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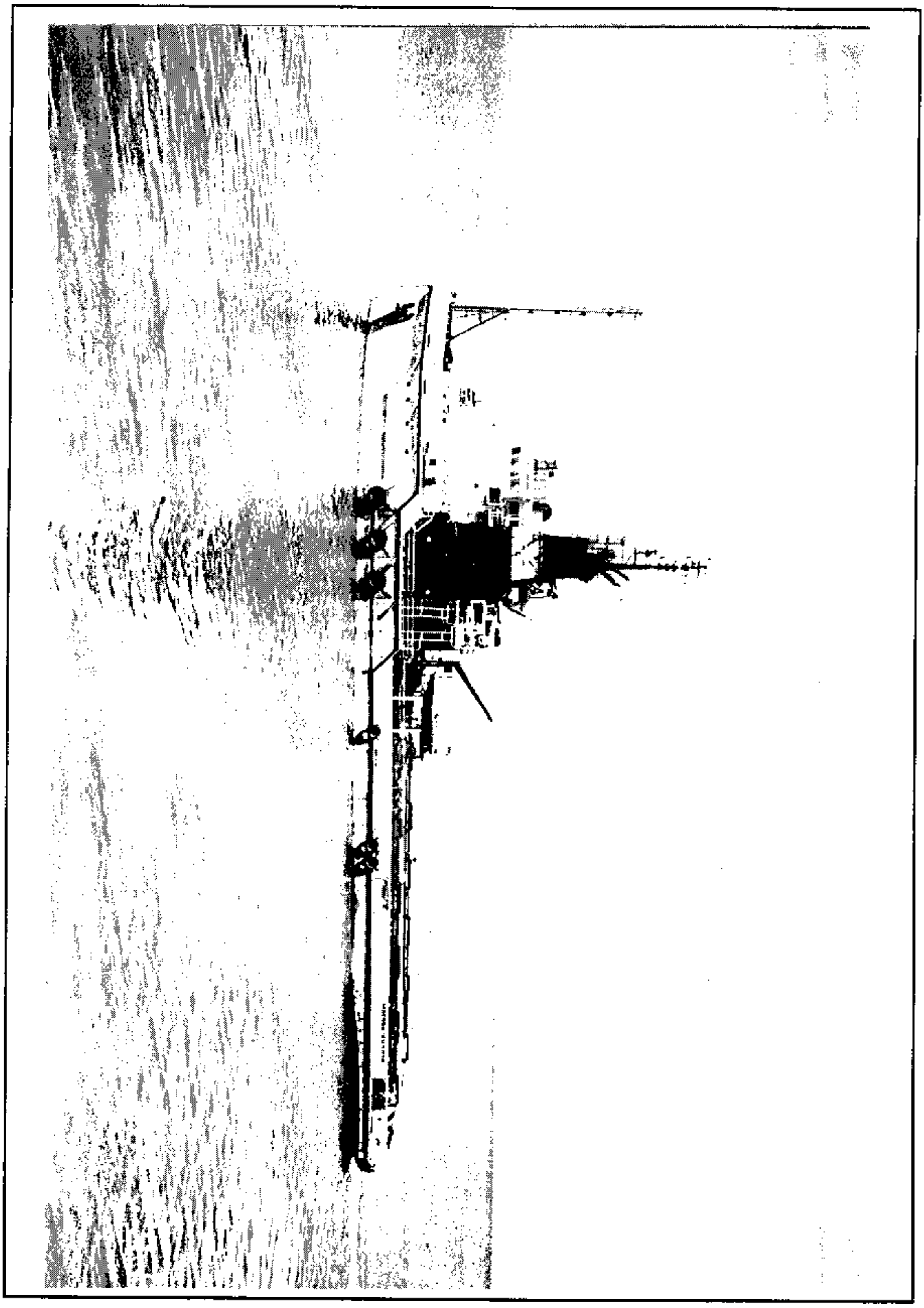


MAERSK RUNNER

Summary

On 28 July 1993, the off-shore supply ship Maersk Runner was employed running out anchors for the mobile drilling unit Atwood Falcon in the Walkley-1 field, on the Australian north-west shelf.

This operation involved the use of a 64mm diameter working wire, or "chaser wire", which is used to haul the anchors out to the correct position and then to lower the anchors to the seabed.

As a dedicated chaser wire had not been provided, the ship had been using the starboard, 70mm towing wire. When this towing wire parted, early that morning, a composite chaser wire, made up from a number of wire pendants shackled together, was used.

In the early part of the afternoon, one of the anchors failed to set in the seabed and had to be lifted and repositioned. As Maersk Runner started to lift this anchor, the composite chaser wire parted at a spelter socket, positioned just off the winch. The Mate was struck and thrown by flaying wire, suffering severe head and pelvic wounds, as a result of which he died.

Sources of information

Maersk Runner:

Master, Additional Master, Chief Engineer, Second Engineer, Integrated Ratings.

The Inspector of Marine Accidents contracted ETRS Pty Ltd, Silverwater, NSW, to conduct analytical tests on the failed socket to determine its chemical composition for compliance with AS 2074-1982 and to ascertain the causes of its failure.

He also sought advice from overseas authorities and agencies, including ship Classification Societies, overseas safety investigation authorities and Tension Technology International Ltd, UK.

The Inspector gratefully acknowledges the assistance of the following:

Australian Offshore Services, Melbourne, Vic.
Bullivants, WA
Law Castings, WA
Noble & Sons, Australia, Limited.
Swire Pacific Offshore, Perth, WA
Tidewater Port Jackson Limited, Melbourne, Vic.

The Ship

Maersk Runner is an offshore tug/supply ship, built in 1980 for Maersk Company (Isle of Man) Limited. Offshore tug/supply ships are the work-horses of the offshore industry, being used for towing rigs between locations, handling rig anchors and supplying equipment to the rigs.

The ship was under a twelve months demise charter to Australian Offshore Services of Melbourne and operated by them with an Australian crew, normally consisting of a master, mate, chief and second engineers and five integrated ratings. For anchor handling operations, which involves prolonged, continuous work periods, an additional master and engineer supplement the ship's complement.

The ship, with a power of 13000 BHP (9700 kW) and a bollard pull of 147 tonnes, has an overall length of 67m and a moulded breadth of 15.5m. The accommodation block is situated well forward, providing a long (37m), clear working deck aft. On the working deck, a 2m high safety barrier, 1.5m inboard on each side and running the length of the deck, protects pipework and provides safe passage for the crew.

The stern is effectively open, with a 2.5m diameter central roller, for the handling of wires, cables, anchors and buoys over the stern.

The working deck machinery comprises two towing winches, capable of spooling large diameter towing wires, a main working winch, also capable of spooling large diameter wires, and two small working, or "tugger", winches. The ship is also fitted with two windlasses, with chain lockers, located one on each side immediately inboard of the safety barriers and aft of the main winches, for handling spare rig anchor cables.

The two towing winches are located immediately aft of the accommodation, one either side of the centre line and the working winch is located immediately aft of the towing winches, on the centre line. These three winches are controlled from the bridge. Immediately aft of these three winches there is a heavy, tubular steel framework, supporting hydraulic wire guides for the towing winches and providing a safety barrier.

The two tugger winches, so named as they are used to "tug" heavy items about the working deck, are located immediately aft of this framework, one at maindeck level, to port of the centre line, the other on a platform 3.5m above the maindeck and to starboard. These two winches are controlled locally at the respective winch.

The main ship propulsion manoeuvring controls, located in the forward part of the bridge, are duplicated at the after end, overlooking the working deck, to provide full control from that position when carrying out anchor handling operations. The controls for the two towing winches and working winch are located at the bridge after control station, to port of the manoeuvring controls. These are operated by an engineer officer, to the orders of the Master at the manoeuvring controls.

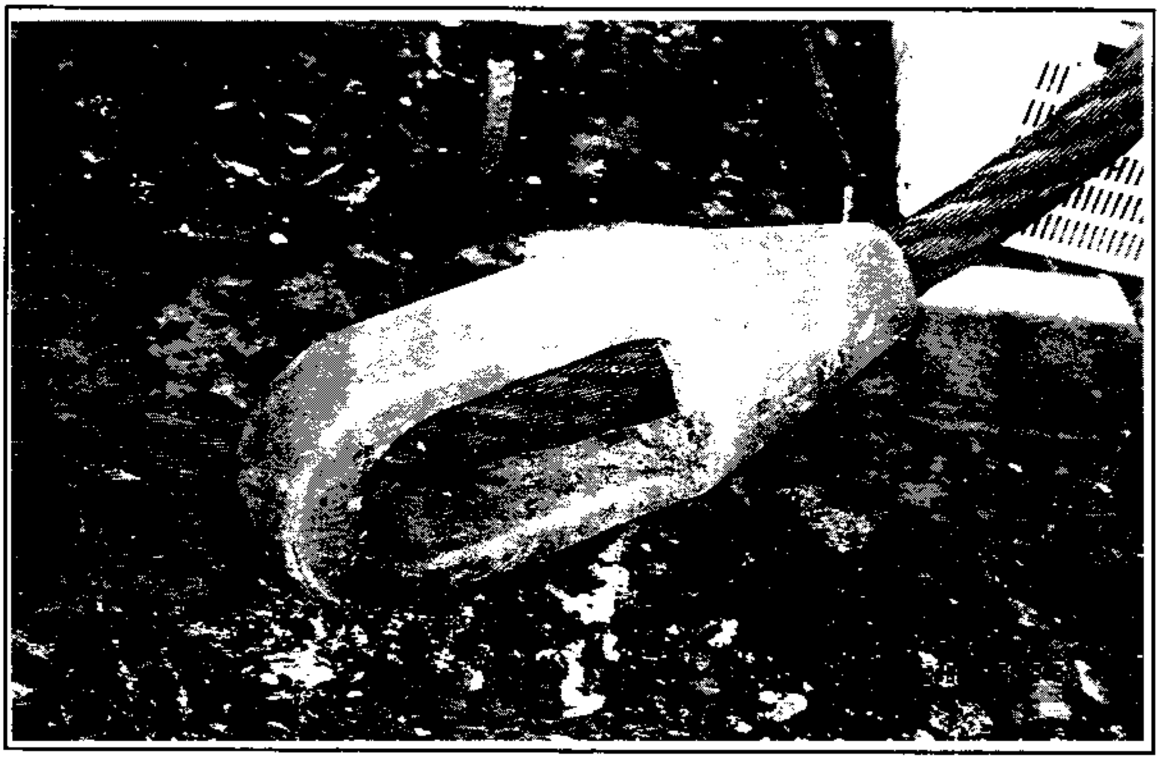
Visibility from the control positions is restricted to the after half of the working deck and to compensate for this there are three fixed TV monitors. Two colour monitors provide a close-up view of the main winch drum in use, the camera being located forward of the winches, and an elevated view aft along the deck, but only for about 14m. A smaller, black and white monitor provides a view across the deck, from starboard to port, immediately aft of the tubular steel framework.

The Operation

Semi-submersible Mobile Offshore Drilling Units (rigs) position and lie to anchors, that are an integral part of the rig's equipment and which are deployed in a pattern to maintain the rig in position. Typically eight anchors are used for this purpose.

When a rig arrives at a drilling location the anchors are run out from the rig by attending offshore support, anchor handling ships and positioned on the seabed. To assist in the anchor handling, positioning and recovery in deep water, without the use of surface marker buoys and associated wire pendants, pieces of equipment known as "chasers" are used. A chaser is a steel collar, similar in design to a horse collar, to which is attached a 70mm diameter wire pendant, usually about 30m in length. The chaser is designed to fit over the shank of the anchor, and so that the anchor cable and joining shackles will pass easily through it.

The Australian offshore industry does not normally make use of eye splices on the heavy mooring and working wires used. Instead closed end terminal sockets, commonly known as spelter sockets, are used. These are heavy steel or alloy castings or forgings, with a cone shaped "basket", to take the end of the wire, and a



Spelter socket

stirrup, to take a joining shackle, for attaching to other wires or equipment.

On arrival at a drilling location, the rig is towed in a predetermined direction and, at a precalculated position, lets go the first anchor. The rig is then towed in the same direction until sited over the drilling position, where it is held by the towing ship while a support ship, or ships, runs out further anchors.

The support ship approaches the rig's anchor stowage positions stern first and receives the free end of the chaser pendant, which is normally fitted with a spelter socket. This is shackled to the ship's chaser wire, a 64mm diameter wire rope, between 1.25 and 1.5 times the depth of working water in length, and which is spooled on to the working drum located at the forward end of the working deck, immediately aft of the accommodation housing. The weight is taken on the chaser wire and the rig pays out on the anchor cable while the support ship heaves in on the chaser wire until such time as the anchor is positioned just below the stern roller. During this operation it is essential that the chaser remains in the correct position on the anchor shank, hard against the head of the anchor.
The support ship then steams out in the direction ordered by the rig, dragging the anchor cable along the seabed as it is paid out by the rig, until told to stop and lower the anchor to the bottom. The lowering is conducted while the engines are on ahead power, in order to ensure that the anchor cable is fully stretched out. The wires and equipment are under considerable tension throughout this operation. When the anchor is on the bottom, the rig tensions the cable, to ensure that the anchor is holding. If all is satisfactory, the support ship returns to the rig, pulling the chaser back along the anchor cable, and passes the end of the chaser pendant back to the rig.

This operation is repeated until all of the rig's anchors (normally eight) have been run out and the rig is securely moored in position. Once the rig mooring operation has commenced, it proceeds uninterrupted to completion.

Where two or more wires are joined together by shackles and spooled on to a working drum, it is essential to ensure that the wire is not "buried" or snagged by the joining shackle(s). To avoid this, the normal practice is to ensure that the shackles locate at the edge of the drum and that the wire spools clear of the shackles. To achieve this, what are known as "tugger" wires are used, 20mm diametre wires spooled on to small working winches. These tugger wires are rigged one on each side, either around roller leads or through blocks to provide a transverse pull, and looped over the main wire, using either a shackle or length of chain. These are then used to guide the main wire on to the main winch drum, to ensure that the shackles locate properly at the sides and the wire then spools clear of the shackles, by heaving on the appropriate tugger wire. The tugger winch drivers normally receive their instructions from the person in charge of the deck party, who needs to be in such a position as to be able to observe the lead of the wire on to the drum and where he can be seen by both winch drivers.

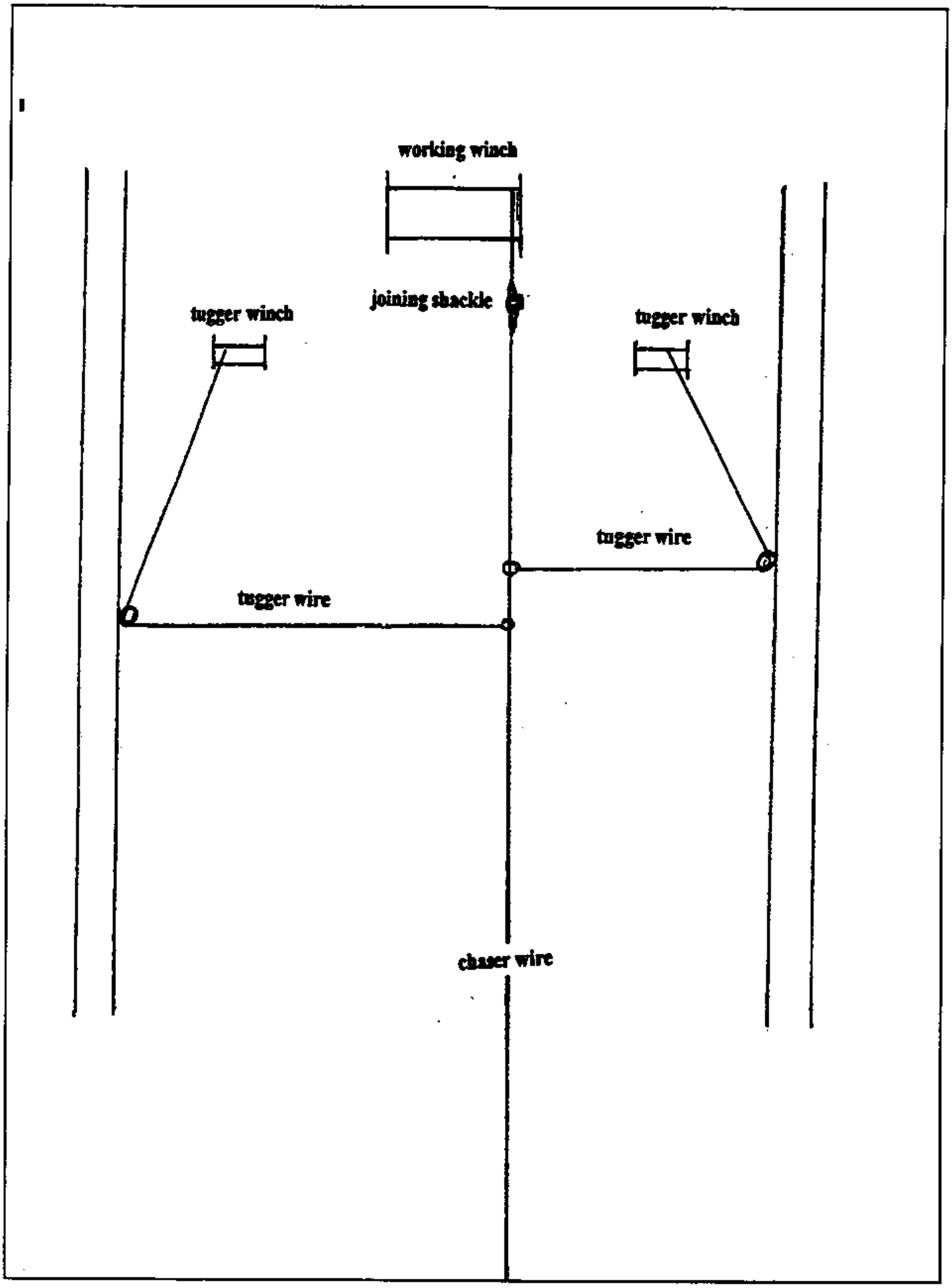


Diagram showing tugger wire arrangement

Sequence of events

In mid July 1993, Maersk Runner was employed attending the jack-up rig Ron Tappmayer, which was towed to location 30 miles west of Dampier. After the Ron Tappmayer had been positioned, Maersk Runner was chartered by Ampolex, to assist in the mooring of the semi-submersible drilling rig Atwood Falcon, in the Walkley-1 field, on the North-west Shelf. Maersk Runner therefore proceeded to Broome, where it was to load stores for the rig, arriving there on Saturday 24 July.

In accordance with company policy, Australian Offshore Services assigned two additional officers, the Master from the other "swing" and an engineer, to assist with the mooring operation. This permits a twelve hours on, six hours off working regime on deck, with the additional Master relieving first the Mate and then the Master. The additional officers joined at Broome on 24 July.

Under terms of the charter party, the charterer, Ampolex, was to provide Maersk Runner with the appropriate wires for the anchor running operation. In this instance, Ampolex did not have a suitable chaser wire readily available, but arranged for the supply ship Pacific Commander to transfer a new wire to Maersk Runner at Broome. However, Pacific Commander experienced winch motor problems and was unable to run the wire off the drum before Maersk Runner sailed. As the chaser wire was not transferred, it was agreed between the various parties that Maersk Runner would use the 70mm starboard towing wire as a chaser wire, Ampolex signing an indemnity to cover any damage occurring to the towing wire during the anchor running operation.

The loading of the cargo destined for the rig, which included two anchors and a number of 64mm wire pendants, was completed late on the Sunday afternoon, 25 July. After securing for sea, Maersk Runner sailed at 1800 hours and proceeded towards the Walkley-1 field, 225 miles north-west of Broome, to rendezvous with Atwood Falcon, under tow by the supply ship Pacific Conqueror.

At 2200 26 July, the Master brought Maersk Runner to anchor, in a position approximately 20 miles south-east of the rendezvous position, to enable the officers to have a good night's sleep before commencing operations with the rig the next day. Maersk Runner was under way again at 0845 27 July and rendezvoused with Atwood Falcon at 1230, when arrangements were made to transfer the cargo.

Because of space and deck weight-loading restrictions on board Atwood Falcon, the rig master requested that the two anchors and a number of wire pendants be retained aboard Maersk Runner. The Master was not very happy with this, as he preferred to have a clear deck for anchor operations. However, as there would be no requirement to take anchor marker buoys and their pendants on deck, he agreed to the rig master's request.

The transfer of cargo was completed at 1515 hours, after which the two anchors and the wire pendants were restowed further up the working deck, one anchor on each side. The Additional Master took over from the Master on the bridge at 1630, Maersk Runner following astern of the tow.

The Master returned to the bridge at 2045, as Atwood Falcon neared the drill location. The Mate resumed duty at this time, to take charge of the deck work party, and the Additional Master went off duty to get some sleep.

Arriving on location, Atwood Falcon let go the first anchor (No 7) at 2058. * Pacific Conqueror took up station, keeping Atwood Falcon under tow, to keep the rig in location, and Maersk Runner began the task of running out the other anchors.

The chaser pendant of No 3 anchor was taken on board at 2145 and running out of the anchor commenced at 2220. The mooring pattern of the rig required 5500 feet (1676m) of cable to be deployed on each anchor, Maersk Runner running out in the direction ordered by the rig until told that the required amount of cable had been paid out. The anchor would then be lowered to the bottom. No3 anchor was on the bottom at 2300, after which the chaser was towed back along the cable to the rig, the chaser pendant being returned aboard the rig at 2400.

When deploying an anchor, after the chaser pendant had been shackled to the ship's chaser wire, the deck party would clear from the deck, not being required again until the pendant had to be unshackled for delivery back to the rig. While the anchor was actually being run and the chaser being towed back towards the rig, the Mate would go to the bridge and rest on the settee.

* All anchor handling times are those recorded in Maersk Runner's deck log book

The operation of running the next anchor, No 6, took from 0030 to 0350 (28th) The Additional Master awoke at 0400 and went up to the bridge, where he watched how the Master conducted the operation as No 2 anchor was run out. Atwood Falcon was beeing moored in much deeper water than the rigs of his previous experience and he wished to see if the tactics were the same. No 2 anchor was completed at 0550, at which time the Additional Master took over on deck and the Mate went to bed.

No1 anchor chaser pendant was taken on board at 0605 and that anchor was run out. As the anchor was being lowered to the bottom, at 0640, and as the shackle joining the chaser pendant to the ship's wire was passing over the stern roller, the ship's wire parted. The wire parted at the point of entry into the spelter socket, but although the wire was under tension, it did not recoil, merely dropping on the deck.

The Master and Additional Master held a discussion on which wire should be used to continue the anchor running operation. Although they had another towing wire on board, they were reluctant to use this; it was a relatively new (1990) wire and could sustain internal damage during anchor handling operations that would not be readily discernable for the purposes of the charterer's indemnity. Also, it was fitted with a towing chafer that would take considerable time to remove. After consultation with the rig master, it was decided to shackle together three of the deck cargo pendants which had been retained on board at the request of the rig master.

First, a 200m wire was shackled to the wire on the ship's working drum, the rig's crane being used to lift the coil while the wire was spooled on to the drum. Then two 400ft (122m) wire pendants were added. The full length was then run out over the stern, then respooled on the working drum, using tugger wires to position the three joining shackles on the right (starboard) side of the drum and to keep the wire clear of the shackles. This operation took until 0930.

At 0955, the chaser pendant of No8 anchor was taken on board and that anchor run out. When the anchor was lowered to the bottom, the Additional Master made a point of noting, on the bridge TV monitor, how much wire was paid out to achieve this and to tow the chaser back to the rig. The shackle joining the 200m wire pendant to the ship's working wire was immediately on top of the drum, with the spelter socket of the pendant just clear of it.

When the ship arrived back at the rig, and as the chaser was hauled up the cable, to bring the end of the chaser pendant on board for unshackling and returning to the rig, the chaser wire was guided on to the working drum using two tugger wires. In rigging the tugger wires, the Additional Master used a 35 tonnes shackle on the end of each tugger, the shackle being fastened around the chaser wire. In order to see how the wire was leading on to the working drum, so as to be able to direct the ratings operating the tugger winches, the Additional Master stationed himself immediately aft of the anchor stowed on the port side of the deck. Being tall, he was able to see over the top of the anchor head.

The Mate came back on duty at about the time No8 anchor operation was completed, at 1120. The Additional Master handed over to him, explaining what had happened, that they were now using the composite chaser wire and how he had rigged the tugger wires. The Additional Master then went and showered, before going to the bridge to relieve the Master.

When the Additional Master took over from the Master, the anchor running operation was under temporary suspension, while a helicopter operation took place on the rig. At this time the Second Engineer relieved the Third Engineer at the main winch controls.

Anchor running resumed at 1250, with No5 anchor being the next to be run. After being run out this was lowered to the bottom at 1327, the chaser wire being paid out the same amount as on the previous run, until the joining shackle between the ship's working wire and the 200m pendant was on top of the drum. After the rig had tensioned the anchor, the ship started to return the chaser to the rig. When about half way back to the rig, the ship was advised by the rig master that anchor No5 had not "set", that about 200ft to 300ft (60m to 90m) of cable had been retrieved. The Additional Master therefore headed the ship back towards the anchor. He advised the Mate what was happening and, while the chaser was being towed back to the anchor, the deck party rigged the tugger wires in preparation for heaving in and spooling the chaser wire should it be necessary. As soon as the tugger wires were rigged, the deck party then stood clear, outboard of the port tugger winch.

When the chaser had been pulled back to the anchor, indicated by the ship being brought to a stop, the Additional Master increased the propeller pitch to 3 (50per cent) to ensure that the chaser was fully on the anchor, and then more pitch was used to ensure the cable was stretched. The rig master advised that 550' (168m) of cable had been retrieved and that it was necessary for the anchor to be lifted and repositioned.

Satisfied that the chaser was correctly positioned on the anchor, the Additional Master advised the Mate, over the deck tannoy system, that he was ready to heave up. The Mate positioned himself on the shank of the anchor stowed on the port side of the deck, from where he could observe how the chaser wire was leading on to the work drum, so that he could direct the tugger winch drivers. He instructed one of the Ratings to tension and then to heave a little on the port tugger wire, instructed the other Rating to stand by the starboard tugger winch, and then, using his portable VHF set, advised the Additional Master that the deck party was ready.

The Additional Master reduced to 10 per cent power, to hold the ship in position, then instructed the Second Engineer to start heaving on the chaser wire. The Second Engineer moved the control leaver to heave and, watching the TV monitor, observed the winch heave in about four or five inches (12cm) of wire. At this moment a loud "bang" was heard and the Additional Master saw the chaser wire "snake" down the deck and over the stern. He could clearly see the broken spelter socket on the end of the wire, which flew down the deck, at a height of about 10ft (3m). The time was recorded in the deck log book as 1400.

The Rating who had been instructed to stand by the starboard tugger winch had started to move across from the port side, aft of the working drum, but a creaking sound from the region of the working drum caused him to turn and start towards the port side ladder. He had only moved about one metre when there was a loud "crack". He turned and saw the two tuger wires whip aft down the deck.

The Rating operating the port tugger winch, on instructions from the Mate, had first tensioned the port tugger wire, and then heaved "a bit more". He had just taken his hand off the stop valve when there was the loud "bang". He moved one pace to his right, to port, looked down the deck and saw the Mate being thrown to the outboard side of the anchor. He then ran towards the Mate.

The Second Engineer, watching the monitors, saw the rapid movement of the Rating, realised there was something wrong, and advised the Additional Master. The Additional Master stood up, leaned right over to the window, and could see the bottom of the Mate's legs, in a position indicating the Mate was lying on the deck. The Master was called and after being advised of what had happened, took over. The Additional Master and Second Engineer then went down to the deck.

The Rating found the Mate lying on his back, safety helmet gone, his head very close to a lug welded to the deck below the safety barrier. He thought the Mate was dead. He went back to the other Rating, told him to attend to the Mate, to make sure that if he came-to he did not move, then went to the mess room to get additional help.

A third Rating, the Additional Master and Second Engineer, all arrived on the scene in a short space of time. The Mate was moved gently clear of the safety barrier and moved into the coma position. He was found to be bleeding from what appeared to be superficial wounds to the head and from a small puncture wound in the small of the back.

The Master contacted the rig, advised them of the accident and requested that their Medic board the ship to provide assistance. He also requested the rig to arrange for the evacuation of the Mate by helicopter.

As the ship was returning to the rig, the Additional Master and members of the crew comforted the Mate as well as they could, restraining him from movement.

The Medic boarded as soon as the ship arrived alongside the rig, and when appraised of the situation arranged the transfer of the Mate to the rig, this being accomplished at 1435. Rig personnel contacted the hospital in Broome and received advice to administer pethedine to help soothe the patient. Accordingly, 50mg of pethedine was administered intramuscularly at 1520.

After a second administration of 50mg of pethadine at 1550, the Mate appeared to be more settled, but at 1645, his breathing became irregular and stopped at 1650. The rig personnel carried out resuscitation procedures, which were continued by a doctor who arrived with the helicopter at 1750, but these were unsuccessful and the Mate was pronounced to be dead at 1810. Advice of the death was passed to the Master at 1905.

At 2020, Maersk Runner departed from Atwood Falcon to proceed to more shallow water for a rest period, anchoring at 2220. Although the ship returned to location the next morning (29 July), instructions were received from Australian Offshore Services to retain the accident scene intact, which precluded further anchor running operations. Representatives of Australian Offshore Services arrived on board by helicopter at 1435, and, having been released from service by Atwood Falcon, the ship departed for Broome at 1440.

The body of the Mate was removed from the rig and flown to Perth, where an autopsy indicated that the Mate had died as a result of severe head and pelvic wounds.

Comment

This accident was the culmination of a series of isolated incidents:

> the charterer, in the first instance, did not have the appropriate chaser wire to be provided under the terms of the charter party;
>
> the ship contracted to provide a chaser wire experienced winch motor problems and was unable to run the wire off the winch;
>
> the ship's towing wire, being used as a chaser wire, parted, which resulted in the decision to use a "composite" chaser wire, made up of the wire pendants in the deck cargo, necessitating the use of tugger wires;
>
> No 5 anchor failed to set, necessitating that anchor to be hove up off the bottom for repositioning.

The crucial factors were the eventual use of the composite chaser wire, necessitating the use of tugger wires, and the fact that No 5 anchor did not set, necessitating the chaser to be pulled back on to the anchor, so that the anchor could be raised and re-run.

The accident was caused by the spelter socket breaking and was a result of the Mate being stationed where he was at the time. It is therefore appropriate to examine the operation, to ascertain whether the Mate unnecessarily exposed himself to danger, to examine the spelter socket, to ascertain the cause of it breaking, and to look at the use of spelter sockets in such an operation.

The composite chaser wire

When the starboard towing wire failed, to expedite the resumption of anchor running as speedily as possible, the Master and Additional Master had two options open to them - to use the port towing wire, or to make up a wire of sufficient length, using a number of the wire pendants carried as deck cargo. Pacific Conqueror had a 500m chaser wire spooled on its working winch, but that ship was still engaged in maintaining the rig in position and a transfer operation would not have been viable under those circumstances.

The reluctance by the two men to use the port towing wire, based on the possibility of that wire being damaged in such a manner as not to be readily apparent and the time that would be involved in removing the chafer, is considered to have been reasonable.

The wire pendants that were used were all of 64mm diameter and of similar construction to the wire normally used for chaser wires, and were therefore suitable for the job in hand.

Despite the fact that using a composite wire would necessitate the use of tugger wires, the decision to use the wire pendants is considered to have been reasonable.

The Officer

The Mate was an experienced offshore supply ship officer, having been employed in the offshore industry continuously from May 1983 until his death. He had served in positions ranging from Second Mate to Master and was described as being a keen and conscientious officer, and safety conscious.

The operation

It is standard safety practice aboard offshore support ships for the deck party to stand clear of the working deck when there is tension on heavy wires, other than when it is necessary to stopper the wires off for joining and disconnecting purposes. However, the use of the composite chaser wire necessitated the correct positioning of the joining shackles on the working drum, which required the use of the tugger wires, there being no hydraulic spooling system for the working winch.

Although no directive was given to the Mate to rig the tugger wires, he set about rigging them as soon as he was notified that the anchor had to be lifted. As the chaser wire had been paid out to the point where the joining shackle was on the top of the winch drum, the tugger wires were going to be needed as soon as lifting started, to keep the wire clear.

From the control positions of the two tugger winches it is not possible for the winch drivers to see how the chaser wire is leading on to the working drum, therefore it is necessary for the person in charge of the deck party to give them directions. When spooling the composite wire on to the working drum and when returning the pendant of No 8 anchor to the rig, the Additional Master had positioned himself down the deck, immediately astern of the anchor stowed on the port side. Being tall, he was able to see over the top of the anchor head and from this position had a good view of the chaser wire leading on to the working drum and was also able to direct the winchmen. In that position, he was afforded some protection by the anchor.

For lifting No 5 anchor, the Mate had also positioned himself down the deck, but being a much shorter person, 164cm, he had stood on the anchor shank, so as to be able to watch the wire spooling on to the working drum.

Due to the heavy steel framework immediately aft of the towing and working winches, which largely conceal them from view, to obtain a similar view from outboard of the safety barrier, the Mate would have had to position himself only about 8m from the stern, 33m from the winch drum. At this distance, because of the dimness of light caused by the framework and surrounding structure, it would be difficult to get a clear view of the drum.

It is considered that, practically, there was nowhere else the Mate could have stationed himself to perform the directory function.

At the moment the socket failed there was a strain on the wire, from the effect of the ship pulling ahead at 10per cent power, from the power of the winch commencing to heave, and the tension on the port tugger wire. Because of the tension on the tugger wire it is most probable that the chaser wire was immediately deflected to port as it ran aft. Fresh chafe marks on the inboard fluke of the anchor on which the Mate was standing, indicate that the fluke was struck by the chaser wire. However, whether the Mate was struck by the 64mm chaser wire, or by the chain on the end of the port tugger wire as it too was pulled aft, is not certain.

As there was no suitably sized projection near the scene of the accident, it is possible that the wound in the Mate's back was caused by a link of the chain. The main injury to his head was on the crown, therefore it is probable that this was sustained by his head striking either the safety barrier itself, or the lug at deck level.

The spelter socket

The socket that broke was reportedly new, having been provided to Bullivants by Law Castings foundry, it was not one that had been returned for re-use.

The socket was one of a batch made by the foundry for Bullivants, cast in moulds formed from a pattern provided by them. The steel used was selected from scrap steel complying with category L1B of Australian Standard 2074-1982. Bullivants made no request for ultrasonic or magnetic particle tests to be carried out on the castings, therefore none were performed.

The casting was one of a pair used in the preparation of a 200m 64mm diameter wire pendant for Swires Pacific. The wire was purchased for Pacific Conqueror, as an extension wire for that ship's 500m chaser wire. A copy of the certificate of test covering the wire, issued to Bullivants by Australian Wire Industries Pty Ltd, Newcastle Rope Testing Laboratory, was provided to Swires Pacific, with the hand written annotation "1 x 200m length with resin fitted closed sockets each end". Prior to their being fitted to the wire, no testing was carried out by Bullivants on the sockets.

At the request of the Inspector, the broken socket was examined by ETRS Pty Ltd of Silverwater, NSW.

The examination found (Attachment 5) that the fracture surface on both arms of the stirrup contained centreline shrinkage, which made up approximately 2per cent of the cross sectional area. One fracture surface also contained a small casting defect on the outer side, about half the size of a two-cent coin, the defect extending to a depth of about 10mm. The surface of this defect exhibited a lightly decarburised layer, confirming its presence in the casting before it went into service. The indications were that the fracture initiated at this defect. There was no evidence of any fatigue type cracking on either of the fractures.

Bruising at the inner surface at the bottom of the stirrup indicated that either the socket had been in service for a considerable time, or the initial loading was greater than the design capability.

Material identification indicated that the steel did not fully comply with standard AS2074-1982 Grade L1B, in that the manganese content was significantly lower than that specified. Under mechanical testing the tensile strength, proof stress and impact results all failed the requirements of AS2074-1982 Grade L1B.

It was concluded that the spelter socket failed as the result of a shock overload and that the small casting defect acted as a stress concentrater for the initiation of the fracture.

Regulatory requirements

During the course of the investigation it was suggested that chaser wires and their associated spelter sockets were considered to be mooring equipment as against lifting equipment. All wires, irrespective of their use, are supplied with a certificate of test. Mooring equipment is provided to ships to the requirements of the classification societies, the societies' rules covering the specification, testing and certification requirements. Anchors, cables, shackles and wires are all required to have certificates of test and examination. However, the requirements for spelter sockets appear to be less rigid. Sockets are accepted provided they are formed in accordance with recognised standards and initial tests are conducted to show that the sockets have a minimum strength, in the case for ropes exceeding 50mm diameter, of 90per cent of the breaking load of the wire on which they are to be used. Proof testing to twice the safe working load of the wire rope is waived where resin or zinc is used in the socket. Whereas marking and certification of sockets may be a requirement, this does not appear to have been a general practice.

It appears that, in fact, chaser wires and their associated spelter sockets have been classed neither as mooring equipment, nor lifting equipment, and are therefore not covered by any regulation or classification society rules.

In the main, drilling rigs operating off the Australian coast are registered overseas and contracted for particular drilling operations and the standards for equipment are generally those of the flag state and classification society country.

The support ships operating around the Australian coast are operated by Australian companies, either owning or chartering the ships. Equipment for these ships is provided by Australian industry.

There are a number of manufacturers/suppliers of spelter sockets and although the designs are similar, being based on the original American "Crosby" socket, they vary. The sockets are manufactured to Australian Standard 2074-1982, "Steel Castings", which details the requirements for chemical composition and tensile properties.

There are no mandatory test requirements for spelter sockets manufactured or used in Australia, or for the sockets to be marked with an identification number, or with the safe working load. There are a number of overseas standards pertaining to sockets, in which testing requirements are limited to ultrasonic and magnetic particle testing. A purchaser may request tensile strength testing and where this is so requested, the requirement is for a minimum of twice the safe working load of the wire to which it is attached. Tensile testing is only conducted on axial tension, or straight pull, no radial testing is required.

This anomaly of lack of regulation of spelter sockets in Australia is considered to be a matter of importance that needs to be urgently addressed. As the sockets used aboard offshore supply ships are used on chaser wires, for lifting and lowering anchors, it is considerd that they would be more correctly classed as lifting equipment, rather than mooring equipment. The classification of chaser wires as lifting equipment is supported by the BMT Cortec Ltd report (11 March 1992) on a study into rig anchor handling practices on offshore supply vessels for the UK Department of Transport. It is considered appropriate, therefore, that chaser wires and their ancillary equipment, including spelter sockets, should be governed by the regulations covering lifting equipment and that appropriate Australian standards for their manufacturing and testing should be established.

Socket failures

The "crosby" type spelter sockets are designed for a straight, axial tension and under uniform axial loadings are very strong.

Although there is no documentary evidence, information from the offshore industry indicates that there have been a number of spelter socket failures over the years, particularly in recent years, although no other fatalities have been caused. Failures are normally in the form of distortion of the stirrup, or fractures developing in one of the stirrup arms, where they join the socket. Where this has occurred, the spelter socket has been discarded. The majority of the failures have occurred to long stirrup type sockets, although recently there have been failures to the short stirrup type.

When used on anchor handling wires, there will be times when the sockets will be under tension either on the stern roller or on the winch drum. At such times, a fulcrum will be created by the drum, acting at the maximum girth of the socket, and a considerable radial tension, rather than an axial one, will be applied to the stirrup. Radial tension will induce stresses for which the socket is not designed and may cause both distortion and fracture of the stirrup. To avoid sockets being spooled on to winch drums, chaser wires should be of one continuous length, a viewpoint put forward by crew members of Maersk Runner and also a recommendation of the BMT Cortec report.

Failures reportedly occur mainly during anchor lifting, rather than anchor running operations, when heavy shock loadings on the chaser wires are experienced, particularly when the chaser itself "homes" on the anchor. At this time the ship is often proceeding ahead at between two and four knots and is brought to a relatively sudden stop.

It is considered that the failures are due to a combination of the shock loadings experienced during anchor lifting operations and to the effects of radial loadings as the sockets pass over stern rollers and are spooled on to drums.

In the Maersk Runner incident, not only had the socket been subjected to radial loadings on the working drum during the running of two anchors, but it also underwent shock loading when the chaser was run back on to the anchor preparatory for lifting. Just before the lifting commenced and the socket broke, one of the Ratings turned back from walking across the deck, under the wire, because of a creaking sound from the region of the working drum.
It is therefore considered most probable that the socket started to fail as a result of the shock loading induced by the operation of "homing" the chaser on the anchor stock.

The Unit has sought information and advice internationally. Information provided by Mr Mike Parsey, of Tension Technology International Ltd, UK, an accepted authority on wire moorings and recommended by the UK Marine Accident Investigation Branch, is that:

"1 Failures of Spelter Sockets are very rare in single straight loading up to the normal maximum design working load of 55per cent of wire rope break. Socket failures in axial tension fatigue are somewhat more common on resin socketed terminations.

2 It is bad practice to use Closed Spelter Sockets in conditions in which the socket passes over a roller or winch barrel under significant tension, as in

anchor handling operations. My colleagues inform me that in the early days of North Sea development failures occurred with both open and closed Spelter Sockets in this operation, leading to their early replacement by thimbles/shackles.

Because Closed Spelter Sockets are known to perform poorly in bending, they are not generally used in that way, and so significant test data is not available.

3 Again, since Closed Spelter Sockets are not intended for such use, no consideration is generally given to external radial or bending stress in socket design.

4 It is good practice to allow for the effects of both shock loading and fatigue by ascribing adequate safety factors in the anchor handling operation. Unfortunately, this practice is not always followed."

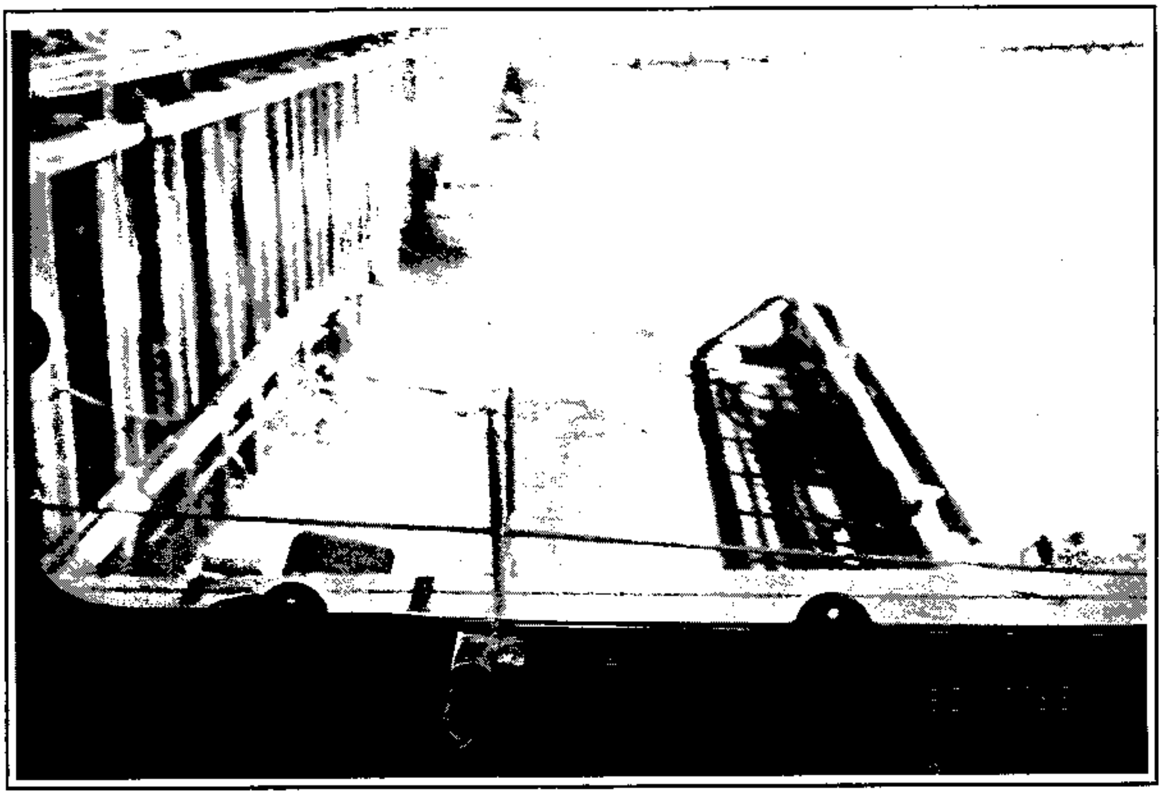
The ETRS report indicates that in this instance the failure of the socket was due to the effect of shock overload, that radial tension was not indicated.

However, the Inspector considers the information provided by Tension Technology International Ltd and the Australian offshore industry strongly indicates that radial tension applied to sockets passing over stern rollers and spooled on to winch drums is, in general, a contributing factor towards spelter socket failures. While radial failures do not seem to have resulted in death or serious injury, there is sufficient doubt as to the safety of passing spelter sockets over rollers and spooling them on to winch drums that warrants a proper objective study of the practice.

Working wire control

During the course of the investigaion, a number of the ratings suggested that the tugger winch drivers could be directed by the engineer at the main winch controls, guided by a TV monitor. This would appear to have considerable merit, particularly from the safety view point. However, the officers considered that this would require an additional monitor, which not only could not provide the correct field of view and perspective, but would detract the engineer's attention from the other controls.

The design of Maersk Runner is such that the engineer at the controls cannot see the winch drums. Whereas the towing winches are equipped with hydraulic spooling gear, the working winch is not. It is considered that it would have been appropriate, due to the absence of direct visual capability, for the working winch also to be fitted with hydraulic spooling gear.



Photograph: view from winch control position aboard Maersk Runner. Winches and "blind" area of working deck are covered by TV monitors.(Photograph: Captain D J Dillon)

Photograph: clear view from winch control position aboard Lady Cynthia, showing hydraulic spooling for towing and working drums. (Photograph: Captain D J Dillon)

Conclusions

1 The Mate died as a result of injuries received from being struck and thrown by the chain on the end of the port tugger wire and/or the 64mm diameter chaser wire.

2 The cause of the Mate being struck by the chain/wire was the failure of the spelter socket at the inboard end of a 200m 64mm diameter wire pendant, shackled to the ship's working wire and being used as part of a "composite" chaser wire.

3 The spelter socket failed because of the effects of shock overload when the chaser was "homed" on the anchor.

4 The Mate's standing in an exposed position was brought about by the requirements of the particular operation.

5 The operation of using tugger wires on chaser wires, although not a common or usual pratice, is necessary when using a composite wire with connecting shackles and sockets within its length.

6 There was no negligence on the part of the Mate, the Master or crew of Maersk Runner.

7 The long, straight stirrup "Crosby" design of spelter socket is not suitable for spooling on to a winch drum of a diameter the size of the normal working drum.

8 Chaser wires should be of one continuous length, to avoid shackles and spelter sockets being spooled on to the drum, and thus also avoid the need for the use of tugger wires.

Industry Response

After the incident Bullivants' Management contracted a consultant to computer model their socket and to conduct a computer analysis of axial tensile strength. They also wrote and implemented new, detailed instructions for the ordering and manufacturing contract requirements, which include identification number marking, ultrasonic and magnetic particle testing of all new sockets, and tensile proof testing of random sockets.

BHP Steel, Parent Company of Bullivants, also contracted for analytical tests to be conducted by Newcastle University.

The Standards Committee, Standards Association of Australia, have included test requirements for spelter sockets in the draft amendments to AS 1666, Wire rope slings.

The Australian Maritime Safety Authority has issued a Marine Notice on the use of spelter sockets and has held formal discussions with the Australian offshore industry on offshore safety issues.

The Inspector understands that one offshore support company, with operations world wide, has now ceased using spelter sockets on anchor chaser wires, in favour of hard thimbles and wire splices. The company has also increased the size of the wires used.

Finding on Inquiry

The finding of the Coronial inquiry into the death of the Chief officer contained the following riders:

(1) The Australian Standards Committee should introduce a standard for testing terminal sockets in wire ropes for both lifting and mooring equipment.

(2) The standard should require the following:

(a) The sockets to be examined by the manufacturer to ensure quality of manufacture.

(b) All sockets to be stamped with a batch number identifiable against a manufacturer's certificate of inspection and test.

(c) All sockets to be stamped with the breaking load appropriate to its size.

(d) A certified copy of the test certificate shall be provided to the purchaser.

(3) Working wire ropes used by offshore support vessels should be of a single continuous length.

Attachment 1

Details of ship

Name:	Maersk Runner
IMO Number:	7814876
Flag:	Isle of Man (British)
Ship type:	Tug/Supply ship
Owner:	Maersk Co. (I.O.M) Ltd
Demise charterer:	Australian Offshore Services
Voyage charterer:	Ampolex Ltd
Crew:	11 Australian
Year of build:	1980
Place:	Odense
GRT:	1296
NRT:	485
Length overall:	67m
Moulded breadth:	15.5m
Engine power:	13000 BHP (9700 kW)
Bollard pull:	147 tonnes
Classification Society:	Lloyd's Register of Shipping

Closed Spelter Sockets

There are a number of different types of socket, the most common being the "crosby" type, with either a long or a short stirrup. Actual Crosby sockets are manufactured in the United States of America, to Federal Standard RR-S-550D, bear an identification number, and are supplied complete with a certificate. "Crosby" type sockets are manufactured/supplied by a number of companies within Australia, being manufactured (cast) to AS 2074. It is understood that other "crosby" type sockets, of Asian origin, occasionally arrive aboard overseas registered offshore supply ships, but the standards to which these were designed and manufactured are not known.

Another, more expensive, type of socket available is the "bull nose", a fully "drop forged" socket, which has a much shorter stirrup, moulded to take a shackle pin. The American manufactured model, the "gold nose", is designed to accommodate a 120 ton anchor shackle and for use over stern rollers. As the standard sizes of the "gold nose" socket are for 58mm and 76mm wires, they are not normally used for anchor handling operations within the Australian industry, where 64mm wires are used. "Gold nose" sockets suitable for use with 64mm wires are available, to order, but on a 4-month delivery basis.

Another "bull nose" socket is the Dutch "green pin", reportedly considerably more expensive than the "gold nose".

SPELTER SOCKETS - STANDARDS

International:

ISO 3189 Sockets for wire ropes for general purposes
Part 1 General characteristics and conditions of acceptance
Part 2 Special requirements for sockets produced by forging, or machined from solid.
Part 3 special requirements for sockets produced by casting.

Germany:

DIN 3092 Socketing of wire ropes, casting in metal, safety requirements and testing (English version)

DIN83313 Wire rope sockets (English version).

UK:

BS 463 Specifications for sockets for wire ropes
Part 2 Metric Units

BS 7035 Code of Practice for socketing of stranded steel wire ropes.

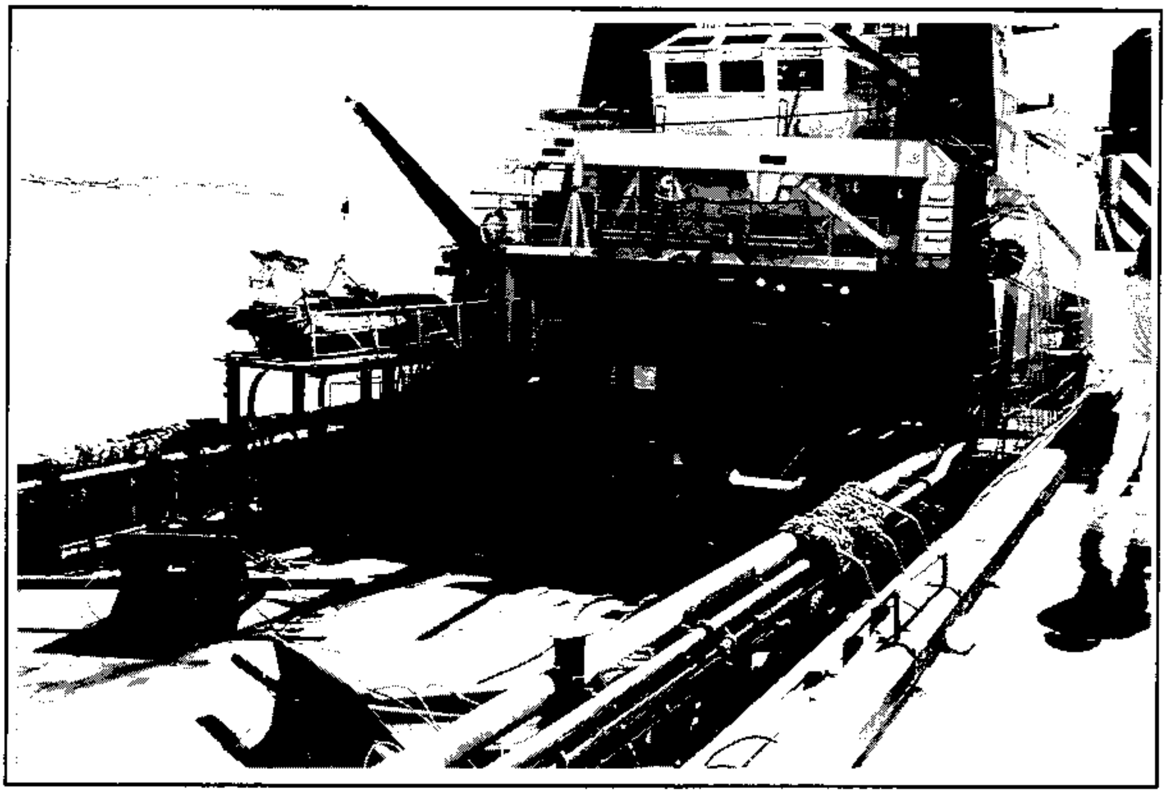
USA:

FS RR-S-550D

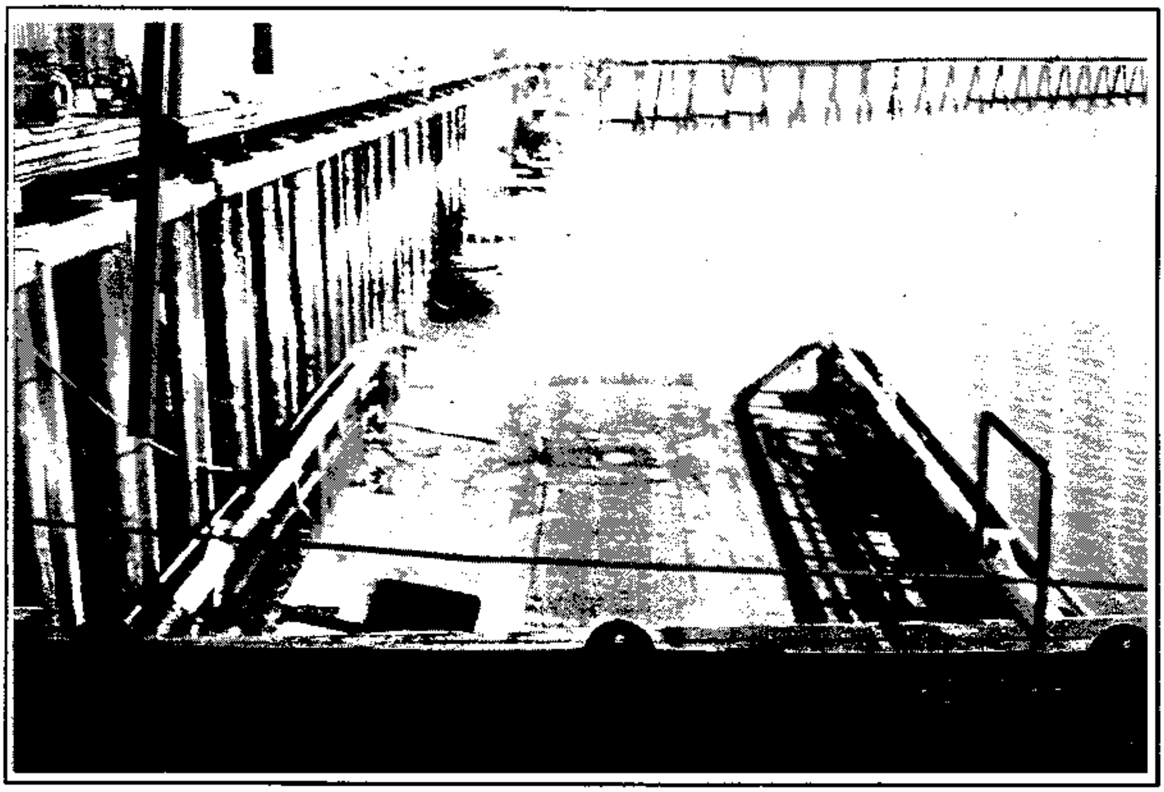
Australian Standards:

AS 2974 -1982 Steel casting

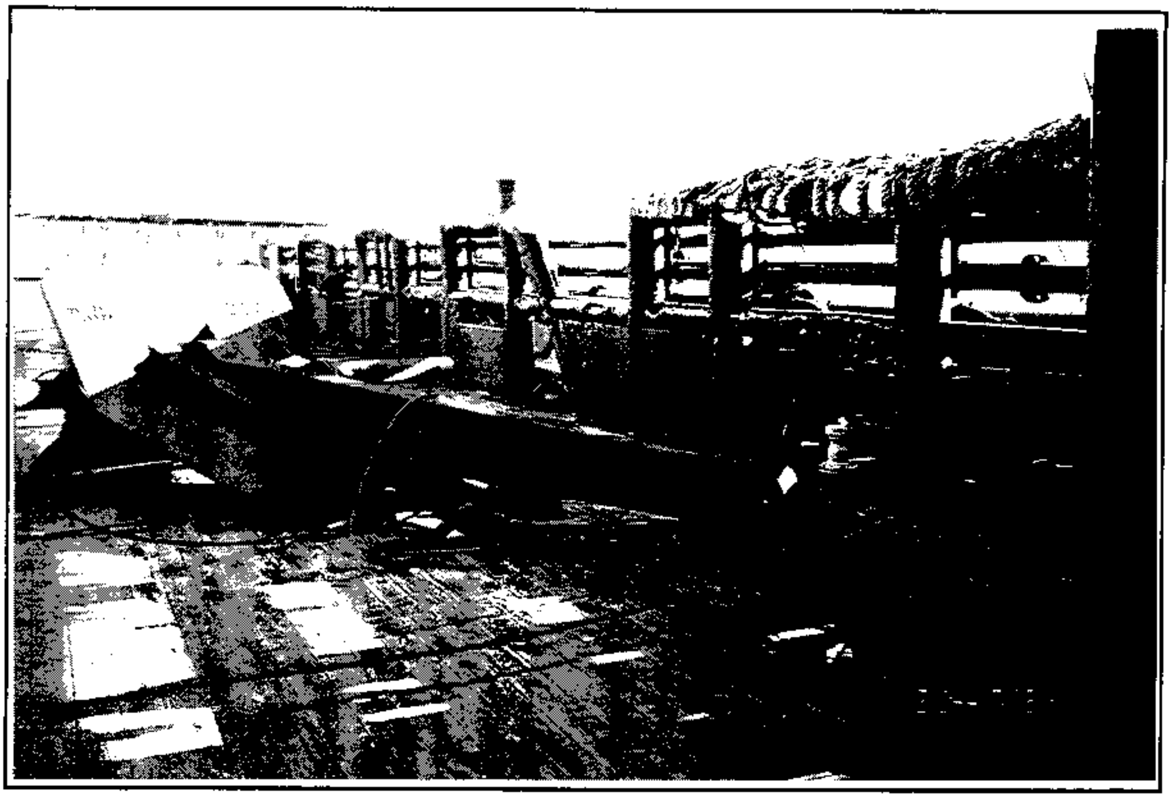
AS 2759 Steel wire rope application guide



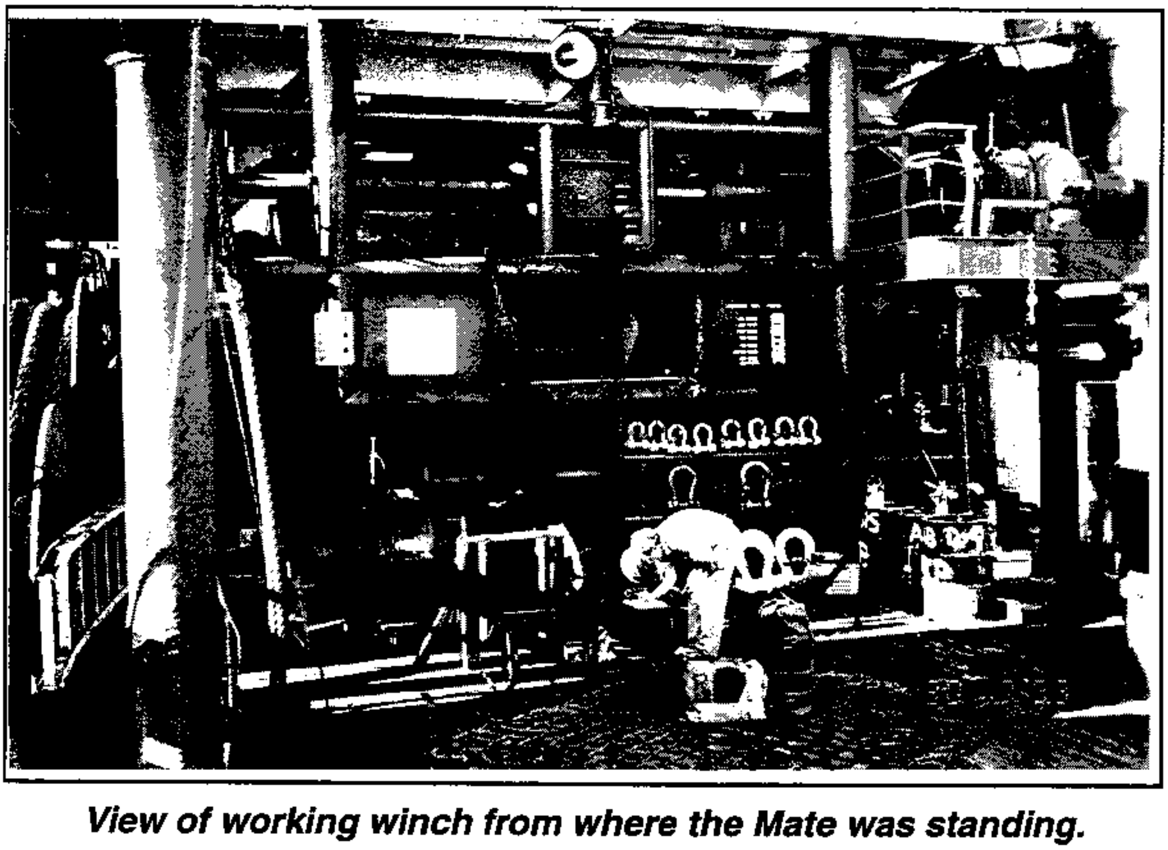
View of forward end of working deck



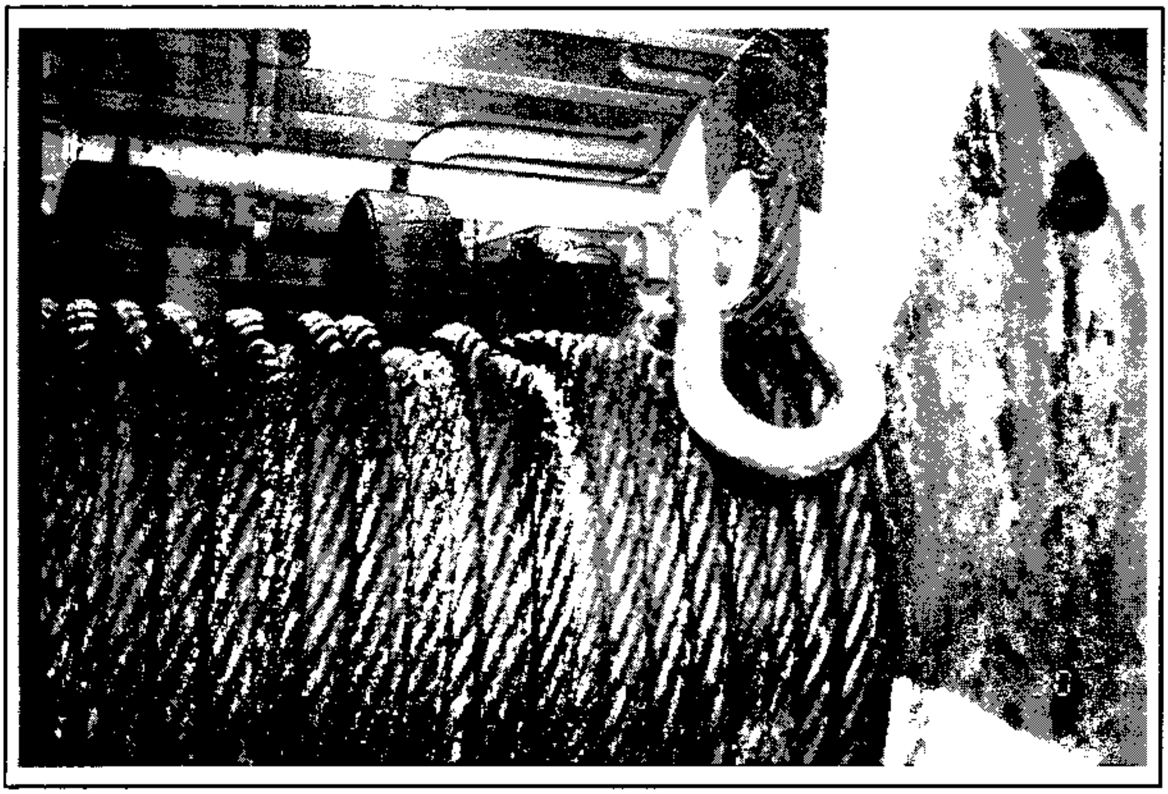
View of working deck from control position



Anchor upon which the mate was standing, also showing dummy roller (right hand side) around which tugger wire had been lead.



View of working winch from where the Mate was standing.



Position of shackle on working winch.

Cut-away in plate where the Mate's head was resting (showing fresh chipping of paint work on barrier plate).

Attachment 5

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REPORT NUMBER: NC93-135

DATE: 1st September 1993

Department of Transport & Communication
G.P.O Box 594
CANBERRA ACT 2601

CLIENT CONTACT: Mr. C. Filor

ORDER NO: Consultancy Commission No. 93/767

SUBJECT: Covering the examination of Spelter Socket- 'Maersk Runner'.

INVESTIGATED AND REPORTED BY:

John GRAY
Manager Materials Scientist

REPORT REVIEWED BY:

pl Joe ABELA
Materials Scientist

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1. INTRODUCTION

One fractured spelter socket was submitted by the Client for metallurgical examination and testing.

The object of this work was to determine if possible, the mode and cause of failure. It was also requested that if possible comments be made with respect to the likelyhood of the component being new at the time of failure.

2. BACKGROUND INFORMATION

The following information was supplied by the Client.

The spelter socket failed in service on 28.07.93. At the time of failure the socket and attached wire were in use on board the 'Maersk Runner' which was on the North West shelf.

Under normal circumstances the socket is used in lieu of a splice and is attached to a shackle for mooring purposes.

At the time of failure the socket and wire were being used to replace a length of wire which had already broken. Failure is believed to have occurred when the socket was approx. 1 metre clear of the winding drum.

It was advised that the socket is supposed to have been manufactured in accordance with AS 2074-1982 Grade LIB.

3. VISUAL EXAMINATION

3.1 Procedure

The components were examined with the aid of a low powered metallurgical microscope and all significant observations recorded.

3.2 RESULTS

The socket had failed at the two (2) junctions of the 'U' shape to the conical section.

Both fracture surfaces exhibited an appearance which is characteristic of a cleavage type failure. This means that at the time of failure the socket failed in a brittle manner.

Both fracture surfaces exhibited centreline shrinkage which made up approximately 2% of the cross-sectional area.

For the purposes of this discussion the two (2) fracture surfaces were identified by ETRS as A and B.

Fracture A exhibited a small casting defect on the outside surface. This defect was probably a shrinkage cavity, was approximately the size of half a two cent coin and extended to a depth of approximately 10mm. The general appearance of fracture A indicated that the fracture initiated at this casting defect and propagated through the cross-section to the inside surface of the 'U'.

The origin of the fracture on fracture B was not able to be determined. Most of the fracture surface exhibited cleavage type facets similar to those observed on fracture A.

There was no evidence of any fatigue type cracking on either of the fracture surfaces.

The leg of the 'U' on the side of fracture B had bent outwards.

At the bottom of the 'U' were two bruises on the inside surface. These bruises were typical in appearance of that expected from contact with a shackle.

The severity of this bruising indicated that either the socket had been in service for a considerable period of time and the bruising was in fact a mixture of wear and bruising or that the type of load applied for the first time was greater than the design capability of the component.

Several areas on the outer surfaces of the 'U' shape exhibited damage characteristic of a stranded wire being dragged across the surface.

The overall appearance of the fracture surfaces and the bend in the leg which contained fracture B indicated that side A fractured first followed by bending of leg B and subsequent fracturing at B.

(Refer figures 1-5 attached)

4. MATERIAL IDENTIFICATION

4.1 Procedure

A section was excised from the 'U' and analysed using Atomic Emission Spectroscopy.

4.2 Results

All the figures except manganese comply with that specified in AS 2074-1982 Grade LIB.

The manganese figure is significantly lower than that specified.

(Refer NC93-135A attached)

5. METALLOGRAPHIC EXAMINATION

5.1 Procedure

A section was excised from the A fracture surface, prepared using standard metallographic techniques and examined using high powered metallurgical microscopes up to a magnification of 1000X.

The position of this section was chosen such that it included part of the small defect where it is believed the fracture initiated.

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5.2 Results

This sample exhibited a normalised type structure which is one of the three (3) allowable conditions specified in AS 2074-1982 Grade L1B.

The surface of the defect exhibited a lightly decarburised layer which confirms its presence in the casting before it went into service.

6. MECHANICAL TESTING

6.1 Procedure

The 'U' was sectioned, prepared for mechanical testing in accordance with AS 1391-1991, tested and the results compared with the properties specified for Grade L1B.

6.2 Results

The tensile strength, proof stress and impact results all failed the requirements of AS 2074-1982 Grade L1B.

The fracture surfaces on the tensile specimens exhibited a fibrous appearance indicating a certain amount of ductile behaviour whilst the impact specimens exhibited cleavage an indication of brittle behaviour.

(Refer NC93-135M attached)

7. DISCUSSION

The cleavage facets exhibited by the two fracture surfaces means that the socket failed in a non-ductile manner.

This can occur under one of two circumstances. Either the metal is inherently 'brittle' or the load which caused the failure was applied rapidly. Materials which are normally ductile, can behave in a brittle manner if they are subjected to a high strain rate. The tensile specimens (low strain rate) exhibited a more ductile behaviour whilst the impact specimens (high strain rate) exhibited a more brittle behaviour. From this it can be concluded that the spelter socket failed as the result of a high strain rate ie: the rapid application of a load.

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The presence of the centreline shrinkage will have slightly reduced the strength of the socket because of a reduction in the effective cross sectional area. This effect is however considered to be relatively insignificant with respect to the cause of failure.

The casting defect from which the fracture initiated will have acted as a stress concentrater, however it is quite probable that failure would have occurred if the defect had not been present.

The lower than specified impact and tensile results will have rendered the socket more susceptible to failure by shock overload.

The presence of the bruising on the bottom of the 'U' is consistent with that expected from a rapid overload situation.

8. CONCLUSIONS

1/ The spelter socket failed as a result of a shock overload. The circumstances which produced this overload are unknown.

2/ The small casting defect at the surface has acted as a stress concentrater for the initiation of the fracture.

3/ It is quite probable that failure would have occurred if this defect had not been present.

4/ The mechanical and chemical properties of this material do not meet the requirements of AS 2074-1982 Grade L1B.

5/ The lower than specified mechanical properties will have rendered the socket more susceptible to this type of failure.

6/ The bruising at the bottom of the 'U' is consistent with the above mode of failure.

7/ There was no evidence of any fatigue being present on the fracture surfaces.

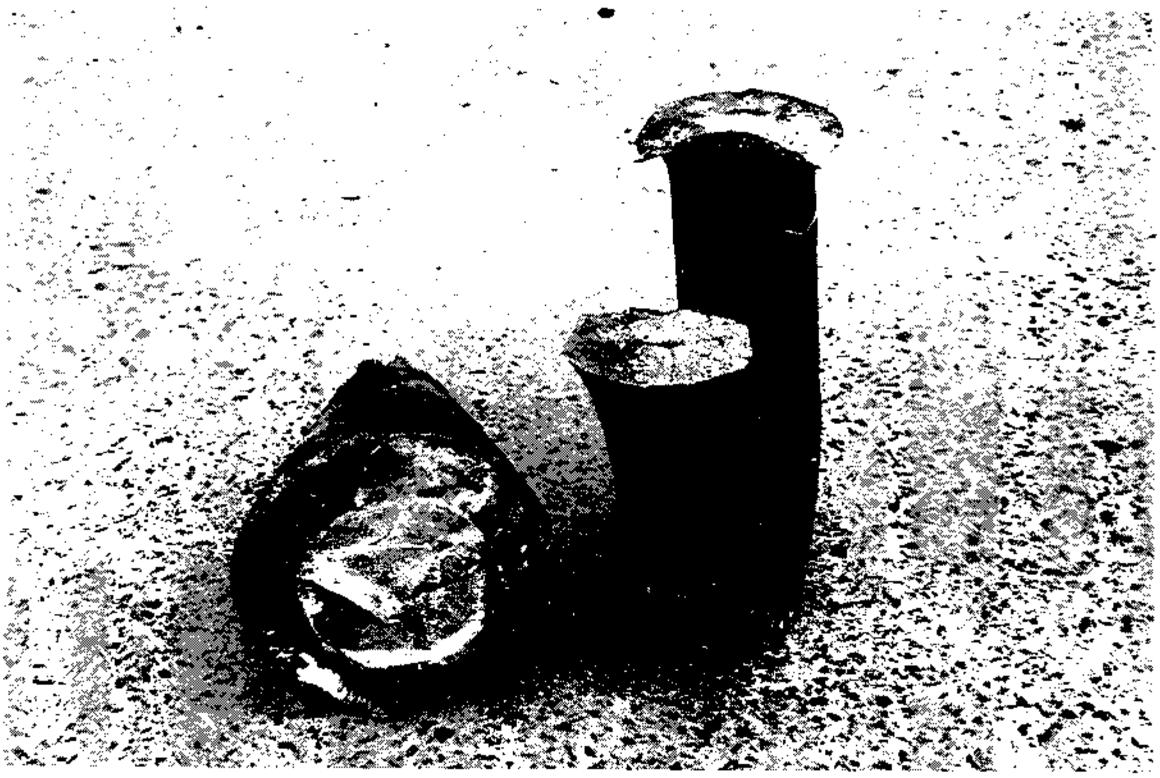

Figure 1: Showing the two halves of the fractured spelter socket.

Figure 2: Showing the fracture surface at A.

Note centreline shrinkage and the small casting defect towards the top at the photograph.

Figure 3 : Showing fracture surface B.
Note the centreline shrinkage.

Figure 4: Showing the bruising in the bottom of the 'U'.

Figure 5: Showing the abrasions on the outer surface of the 'U' caused by stranded wire.

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REPORT NUMBER: NC93-135A

DATED: 1st September 1993

Dept. of Transport & Communication
8th Floor, 363 Adelaide Street
BRISBANE QLD 4106

CLIENT CONTACT: Mr. K. Filor

ORDER NUMBER: Consultancy Commission No. 93/767

CORRELATION NUMBER: Q044148 25th August 1993

DESCRIPTION: The chemical analysis of one (1) only steel sample identified: 135.

PERFORMED BY: Atomic Emission Spectroscopy to AS 2883-1986. (Unless indicated, samples analysed as presented).

RESULTS:

Element (%)	(1)	AS 2074-1982 Grade LIB
Iron	BAL	BAL
Carbon	0.27	0.25-0.33
Manganese	0.75	1.20-1.60
Silicon	0.52	0.6 MAX
Sulphur	0.013	.050 MAX
Phosphorus	0.027	.050 MAX
Chromium	0.15	
Nickel	0.05	
Molybdenum	<0.01	
Copper	0.42	
Titanium	<0.02	
Aluminium	<0.005	
Vanadium	<0.02	
Niobium	<0.010	
Boron	<0.0005	

Note:
(a) < denotes 'less than'.
(b) The above mentioned analyses were performed at ETRS Brisbane Office, NATA laboratory number 1353.
(c) The precision of all results greater than four times the limit of detection is such that 99.7% of all results shall be within +/- 5% of the true mean.
(d) Samples will be disposed of 30 days after issue of this report unless otherwise notified.

Joe ABELA
Materials Scientist

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REPORT NUMBER: NC93-135/M

DATE: 30th August 1993

Dept of Transport & Communication
8th Floor, 363 Adelaide Street
BRISBANE NSW 4016

CLIENT CONTACT: Mr K. Filor

DESCRIPTION: The machining and mechanical testing of one (1) only spelter socket.

MATERIAL: Not Specified

TEST SPECIFICATION: AS 1391 - 1991

TEST RESULTS:

TENSILE

Dimensions	mm	13.84 Dia
Proof Stress 0.2%		
Load	kN	42.5
Stress	MPa	283
Tensile Strength		
Load	kN	83.0
Stress	MPa	552
Gauge Length	mm	69
Elongation	%	20
Final Diameter	mm	11.53
Reduction of Area	%	31

IMPACT I170R
Ambient Temp. 19°C
Test Temp. 19°C — Absorbed Energy (J)

Notch 1, 2, 3 — 16, 18, 16

Peter SCHULLER
Materials Scientist

Geoffrey ACKERMAN
Manager Mechanical Testing
Approved Signatory