Contents

Summary

On 19 January 1994, the Australian flag tanker Osco Star was loading a cargo of petroleum products at No.2 Jetty of the BP Refinery at Kwinana, near Fremantle, W.A.

At about 1420, aviation jet fuel (Avtur) was being loaded into No.5 port and starboard wing tanks and nearing the required finishing ullage in both tanks when the duty mate in the cargo control room shut No.5 port wing tank filling valve. This action put the full loading rate, of about 1200 m^3 /hour, into No.5 starboard tank and, shortly afterwards, cargo overflowed onto the deck from the pressure/vacuum release valve on No.5 starboard cargo tank.

Immediately, shore pumping was stopped, no.1 centre was opened as a "crash tank" and the manifold valves and all cargo tank filling valves were closed.

When the clean up of the spilt oil was completed, soundings were taken of all cargo tanks. From these, it was established that the level in No.5 starboard tank was falling, while that in No.4 starboard was increasing - an indication that these two tanks were now common in some way.

The cargo in Nos.4 and 5 starboard tanks was pumped to other tanks in the ship and the two tanks were then cleaned and gas-freed prior to being inspected.

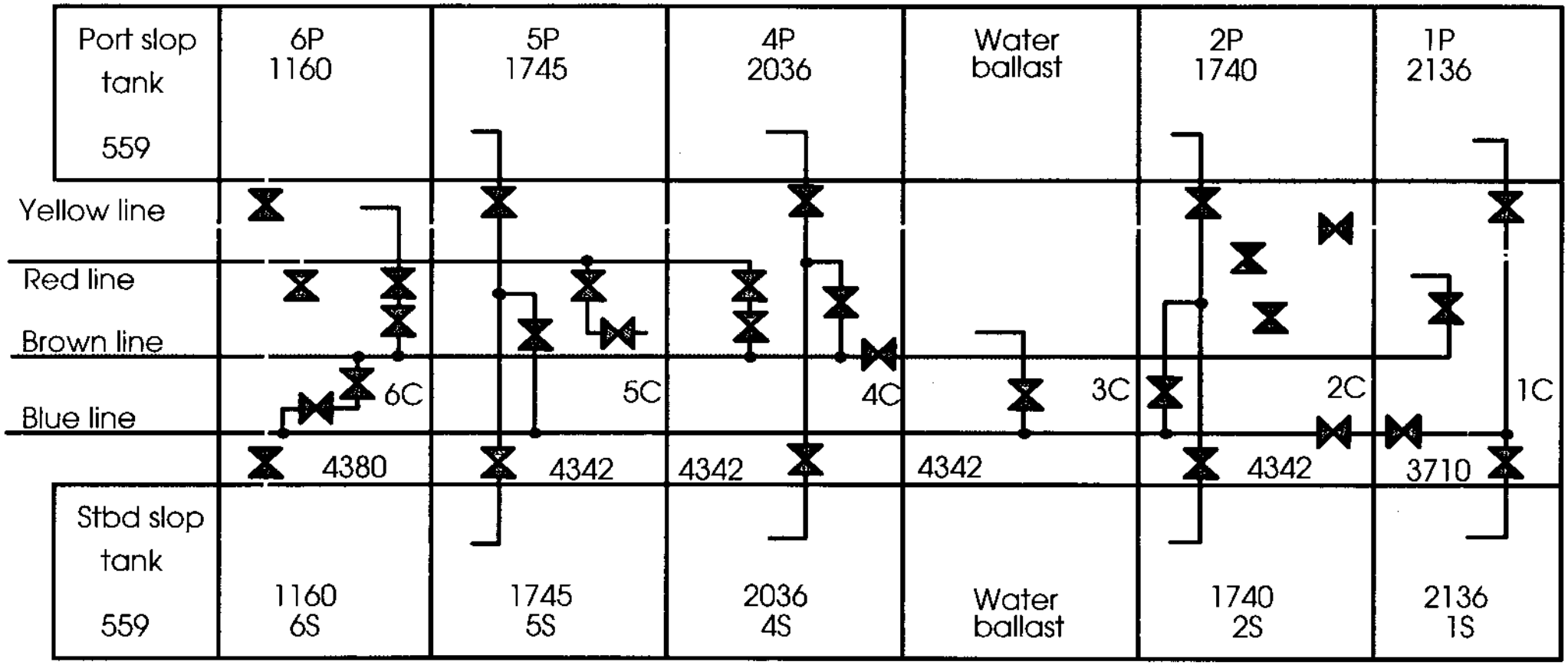
Inspection revealed that there was extensive damage to the structure between the two tanks caused by No.5 starboard tank having been hydraulically over-pressurised. The bulkhead had ruptured, leaving a hole of approximately 1 X 1.5 metres. Various other sections of the corrugated bulkhead were bulging, and a weld fracture was found in the aft bulkhead of No.5 starboard tank.

The vessel was eventually allowed to load its original cargo and to proceed to Sydney and thence Geelong for temporary repairs.

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

Sources of information

The Master, officers and crew of
Osco Star
Australian Maritime Safety Authority
ASP Ship Management
Det Norske Veritas
Autronica A/S, Norway



OSCO STAR

Cargo tank and pipeline diagram

(Tank capacities shown in cubic metres @ 98%)

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, Yugoslavia and was originally registered under the Norwegian flag (second register), owned by 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. 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 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 if the inert gas system was inadvertently closed off. It is not designed for, or capable of, relieving pressure in the case of over-filling a tank.

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 Shell Australia 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 for northern ports of Queensland, the Northern Territory and Western Australia and back-loading crude oil from Dampier or Barrow Island.

The ship operates on a two-crew or "swing" system. At any one time the ship has a crew of twenty, with two or three additional cadets or provisional integrated ratings under training.

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.

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 by means of a

remote-controlled valve operating system. 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 integrated rating 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, such as to stand by cargo tanks which are being topped off.

Cargo monitoring

While either loading or discharging cargo or ballast, the level in the individual cargo or ballast tanks is continuously monitored by an Autronica NL100 Level Display/ Monitoring System working on the principle of radar ullaging.

Set onto the top of each tank is a sensor containing a microwave radar transducer, the signal from which is emitted as a narrow (10°) beam of electromagnetic waves through a small hole in the tank top. The reflected signal, or echo, is received by the same sensor and the ullage (or distance to the liquid surface) is, in principle, derived from the time delay of the reflected signal. The software utilised in signal processing ensures that accuracy of the level measurement is not affected by a trim or list of the vessel by up to 4°. In addition, the software contains self-check and fault diagnosis facilities for the supervision of each sensor, including an automatic warning should excessive deposits build up on the transducer surface. The accuracy of the system is stated by the manufacturer as being ± 2mm at 40 metres, varying by as little as 0.02 per cent under the most extreme of tank atmospheric conditions.

Programmed into the computer are three level alarm settings for each tank, these are a low-level, high level and a high-high level. The high-high level alarm is set at 98 per cent and cannot be altered by the operator, while the high and low level alarms can be set as required on the computer. The cargo tank high level alarms are usually set at 95 per cent, and are rarely altered by the ship's staff.

The signal from each tank sensor is fed to a central channel unit in the Cargo Control Room containing a number of individual channel modules and, after processing in a micro-computer, to a desk-top computer screen on which can be displayed, simultaneously, the levels in any required grouping of tanks. The screen also displays a number of other parameters, such as the temperature of the cargo in each tank, the tank level alarm settings and any activated alarms. In addition, the computer will calculate the loading rate for each tank and, if the correct screen is displayed, will show the remaining time to go before a tank is full.

The signal from the central channel unit, in addition to going to the desk-top computer, is also fed to the main alarm panel and to a digital display unit on which can be selected, individually for each tank, the level, tank temperature etc. Only one

parameter, for a single tank, can be displayed on this unit at any time.

The desk-top computer station is situated at the starboard side of the Cargo Control Room, the digital display unit being situated near the centre of the control room on the after bulkhead, four or five metres away. Close to the digital display unit is the main alarm panel at which the audible alarms for the Autronica system must be cancelled.

If a tank alarm is activated, it is necessary to first cancel the audible alarm with the button on the main alarm panel and then to "accept" the alarm using the keyboard of the computer at the starboard side of the control room. Once the audible alarm has been cancelled, the computer screen will continue to show the appropriate alarm as a flashing, red highlighted, indication, until such time as it is "accepted" at the keyboard. Once accepted, it will change to a steady indication.

Unless an alarm is "accepted" at the computer, no other subsequent alarms will be sounded audibly.

Standing orders and loading procedures

Cargo operations are conducted in accordance with "Cargo Operations Standing Orders (For Deck Officers)" which each deck officer is required to read, understand and follow. These standing orders were reviewed from time to time.

A document dated 20 December 1993, supplementing the standing orders, was prepared by the ship's staff and sent to ASP Ship Management. This dealt with the time that the cargo tank valves took to open and shut and, because the tank valves were of "butterfly" configuration, they should be either fully open or fully shut to avoid shearing the valve spindles. The document also dealt with loading rates and stipulated a maximum rate of loading of not more than 250 m^3/hr into any tank being topped off.

Loading of any individual cargo followed a plan drawn up by the Mate, depending upon the grades of cargo to be loaded. This plan included loading and de-ballasting.

Narrative - 19 January 1994

Following a ballast voyage from Darwin, Osco Star berthed at No.2 jetty of the BP Oil Refinery at Kwinana, near Fremantle, at 1015 on 17 January 1994. On completion of the discharge of tank washings and cargo slops, the vessel was ready to load its next cargo of Avtur, * and two grades of motor spirit for discharge at Sydney and Geelong.

At the request of the refinery, there was a 24 hour delay before the loading of cargo commenced at 0340 on 19 January.

The Mate's loading plan provided that each of the tanks designated for the parcel of Avtur would be loaded to, or close to, 98 per cent capacity.

The Second Mate was on watch in the cargo control room during the afternoon watch (1200 to 1600) on the 19th and was supervising the loading of premium motor spirit (PMS) into No.4 centre tank and Avtur into No.5 port and starboard wing tanks. He topped off No.4 centre tank at 1244 and continued loading PMS into No.5 centre tank. At 1410, he completed de-ballasting No.4 double-bottom ballast tank. Also at about 1410, the Master, who was with the Ship Manager (on board for a routine visit) in the conference room next door looked into the control room and told the Second Mate that a routine audit of the ship's charts was satisfactory.

At 1400, the Second Mate had taken readings of the tanks being loaded and calculated how much time there was to go before No.5 wing tank would reach their final ullage. He estimated that it would take a further 25 minutes. The ship at that time had a slight list to port. At about 1415, both the wing tanks were approaching their final ullage when, with about 70 m^3 still to go in each tank, he shut the filling valve on No.5 port tank to rectify the port list. This put the full loading rate of Avtur, which at that time was approximately 1200 m^3 / hour, into No.5 starboard tank.

He had previously opened the blue line to brown line cross-over valves and the isolating valve on the brown line, ready to chage over the filling from No.5 wing tanks to No.1 centre tank which already contained some product loaded at 1100 for the purposes of sampling and stress reduction. The tank filling valve on No.1 centre tank, however, was still closed. (See pipeline diagram on page 4)

At 1420, the Master, in the vessel's conference room, stood up to cross the room and, as he did so, noticed a plume of oil spray about 5 metres into the air from the pressure/vacuum breaker valve on No.5 starboard cargo tank. He raced to the adjacent cargo control room and told the Second Mate

* Aviation Turbine fuel. A volatile kerosene-based jet fuel with a flash point of approx. 40°C. Volatile cargoes are those with flash point below 60°C.

to stop loading. Almost simultaneously, the integrated rating on watch on deck was calling the cargo control room by radio to advise of an oil spill. The shore was contacted and loading was stopped almost instantly. The filling valve on No.1 centre tank was opened to use it as a "crash tank" to take any further overflow and all other valves were then closed. All ullages, as displayed by the Autronica system were recorded.

A strong wind was blowing from the starboard beam at the time of the spill and the spray of oil was mostly blown back across the deck instead of over the vessel's side. The spill was thus contained on board the ship with very little, probably less than 10 litres, polluting the harbour. At 1425, the Master telephoned the Fremantle Port Authority to advise them of the incident.

At 1435, ASP Ship Management and the Shell Company of Australia were advised of the spill and, at the same time, all available hands, including the catering ratings, were called to assist in cleaning up the oil spilled on deck.

During the process of cleaning up, it became evident that there was a vacuum forming in No.5 starboard cargo tank, air being drawn in through the vacuum release side of the P/V valve. It was also discovered, when a manual ullage was taken, that the level in No.4 starboard tank had risen significantly.

Fearing that structural damage had occurred to the bulkhead between Nos.4 and 5 starboard tanks, the suction valves of Nos.5 port and 5 starboard tanks were opened. It was soon observed that cargo was flowing from No.5 port, via No.5 starboard, to No.4 starboard. A manual ullage was then taken of all cargo tanks.

Once it had been confirmed that Nos.4 and 5 starboard cargo tanks were common in some way, it was decided to transfer the cargo from those tanks to Nos.1 and 6 centre tanks and to wash and gas-free Nos. 4 and 5 starboard cargo tanks in preparation for tank entry.

AMSA and Det Norske Veritas were informed of the incident, and the next morning the tanks were entered and inspected.

Damage

The inspection of No.5 starboard tank revealed substantial damage to the (forward) bulkhead between Nos.4 and 5 starboard wing tanks. There was, in addition, some damage to the (aft) bulkhead between Nos.5 and 6 starboard wing tanks.

1. Forward bulkhead - frame 26

. Buckling approximately 80 mm deep in the centre of the second diaphragm from the top.

. Attachment to tank no.5 centre, diaphragm No.3 torn - damaged area approximately 1 metre X 1.5 metres. Plate pushed back towards No.4 starboard. Brackets fractured on both sides of the diaphragm.

2. Aft bulkhead - frame 72

. Two buckled areas in the centre of the second diaphragm, approximately 100 m deep.

. Fractured weld on bracket between bulkhead and stringer, the second diaphragm and longitudinal bulkhead of tank No.5 starboard and No.5 centre.

3. Ship side

. Starboard side plating buckled approximately 80 mm deep in the vicinity of the second diaphragm of the transverse bulkhead at frame 72.

In view of the fact that the tank was full, as evidenced by cargo issuing from the pressure/vacuum release valve, and loading at about 1200 m^3/ hour was still taking place, it can be concluded that the damage was caused by hydraulic over-pressurisation of the tank.

Following the assessment of the damage, calculations on the vessel's loading computer showed that the stress in the damaged bulkheads was no more than 30 per cent of the maximum safe sea condition. On this basis it was decided, after consultation between AMSA, Det Norske Veritas and ASP, the ship managers, that the vessel would be allowed to deliver its cargo to Sydney and Geelong. Conditions imposed were that, for departure from Kwinana, the shear forces should not exceed 32 per cent and bending moments 22 per cent, while for departure from Sydney these should not exceed 30 per cent and 33 per cent respectively. Nos. 4,5 and 6 starboard tanks were all to be filled together. All precautions were to be taken regarding bad weather.

Upon completion of the voyage, temporary repairs to AMSA and Class requirements were to be undertaken at Geelong.

Damage to bulkhead caused by over-pressurisation of No.5 Starboard cargo tank

Comment and Analysis

At 1410 on 19 January, the Master had looked into the control room briefly to confirm that an element of the routine management inspection, for which the Second Mate was responsible, was satisfactory. At that time, 10 minutes before the incident, the loading operation appeared to be continuing routinely. However within the next ten minutes the Second Mate failed to change from No. 5 wing cargo tanks to No.1 centre tank safely and efficiently.

The structural failure of No. 5 starboard cargo tank was caused by the overfilling of the tank and the subsequent hydraulic pressure exerted on the tank structure by the cargo within the tank.

This occurred as a result of the failure of the Second Mate to perform a number of routine but critical procedures, to:

- slow the loading rate while topping off the tanks.
- top off two tanks and open a third, to take the balance of the parcel of cargo.
- switch the digital tank level display from no.5 port to no.5 starboard tank.
- correctly calculate the "time to go" for the jet fuel, from 1400 hrs.
- accept an alarm displayed on the Autronica VDU.

The Second Mate's failure to perform adequately in the particular circumstances of the early afternoon of 19 January needs to be examined in the context of the safety system in place on board Osco Star for loading cargo.

Human factors

The evidence was that the Second Mate was a motivated and conscientious individual. He had, on the two previous mornings of 18 January and 19 January, undertaken duties beyond his normal watch period.

However, it is significant that during the 62 hours leading up to the incident of the afternoon of 19 January, the Second Mate had a total of not more than 15 hours sleep in three periods, not one of which was more than 5 hours in duration. The choice to forgo the opportunity to sleep was his own.

He had gone ashore on the afternoon/ evening of 17 January, returning to take up his watch from 0000 to 0400 on 18 January, during which time cargo was not being loaded. He volunteered to assist one of the engineers to change the seals on a cargo tank valve and finished work at 0600 on 18 January.

After his watch on the afternoon of 18 January he went ashore, returning at 0130 on 19 January, as arranged with the Third Officer. It was during this watch that cargo loading started and he remained on watch until 0600, to extend the Mate's opportunity to rest, as the Mate had been on duty for the start of cargo. He had the opportunity to sleep from some time after 0600 until he had to get ready to go on watch at noon.

During his watch from 1200 on 19 January, he performed routine tasks involved with de-ballasting and he topped off No. 4 centre cargo tank and changed to No.5 centre tank. Although the Autronica screen is capable of displaying a figure for "time to go" before a tank or tanks are full, the Second Mate had, after taking his readings at 1400, made a calculation to work out the time at which he expected to be topping-off No.5 wing tanks. From the Autronica, he obtained a figure for "cubic metres to go" (before the two tanks had reached their final planned ullage) and divided this by the rate of loading in m^3/hour. His answer was 0.25, which he then mistakenly took to be 25 minutes, instead of 0.25 x 60, i.e. 15 minutes. In addition to this, shutting off No.5 port, when it still had 70 m^3 to go, effectively doubled the loading rate into No.5 starboard.

The sleep pattern and the subsequent slip in calculation indicate to the Inspector that there is a probability that fatigue was a factor. The lack of sleep and possible preoccupation with a personal problem affecting the Second Mate at that time, were factors which fostered distractions, a failure in concentration and reduced performance during the topping-off of No.5 wing cargo tanks. Any fatigue was, to a major degree, the result of the Second Mate's own actions.

Experience and training

The Second Mate held a certificate of competency as Master Class 1 issued on 26 September 1991, he had also completed a basic oil tanker safety course meeting the requirements of Marine Orders Part 3, Appendix 4. He had completed a cadetship with the Australian National Line before being appointed as Extra Third Mate in late 1985. His seagoing experience from that point onwards was mostly in dry cargo vessels, particularly container ships. However, he had sailed as third mate on a tanker for one month from December 1990 to January 1991, between Port Stanvac, South Australia and south-eastern ports, in which time he was involved in two, possibly three, loading operations. He had also sailed as third and second mate on a gas carrier between April 1992 and July 1993. He held a gas carrier endorsement obtained in April 1993, qualifying him as a "responsible officer" on board gas carriers, as defined by Marine Orders Part 3, Seagoing Qualifications.

When first appointed to the ship in September 1993, he had arrived on board at 2200 in the port of Darwin. He went on watch with the previous Second Mate for the 12-4 watch that night. As the vessel sailed at 0600 the

following morning, those four hours constituted the total hand-over of his duties from the previous officer. At the next and subsequent ports where cargo was worked he was left on his own, with the responsibility of the Duty Mate, subject to the "Cargo Operations Standing Orders" and the Mate's loading instructions.

At the time of the incident, the Second Mate had been on the Osco Star for a total of ten weeks - a previous "swing" of six weeks duration and approximately four weeks prior to the incident. During his time on the Osco Star, he had experienced only two cargo loadings on the ship before the one in which the incident occurred.

In spite of his limited experience, however, the Second Mate expressed confidence in his knowledge of the ship and the cargo systems and in his ability to carry out his duties. This air of confidence was noticed by the Master and the other deck officers, all of whom, it appears, made the assumption that his experience of oil tanker operations was considerably more extensive than was actually the case. While performing his duties on the two occasions he was involved in loading Osco Star, he did nothing that led to a change in their assessment. His general air of confidence seems to have contributed to the lack of supervision afforded to him in the early stages after he first joined the vessel.

At that time, the Ship Managers had no policy in place for advising Masters, in any detail, about the level of experience of new officers joining a ship.

Standing instructions for cargo operations on Osco Star had been drawn up when the ship came under Australian management. The "Cargo Operation Standing Orders" included an instruction:

3. No alarms are to remain unaccepted on the Autronica screen, and the significance of all alarms must be fully considered. All high level . . ."

9. REMEMBER.. IF IN ANY DOUBT ABOUT ANY ASPECT OF CARGO OPERATIONS DO NOT HESITATE TO CALL THE CHIEF OFFICER AND IF NECESSARY DO NOT HESITATE TO STOP ALL CARGO OPERATIONS IMMEDIATELY.

The standing orders had been amended by ship's staff in December and a copy of the amendments were sent to ASP Ship Management on 20 December 1993. These amendments formed part of the general standing orders but were separate from the pages signed by the officers on board, as having read and understood the instructions. It was this amendment that referred to a maximum loading rate of 250 m^3/hr when topping off a single tank.

The Second Mate, being the deck officer on duty, was left in charge of the watch. His duties included monitoring the level of oil in the cargo tanks and discharging ballast from the double bottoms. During the watch tanks were to be topped off and No.1 centre tank was to be opened to take the balance of the Avtur. The Second Mate had lined up the system so that No.1 centre cargo tank could be

opened to take the balance of Avtur fuel when No. 5 wing cargo tanks were filled. Loading of Avtur fuel on 19 January, was at about 1200 m^3/hr.

As the valves were of the "butterfly" type, they are not designed to control the rate of flow and the instructions were that the valves to the tanks had to be fully open or fully shut. The valve to no.1 centre could not be used to control the rate of flow to the wing tank, as would be possible with "gate" type valves. Therefore it was necessary to slow the rate of loading from the shore. However, the Second Mate neither slowed the loading rate before or after closing No. 5 port tank, nor did he open the tank valve to start filling No.1 centre, either before closing No.5 port tank or before No.5 starboard overflowed.

The Ship Managers submitted that the Second Mate had sailed on the vessel for ten weeks, he was qualified as a Master Class 1, had served as Mate on a container ship and was in all respects sufficiently trained and experienced. The Managers stated that, although he did not have an oil tanker endorsement, he held a gas carrier endorsement and this, together with his experience on gas carriers, made him a suitable officer of the watch, able to undertake routine manipulation of the valves and to top off tanks.

The Ship Managers referred to the fact that the Second Mate had topped off No.4 centre tank successfully on the afternoon of 19 January, a short time before the overfilling of No.5 starboard and they stated that there should be no reason to believe that he would not complete No.5 port and starboard tanks and open No.1 centre tank to take the balance of the Avtur.

The importance of topping off is recognised in the "Cargo Operations Standing Orders" which required:

"4.*Entry is to be restricted into the cargo control room by use of the barrier during all critical operations, such as changing grades, topping tanks, stripping tanks etc.*"

The Inspector cannot agree that the Second Mate was "experienced" in the loading of oil tankers. Although experienced in navigation, general ship duties and gas carrier operation, he was not sufficiently experienced in oil tanker operation to be left in charge of critical operations such as topping off cargo tanks. Although such an operation is routine in nature, the risk of an accident is increased during such times, with the decreasing ullage in the tanks, the ever reducing time in which to react and the need to manipulate the correct valves in the correct sequence, as well as to correctly monitor the tanks involved.

It is important that individuals handling cargo in such situations have the rules learnt through experience upon which to rely. The Second Mate did not have such experience. In this incident, having neglected to slow the loading rate and having closed No.5 port cargo tank, the final 70 m^3 of No.5 starboard cargo tank would have taken just 3 to 4 minutes to overflow the tank.

His experience of tanker loading operations was limited to the two

loadings on Osco Star and the loading he experienced in the four weeks in 1990/91, three years previously. In identifying the factors that contributed to the chain of events leading to the incident, the Second Mate's inexperience was a further causal factor.

Responsible Officer

There are no specific Marine Orders concerned with oil tanker loading and unloading. However Marine Orders Part 3, Seagoing Qualifications, provides that a person is not qualified to be a "responsible officer" on an oil tanker unless that person's certificate of competency bears an oil tanker endorsement. A "responsible officer" is defined in Marine Orders part 3, Sect.1.1, as a "...master, chief mate, chief engineer officer, second engineer officer, or any other person with immediate responsibility for loading, discharging, care in transit or other handling of cargo."

The responsibility for the handling of the cargo rested with those officers holding the required endorsement under Marine Orders Part 3, Annex 4.1. Internationally, there would appear to be a range of views in relation to the involvement of a "responsible officer". These range from a very literal interpretation, similar to the Australian Maritime Safety Authority's position in April 1994, that any officer left in charge of a cargo watch loading or discharging an oil cargo must hold a Tanker Endorsement, to one that requires a "responsible officer"to be available, his/her direct supervision depending upon the circumstances of the operation.

Aboard Osco Star, the Master and the Mate were the two deck officers qualified as having immediate responsibility for loading cargo. The Master and the Mate, therefore, both have a responsibility to ensure that any officer to whom their own responsibility is delegated for such matters as cargo handling, is both suitably qualified and capable of fulfilling that responsibility without endangering the vessel. Where there is some doubt, then it is expected that the Mate would ensure that he was present, at least, at critical phases such as topping-off tanks.

The Mate is regarded as always being "on call" during all cargo loading and discharging operations. Although it was customary for the Second Mate and Third Mate to work 6 hour watches under certain circumstances when the Mate is subjected to a particularly heavy cargo workload, it was the Managers' stated policy to maintain sea watches (4 hours on, eight hours off) in port to avoid undue fatigue.

It was ASP Ship Managment's view that it was unreasonable to expect all officers on a tanker to hold a tanker endorsement, as such a requirement made no provision for junior officers to obtain the necessary qualifying time and experience. They also submitted that, with reduced crew numbers, to require either the Master or the Mate to be present at critical stages of loading, discharging and handling cargo was

unreasonable and introduced further aspects of fatigue, to the detriment of overall safety.

To qualify for a tanker endorsement requires a period of six months service on a tanker. It should also be recognised that experience in tanker operation is gained in loading discharging, tank cleaning or care of cargo in transit, the extent of such experience in a six month period depends upon the trading pattern of the vessel. A "tanker endorsement" is an indication of a minimum level of experience.

The Second Mate did not have sufficient service on tankers to qualify him to hold a "tanker endorsement", in fact he had served only 14 of the 26 week qualifying time for the endorsement. As far as the loading of any oil tanker was concerned, he was not a "responsible officer".

Oil cargoes are usually volatile and, in addition to any flammable or explosive qualities, carry the additional risk of pollution. In the Inspector's opinion, it does not matter how routine a procedure has become if it is of such a critical nature that it carries extra risk and any margin for error is reduced. Any incorrect decision or omission can, as in this case, lead to a significant incident.

By the very nature of critical operations, such as topping off, there comes a time when the standing orders to call the Mate or Master "if in doubt" becomes operationally impracticable, as there is insufficient time for either to reach the control room (or deck) and take effective control.

From the time that it becomes impracticable to call the Master or the Mate for assistance, the officer in charge of loading operations is the only person in a position to exercise "immediate responsibility."

The Managers also pointed out that, with the reduced manning and the constraints placed on manning levels as a result of developments from the Maritime Industry Development Committee process, opportunities for on board training were reduced. They also expressed the view that the issue of whether or not the Second Mate held a "tanker endorsement" was not material to the cause of the incident. To be officer in charge of the operation did not, in their view, constitute immediate responsibility for loading.

The Inspector considers that any person directly responsible for critical loading operations, as defined by the Ship managers in the "Cargo Operation Standing Orders", should be recognised as exercising immediate responsibility for loading, a task for which the Second Mate was not qualified, either by experience or by virtue of a formal oil tanker endorsement.

The Autronica system

When a valve control is activated from the console in the Cargo Control Room to either open or close one of the deck

or tank valves, the hydraulics may take as much as forty seconds to stroke the valve from fully open to fully shut. During this time, in the case of loading, cargo is still going through the valve into the tank. The Second Mate stated that he had the digital display switched to No.5 port tank, to display the ullage in that tank, at the time he shut the filling valve. After shutting off the cargo to No.5 port, he forgot to change over the switch in order for the digital display to read the level in No.5 starboard.

Having closed the cargo valve to No.5 port, all the Avtur cargo, at approximately 1200 m^3/ hour, was going to No.5 starboard while the Second Mate was still watching the level of No.5 port on the digital display. Because of the time taken for the tank filling valve to close, the indicated level was still rising slowly and he was unaware that he was watching the level in the wrong tank.

The Autronica computer screen, which can display the ullages in any selected group of tanks, does not quite give a "real time" display but has a time lag, according to the manufacturers, of 5 seconds between updates of the tank levels. The digital display, even though it can display only one parameter at a time, has a shorter time delay as it updates every 3 seconds.

The fact that there was a delay in each case was well known to the officers who stood watches in the Cargo Control Room, although the delays on the updating of the Autronica screen and the digital display were understood by them to be 20 and 6 seconds respectively. For this reason, when topping off tanks, it was always customary to watch the tank ullage approaching its final value using the digital display.

Although the high and high-high level alarms for No.5 starboard tank would have shown up on the computer monitor as flashing red indications at the bottom of the screen, even though no audible alarm sounded, the Second Mate would not necessarily have been aware of this, as the visual alarm is small and he was concentrating on the digital display some meters away.

If an alarm is cancelled at the main alarm panel, next to the digital display, but is not accepted on the computer screen, then any subsequent alarms which are activated will not be accompanied by an audible annunciation. No alarms for either a "high" or "high-high" level in No.5 starboard tank sounded in the Cargo Control Room prior to the overflow of the tank. This was most probably due to the fact that some other alarm was activated earlier, but had not been accepted at the computer screen.

No.3 centre cargo tank had been topped off at 0830 that morning to 97.3 per cent of total capacity, with 4310 m^3 of Avtur. Throughout the morning the high level alarm in No.3 centre cargo tank had activated with change of trim and list. Following the overflow of No.5 starboard cargo tank, the Master established that the high level alarm on No.3 centre tank had not been accepted, which would have muted the audible system unless aknowledged. The Third Mate, who handed over the

watch to the Second Mate at 1200, assured the Master that no alarms were left un-accepted at the end of his watch.

On 5 November 1993, the Second Mate had signed the ship's Cargo Operations Standing Orders as having read and understood them. Paragraph 3 of these orders states (in part):-

"No alarms are to remain unaccepted on the Autronica screen, and the significance of all alarms must be fully considered."

After the incident ASP Ship Management asked the Second Mate whether or not he understood the standing order and did he understand the alarm sequence, to which he answered "yes" on both counts.

However, when asked detailed questions by the Investigator, it was apparent that he did not have a thorough appreciation of the system and he stated that he was unaware that it was necessary for all alarms to be accepted at the computer screen before a subsequent alarm would sound audibly.

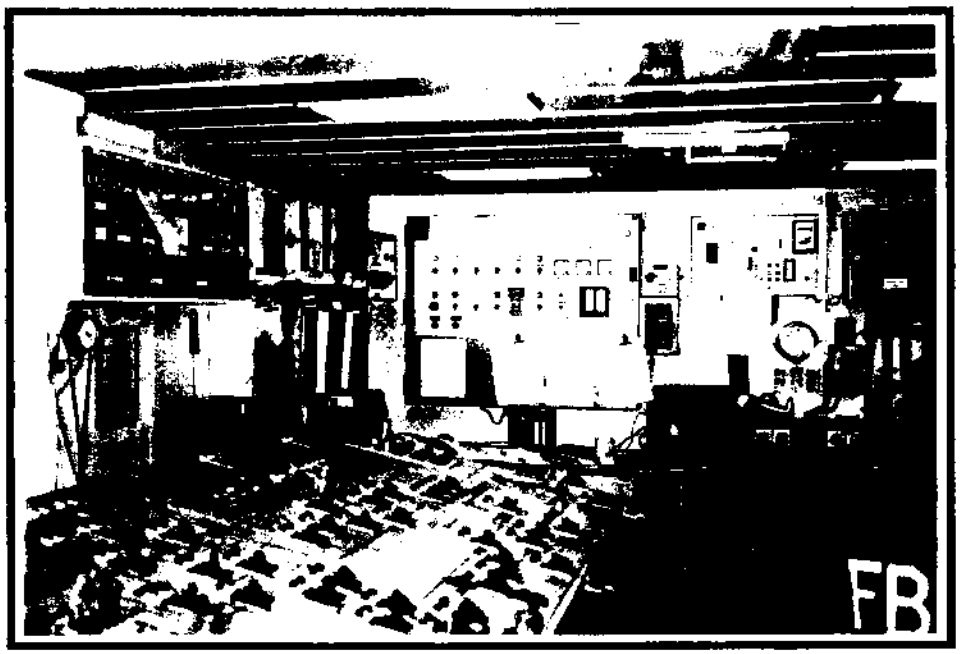
The design of the control room in relation to the cargo tank monitoring and remote valve positions must also be considered a possible factor in this incident. The Autronica computer monitor was placed on a desk on the inboard fore and aft bulkhead and is removed by a few metres from the digital display at the after bulkhead, used for topping off individual tanks. Also, both the digital display, the VDU monitor and the valve controls are separated from each other within the control room, so that the person manipulating the valves has his/her back to the digital monitor and at right angles to the VDU.

In addition, the digital display indicates which tank it is monitoring by a code or channel number, rather than the actual tank number. The list of channel numbers is attached to the monitor.

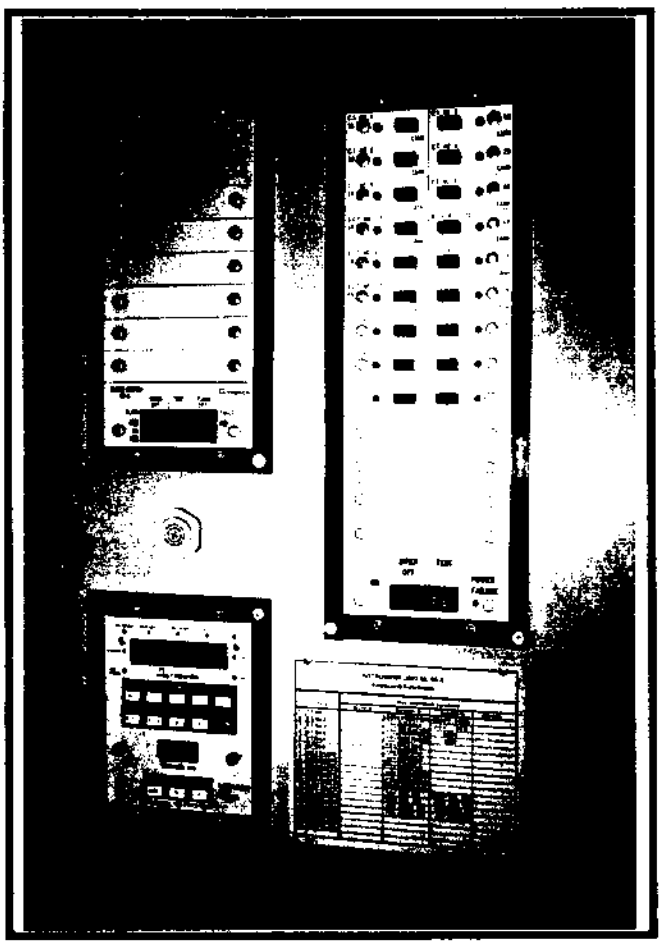
Although it may be argued that an officer should be able to handle such an arrangement, it does seem that the arrangement would add another risk factor to cargo operations.

Actions immediately following the incident

The actions of the Master, officers and crew immediately following the incident were correct in all respects. The loading of cargo was stopped immediately, no.1 centre tank was opened as a "crash tank" and all other valves were closed. The spill on deck was promptly and effectively dealt with. The Master immediately advised all the appropriate authorities.



General view of cargo control room showing cargo control console (foreground) and Autronica computer terminal equipment (background)



Autronica digital display units on after control room bulkhead

Conclusions

These conclusions identify the different factors contributing to the accident and should not be read as apportioning blame or liability to any particular organisation or individual.

1. The structural damage to the vessel was caused by hydraulic over-pressurisation of No.5 starboard wing cargo tank during the loading of a cargo of jet fuel. The facility for relief of pressure, i.e. a single "Press-Vac" pressure/ vacuum relief valve is not designed to be able to relieve excess pressure under these circumstances.

2. The over-pressurisation of No.5 starboard wing tank was caused by operational errors on the part of the duty deck officer, the Second Mate, in the Cargo Control Room. These were:-

i) Loading at an excessive rate into a single wing tank.

ii) Not opening the filling valve to No.1centre cargo tank before closing off the filling valve to No.5 port.

iii) Not switching the digital display readout to no.5 starboard tank immediately after shutting off No.5 port.

iv) A mathematical error in his calculations for "time to go" before topping-off No.5 wing tanks.

v) Not accepting an alarm displayed on the Autronica VDU.

3. The Second Mate was not fully aware of all aspects of the operation of the Autronica ullage monitoring system, in particular, the fact that "unaccepted" alarms on the computer screen will inhibit the sounding of any further alarms which may be activated.

4. It is probable that the Second Mate's thought processes and concentration were affected to some degree by both fatigue and personal problems. This may account for his forgetting to open the filling valve to No.1 centre, forgetting to switch over the selector switch on the digital display to No.5 starboard tank after closing off the cargo filling to No.5 port, and his mathematical error when calculating the "time to go" before topping-off the wing tanks.

5. Both the training and experience of the Second Mate appear to the Inspector to be insufficient for the operation in which he was employed and the responsibility which he held at the time of the incident. This was due, in part, to the lack of opportunity for an effective induction into the ship's routines and systems, and in part to the lack of information, concerning the level of his

experience, being passed to the Master by ASP Ship Management.

6. The definition and literal meaning of the responsibilities of a "responsible officer" as detailed in Marine Orders Part 3, Seagoing Qualifications, indicate that it was not appropriate for the Second Mate to take responsibility for critical cargo-handling duties, such as the topping-off of cargo tanks.

9. The position of the cargo valve control console, the Autronica computer VDU screen and the tank digital display unit are such as to constitute a poor ergonomic layout for single person operation of the control room.

Submissions

The Master and Mate made a joint submission on the final draft report. Where appropriate, the text has been amended to reflect their comments. Where the report has not been amended their comments are reproduced below.

1. In relation to possible personal problems experienced by the Second Mate:

We feel that it is not unreasonable to expect that a person of his year, with his qualifications and with his experience should be responsible enough to speak up about any influence which might affect his work performance before a disaster rather than after, these influences could include his self inflicted lack of sleep and his alleged personal problems.

2. Supervision:

We do not feel that he was lacking in supervision, he indicated minutes before the accident that all was well and he knew that he could call the mate or the master and where they were and he had expressed no concerns. He was left in charge of his watch but was not lacking in supervision . The degree was varied according to the operation in progress.

3. Topping off tanks:

The importance of topping off is recognised and the barrier serves the purpose of keeping out passers-by during operations where the duty mate wishes to work undisturbed. The CCR is adjacent to the mess room and entry to the accommodation. Disturbance is therefore common both from ship's personnel and shore-siders. The barrier was put there as a deterrent in the interests of successful cargo operations.

We accept that topping off is a different situation, for example to calling the master if visibility diminishes, however, in our experience persons who are worried about any particular operation do not begin to worry in the last seconds but rather worry for a long time before the event, very often calling people to ask questions etc. In this case, (the Second Mate) indicated to the master, just minutes before, all was well. Regardless of the time necessary to summons either the master or the mate to the cargo control room, the first and easiest option is to use the radio to stop loading. It is the practical option, even if calling someone is not, or has been left, too late. (The Second Mate) obviously was aware because this is exactly what he did when told of the problem.

4. Autronica system

Alarms: It is not unreasonable, having explained the alarms to a person of his age and experience, and him having signed that he understood the significance of the alarms, that he would believe that he indeed understood them and that his response to the original questions (by the Master and Ship Manager after the incident) *was correct and the story changed later when the consequences of his action were known.*

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)