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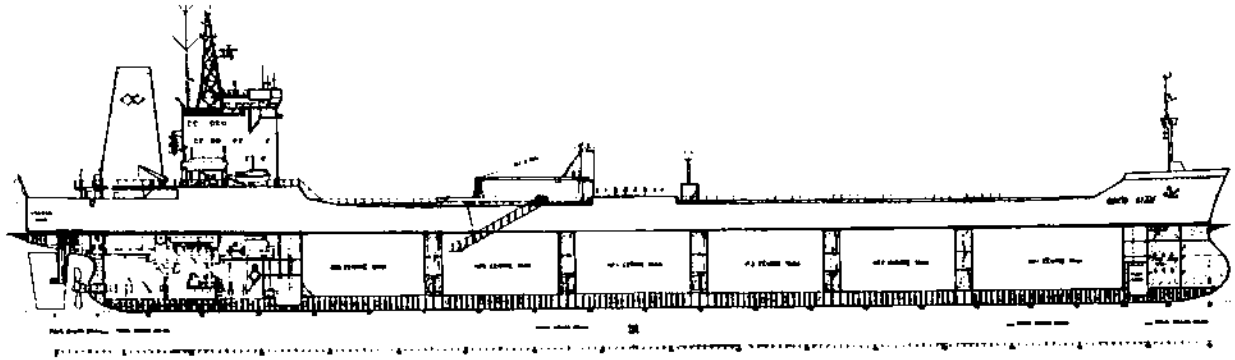
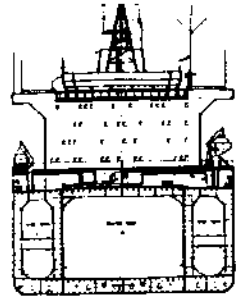
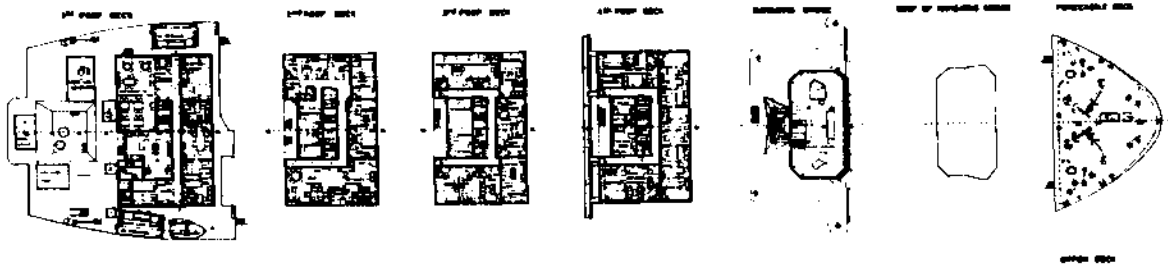
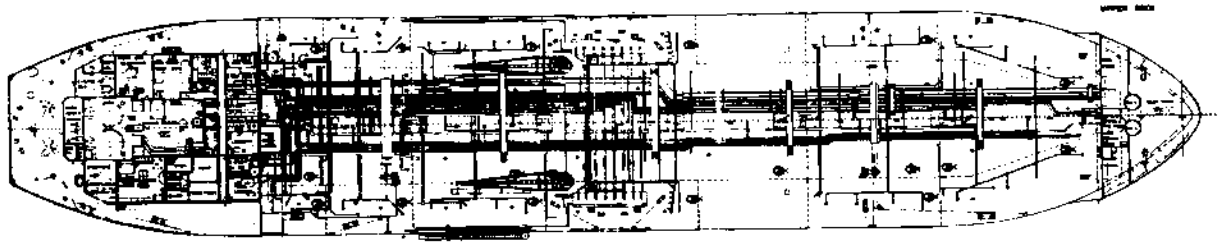
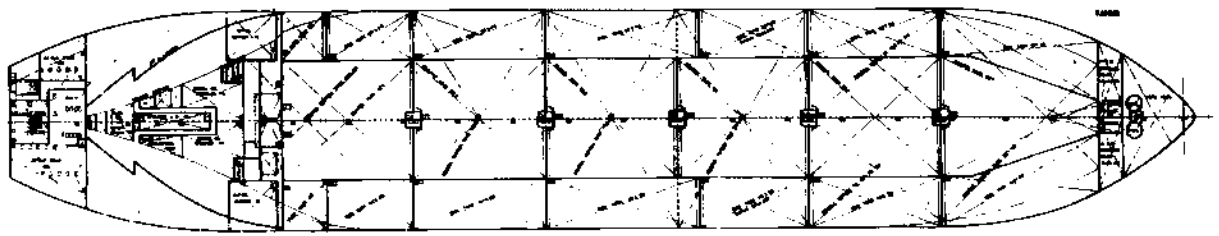






"OSCO STAR"





PORT OF REGISTRY : OSLO
SIGNAL LETTERS : LAJM
OFFICIAL NUMBER :
GROSS TONNAGE : 23672
NET TONNAGE : 13066

MAIN PARTICULARS

LENGTH OVERALL ..... 176.00m 577' 5 1/8"
LENGTH B.P. ..... 169.00m 554' 5 11/16"
BREADTH MOULDED ..... 32.00m 104' 11 7/16"
DEPTH MOULDED ..... 15.10m 49' 6 1/2"
DESIGN DRAUGHT ..... 10.00m 32' 9 11/64"
DEADWEIGHT AT DESIGN DRAUGHT ..... abt 36681 t tonnes
DRAUGHT (MAX) ..... 11.227m 36' 10"
DEADWEIGHT AT MAX DRAUGHT ..... abt 40641.4 tonnes
MAIN ENGINE ..... M.A.N. - B&W 6 S 70 MC
SPECIFIED MCR ..... 7530 kW
REVS ..... 111 RPM
SPEED 6 knots /11.2m,(4680 kW) ..... 14.3 kn
CLASS : DET NORSKE VERITAS
*1A1, TANKER FOR OIL, CAUSTIC SODA, EO, COW, INERT

TANKER FOR OIL 40 000 DWT

1 : 101 391 395

Summary

On 10 December 1993, the Australian flag tanker Osco Star was loading a cargo of petroleum products at the Shell refinery Geelong (Corio). A little after midnight, as the officer of the off-going watch was checking the deck, he opened the sighting port to no.4 port cargo tank and heard the rush of liquid falling into what should have been an empty tank. On checking he found that the gas oil cargo in no.3 centre tank was flowing into no.4 port.

Cargo operations were suspended and an inspection made of the area. It was subsequently discovered that gas oil had also entered the trunk-way to no.4 double bottom ballast tank.

Initially, it was considered that the ship had been over-stressed during cargo operations. However, by late morning on the 11th, it was accepted that the tank structure had suffered damage due to over-pressurisation, caused by the failure of the pressure/ vacuum relief valve on no.3 centre cargo tank, a valve which is designed to vent the displaced gas in the tank when loading, or to relieve vacuum when discharging.

Substantial damage was sustained by the vessel's structure, with splits occurring between no.3 centre cargo tank and no.4 port wing tank and the trunk-way to no.4 double-bottom ballast tank. The top of the bulkhead between nos.3 and 4 centre cargo tanks was set back approximately 750mm and the main deck above the tank was set up by 116mm.

The Marine Incident Investigation Unit investigated the incident under the provisions of the Navigation (Marine Casualty) Regulations.

Sources of information

The Master, officers and crew of Osco Star
ASP Ship Management
The Shell Company of Australia Ltd.
Det Norske Veritas
The Geelong Harbour Master
Press-Vac Engineering A/S, Denmark
The Salvage Association, UK

Terminology

The Osco Star, in common with many other Australian registered vessels, operates an alternating two-crew or "swing" system. The Chief Officer is normally known as The Mate or the Chief Mate.

For the period covering this incident, the Chief Mate from the "swing" which was at that time on leave, was employed on board the vessel during its stay in Geelong to assist with the extra workload normally encountered in that port. As there was already a Chief Mate on board, for the purposes of this report this extra Chief Mate is referred to as the "First Mate".

Pressure/vacuum relief valves are commonly known on tankers by the terms "P/V valves", "Hi-Jets" or "Press-Vacs". The last two are trade names of valves from particular manufacturers.

Crews on Australian flag vessels are now mostly Integrated Ratings - commonly referred to as IR's.

Osco Star

Osco Star is a tanker of 40,541 tonnes summer deadweight at a draught of 11.215m. It was built in 1989 at Pula, formally Yugoslavia and was originally registered under the Norwegian flag (second register), owned by AA 64 K/S UL Osco Star of Denmark, and operated by Osco Shipping Services Norway.

Osco Star is 176m in length, with a beam of 32m and a moulded depth of 15.1m. Designed to carry crude oil, oil products or chemicals, it has six centre cargo tanks, five sets of wing tanks and a set of small capacity wing slop tanks. The cargo spaces are protected by inert gas (IG) generated by a dedicated IG generator, fired by diesel oil. The cargo tanks are fitted with a fixed washing system allowing either crude oil washing or water washing (hot or cold) .

Ballast is carried in dedicated spaces which consist of double bottom tanks beneath the cargo spaces and one set of permanent wing ballast tanks (no.3 port and starboard wing tanks). The double bottom spaces are accessed by vertical trunk-ways located on the centre line at the transverse cargo tank bulkheads.

Each cargo and ballast tank is fitted with a single "pressure/vacuum" (P/V) relief valve, designed to relieve either the pressure of displaced gas when loading, or the vacuum which would form in the tank when discharging. The valve is affixed atop a pipe approximately 2 metres high, leading from the side of the tank-lid coaming.

The ship is powered by a 5 cylinder B&W 5L60MC diesel engine, producing 6880 kW, which drives a single shaft and propeller to give a service speed of 14 knots.

In April 1992, the ship was engaged by The Shell Company of Australia Ltd. on a long-term bareboat charter and transferred to the Australian flag. The ship is managed by ASP Ship Management, Melbourne, who provide Australian masters and crew.

Osco Star is engaged on a regular coastal run, generally loading products at Geelong for northern ports of Queensland, the Northern Territory and Western Australia and back-loading crude oil from Dampier or Barrow Island. As such, the vessel is rarely in a ballasted condition.

The ship operates on a two-crew or "swing" system. At any one time the ship has a crew of twenty, with an additional cadet and provisional integrated rating. The deck officers consist of the Master and three mates. The three mates are responsible for keeping sea and port watches, with the Chief Mate keeping sea watches in port where practicable, otherwise reverting to a system where the Second and Third Mates split the cargo watch between them, leaving the Chief Mate free to supervise the cargo operation and to be ready and on call at any time. Notwithstanding the system of watchkeeping, the Chief Mate was always "on call" and is normally in the control room for the start and completion of any major operation.

In view of the heavy work load (including storing, tank cleaning and

loading) at the vessel's terminal port, Geelong, an additional mate was employed to maintain a cargo watch to relieve the work load on the Chief Mate.

When loading, the officer of the watch generally stays in the control room, situated one deck above the main deck at the forward end of the accommodation. In the control room, the officer monitors the discharge or loading of cargo and operates the valves to the tanks. Simultaneously with cargo work, ballasting or de-ballasting can be carried out and the stresses on the ship continuously monitored. Windows at the forward end of the control room give a restricted view of the deck. As part of the standard procedures on board, an IR keeps a physical watch on deck, monitoring the cargo manifold for leaks, checking the pumproom from time to time, tending the moorings and gangway and carrying out instructions passed by radio from the officer in the control room.

Sequence of events

The Osco Star loaded at Geelong and sailed on 3 November 1993 on a voyage to Darwin, Port Hedland and Dampier with petroleum products. After discharging its cargo in Dampier, the vessel made the short voyage of about 80 miles to Barrow Island where it loaded a full cargo of crude oil for the BP refinery at Kwinana, near Fremantle. At Kwinana, the crude oil (distillate) was discharged, tanks washed and motor spirit loaded for the Geelong terminal.

At Barrow Island

When loading at Barrow Island, the ship loaded distillate into no.3 centre and nos.1 and 5 wing cargo tanks at a rate of nearly 2000 cubic metres per hour. During the course of this loading, the difference in ullage between no.1 starboard and no.1 port began to increase. No.1 port ullage kept pace with the other tanks, but it became apparent that much less cargo was going into no.1 starboard - to the point where the ship began to develop a slight list to port.

The duty mate asked the IR on watch to check the P/V valve on no.1 starboard and received an answer which he understood to be confirming that the valve was lifting. The differential between no.1 starboard and no.1 port, however, continued to increase. The duty mate then shut off no.1 port and continued loading into the other tanks. No.1 starboard still failed to fill at the expected rate. Knowing that something was wrong, he isolated the deck filling line to the two forward wing tanks and opened the suction valves on the two tanks such that they should both level. Instead of the two tanks levelling, however, much to his surprise, the lower tank, no.1 starboard, flowed rapidly (at a rate of approximately 150 tonnes per hour) into no.1 port which at that time had a level some 5 metres higher than that in no.1 starboard.

At around this time, the Chief Mate happened to call the cargo control room to see how the cargo was progressing and was advised of the situation with no.1 starboard. On arriving in the cargo control room, he sent the duty mate to check the tank. Having understood from the duty IR that the tank was venting satisfactorily, the duty mate suspected a false reading on the Autronica* and intended to take a manual ullage, but the Mate, believing that the tank could be pressurised, instructed him to first check the tank. Upon arriving at no.1 starboard tank, the duty mate could hear gas hissing at high pressure from the drain hole on the P/V valve, but could see that the P/V valve itself was not lifting and he realised that the tank had not been venting. He immediately opened the tank sighting port, allowing considerable pressure to be vented from the tank. When examined it was found that the P/V valve had jammed

* Autronica - An automated ullage measuring system providing readings on a computer in the cargo control room.

in the shut position. Loading of no.1 starboard was completed in the "open loading" condition.

In addition to the problems experienced at Barrow Island with the valve on no.1 starboard, the P/V valve on no.3 centre tank also jammed, but in the open position and had to be manually tapped closed.

At sea

The P/V valve on no.1 starboard tank was removed and overhauled while the vessel was on passage between Barrow Island and Kwinana. It was dismantled, cleaned and lubricated with a special aluminium based lubricant. This valve was inspected by the Chief and Second Engineers before being reassembled and replaced.

An attempt was made to remove the valve on no.3 centre for overhaul, however this attempt had to be abandoned because of the efflux of volatile vapours from the cargo and the fact that some of the cargo was forced up the vent pipe and onto the deck with the motion of the ship, drenching two IRs with crude oil.

At Kwinana

After discharge of the crude oil cargo at Kwinana, the cargo tanks were cleaned for a cargo of motor spirit for Geelong, which was loaded into the no.2 and no.5 wing tanks and also into no.3 centre tank.

Shortly after the Second Mate came on watch during the loading, he noticed that, although the levels in all the wing tanks were similar, at an ullage of approximately 6 metres, the level in no.3 centre was markedly lower. This struck him as somewhat unusual as the vessel was trimmed slightly by the stern and he expected no.3 centre tank to fill slightly faster than the forward wing tanks.

Recalling problems with the P/V valves in Barrow Island, the Second Mate had told the duty rating, at the commencement of loading into no.3 centre, to advise him as soon as the P/V valve on that tank lifted. He had, however, had no report back from the rating. By the time no.3 centre had been filling for approximately 30 minutes he observed the difference in tank levels.

The Second Mate went straight to the deck, up to no.3 centre and the P/V valve, where all that was coming out was a slight hiss of gas. He turned the "checklift" lever, but the cone on top of the valve did not lift. After donning a safety helmet, goggles and earmuffs, he climbed up to the valve and attempted to free it by hand, trying to twist the cone and tapping it with an adjustable spanner.

His attempts to free the valve were unsuccessful, and so he opened the sighting port, whereupon considerable pressure was released from the tank. For the remainder of the cargo loading to that tank, the ship was effectively "open loading".

On the next occasion that they met, the Second Mate advised the Chief Mate of what had happened.

Osco Star -

10/11 December 1993

The ship arrived at the Geelong oil terminal in Corio Bay on 9 December and berthed starboard side to no.2 berth of the refinery pier. After discharging the cargo of motor spirit loaded at Fremantle, the tanks were water-washed to take a cargo of kerosene, gas oil and a small quantity of premium unleaded petrol (in the two small-capacity slop tanks), the whole cargo being for discharge at Adelaide. Adelaide was not a normal port of call for the Osco Star, however Shell was short of certain products in the Adelaide area and the cargo was required as a matter of some commercial urgency.

An additional (First) Mate joined Osco Star on arrival. He was, in fact, the Chief Mate from the other "swing" and was well acquainted with the ship.

At 1530 on 10 December, the ship was ready to load all grades. At 1555 loading of kerosene started into no.2 centre tank. The Chief Mate was in the control room overseeing the start of the cargo. The Second Mate followed the normal procedure for starting the loading of any new parcel of cargo. As the IR opened the main manifold valve, he checked the off (port) side to ensure that there were no leaks. He then checked the cargo line and pumproom. Having completed this routine he returned to the control room at about 1615 where he handed over the watch to the Third Mate.

At 1615, the cargo of gas oil was started to no.3 centre tank and no.5 port and starboard tanks. However, the Third Mate, assuming that all the necessary checks had been carried out, did not follow the normal starting up routine. The IR, once he had opened the manifold valve, checked for leaks on the off-side and checked the pumproom. The P/V valves were not tested to ensure that they were operating.

At 1635, loading of kerosene was suspended, for sampling and testing.

At 1645, the cargo of petrol started to the slop tanks. The watch continued routinely with the loading rates varying as required by the terminal. The Third Mate monitored the operation. At 1730, he closed no.5 port and starboard tanks and the gas oil cargo continued to be loaded into no.3 centre alone. At 1830, the cargo of petrol to the two slop tanks was suspended at the shore terminal's request.

The additional (First) Mate had agreed to exchange watch routines and to relieve the Third Mate early to enable him to go ashore for the evening. At about 1900, the two officers discussed the cargo operation. The First Mate who, from previous hand-over conversations with the Second Mate, understood that the P/V valve on no.3 centre tank was unreliable, asked about the operation of the valve. He was told by the Third Mate that the test lever was sheared but, as far as he knew, the valve was operating correctly. The Third Mate made his routine inspection of the deck and pumproom and at 1915 handed over to the First Mate.

At 1935, the loading of petrol resumed. The loading of the two grades of cargo and the discharge of ballast continued routinely for a further 40 minutes. Shortly after assuming the watch, the First Mate asked the duty IR to open no.3 centre tank sighting port by a few turns of the securing dog, as he was concerned that the P/V valve might not operate properly. The escape of the tank atmosphere to the open deck did not concern him as the gas oil was non-volatile, having a flash point * above 60°C and that by opening the sighting port only a little, the flame screen, which was rather too small for its seating, would remain in place. The IR confirmed by radio that he had opened the sighting port as directed.

At 2000, the 4-8 IR was relieved by the 8-12 IR. The 4-8 IR, who had been attached to the ship since it came under the Australian flag, did not leave immediately and stayed, talking to his relief.

At a time put at around 2015, the two IRs heard a loud "bang", immediately followed by a gushing sound, of what may have been cargo, beneath the deck. The "bang" was also heard by the fitters manning the jetty shed at Osco Star's berth and at an adjacent berth. The 8-12 IR immediately contacted the First Mate in the control room, reporting the loud noise. The First Mate, who had heard nothing and considered that it was probably the pressure in the tank lifting the P/V valve, asked the IR to open the sighting port by a few more turns of the securing dog. The two IRs checked around the deck area adjacent to no.3 centre tank, but could find nothing unusual.

After checking, the 4-8 IR went to the control room and made a verbal report of the incident to the duty mate, prior to his going off watch. At this time the petrol in the port slop tank was nearing its final ullage and the First Mate was concentrating on completing the parcel of motor spirit. The port slop tank was shut at 2030 and loading of the petrol was completed at 2045.

Some 45 minutes after the "bang" was heard, the 8-12 IR went to the control room for a cup of coffee and again commented on the noise that they had heard on deck, emphasising his concerns that the noise was not one usually heard during cargo operations. The First Mate, however, knowing that the IR had been on the ship for only a few weeks, felt sure that what he had heard was the lifting of the P/V valve on no.3 centre, as the tank had been loading for some time, and thus did not give it further consideration.

Cargo operations continued routinely with the First Mate recording the ullages of the tanks being loaded, discharging ballast to ensure that the stresses on the ship were maintained at a minimum and monitoring the trim and list of the ship. At some time after 2100, or nearly one hour after the incident at 2015, the IR on deck was standing by no.4 port wing tank, when the P/V valve on that tank lifted, startling him. Using his radio, he reported the lifting to the First Mate, who, knowing that no cargo was being loaded into no.4 starboard, assumed

* Flashpoint, the lowest temperature at which a liquid gives off sufficient gas to form a flammable gas mixture near the surface of the liquid.

that the IR was referring to the P/V valve on no.3 centre tank and suggested to the IR that this, in fact, was the case. The IR, who had by this time walked away from the valve, was not confident in his familiarity with the ship and agreed that it may have been no.3 centre.

At 2145, to keep the trim within reasonable limits, the First Mate opened no.5 wing tanks and closed no.3 centre, 3 centre having been filled to within 400 cubic metres of its final ullage. At about 2300, the First Mate noted an increase in loading rate and, considering the possibility that this might have something to do with tank pressurisation, went on deck himself and opened the sighting port to its full extent. He also checked that the valves on the slop tanks were properly closed.

At 2350, loading of gas oil to no.3 centre resumed and no.5 wings were shut with the cargo in those tanks at its final ullage.

Shortly before midnight the Chief Mate went to the control room in preparation for completing the gas oil parcel and starting a parcel of kerosene. He was closely followed by the Second Mate who went to the control room to relieve the First Mate and take over the cargo watch.

The cargo in no.3 centre was nearing completion and the First Mate was at the computer monitoring the cargo and ballast condition. With the Second Mate at his shoulder he was flicking quickly through the relevant displays. While the ballast condition display was on the screen the Second Mate noticed that the sounding of no.4 double bottom ballast tank had risen from an original 5m to 14m, indicating that the ballast water was near the top of the vertical access trunk-way set into the after transverse bulkhead of no.3 centre tank. The Second Mate remarked to the First Mate "Are you washing the deck?". However, the First Mate had already returned to the cargo screen and did not really consider the comment. He did, however, note a reading showing a small amount of cargo in no.4 port wing tank but, considering that it was probably a false reading, he handed over to the Second Mate and started his rounds to check the deck.

At 0020 on 11 December, the loading of gas oil was suspended and 3 centre was shut off with a planned final volume of 4275 cubic metres. The pipeline system was then aligned for the kerosene cargo and, at 0040, loading of kerosene into no.2 centre was resumed.

While on deck the First Mate went to check no.4 port. Having observed a small reading in this tank (on the "Autronica" tank ullaging system), a tank that was to remain empty, he decided to carry out a visual check of the tank while on his rounds. He opened up the sighting port, and as he did so, heard the sound of liquid pouring into the tank. Being unable to see anything from the sighting port, he opened up the Butterworth plate, to observe cargo spraying into the tank.

At about this time the Second Officer and the Chief Mate realised that the volume of cargo in no.3 centre was decreasing and, by 0053, nearly 100 cubic metres had been lost from the tank.

At 0053 on 11 December, all cargo loading operations were suspended and at approximately 0100 the Master was advised that product was leaking from no.3 centre to no.4 port.

After a quick assessment, the gas oil in no.3 centre was run to nos.4 and 5 centre tanks. By 0155, cargo transfer operations had been suspended and the tank lid opened. The Master, wearing breathing apparatus, entered no.4 port cargo tank and was able to see a split, about 2 metres below the deck-head, in the bulkhead between nos.3 centre and 4 port tanks. Further inspection revealed a split in the port side of the trunkway leading down to no.4 double-bottom ballast tank, allowing the cargo of gas oil in no.3 centre to flow into the trunkway and down onto the ballast water in that tank.

At approximately 0230 the Master telephoned the ASP Ship Manager who, in turn, advised the management of the Shell Company.

The initial reaction by the shore superintendent and the ship's staff, with the exception of the First Mate, was that the ship had been over-stressed. The First Mate, however was adamant that the allowable stresses had never been exceeded and the cause had to be over-pressurisation. The stresses, as monitored by him, never rose above 55 per cent of the permitted maximum.

During the remainder of the morning the gas oil in no.3 centre was transferred to nos.4 centre, 5 centre and to shore. An air driven salvage pump was used to pump the gas oil in no.4 double bottom ballast tank and the associated trunkway, to shore.

During the afternoon of the 11th, no.4 port was discharged to shore and the tank was washed. At 1635, loading operations were resumed with kerosene going into no.2 centre.

Damage

During that afternoon, an inspection was made of the trunkway to no.4 double bottom ballast tank, and, on the following day when no.3 centre tank had been gas-freed, that tank was inspected by a surveyor from Det Norske Veritas, the classification society. These, and subsequent, inspections revealed that the following damage had occurred:-

- The main deck in way of the tank had been set up (ie. was bulging upwards) to a maximum of 116 mm, with associated damage to the underdeck structure.

- The deep longitudinal centre-line girder had buckled on the flat bar stiffener between frames 128 and 132.

- Deep frame 128 was creased on the port side.

- Deep frame 132 was creased on both port and starboard sides and the deckhead weld was torn for approximately 250mm.

- Deep frame 136 was creased on both port and starboard sides and a weld torn on the starboard side for approximately 50mm.

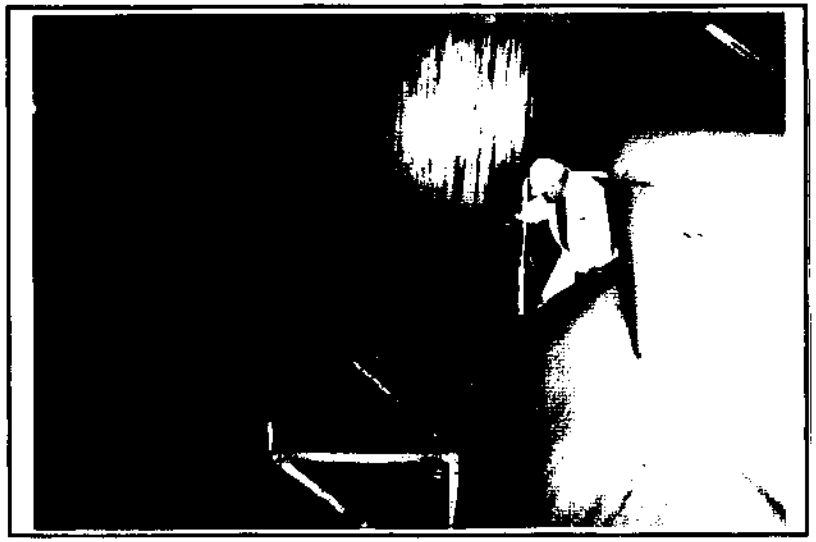
- The bulkhead between nos.3 and 4 centre tanks had been distorted on the port side in way of the top

Damage in no.4 double bottom access trunk

Split between no.3 centre and no.4 port cargo tanks

Damage between no.3 centre tank and no.4 double bottom access trunk

Bulkhead between no.3 and no.4 centre tanks - top diaphragm bulging into no.4 centre tank



horizontal diaphragm. The diaphragm had collapsed approximately 750mm into no.4 centre tank.

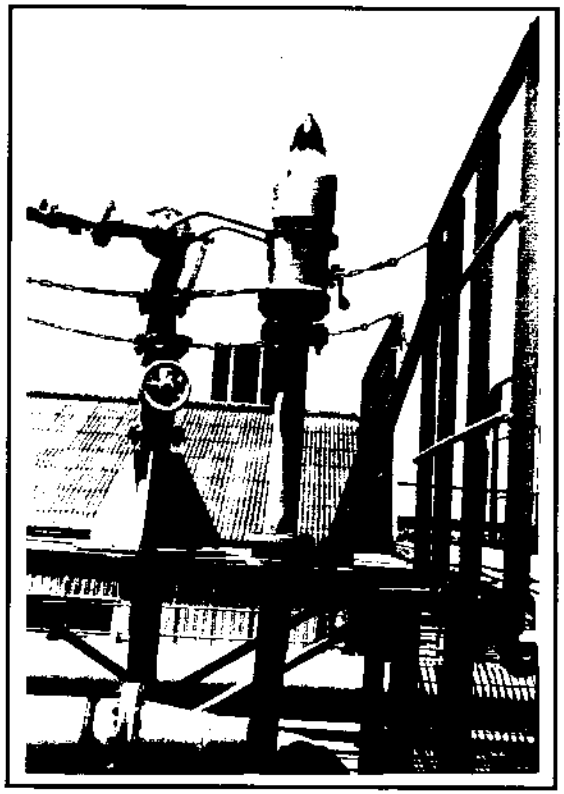
- The attachment of the transverse bulkhead to the access trunkway to no.4 double bottom ballast tank was distorted and torn. The attachment of the transverse bulkhead to no.4 port wing tank longitudinal bulkhead was distorted and torn. These two tears had allowed cargo to flow from no.3 centre to no.4 port wing tank and into the access trunkway to no.4 double bottom tank.

- Nine brackets attaching the top diaphragm to the deck were torn away from the diaphragm and the diaphragm plate itself torn at the toe of each bracket.

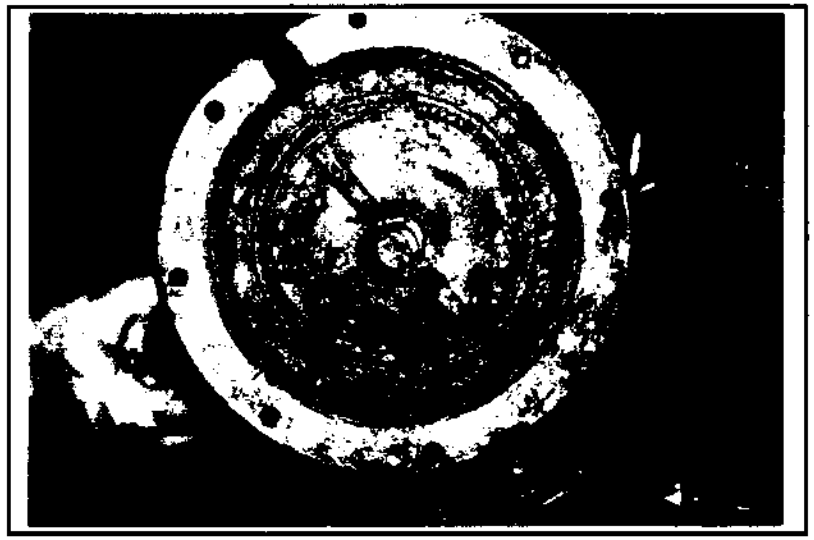
On 20 December, the P/V valve on no.3 centre was removed from the tank and opened up. It was found that the main spindle of the valve (for pressure relief) was seized solid (See photographs page 15).

An assessment was made, using the vessel's loading computer, of the stresses in the damaged bulkheads with the ship in the port loading condition. When it was determined that these stresses did not exceed 25% of the maximum permitted for the safe sea condition, it was decided to drill stop-holes at the ends of the major cracks and to allow the vessel to deliver its cargo to Adelaide and then to return to Geelong. This would be a round voyage of approximately one week. A Condition of Class was placed on the vessel, restricting bending moments and shear forces to 35% for the single voyage. The Master was advised to avoid any adverse weather.

This decision was taken in consultation between ASP Ship Management, Shell Marine Management and Det Norske Veritas. The Shell oil terminal had earlier been informed that "there was a problem on board, but that there had been no oil pollution". The Geelong Harbour Master, The Australian Maritime Safety Authority and the Inspector of Marine Accidents were all unaware that the incident had occurred until after the vessel had completed loading and had sailed for Adelaide on 12 December.

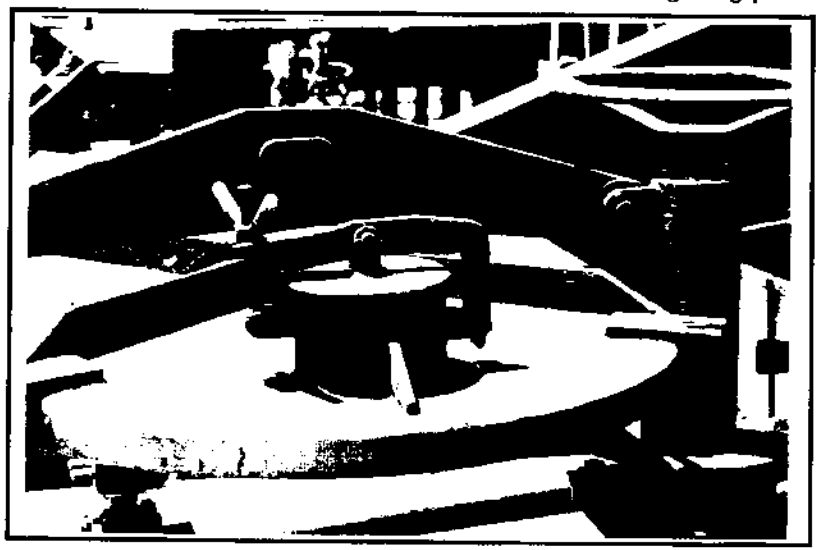


Typical pressure release valve in situ

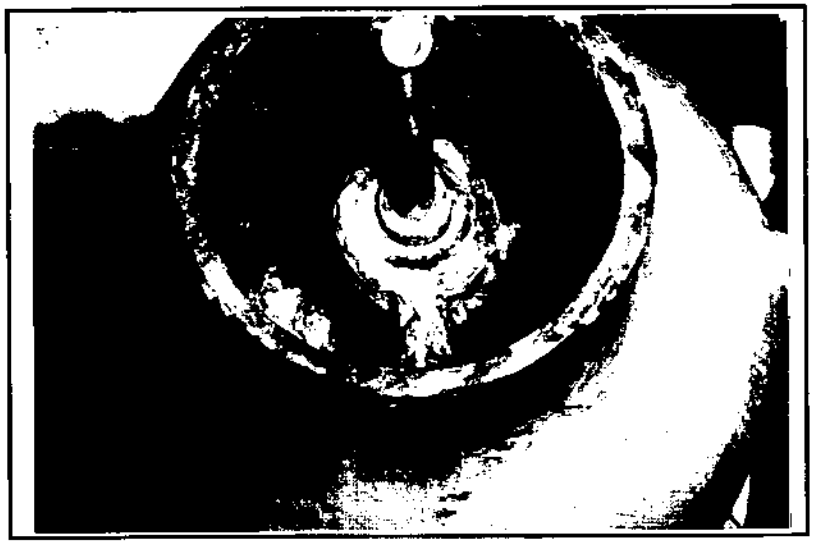


Pressure release valve opened up - view of underside of valve disc

Tank sighting port



Pressure release valve opened up - view of spindle in top guide bush



Comment

Over-pressurisation

The structural damage experienced by the vessel, in the vicinity of no.3 centre and no.4 port wing cargo tanks, was caused by an excessive build-up of gas pressure in no.3 centre tank as the tank was loaded. This was, in turn, caused by the failure of the single P/V valve, on no.3 centre tank, to open and vent the tank.

Upon arrival at Geelong on 9 December, the Osco Star had completed a five week voyage which had involved both discharging and loading. When loading in Barrow Island the P/V valve on no.1 starboard tank had jammed shut. When this was discovered, before any damage had been done, the tank sighting port was opened and allowed to vent to atmosphere. Again, following the discharge of the Barrow Island cargo and tank cleaning at Kwinana, no.3 centre P/V valve seized closed and the loading was completed with no.3 centre venting to atmosphere through the sighting port.

It seems that, although the Chief Mate was aware of the P/V valve problems, it was not mentioned at the daily management meeting and no provision was made to overhaul the P/V valve on no.3 centre before loading at either Kwinana or Geelong. On passage this was not practicable, given that the tank was loaded with crude oil and petrol respectively - volatile, low flash-point cargoes. However, during or after tank washing at either Kwinana or Geelong, there was an opportunity to do so. With no formal system in place for noting deficiencies in the operation of P/V valves on either the cargo control room white-board or the cargo information board, it seems that the defective valve slipped the Chief Mate's memory when dealing with his other duties.

Other members of the ship's staff were also aware of the problem with the P/V valves in general and of the fact that they were obliged to "open load" in Kwinana. This information was not discussed or acted upon. It seems that, with the exception of the Chief Mate, who accepted responsibility, all those aware of the problem, either assumed that somebody else would act on the problem, or did not appreciate the significance or dangers of a P/V valve failure.

Although the potential for faulty operation of the P/V valves seems to have been appreciated by the senior ship's staff and the order for a spare P/V valve was placed by the ship in July, the shore management, both the Ship Managers and Shell Marine Management, seemed to be unaware that the ship was experiencing problems with the P/V valves. No report of the problems, at either Barrow Island or Kwinana, was made to management before the issue was raised at a routine shipboard meeting between the ship's staff and the ASP Ship Manager on 9 December. At this meeting, the responsibility for maintenance of P/V valves was

discussed and it was noted that the ship should slow the loading, as necessary, if the P/V valves did not operate properly.

Unless a ship's tanks can expel or receive gas atmosphere at the rate cargo is pumped in or out, a pressure or vacuum will result. The tanks, therefore, are potentially pressure vessels and they rely on an effective P/V relief system. Gas tankers (LPG and LNG) are required to have at least two P/V valves of equal capacity on each cargo tank* allowing for redundancy in the event of over-pressurisation. Instrumentation is provided on such ships so that the pressure in each gas space can be monitored.

In the case of petroleum tankers, only one venting system per tank is required, allowing no redundancy in the case of a malfunction. Neither are petroleum tankers required to monitor the pressure in tanks. Local gauges, fitted on tank coamings would be subject to the same conditions as the P/V valves and would be similarly affected by cargo deposits.

However, remote sensing devices do exist and are available. In fact the remote sensing equipment fitted on Osco Star to monitor the tank ullage also has a remote pressure sensing option, but in the case of Osco Star such an option was not fitted when the ship was built.

Over-pressurisation incidents aboard ships, particularly tankers, are not uncommon. On tankers such incidents have the potential to result in explosion, subsequent loss of life and pollution.

On 7 November 1989, the Bermuda flag very large crude carrier, Mobil Petrel, suffered major structural damage to cargo tank bulkheads when a tank was over-pressurised. No pollution occurred. The report** by the United Kingdom's Marine Accident Investigation Branch (MAIB) noted at paragraph 12.1 that the Salvage Association's Casualty Information Retrieval System revealed that five such incidents occurred in the years 1984 to 1988.

The MAIB report made a number of recommendations including:

5.3 To have provision for monitoring IG pressure in individual cargo tanks of oil tankers.

5.4 To have a sensor measuring alarm device advising the CCR (Cargo Control Room) that a cargo tank is experiencing excessive pressure approaching the tank design pressure limit.

5.6 To have precise and detailed requirements for the overhaul and workshop testing of P/V valves.

Subsequent enquiries of the Salvage Association by the Inspector show that, since 1989 and the incident to Mobil Petrel, the Salvage Association has records of six incidents of over-pressurisation of tanks aboard tankers

* IMO Gas Code

** Marine Accident Investigation Branch (UK Dept of Transport). Report of the Investigation into the over-pressurisation of a cargo tank on the oil tanker Mobil Petrel at Fawley Oil Terminal on 7 November 1989. HMSO, London, 1991.

at a total repair cost of about US$ 6.4 million and a total repair time of 205 days. Over-pressurisation of tanks is not confined to tankers, with nine incidents involving the ballast tanks of other types of vessel occurring between 1 January 1990 and October 1992.

The Mobil Petrel report and its recommendations were known to the industry, including Shell Marine Management who passed the report to ASP Ship Management. ASP assured Shell that the equipment on board was satisfactory and that training and procedures were in place to ensure correct operation of the P/V valves. It does appear, however, that the shipping industry as a whole does not appreciate the relative frequency with which over-pressurisation of tanks occurs.

Pressure/vacuum relief valves

The P/V relief valves are type "HS4" manufactured by Press-Vac Engineering A/S, Denmark, and are designed to be able to vent the tanks at loading rates in excess of 3,000 cubic metres per hour without the tank pressure rising above 0.14 bar. An essential feature of the design is that sufficient velocity is imparted to the discharging gas under conditions of limited tank pressure for it to be carried high into the air, well clear of the ship's decks.

At the comparatively low rates of loading experienced by the Osco Star, the valve would not usually "float" continuously, but would be seated for much of the time until the pressure within the cargo tank built up to 0.14 bar, when the valve would then lift and relieve the pressure before again re-seating, much like the action of a boiler relief valve. At high loading rates, the valve could be expected to "float" continuously. This meant that a purely visual check on the operation of a valve would be inconclusive, as, if the valve was seated at the time of the observation, it could be between "lifts" but operating correctly, or it could be jammed shut.

The valves as fitted on the Osco Star are manufactured from materials as listed in 'Spec.5' of the illustration on the next page - with the exception that item 4 (Valve Top) is made of stainless steel and not bronze as listed.

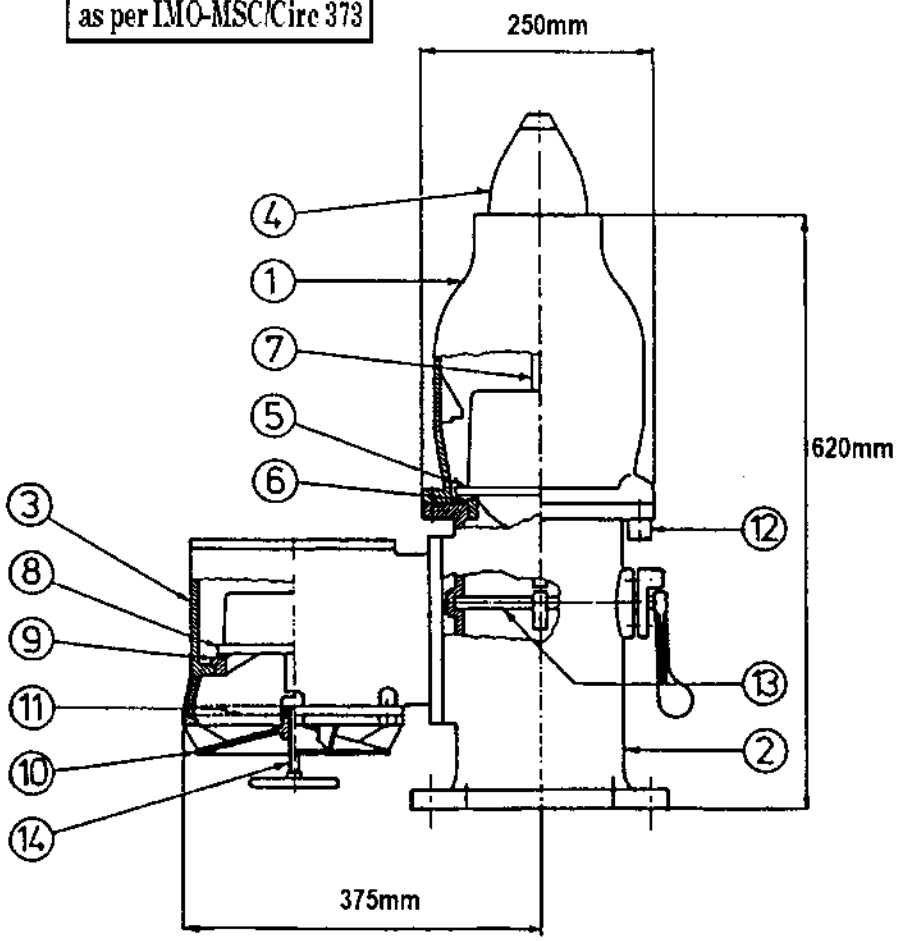
A test lever is fitted on the side of the valve such that 180 degrees rotation of this lever rotates a cam under the bottom of the valve spindle thus lifting the valve spindle, valve disc and the valve top, a short distance. If the valve is free to operate correctly, this movement of the valve top can be observed during routine testing of the valve and can be taken to indicate that the valve is in good working order.

When the valve on no.3 centre cargo tank had been removed and opened up, it was found that the cross-spindle, ("checklift" - item 13) carrying the cam, was seized in the valve adaptor (item 2) and the roll-pin securing the lever to the end of this spindle had sheared.

Operation of the test lever in this condition provided some resistance to movement, as the lever rotated on the

Item	Description	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
1	House	Cast iron	Cast iron	Stainl. steel	Bronze	Cast iron
2	Adapter	Cast iron	Cast iron	Stainl. steel	Bronze	Cast iron
3	Vacuum House	Cast iron	Cast iron	Stainl. steel	Bronze	Cast iron
4	Valve Top	Stainl. steel	Stainl. steel	Stainl. steel	Bronze	Bronze
5	Pressure Disc	Stainl. steel	Stainl. steel	Stainl. steel	Bronze	Bronze
6	Pressure Seat	Stainl. steel	Stainl. steel	Stainl. steel	Bronze	Bronze
7	Stem	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel
8	Vacuum Disc	Bronze	Stainl. steel	Stainl. steel	Bronze	Bronze
9	Vacuum Seat	Bronze	Stainl. steel	Stainl. steel	Bronze	Bronze
10	Venting Cover	Bronze	Stainl. steel	Stainl. steel	Bronze	Bronze
11	Flame Screen	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel
12	Drain	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel
13	Checklift	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel
14	Checklift	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel	Stainl. steel

IMO Type Test Approved
as per IMO-MSC/Circ 373



Pressure/vacuum release valve arrangement

end of the spindle with the pieces of the sheared pin still in place. With the cam spindle seized, however, the valve would not lift and no movement of the valve top (Item 4) would be observed, although in the case of a cursory test, moving the lever and feeling the resistance might give the impression that the valve was lifting.

On 20 December, when the ship had arrived back in Geelong after its voyage to Adelaide, all 16 P/V valves were removed ashore for overhaul. Initially some valves were tested before being stripped down. Results of these tests were:-

- No.3 centre valve - had not lifted when the test pressure reached 1.54 bar.
- No.1 centre valve* - lifted at 0.32 bar, then jammed open. It was closed by tapping the top of the valve with a mallet, but it then would not lift until the pressure reached 0.5 bar.
- No.5 centre valve - lifted at 0.35 bar, closed correctly, but then would not lift again with a test pressure of 1.5 bar.

In view of the failure rate, testing was suspended and all valves were stripped down for overhaul.

Examination of the valve from no.3 centre tank revealed that a buildup of a lacquer-like residue, combined with corrosion, had reduced the clearance between the edges of the valve disk (item 5) and the housing (item 1). In addition, it appeared that the valve spindle (item 7) was binding in its upper guide bush (not displayed in the illustrations on page 20) and the cone (valve top, item 4) was tight in the top of the housing owing to a buildup of dried cargo residue (See photograph page 15).

The routine testing of a valve by means of the "checklift" lever will indicate that the valve is free to lift. However, fouling of the valve disc, cone or spindle by either cargo residue or corrosion, will affect the pressure at which the valve will lift and will affect the reliability of the valve. This check gives no indication of the pressure at which the valve will lift as can be seen by the results, above, of the tests carried out ashore in Geelong.

Maintenance

The responsibility for the maintenance and running of all the ship's equipment rested with the Chief Engineer while overall responsibility for the safety and management of the ship remained with the Master.

Routine ship maintenance was under the day-to-day control of a ship management committee consisting of the Master, Chief Engineer, Chief Mate, Second Engineer, Chief Integrated Rating and the Chief Steward. The committee would decide the priorities of work and direct those ratings not assigned to keeping a navigation watch, to the agreed tasks.

* According to the report of the Classification Society surveyor. As reported by the ship's staff, this was not the valve from No.1 Centre, but from No.1 Starboard tank.

The maintenance of the vessel's P/V valves was determined at these daily meetings, partly on the basis of defects which had been reported and partly on a planned maintenance basis.

According to maintenance schedules complying with IMO standards, the vessel's P/V valves have to be inspected to ensure correct functioning and, if necessary, cleaned every six months, this being the minimum requirement.

After a further six months of operation, the valves must be stripped down and cleaned.

There is a note, however, to the effect that the frequency of these inspections and overhauls may need to be increased depending on such things as operating conditions, the number of loadings and discharges and the types of cargo carried.

However, given Osco Star's trading pattern with very few passages in ballast, the maintenance of the P/V valves had to be undertaken on an opportunity basis. Attempting to remove valves for overhaul, while the tank concerned was loaded and the ship underway, often resulted in some cargo spilling onto the deck, together with the emission of heavy inflammable and toxic vapours.

No spare P/V valve was carried by the ship to make the overhauls possible on a "unit swap" basis. A spare valve was ordered by the Chief Engineer on 23 July 1993, but the Ship Managers deferred processing the order, because of financial constraints, until the next year's budget.

All the vessel's P/V valves were opened up and overhauled between 29 January 1993 and 3 February 1993.

Following that, during the period from 12 February 1993 to 26 November 1993, P/V valves were stripped down and overhauled on 17 occasions, and on a further 30 occasions, the vacuum side was removed and the pressure side was checked free and greased through the vacuum side.

During these checks and overhauls, two other valves were found to have sheared roll-pins in their "checklift" handles.

The vessel's records indicate that the P/V valve on no.3 centre tank had had its vacuum side removed for inspection and greasing on 31 August 1993, although it was not completely overhauled.

The maintenance routine was assigned to the ratings, under the direction of the Chief Integrated Rating. They stripped down the assembly and routinely cleaned the inside of the valve housing with a rotary wire brush and a high-pressure water blaster. Other components were cleaned, greased and checked free.

There is no reason to suppose that the seizing of no.3 centre P/V valve was due to faulty maintenance. However, the interior of the valves were not systematically examined by qualified engineers, who may have had an appreciation of the rate of the build up of deposits and any deterioration through corrosion. The IRs' work was not subject to any quality control

system whereby the Chief Engineer could audit either the standard of work or the on-going condition of the valves. This is considered to be a deficiency in the working of the Daily Management Committee and in the communications between the Committee and the Chief Engineer and Master, who are ultimately responsible.

Check lists and operational procedures

Osco Star carried a range of written instructions and check lists to try and ensure safe operation of the ship. The management of Osco Star has made an attempt to produce a realistic system of instructions, all contained in a single volume. It is reasonable to expect those concerned to read and understand the sections relevant to them.

The system implemented aboard the vessel includes a number of check-lists used for the routine arrival, cargo operations, and departure from ports. Osco Star operates with an "Arrival Check list", in line with the International Safety Guide for Oil Tankers and Terminals. The "Start of cargo" check-list, is supposed to be completed and signed by the duty deck officer prior to the start of cargo operations. Item 11 (of 20 items on the check-list) states "All Hi-Jets are tested - pressure and vacuum".

A further check list, "End of Cargo Check List", has been implemented as an aid to ensuring that the cargo deck is secure and ready for sea.

While there was a start of cargo check list, there was no formal system for starting individual parcels, which, given the need for separation to prevent contamination, are in themselves sub-sets of a "start of cargo" operation.

However, before the start of each parcel there was an agreed procedure involving the Chief Mate, the officer of the watch and the IR. This was not contained in any instruction or check list, but had evolved under the direction of ASP Ship Management and the Chief Mates following an incident of cargo contamination which had occurred on the vessel at an earlier date.

As a matter of standard routine, the Chief Mate took charge of the control room at the start of each parcel, allowing the officer of the watch to be on deck, together with the duty IR to check the manifold, pipelines, pumproom and the P/V valves. This procedure involved either the duty officer physically testing the P/V valve by operating the "check lift" handle and seeing the cone rise, or by instructing the duty IR to test the valve. The duty IRs that had been with the ship from the outset were aware that the check involved sighting the cone rise as well as turning the check lift handle. Those IRs new to the ship, however, would not necessarily have been made aware of this, as the testing of P/V valves was not on their list of duties and, in addition, there were no written instructions in any of the ship's orders on just how the P/V valves were to be tested.

The ship had been working cargo since its arrival in Geelong on 9 December, when it discharged the cargo loaded in Kwinana. Upon completion of

discharging, the ship had been prepared to load a number of refined products for Adelaide. After the necessary tanks had been washed the ship made ready to load cargo. On the occasion of this particular cargo operation on 10 December, no "Start of Cargo" check list had been completed before the discharge of cargo on arrival, neither was one completed before the start of loading the Adelaide cargo.

When the kerosene parcel started at 1555 the Second Officer followed this standard routine. However, the parcel of gas oil and, subsequently, the parcel of petrol to the slop tanks, started during the hand-over of the watch and it seems that the Third Mate did not follow the standard procedure and did not go to the deck. Neither he nor the duty IR were able to confirm that they checked any of the P/V valves on the tanks being loaded.

The IRs maintained their deck watch guided by a 16 point memorandum instructing them on their duties with regard to the cargo watch, which included instructions on moorings, gangway and monitoring the cargo lines, pumproom and tanks. These instructions contained only one reference to the P/V valves:

> *14) Stand by Hi-Jets whilst topping up tanks and inform OOW if any signs of liquid sprays or overflow of products occurs.*

Although the instruction to "test all Hi-Jets, pressure & vacuum" is contained in the "Start of cargo checklist", it became apparent during the course of the investigation that the officers considered that testing the P/V valves was a routine duty which was supposed to be carried out by the IR, while the IR were of the opinion that, unless specifically requested to check the P/V valves, there was no requirement they should do so and there were no written orders instructing that they should.

Cargo watch 1900 to 2400, 10 December 1993

The First Mate relieved the Third Mate at about 1900 and assumed control of the watch. The Third Mate completed his rounds of the deck at 1915. He did not test any of the P/V valves and did not detect that no.3 centre tank was not venting. He did indicate that, as far as he knew, the P/V valve on no.3 centre tank was working but had not positively established this fact.

The First Mate had been told by the Second Mate of the problems with the P/V valves in Barrow Island and Kwinana, "in passing". However, the Chief Mate had not told him of any specific problem, and no reference was made to possible faulty valves either verbally or in the Chief Mate's written orders covering the loading in Geelong. As two parcels were being loaded simultaneously, gas oil (with high flash point) and unleaded petrol (with low flash point), it was essential that neither parcel should be allowed to contaminate the other. Hence it was important that not only should the cargo pipelines be isolated but also the inert gas line, which was common to all tanks.

The First Mate did not have the option of using the inert gas line as a possible safety valve. He did, as a precaution order that no.3 centre sighting port top be opened by a few turns of the dog. These few turns, confirmed as the amount by which the IR had opened the sighting port as instructed, did not allow sufficient gas to escape to prevent the over-pressurisation. The escape of gas from the sighting port must have been audible, and had it been heard by an experienced officer the over-pressurisation should have been detected before structural failure resulted. Between the time that the First Mate took over the watch and 2045, he was fully occupied with loading cargo and ballast operations and therefore had limited opportunity to go out on deck himself.

The control room loading record shows that the loading rate had dropped from an initial 958 cubic metres per hour to about 800 cubic metres per hour but, when no.5 wings were opened and no.3 centre was closed, the rate rose to over 1000 cubic metres per hour. While this may have indicated that the loading rate was being affected by a back pressure in the ship's tanks (as experienced while loading at Barrow Island), the loading of gas oil into no.5 wing tanks coincided, at 2205, with a change-over of shore storage tanks and the increased rate could have been attributed to this factor.

Subsequent calculations, using the ship's loading computer, confirm the First Mate's contention that the stresses placed on the ship did not exceed 55 per cent of the maximum allowable.

Any action taken after 2015, when the IRs on deck and the jetty personnel heard the "bang", would not have altered the outcome.

Conclusions

1. The structural damage experienced by the vessel, in the vicinity of no.3 centre and no.4 port wing cargo tanks, was caused by an excessive buildup of gas pressure in no.3 centre tank as the tank was loaded. This was, in turn, caused by the failure of the single P/V valve on no.3 centre tank to open and vent the tank.

2. The P/V valve met the International Maritime Organisation standard and was of proven design. However, the cast iron used in the P/V valves on Osco Star resulted in a build up of rust and cargo residues in the critical area between the valve housing and the edge of the valve disk and also between the valve housing and the top cone.

3. Due to the fact that the ship made relatively few voyages in ballast, the opportunity to overhaul the P/V valves at sea was limited.

4. The Chief Mate knew of a deficiency in no.3 centre tank P/V valve, but did not ensure that the valve was repaired or that alternative open loading procedures were followed before loading cargo to that tank. It is probable that the need to ensure that the valve was repaired slipped his mind.

5. Other members of the ship's staff were aware of the defect in no.3 centre P/V valve but no action was taken to rectify the situation, and only a limited and low key reminder was given to the officer of the watch, and no alternative open loading procedure was suggested.

6. The Third Mate, when handing over his watch, indicated that the P/V valve on no.3 centre tank was functioning correctly, without having previously established that this was the case.

7. There was a break-down in procedures in addressing the repair of no.3 centre P/V valve and a failure of communications concerning the importance of ensuring the valve worked correctly.

8. The information obtained during the course of this investigation, with particular reference to the report of the Salvage Association, UK, would demonstrate that incidents of over-pressurisation of cargo and ballast tanks, with the associated danger to life and the risk of pollution, occur very much more frequently than is commonly appreciated throughout the maritime industry.

Submissions

Under the provisions of sub-regulations 16(3) and (4) of the Navigation (Marine Casualty) Regulations, if a report, or part of a report, refers to a persons's affairs to a material extent, the Inspector must, if it is reasonable, give the person the report, or part of the report, to allow the person to provide written comments or information relating to the report.

Parts of the draft report were sent to:

The Master of the Osco Star
The Chief Engineer of the Osco Star
The Chief Officer of the Osco Star
The Third Officer of the Osco Star
The Shell Company of Australia Ltd.
ASP Ship Management.

Where comments or information were received, they have been carefully considered and, where appropriate, the text of the report has been altered to reflect the facts of the incident. In the case of other submissions, the issues are outlined below.

Chief Mate

The Chief Mate submitted that the normal routine for checking that a P/V valve is venting was carried out at the commencement of loading into no.3 centre cargo tank in Geelong. His submission states :

".....The IR returns to the deck and the tank that loading has just commenced into, I then request him/her to confirm that the tank is venting. This was done when the loading started in 3C in Geelong"

Inspector's comments

Evidence was provided to the investigation from the Third Mate, who was the duty officer at the time that loading into no.3 centre commenced, from the duty IR and from the Second Mate, who was completing his inspection of the deck. None of these could confirm that they either tested the P/V valve on no.3 centre or reported that it was venting.

The Inspector is satisfied that, although the Chief Mate may have otherwise followed the usual routine for commencing loading into a tank, this particular check was overlooked.

Third Mate

The Third Mate submitted that:

"...on the day of the event at approximately 1605, I as 3/O took over the watch from the C/O and conducted my duties as per usual. The Geelong loading was no different to any other loadings performed in Geelong and I wish to emphasise that to my knowledge, all the normal checks had been completed prior to loading commencement."

Master

The Master submitted that every effort was made to contact AMSA in Canberra and Geelong over the weekend to notify them of the incident and that he was unable to obtain an answer in every case.

Inspector's comments

The Inspector appreciates that these efforts were made, but cannot accept this argument as no report was passed to the Maritime Rescue Coordination Centre (Federal Sea Safety Centre) in Canberra which is manned 24 hours a day. The consequence of this was that AMSA was unaware of the incident until after the vessel had sailed from Geelong.

Following this incident, AMSA has ensured that a list of after-hours contact numbers is available to the industry.

ASP Ship Management

ASP Ship Management submitted that *"The Marine Incident Investigation Unit is called into play by AMSA not by the owner."*

Inspector's comments

The Inspector does not accept this argument. The Navigation (Marine Casualty) Regulations, under sub regulation 4(1)(b), specifically state:

".....The Master of the ship must report the incident to the Inspector as soon as practicable and by the quickest means possible."

Section 4 goes on to state in subsection (2) that, *"A report made as soon as practicable, and by the quickest means possible, to the Federal Sea Safety Centre under section 268, 269 or 417 of the Act is to be taken to have been made under subregulation (1)."*

ASP Ship Management

ASP Ship Management pointed out in their submission that no follow-up action has so far been taken, following the publication of the Mobil Petrel report, by either the International Maritime Organization, the Classification Societies, or the regulatory authorities.

Inspector's comments

The Inspector acknowledges this to be the case.

ASP Ship Management

ASP Ship Management stated that the order for the spare P/V valve was deferred with the full knowledge and agreement of the Shipboard Management Team.

Details of ship

Name:	Osco Star
IMO Number:	8617017
Flag:	Australian
Classification Society:	Det Norske Veritas
Ship Type:	Tanker
Owner:	AA 64 K/S UL Osco Star (Kopenhagen) Denmark
Demise Charter:	Shell Company of Australia Ltd.
Ship Managers:	ASP Ship Management
Crew:	20 Australian
Year of Build:	1989
Place of Build:	Pula, Croatia (former Yugoslavia)
GRT:	22572
NRT:	13055
DWT:	40541
Length overall:	176m
Moulded breadth:	32m
Engine Power:	9353 bhp (6880kW)