Report on the investigation

of the parting of a mooring line

while the Bahamian registered tanker

Alfa Britannia

was berthing at Tranmere oil terminal

causing injuries to crew on board a gig-boat

on 18 November 1999

Marine Accident Investigation Branch
First Floor, Carlton House
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Report No 1/2001

Extract from
The Merchant Shipping
(Accident Reporting and Investigation)
Regulations 1999

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the cause with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

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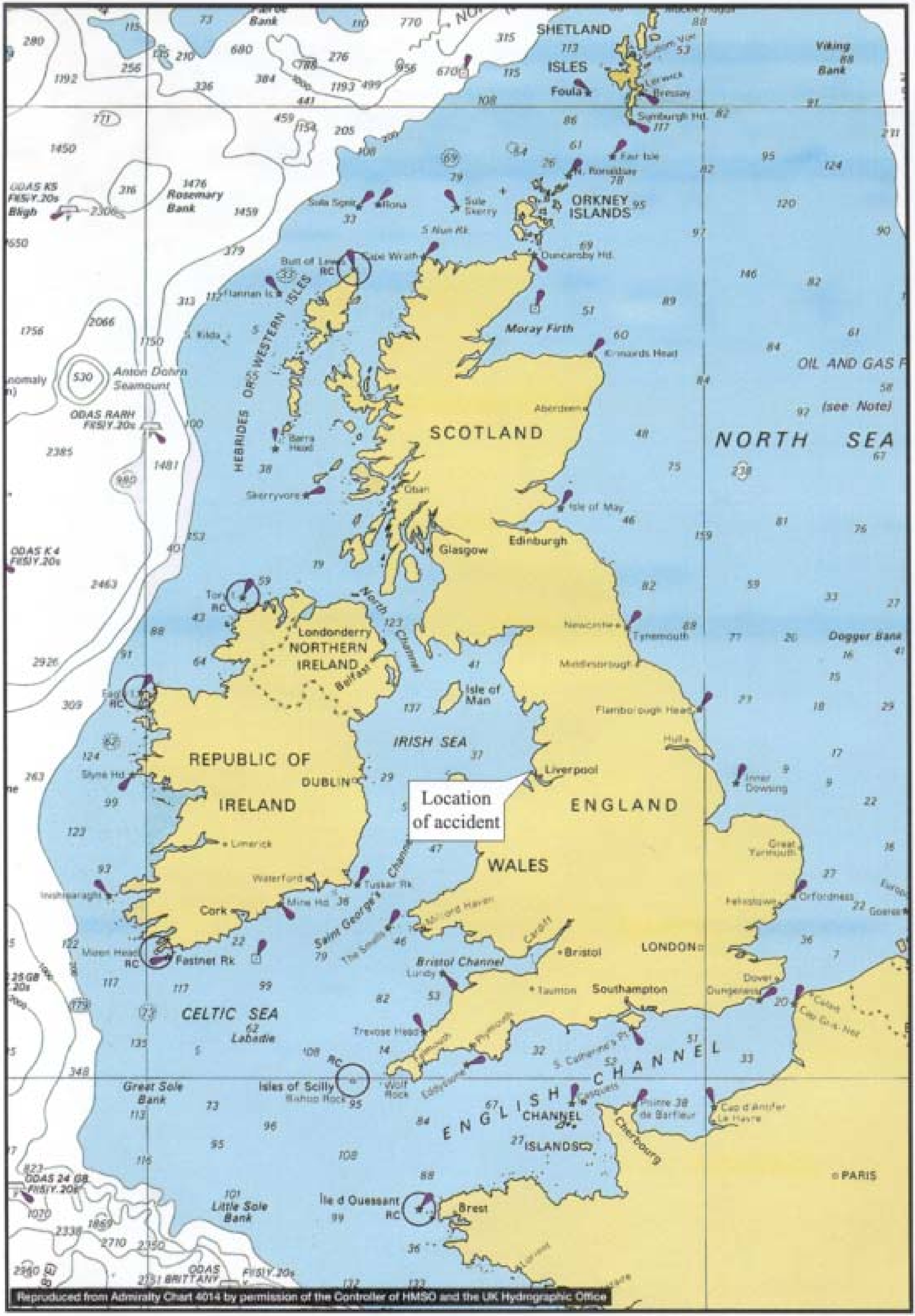
GLOSSARY OF ABBREVIATIONS AND ACRONYMS

BS	British Standard
gt	gross tonnage
IMO	International Maritime Organization
km	kilometre
kW	kilowatt
m	metre
mm	millimetre
POLAS	Port of Liverpool Ancilliary Service
SAFE	Ships Available For Employment
SIRE	Ship **I**nspection **R**eport programme
STASCO	Shell International Trading and Shipping Company
UK	United Kingdom
UTC	Universal co-ordinated time
VLCC	Very large crude carrier



SHETLAND ISLES
ORKNEY ISLANDS
SCOTLAND
NORTH SEA
OIL AND GAS
HEBRIDES OR WESTERN ISLES
Moray Firth
Aberdeen
Edinburgh
Glasgow
NORTHERN IRELAND
Londonderry
Belfast
North Channel
Isle of Man
IRISH SEA
REPUBLIC OF IRELAND
DUBLIN
Liverpool
Location of accident
ENGLAND
WALES
Saint George's Channel
Bristol Channel
Bristol
LONDON
Southampton
CELTIC SEA
Isles of Scilly
ENGLISH CHANNEL
CHANNEL ISLANDS
Cherbourg
PARIS
Brest
Dogger Bank
Viking Bank
Rosemary Bank
Anton Dohrn Seamount
Great Sole Bank
Little Sole Bank
Cork
Limerick
Waterford
Fastnet Rk
Reproduced from Admiralty Chart 4014 by permission of the Controller of HMSO and the UK Hydrographic Office

SYNOPSIS

At 1932 (UTC) on 18 November 1999, while the 56,115gt tanker *Alfa Britannia* was berthing at the North Stage of Tranmere oil terminal in the River Mersey, a mooring line parted, whiplashed and struck the gig-boat *Osprey*, causing various injuries to all of her four crew members. Liverpool Coastguard informed the Marine Accident Investigation Branch (MAIB) of the accident at 2048 that day.

The tanker was delivering a cargo of crude oil to the terminal and was berthing at the stage, which had a number of dolphins. The first line forward was a breast line, which was taken to dolphin No8 by *Osprey* and her crew. The wire line had an 11m long nylon tail, the eye of which was placed over a bollard on the dolphin. The mooring line was heaved in by the ship's crew and made fast. When the gig-boat was taking the second mooring line, by the ship's side, the first mooring parted. The whiplash caused the line to hit the gig-boat, resulting in injuries to the crew and one in particular, who suffered multiple injuries. Another crew member was thrown into the river but was rescued by *Osprey* in difficult circumstances.

Two different test-houses examined the nylon tail, and found that dynamic loading had caused it to part. The load imposed on the tail originated from the movement of the ship as she finally came alongside.

The pilot's intended instruction to the master had been for him not to make the breast lines fast before the ship was in her final position alongside. However, there is conflicting evidence between what the pilot thought he had instructed and what the master thought the pilot had instructed. The master thought the pilot had instructed him to keep the first breast line tight, and he ordered the chief officer, who was in charge of the forward mooring party, to do so. Because all verbal communications were in Korean, the pilot did not know whether his intended instruction had been passed properly, or at all, to the chief officer.

The accident was caused by a breakdown in communications between the pilot and the ship's officers in that his intended instruction not to make the breast line fast was not carried out.

Recommendations are made to Shell UK Oil Products Limited on producing mooring guidelines, specific to the operational requirements and conditions for Tranmere oil terminal, and specific mooring plans for each ship.

PARTICULARS OF THE VESSELS AND THE ACCIDENT

VESSEL DETAILS

Name	:	*Alfa Britannia* **(Photograph 1)**	*Osprey* **(Photograph 2)**
Registered Owner	:	Shinbou Shipping Co. Ltd	Mersey Docks & Harbour Board Company
Manager	:	Lundqvist Rederierna	
Port of registry	:	Nassau	
Flag	:	Bahamas	
Classification Society	:	Det Norske Veritas	
Built	:	1998 in South Korea	1994 at Brombrough
Construction	:	Steel	Steel
Type	:	Tanker	Gig-boat for running ships' mooring lines
Length overall	:	248.0m	8.8m
Gross tonnage	:	56,115	
Deadweight	:	99,280	
Engine power	:	14,048kW	95.5kW

ACCIDENT DETAILS

Persons on board	:	21	4
Injuries	:	None	Various to all four crew members - serious to two of them
Damage	:	None	Broken window panes
Location of incident	:	Tranmere oil terminal on the River Mersey	
Time and date	:	1932 (UTC) 18 November 1999	

Photograph 1

The bow of *Alfa Britannia* and three of the mooring dolphins at Tranmere oil terminal

SECTION 1 - FACTUAL INFORMATION

1.1 NARRATIVE (All times are UTC)

On 18 November 1999, *Alfa Britannia* anchored off the Isle of Man at 0550 to wait for a Mersey pilot. She was on passage from Sullom Voe to the Tranmere oil terminal in the River Mersey, carrying a cargo of crude oil. Because a northerly gale was forecast, normal pilot boarding stations off the River Mersey had been closed. The pilot flew to the Isle of Man, where he took a local boat to the anchored ship; boarding her at about 1000. The pilot discussed the passage plan with the Korean master, which included the arrangements for tugs, and procedures and plans for mooring the ship alongside the North Stage of the terminal.

At about 1650 *Alfa Britannia*, now inbound to the oil terminal, passed the Bar light float. The bridge team consisted of the pilot, master, officer-of-the-watch and helmsman. At about 1820 the ship passed between New Brighton and Seaforth Docks. By 1845, when passing between Birkenhead and the city centre of Liverpool, the tugs *Ashgarth* (49 tonnes bollard pull) and *Oakgarth* (52 tonnes bollard pull) had been made fast **(see Diagram 1)**. At this time the ship was making good a course of 168° and a speed of nearly 6 knots.

The pilot contacted the fore and after gig-boats, which were to run the mooring lines to the dolphins, on VHF radio channel 72 to confirm the mooring arrangements.

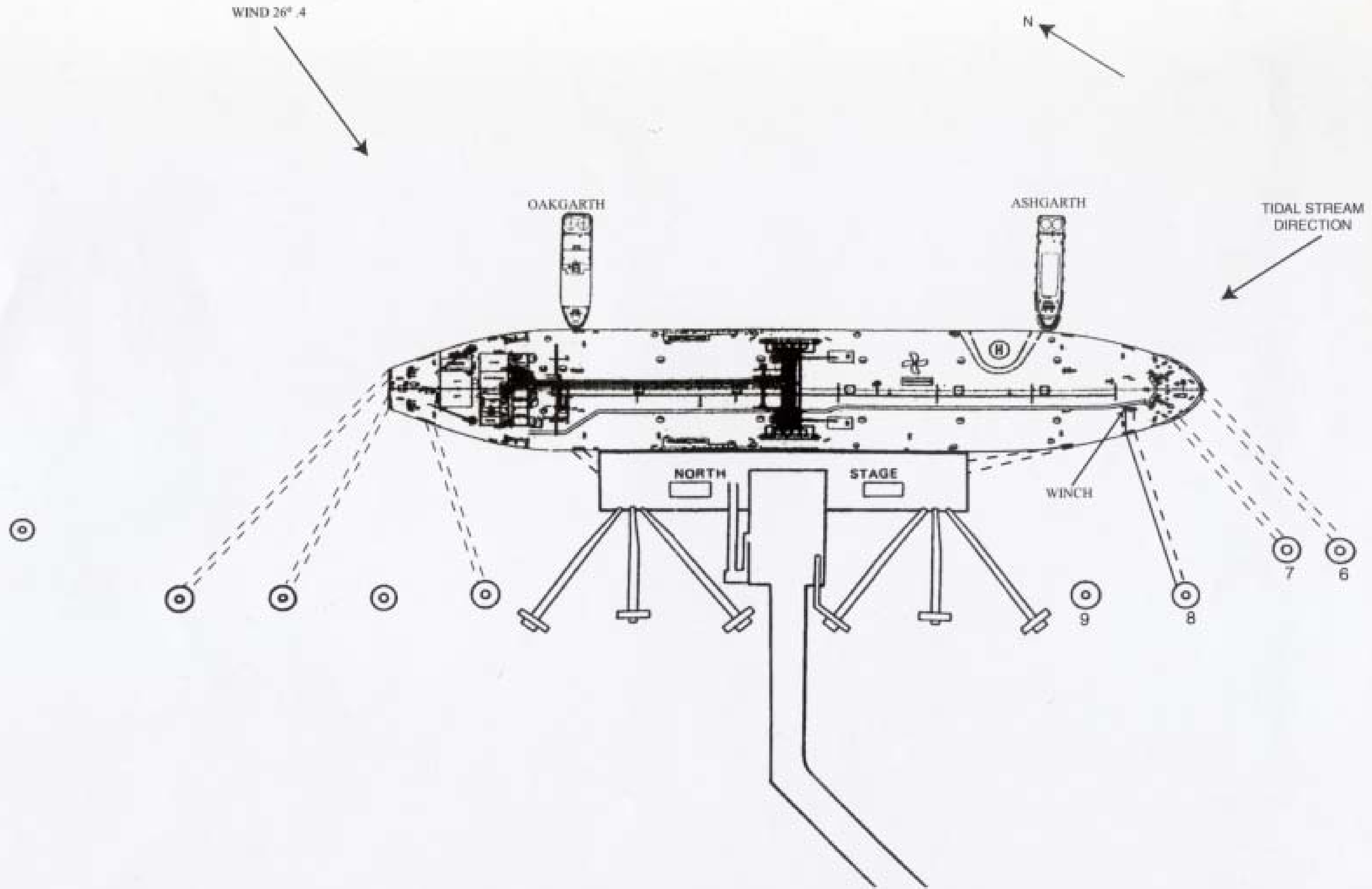
At 1902 with about 2 cables to run to the North Stage of the oil terminal and making good about 2 knots, the ship altered course to 153° to make her final approach. The pilot made a slow approach to the stage because of the quarterly wind. He reiterated to the master that the crew should send out the two forward breast lines and the two after backsprings, and intended that the breast lines should not be made fast before the ship was in her final position alongside.

However, there is conflicting evidence between what the pilot thought he instructed and what the master thought the pilot instructed. The master thought the pilot instructed him to keep the first breast line tight, and he ordered the chief officer, who was in charge of the forward mooring party, to do so.

The gig-boat *Osprey*, with four crew members on board, had been tasked to run the forward mooring lines to the dolphins. The ship's crew had lowered the first breast line, which consisted of a wire line with a nylon tail, to the water's edge. When the ship was about 10m from the stage, the nylon tail was taken on board the gig-boat and stoppered off on her tow rail. *Osprey* ran the line to No 8 dolphin where the eye of the nylon tail was placed over a hook.

When the gig-boat was returning to the ship's side, the breast line was heaved in and made fast. The gig-boat's crew noted there was little run in the tide. The heaving line for the first of the after back springs had been landed ashore. The berthing master observed from his position on the stage that the ship had 3m to move longitudinally to align the ship's manifolds with the shore discharge pipes.

Diagram 1



Intended mooring plan for *Alfa Britannia* showing environmental conditions and positions of the tugs at the time of the incident

Alfa Britannia landed gently on the stage forward, while the stern was about 2m off. As soon as the ship landed, the pilot ordered the two tugs to push up. While the second breast line was being lowered to the waterline, the coxswain placed the bow of the gig-boat against the ship's side with the stern pointing towards No8 dolphin. One crew member was on the fore deck to receive the line. Then the gig-boat crew heard a loud retort of the first breast mooring line parting, which caused the line to whip back towards the ship and the gig-boat. The coxswain was knocked to the deck and covered in broken glass. He saw that the first crew member, who was next to him, was bleeding from the mouth, had a gash above his eye and was unconcious. The coxswain attempted to remove the breast line wire from around the first crew member and called for assistance from the second crew member who was in the stern of the gig-boat, but received no response.

The coxswain realised that the third crew member was not on board and then saw him in the water, about 10m away, clinging to a section of the wire. The coxswain reversed the gig-boat towards the third crew member, but this pulled the first crew member across the deck by the wire, causing him to scream out in pain.

The coxswain threw a lifebuoy towards the third crew member but the latter did not move to where it had landed in the water. He then used his VHF radio set and asked for assistance from the other gig-boat. The pilot asked the berthing master on VHF radio channel 72 whether Liverpool port operations should be contacted and emergency assistance requested. He was advised that all emergency procedures had been put into place by Shell personnel. The third crew member was calling out to be rescued and the coxswain tried again to manoeuvre the gig-boat towards him, but the engine cut out. He managed to get the engine running again, manoeuvre the gig-boat to the third crew member and grab his arm, but was unable to lift him inboard. The other gig-boat arrived and the third crew member was recovered on board *Osprey*.

Shortly afterwards a rescue boat arrived, followed by paramedics who tended to the crew members. *Alfa Britannia*'s crew heaved in the parted mooring line, releasing the gig-boat from the wire. The first and third crew members were taken by the rescue boat to a landing stage and then to hospital. The coxswain and the second crew member were also taken to hospital for treatment.

The breast line parted at 1932; the ambulance arrived at 1935; the ambulance left at 2012; mooring operations resumed and, at 2112, the ship was all fast alongside.

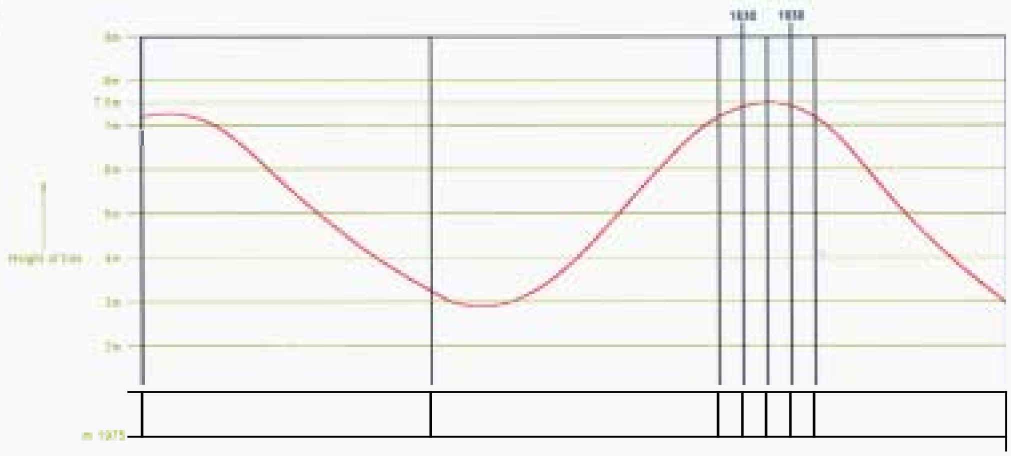
1.2 ENVIRONMENTAL CONDITIONS

The following table shows readings taken by an oceanographic laboratory, which was about 6km inland from the terminal:

Time Period	Wind Speed Max (knots)	Time of Gust	Mean Wind Speed (knots)	Mean Direction (degrees)
1900	21.09	1852	13.04	4.6
1910	20.28	1904	12.16	10.1
1920	18.66	1918	10.31	21.8
1930	16.22	1928	8.89	26.4
1940	19.47	1938	11.93	14.5
1950	21.90	1947	13.08	16.5
2000	26.77	1957	13.61	9.8

Predicted high water at Liverpool was at 1851 with a height of 7.8m, and it was one day after neaps.

The graphical recording of the actual height of tide **(see Diagram 2)** shows that high water occurred at 1900. It was estimated that the clock was about 3 minutes slow, so the actual time would have been 1903; 12 minutes after predicted high water. The graph also shows that the maximum height of tide was 7.5m, which was 0.3m less than predicted.



On 13 January 1997, a current observation was made for the Tranmere North Stage. This showed that at half an hour after high water (the same time as the accident) the ebbing current was setting 300° at a rate of about 0.1 knot.

It was dark.

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1.3 PILOTAGE

Of the 50 Liverpool pilots, 8 are specialised in berthing and unberthing tankers at Tranmere oil terminal. These selected pilots are drawn from first class pilots (licensed for ships greater than 180m in length) who have had at least two years experience in that class. They then understudy a specialised pilot to gain further experience in pilotage of tankers to and from Tranmere oil terminal. The pilot on board at the time of the accident, had regularly berthed ships at the oil terminal.

The North Stage annually receives cold crude oil cargoes from about 125 ships, while the South Stage receives heated crude oil cargoes from about 25 ships annually.

A document entitled *Procedures for vessels bound to and from Tranmere oil terminal* was drawn up between the Mersey Docks & Harbour Board, Shell UK Oil Products Limited and Liverpool Pilotage Services Ltd. For the purposes of the document *Alfa Britannia* was classed as a *Large Vessel* in that she was restricted in her ability to manoeuvre by reason of her draught.

The following is a guideline for times of entry and passage of the main channel when vessels are to berth at Tranmere: **(see chart extract opposite)**.

Bar	at 2 hours before high water
Formby	at 1 hour 30 minutes before high water
Crosby	at 1 hour before high water
Burbo	at 45 minutes before high water
Rock Light	at 30 minutes before high water
Woodside	at 10 minutes before high water
Tranmere	at 15 minutes after high water

The minimum under-keel clearance for a *Large Vessel* should not, at any time, be less than 1m and the ship should be attended by two tractor tugs.

1.4 MOORING GUIDELINES AND ARRANGEMENTS AT TRANMERE

Shell Trading and Shipping Company (STASCO) carries out crude oil trading and crude ship chartering. As part of the procedure, all ships are vetted against the STASCO system known as Ships Available For Employment (SAFE), which is a database of Shell reports drawn from approved inspectors. Where there is not a recent Shell report (within the previous 12 months), the SAFE system will draw from the international Ship Inspection Report programme (SIRE) system and make an assessment based on that report and transfer it into Shell's database.

For a first time caller to Tranmere, the terminal operator will be contacted with the ship's particulars and asked to give terminal acceptance. This would require receipt of the ship's mooring information, including either the mooring diagram and particulars from the IMO *Vessel's Particulars Questionnaire* or, if time permits, the ship's general arrangement. Each time a ship visits, her agent's questionnaire will ask for information on the ship's mooring arrangements, to check that no changes have taken place since the last visit.

On 14 November 1999, the ship's agent asked the master to provide the following information for the oil terminal's records:

1. the number of forward and aft wire mooring lines;

2. the size of wires and their minimum breaking load;

3. the brake holding power of the mooring winches; and

4. the heave and render loads for the winches.

(The master replied with the details given in **Section 1.6**.)

If there have been changes to the mooring arrangements, the mooring pattern for the stage is reassessed. The first time a ship visits Tranmere, a member of the Marine Department will board her after she has berthed to assess the effectiveness of her mooring patterns and draw up a plan of the existing mooring arrangements for its records. This serves as a suitable mooring pattern for subsequent visits.

Alfa Britannia had visited Tranmere on one previous occasion and would have been through the above vetting system. However, Shell UK Oil Products Limited was unable to obtain a general arrangement for the ship.

From the *Procedures for vessels bound to and from Tranmere oil terminal*, mentioned in **Section 1.3** above, *Large Vessels* normally berth at Tranmere shortly after high water at Liverpool. The procedures guide states that, on approaching the stage, a breast line is normally passed first to the forward gig-boat. An after back spring should then be landed on the stage and, while the ship is being held in position by the tugs, all further ropes and lines are secured.

Large vessels are not berthed when winds of more than 45 knots have been forecast.

1.5 GIG-BOAT OPERATIONS AND *OSPREY'S* CREW

There were two gig-boats in operation for the mooring of ***Alfa Britannia;*** Osprey forward and ***Mermaid*** aft, each with four crew members. There were eight men on the stage, one of whom was the foreman.

Photograph 2

Gig-boat *Osprey* at Tranmere oil terminal after the accident

On this occasion, it was intended to make fast forward the two breast lines, followed by four head lines and lastly two back springs **(see Diagram 1).**

Depending on their size and type, some ships use wire-mooring lines to make fast to the stage and the dolphins. Because two wires are too heavy for the gig-boat, it can only run out one line at a time from the ship to the dolphins. The mooring line is stoppered off on the gig-boats towing post and the tail is laid along the starboard side, with the eye on the fore deck.

Photograph 3

A view of dolphin No 8 taken from *Alfa Britannia*
showing the two breast lines

The dolphins consist of a round platform, which can revolve around a central post and move up and down with the rise and fall of the tide **(see Photograph 3).** There is a mixture of releasable hooks and bollards over which to place the eye of the mooring lines. The gig-boat crew members can place the eye of a mooring line over a hook without leaving the boat. This is not the case with the bollards. Because the hooks can be released in an emergency, and are more accessible to the gig-boat, they are preferred to the bollards.

The gig-boat lands starboard side alongside the dolphin and head to tide. Because the platform can revolve, the hooks may not be nearest to the ship. After the eye of the mooring line has been placed on a hook and the ship's crew has begun to heave in the line, the platform will turn, causing the line to slacken and then tighten with a jerk, as the hook revolves round towards the ship.

The coxswain was 47 years old and had joined his family business of boatmen in 1969. He became a coxswain in 1974 and has been handling the moorings at Tranmere oil terminal ever since. He was transferred to the Mersey Docks and Harbour Company in 1985. As a result of the accident, he suffered concussion and various cuts and abrasions.

The first crew member was 54 years old. He had been in the merchant navy from 1961 to 1978 and was a qualified able bodied seaman. He joined the Docks and Stages company in 1978 and was transferred to Port of Liverpool Ancilliary Service (POLAS) in 1990, giving him more than 9 years experience as a boatman. As a result of the accident, he suffered extensive injuries to his head, ribs, back and legs.

The second crew member was 55 years old and had been originally trained as a diver before being employed as a boatman. He was transferred to the Mersey Docks and Harbour Company in 1985. He suffered from shock as a result of the accident.

The third crew member was 53 years old. He had been in the merchant navy from 1963 to 1974 and was a qualified able bodied seaman. From 1975 to 1977 he worked on the Mersey ferries, after which he worked for the Docks and Stages company involving the berthing of ships in the port. He joined POLAS in March 1997. As a result of the accident, he suffered a broken arm and the effects of immersion in water.

1.6 THE DECK-MOORING WINCHES

Aquamaster-Rauma Ltd of Finland manufactured the deck-mooring winch. It had two split drums and one warping end, all of which were hydraulically powered **(see Annex, Section 3).**

The mooring drum had a nominal pull of 15 tonnes and, at this load, a hauling speed of 0-15m/minute. The brake holding load for the winch was 59 tonnes **(see Annex, Section 4).**

Photograph 4

An overall picture of the starboard side forward deck-mooring winch

Eight mooring wires were stored on drums for each fore and aft station; the wires were 36mm in diameter with a breaking load of 91.8 tonnes. Nylon tails which were attached to the wires, were rated to a specified breaking load of 110 tonnes. The deck-mooring winch being used at the time of the accident was sited about 6m aft of the starboard anchor windlass.

(Note: The wire was rated at 91.8 tonnes and, fiom **Annex, Section 4,** it is recommended that the winch brake should hold 60% of this figure, which is 55.I tonnes, to give a safety margin. This latter figure is close to the tested 59 tonnes.)

Each deck-mooring winch had a single shaft to drive the two split drums (each with a tension and a storage drum) and the warping end. Normally, one drum was operated at a time. It had to be clutched into the shaft, by means of a lever, before the hand wheel brake was released. To change fiom one drum to the other, the hand wheel brake of the first drum had to be applied and the drum de-clutched before the second drum could be engaged. Both split drums could be operated at the same time but only in the same direction (heave or slack) **(see Photographs 4 and 5).**

Photograph 5

The deck-mooring winch showing the brake and clutch mechanism

The brake holding load was tested on 28 September 1999, which confirmed that the manufacturer's force of 59 tonnes could still be met. The design of the winch was such that if the brake was applied harder than at the time of the test, the holding power could be increased to greater than 59 tonnes **(see Annex, Section 4).**

17 TESTING OF THE NYLON TAIL

The nylon rope tail section of mooring line parted cleanly close to the splice at the dolphin end. It was a multifilament eight-strand rope, 80mm in diameter, 11m long with a certified breaking load of 110 tonnes.

Photograph 6

The broken nylon tail

The MAIB had the tail examined by Lloyd's British Testing in Wigan, whose report stated:

> ***No identification mark was observed.***
>
> ***No visible sign of rope fibre deterioration was observed.***
>
> ***Other than the breakpoint, the rope was in a serviceable condition.***
>
> ***The position of the break indicates the rope being overloaded, as this would be where an overload would be expected to break.***

A splice is normally stronger than the rope itself and breaks tend to occur close to the splice where there is a change of modulus/thickness **(see Annex, Section 2).** There was no distortion in the tail and it had returned to its original size. It was uncertain whether there had been a gradual or sudden load imposed on the rope **(see Annex, Sections 1 and 2).**

On 9 December 1999 the rope was released to *Alfa Britannia's* representatives and was transported to Tension Technology International Ltd in Arbroath, Scotland, for further examination. The latter's initial report stated:

> *There is little evidence of environmental degradation, though one or two yarn breaks could be possibly so attributed. Apart from some limited inter-yam fusion resulting from lashback, there is no evidence of any form of internal failure.*
>
> *There is considerable evidence of surface wear failures (both fusion and abrasion) on the strand crowns adjacent to the break.*
>
> *....., our overall inspection today suggests tensile overload failure. The form of failure, in which all strands have failed very close to each other and, adjacent to the 'Node' formed at the end of splice taper, is symptomatic of shock loading failure.*

The report observed that the rope had some surface wear, which may have reduced its strength, and the sample was too short to be fully tested. To quanti& the effects of such surface wear and damage over the whole of the tail, a realisation test (specified in BS 4928 and BS 5053 and incorporated into EN 919:1995) was carried out in the company's testing house in Preston. This technique tests yarns from each strand and from layers in each strand, proportional to the number of yarns in that layer.

Photograph 7

A yarn from the nylon tail undergoing a realisation test in Preston

The tests determined the strength of the rope by realisation using the following method:

a) determine mean yarn strength by test;

b) multiply a) by the realisation factor of 0.66 in EN 919:1995;

c) multiply b) by the number of unbroken yarns in this rope before failure.

The final report by the Arbroath test house observed there were a number of broken outer yarns, especially in a region 2 to 3m from the intact splice end. This surface wear had resulted in the tail being under-strength before it failed. However, there was little evidence of surface wear and abrasion at the point of failure.

The realisation tests showed that the total strength of the rope was 65.5 tonnes. However, because there was less wear in the region of the failure (as well as for reasons due to test methodology and rope binding effects) the realisation figure was an underestimate. The report estimated that the strength of the rope at the broken region was about 75 to 80 tonnes.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations, if any, with the aim of preventing similar accidents occurring again.

This section will examine how and why a strong nylon tail of a mooring line parted during the routine berthing of a tanker in moderate winds and weak neap tidal streams, causing serious injuries to the gig-boat crew members.

2.2 THE PURPOSE OF MOORING A SHIP

The safe mooring of a ship at a berth is a joint venture between the ship's personnel, the pilot, the tugs, the gig-boat crews and the shore operators. The term *mooring* refers to the system for securing a ship to a berth. The mooring system must be able to deal with the environmental conditions from any direction and is the general guideline for an effective mooring pattern. Forces acting on a ship can be split into longitudinal and transverse, and derive from the effects of wind on the air draught and the effects of tidal streams on the hull form beneath the waterline.

2.3 FORCES ACTING ON A SHIP

The most effective lead for a mooring line to resist any environmental condition would be in the same direction as the load. This would be impractical due to the variations in the directions of the loads and the different but static layouts of mooring points at each berth. Spring lines restrain the ship in the fore and aft line (two directions) and breast lines restrain the ship from moving off the berth (one direction). Therefore all breast lines will be stressed by an off-berth environmental condition.

If a ship experiences a wind on the aft quarter (as in this case) it will impose both a transverse and longitudinal force as it is striking both the stern and the side of the ship. For any given velocity, the longitudinal and transverse forces imposed by a quarterly wind will be less than that by the corresponding forces caused by an astern or an abeam wind.

Currents follow the same pattern as winds, but tidal forces acting on a hull increase with reduced underwater keel clearance. The majority of berths are orientated parallel to the prevailing tidal streams. However, even a small angle off the ship's longitudinal axis can impose large forces on the hull.

2.4 THE PARTING OF THE NYLON TAIL

When the nylon tail parted, *Alfa Britannia*'s forward mooring party had heaved in and tightened the first breast line on the after drum, engaged the after winch brake, and de-clutched it. They then clutched in the forward drum, released the brake and were in the process of passing the second breast line to the gig-boat.

The nature of the break in the nylon tail indicates that there was a sudden and dynamic load imposed on the line **(see Section 1.6 and Annex, Section 2)**. However, due to its elasticity, the purpose of a nylon tail is to be a shock absorber for the stiff wire part of the mooring line. Nylon has good resistance to abrasion, is rot-proof and is not damaged by oils, gasoline, grease, marine growth or most chemicals. However, the range of design factors contains provision for very modest dynamic loads. This means that the load must be handled slowly and smoothly to minimise dynamic effects. The test reports state that the condition of the nylon tail was not a cause of the break.

The realisation test estimated the strength of the nylon tail as 75 to 80 tonnes at the break point, which is greater than the tested brake holding load of the winch, but less than the breaking load for the wire section of the line. It is probable that the brake was tightened to an extent that its holding power was greater than the tested holding load such that it failed to render and so prevent the nylon tail parting.

2.5 THE CAUSES OF THE PARTING

The accident happened at a vulnerable phase of the operations when only one mooring line had been made fast forward. Until then, the passage up the River Mersey and the approach to the berth had been in accordance with *Procedures for vessels bound to and from Tranmere oil terminal* **(see Section 1.3)**.

The wind had been northerly force 6 to 7 during the ship's passage from the anchorage to the river. From the data in **Section 1.2**, at 1930, only several minutes before the accident, the wind was recorded to have gusted to a maximum of about 16 knots (force 4 to 5), with a mean wind speed of about 9 knots from a mean direction of 026°. These were the lowest readings taken 30 minutes before and after 1930. Because the observations were made inland, and some distance from Tranmere, the data gives only an approximation of the conditions the ship experienced. The wind was comparatively light and there were no extreme gusts. The wind was about 25° to 30° abaft the port beam and pushing the ship on to the berth.

From **Section 1.2**, the actual high water was cut by 0.3m and occurred 12 minutes after predicted high water, which was half an hour before the accident. The 1997 survey observed that the tidal stream to be 0.1 knot at this time, and would have been acting about 30° on the port bow. Therefore, the ebbing tidal stream was weak, and even weaker still because high water did not reach its predicted height. *Osprey*'s crew noted that the tidal stream was weak that night.

Therefore the environmental conditions were not extreme and were not subject to sudden increases in direction or velocity.

The ship's movement would have been the only mode in which to impose a sudden dynamic load and to part the breast line tail in the manner that it did. Because the breast line was leading out at about right angles to the ship's fore and aft line; the movement would have been in a direction away from the shore - that is, the bow moved to port. Neither the bridge team, the shore mooring gang, nor the gig-boat crews saw the ship make a sudden move. The berthing master, who was standing in the centre of the stage, did not see the ship move off the quay. However, the stage can move in and out. Therefore, if the ship had moved away from the berth, it would not have been readily apparent.

The ship made a slow approach to the stage. The pilot was mindful of the wind acting on the port quarter and on the accommodation superstructure. He did not use the tugs to push up the ship until she had landed alongside. Had he done so before landing, the ship would have rebounded off the stage. The ship landed gently alongside forward, while the stern was 2m off. Therefore when the tugs began to push the ship, the stern would have moved to starboard. The reaction of this movement was that the bow would have tended to move to port. By this time the forward mooring party had heaved in and made fast the first breast line. Although the movement was small and not easily noticeable, it was enough to part the nylon tail. The winch brake must have been applied with such force that it did not render before the parting of the mooring line.

The pilot's intended instruction to the master had been for him not to make the breast lines fast before the ship was in her final position alongside. However, there is conflicting evidence between what the pilot thought he had instructed and what the master thought the pilot had instructed. The master thought the pilot had instructed him to keep the first breast line tight, and he had ordered the chief officer to do so. Because all verbal communications were in Korean, the pilot did not know whether his intended instruction not to make the breast line fast had been passed properly, or at all, to the chief officer. During the running out and subsequent heaving in of the breast line, the pilot was unable to see the rope because it was dark.

To have carried out the pilot's intended instruction, the first breast line should have been heaved in some way but left sufficiently slack for any movement of the ship, with the brake nominally applied. Then when both breast lines were fast to the dolphin and confirmation had been given that the ship was in her final position alongside, they could have been tightened and made fast.

There was a breakdown in communications between the pilot and the ship's officers in that his intended instruction was not carried out. Had the ship received clearer instructions before she arrived, and the officers been better prepared for the specific mooring requirements and operations at Tranmere oil terminal, this might have been overcome.

2.6 MOORING GUIDELINES

It is incumbent on the pilots to brief the ship's personnel on berthing requirements and to make the final adjustments to mooring arrangements once the ship has confirmed which manifolds are to be used for discharge. This operational requirement determines the fore and aft position of the ship on the stage. Shell's mooring arrangement booklet for Tranmere oil terminal is only a general guide and the actual pattern can be adjusted at the time of berthing. The only ships that are provided with a pre-designated mooring pattern plan are VLCC's of over 250,000 tonnes deadweight.

While the safe mooring of a ship is the master's prime responsibility, the shore operators are in the best place to advise him on such subjects as mooring line layout and operating limitations because of their knowledge of the prevailing environment, the site and the equipment.

There are wide variations in ships' mooring equipment, such as rated winch brake capacities, layout and types of lines, crew competence and experience and maintenance of mooring equipment. The shore operators can reduce risk by:

1. developing guidelines for the safe mooring of ships pertaining to their particular site and environment;

2. obtaining mooring information from the ship before arrival; and

3. examining the ship's mooring equipment after berthing to adjust the guidelines in view of the state of maintenance and crew competence.

While the second and third points are carried out by Shell, the first point is covered in the *Procedures for vessels bound to and from Tranmere oil terminal* mentioned in **Sections 1.3 and 1.4** above. However, this procedures guide is primarily directed at pilots.

If guidelines (in 1. above) together with a specific mooring plan were sent to each ship before arrival, ship's personnel would be better prepared for the specific operational requirements and conditions for and at Tranmere oil terminal.

SECTION 3 - CONCLUSIONS

3.1 FINDINGS

1. *Alfa Britannia*'s passage up the River Mersey and the approach to Tranmere oil terminal was made in accordance with *Procedures for vessels bound to and from Tranmere oil terminal.* [2.5]

2. The after drum of the mooring winch holding the first breast lines had been braked and de-clutched. [2.4]

3. The forward drum had been clutched in and the brake had been released and the second breast line was being passed to the gig-boat. [2.4]

4. The accident happened at a vulnerable phase of the operations when only one mooring line had been made fast. [2.5]

5. The nature of the break in the nylon tail indicates that there was sudden and dynamic load imposed on the line. [2.4]

6. The realisation test gave an estimation of the strength of the nylon at the break point to be between 75 and 80 tonnes and less than that of the wire section of the line. [1.7, 2.4]

7. The manufacturer's minimum brake-rendering load for the winch was 59 tonnes. [1.6, 2.4]

8. It is probable that the brake had been applied with some force and, being a relatively new ship with the shoe linings in good condition, the rendering load was higher than that tested, which had been carried less than two months before the accident. [2.4]

9. The brake did not render before the parting of the rope. [2.5]

10. The condition of the nylon tail was not a cause of its parting. [2.4]

11. The environmental conditions were not extreme and were not subject to sudden increases in direction or velocity. [2.5]

12. The movement of the ship was the only mode in which to impose a sudden dynamic load and to part the nylon tail. [2.5]

13. The movement would have been away from the shore and to port. [2.5]

14. This movement happened because the ship landed firstly on the stage forward and then, as the stern came in alongside (assisted by the two pushing tugs), the bow moved out to port. [2.5]

15. Although the movement was small it was enough to part the nylon tail. [2.5]

16. The pilot's intended instruction to the master had been for him not to make the breast lines fast before the ship was in her final position alongside. [2.5]

17. There is conflicting evidence between what the pilot thought he had instructed and what the master thought the pilot had instructed. [2.5]

18. The master thought the pilot had instructed him to keep the first breast line tight, and he ordered the chief officer to do so. [2.5]

19. The pilot was unable to determine if his intended instruction had been passed to the chief officer, who was in charge of the forward mooring party, as all verbal communications were in Korean. [2.5]

20. The pilot was unable to see the breast line being heaved up tight. [2.5]

21. If mooring guidelines and a specific mooring plan had been sent to the ship before arrival, the ship's personnel might have been better prepared for the operational requirements and conditions for and at Tranmere oil terminal. [2.6]

3.2 CAUSE

1. A breakdown in communications between the pilot and the ship's officers, in that his intended instruction not to make the breast lines fast before the ship was in position, was not carried out. [2.5]

3.3 CONTRIBUTORY CAUSES

1. The winch brake had been applied with some force and did not render before the parting of the nylon tail. [2.4]

2. The movement of the stern to starboard and the bow to port imposed a dynamic load on the nylon tail. [2.5]

3. Because all verbal communications between the crew were in Korean, the pilot did not know whether his intended instruction had been passed properly, or at all, to the chief officer. [2.5]

4. The pilot was unable to see the rope because it was dark. [2.5]

SECTION 4 - RECOMMENDATIONS

Shell UK Oil Products Limited is recommended to:

1. Produce mooring guidelines, specific to the operational requirements and conditions for Tranmere oil terminal, and specific mooring plans for large ships, which can be sent to a ship before arrival.

Marine Accident Investigation Branch
January 2001

ANNEX

1. Mooring wires with tails

Elasticity in a mooring line helps to absorb higher dynamic loads. Wire lines are very stiff whereas a fibre line can stretch up to ten times more. Large ships use wire lines fitted with a synthetic rope (nylon in this case) or tail at the shore end of the line. This added elasticity helps to reduce dynamic loads and to respond to variations in environmental conditions, as well as movement caused by ships passing nearby and helps to distribute the loadings more evenly among the mooring lines. The addition of an 11m tail would increase elasticity of a 45m wire line by five to six times.

The main disadvantage of tails is that they introduce a weak link into a mooring line. Therefore, tails should be made of a material with a high breaking load such as nylon. The tail should be of a size that it can be easily handled and have a breaking strength 25% greater than the wire. There should be a further 10% added for reduction in wet conditions. Nylon is more elastic than any other material and will stretch 12% or more at 50% of the minimum breaking load. If tails are used, they should be on all of the wires and be of the same size and material.

Minimum breaking strength is based on data from a number of manufacturers and represents a value of 2 standard deviations below the mean, as established by regression analysis. The working load of a rope is determined by dividing the minimum breaking strength by the design factor. Design factors range from 5:1 to 12:1 for normal service and modest dynamic loading, and should be higher for critical applications.

Because of the wide range of rope use, rope condition, exposure to several factors affecting rope behaviour, it is not realistic to make standard recommendations as to the design factors or working loads. However, to provide guidelines, a range of design factors and working loads are provided for a rope in good condition, with appropriate splices, in non-critical applications and under normal service conditions. Normal service is generally considered to be use under static or very modest dynamic load conditions.

2. Dynamic loading on nylon tails

Ideally nylon tails should be able to incur dynamic loads without failure. The rope should be designed for the particular task it has to carry out and to absorb dynamic loadings. However, safety margins may be reduced, as precise and actual loading conditions may not be known. The actual speed of loadings may be higher than those simulated in laboratories. Most materials show a different behaviour when the straining speed is changed.

If a load is applied slowly, a rope will break at its weakest point. If the load is applied rapidly, it will not break at the weakest point but at a point of stiffness discontinuity, which, in this case, would have been at the end of the eye splice.

If the velocity of a load of a rope is increased, a strain is set up locally and propagates in the form of a wave along the length of the rope. The tensile strain wave reaches the fixed end of the rope and is reflected so that the maximum strain in the rope is doubled. Therefore, the dynamic load exceeds the quasi-static load due to reflection at the stiffness discontinuity.

3. Split winch drums

The split drum was designed to prevent wires biting into each when under load, which can happen on an undivided drum. The split drum is divided into a tension drum and a storage drum. When making fast at a berth, the nylon tail and a sufficient length of the wire are slackened from the tension drum and then from the storage drum to reach the shore bollard. After the line is made fast to the shore bollard, the ship's crew heave in the line until there is enough slack to provide sufficient number of turns on the tension drum – usually not more than one layer. At this time the wire is fed through the slot from the storage drum to the tension drum.

4. Winch band brakes

Each split drum has a brake, which has the prime aim of securing the mooring line at the shipboard side. When the load on the mooring line becomes excessive, the brake has an added safety function of rendering and allowing the load on the line to shed before it parts. However, the load at which the brake renders is dependent on its condition and the degree to which it has been tightened.

The winches on board *Alfa Britannia* had band brakes, which consisted of round segments of shoe linings, and relied on the coefficient of friction against a brake drum to hold the force on a line. Relatively little force is needed to hold a high load. The band is tightened or released by means of a hand-wheel **(see Photographs 4 and 5)**, which is easy to apply. The band brake has the disadvantages of sensitivity to changes in friction, dependency of the setting of the hand-wheel and sensitivity to reeling direction. Oil, moisture or heavy rust on the brake linings or brake drum can reduce the brake load capacity.

The brake should be periodically tested to ensure safe mooring. The brake holding load is measured by fixing a hydraulic jack to the drum end plate. The hydraulic pressure within the jack is related to the torque applied by the jack. With the brake applied, hydraulic pressure is gradually increased to a high and known load, which in this case was the manufacturer's load of 59 tonnes. By noting the hydraulic pressure and by calculation, a holding load is found for that brake setting.

The brake should be set to hold 60% of the mooring line's minimum breaking load, but since a brake deteriorates, it is recommended that it should be designed to hold 80% of the line's minimum breaking load. This higher figure allows the brake to adjust down to the 60%.