWT up to 230000 DWT. The Kirki was typical of the type of tanker managed by Mayamar with 97000 DWT. She had no unusual operational features or peculiarities and any capable officer or seaman would have no difficulty in serving on board. There are hundreds of very similar tankers plying the oil trade routes of the world.

Mayamar vessels have a particularly good safety record. In the whole of their history there have been no actual total losses, there have been two constructive total losses, the Epimonos, badly damaged in a fire off Rouen in 1979, and the Ariadne, struck by a missile in the Gulf during the Iran/Iraq war. This can be confirmed by consulting Lloyds Confidential Index.

Mayamar also state that only one of their vessels has ever suffered from collision - the Kriti in 1979 was involved in a collision with Hellenic Laurel, in the Bosphorus.

There have been only three previous instances of fires breaking out on a Mayamar managed vessel, in the whole of their history. The Dafni had a fire as the result of a missile strike in the Persian Gulf in 1988. The Faedra had a fire at sea in the accommodation in 1988 which was extinguished by the crew. The Drastirios had an Engine Room fire in 1989, which was also extinguished by the crew.

There have been no serious casualties other than these listed above in the whole of the history of the company. None of these casualties gave rise to loss of life or even injury. No officer or seaman has ever died as the result of any casualty or incident on any vessel managed by Mayamar.

The company and individual officers have frequently received acclaim and awards of one sort or another from government institutions and authorities around the world, e.g. the US Coast Guard for contributions to the Amver rescue system and recognition from the United Nations Organisation for rescue of Vietnamese refugees (boat people) in the South China Sea.

Mayamar tankers have constantly been employed or chartered by the oil majors including Exxon, Texaco, Shell, Mobil and BP. Many leading first class oil companies charter Mayamar tankers including Agip, Chevron, Total, Coastal States, Vitol and KPC.

BP Australia have had different Mayamar tankers on charter continuously since 1987 e.g. Tolmiros, Dafni, Promitheas, Filikos, Synetos and Elounda. These vessels including the Kirki have traded to Australia and New Zealand continuously since 1987 without any complaints from either BP Australia or from any Australian Port Authority or surveyor.

The Synetos (built 1967) called at Kwinana for discharge in August 1991, under charter to BP Australia was rigorously inspected by the Department of Transport and Communications Marine Surveyor, and found with only 12 minor deficiencies, fit to discharge. The Australian surveyor congratulated the owners on maintaining the Synetos in such excellent condition. The Synetos discharged without incident. She was older than Kirki by 2 years. The managers are confident that all their vessels are maintained to the highest standard. The company has always since its inception followed a policy of purchasing second-hand vessels, and constantly improving and upgrading the standard of seaworthiness and maintenance to the very highest. All their vessels have been purchased with equity funding i.e. cash. The Kirki was unencumbered with any mortgage or bank loan at the time of this casualty.

It is and always has been the company's policy that vessels trading worldwide fly the Greek flag and employ Greek crews. Greece is not a flag of convenience.

The company employs seven superintendent engineers and three port captains, whose sole function is to inspect each ship and ensure its continued seaworthiness in every aspect. The policy of the company is that there shall be present at every port of discharge of every vessel an engineer or port captain in order to assist the master, ensure smooth operation, and inspect the condition of the vessel. This policy has been followed in relation to the Kirki."

2. *The actions and competence of the salvors*

The owners make a number of detailed submissions in relation to the salvage crew aboard the Kirki.

A number of these submissions do not relate to the failure of the bow, the subsequent fire or the loss of oil during the tow to the position east of the Monte Bello Islands. They are essentially matters that will be properly considered by the salvage arbitrator.

Submission by BP Australia Ltd.

BP emphasised in its submission that the inspection by BP Vetting and AMSA did not include the structure or the tank internals.

Submission by Germanischer Lloyd

The ship's classification society, Germanischer Lloyd (GL), stated that the report contains several allegations and assumptions that the society cannot accept. In particular, it objected to "those parts of the report in which the Classification Society is blamed for allegedly not having acted in compliance with classification rules". The Society maintained that all surveys had been carried out on the basis of and in accordance with the applicable rules.

"In addition it does not accept the blame laid on the Classification Society without taking into consideration that it is the Shipowner's first duty and obligation to maintain the vessel's condition and to maintain her in a seaworthy state."

In reference to the issue of a full term Load Line Certificate, the Society points out that the issue of a full-term Load Line Certificate is on the basis of a current valid class certificate, providing class is not limited in any way. This procedure is in compliance with the International Load Line Convention 1966, Annex 1, Regulation 1 (quoted in the report). This procedure is covered in GL's rules:

"4. If for some reason a vessel's class has expired or been withdrawn by GL, irrespective of any regulations of the competent flag State, the certificates issued by GL, for which validity of class constitutes the technical basis, will automatically become void. If subsequently the class is renewed or re-assigned, validity of these certificates will within the scope of its original period of validity be revived, provided that all surveys meanwhile having fallen due have been carried out."

GL notes the report is critical of the scope of the Load Line Survey and that the survey did include proof of the Kirki's structural strength. As class was not restricted, GL submitted that the sections of the report should be deleted.

GL referred to the statutory items (equipment) as not being in compliance with the required standard. The Society stated its concern and have referred the items to their surveyors in charge in the field for comment. It notes, however, that this equipment had no influence on the actual casualty.

Casualties involving structural failure to older ships, particularly bulk carriers, have been a cause of concern to the shipping community, including classification societies, for some years.

GL submitted that the Kirki is typical of the world-wide problem of ageing tonnage. It points out that in view of incidents to older ships, classification societies took individual and collective action at an early stage to substantially strengthen procedures for the survey of water ballast tanks, including shortening the interval between surveys. The new regulations agreed by the International Association of Classification Societies (IACS) ("Unified Requirement" 27) came into force for member societies on 1 July 1991.

GL states that under procedures in force prior to 1 July 1991 (Kirki's most recent survey for an International Load Line survey was conducted in February 1991) tanks 13 and 14 were not required to be inspected between special safety construction surveys (4 years + 1 year of grace). However, these tanks would have been inspected under the new IACS regulations in November 1991.

GL concluded by submitting that, in an increasing number of cases the ship owner, who should cooperate with the classification society in supervising the condition of the ship, no longer ensure sufficient compliance with class requirements.

**GENERAL WEATHER DESCRIPTION
AND SEA CONDITIONS**

BUREAU OF METEOROLOGY

21 July 1991

At 0000 UTC the low was near Esperance. A secondary low centre appears to have developed off the southwest coast with associated thunderstorm activity. It is unlikely that these thunderstorms extended to 30S, although showers would have continued. The linking of these two features (indicated by a trough on the surface chart) eased winds over coastal localities south of Jurien Bay. Winds would have shifted more to the west initially but would have eased dramatically from 0400 UTC onwards as the trough appears to have drifted to the north. By 1000 UTC, a light to moderate southerly wind prevailed over the 'Kirki' region. Little change would have occurred during the remainder of the period to the 22nd, with the pressure gradient weakening considerably.

COMMENTS ON WIND, SEA WAVE AND SWELL WAVE ESTIMATES

As the study was performed on a manual basis, errors due to approximations need to be defined. Some of the difficulties associated with making these estimates are also mentioned below.

Estimates of sea state and wind were based primarily on analyses for the whole of the Indian Ocean of mean sea level pressure. Efforts were made to re-analyse certain of these pressure charts, but not every chart was re-analysed. The more detailed Western Australian region surface charts were also used, however, no attempt was made to re-analyse these charts. All charts had been analysed in an operational working environment. The process of re-analysis involves scrutiny of satellite imagery and observations without the severe time constraints of the operational working environment. A post analysis also has the advantage of a knowledge of the future weather which makes the task easier. Other aids used in this study were computer generated fields of swell wave height and Marine Boundary Layer (MARBL) surface winds. Both of these are operational fields from the Australian Bureau of Meteorology in Melbourne. Final estimates resulted in the interpretation of the compilation of these information sources. This interpretation is based on traditional methods such as estimating winds from pressure gradients in conjunction with observations, and the World Meteorological Organization's "Guide to Wave Analysis and Forecasting".

Observations from ships are important to verify results, however the accuracy of observations varies markedly with each ship and difficulties arise when attempting to interpret discrepancies between different ships and apparent weather conditions. This is particularly noticeable with sea and swell estimates which are often made well above sea level, and also accuracy seems to diminish in rough or stormy weather. Nevertheless, ship observations were useful especially in the pressure analysis over the ocean, comparing changes in weather from a ship in time, and comparing observations from different ships to gain an idea of reliability.

The availability of data is also crucial to any study and unfortunately the Indian Ocean is largely data sparse. This creates problems for the initial surface analysis and any interpretation such as this one. Analysis relies heavily on the interpretation of satellite imagery. The lack of detailed ship observations was a particular problem in this instance in relation to the "cut-off low" which affected regions near the coast between 18-20 July 1991. Its development and movement were very complicated. On 18 July the low developed more than one centre. The positions and structure of these "mesoscale" lows are often difficult to resolve which causes additional inaccuracies. Locally stronger winds and consequently increased local seas can result due to the presence of such lows. Also, thunderstorms which may have affected the ship on 18 and 19 July can cause local rough seas and strong gusts in squalls. Such wind and sea state are very difficult to quantify without the appropriate instrumentation and generally the given values would have been less than those existing under such situations.

Generally, estimates are considered to be within the following values of the actual conditions - to 5 knots for wind speeds with the greater inaccuracy occurring with stronger winds, 30 degrees for wind direction, 0.5 - 1.0m for sea wave heights, and 1.0 - 1.5m for swell wave heights.

It is quite possible that these limits have been exceeded at times due to local conditions, or if some of the ship observations were in error, or if synoptic scale pressure gradients were not resolved fully on the surface analyses. The swells specified are the dominant swells. It is likely that residual swells from other directions occurred at various times but these were not estimated to be above 2m and are not quoted here. For these reasons, the ESE swell is not mentioned after 16 July and the S'ly swell is not mentioned after 0600 UTC 21 July.

Of particular interest is the weather on 20 and 21 July. On 20 July a strong SSW wind generated high seas, with a significant swell from the south also occurring. As the ship came closer to the coast, this southerly swell is believed to have weakened as the southwest capes of Western Australia would have acted as a barrier. The extent and timing of this weakening is dependent on the precise position of the ship as the swell would have varied considerably depending on the distance from the coastline. Values have been determined from the interpolated positions indicated. If the ship was closer to the coast at this time, then the swell would have been appreciably less than the estimated figure given.

On 21 July, a trough moved northwards resulting in a dramatic easing of the WSW wind to a light southerly. At this point, the wind speed dropped below the value needed to maintain the heights of the existing sea waves, and these waves have then been described as swell waves.

It must be emphasised also that swell heights are average or characteristic. Higher individual waves do occur with the maximum height being generally approximated as twice the average swell. However, when more than one swell is occurring or a sea wave and swell occur from different directions, then the maximum swell height is approximated by twice the square root of the sum of the squared averaged heights. Hence at 20 1800UTC, the maximum individual wave that could be expected would approximate to nearly 13m.

WIND, SEA WAVE AND SWELL WAVE ESTIMATES FOR "KIRKI"
19 - 22 JULY 1991

DATE	TIME (UTC)	WIND		SEAS (M)	SWELL		DIRECTION FROM	HEIGHT (M)
		DIRECTION ° TRUE	SPEED KNOTS		DIRECTION FROM	HEIGHT (M)		
19	0000	200	20-25	2.0	SSW	4.0		
	0600	200	20-25	2.0	SSW	5.0		
	1200 #	180-240	30	2.8	SSW	5.0		
	1800 #	220	35	4.5	SSW	5.0		
20	0000	200	30	4.5	SSW	5.0		
	0600	240	30	4.5	SSW	4.5		
	1200	220	30	5.0	S	4.5		
	1800	250	30	5.0	S	4.0		
21	0000	250	30	5.0	S	4.0		
	0600	250	25	4.5	S	3.0		
	1200	180	10	0.5	S	2.5	WSW	3.5
	1800	180	10	0.5	S	2.0	WSW	3.0
22	0000	190	10	0.5	WSW	2.5		

Gusts to 50 knots are possible with local seas possibly higher.

WIND ESTIMATES FOR AREA NEAR 30S 114E FOR 'KIRKI' 22-24 JULY 1991

DATE	TIME UTC	WIND DIRECTION DEGREES	WIND SPEED KNOTS	COMMENTS
22	0000	190	10	
22	0600	220	5	
22	1200	270	8	
22	1800	270	10	Wind increasing
23	0001	280	15	Wind shifting to NW after 0200
23	0600	300	25-30	Frontal passage, winds shift NW to WNW
23	1200	300	30	
23	1800	270	25-30	
24	0001	240	22	Wind easing, Weak wind shift at approximately 2100
24	0600	230	18	
24	1200	230	10	
24	1800	250	5	

Note: Higher gusts likely in showery, squally periods from 230200UTC to 240400UTC especially on and for a period after the front.

CONSULTANT REPORT

**METALLURGICAL INVESTIGATION OF A SAMPLE TAKEN
FROM THE DECK OF THE TANKER "KIRKI"**

S.J. ALKEMADE and D.S. SAUNDERS

MATERIALS RESEARCH LABORATORY
DSTO

Report No C91/6003/MD

Copy No 1 of 4

CONSULTANT REPORT

METALLURGICAL INVESTIGATION OF A SAMPLE TAKEN
FROM THE DECK OF THE TANKER "KIRKI"

S.J. ALKEMADE and D.S. SAUNDERS

Approved By

Prepared By

W. de Morlan 11/11/91

Chief, Materials Division

S. J. Alkemade
D. S. Saunders

Author

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CONSULTANT REPORT

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S.J. ALKEMADE and D.S. SAUNDERS

SUMMARY

A sample of plate taken from the damaged tanker "Kirki", from a position adjacent to the main fracture line at the bow, was examined and found to be in a severely corroded state, with up to 90% of the plate thickness having been lost in some areas. The corrosion was predominantly of a general nature with some shallow pitting attack. The location of the major fracture surfaces suggested that the corrosive attack occurred mainly on the under-side of the deck plate, possibly in the region of the forward ballast tank of the vessel.

The fracture surfaces on the sample were considered to have been produced by overloads, probably at the time of the bow fracture. The fracture surfaces through the thick sections of the plate showed the fracture was a ductile fracture, which was typical behaviour of the steel.

The exact cause of the bow fracture could not be established from examination of this sample.

Report C91/6003/MD

METALLURGICAL INVESTIGATION OF A SAMPLE TAKEN
FROM THE DECK OF THE TANKER "KIRKI"

1. INTRODUCTION

MRL was requested by the Department of Transport and Communications (DTC) to undertake the analysis of a sample of steel work from the tanker "Kirki" and to determine its various characteristics related to its quality and age [1]. This work was requested as part of the Marine Accident Unit undertaking of a full technical enquiry into the casualty of the Greek-registered tanker "Kirki" off the West Australian Coast on 21st of July 1991.

A loosely adherent sample, taken from the upper deck of the tanker "Kirki", was received for study from the Department of Transport and Communications. The sample was taken by the Inspector of Marine Accidents and was claimed [1] to have been taken from the forepart or leading edge of the failure line of the vessel. The sample was taken from the starboard side, approximately 6 metres from the centre-line of the vessel. The sample, as received, is shown in Figure 1.

DTC also supplied photographs [1] of the forward ship structure which showed general views of the failure. Of particular interest in these photographs was the thinning of the deck plates; the deck plates appearing perforated at certain locations. The photographs showed that the deck plates were severely corroded at specific locations. In addition, some of these photographs showed the extremities of what are presumably longitudinal support members which appear to have been foreshortened, possibly by fracture. The condition of these members may be an important factor in determining the cause of bow fracture.

2.

2. RESULTS AND DISCUSSION

The sample, as received, was covered with oily deposits and was in a corroded state, all of the surfaces being covered with an iron oxide (rust). No chemical analyses were conducted on the deposits or the corrosion products.

On cleaning, examination showed that the main fracture surfaces were located at either end of the thicker section, see Figure 1. Some tearing was noted in the thin sections of the sample. Remnants of weld metal can be seen delineating the edges of the thicker section and indicate the location of a second plate or bulkhead at this position.

It was difficult to ascribe an orientation for this specimen, since no photographic evidence of its provenance was supplied. It was suggested [1] that the flat surface of the sample was the under-surface of the deck plate and the 30 x 100 mm raised section marks where the after fo'c'sle bulk head was situated and which ran across the deck. It was not possible, however, to reconcile the fracture locations and plate thinning with this particular orientation. As stated in the paragraph above, the two main fracture surfaces occurred in the thick section of the plate and it is considered that, for this to occur, significant loads would need to be imposed along the length of the raised section. It is difficult to see how such loads would have occurred with this section being across the deck. It is considered therefore, that the raised section would need to be orientated along the axis of the ship and this raised section would be where the plate was welded to a longitudinal stiffener. It is likely, therefore that the fracture surfaces were generated at the time of the failure of the ship as the fracture forward of frame No. 93 occurred.

Wear or rub marks were in evidence on the flat surface, which is considered to be the upper surface of the plate, as shown in Figure 2. These marks appeared to be relatively "new" as they were not as highly corroded as were other sections of the sample. It was not possible to ascertain the cause of the rub marks on the upper side of the deck plate. These rub marks may have been caused by one section failing shortly before the second (and final) fracture. This early fracture may have resulted in a surface which moved under a deck plate creating the rub marks.

The sample section had been substantially thinned by corrosion attack in all regions except those which had been shielded by the attached plate. If, as the evidence suggests, the raised section was over a longitudinal stiffener, then the region of most corrosion was in the under-deck region; in the forward ballast tank. The thickness of the sample varied from 11 mm in the thick central section and reduced progressively with distance to approximately 1 mm at the sample extremities. See section A-A shown in Figure 3. The attachment welds had also been substantially reduced in size by corrosion.

Optical microscopy of the upper and lower surfaces of the deck plate showed that the corrosion attack was predominantly of a general nature. There was no evidence of intergranular cracking, but some shallow pits were in evidence on the surface, as shown in section B-B in Figure 4. This figure also shows the microstructure of the sample which is composed of ferrite and pearlite, entirely as expected from mild steel to Lloyd's Grade A specification.

3.

A chemical analysis of the steel plate was undertaken and the results are given in Table I. The results confirm that the steel conforms to the chemical requirements of Lloyd's Grade A specification which is summarised in Table II.

Hardness tests were conducted on the plate. The hardness of the plate varied from 195-210 HV10 in the thick section to 160-170 HV10 in the thinner section. These hardness values were considered high for this material (typically 140 HV10), but may be due to work hardening during deformation and fracture.

It was not possible to undertake detailed fractographic studies of the two main fracture surfaces on the sample because of their corroded state, however, fracture profiles were examined under an optical microscope. A typical region from a fracture surface, section C-C, is shown in Figures 5a and 5b. The fracture surface exhibits evidence of grain elongation and necking indicative of a ductile fracture mode. It should be noted that this is the type of fracture normally associated with high loads. A low carbon steel in this microstructural condition does not fail as a result of "crystallization" as a popularly held misconception would suggest.

3, CONCLUSIONS

In the absence of details on the provenance of the sample, the location of the fractures has suggested that the sample was originally orientated on the vessel such that the flat surface was the upper-side of the deck and the raised section was where the plate was welded to a longitudinal stiffener.

The extensive reduction in thickness of the plate, primarily from the under (deck) surface was attributed to general corrosion under the marine environment. The thicker region on the sample was a region protected from corrosion by the presence of a bulkhead welded under the deck plate. Corrosion of this region of the deck *may* be exacerbated by the wash within the ballast tank. It is considered that extensive corrosion of the weld metal occurred as well, much appeared to have been removed in the sample examined in the present work. Thus, it was not possible to judge the soundness of the welds.

The fracture surfaces across the thick sections of the plate were produced by a ductile overload mechanism. The fractures were therefore overload failures as a result of high loads on this section of deck plate.

REFERENCE:

1. Department of Transport and Communications letter dated 29 July 1991.

Materials Research Laboratory

October 1991

TABLE I
Chemical Analysis of Kirki Sample, wt %

C	Mn	Si	A	P	Ni	Cr	Mo	Cu	V	Nb	Ti	Al	B
0.009	0.40	0.28	0.27	0.015	0.01	<0.01	<0.01	<0.03	<0.01	<0.01	<0.01	<0.006	<0.0005

TABLE II
Lloyd's Grade A Steel Plate Specification, wt %

	C	Mn	Si	S	P
Max. levels:	0.23	-	0.5	0.04	0.04
Min. levels:	-	2.5 x % C	-	-	-

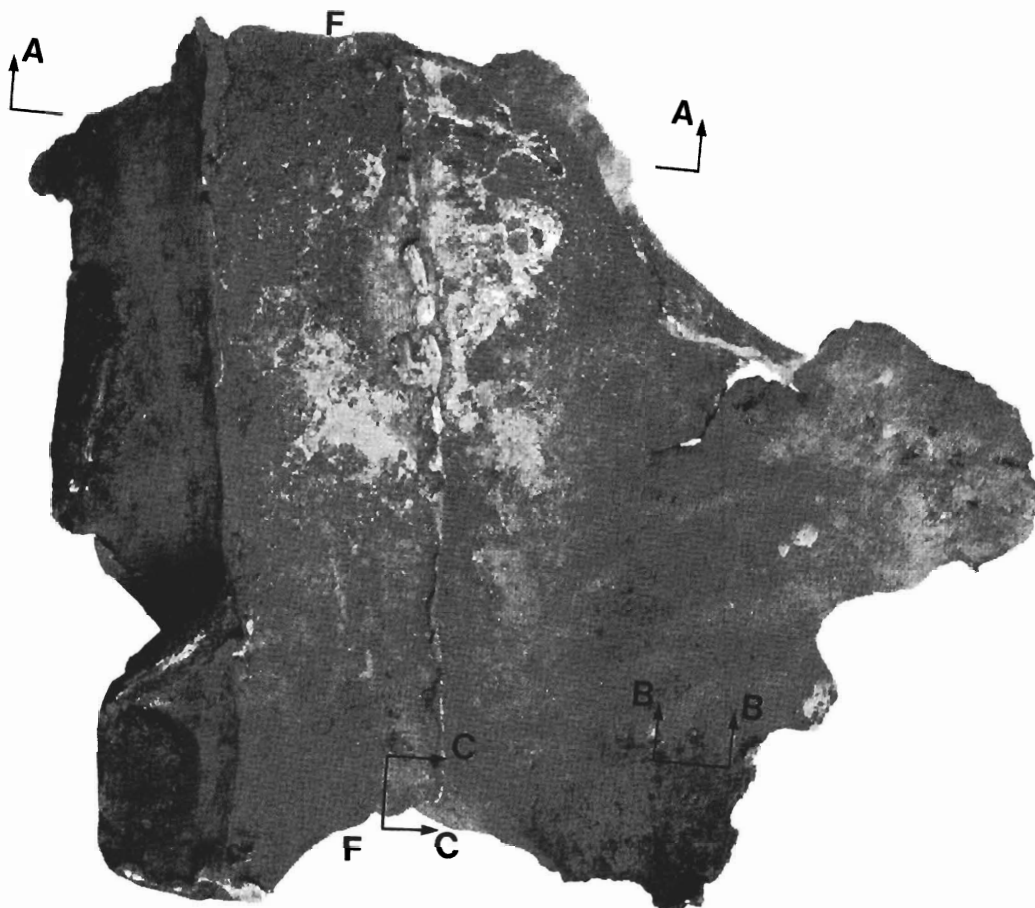


Figure 1. As received sample of upper deck plate from the tanker "Kirki" showing :

- a. Weld remnants (two lines of projections running top to bottom) delineating site of previously attached plate.
- b. Main fractures (marked F).
- c. Sections taken for further study: A-A, B-B and C-C.

(Mag. X 1 approx.)



Figure 2. Reverse side of the view shown in Fig. 1 showing rub marks.
(Mag. X 0.9 approx.)

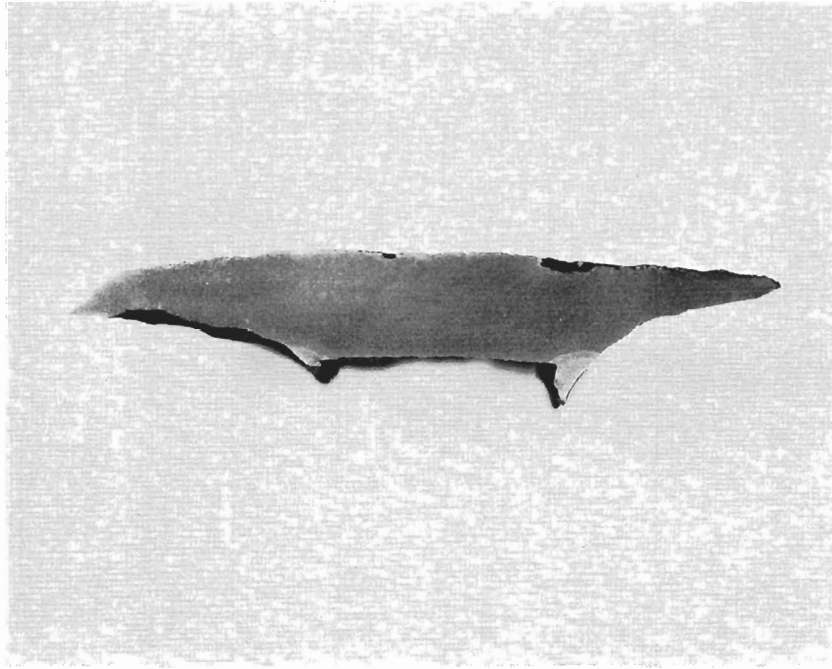


Figure 3. Section A-A (Refer Fig. 1), showing extent of plate thinning by corrosion. Weld remnants mark the site of a previously attached plate.

(Mag. X 1.4 approx.)

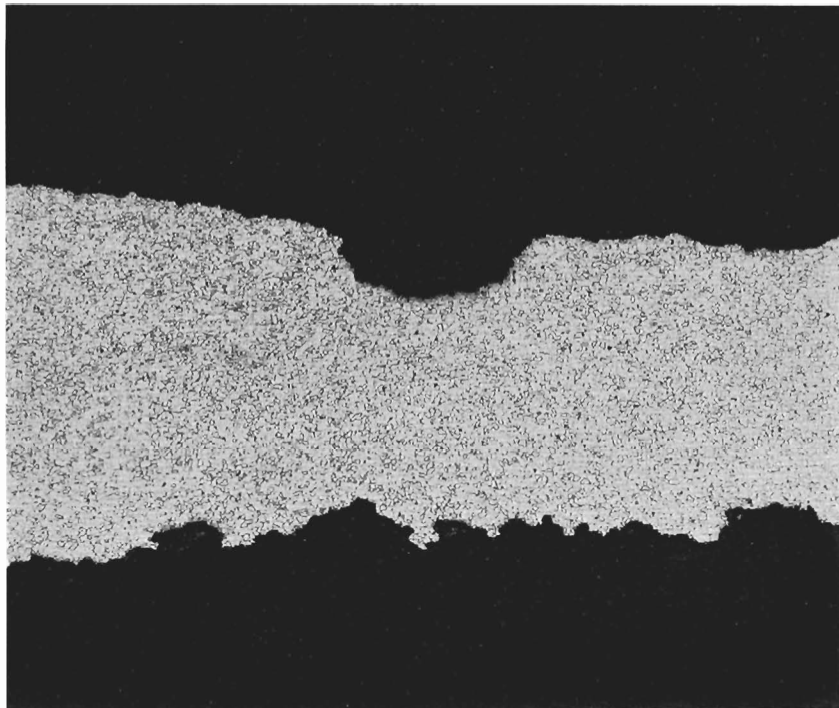


Figure 4. Optical micrograph of section B-B showing corrosion attack on upper and lower surfaces of samples.

(Mag. X 20 approx.)

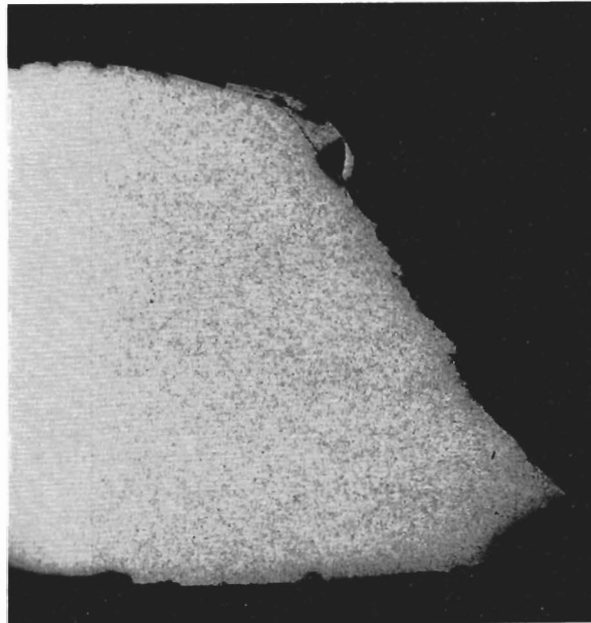


Figure 5a. Section C-C (Refer Fig. 1), through fracture in thick region. Fracture surface is at right.

(Mag, X 7 approx,)

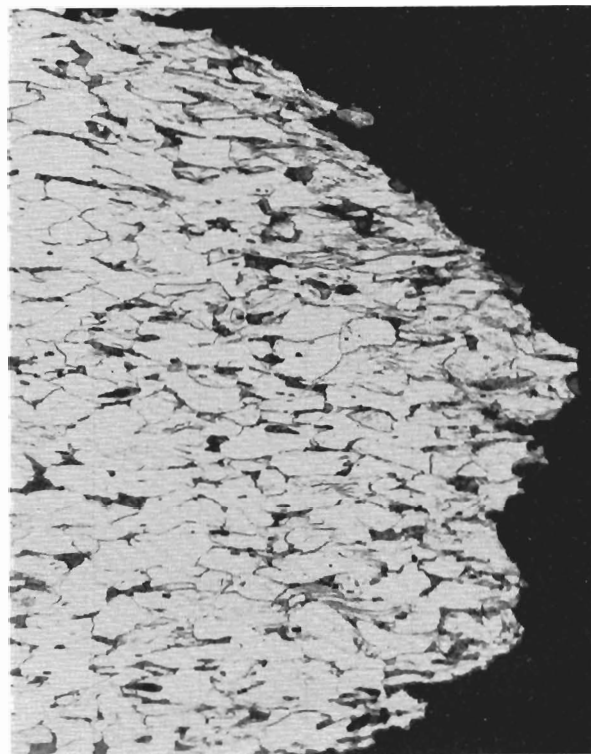


Figure 5b. Magnified view of Fig. 5a showing elongated grains adjacent to fracture, indicative of ductile overload.

(Mag. X 200 approx.)

**THICKNESS MEASUREMENTS OF *KIRK'S* DECK PLATING
23 JULY AND 11 AUGUST 1991**

Vernier gauge readings taken on 23.7.91 of the deck plating and some brackets at frame 93.5. (* approx position of readings).

Ultrasonic readings taken of adjacent deck plating on 11.8.91 (number inside circle show approx position of readings).

M.T. Kirki

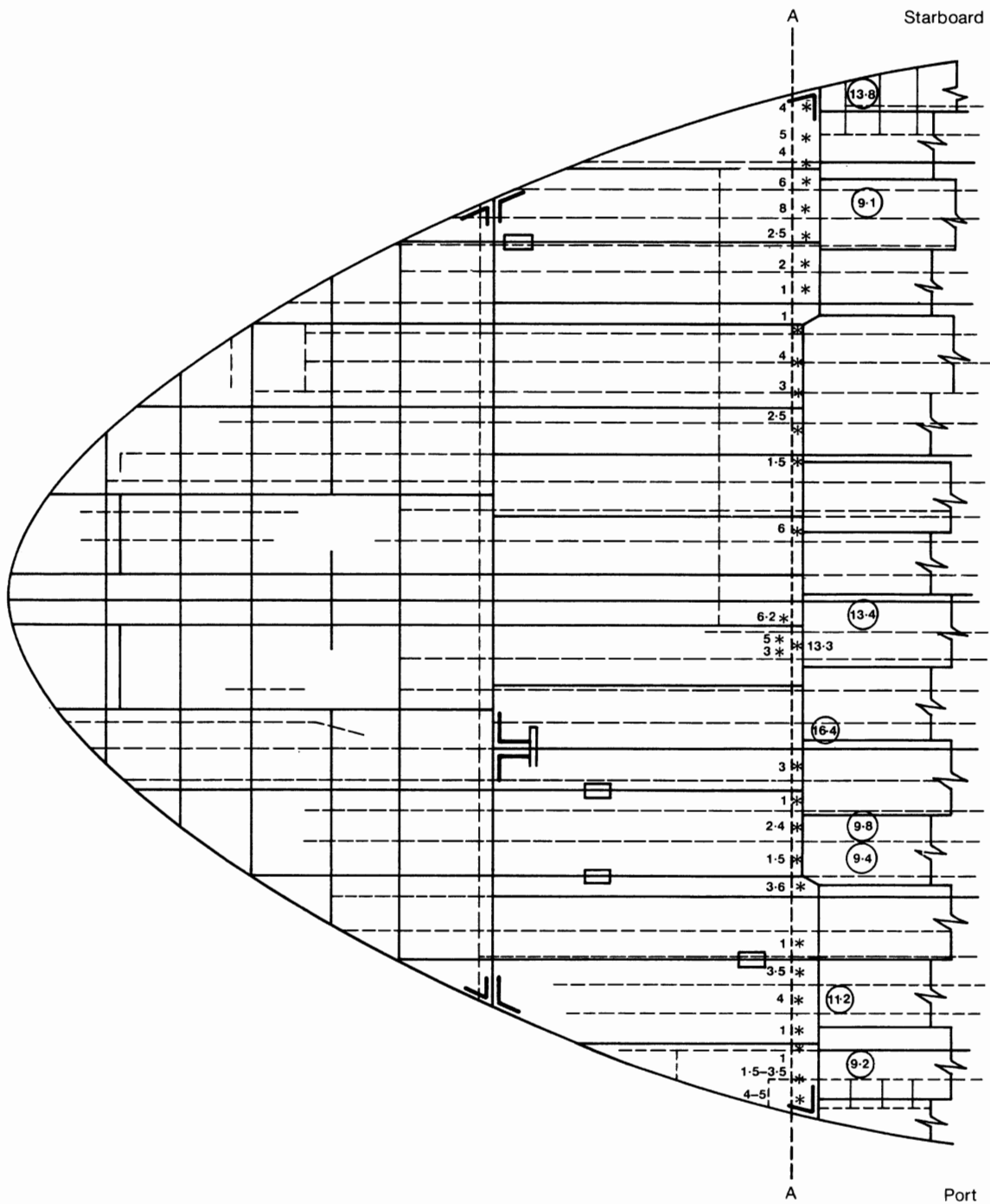
Diagram of deck plating thickness measurements

A-A line of structural failure

All dimensions in millimetres

'*' measurements by calliper 23 July 1992

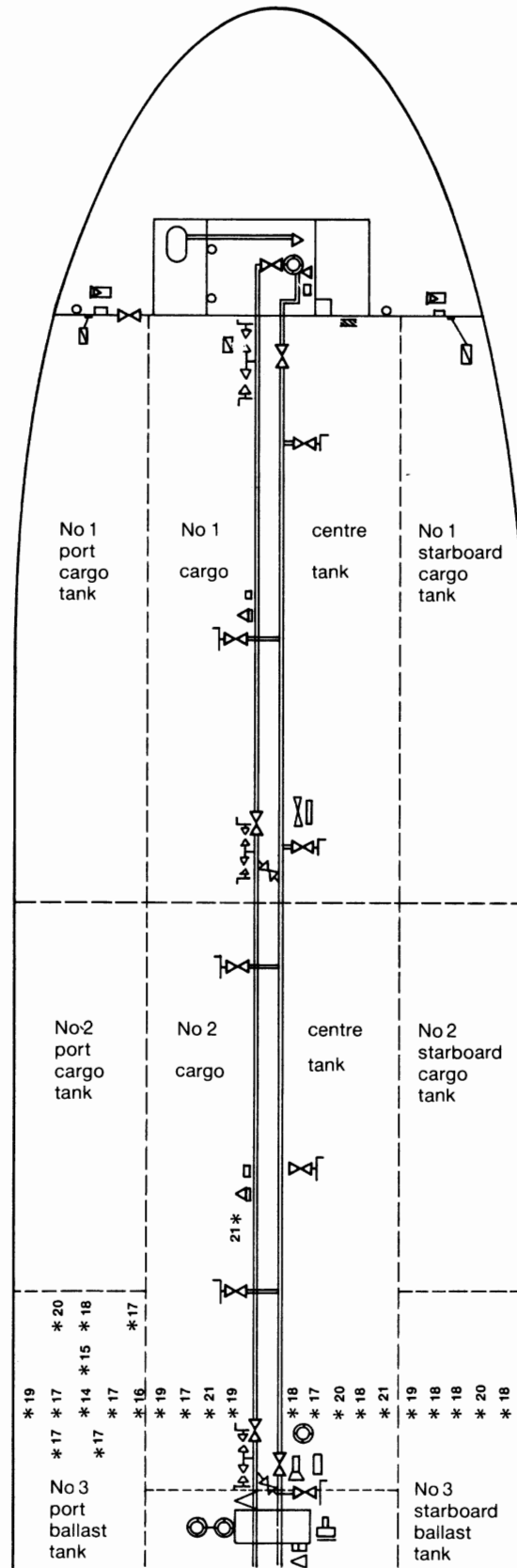
○ Ultrasonic readings taken on 11 August 1991



M.T. Kirki

Ultrasonic thickness tests 4 August 1991

All dimensions in millimetres



Diagram

THICKNESS MEASUREMENTS BY POLY NDT
SINGAPORE 17 - 18 SEPTEMBER 1991

Vessel	:	KIRKI
Date of Test	:	18th September 1991
Location	:	Singapore

Our Ref: 910806

Your Ref:

Date: 18/9/91

ULTRASONIC THICKNESS SURVEY REPORT

Tested for : Furlina Shipping Services Pte Ltd
108 Robinson Road #11-01
GMG Building
Singapore 0106

Date of Test : 17th - 18th September 1991

Job Identification : Vessel - KIRKI

Job Description : Areas gauged were :

DESCRIPTION

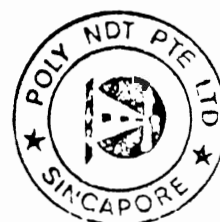
Page No

a) Main Deck Plating between Frs 92/93	01 - 02
b) Transverse Belt between Frs 92/93	03 - 05
c) Transverse Bulkhead at Fr 93	06 - 07
d) Deck Bracket at Bulkhead 93	08 - 09

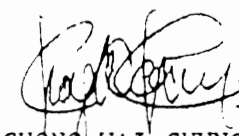
Equipment : Krautkramer DM-2 meter with probe DA 201 (5 MHz)

Accuracy : Within ± 0.1 mm

Reading : All readings are in millimeter



POLY NDT PTE LTD


CHONG WAI CHUNG
INSPECTOR

POLY NDT PTE LTD
ULTRASONIC THICKNESS SURVEY REPORT

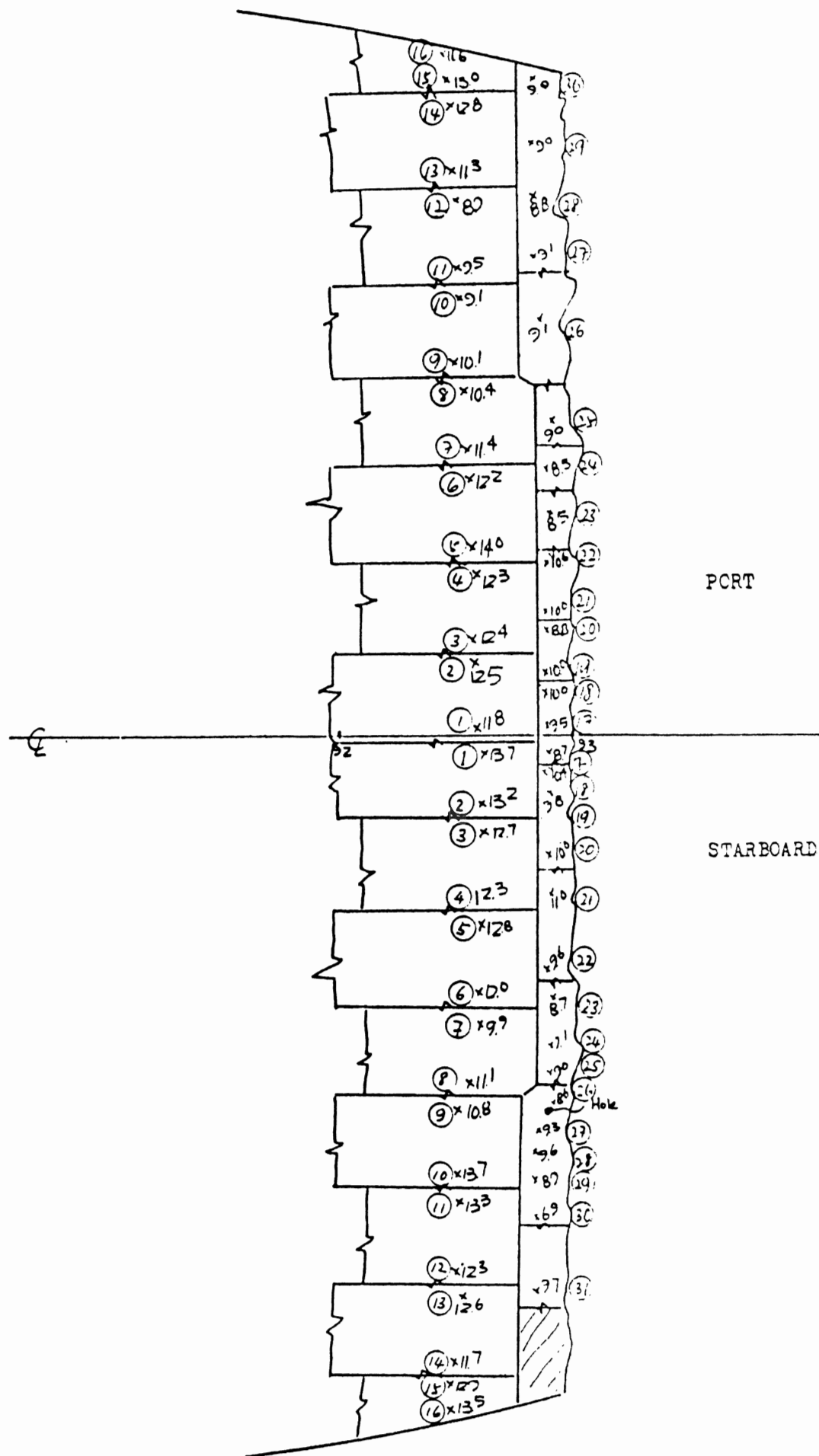
Our Ref : 910806

Date : 17 - 18/9/91

Vessel : KIRKI

Subject : MAIN DECK PLATING BETWEEN FRS 92/93

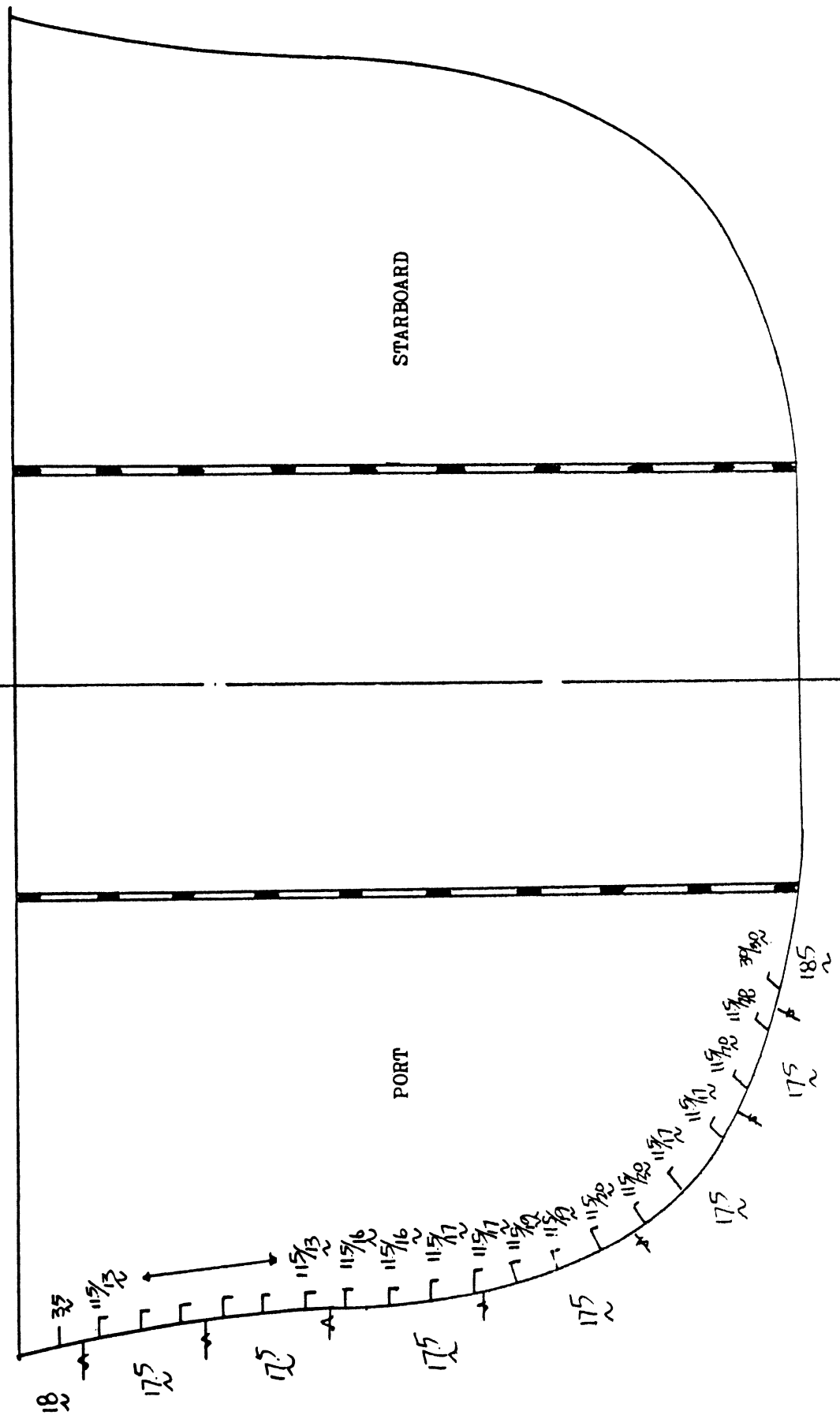
PORT				STARBOARD			
PLATE NO	ORIG	THK	DIMINUTION	PLATE NO	ORIG	THK	DIMINUTION
/READING	THK	GAUGED	mm %LOSS	/READING	THK	GAUGED	mm %LOSS
1		11.8		1		13.7	
2		12.5		2		13.2	
3		12.4		3		12.7	
4		12.3		4		12.3	
5		14.0		5		12.8	
6		12.2		6		12.0	
7		11.4		7		9.9	
8		10.4		8		11.1	
9		10.1		9		10.8	
10		9.1		10		13.7	
11		9.5		11		13.3	
12		8.9		12		12.3	
13		11.3		13		12.6	
14		12.8		14		11.7	
15		13.0		15		12.9	
16		11.6		16		13.5	
17		9.5		17		8.7	
18		10.0		18		10.4	
19		10.0		19		9.8	
20		8.8		20		10.0	
21		10.0		21		11.0	
22		10.6		22		9.6	
23		8.5		23		8.7	
24		8.5		24		7.1	
25		9.0		25		9.0	
26		9.1		26		8.6	
27		9.1		27		9.3	
28		8.8		28		9.6	
29		9.0		29		8.9	
30		9.0		30		6.9	
				31		9.7	



POLYNDT

SUBJECT MAIN DECK PLATING BETWEEN FRS 92/93

VESSEL KIRK



SUBJECT TRANSVERSE HULL BETWEEN FRS 92/93

DATE 17 - 18/11/91



VESSEL KIKKI

POLY NDT PTE LTD
ULTRASONIC THICKNESS SURVEY REPORT

Our Ref : 910806

Date : 17 - 18/9/91

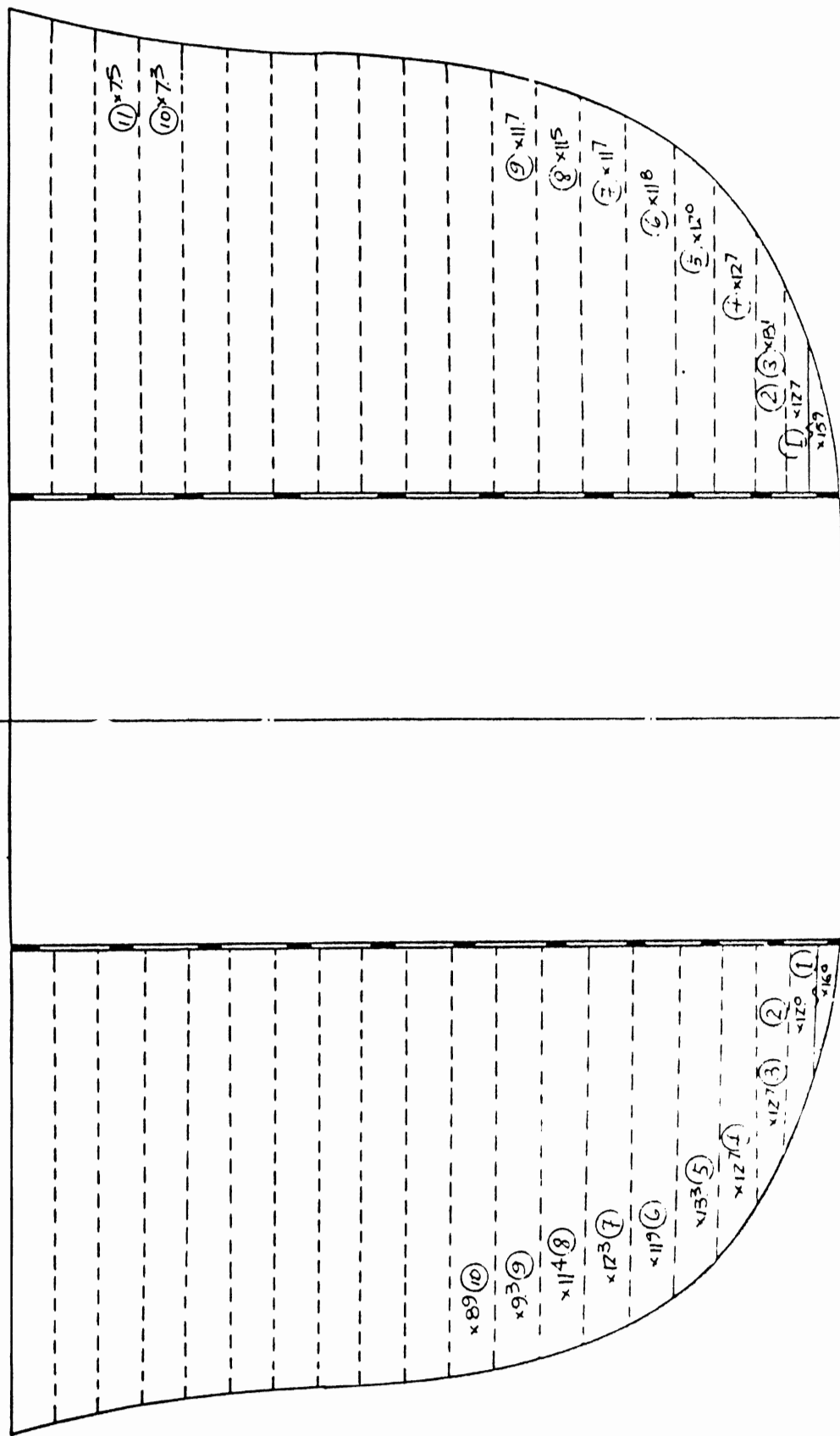
Vessel : KIRKI

Subject : TRANSVERSE BULKHEAD AT FRAME 93

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		THK	GAUGED				THK	GAUGED	
1		16.0			1		15.9		
2		12.0			2		12.7		
3		12.7			3		13.1		
4		12.7			4		12.7		
5		13.3			5		12.0		
6		11.9			6		11.8		
7		12.3			7		11.7		
8		11.4			8		11.5		
9		9.3			9		11.7		
10		8.9			10		7.3		
					11		7.5		

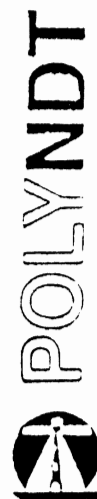
PORT

STARBOARD



4

SUBJECT TRANSVERSE BULKHEAD AT FRAME 93



VESSEL KIRKI

DATE 17-18/9/91

POLY NDT PTE LTD
ULTRASONIC THICKNESS SURVEY REPORT

Our Ref : 910806

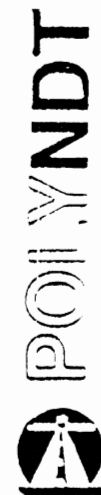
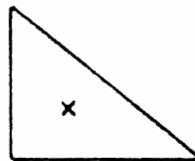
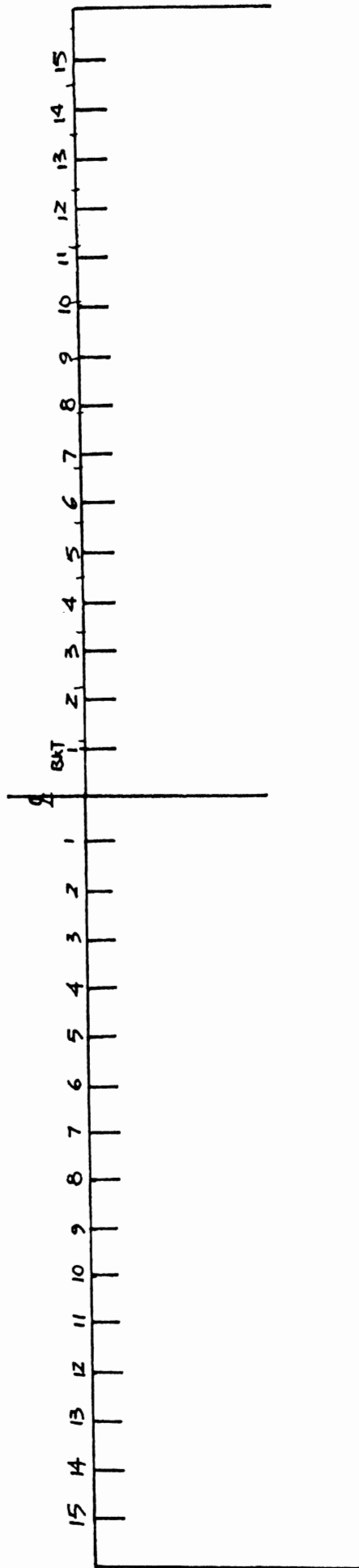
Date : 17 - 18/9/91

Vessel : KIRKI

Subject : DECK BRACKET AT BULKHEAD 93

PORT				STARBOARD			
PLATE NO	ORIG THK	THK GAUGED	DIMINUTION mm %LOSS	PLATE NO	ORIG THK	THK GAUGED	DIMINUTION mm %LOSS
/READING				/READING			
CENTRE BRACKET							
1		18.5		1		15.0	
2		20.2		2		17.6	
3		-		3		15.3	
4		27.5		4		18.8	
5		-		5		-	
6		15.7		6		14.1	
7		15.6		7		13.5	
8		15.1		8		14.8	
9		13.0		9		14.2	
10		-		10		-	
11		19.4		11		22.2	
12		18.3		12		-	
13		17.7		13		21.0	
14		18.0		14		17.2	
15		23.6		15		21.0	

ARRANGEMENT OF BRACKET



SUBJECT DECK BRACKET AT BULKHEAD 93

VESSEL KIRK I

DATE 11 - 18/9/91