Report 99-205

ro-ro cargo vessel *Union Rotoiti*

machinery failure, loss of and damage to cargo

Tasman Sea

23 April 1999

Abstract

On Friday, 23 April 1999, the ro-ro cargo vessel *Union Rotoiti*, with 19 crew on board, was on passage from Melbourne to Auckland when it encountered heavy weather. The master had deviated to avoid the leading quadrant of a depression and to reduce the motion of the vessel. Due to fuel filtration problems, the *Union Rotoiti* lost all power for about 50 minutes during which it lay broached to the sea and swell, rolling violently.

By the time power was restored, *Union Rotoiti* had suffered a substantial shift of cargo above and below deck, losing eight 40-foot and four 20-foot containers overboard.

Safety issues identified included:

- upper deck containers located on worn or damaged deck sockets
- incomplete locking of twistlocks within the upper deck stow
- the use of stacking cones between tiers of containers in the main vehicle deck where twistlocks would be more appropriate
- ambiguous instructions in the cargo securing manual for the lashing of containers in the main vehicle deck
- insufficient crew numbers to keep pace with lashing requirements during busy periods of cargowork
- an over-reliance by ship staff on the ability of the stabilisers to always provide a steady platform
- the incomplete dissemination of lessons learned from a previous occurrence.

Several safety actions were put in place by the operator and the charterer (as new owner) to address the majority of the safety issues and safety recommendations were made to address ambiguities in the cargo securing manual.

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The *Union Rotoiti* on arrival at Auckland

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List of Abbreviations

DG	diesel generator
GM	metacentric height (measure of a vessel's statical stability)
hPa	hectopascals
IR	integrated rating
Inmarsat	international marine satellite organisation
kW	kilowatt
m	metres
ro-ro	roll on - roll off
SOLAS	International Convention for Safety of Life At Sea
t	tonnes
UMS	unmanned machinery space
UTC	universal time (co-ordinated)

Glossary

aft	rear of the vessel
athwartships	transversely across a ship
ballast	weight, usually sea water, put into a ship to improve stability
beam	width of a vessel
bridge	structure from where a vessel is navigated and directed
class	category in classification register
draught	depth in water at which a ship floats
gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
heel	angle of tilt caused by external forces
hove-to	when a vessel is slowed or stopped and lying at an angle to the wind and sea which affords the safest and most comfortable ride
knot	one nautical mile per hour
list	angle of tilt caused by internal distribution of weights
nett tonnage	derived from gross tonnage by deducting spaces allowed for crew and propelling equipment
port	left hand side when facing forward
starboard	right hand side when facing forward
stability	property of a ship by which it maintains a position of equilibrium, or returns to that position when a force that has displaced it ceases to act
zone time	time kept at sea for official purposes; each one hour zone equals 15° of longitude

Marine Accident Report 99-205

Data Summary

Vessel particulars:

Type:	ro-ro (roll-on roll-off) cargo vessel
Classification:	Lloyd's Register of Shipping, +100 A1 LMC vehicle and container ferry
Class:	SOLAS class VII
Port of registry:	Auckland, New Zealand
Length (overall):	203.11 m
Breadth:	26.25 m
Draught (summer):	9.525 m
Gross tonnage:	22 228 t
Net tonnage:	6668 t
Construction:	steel
Built:	by Whyalla Shipbuilding & Engineering Works, Whyalla, South Australia in 1977
Propulsion:	three 5540 kW Wartsila diesel generators providing power to two pairs of electric propulsion motors driving two 4-bladed controllable-pitch propellers
Normal operating speed:	16 knots
Owner:	Union Shipping New Zealand Limited
Charterer:	Australia-New Zealand Direct Line

Location: Tasman Sea in:
latitude: 35º 23.8' South
longitude: 156º 13.0' East

Date and time: 23 April 1999, between 0520 and 0610[1]

Persons on board: crew: 19

Injuries: 3 minor

Nature of damage: extensive to cargo, moderate to vessel

Investigator-in-Charge: Captain John Mockett

[1] All times in this report refer to ship's local time. The ship was keeping zone time UTC + 10 in Melbourne and changed to zone time UTC +11 during the night of 21 April 1999.

1. Factual Information

1.1 History of the trip

1.1.1 *Union Rotoiti* was engaged on voyage 657/659 of a liner trade between New Zealand and Australia. The vessel exchanged cargo at the Australian ports of Brisbane, Sydney and Melbourne, with Melbourne being the final Australian port.

1.1.2 On Wednesday, 21 April 1999, the Melbourne cargo exchange was completed on the upper deck at 0250 and in the main vehicle deck at 0405. The vessel was berthed at Webb Dock and records showed that by 0425 the stern door was shut and housed and the vessel secured for sea. By 0438 the vessel had departed from the berth and was proceeding across Port Phillip Bay. The harbour pilot was disembarked outside Port Phillip Heads at 0747 and the sea passage to Auckland commenced at 0754. The stabiliser fins were deployed at 0800.

1.1.3 The *Union Rotoiti* transited the Bass Strait following the master's usual voyage plan and at 1642, with Hogan Island bearing 163 degrees true at a distance of 4.7 nautical miles (nm), a course of 077 degrees true was set for Cape Reinga. (See Figure 1.)

1.1.4 At that time, a deepening and slow moving low pressure system was forming in the central north Tasman Sea ahead of *Union Rotoiti*. Weather maps were received on board by facsimile from the Australian Bureau of Meteorology, Melbourne. Weather situation updates and forecasts were received in text from Melbourne, Sydney, and New Zealand via Inmarsat C.

1.1.5 The weather recorded in the deck logbook for noon on Thursday, 22 April was wind from the south at 30 knots with very rough sea and a moderate southerly swell; the vessel was moving easily.

1.1.6 The master maintained the course of 077 degrees until 1300 on Thursday, 22 April, at which time the vessel was in position 37º 58.1' South and 153º 08.7' East. A gale and storm warning received at that time from Melbourne forecasted south to south-easterly winds strengthening and possibly reaching 45 to 55 knots later that day.

1.1.7 As the reported depression was almost directly ahead of the vessel, the master considered that it would not be prudent to continue into the severe weather, so he altered course to 050 degrees to run with the wind astern and pass to the north of the low pressure system. (See Figure 2.)

1.1.8 The records in the deck logbook for that afternoon showed the wind backing to the south-east and progressively strengthening to 40 knots. Notations regarding the motion of the vessel ranged from moving easily to rolling moderately.

1.1.9 The master further altered the course to 045 degrees at 2300 on 22 April to ease the motion of the vessel and keep the wind astern. At 2326, with the vessel in position 36º 22.1' South and 155º 13.8' East, he left night orders which instructed the watchkeepers to maintain that course throughout the night but also included an instruction to call him at any time if required, being mindful of the adverse weather conditions.

1.1.10 The *Union Rotoiti* was operating in Unmanned Machinery Space (UMS) mode at this time with all 3 diesel generators (DGs) running. The duty engineer had completed his inspections and reported to the bridge watchkeeper at 2150 that he was leaving the engine-room. No abnormalities were noted in the engine-room logbook.

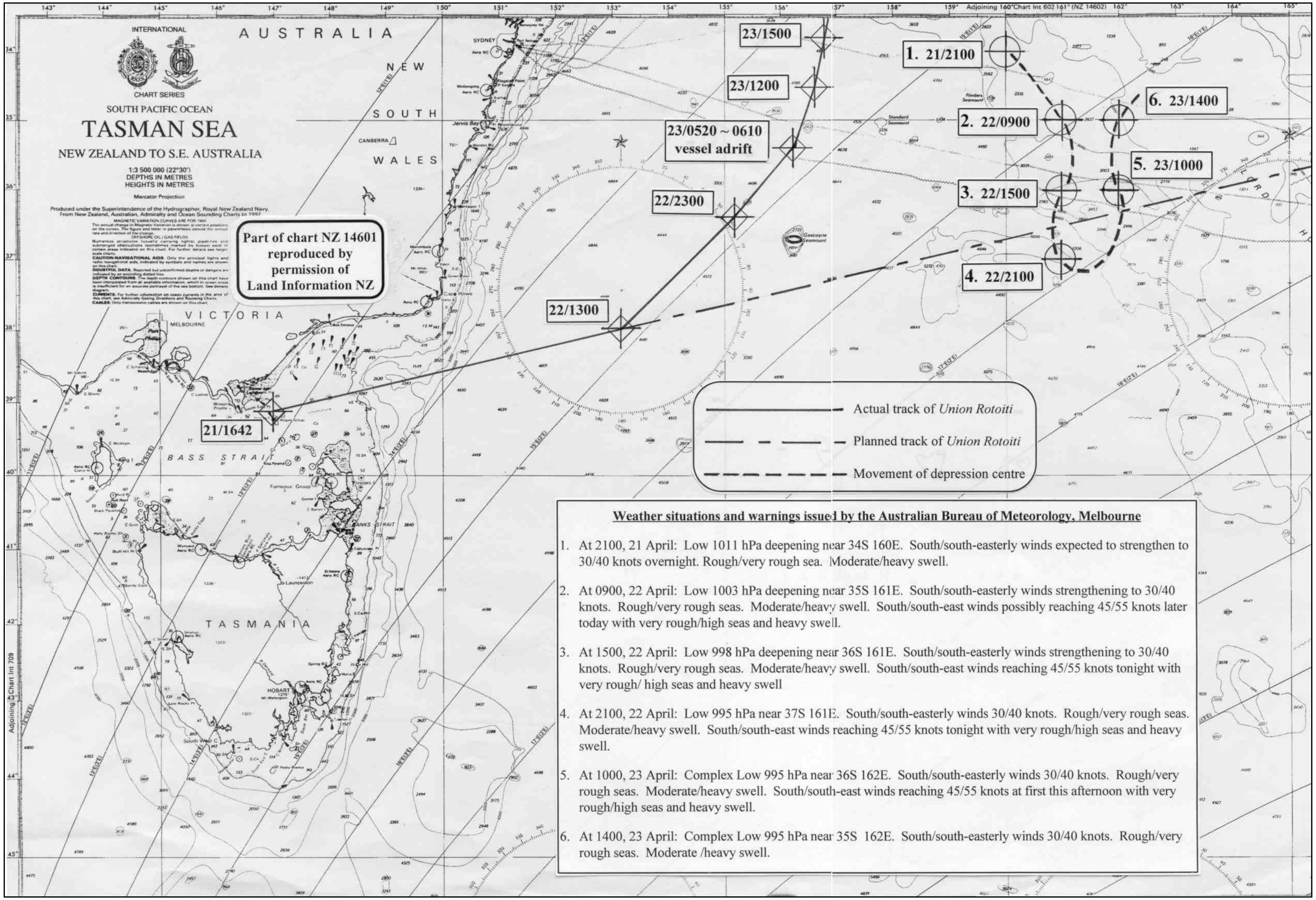


Figure 1
Location chart showing track of *Union Rotoiti* and depression centre.
(All times refer to ship's local time)

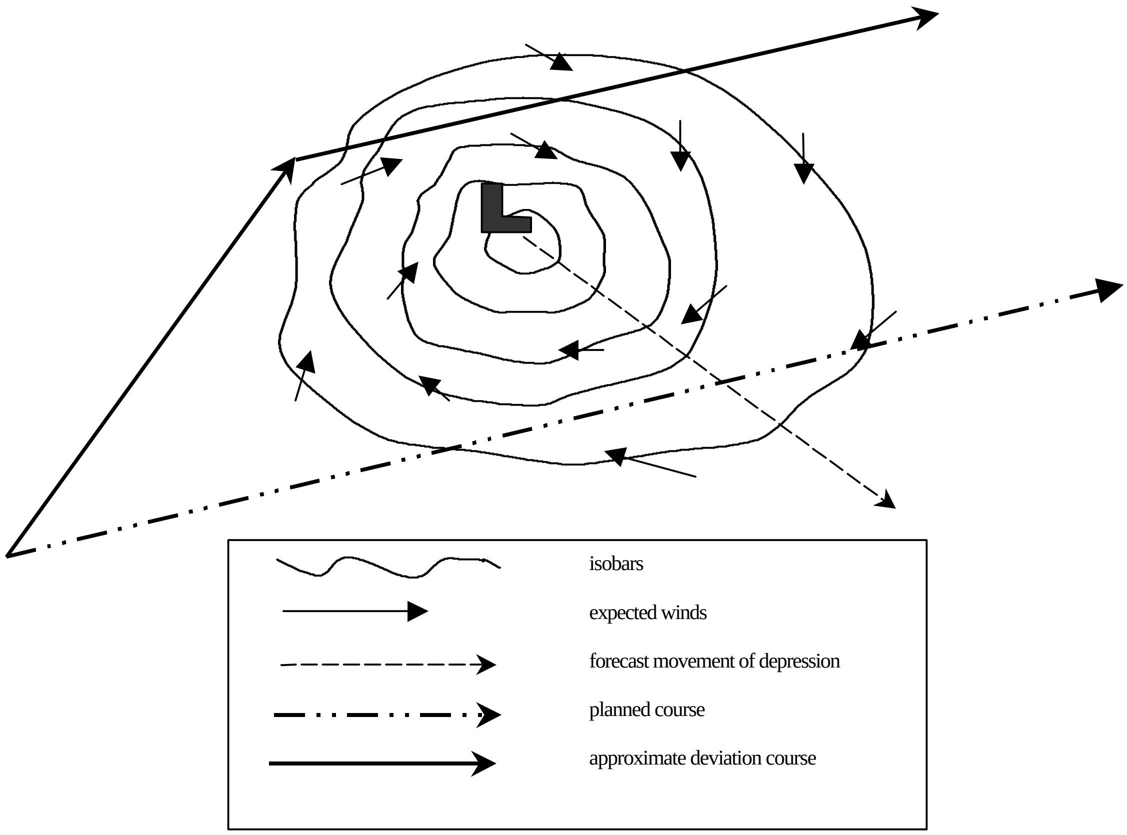


Figure 2
Approximate course deviation to avoid depression

1.1.11 At 0248 on 23 April, the duty engineer was summoned to the engine-room by the UMS alarm. On arrival in the engine-room, he found the alarm had been caused by a blockage in the 200 micron filter for the running fuel feeder pump and that the stand-by pump had come on line. The chief engineer, who was awake due to the motion of the vessel, telephoned the engine control room and asked what the situation was and that he be kept informed.

1.1.12 The duty engineer cleaned the blocked filter and put that pump back on line. He also cleaned the filter on the stand-by pump. A second alarm had been activated indicating that the Moatti filters (automatic back-flushing type) were also blocking so he purged them to clear them. At 0420 he was able to reset both alarms.

1.1.13 The duty engineer noticed that a spare turbo blower case, which was stowed outside the control-room, was moving with the motion of the vessel so he took some time to secure it. At 0430 he reported to the bridge watchkeeper that he was leaving the engine-room and re-instated the UMS mode.

1.1.14 Each watch, the duty Integrated Rating (IR) routinely made a safety round through the accommodation and cargo spaces. Logbook entries for the evening 8 - 12 watch on Thursday, 22 April and the morning 12 - 4 watch on Friday 23 April both stated “rounds made and reported all secure”.

1.1.15 At the change of bridge watch at 0400 on Friday, the vessel was still on a heading of 045 degrees and the conditions were logged as:

- wind south-south-east at 40 knots
- seas from south-south-east, sea scale 8 (very high, towering seas 30 feet or more)
- swell from south-east, swell scale 7 (average length, heavy)
- vessel rolling moderately at times to rough sea and heavy swell
- overcast, fine and clear, very good visibility
- barometric pressure of 1012.2 hPa.

1.1.16 The first mate took the watch at 0400 and sent the duty IR on a safety round. At 0430, the IR reported to the first mate that there had been some cargo movement in the main vehicle deck but that the shifted items were secure. The shifted items were 2 camper vans and a trailer, all of which had moved but become wedged into secure positions.

1.1.17 At about 0515, the master was woken by the motion of the vessel and telephoned the first mate on the bridge for an assessment of the weather. He told the first mate that he was on his way to the bridge.

1.1.18 At 0515, the duty engineer was again summoned to the engine-room by the UMS alarm. On arrival in the engine-room he found the feeder pump filters and the Moatti filters were blocking again. Additionally there were alarms indicating low fuel pressure at the fuel booster pumps and on all 3 DGs.

1.1.19 He telephoned the chief engineer and asked for urgent assistance, saying "I think I'm going to lose it". During that call he warned the chief engineer to take care on the upper deck because two 40-foot containers had shifted in the second height of the stow and were suspended over the walkway and leaning against the ventilator casings at the port aft end of the upper deck.

1.1.20 The chief engineer roused the first engineer and the electrician, telling them that their assistance was required in the engine-room. He then proceeded towards the engine-room. As he was leaving the accommodation, the vessel "blacked out", losing all electrical and motive power.

1.1.21 The emergency generator started automatically shortly after the blackout. The duty engineer started the 2 auxiliary diesel generators, which provided sufficient power for some services but not enough for the propulsion motors.

1.1.22 With all 3 DGs shut down and no motive power, *Union Rotoiti* soon broached to the wind, sea and swell and the subsequent rolling motion became violent. There was insufficient power to operate the stabiliser fins and although they remained extended, no roll dampening was achieved while the vessel was stopped in the water.

1.1.23 Because the weather was on the starboard side, the rolling was biased to port. The bridge inclinometer, which could measure up to 45 degrees, recorded the maximum roll to port with the recording arm remaining hard against the stop. The maximum roll to starboard was recorded as 24 degrees.

1.1.24 The engine alarm log showed that between 0521:54 and 0522:48 the alarm sequence was:

- DG1 overload (number 1 DG attempting to take full load)
- DG3 low load, high temperature (number 3 DG shut down)
- DG2 low load, high temperature (number 2 DG shut down)
- DG1 low load, high temperature (number 1 DG shut down).

1.1.25 By the time all the engineers had made their way to the engine-room, the vessel had broached and was rolling violently. They had to work in difficult conditions. Many loose objects were moving and some falling from high stowage positions making moving around the engine-room hazardous.

1.1.26 The engines had stopped due to falling fuel pressure. A computer-operated load sharing system had attempted to shed power but could not stabilise the situation before all 3 engines failed. Having failed under alarm conditions, the engine stoppage produced many auxiliary and ancillary machinery alarms. Each of those alarm conditions produced an audible alarm until cancelled. As they were mostly genuine alarms they would not reset and continued to come into alarm. There was no facility to mute the alarm system and the continuous noise of alarms made concentration difficult for the engineers in the already adverse conditions.

1.1.27 The alarm printout gave the chief engineer indications of the faults leading to the stoppage. His priority was to regain motive power and return control to the master on the bridge.

1.1.28 He detailed engineers to clean the filters on the feed pumps and to clear the Moatti filters. He and another engineer commenced the process of resetting circuit breakers and readying the engines for re-starting.

1.1.29 Once the fuel filtration path was clear, the chief engineer attempted to restart the engines. Initial attempts were unsuccessful with the engines shutting down on overspeed. The engine starting system used compressed air and the failed starting attempts had run down the main air bottles, adding more concern for the chief engineer.

1.1.30 Because the engines had been tripping on overspeed, the chief engineer got another engineer to manually hold back the fuel lever on number 1 DG while he attempted to start it. This proved to be successful and the DG remained running and built up speed as the fuel lever was gradually released.

1.1.31 The chief engineer realised at this point that the engines had stopped while being starved of fuel, so the computer would have been calling for an increase in fuel and rpm via a speeder motor on the governor in an attempt to meet the load demand on the generator. As a result, the settings on the engine governors had remained with high fuel and rpm requirement at the time they stopped. When attempting to re-start, the engines "raced" to match those settings.

1.1.32 Realising the problem, the chief engineer got the other engineers to reset the governors on numbers 2 and 3 DGs. He was then able to restart those engines.

1.1.33 With 3 DGs running and on the board, the chief engineer reset the propulsion motors and was able to return motive power control to the master at 0610.

1.1.34 Once motive power was restored, the master turned the vessel into the swell to stop the rolling and to re-instate stabiliser operation. After about 5 minutes, when engine and stabiliser operation appeared to be normal, he altered course to 020 degrees to once again run before the weather.

1.1.35 Although the engineering staff continued to have fuel filtration problems, there was no repeat of the blackout and the master was able to continue the voyage, progressively altering the course to pass to the north of the depression as originally planned.

1.2 Cargo and vessel damage information

1.2.1 During the 50-minute period that *Union Rotoiti* was adrift, the vessel remained beam on to the swells, which were recorded as being extreme, and rolled violently through an arc of about 70 degrees; about 50 degrees to port and about 20 degrees to starboard.

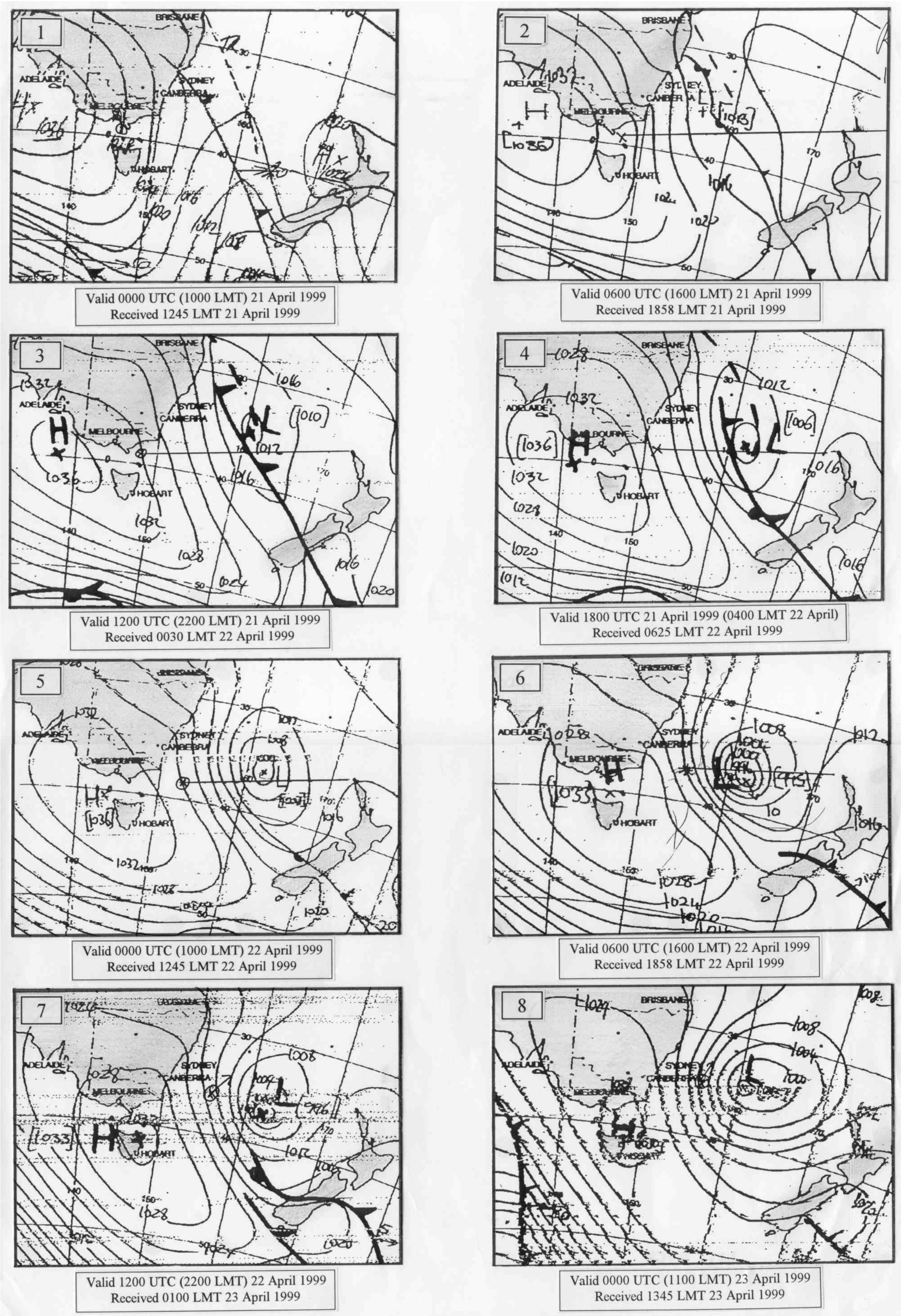


Figure 3
Australian Bureau of Meteorology, Melbourne weather maps showing formation of depression

1.2.2 During the rolling, 12 containers were lost overboard; four 40-foot containers from each side of the forward upper deck and four 20-foot containers from the port side of the aft upper deck. Numerous other containers on the upper deck shifted; some falling onto their sides, others ending upside down. The moving containers caused damage to the ventilators along the port side of the upper deck and the port gangway was carried away by the containers as they went overboard.

1.2.3 One of the units that toppled on the upper deck was a tank container filled with phenol, a toxic and corrosive chemical. The tank came to rest upside down and was severely damaged. The phenol was leaking from the damaged tank onto the deck and over the side of the vessel. The crew, using breathing apparatus, isolated the power to the heating coils and established a continuous washdown using fire hoses. Without heating, the phenol solidified thus stopping the leakage.

1.2.4 In the main vehicle deck the majority of the cargo shifted, mainly to the port side. Containers that had been stowed 2-high fore-and-aft along the sides of the deck toppled and were thrown to the port side. Flatracks of overlength steel had been stowed on top of a row of single containers inboard of the 2-high stacks, and when they shifted, the banding parted allowing loose steel to cascade down. The stow had included camper vans, trailers, tractors, a boat and numerous cars. Very little of the cargo escaped damage.

1.2.5 The cargo stowed in the lower hold appeared, on initial inspection, to have remained secure. However, as discharge in Auckland progressed it became apparent that containers stowed at the aft end behind a block stow had shifted. Number 7 double bottom and wing tank protruded into the lower hold and the welded seams of the tank were fractured. The tank was a sea water ballast tank but had not been full at the time of the accident, so no flooding of the lower hold occurred.

1.2.6 Initially, the *Union Rotoiti* was heeled to port due to the strong wind on the starboard beam but the shift of cargo listed the vessel further to port. During the time that the vessel was adrift, the first mate and third mate went aft to the cargo control room and pumped ballast water from port to starboard to bring the vessel more upright.

1.2.7 Three crew members, who were inside the accommodation, suffered varying degrees of bruising when they were thrown off balance by the violent motion of the vessel. There had been some concern that other crew may have sustained injury from contact with the leaking phenol, but this was not the case.

1.3 Weather information

1.3.1 When *Union Rotoiti* departed from Melbourne, the depression that formed in the central north Tasman Sea did not feature on the weather maps or texts received from the Australian Bureau of Meteorology. There was, however, a cold front running from about Sydney to a low pressure system south of New Zealand. (See Figure 3.)

1.3.2 The depression formed in the middle of the cold front and almost exactly on the planned track for the *Union Rotoiti* from Bass Strait to Cape Reinga. The depression deepened quickly but was slow moving because of a high pressure system over the North Island of New Zealand. A second high pressure system was moving eastwards from Australia which caused the pressure gradient around the depression to increase.

1.3.3 As *Union Rotoiti* approached, the depression continued to deepen and move slowly south-east across the line of the *Union Rotoiti*'s track. The forecasts indicated that the movement would continue to the south-east.

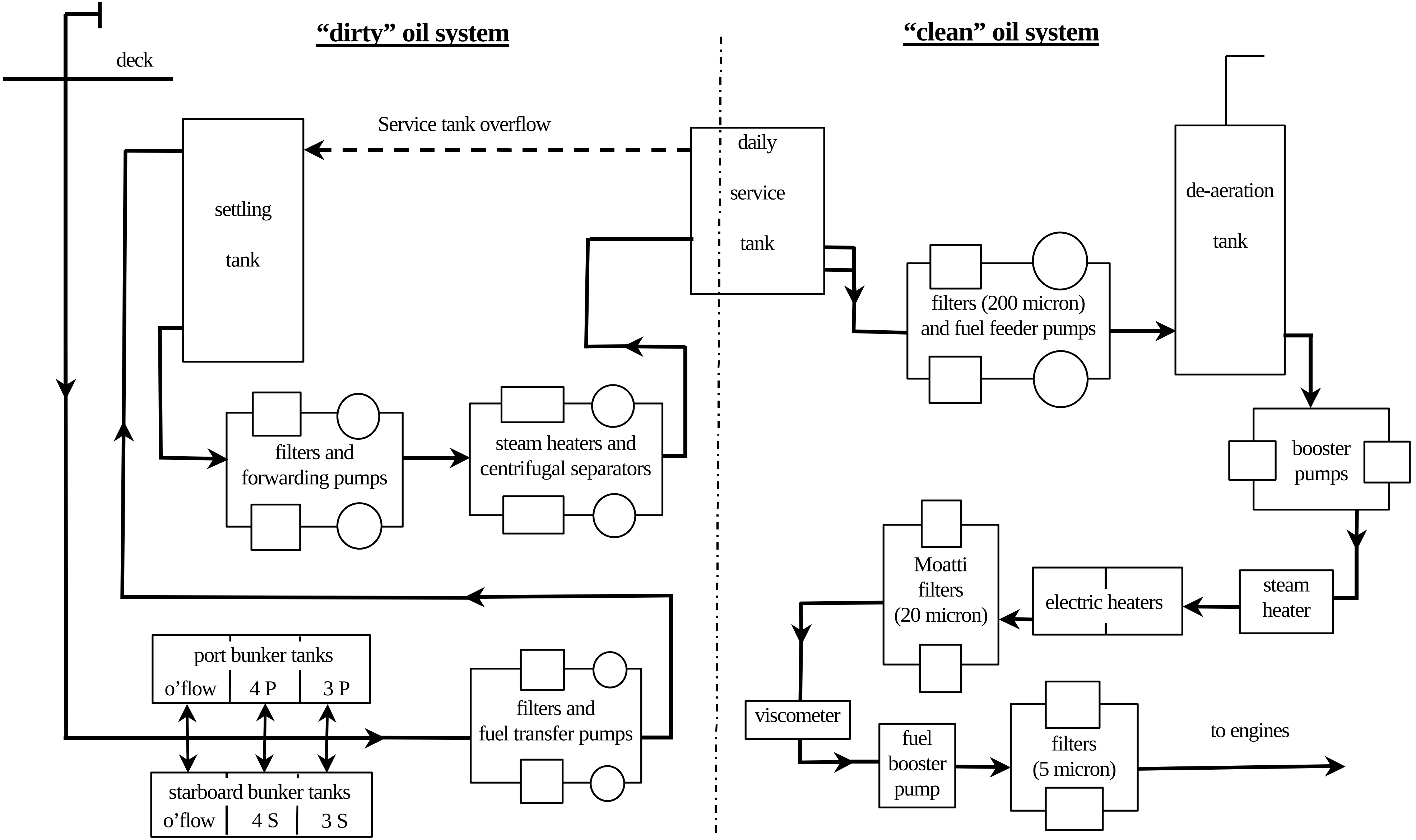


Figure 4
Schematic diagram of *Union Rotoiti* fuel system

1.3.4 At about the same time as warning number 4 (see Figure 1) was received from Melbourne, the following storm warning was received from Sydney:

> Low 1000 hPa near 37S/161E, moving slowly SE and deepening.
>
> Forecast
> SW/SE winds to 30/40 knots, reaching 45/55 knots with 250 nm of low in SW quadrant.
> Seas very rough to high. Heavy swells.
>
> Remarks
> Low may begin moving north overnight to be near 34S 160E Friday morning.

1.3.5 Frequent weather reports were received from Melbourne and Sydney and all indications were that the depression was moving, and would continue to move, slowly to the south east. The forecast from Sydney quoted above was the only one that suggested the possibility that there might be a movement to the north.

1.3.6 In the southern Hemisphere the wind rotation around a depression is clockwise. Winds around this depression were forecast to become 45 to 55 knots within 250 nm in the south-west quadrant. The Beaufort wind scale describes wind of that magnitude as storm force 10, producing a probable mean wave height of 9 m with probable maximum wave height of 12.5 m, which was similar to the wind strengths and wave heights recorded in the deck logbook of *Union Rotoiti*.

1.3.7 Many of those crew spoken to said that the movement before the blackout was unusual and that their personal belongings and furnishings were moving in the accommodation. The rolling produced while the vessel was broached to the weather was said to be the worst they had ever encountered.

1.3.8 After the *Union Rotoiti* resumed passage, the depression changed direction and moved northwards, causing the master to deviate further to the north than he originally planned.

1.4 Fuel system information

1.4.1 When new, *Union Rotoiti* was powered by turbine engines which ran on gas oil. The vessel was re-engined in 1986 with 3 Wartsila diesel engines which ran on heavy fuel oil. Fuel was taken on a voyage basis, usually in Melbourne, with the normal bunkering being about 900 t.

1.4.2 The fuel system can be considered in 2 sections; the “dirty” and “clean” systems (see Figure 4). Fuel oil was taken through a connection on deck to the storage tanks, which were numbers 3 and 4 port and starboard tanks and the port and starboard overflow tanks. From these tanks fuel was transferred to a settling tank. From there it passed through filters and was purified by centrifugal separators, which removed any water and unburnable sludge. The purified oil was then stored in the daily service tank.

1.4.3 The “clean” oil in the service tank was kept at about 80 degrees Celsius. The fuel passed from the service tank through a series of filters reducing from 200 microns to 5 microns just before the engines. Within the system were a de-aeration tank, steam and electric heaters and booster pumps.

1.4.4 The daily service tank originally contained gas oil for the turbines and had been coated internally with an epoxy paint. Since the re-engineing in 1986, gas oil was replaced by heavy fuel oil and although epoxy coating was not required for tanks using heavy oil, neither was it considered detrimental and was thus not removed.

1.5 Vessel information

1.5.1 *Union Rotoiti* was built in 1977 for the then Union Steamship Company of New Zealand and had been engaged on the trans-Tasman trade for the company ever since.

1.5.2 Cargo was carried on 2 internal decks and one weather deck. The weather deck was generally referred to as the upper deck and was split by the accommodation block into a foredeck and an aft deck. Cargo was loaded directly onto the upper deck using shore cranes. (See Figure 5.)

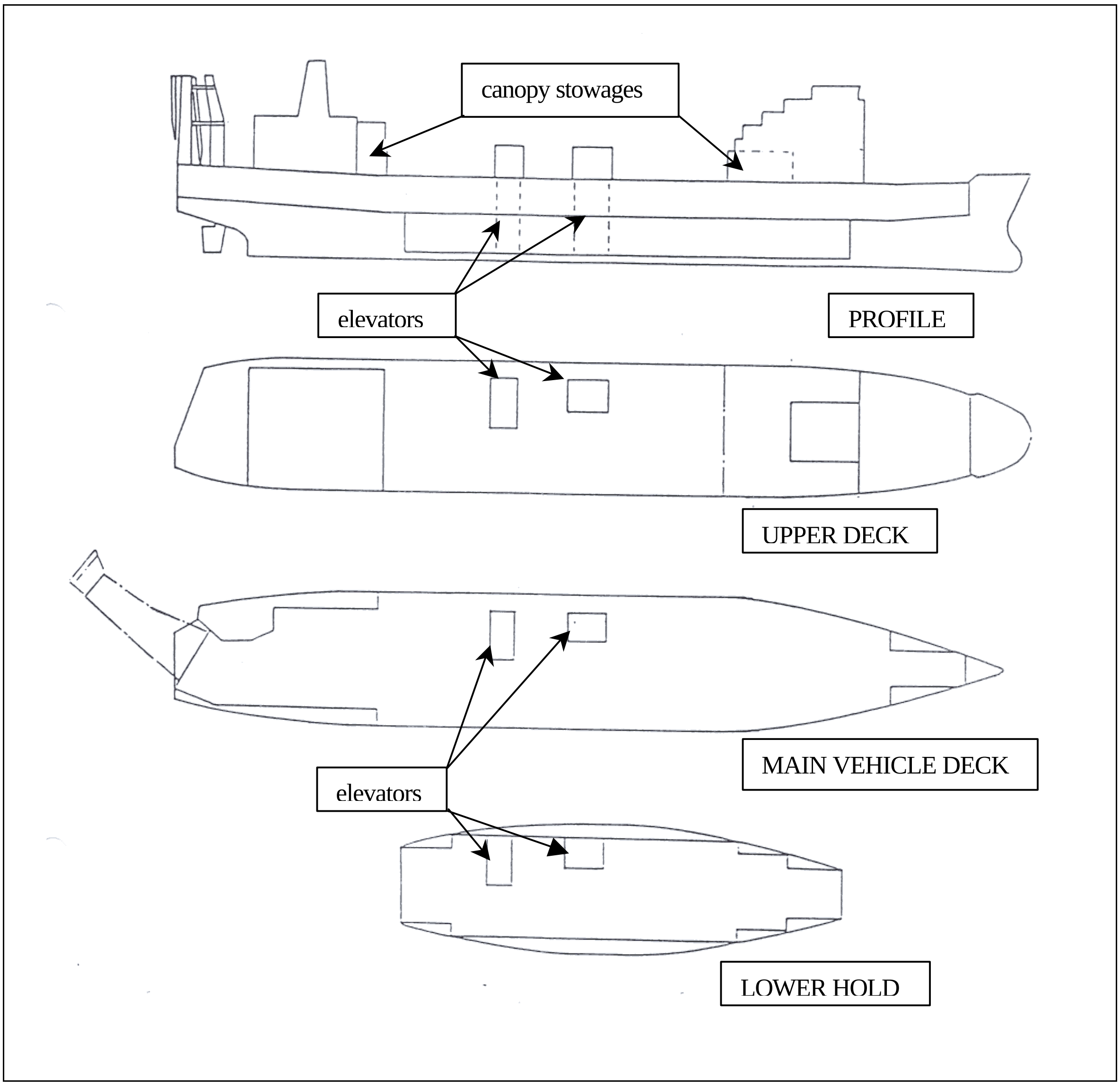


Figure 5
***Union Rotoiti* cargo deck arrangement**

1.5.3 Carriage of containers on the foredeck was a modification since new and was achieved by raising the containers on pedestals over the mooring arrangement. The pedestals were fitted with twistlock sockets the same as those in the other cargo spaces.

1.5.4 The 2 internal decks were referred to as the main vehicle deck and the lower hold. Access to the main vehicle deck was generally gained over the stern ramp but cargo could be loaded into both decks via elevators from the upper deck and then positioned by fork lift.

1.5.5 There was a canopy-covered area at each end of the aft upper deck. These areas were usually used to stow vehicles. On the accident trip, cars were stowed in both areas.

1.5.6 Cargo operations were normally carried out by 2 gangs of wharf labour, working simultaneously on different decks. The exchange of containers on the upper deck was made using shore container cranes, but vehicles were moved up via the elevators. The cargo exchange in the lower decks was made over the stern ramp into the main vehicle deck, utilising the deck elevators to load cargo into the lower hold.

1.5.7 The vessel operated on a trans-Tasman liner service at a service speed of 16 knots. The complement comprised master, 3 deck officers, 4 engineering officers, 8 integrated ratings, and 3 catering ratings, a total of 19.

1.5.8 *Union Rotoiti* was on a time charter to Australia-New Zealand Direct Line (ANZDL), who were responsible for accepting cargo for shipment and planning the cargo stowage.

1.5.9 *Union Rotoiti* was fitted with fin stabilisers which under normal circumstances dampened the motion of the vessel. Electro-hydraulic actuators, controlled by a common computer, constantly adjusted 2 aerofoil-shaped fins to produce lift in the opposite direction to a detected roll. The system was said to be very effective and the vessel had a reputation for being stable in a seaway.

1.6 Container securing arrangement

1.6.1 The cargo securing arrangements throughout the vessel were documented in the cargo securing manual. The manual in use was dated 7 December 1998, had been approved by Lloyds Register of Shipping on 28 January 1999 and issued to the vessel in February 1999. Additionally there was a company standing order titled "Cargo: General" which gave work instructions.

1.6.2 The cargo securing manual stated that the stowing and securing system was designed for use with a maximum metacentric height (GM) of 1.75 m.

1.6.3 The vessel was designed to carry containers, vehicles and unitised general cargo on all decks. A total of 1060 flush mounted clover leaf lashing pots were fitted in a uniform grid pattern on all cargo decks to facilitate cargo lashing.

1.6.4 A total of 107 single and 249 double, surface mounted "U" frame sockets were fitted throughout the vessel to suit container stowage on the upper deck, at the forward end and both wings of the main vehicle deck and in the forward and aft ends of the lower hold.

1.6.5 "U" frame twistlocks were slid into the "U" frame sockets, effectively locking them in place. A container was then located onto the 4 twistlocks which were then locked to the container corner casting by turning the top cone through 90° with the lock actuating lever. In this fashion the bottom-stowed container was locked onto the deck.

1.6.6 Additional to the "U" frame sockets, 99 Breech base deck sockets were fitted at various locations in the cargo decks. These sockets had a star-shaped aperture into which a Breech base twistlock was located and locked in place when turned through 90°.

1.6.7 When loading containers 2-high, twistlocks were used to lock the first and second tier together. The twistlocks in use on *Union Rotoiti* were right-hand locking. (See Figure 6.)

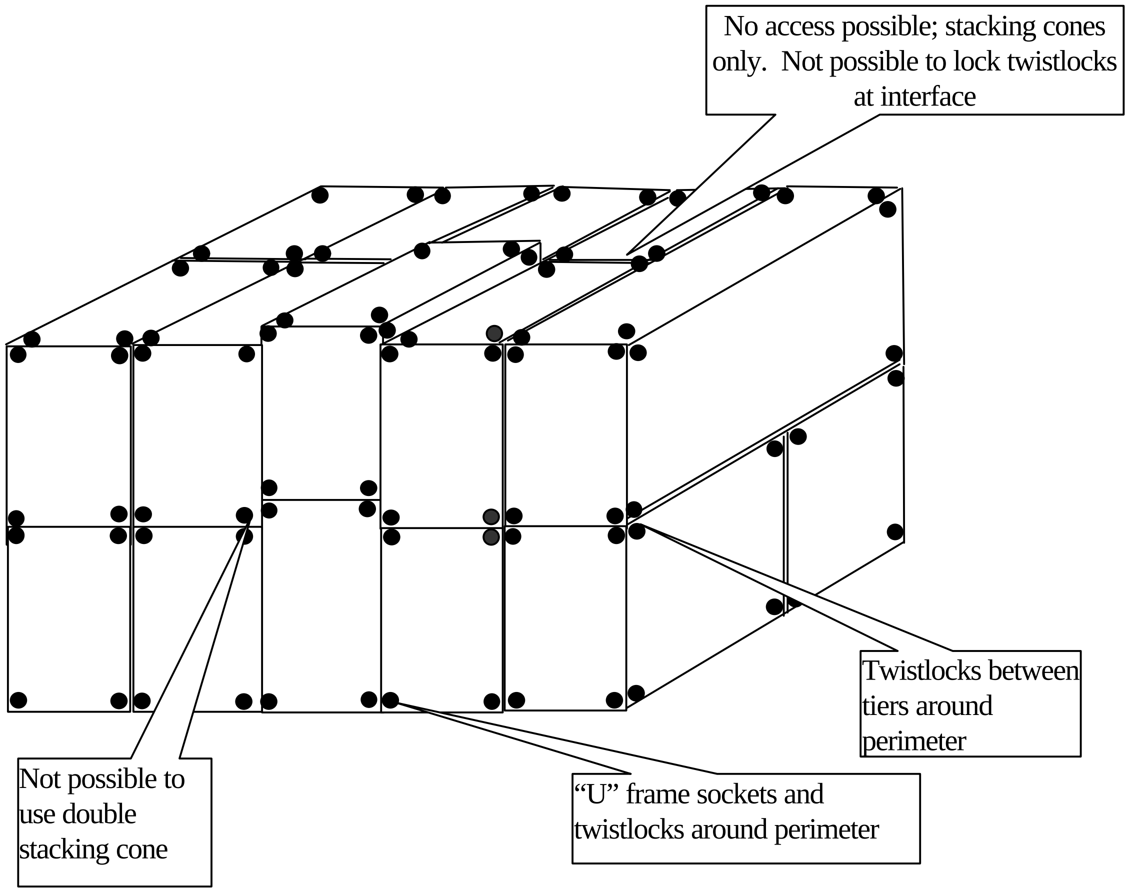


Figure 6
Diagram showing block of containers on *Union Rotoiti*, secured as per cargo securing manual

1.6.8 In certain positions on the upper deck, the sockets were arranged to allow stowage of either 20-foot or 40-foot containers. When used for two 20-foot containers, access to the interface between them was denied due to lack of space. In this case the twistlocks at the interface were used as stacking cones, so effectively the first and second tiers were only locked together at the perimeter of the block stow.

1.6.9 Stocks of stacking twistlocks that were not fitted with a lock actuating handle were painted yellow to differentiate them from the lockable type, which were painted red.

1.6.10 Double stacking cones were available which could be used to good effect to add further security to a stow by connecting adjacent stacks of containers. However, the use of double cones was limited because of variation in container heights and the frequency of adjacent stacks being for differing discharge ports.

1.6.11 The stowage of cargo in the main vehicle deck and the lower hold was not so straightforward because of the wide variety of units making up a typical cargo. Ideally, cargo would be stowed so that each unit wedged and blocked off the unit adjacent to it. If this could be achieved, no additional lashing was required. However, a typical cargo consignment very rarely allowed for this ideal stowage.

1.6.12 Where possible, containers were loaded into designated slots and twistlocks used to secure them. Should the stow not allow the use of deck sockets, rubber matting was placed between the corner castings and the deck to increase friction, a chock twistlocked to the closest deck fitting and the gap tightly filled with dunnage. (See Figures 7 and 8.)

1.6.13 Where deck fittings were distant from a container or unit, the gap was filled using an Acrow Strut, a threaded strut which was extended to take up the gap.

1.6.14 The cargo securing manual contained conflicting instructions for lashing when containers were stowed more than one high. In the section covering "various cargo units, vehicles and stowage blocks", it stated that chains should be used for lashing. A pictorial description showed stacking cones at deck level. However, in the section covering "stowage and securing of containers", it stated that for a fore-and-aft stow, 2 cones per container where container fittings were available should be used on the first tier and 2 cones per container on the exposed block face in the second tier. Container stowage was limited to 2-high below deck.

1.6.15 When cars were stowed, no lashings were applied. Each car had to be stowed fore-and-aft with parking brakes on. Manual cars were left in first gear while automatic cars were left in 'park'. Larger vehicles were lashed using chains; the size and number dependant on the dimensions and weight of the vehicle.

1.6.16 Cargoes were not normally limited to containers and vehicles only. Many different size and weight units could be expected to make up the full cargo. Every effort was made to block stow the cargo such that it became self-securing. A combination of chains, hooks, chocks, struts, matting and dunnage were used to secure the cargo where a block stow was not possible.

1.7 Cargo operation procedures

1.7.1 The deck officers maintained the traditional 3-watch system at sea and in port. At sea one IR was assigned to each watch. When in port, 2 IRs were assigned to each watch as gearmen, with one of them usually on stand-by. The duty mate was responsible for the supervision of loading.

1.7.2 The shore labour was responsible for the placing of twistlocks and stacking cones on the upper deck and for locking the twistlocks. It was the duty mate's responsibility to check the stowage and security of the cargo.

1.7.3 The fitting of lashing equipment to the cargo in the lower decks was the responsibility of the duty mate and gearman. Each watch took responsibility for the cargo loaded during that watch. The IRs were trained and experienced in the use of the equipment but the decisions regarding the securing arrangement lay initially with the duty mate, but ultimately with the first mate.

1.7.4 When working more than one deck, the gearman generally remained in the lower decks placing and securing lashings. The duty mate supervised the overall operation checking the loading and lashing wherever cargo was being worked. The duty mates often assisted with the lashing but if the task became too great for a single gearman to manage, both watch IRs were used.

1.7.5 The vessel was fitted with an automated ballast system to keep it upright during cargo operations. Should the tanks dedicated to the system become full to one side, the duty officer needed to shift ballast between other tanks to regain anti-heeling capability.

1.7.6 The stowage of cargo was pre-planned in the Auckland office of ANZDL. Those plans were forwarded to the vessel and to the cargo terminals. The plan was often amended by the first mate and the stevedore to take account of last minute cancellations or additions to the lifting.

1.7.7 The terminal staff produced work sequence plans that together with the stowage pre-plan enabled ship staff to monitor the loading. During loading, ship staff might make minor changes to facilitate better block stows or easier securing as the loading progressed.

1.7.8 On completion of cargo exchange at each port, the first mate calculated the ship stability taking account of the actual stowage of cargo.

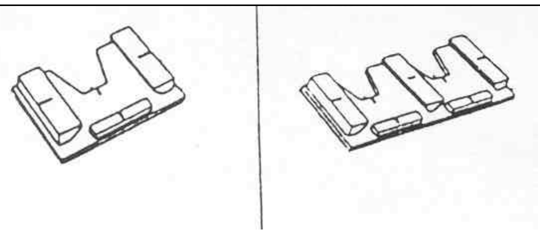
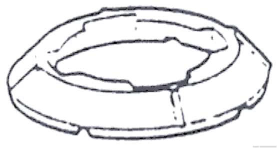
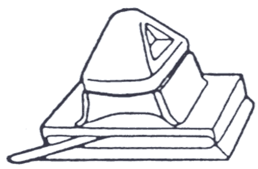
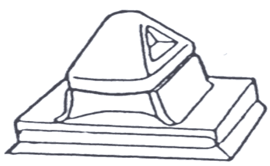
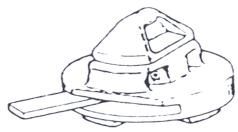
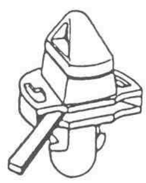
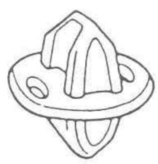
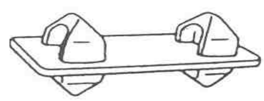
Clover leaf lashing pot 1060 flush mounted pots fitted in grid pattern in all decks	
"U" frame deck socket painted red for twistlock operation, yellow for cone operation 107 single and 249 double surface mounted sockets. upper deck; main vehicle deck: at forward end and in both wings; lower hold: generally forward and aft	
Breech base deck socket painted red for twistlock operation, yellow for cone operation 99 sockets fitted at various locations on all decks	
"U" frame twistlock painted red 333 locks for use on single or double "U" frame deck sockets	
"U" frame twistlock with handle removed (used as stacking cone) painted yellow 412 locks for use on single or double "U" frame deck sockets	
Breech base twistlock Painted red for upper deck use and yellow for main vehicle deck use 64 locks for use in Breech base deck sockets	
Twistlock Painted red 231 locks for use between containers where locking possible	
Stacking cone Painted yellow 438 cones for use between containers	
Doublestacker cone Painted yellow 10 units for use where adjacent stacks are compatible	

Figure 7
Diagram showing container securing devices, copied from cargo securing manual

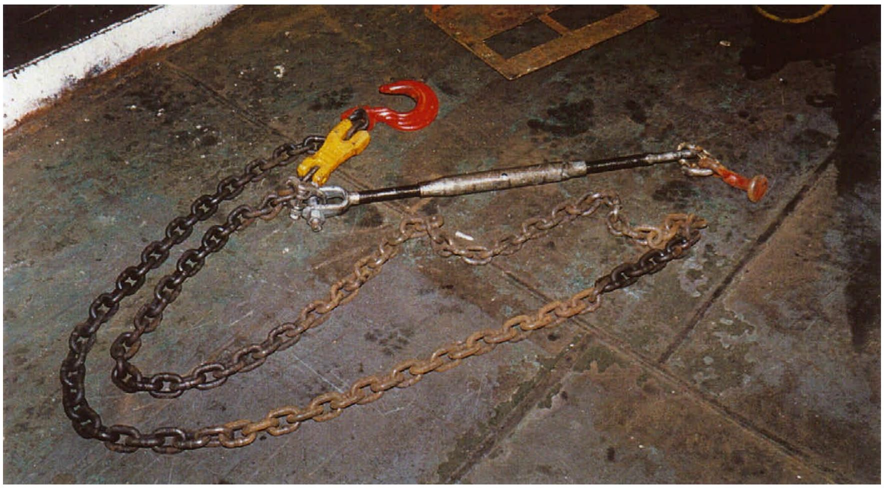
Lashing chain assembly Function: To secure individual containers and unitized cargo where not block stowed. To secure ends of block stowed cargo. To secure wheeled ro-ro cargo. Can be used with rigid lashing rod to provide a cross lashing when securing containers to the deck.	
Chocks for use with twistlocks Function: To provide a lateral chock support in an athwartship direction for container or flat base stowed on main deck or lower hold.	
Acrow strut Function: To provide lateral support in an athwartship direction for container or flat base.	

Figure 8
Photographs of lashing equipment used in main vehicle deck and lower hold, copied from cargo securing manual

Figure 9
Photographs showing toppled containers on upper deck (note open twistlocks)

1.8 Observations of cargo and securing on arrival at Auckland

1.8.1 The cargo loaded in Australia on the accident voyage had been stowed generally in accordance with the pre-plan made by the ANZDL planner in Auckland. The vessel had left Melbourne with a draught of 7.3 m forward and 8.5 m aft, which conformed closely to the draught in the first mate's stability calculations. The calculated GM for departure Melbourne was 1.11 m, well below the maximum for which the cargo securing arrangement was designed.

1.8.2 The first mate had re-calculated the stability estimating the changed position of the cargo that had moved and allowing for the loss of 12 containers from the upper deck. The GM for arrival at Auckland was estimated to be 1.24 m.

1.8.3 When the vessel arrived at Auckland the port authority did not allow it to berth immediately. The vessel was anchored and inspected by hazardous goods experts from the Fire Service. They were particularly concerned with the phenol tank and what residue of the spillage might still be on deck despite there having been a continual washdown since the accident.

1.8.4 The port authority allowed the vessel to berth after the Fire Service inspection but a safety cordon was placed around it until the phenol tank had been discharged and cleaning of the deck completed. The Fire Service officers insisted that the discharge of the phenol tank was carried out during daylight hours. The delay in commencing discharge allowed time for an inspection of the damaged cargo.

1.8.5 Where the 40-foot containers had been lost overboard from bay 02, one of the support pedestals had sheared from the deck. The surface-mounted "U" frame sockets on top of the pedestals were in place but showed little signs of damage. No twistlocks remained in the sockets in the positions from which the containers were lost. There were several loose twistlocks on the foredeck around the pedestal bases. All of those sighted were in the unlocked position. It could not be determined whether or not they were the twistlocks that had been used to secure the lost containers.

1.8.6 Where the 20-foot containers had been lost overboard from bay 27 on the upper deck, many other containers had shifted in the stow. Some units had toppled from second height positions while others had slid within the second height stow. In many positions the containers had pulled away from the deck sockets with the twistlocks still locked to the container bases.

1.8.7 The movement of blocks of containers had been sufficient to shear the twistlock pins securing others. In several positions where containers had moved or toppled, some of the accessible twistlocks that were supposed to be securing them remained in place but were in the unlocked position. (See Figure 9.)

1.8.8 The tank container of phenol had been stowed on the port side of bay 27 inboard of the containers that were lost overboard. It had been pushed to the outboard side and overturned by the movement of other containers around it.

1.8.9 In bays 13, 15 and 17 there had been no movement within full block stows of 2-high containers. An inspection of the accessible twistlocks around the perimeter of those stows revealed that of the 106 locks in place, 35 were not locked including some on the extreme outboard stowage.

1.8.10 All of the cars that had been stowed in the covered canopy areas at each end of the aft upper deck had shifted, sustaining varying degrees of damage.

1.8.11 Cars, camper vans and other vehicles stowed in the centre of the main vehicle deck were virtually destroyed in the crush of moving heavier units. In some instances the contents of containers broke their lashings within the container and the cargo burst out of the side. (See Figure 10.)

Figure 10
Photographs of cargo damage in the main vehicle deck

1.8.12 There was evidence of securing chocks and acrow struts having been in place but the extent of the cargo movement was such that it was not possible to ascertain whether they had been properly placed in sufficient numbers. Some of the securing equipment had failed under load and was found among the cargo; acrow struts, chocks and brackets that had distorted or fractured allowing the initial movement of cargo. No securing chains, broken or otherwise, were evident where the stow of 2-high containers had toppled.

1.9 "U" frame deck socket inspection

1.9.1 The "U" frame sockets on the deck and the twistlocks that fit into them should have been the foundation for the securing of a stack of containers to the deck. Inspection of the exposed deck sockets however showed many of them to be worn or damaged so that they no longer provided a snug fit for the twistlocks. (See Figure 11.) Many of the twistlocks were worn also, further reducing the effectiveness of the "U" frame arrangement.

1.9.2 Crew who saw the containers fall over the side said that the units went overboard in twos, apparently twistlocked together, so they had toppled from the deck level rather than the second height, indicating that the "U" frame arrangements were either ineffective or not locked.

1.10 Fuel filtration system inspection

1.10.1 After the blackout, the filters in the fuel system continued to become choked, although to a lesser degree as the weather improved. The engine-room remained manned for the rest of the passage to Auckland and the filters had to be cleaned on a regular basis.

1.10.2 During an internal inspection of the tank after the accident, it was discovered that the coating had blistered and partly flaked off from around the normal working upper level of the fuel. The detached flakes of coating were found to have settled to the bottom of the tank. The tank had passed a Lloyds Register survey 4 years earlier at which time the problem had not been apparent.

1.10.3 Analysis of the substance blocking the fuel feed pump filters confirmed that it was consistent with a mixture of heated fuel oil and the epoxy coating within the tank.

1.11 Personnel information

1.11.1 The master of *Union Rotoiti* had 37 years sea-going experience, the last 30 of which were with Union Shipping New Zealand. He held a foreign-going masters certificate and gained his first command in 1983. Due to the down-sizing of the fleet he had sailed as master/mate until 1995, when he gained his permanent master position on *Union Rotoiti*.

1.11.2 The first mate had 38 years sea-going experience, the last 27 of which were with Union Shipping New Zealand. He held a foreign-going masters certificate and had sailed predominantly as first mate, occasionally relieving as master, since 1983. He had sailed on *Union Rotoiti* on a number of previous occasions and had been sailing as first mate on the vessel for 10 months before the accident.

Figure 11
Photographs of worn deck sockets and twistlocks

1.11.3 The second mate had 23 years sea-going experience. He held a foreign-going masters certificate and had sailed as master with another company. He had joined Union Shipping New Zealand in December 1998 and had served on *Union Rotoiti* since that time.

1.11.4 The third mate had 24 years sea-going experience and held a foreign-going second mate certificate which he gained in 1998. He had served as third mate on *Union Rotoiti* for one year prior to the accident, and as IR for 5 years before that.

1.11.5 The chief engineer had over 30 years sea-going experience, the last 20 of which were with Union Shipping New Zealand. He held a combined first class motor and steam certificate, gaining motor in 1977 and steam in 1980. He had sailed on *Union Rotoiti* as chief engineer for 6 years prior to the accident and as second engineer for a period before that.

1.11.6 The second engineer, third engineer and third engineer/electrician were experienced officers who had served on *Union Rotoiti* for varying lengths of time but all sufficient to have made them familiar with the vessel.

1.11.7 The IRs on *Union Rotoiti* were all experienced seafarers and were all familiar with the vessel.

2. Analysis

2.1 Navigation and weather

2.1.1 When *Union Rotoiti* left Melbourne none of the weather situation and forecasts received, gave any indication that the vessel would encounter adverse weather. It was therefore appropriate that the master initially follow courses for the normal route to Auckland.

2.1.2 As the depression formed ahead of *Union Rotoiti*, the master monitored the developing situation and appropriately chose to avoid the leading quadrant of the low pressure system. With the depression forecast to move south-east, his decision to alter course and pass to the north and keep the winds astern was appropriate.

2.1.3 The depression continued to move slowly to the south-east as *Union Rotoiti* approached it. The winds in the south-west quadrant increased as per the forecast and the master altered further towards the north, still expecting that he would be able to safely pass to the north with his vessel running before the weather.

2.1.4 In making the track deviation, the master's intention achieved the following:

- avoided the possibility of passing ahead of the depression and subjecting the vessel to gale force head winds and sea
- avoided his vessel entering the quadrant with the strongest winds
- kept winds abaft the beam allowing normal speed to be maintained
- afforded the vessel, its crew and cargo the most comfortable passage available.

2.1.5 In view of the forecast and actual movement of the depression, the master's deviation from the intended track was appropriate, made in timely fashion and should have afforded a safe passage around the area of adverse weather.

2.2 The blackout

2.2.1 On the evening of 22 April 1999, the duty engineer completed his normal engine-room inspection and noted nothing untoward. At that stage the motion of the vessel was recorded in the deck logbook as "moving easily" and should not have been a cause for concern with regard to the machinery spaces.

2.2.2 The duty engineer was called to the engine room before the blackout to attend to blocked filters. This would not be considered to be particularly unusual or of concern as the sole purpose of the filters was to collect debris and the need to clean them could be considered as routine. At the time of the earlier alarms, he would have had no reason to believe that there was any threat of losing all power.

2.2.3 When the duty engineer was called to the engine-room at 0515 on 23 April, the vessel was moving to the weather more and he had further alarms indicating that the blockage in the filters was producing low fuel pressure at the engines. His call to alert the chief engineer and get assistance was appropriate and timely, although too late for assistance to arrive before the engines starved of fuel and stopped.

2.2.4 Although the emergency generator started automatically, the duty engineer also started the auxiliary generators to give a greater and more stable electric power source. Although not sufficient to give any motive power, the auxiliaries were enough to ensure lighting remained on throughout the vessel and other services such as air compressors were available.

2.2.5 There was no evidence to suggest that the fuel bunkered in Melbourne had any unusual sediment or debris in it that may have caused the filters to block. There was no indication that any unusual debris had passed through the bunker storage tanks in use or the settling tank.

2.2.6 The internal coating of the service tank was blistering and flaking off around the area of the normal upper level of stored purified fuel. That area would be covered with fuel as the tank was filled and uncovered as the fuel was used, producing a variation in the temperature of the internal surface of the tank in that area. The temperature fluctuation was probably part of the cause of the detachment of the coating.

2.2.7 The blistering and flaking of the coating had probably been occurring over the period of 4 years since the last classification survey. The engineering staff would have had no indication of the developing problem and would have had no cause to make any internal inspection of the tank between classification surveys.

2.2.8 The detached pieces of coating would have settled to the bottom of the tank below the suction level and the accumulation of debris would have gone undetected until it built up sufficiently to have been drawn into the suction pipe or to the level of the drain cocks, where the engineers might have detected it during routine purging of the cocks.

2.2.9 The motion of the vessel as it approached the depression probably agitated the flakes of coating accumulated in the bottom of the tank. Initially the disturbance would have caused only smaller pieces of debris to be drawn into the suction filters of the feed pumps, and could explain why the first blockage was not sufficient to significantly reduce the fuel pressure at the engines.

2.2.10 As the weather deteriorated and the motion of the vessel increased, so too would the degree of disturbance within the service tank. Greater amounts and larger pieces of debris would have been drawn into the filters causing a more extensive blockage which quickly reduced the fuel pressure at the engines to an extent that they starved of fuel and stopped.

2.2.11 With the loss of motive power came the violent increase in the motion of the vessel. It is to the engineers' credit that they were all able to make their way to the engine-room across the open aft upper deck with containers beginning to move in the stow. Once in the engine-room they worked to restore power in extremely adverse conditions and their actions were commendable.

2.3 Cargo

2.3.1 With ro-ro and container loading, lashing was a continuous process. When cargo was worked both on deck and underdeck, the loading rate could at times be such that the crew available for lashing had difficulties in keeping pace with the incoming cargo, even when the stand-by gearman was employed. Such a situation can encourage shortcuts to be taken. If several voyages are made with no detrimental effect on the cargo, those shortcuts can often become standard practice. It is possible therefore, that the minimal resources dedicated to cargo lashing may have contributed to the poor lashing practices evident on the *Union Rotoiti*.

2.3.2 The stowage of cargo is governed by many criteria, among which are:

- the physical restraints of available space, limited either by the construction of the vessel or the position of existing cargo
- to suit multi-port loading and discharging avoiding re-handling at intermediate ports
- to maintain adequate stability on all passages, avoiding condition values that are either too high or too low
- to keep hull stresses within allowable limits
- to suit any fixed stowage positions of specific cargoes such as containers
- to facilitate best achievable securing, block stowing where possible.

2.3.3 Once stowed, the cargo must be secured before the vessel is taken to sea. Securing should be such that it will withstand any condition that can reasonably be expected to be encountered during the next passage.

2.3.4 On the trans-Tasman trade it is not uncommon to encounter adverse weather at any time of year, and particularly in the winter months. Depressions can form quickly with little warning from existing weather patterns.

2.3.5 A master navigating in adverse weather has several options available to alleviate the effects of the sea and swell on the vessel and thus reduce the forces acting on the cargo and its securing arrangement.

2.3.6 The first option taken is normally to alter the course of the vessel to minimise the motion of the vessel. Alternatively, or additionally, a master might alter the speed of the vessel to reduce the motion. The ultimate combination of speed reduction and course alteration leaves a vessel hove to, maintaining a position heading into the weather.

2.3.7 On a vessel fitted with stabilisers, the master would expect the motion of the vessel to be reduced, allowing a planned course to be maintained longer before any alteration of course or speed was deemed necessary.

2.3.8 The effect of any change in course or speed is dependent on motive power being maintained. While an engine failure should be considered, it would be a reasonable assumption on a multi-engined vessel that at least part of the motive power would be available even if one engine suffered mechanical failure.

2.3.9 *Union Rotoiti* had been employed on the trans-Tasman trade for many years and the cargo securing routine and methods were well established. The fact that the vessel had 3 diesel generators to provide motive power and was fitted with stabilisers appears to have had some influence on the development of shipboard cargo securing practices. An attitude prevailed on board that the stabilisers would always provide a stable platform.

2.3.10 While it might be a reasonable assumption that at least part of the motive power would always be available, the stabilisers were a single item of equipment and subject to non-availability through breakdown. The fact that stabilisers were fitted and were normally reliable should not have influenced the cargo securing practices.

2.3.11 As *Union Rotoiti* approached the depression, the master altered course to change the aspect of the vessel to the weather and to avoid the area of worst weather. During this time the motion of the vessel was dampened by the action of the stabilisers. When the vessel blacked out, the master was no longer able to exercise any of his options to reduce the motion.

2.3.12 When the vessel broached to the sea and swell, the roll was predominantly to port, producing a roll angle to port of about 50 degrees. Ballast water was pumped from port to starboard in an attempt to bring the roll axis more vertical and reduce the roll to port. It is to the credit of the first and third mates that they were able to make their way aft to the cargo control room across the upper deck during the worst of the rolling at a time when there was substantial movement of the cargo.

2.4 Cargo movement upper deck

2.4.1 With the exception of cars stowed in the canopy areas, the cargo on the upper deck consisted of containers stowed into designated positions where twistlocks could be used to secure them to the deck.

2.4.2 A cargo of containers fully secured with twistlocks could be expected to endure the motion of a vessel created by even the most extreme weather conditions, provided the equipment is of good quality and properly locked into position.

2.4.3 On *Union Rotoiti* the container arrangement on the upper deck was such that at some container bay interfaces the twistlocks were inaccessible and could not be locked. This limitation would have made the cargo more vulnerable to movement in extreme conditions, so it was essential that all fixed and portable securing equipment was maintained in good condition and that strict attention was paid to locking all accessible twistlocks.

2.4.4 The inspection of the upper deck when *Union Rotoiti* arrived in Auckland revealed that many of the deck sockets were corroded, worn or otherwise damaged to an extent that when twistlocks were slid into them, a snug fit was not possible. In some cases the twistlock could be lifted vertically out of the deck socket by hand, so effectively the bottom container would not have been secured to the deck.

2.4.5 In various positions through the stow, containers had pulled away from the deck sockets with their twistlocks still locked to their bottom corner castings. Either the sockets, the twistlock edges, or both were worn such that little holding capacity remained.

2.4.6 In instances where some second height containers had toppled, twistlocks that had been between the tiers remained in place but were in the unlocked positions. Had those containers been torn free of locked twistlocks, the result would have been severe damage to the corner castings of the containers and to the twistlocks. The absence of such damage indicated that the twistlocks had not been locked.

2.4.7 The base sockets on the foredeck pedestals in the positions from which the 8 containers were lost overboard showed no signs of damage other than normal wear and tear. There were no twistlocks remaining in the sockets. Had those containers been torn free together with twistlocks that had been locked to the sockets, the result would have been severe damage to the sockets. The absence of such damage indicated that those containers had not been locked in place and the twistlocks had subsequently worked free of the sockets during the violent motion of the vessel.

2.4.8 Of the 8 containers lost from the foredeck, half of them had been stowed on the starboard side. The recorded maximum roll to starboard was 24 degrees, an angle at which locked containers should remain stable, further indicating the probability that the twistlocks had not been locked.

2.4.9 The *Union Rotoiti* was moving to the weather before the engine failure. Even though the motion was dampened by the stabilisers and the master had altered course to reduce the motion, two 40-foot containers moved in the second height of the stow. With the reported degree of motion experienced it was unlikely that those containers would have moved had they been locked in place.

2.4.10 The motion of the vessel before the engine failure caused most of those spoken to to express surprise at the amount of movement which all said was more than they had previously seen on *Union Rotoiti*. A degree of complacency existed that "this ship never moves". The complacency extended beyond cargo considerations in that even personal equipment and furnishings were not properly secured in cabins.

2.4.11 The inspection of 3 intact block stows of containers showed that 35 out of 106 accessible twistlocks had not been locked. With the crew's expectation of little or no movement of the vessel at sea, insufficient attention had been paid to ensuring that all accessible twistlocks were locked on completion of cargowork.

2.5 Cargo movement underdeck

2.5.1 The underdeck cargo, particularly in the main vehicle deck, consisted of various units that did not allow a block stow that might have afforded self-securing.

2.5.2 Not all the bottom containers could be stowed into designated positions and twistlocks used to lock them directly to the deck. Where chocks and acrow struts were used, any space between the container base and the nearest securing point had to be tightly packed for the securing to be effective. Although containers were stacked 2-high in the wings, no locking twistlocks were positioned between each tier and no lashing chains fitted. In the absence of any other securing, the lateral support onto the base of the bottom container produced a pivot point about which the stack would topple when any athwartship force was applied to the stack, and particularly when subjected to the degree of rolling when *Union Rotoiti* lost power.

2.5.3 Regardless of how tightly packed the securing might have been between chocks and container bases, if there were any gaps between cargo units, any small initial movement would loosen the packing and render the securing ineffective.

2.5.4 When *Union Rotoiti* was rolling violently after the blackout, various cargo units would have begun to move to take up small gaps within the stow. The initial movement would have loosened lashing allowing further movement. As cargo units broke loose they would impact on other units, possibly breaking their lashings as well.

2.5.5 The lashing that had been placed on the underdeck cargo was probably less than that described in the cargo securing manual because of a complacency that came with the expectation that the stabilisers would always dampen any movement. The movement of cargo units prior to the blackout indicated that the lashings had been inadequate.

2.5.6 The nature and stowage of the underdeck cargo was such that there would have been inevitable gaps between units. Even if lashings had been applied as described in the cargo securing manual, it was probable that when subjected to the violent rolling created by the blackout the cargo would have shifted to take up those gaps and create slackness in the lashings. Once the lashings became slack they could not be expected to withstand the degree of rolling for the duration that the vessel was broken down.

2.5.7 Although the section of the cargo securing manual dealing specifically with containers indicated that only stacking cones were required in a fore and aft stow, it would have been prudent to have used locking twistlocks. Where the bottom tier could not be stowed on to deck sockets, it would have been prudent to use chains to secure the top of the stow rather than rely solely on chocks at the bottom.

2.5.8 Ambiguities within the cargo securing manual indicate that the manual requires to be critically reviewed by both the company and the classification society that approved it.

2.5.9 The commission investigated a previous incident in which another company ro-ro vessel suffered a loss and shift of cargo during adverse weather in July 1998 (Report 98-208). That investigation identified lashing procedures and the condition of lashing equipment among the contributory factors.

2.5.10 After the previous incident, the company undertook, among other things, to conduct an inspection of lashing equipment and remove any defective items from use, to continue to replace defective equipment with equipment of suitable quality, to review lashing procedures and to implement a lashing equipment maintenance plan for that vessel.

2.5.11 With respect to *Union Rotoiti*, no full inspection of the lashing equipment was carried out, but the company had intended to do so when dry-docking the vessel in early 2000. After the accident, many fittings were found to be worn, damaged or corroded beyond acceptable limits.

2.5.12 The cargo securing manual for *Union Rotoiti* had been reviewed and a new manual, approved by the Lloyds Register classification society, was issued to the vessel in February 1999. Although that manual contained instructions for reporting on inspections and testing of cargo securing devices, no such reports were made and the company did not monitor compliance with the required inspections.

2.5.13 For the lessons learned from the previous incident to have been fully effective, it would been prudent to have applied all the safety actions to other company vessels and to have monitored the effectiveness of those actions.

3. Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

3.1 The *Union Rotoiti* was crewed as required by its safe manning certificate, and its statutory and trading certificates were valid.

3.2 The stability of the *Union Rotoiti* at the time of the blackout was within the limitations stipulated for the lashing system.

3.3 The course deviation made by the master to avoid adverse weather was made in timely fashion and was appropriate for the forecasted conditions and movement of the weather system.

3.4 The weather and sea conditions encountered by *Union Rotoiti* were adverse, but not beyond those which the vessel and its cargo could be reasonably expected to endure under normal circumstances.

3.5 The internal epoxy coating of the service tank had become blistered with sections flaking off and detached pieces of coating settled to the bottom of the tank.

3.6 When the vessel was moving in adverse weather, the debris became agitated and was drawn into the suction lines blocking the filters at the fuel feeder pumps and partially blocking other filters within the fuel system.

3.7 The blockage in the filters reduced the fuel pressure at the diesel generators such that they starved of fuel and stopped leaving *Union Rotoiti* without motive power or stabilisation.

3.8 With no motive power, the master lost the options normally available for him to reduce the motion and *Union Rotoiti* broached to the sea and swell.

3.9 Once the vessel was stopped in the water and broached to the sea and swell, the rolling became excessive.

3.10 In the extreme conditions experienced while *Union Rotoiti* was disabled, the forces acting on the upper deck container securing arrangement might have exceeded those which it was designed to withstand. However, had all the accessible twistlocks been locked and the equipment, both fixed and portable, been in good condition the extent of the damage and loss of cargo would not have been as extensive.

3.11 Twistlocks were properly positioned throughout the upper deck stow, but in many cases were not locked allowing containers to topple or move when subjected to the excessive rolling.

3.12 Many of the deck sockets were worn or damaged to an extent that they failed to secure the containers in the manner intended when subjected to the excessive rolling.

3.13 The ro-ro cargo in the lower decks contained a wide variety of units and there would inevitably have been small gaps within the stow, which under normal circumstances would have been acceptable. However, when subjected to extreme rolling for a 50 minute duration, it would be an unrealistic expectation for the stow to have remained secure.

3.14 The cargo securing manual contained ambiguous instructions with regard to the securing of containers stowed 2-high in the main vehicle deck. The practice on the vessel was to secure those stows as instructed in the section of the manual dedicated to containers.

3.15 Had twistlocks been used between tiers or chain lashings used to secure the top of the stow of containers in the main vehicle deck, the amount of cargo movement might have been reduced.

3.16 Insufficient number of crew were utilised to adequately check and lash cargo during busy periods of cargowork, particularly if the ro-ro stow was complicated.

3.17 The container lashing equipment on board *Union Rotoiti* was generally in poor condition.

3.18 The factors contributing to the loss and shift of cargo were similar to those that had contributed to a previous incident on another Union Shipping Company ro-ro vessel. The lessons learned from the previous incident did not appear to have been applied to *Union Rotoiti*.

4. Safety Actions

4.1 The internal surfaces of the service tank were scraped and any loose coating was removed where blistering and flaking had occurred. The tank was cleaned of all accumulated debris.

4.2 The service tank was inspected again after the following voyage to ensure that no further blistering or flaking was occurring.

4.3 Following the accident, the "U" frame deck sockets were inspected and those that were found to be worn or damaged were renewed as necessary.

4.4 Since the accident, where first tier containers are located into designated slots in the main vehicle deck, twistlocks are used rather than stacking cones.

4.5 Since the accident a lashing practice for containers more than one high in the main vehicle deck has been adopted where twistlocks rather than stacking cones are used between tiers.

4.6 Since the accident, Australia-New Zealand Direct Line have purchased the vessel and have introduced a policy of employing stevedores for cargo lashing on all decks.

4.7 Australia-New Zealand Direct Line intend to dry-dock the vessel in February 2000, at which time the cargo securing arrangements, including all fixed and portable items, will be inspected and repaired or replaced as required.

4.8 In conjunction with a ship management company, Australia-New Zealand Direct Line intend a review of policy and procedures on *Union Rotoiti*.

5. Safety Recommendations

5.1 On 1 December 1999 the Commission recommended to the chief executive of Australia-New Zealand Direct Line that he:

5.1.1 liase with Lloyds Register of Shipping to review the cargo securing manual to clarify the lashing required when containers are loaded more than one high in the main vehicle deck (069/99); and

5.1.2 review the lashing systems and equipment on all company vessels to ensure that they meet the standard required by legislation and that for prudent seamanship. (070/99)

5.2 On 13 December 1999 the chief executive of Australia-New Zealand Direct Line responded as follows:

5.2.1 Following the purchase of the Union Rotoiti and Union Rotoma by ANZDL in September this year, an assessment of remedial action required in relation to cargo securing for both vessels is being carried out. Part of which will be completed during dry docking of both vessels. As part of this process a review of the cargo securing manual in conjunction with Lloyds Register is to be completed together with the incorporation of the recommendations made in Report 99-205 in reviewing the lashing systems and lashing equipment.

The cargo manual is to be reviewed with Lloyds through December and early January, to be completed in time for any structural remediation to take place within the docking period. Dry docking of the vessels will commence with the Rotoma in late January 2000 and be completed with the Rotoiti returning to service in late March 2000.

In relation to safety recommendations 069/99 and 070/99 we can therefore confirm:

069/99

a) The recommendation will be adopted.

b) Implementation is expected to be completed by 25 January 2000.

070/99

a) The recommendation will be adopted.

b) Implementation is expected to be completed by 30 March 2000.

Approved for publication 1 December 1999

Hon. W P Jeffries
Chief Commissioner