Report of the Investigation

into the Lifeboat Accident on

# PRIDE OF HAMPSHIRE

on 25 September 1994

Marine Accident Investigation Branch
5/7 Brunswick Place
SOUTHAMPTON
Hants SO15 2AN

London: HMSO

**Extract from**
**The Merchant Shipping**
**(Accident Reporting and Investigation)**
**Regulations 1994**

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the causes 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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## 1. SUMMARY

The ro-ro passenger ferry PRIDE OF HAMPSHIRE was berthed at Cherbourg on the morning of 25 September 1994 when No 2 lifeboat launching equipment failed whilst the crew were undergoing lifeboat drill. The lifeboat fell, pitching six of the 32 occupants into the water. All were accounted for, but 16 persons were taken to hospital. The cause of the accident was due to breakage of the lifeboat suspension link joining the aft lifeboat hook to the suspension chain of the fall block.

The suspension link was made of alloy steel which had not been suitably heat treated for use in a marine environment. As a result the link weakened due to stress corrosion cracking, finally breaking catastrophically.

Examination of the damaged davit structure found that welded joints, crucial to the integrity of the structure, were of inferior quality with incomplete penetration and lack of fusion. These welds rendered the davits unsafe, although they did not contribute to the accident.

The investigation raises issues of quality control procedures for lifeboat davit suspension components and davit structure welds. The problem of quality control is a matter that must be addressed by the shipping industry as a whole and not just by P&O Ferries.

# PART I FACTUAL ACCOUNT

## 2. PARTICULARS OF VESSEL AND CREW

| | | | |
|---|---|---|---|
| 2.1 | Type | : | Ro-Ro passenger ferry |
| | Name | : | PRIDE OF HAMPSHIRE |
| | Port of Registry | : | Portsmouth |
| | Built | : | 1974 |
| | Length | : | 143.66m |
| | Breadth | : | 23.47m |
| | Gross tonnage | : | 14,760 |
| | Manager | : | P&O European Ferries, Portsmouth |
| | Classification | : | Lloyds Register of Shipping |

2.2 There was a total crew of 85, comprising the Master, four deck officers, one technical officer, 11 deck ratings, six engineer officers, five engineer ratings, and four officers with 53 ratings from the Hotel Services Department.

2.3 The vessel operates a regular service between Portsmouth and Cherbourg. The Passenger Certificate in force at the time of the accident was issued by the Department of Transport's Marine Safety Agency (MSA).

2.4 All lifeboats on the vessel are of the open type. There are six hand propelled 79-person lifeboats, two motor propelled 42-person lifeboats, and two motor propelled 120-person lifeboats. The ten lifeboats are numbered 1 to 10 from forward; odd numbers to starboard and even numbers to port. The most forward lifeboats Nos 1 and 2 are the 120-person lifeboats (see Figure 1). These were installed on the vessel in 1986 at Schichau Unterweser, Bremerhaven, when she was lengthened to increase her cargo carrying capacity.

## 2.5 Design of the lifeboat launching equipment for Nos 1 and 2 lifeboats

Two single pivot davit arms turn out each lifeboat from the stowed position to the embarkation position. At the embarkation position the davit arms are in contact with their davit arm stops. Embarkation of the lifeboat takes place once the bowsing tackles are secured and tricing pendants released. Lowering of the lifeboat is controlled by direct hand operation of the winch brake lever.

The two open 120-person lifeboats are fitted with traditional plain lifting hooks which are connected to their respective fall wire lower block by a suspension chain assembly shown in Figure 2. The swivel link is attached to the fall block and the suspension link at the lower end of the assembly is hooked on to the lifeboat hook. The tricing pendant link and bowsing tackle egg link are loosely clamped to the suspension link by way of a monkey face bracket.

The lifeboat and davit specifications have been listed in Annex 1.

## 3. NARRATIVE

**All times are Universal Co-ordinated Time**

3.1 A practice emergency fire and abandon ship exercise took place on board PRIDE OF HAMPSHIRE at 0920 hrs on 25 September 1994 whilst she was starboard side alongside in Cherbourg, and after all passengers had disembarked. For the purposes of the exercise it was assumed that a fire had broken out in the vessel's galley. The crew were sent to their emergency stations and on the Master's instructions the Boat Preparation Party lowered the port side lifeboats to the embarkation decks and rigged the bowsing-in tackles.

3.2 The fire exercise was completed at 0945 hrs, and the crew were mustered at their lifeboat and liferaft stations where they were checked by the Chief and Second Officers. Once this was completed the Master was informed and, by hand-held radio and public address system, he instructed all those mustered on the starboard side, together with those mustered at No 4 liferaft station to board No 2 lifeboat. The Master and Chief Engineer were able to observe the embarkation of No 2 lifeboat from the port bridge wing.

3.3 The coxswain and the Second Officer, who was designated as being in charge of No 2 lifeboat, did not arrive at the boat station until after some crew had already boarded, the majority of whom were sitting at the forward end of the lifeboat. The Second Officer told the crew waiting to board the boat to sit at the aft end. The Master instructed the Second Officer to lower the lifeboat once he was satisfied that all was ready.

3.4 At 0955 hrs, after 32 crew had boarded, the after end of the lifeboat suddenly swung downwards pivoting about its forward hook causing six people to be thrown into the water. The boat's downward momentum, together with its total weight, caused the forward davit arm to be pulled off its deck stop and to land heavily on the deck. The forward fall wire parted and the davit's pivot end broke away from its pin bosses, causing the boat to plummet into the water. The forward davit arm, bowsing tackle, tricing pendant and fall block all fell into the boat, which remained floating upright. Some of the weight of the davit arm was taken by the span wire which remained attached to the undisturbed aft davit.

3.5 The Master immediately informed the Duty Manager ashore by radio and requested as many ambulances as possible to attend the vessel.

3.6 An embarkation ladder was lowered over the port side and two of those in the water managed to climb back on board. Two others managed to hold onto the bottom of the ladder and the other two still in the water were assisted back into No 2 lifeboat. Blankets were thrown down into No 2 lifeboat and distributed among those on board. No 4 lifeboat was launched and manoeuvred alongside it.

3.7 With the exception of one man who was in extreme pain, all injured persons and those in a state of shock were transferred to No 4 lifeboat. The two persons holding onto the bottom of the embarkation ladder were also taken on board before the lifeboat went alongside the quay to disembark the casualties.

3.8 A field hospital was set up on the quay and using an inflatable boat emergency service personnel proceeded alongside No 2 lifeboat. The remaining injured person was successfully transferred by means of an inflatable stretcher. Finally the crew still left in No 2 lifeboat were transferred to No 4 lifeboat and were landed ashore.

3.9 All crew, with the exception of No 4 lifeboat crew and those persons who had been landed ashore, were instructed to muster on board. As a precaution, two divers commenced an underwater search in the vicinity of No 2 lifeboat.

3.10 All crew were accounted for at 1112 hrs and the underwater search was terminated. Sixteen crew members were taken to hospital.

# PART II CONSIDERATION OF POSSIBLE FACTORS

## 4. EXTENT OF DAMAGE TO No 2 LIFEBOAT LAUNCHING INSTALLATION

### 4.1 Introduction

The day after the accident the Inspectors examined the damage to the installation. PRIDE OF HAMPSHIRE had not moved from the berth in Cherbourg where the accident occurred. It was not possible to confirm the details of marks stamped on the suspension link fitted to this davit installation. However the geometry of the suspension links on No 1 installation matched that which was specified on the drawings.

The two fall wires of both davits on No 2 installation were turned correctly around the winch barrels but were hanging slack on the sheaves of the installation.

### 4.2 Aft Davit

The aft davit arm was undamaged and positioned in the outreach position. The aft fall block hung from the fall wire with its suspension chain still attached. Part of the suspension link and monkey face bracket was found hanging by its tricing pendant which was suspended from its davit lug. That part of the broken link without the monkey face bracket attached could not be found. It was probably lost in the dock.

The suspension link was fractured almost through its major axis along the apparent lifting line of the hook. Of the two fracture sections the whole of the surface of the lower section (hook end) was discoloured a rusty brown, while the surface of the top section (chain end) had a similar rusty brown colour surrounding what appeared to be a smaller, less rusty, coloured area. On this same section there was a crescent shaped darker colour at the intrados (inner curved surface) of the link. Both fracture surfaces appeared to be flat, of rough texture, with chisel shaped shear lips at the outer edges of each surface.

The fracture surfaces were examined about 24 hours after the accident, which was sufficient time for the them to oxidise. However, a ship's officer confirmed that when he examined the broken link soon after the accident there appeared to have been a pre-existing crack on the hook end section covering about 10% of the fracture surface. The rest of the surface indicated a newly exposed shiny steel surface.

## 4.3 Forward Davit

At the forward end of the installation, the fall wire was broken in way of the fall block which was found in the lifeboat. The deck edge guard rails were buckled and there was an indentation in the deck just aft of the davit arm deck stop.

The standing structure of the installation was intact except that welding on the part supporting the davit arm pivot bearings was cracked. The davit arm was detached from its two pivot bosses. The pivots remained on the davit arm pivot pins which were still located in their bearings fixed to the standing structure. The davit arm had pulled away from the welded joint connecting it to the pivot bosses.

The davit arm lay in the lifeboat in an approximately fore and aft direction with its head end pointing aft and suspended by the span wire attaching it to the aft davit arm. The pivot end of the davit arm lay at the bottom of the lifeboat which partly supported its weight.

The complete suspension chain and link assembly was found in the lifeboat still attached to the fall block.

The tricing pendant lug was undamaged with the tricing pendant attached to it. The rope lashing at the lifeboat end of the tricing pendant was broken in two places. The bowsing tackle was detached from the bowsing link of the monkey face bracket and its rope lashing was broken in three places. The bowsing tackle was still attached to the davit arm but its rope was jammed in the block attached to the davit.

The two welded pivot bosses were missing.

## 4.4 Lifeboat

No 2 lifeboat was floating in the water directly below its embarkation deck, facing forward. Its GRP hull appeared undamaged and was reasonably dry inside. Slight impact damage was found on the GRP buoyancy tanks. The forward lifeboat hook was pushed forward against the lifeboat stem with a lifting plate securing bolt sheared in line with the forward movement of the hook. The aft hook was undamaged and secured in position. Wooden thwarts of the lifeboat were fractured and canopy frames buckled.

## 5. DISCUSSION ON THE DAMAGE

### 5.1 Sequence of failure

When the accident occurred No 2 davit arms were in the full outreach position and the lifeboat with 32 people on board was bowsed into the vessel's side with the tricing pendants still attached. From witness evidence and the observed pattern of damage, described in the previous section, the following was deduced.

The initial cause of the collapse of No 2 lifeboat davit installation was the breakage of the aft suspension link, which in turn caused the aft end of the lifeboat to drop pulling the still attached forward fall block and davit with it. The forward davit, bowsing tackle, tricing pendant and fall block sheave were projected into the lifeboat. The davit arm came to rest suspended by the span wire which remained connected to the undisturbed aft davit.

### 5.2 Failure of the Suspension Link

At the time of the accident the load on the aft suspension link was below its maximum safe working load.

The pattern of discolouration of the fracture surfaces of the suspension link indicated that the chain end of the link may have been cracked across the whole section some time before the accident. At the hook end section, pre-existing surface cracks were probably present.

The geometry of the remaining part of the link matched that specified in a supplier's drawing and manufacturer's specification of a similarly sized link. This evidence, together with the observation of the chisel shaped shear lips on both flat fracture surfaces, indicated that the link probably failed in a brittle manner.

### 5.3 Failure of the Standing Structure

The welded joint connecting the lower end of the forward davit arm to the pivot pin boss appeared defective. Discolouration of the cracked surface indicated that the weld was cracked before the accident. Sections of the weld run showed lack of penetration (see Figures 3 and 4).

## 6. METALLURGICAL EXAMINATION OF THE SUSPENSION LINKS AND WELD JOINTS ON DAVIT STRUCTURE

### 6.1 Suspension Links

A metallurgical examination of the fractured suspension link and weldments of No 2 lifeboat davit structure was considered necessary to ascertain cause of failure.

Unfortunately, the suspension link which was suspected to have been the original cause of the structural collapse was not made available to the Inspectors for such an examination. One part of the link was lost in the harbour where the incident occurred, and the other section was taken into custody by the French Authorities. For legal reasons they were unable to release the link section to other interested parties, including MAIB.

In view of this, two similar suspension links were taken from No 1 lifeboat davit for examination. For the purpose of identification, the two sets of suspension links and chain components were marked "A" and "B". An expert consultant metallurgist was commissioned to undertake the detailed examination, and a summary of the results is as follows:

The suspension links appeared to be marked as follows:

SWL 13.3
FRAM T8
28.B.6

The first mark shows the safe working load (SWL) of 13.3 tonnes (the last digit was difficult to decipher and could be read as .8 instead of .3). The second mark is related to the manufacturer's trade name (FRAM) and the material (T8), that is, Alloy Chain Grade 80, which was used for the manufacture of the suspension links. The third mark is a manufacturer's identification mark.

The links were of a welded, forged and swaged manufacture. The welded joint was on that part of the link where the diameter was enlarged (see Figure 5). The visual examination of the link on chain "B" revealed that the monkey face bracket had been seized on the enlarged diameter part of the link for some time.

It was observed that the protective coating on both suspension links had suffered some mechanical damage at the surface of the intrados due to interlink hammering and rubbing.

6.2 Magnetic particle inspection of the suspension links confirmed the existence of cracks situated at the intrados at each end of both suspension links where contact was made with the D shackle and the lifeboat hook. An example of these cracks is indicated by the arrows in Figure 5. There was no evidence of cracking on the other surface regions.

Metallic particle inspection of the other components of the suspension chain assembly showed no evidence of cracking.

Figure 6 shows a section of the mating fracture surfaces of one of the suspension links. The fracture surfaces of the pre-existing cracks, indicated by the blackened area at arrow A, show that fractures had occurred without any noticeable deformation accompanying the failures.

An analysis of the corrosion product, in way of the blackened area, indicated corrosion of the steel caused by a marine environment.

6.3 An analysis of the results of the material tests of the suspension link "A" and suspension chain components was undertaken. These were:

**Chemical Analysis**

A sample taken from the lifeboat hook suspension link was spectrographically analysed. The results indicate that the material of the link was a low ("lean") alloy steel containing boron. The addition of a minute amount of boron causes a marked increase in the hardenability of low alloy steels.

**Hardness Test**

Vickers hardness tests on the suspension link gave the following results:

| | Vickers Hardness (VPN/10 kgf) |
|---|---|
| Typical Structure: | 564 |
| Weld Metal: | 490 |
| Heat Affected Zone: | 470 - 600 |

These values were much higher than those for other davit suspension chain components which were within the range of 145 to 260.

**Charpy Impact Test**

Three Charpy impact test pieces were machined from the suspension link and tested at 0 °C.

The average value obtained was 47.7 joules.

**Tensile Test**

Tensile tests of samples machined from the suspension link gave the following results:

Ultimate tensile strength: 1393 MPa

Yield strength: 1332 MPa

Elongation %: 18%

## 6.4 Metallographic Examination

Selected sections were cut from suspension link "A", covering the region of cracking and the weld, and prepared for examination under a microscope. Examination of unetched sections showed that cracks of a branching nature had initiated at the surface of the intrados. The characteristics of these cracks were typical of stress corrosion in this type of material. There was evidence of associated surface corrosion pits which is another relevant feature of this type of failure.

Etched sections (Figure 7) showed that the regions of cracking were found to be martensite (a hard, strong, brittle needle-like structure produced by rapid quenching of the link). The presence of martensite and the absence of any prior deformation in the vicinity confirmed the brittle nature of the fracture surface. Figure 7 also indicates corrosion products on the surface of the link and within the cracks.

The microstructure of the material in the region of the welded joint indicated that the link had been cooled from the finishing temperatures after welding.

## 6.5 Check on Heat Treatment

If suitable heat treatment had been carried out during manufacture of the suspension links, the strength of the material would have been significantly lower than that indicated by the hardness tests on the link and of a value similar to the hardness measured on other components of the suspension chain.

In order to demonstrate this, heat treatment tests were carried out on two sections cut from the link.

Vickers hardness tests using a diamond indentor and 10 kilograms load were then carried out on the two sections with the following results:

| | Vickers Hardness (VPN/10 kgf) |
|---|---|
| Specimen No 1 - Quenched from 870 °C followed by tempering at 550 °C | 237-240 |
| Specimen No 2 - Tempered only, at 550 °C | 222-228 |

The hardness of the original typical structure of the suspension link, before any heat treatment, was approximately 564 (see Section 6.3). Therefore the results of the hardness tests after heat treatment show a fall of approximately 330 points, giving a hardness level more consistent with other components of the davit suspension chain.

## 6.6 The Pivot Bosses

Visual examination of the pivot pin boss welds indicated that they were of inferior quality, lacking in penetration and root fusion over part of their length. The appearance of the fracture surfaces suggested that the weld on both pivot pin bosses had failed by ductile tearing due to overloading.

Macro and micro examination of the pivot pin boss welds were undertaken which identified weld root cracking and slag inclusion. Figure 8 shows a typical sample of the faults found.

Micro examination showed a structure of a plain carbon structural steel in the normalised condition. Examination of the same fracture surfaces confirmed that they were of a ductile nature, there being clear evidence of prior plastic deformation in the vicinity. In other sections, the absence of plastic deformation between two regions of plastically deformed material was considered to be due fundamentally to lack of fusion. Thus, at the time of failure, deformation would not have occurred because the load could not be sustained in the region of the weld defect.

## 7. DISCUSSION ON THE METALLURGICAL EXAMINATION OF THE SUSPENSION LINKS AND PIVOT PIN BOSS WELD JOINTS

### 7.1 Suspension Links

Metallurgical examination of the suspension link clearly showed that cracking was due to stress corrosion in a chloride (marine) environment. This cracking occurred at the intrados at each end of the link.

The cracking occurred at these locations because of the combined effects of three factors:

- Firstly, the stress was of sufficiently high value at the surface of the intrados of the link.

- Secondly, chloride could concentrate in the area between the surface of the intrados of the link and the adjacent surfaces of the lifeboat hook and D shackle.

- Thirdly, under service conditions the surface of the intrados of the link was subjected to abrasion, with resultant mechanical damage to the protective coating.

The stresses necessary to cause cracking were most likely of the residual type, induced during the manufacture of the suspension links to give a high yield and high tensile strength of 1332 MPa and 1393 MPa respectively (see Section 6.3).

A review, in Smithells Metals Reference Book (Seventh Edition) on the stress corrosion behaviour of mild and high strength steels, shows that high strength steels with a yield strength greater than 1000 MPa (1000 $N/mm^2$) are generally susceptible to stress corrosion cracking in environments containing chlorides. The susceptibility to stress corrosion cracking increases with increasing strength.

7.2 According to the mark on the suspension link the material used was Alloy Chain Grade 80 (T8). BS:4942 Part 5 1981 (ISO 3036 1984) "Specification for Grade T(8) Non-calibrated Chain" states that the components should be suitably heat treated after manufacture, by hardening and then tempering at a temperature not less than 400 °C.

The high strength of the material used for the suspension links resulted from a failure to heat treat the link after the forming and welding operations had been carried out. Correct heat treatment in accordance with the above Standard, would have significantly reduced both the yield and tensile strength of the link.

After heat treatment on samples cut from the link, in accordance with the provisions of these Standards, hardness tests showed a fall of more than 300 points in the value of the Vickers Hardness Number. An upper value of 240 VPN was achieved, equivalent to a tensile strength of the order of 800 MPa.

These findings show that the material of the links examined were of such strength as to render them unfit for the service intended. If the links had been heat treated to give a lower tensile strength, there is little doubt that the stress corrosion cracking would not have occurred since the material would have offered satisfactory resistance to the marine environment.

7.3 Fitness for purpose of the suspension links depends upon the link material being in a satisfactory condition which should be beyond question and assured by quality control procedures. The Norwegian manufacturer of the link advises that the link examined from No 1 lifeboat marked "26.B.6" was produced before 1987. These links were made in accordance with Norwegian requirements for lifting equipment and were quenched in water from 900 °C and tempered to 200 °C. The manufacturer advises that in this condition the links are unsuitable for use in a marine environment. When the links are to be used in a marine environment they should be similarly hardened but tempered to 450 °C. This higher tempering temperature would be reflected in the lower safe working load shown on the Test Certificate. This view confirms that of the metallurgist whose examination of the PRIDE OF HAMPSHIRE links indicated that heat treatment was unsuitable and consequently unfit for the service intended.

7.4 Finally, the seizure of the monkey face bracket on the suspension link did not contribute to the failure of the link. However, it is not good practice, from a safety point of view, to permit such a seizure to occur.

7.5 **Davit Pivot Boss Weld Joints**

Examination of the fillet welded joints connecting the lower end of the forward davit arm to the pivot pin bosses showed that failure had been brought about by rapid overload. The rapid overload forward resulted as a consequence of the failure of the aft suspension link and rapid release of the load aft.

Although these fillet welded joints had suffered damage subsequent to failure of the suspension link, it was apparent that the quality of the welded joints was substandard because of incomplete penetration and lack of fusion.

The integrity and safety of davits in service depends on the quality of the welded joints. The poor quality of the welds examined highlights the importance of effective inspection and quality control procedures which, in this case, did not exist.

According to Watercraft Ltd, inspection and non-destructive testing procedures (magnetic particle inspection) were applicable when No 2 davit structure was manufactured. These procedures included a random examination of 10% of all load bearing welds (including areas found to be suspect when visually inspected), a high proportion of different types of welds, and stop/start positions of the welding operations.

This investigation indicates that random testing of structural welds is ineffective in exposing critical defects. Important applications, such as the fillet welded joints connecting the davit arm to the pivot pin bosses, should be specifically tested by non-destructive methods (magnetic particle inspection) for the presence of defects.

## 8. MARINE SAFETY AGENCY REQUIREMENTS FOR LIFEBOAT LAUNCHING EQUIPMENT BLOCKS AND ATTACHMENTS

8.1 The MSA requirements for blocks and attachments used for the hoisting and lowering of lifeboats are specified in the Merchant Shipping Regulations and in the Agency's "Survey of Life-Saving Appliances - Volume 1 - Instructions for the guidance of surveyors". The Merchant Shipping (Life-saving Appliances) Regulations 1980 applied to Nos 1 and 2 lifeboat launching installations fitted to PRIDE OF HAMPSHIRE in 1987.

Section 18.10 Blocks and Chains, 1994 edition of the Instructions for the guidance of surveyors, states:

> *"... Where the design so dictates, a chain suitably shackled may be interposed between the lower fall block and the ring or lower link plate.*
>
> *The links, chains shackles etc should be of steel and manufactured in accordance with the appropriate British Standard or other accepted specification, but such equipment manufactured to other equivalent national codes can be accepted at the Surveyor's discretion. All links, chains, shackles etc should be proof tested to 2.2 times their respective working load and the results recorded on Form 86 prescribed by the Health and Safety Executive for the purpose of the Docks Regulations. (Other equivalent national forms may be used for this purpose). These forms should be included with the records on completion of the ship. All hooks, link plates, links, chains, shackles and swivels should work freely and bed fairly together without wedging action...*
>
> *... The safe working load of chains should ensure a factor of safety of not less than 6 based on the minimum breaking load for the chain.*
>
> *The surveyor should ensure that the chain can be identified and that its quality is indicated on the chain and recorded in the davit manufacturer's instruction book on the ship. If alloy chain is used the instruction book should also make it clear that the chains should not be periodically heat treated."*

8.2 The appropriate British Standards with regard to Alloy Steel link components (referred to in Section 7.2), BS:4942 Part 5, states that the manufacturer shall, if required, supply a Certificate of Test and Examination containing information detailed in ISO 1834 with every chain supplied. An example of such a Certificate is given at Annex 2.

Although recorded proof tests of suspension chain (sling) and link assemblies is sometimes recorded by MSA and shipping companies, it is unusual to identify and record the heat treatment processes undertaken on the equipment. For example, in the case of alloy steel assemblies, Certificates of Tests indicating heat treatment in accordance with British Standards is neither supplied voluntarily by the manufacturer or supplier of the suspension equipment, nor demanded by the MSA or the shipping company.

8.3 The Certificate of Test and Examination indicating proof test and heat treatment was not supplied for the suspension chain assemblies used on PRIDE OF HAMPSHIRE. It appears therefore that the interpretation of MSA instructions is inconsistent and that requirements on assurance of correct heat treatment of links and chains are ignored. MSA instructions should clearly state the relevant British and ISO Standards and should be amended so that the requirements to document the identity and quality of the equipment are clearly stated.

8.4 When a lifeboat launching system is installed on board, it may be assembled using components from several different sources. A check-list of davit lifeboat launching installation equipment, which is required to have mandatory Certification of Tests in accordance with British Standards or other similar standards, would be a useful aid to the MSA, P&O Ferries and other companies. It would ensure that the equipment is properly identified and that it is of the correct quality which includes heat treatment as required. A dossier should be supplied on board ship of supporting certification, approved details and drawings of components, sub-assemblies and completed installation. This dossier should be updated as the installation is tested and the components and sub-assemblies are tested or replaced.

8.5 Lifeboat launching equipment on UK registered vessels is required to be surveyed annually by the MSA. Specifically, lifeboat davits, lowering gear including blocks and falls, fairleads, tricing gear, the bowsing-in tackles and boat lowering winches should all be inspected. The survey should consist of a visual examination (of sufficient extent) and tests, considered necessary by the surveyor in order to confirm that the equipment is in a state of operational readiness and that its condition is being properly maintained. As many lifeboats as possible should be lowered into the water to check their watertightness. The thoroughness or stringency of a survey should depend upon the condition of the equipment. In the case of a limited number of specialised designs of davits which require some structural dismantling to enable a proper examination of all parts of the davit structure, it should be arranged that such thorough examination be made at intervals not normally exceeding five years.

8.6 The Merchant Shipping (Life-saving Appliances Regulations 1980) (Amendment) Regulations 1986 and The Merchant Shipping (Life-saving Appliances) Regulations 1986 require the maintenance of lifeboat launching equipment to be undertaken in accordance with instructions for on board maintenance or with a shipboard planned maintenance programme. In this regard, lifeboat launching equipment is required to be visually inspected on a weekly basis in order to ensure that it is ready for use. On board maintenance instructions are required to include the following:

- a checklist for use when carrying out life-saving equipment inspections;
- maintenance and repair instructions;
- schedule of periodic maintenance;
- diagram of lubrication points with the recommended lubricants;
- list of replaceable parts;
- list of sources of spare parts; and
- log for records of inspections and maintenance.

8.7 On and after 1 July 1998 launching appliances will be subject to a thorough examination and 1.1 SWL operational tests will take place at least every five years.

8.8 The above requirements make no attempt to specify exactly what form the visual inspection and thorough examination should take. Instead, they place the responsibility for determining the thoroughness of any examination on the MSA surveyor and the Owner's and Master's representative. This approach relies totally upon the competence of the representative or surveyor in his ability to satisfactorily detect defects or weaknesses within the launching equipment. In order to reduce the risk of an accident during load testing of a lifeboat launching installation, it must first be established, to a reasonable extent, that its components, such as lifeboat suspension chains and links, are in good condition.

8.9 The Merchant Shipping (Hatches and Lifting Plant) Regulations 1988 provide stringent requirements for testing, examination and recording of lifting plant. The definition of lifting plant excludes life-saving appliances. The Regulations require that the employer and Master ensure that no lifting plant is used unless it has been suitably examined and tested by a competent person within certain mandatory periods. A competent person is defined in the Regulations as a person over the age of 18 years possessing knowledge and experience required for the performance of thorough examinations and tests of ship's lifting plant. Unlike the Lifting Plant Regulations, the Merchant Shipping Life-saving Appliances Regulations do not define a competent person.

The competence necessary to be able to locate the faults is expected of MSA Surveyors. However, ship's staff do not necessarily have this competence, yet are still expected to examine and report defects found. Now that load testing of these installations is to become mandatory, it will be even more important to ensure that the competence required by ship's staff to inspect these installations is recognised and defined. It is the responsibility of the ship owner to ensure that the person assigned is competent to the standard deemed necessary.

## 9. FURTHER OBSERVATIONS

### 9.1 General

The investigation into this accident highlighted a number of other areas of concern related to the operation of the lifeboat launching equipment. Although they were not contributory factors in the failure of the suspension link they deserve to be referred to in this report.

### 9.2 Bowsing and Tricing Arrangement

Bowsing and tricing arrangements for No 2 lifeboat davits were illustrated in the Rigging Tackle Specification drawing, the Manufacturer's instructions, and the Training Manual, all of which were available on PRIDE OF HAMPSHIRE. However, all the illustrations in these documents differed with respect to equipment detail, and none of them wholly represented the arrangement as fitted.

Each suspension link was fitted with a monkey face bracket, which provided a means by which the tricing pendant and the bowsing tackle could be independently connected to the suspension link. It was intended that the tricing pendant should be connected to the upper part, and the bowsing tackle to the lower part of the monkey face bracket. For this purpose, a long link was fitted to the upper part of the monkey face bracket through which the slip hook of the tricing pendant could be passed. A shackle was fitted to the lower part of the monkey face bracket on the egg link on which the bowsing tackle block would be hooked (see Figure 2).

In practice, on PRIDE OF HAMPSHIRE, the tricing pendant was attached to the long link, as intended. However, the bowsing tackle was also hooked on to the long link because the size of the shackle fitted on the egg link did not allow an easy means of connection. In this regard the lower part of each of the suspension link monkey face brackets associated with No 1 lifeboat davits were subsequently found not to be fitted with any means with which to connect the bowsing tackle to the suspension link.

During the period between launching and recovery of No 1 lifeboat, the suspension link and the monkey face bracket became inverted so that the positions of the long link and the egg link were reversed, that is the long link was below the egg link (Figure 9). The effect of connecting both the tricing pendant and the bowsing tackle to the long link and the effect of inverting the suspension link resulted in the suspension link being intermittently loaded in a manner contrary to that intended by the original design. Despite this, it was considered that this loading did not affect the cracks found in the suspension links of No 1 lifeboat launching installation.

## 9.3 Procedures for Launching the Lifeboat

The Training Manual requires the launching of a lifeboat to be undertaken in two phases. Phase 1 covers the preparation of the lifeboat and its lowering to the embarkation level. Phase 2 covers the embarkation of crew and passengers followed by lowering and launching.

It was normal practice for Phase 1 to be undertaken by the Boat Preparation Party. During the emergency fire drill on 25 September 1994, the Boat Preparation Party lowered all the lifeboats on the port side to embarkation level. The required preparation routine, set out in the Training Manual, included rigging of the bowsing tackle then letting go of the tricing pendants when the lifeboat is at embarkation level. However, in the course of training/equipment use, P&O state that lifeboats are frequently lowered to embarkation deck without the crews boarding, therefore although the bowsing tackles are attached it is normal practice to leave the tricing pendants attached until such time as it is clarified which boats are to be used in the exercise. Once it has been determined which lifeboats are to be boarded and lowered into the water the tricing pendants are released prior to the crew embarkation.

On the day of the accident, embarkation of No 2 lifeboat started before the coxswain or the second officer had arrived, and consequently the need to release the tricing pendants was overlooked.

The procedure for embarking the lifeboats with both the tricing pendants and bowsing tackles rigged could possibly overload the lifeboat launching installation with catastrophic consequences.

## 10. QUALITY ASSURANCE

This investigation has shown that the interpretation of the MSA "Survey of Life-Saving Appliances - Volume 1 -Instructions for the guidance of surveyors" was inconsistent. Also that the instructions were not followed in the necessary detail as neither the suspension links and chains were identified nor the quality of the equipment recorded.

From 1 July 1996 the International Safety Management (ISM) Code is applicable for all sea-going passenger ro-ro ferries operating on a regular service to or from ports in the European Union. The Code requires shipowners, managers and operators to put in place a Safety Management System (SMS) by the establishment and documentation of procedures for key operations concerning the safety of ships and prevention of pollution. P&O Ferries have implemented the Code.

In order to enhance their effectiveness, as the body with responsibility for survey and certification, MSA is developing a quality management system. A key part of that development is to achieve ISO 9000 Certification by the latter part of 1996.

Both the ISM Code and ISO 9000 provide for management procedures to ensure that mandatory equipment and its installation, such as life-saving systems, are up to the standard required. With the combined implementation of the ISM Code and certification to ISO 9000 the shortcomings in procedures which have been identified by this investigation should be rectified.

## 11. SUBSEQUENT ACTION

### 11.1 Interim Recommendations

During the course of the Investigation two interim recommendations were made, both were addressed to the Marine Safety Agency and also to P&O Ferries.

1. Lifeboat hook suspension links of a similar specification to those installed on No 2 lifeboat launching equipment on PRIDE OF HAMPSHIRE should be withdrawn from service until it is assured that the links have been satisfactorily examined for cracks and proof tested to at least 1.1 times the total weight of the lifeboats including equipment and full complement of people.

2. Lifeboat launching equipment of similar design and specification to No 2 lifeboat davits on PRIDE OF HAMPSHIRE should be withdrawn from service until the integrity of the weld in way of the davit arm pivot boss has been assured and the strength of the davit arm has been satisfactorily tested in accordance with the requirements of the relevant Merchant Shipping regulations.

The interim recommendations were fully accepted by the MSA and P&O Ferries and the findings of the metallurgical investigation fully support MAIB's interim recommendations.

### 11.2 Action Taken on Interim Recommendations

Three other P&O Ferries have retro-fitted lifeboat launching installations similar to Nos 1 and 2 on PRIDE OF HAMPSHIRE. These are PRIDE OF CHERBOURG (Portsmouth/Cherbourg route), PRIDE OF RATHLIN and PRIDE OF AILSA (both on Larne/Cairnryan route).

On PRIDE OF RATHLIN and PRIDE OF AILSA instead of the chain span in the suspension assembly, a wire strop was used. The other components such as the swivel link, suspension link and "D" shackle were similar to those on PRIDE OF HAMPSHIRE.

In response to the interim recommendations, these installations were excluded from the approved muster list and the number of passengers that the vessels were allowed to carry was adjusted accordingly.

MSA surveyors and P&0 management examined the installations affected and their findings and actions on each of the three vessels are summarised below:

## PRIDE OF RATHLIN

### Suspension Links

The links were examined by magnetic particle test and found to have no surface cracks. However, further X-ray tests showed that three out of four had internal faults. All links were condemned.

### Davit arms

The davit arms were examined by magnetic particle test. A number of cracks were found in the davit arm to pivot attachment. These were the cause of the greatest concern as the access was limited and a full examination could not be made. As a rough guidance, approximately 50% of the weld could be accessed and of that, about 50% exhibited some form of crack or weld fault. In view of this, it was recommended that the davit arms were removed for further tests and to effect controlled repairs.

Further cracks were found in the standing structure of the davits in way of insert plates which support the pivot pin bearing assemblies. In addition there were un-recorded welds within these plates. A number of these welds showed faults.

## PRIDE OF AILSA

### Suspension Links

The links were examined by X-ray and one out of four were found to have internal faults. The remainder of the suspension strop assembly was tested by magnetic particle test and numerous deficiencies were found in all its components. All the suspension strops examined were condemned.

### Davit arms

The davit arms were examined by magnetic particle test and a number of cracks were found.

## PRIDE OF CHERBOURG

Similar faults to those on PRIDE OF HAMPSHIRE lifeboat davit installation were found. These were mainly lack of weld penetrations in way of the davit arm pivot boss assembly.

All eight sets of davits belonging to the four vessels were removed and taken ashore. In some cases the base and pivot bosses of the davit arms and the standing structure frame supporting the pivot pin bearing assembly were renewed. In other cases cracks were "vee'd out" and welded. Following the repairs and static load tests, the davits were replaced on board the vessels and dynamically load tested. All the suspension chains and links were replaced by modified versions.

# PART III CONCLUSIONS

## 12. FINDINGS

12.1 The collapse of No 2 lifeboat davit installation and subsequent injuries to crew members was due to the failure of the aft lifeboat hook suspension link.

12.2 Failure of the link was caused by pre-existing cracks at its intrados (inner curved surface) and the effect of stress corrosion in these cracks.

12.3 The cracking initiated in the area between the contact surface of the intrados (inner curved surface) of the lifeboat hook suspension link and the adjacent surfaces of the lifeboat hook and suspension chain D shackle.

12.4 The primary cause of cracking was due to the high tensile strength of the suspension link material which, in this state, is susceptible to stress corrosion in the marine environment.

12.5 The high tensile strength of the material used for the lifeboat hook suspension link resulted because the link was not heat treated in accordance with the requirements of British Standards specifications.

12.6 Had the lifeboat hook suspension links been heat treated under suitable conditions to give a lower tensile strength, it is considered that stress corrosion cracking would not have occurred.

12.7 Neither the MSA, P&O Ferries nor the supplier have any record to show that a Certificate of Test had been issued for the suspension chain and the associated link which fractured catastrophically on PRIDE OF HAMPSHIRE. Similarly, there are no records of Test Certificates for the other suspension chain components on this vessel and on other vessels in P&O Ferries.

12.8 The finding that davit suspension chain components are not correctly certificated is not confined to P&O Ferries alone, but is a universal problem throughout the shipping industry.

12.9 Failure of the fillet welded joints connecting the lower end of the forward davit arm to the pivot pin bosses of No 2 lifeboat launching installation was brought about by rapid overload. However, this was a consequence of the failure of the suspension link, and not a cause of the accident.

12.10 The fillet welded joints connecting the lower end of the forward davit arm to the pivot pin bosses were of inferior quality because of incomplete penetration and lack of fusion.

12.11 The visual inspection and non-destructive testing (magnetic particle inspection) procedures for davit load bearing welds had not been effective in detecting the inferior quality fillet welded joints connecting the lower end of the forward davit arm to the pivot pin bosses on PRIDE OF HAMPSHIRE.

12.12 The quality assurance procedures carried out by the manufacturers of the lifeboat davit structures on other vessels did not detect faults in welded joints that were critical in maintaining the integrity of the structure.

12.13 Lifeboat davit suspension chains and links, and davit installations of the same type installed on other vessels in the P&O Ferries fleet, were found to have similar structural defects to those on PRIDE OF HAMPSHIRE. All the defects rendered the installations unsafe, posing a serious threat to their structural integrity.

12.14 Despite the advice given in the Marine Safety Agency "Survey of Life-Saving Appliances - Volume 1 - Instructions for the guidance of surveyors" regarding the requirements for the survey and approval of lifeboat davit lifting chains, the components, which included suspension links on PRIDE OF HAMPSHIRE and other vessels, were not correctly identified and certificated.

12.15 The effect of connecting both the tricing pendant and the bowsing tackle to the long link and of inverting the suspension link resulted in the suspension link being intermittently loaded in a manner contrary to that intended by the original design. However, this loading did not affect the cracks found in the suspension links of No 1 lifeboat launching installation, nor was this loading a causative factor of the accident.

## 13. RECOMMENDATIONS

In addition to the interim recommendations (Section 11.1), final recommendations have been made as a result of the completed investigation into the accident. These are:

**To the Marine Safety Agency and to P&O Ferries**

1. To prevent the possibility of further serious problems resulting from the omission of heat treatment, normally undertaken during manufacture of alloy steel lifeboat hook suspension links and sling assemblies, hardness tests should be carried out on new components to confirm that the material has been suitably heat treated. The results of these tests should be recorded, together with particulars of the heat treatment, preferably in the form of a Certificate of Test. The Certificate should also include particulars of the material and the safe working load (SWL). The records should be available on board the vessel for inspection.

2. Those alloy steel lifeboat suspension links and chains already in use which do not have the required quality assurance records, should be hardness tested. The equipment should be replaced if found to be unsuitable.

3. Officers and crew should be informed that there is a possibility of overloading the lifeboat davit structure if the lifeboat is embarked with tricing pendants attached. Embarkation should only take place when the lifeboat is bowsed in by the bowsing tackles and after the tricing pendants have been detached.

**To the Marine Safety Agency**

4. Surveyors should ensure that suspension chain components satisfy the relevant British Standard or equivalent. The MSA "Survey of Life-Saving Appliances - Volume 1 - Instructions for the guidance of surveyors", should therefore be revised so that the standard requirements for the certification of alloy steel suspension chains and links are clearly stated.

5. With the objective of providing an effective inspection and non-destructive testing procedure to eliminate faults in critical weld joints in lifeboat davit installations, the present quality control procedures for detecting these faults should be reviewed.

6. Alloy links and chain should be examined regularly by a person with a defined competence. A Certificate of Examination should be signed by that person.

7. When the lifeboat launching system is installed on board, the system may be assembled using components supplied from several different sources. A dossier should be placed on the vessel containing drawings of components, sub-assemblies and completed installation, together with approved details and supporting certification. This dossier should be up-dated when the complete installation is tested and also when the components and sub-assemblies are tested or replaced.

ANNEX 1

## SPECIFICATIONS

Details of No 2 lifeboat and davits on PRIDE OF HAMPSHIRE:

**Lifeboat**

| | | |
|---|---|---|
| Manufacturer | : | Watercraft Ltd, Gosport |
| Certified | : | 17 March 1986 |
| Builders No | : | 8612366 GS |
| Builders Type | : | W 120 M 4 knots |
| Hull | : | GRP spray deposited monocoque |
| Weight of boat (fully laden) | : | 14,889 kg |
| (fixed equipment) | : | 4,966 kg |
| Serial number of lifting hooks | : | Fwd WH 176<br>Aft WH 174 |
| Lifting hook test load | : | 22.4 tonnes |

**Davits**

| | | |
|---|---|---|
| Manufacturer | : | Watercraft Ltd<br>Gosport |
| Work Test Certificate | : | P W 566 |
| Work Order No | : | 5985 |
| Type | : | WP/10.97 |
| Specification | : | GA/AO - 05306 |
| SWL | : | 15,000 kg |
| Aft Davit Arm | : | SWL 7,500 kg |
| | : | Static test 17,050 kg |
| Fwd Davit Arm | : | SWL 7,500 kg |
| | : | Static test 17,050 kg |
| Lower block | : | Static test 19,375 kg |
| Certified | : | 17/3/86 |

# EXAMPLE OF CERTIFICATE OF TEST AND EXAMINATION

We hereby warrant that all the chain supplied as described hereunder conforms in all respects to ISO 1834.

Quantity : .....

Description : .....

.....

Samples truly representing all the chain of which this consignment forms part were selected and tested in accordance with the specified requirements.

The actual results are tabulated below:

| Identification | Nominal size of chain<br>mm | Proof force<br>kN | Breaking force of sample<br>kN | Total ultimate elongation<br>% |
|---|---|---|---|---|
| | | | | |

The chain was subjected in manufacture to the following heat treatment:

.....

.....

Manufacturer .....

Signatures and/or stamps Date

Manufacturer's Inspector .....

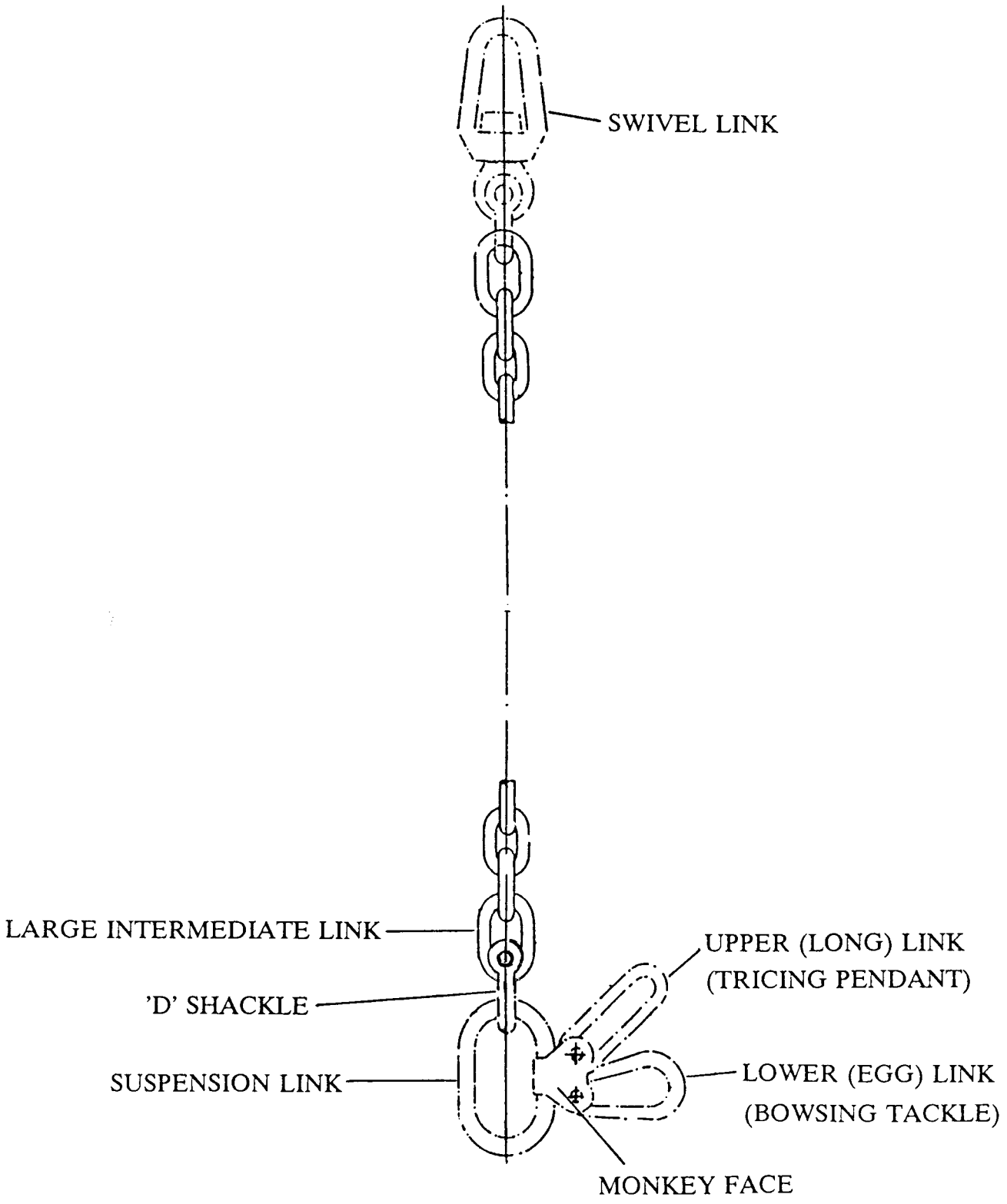
and/or purchaser's Inspector .....

ANNEX 2

FIGURE 1

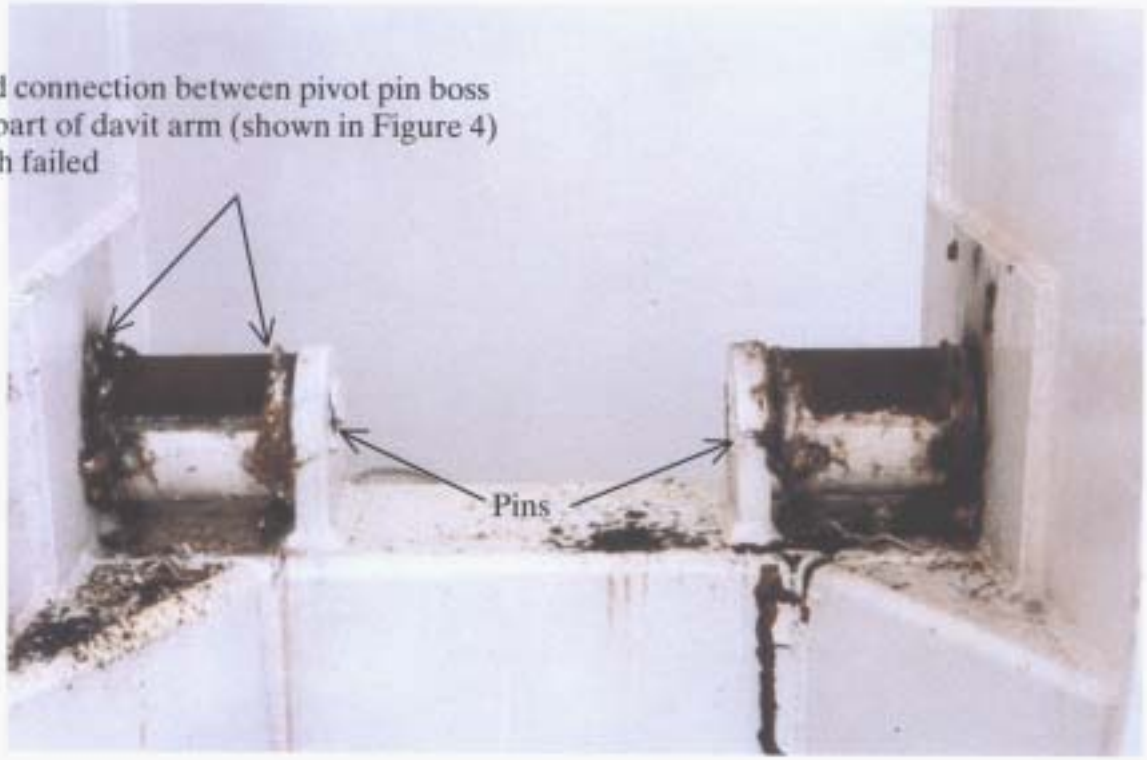

The PRIDE OF HAMPSHIRE showing No 1 lifeboat
in the stowed position forward of the bridge

FIGURE 2




LIFEBOAT DAVIT SUSPENSION CHAIN ASSEMBLY

FIGURE 3

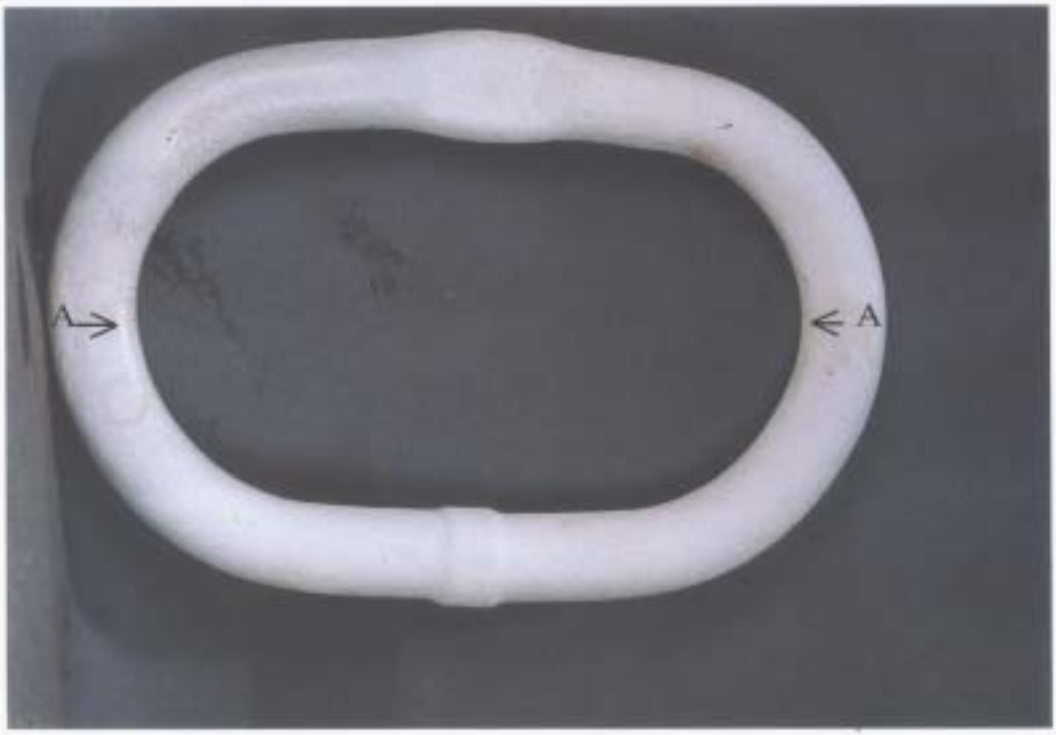



No 2 forward davit pivot pin bosses
indicating rupture along welded joint

FIGURE 4

Part of No 2 davit arm indicating lack of penetration forward
along joint where it was welded to the pivot pin boss

FIGURE 5



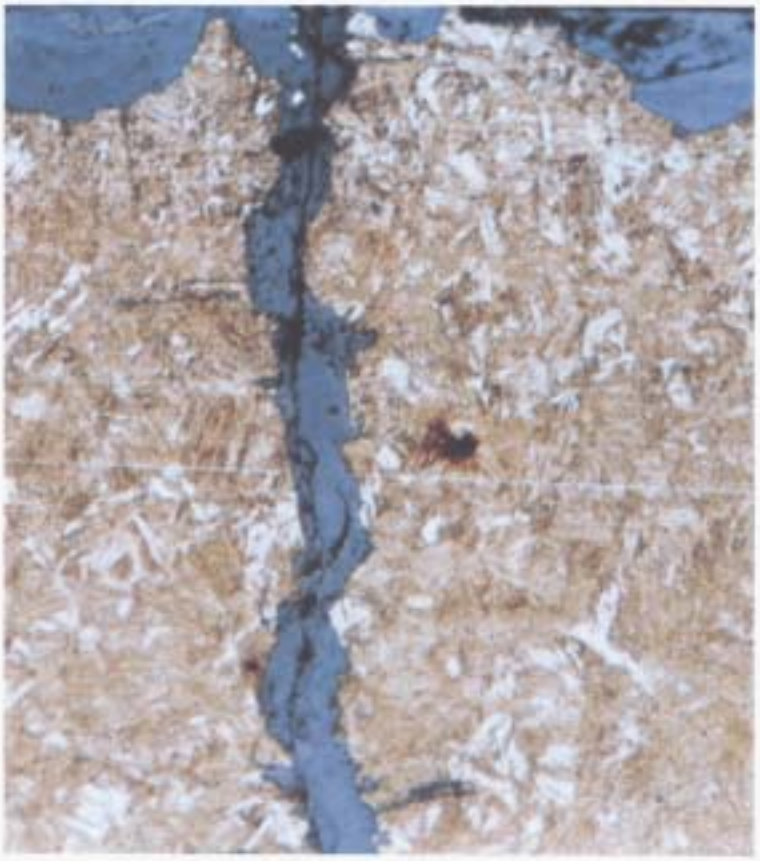

General view of the suspension link 'A' of No 1 lifeboat davit showing position of cracking at intrados - arrowed A

FIGURE 6


Typical appearance of mating fracture surfaces

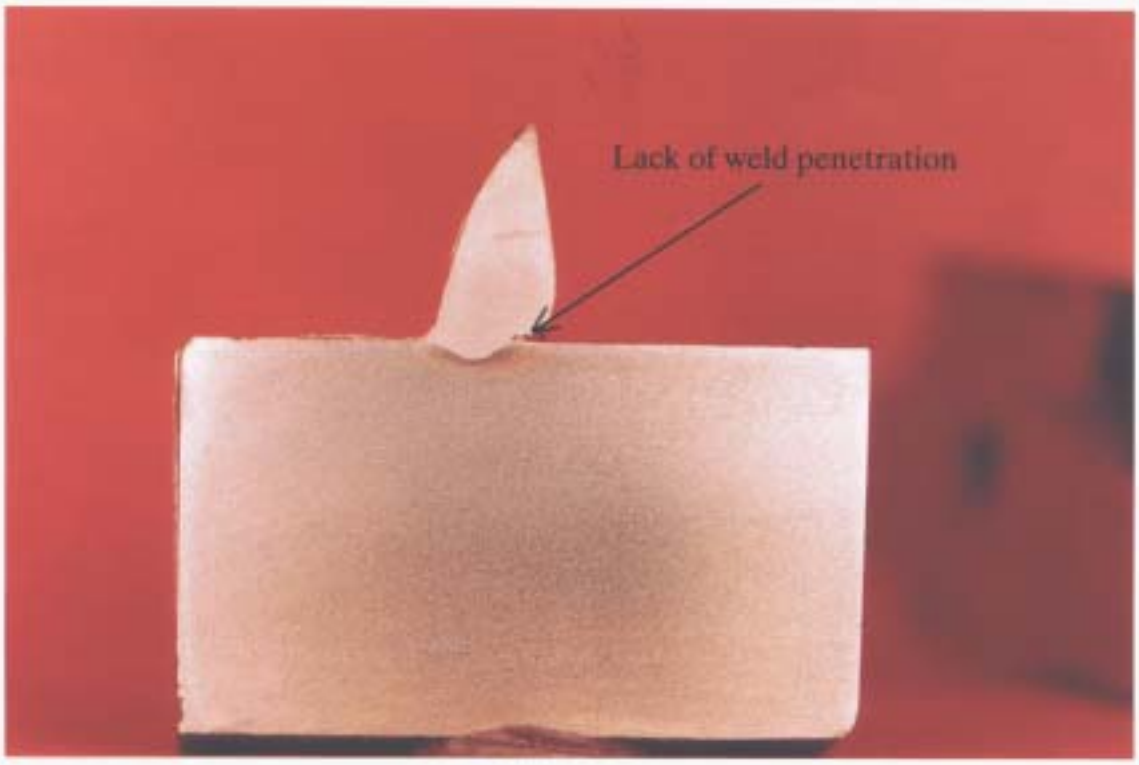
Note:
A - Pre-existing crack
B - Saw cut
C - Intentional fracture

FIGURE 7



Etched Section in regions of cracking showing martensite

FIGURE 8




Macro Section B1