Report on the investigation of

the failure of the starboard bow door on

Pride of Provence

at Calais

on 22 February 2004

Marine Accident Investigation Branch
First Floor
Carlton House
Carlton Place
Southampton
United Kingdom
SO15 2DZ

Report No 16/2004
December 2004

Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999 – Regulation 4:

"The fundamental purpose of investigating an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 1999 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."

NOTE

This report is not written with liability in mind and is not intended to be used in court for the purpose of litigation. It endeavours to identify and analyse the relevant safety issues pertaining to the specific accident, and to make recommendations aimed at preventing similar accidents in the future.

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

CCTV	-	Closed Circuit Television
DNV	-	Det Norske Veritas
EWS	-	Early Warning System
IACS	-	International Association of Classification Societies
IMO	-	International Maritime Organisation
ISM	-	International Safety Management Code
LRS	-	Lloyd's Register of Shipping
MAIB	-	Marine Accident Investigation Branch
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MPI	-	Magnetic Particle Inspection
NDT	-	Non destructive testing
QA	-	Quality Assurance
Ro-Ro	-	Roll on – Roll off
SMS	-	Safety Management System
SMSI	-	Swedish Maritime Safety Inspectorate
UR	-	Unified Requirements

DEFINITIONS

Weathertight:

- A closing appliance is considered weathertight if it is watertight in any sea conditions.
- Generally, all openings in the freeboard deck and in enclosed superstructures are to be provided with weathertight closing appliances.

Watertight:

- A closing appliance is considered watertight if it is designed to be watertight in either direction under a head of water for which the surrounding structure is designed.
- Generally, all openings below the freeboard deck in the outer shell/envelope (and in main bulkheads) are to be fitted with permanent means of watertight closing.

SYNOPSIS

At 1212, on 22 February 2004, the starboard outer bow door on the P&O cross-channel ro-ro passenger ferry *Pride of Provence* failed as it was being closed prior to departure from the port of Calais. The vessel was rendered unseaworthy and the passengers and vehicles were disembarked.

Cracks in the hinge of the bow door had been discovered 6 days earlier and had been inspected by the company technical department, a Class surveyor and a ship repair yard. The MCA had also been informed. Following a visual inspection, the Class surveyor issued the vessel with a Condition of Class, which allowed the vessel to continue trading until the end of the month. Ship's staff carried out daily inspections of the cracks. The vessel continued to operate without a detailed examination of the cracks and without any operational limitations particularly with regard to weather conditions.

The cracks might have been found earlier and been rectified had non-destructive testing (NDT) been carried out on the bow doors and supporting structure during the refit which was completed a month prior to the failure. Although this work was in the refit specification, it was overlooked and was not carried out.

During the MAIB investigation, it became apparent that the vessel had suffered previous cracking to the starboard bow door support structure, and that the starboard door made contact with the "cowcatcher" framework when opened. However, neither the vessel owner nor the Classification Society for the vessel had carried out effective investigations into the cause of the cracking, but they had repaired and strengthened attachments with no further repeat of any cracking for over a year. Neither party had perceived the significance of the contact with the "cowcatcher".

Early in the investigation, MAIB was advised that hydraulically operated locking wedges had been removed from the door structure some years before the incident by a previous owner, but neither Lloyd's Register nor P&O Ferries had been aware of this fact prior to the incident. The MAIB investigation also highlighted apparent deficiencies in the International Association of Classification Societies (IACS) rules for bow door securing devices.

As a result of their own and the MAIB investigation, P&O Ferries Ltd and Lloyd's Register of Shipping have initiated measures to prevent similar accidents in the future. Action has also been taken by the MCA. Recommendations arising from the MAIB investigation have been addressed to P&O Ferries Ltd, Lloyd's Register of Shipping, IACS and the bow door manufacturer.

Courtesy of FotoFlite

Figure 1

Pride of Provence

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *PRIDE OF PROVENCE* AND INCIDENT

Vessel details (see Figure 1)

Registered owner	:	P&O Ferries Ltd
Port of registry	:	London
Flag	:	UK
Type	:	Class II ro-ro passenger vessel
Built	:	1983 Chantiers de France, Dunkerque
Classification society	:	Lloyd's
Construction material	:	Steel
Length overall	:	154.89m
Gross tonnage	:	28,559gt
Passenger and cargo capacity	:	2,036 passengers, 530 cars or 84 articulated lorries
Engine type and power	:	4 x V12 Sulzer four stroke medium speed diesel engines. Total power 25612kW
Service speed	:	19 knots
Other relevant info	:	Outer bow doors: clam type, hydraulically operated

Accident details

Time and date	:	1212UTC on 22 February 2004
Location of incident	:	Calais, number 7 ro-ro berth
Persons on board	:	1125
Injuries/fatalities	:	None
Damage	:	Starboard bow door upper hinge failure

1.2 BACKGROUND

Pride of Provence is one of several cross-channel ro-ro passenger ferries operated by P&O Ferries Ltd out of Dover. The ferries operate between Dover and Calais on a continuous service throughout each day carrying passengers and their vehicles, and freight. The crossing time is about 1.5 hours and the turn-round time is 45 minutes. P&O Ferries Ltd also operates other ferry services in the North Sea, Western Channel and Irish Sea.

Pride of Provence, a Class II ro-ro passenger vessel, was built during the period 4 June 1980 to 11 February 1983 at Chantiers de France shipyard, Dunkerque, to Det Norske Veritas (DNV) Rules and was originally classed with DNV. The vessel is fitted with bow doors, inner bow doors and stern doors, which enable vehicles to embark and disembark efficiently. Two fixed vehicle decks, accessed by three ramps, provide a total vehicle lane length of 1800m, giving a capacity of about 530 cars or 84 freight vehicles. Above the vehicle decks are seven decks of accommodation and public rooms to accommodate 2036 passengers.

Originally named *Stena Jutlandica* and operated by Stena Line AB in the Kattegatt on the Gothenberg to Frederikshavn route, she transferred from the Swedish flag to the UK flag, and her name was changed to *Stena Empereur* in 1996. Following a refit in Bremerhaven, which included modifications for the new service, she began operating on the cross-channel Dover to Calais route.

In 1998, after the formation of P&O Stena Line, the vessel was re-named *P&OSL Provence,* and continued on the same cross-channel route.

In 2000, the vessel transferred Class from Det Norske Veritas (DNV) to Lloyd's Register of Shipping (LRS).

In 2002, P&O Ferries Ltd was formed after purchase of Stena's share of P&O Stena Line and the vessel was re-named *Pride of Provence.*

1.3 NARRATIVE OF THE INCIDENT

On 16 February 2004, during a routine inspection, cracks were found in the upper hinge assembly of *Pride of Provence*'s starboard bow door. Lloyd's Register of Shipping (LRS) and the Maritime and Coastguard Agency (MCA) were informed. A Lloyd's surveyor attended the vessel the following day and, after inspection, issued an interim certificate of class valid until the end of the month.

At 1126 on Sunday 22 February, *Pride of Provence* arrived at number 7 berth in the port of Calais, after her second crossing of the channel that day. She was head to the berth.

The outer bow doors were swung open, the vehicle ramp was lowered, and the inner watertight doors were also opened. The disembarkation of vehicles and passengers then began.

Since few vehicles, and only 371 passengers were carried on that voyage, the disembarkation was completed within 10 minutes, and embarkation for the return voyage began shortly after.

By 1212, 1125 passengers and their vehicles had embarked, and the hydraulically operated bow doors were about to be closed by a crew member in preparation for the scheduled 1215 sailing.

As soon as the operating lever for the hydraulic rams was moved to the door closed position, the starboard outer bow door upper hinge failed.

The failure of the upper hinge caused the 20 tonne weight of the bow door to bear on the hydraulic operating cylinder and the lower hinge bearing assembly, which distorted. The door came to rest against a transverse section of the “cowcatcher”, with the lower part of the door submerged about a metre in the water **(Figure 2)**. Additionally, the vessel had sustained some local minor damage to her structure.

Figure 2

View of damaged starboard bow door

The starboard bow door could not be closed, and *Pride of Provence* was rendered unseaworthy. The incident was immediately reported to the company and to the MCA.

After a preliminary examination by ship's staff, 1035 passengers and their vehicles were disembarked from upper car deck 5 at about 1300. The main vehicle deck was unable to be offloaded, and 90 passengers and their vehicles remained on board.

A local ship repair yard was contacted for assistance and, in the meantime, ship's staff used chain blocks and mooring winches to secure the bow door and prevent further movement.

By 2030, the ship repair contractors had braced the bow door in the open position, and the vessel had been swung to allow the remaining vehicles on the main deck to disembark from her stern. This was completed at about 2142.

With tug assistance*, Pride of Provence* was moved to a lay-by berth in Calais to enable re-positioning of the bow door to be carried out.

The following day, the starboard bow door was lifted back into position and the fractured hinge plate re-welded and braced. Using the hydraulic cylinder, the door was then successfully closed and secured in position.

The vessel's Class surveyor issued an Interim Certificate of Class, with a Condition of Class, early on 24 February to allow passage to a shipyard in Dunkerque where permanent repairs were to be carried out.

Pride of Provence departed Calais for Dunkerque at 0600 on 24 February.

1.4 ENVIRONMENT

During the vessel's first crossing of the channel to Dover, on the morning of 22 February, the wind direction and speed was north-north-easterly 6 to 7 (Beaufort scale) with a rough sea and large swell. The conditions had eased slightly on the return crossing to Calais, with a wind direction and speed of north-easterly 6 with a rough sea and moderate swell.

1.5 BOW DOORS

Through access to the vehicle space is provided when ro-ro vessels are fitted with both bow doors and stern doors. Although this facilitates the loading and discharge of vehicles, it does mean that the doors must be large enough to allow all freight vehicles to pass through. Additionally, owing to their size, and the fact that they are sited at the ends of a vessel, the doors must be sufficiently strong to withstand the rigours of the sea. They need to be kept securely closed at sea to prevent flooding. The bow doors provide the initial weathertight integrity. Additionally, a set of full height inner bow doors is located at the collision bulkhead in accordance with the improved classification society

requirements as a direct result of the Estonian ferry '*Estonia*' which sank with the loss of 852 lives in 1994. These weathertight doors are dimensioned to withstand static high water pressure. Further, the bow ramp, located between the inner and outer bow doors, has a degree of weathertight sealing when locked in the stowed position.

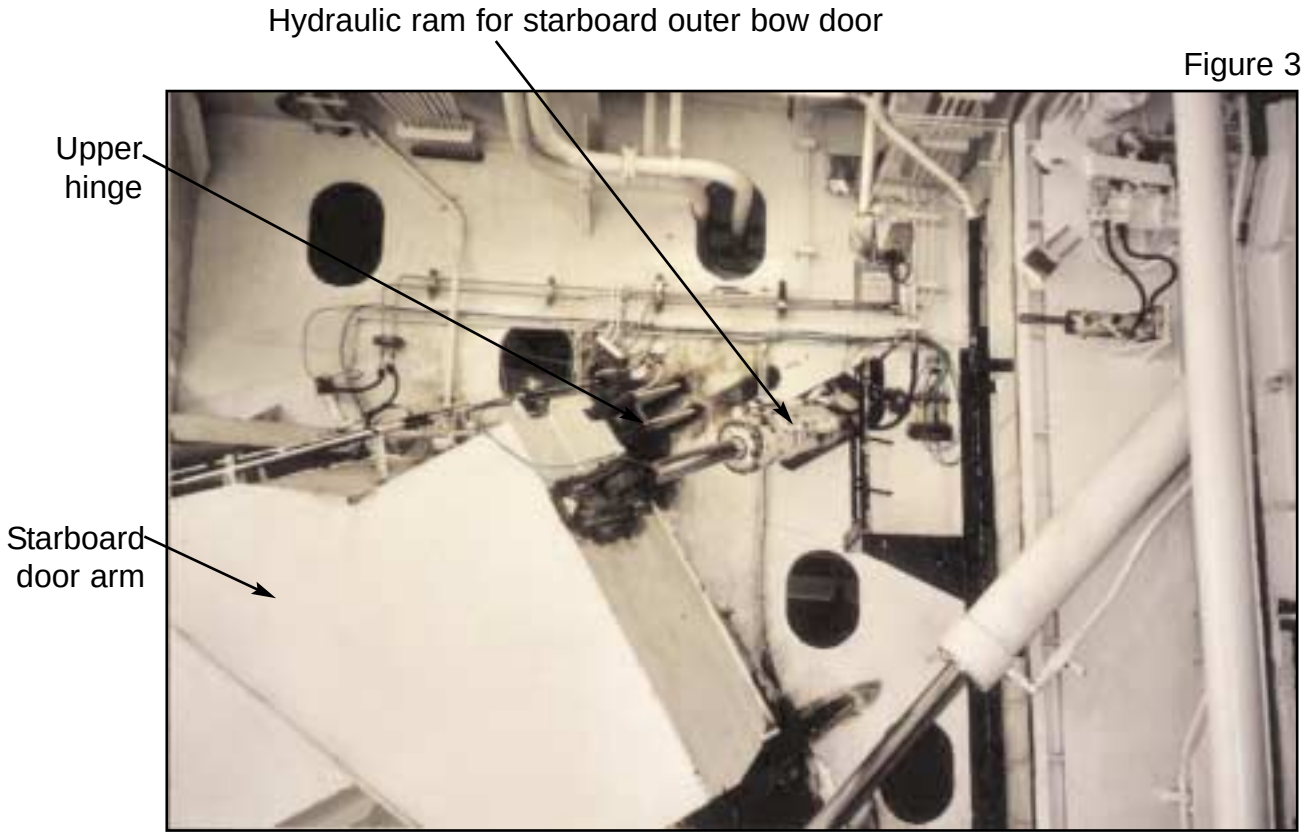
1.6 THE BOW DOORS ON *PRIDE OF PROVENCE*

Pride of Provence is fitted with the side opening or clam type of bow door. The design comprises two doors positioned port and starboard of the ship's centreline. Each door originally weighed about 18 tonnes, but this increased to about 20 tonnes with the addition of further steelwork to strengthen each door so that it complied with updated Classification Society Rules. Each door has two hinges and is operated by a hydraulic ram, which has a pivot at each end **(Figure 3)**.

Three hydraulically operated over-centre cleats are used to lock the bow doors together before the vessel goes to sea.

The upper hinge on each door uses a spherical bearing mounted on a bearing pin held between cheek plates. The hinge plate, connected to the door box section hinge arm, is welded to the bearing retaining ring. The hinge plate from the original construction drawing **(Figure 4)** was 30mm thick. The bearing is lubricated through a central lubrication channel in the pin.

Figure 3



Photograph of starboard side outer bow door opening mechanism

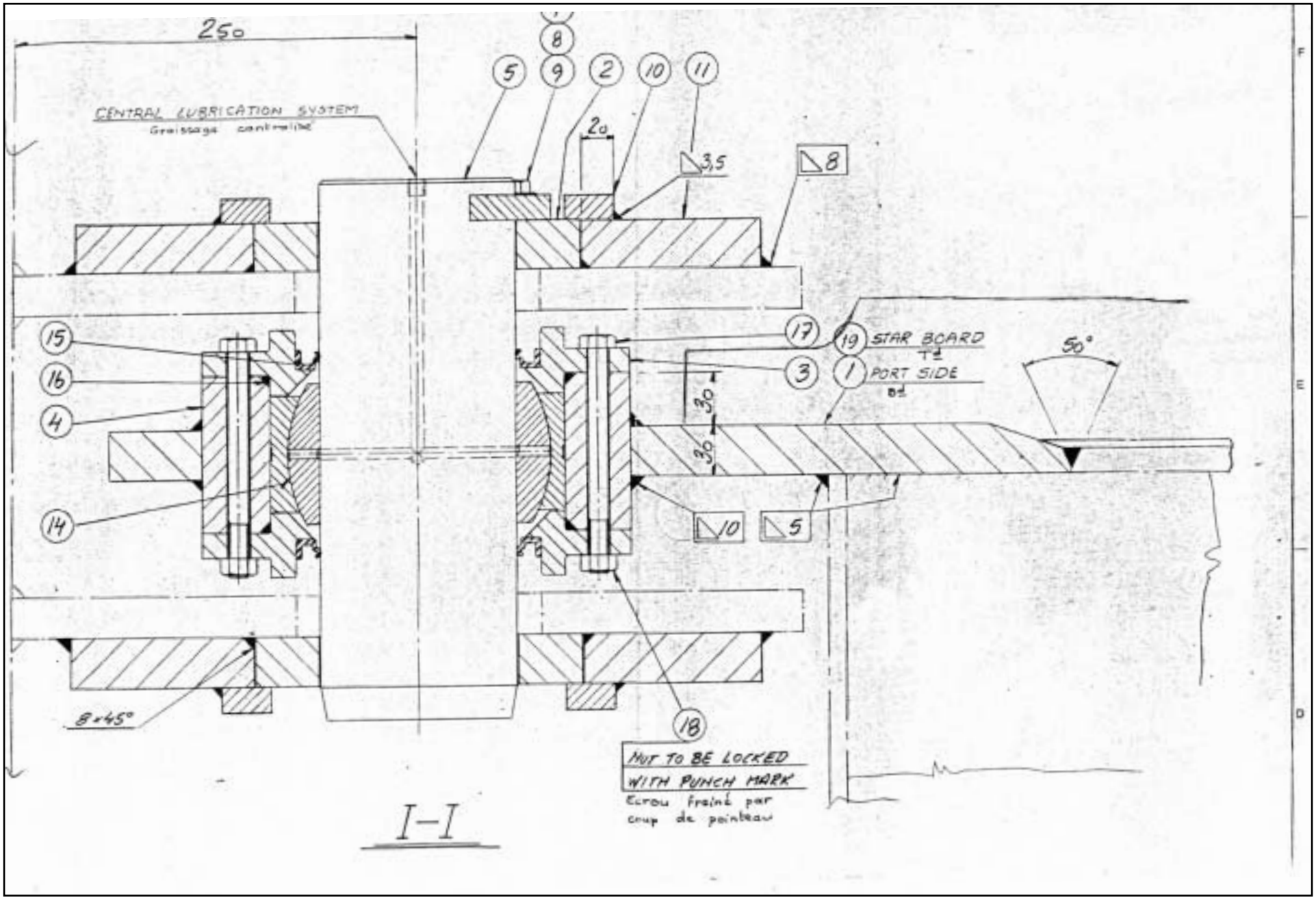


Figure 4

Drawing of bow door upper bearing hinge arrangement

To accurately position the upper pivot point to ensure good location and weathertight sealing of the door, the bearing can be adjusted using steel chocks. The chocks are located on both the upper and lower cheek plates, and are welded in position **(Figure 5)**. Alignment checks and adjustment at regular intervals are necessary to keep the doors operating correctly.

The upper and lower bearings are the same distance from the vessel's centreline, but they are not vertically in line, the upper bearing is set at an angle of 30° forward of the lower bearing. Without any device to retain the doors in the closed position, they are free to swing open.

The hydraulic system for opening and closing the bow doors is operated manually by a suitably trained crew member.

Figure 5

Underside of upper hinge assembly
(chocks are fitted similarly on the upper side)

The hydraulic system **(Figure 6)** comprises:

- A hydraulic powerpack, incorporating 3 variable displacement, automatic constant pressure, hydraulic pumps operating at 175 bar and a relief pressure of 205 bar;
- a control station that includes two levers for operating the locking devices and the rams;
- two door operating rams with cylinder diameters of 250mm, a rod diameter of 125mm and a stroke of 765mm; each ram is attached to its respective door and inner hull structure via spherical bearings;
- three centreline over-centre locking cleats;
- two door locking pins for holding the doors in the open position and;
- two 'ice breaker' pins at the lower edge of the doors to initiate the door opening process.

In addition to the above, the hydraulic system drawing depicts three hydraulically operated locking pins or wedges (items 26 and 27 of Figure 6). Two are for attachment to the upper forward end of the doors, and are intended to hold the upper part of the door closed against the vessel structure, the third locking pin is at the lower part of the doors for the same purpose.

These locking wedges were not fitted to *Pride of Provence* at the time of the incident, or at any time since P&O Ferries had acquired the vessel. The fittings for the wedges are clearly visible on the door and hull structure close to the vessel centreline **(Figures 7 & 8)**. The MAIB was unable to discover any approved drawings for these wedges.

To open the bow doors, the hydraulic powerpack is started and then the door operator, from the door control position which overlooks the bow door space on the starboard side of the vehicle ramp, releases the centreline cleats. In the original design, this action would have also operated the three locking wedges.

When the locking devices have been released, a second lever, which controls the hydraulic rams, is operated. The lever is held in the open position until the rams have reached their full extension. The control lever can then be released, at which point two 'door open' locking pins engage into the hinge arms. At this stage, a 'door open' indicator light illuminates. The system does not include any method to limit the stroke of the ram, which was designed to extend to its full length.

During the door closing operation, the operating lever for the rams is held in the 'close' position until the 'door open' locking pins have retracted, the doors have closed and the locking cleats have been operated and fully engaged to pull the doors tightly together. To prevent the cleats from becoming fouled while the doors are closing, the lever for the cleats is held in the open position.

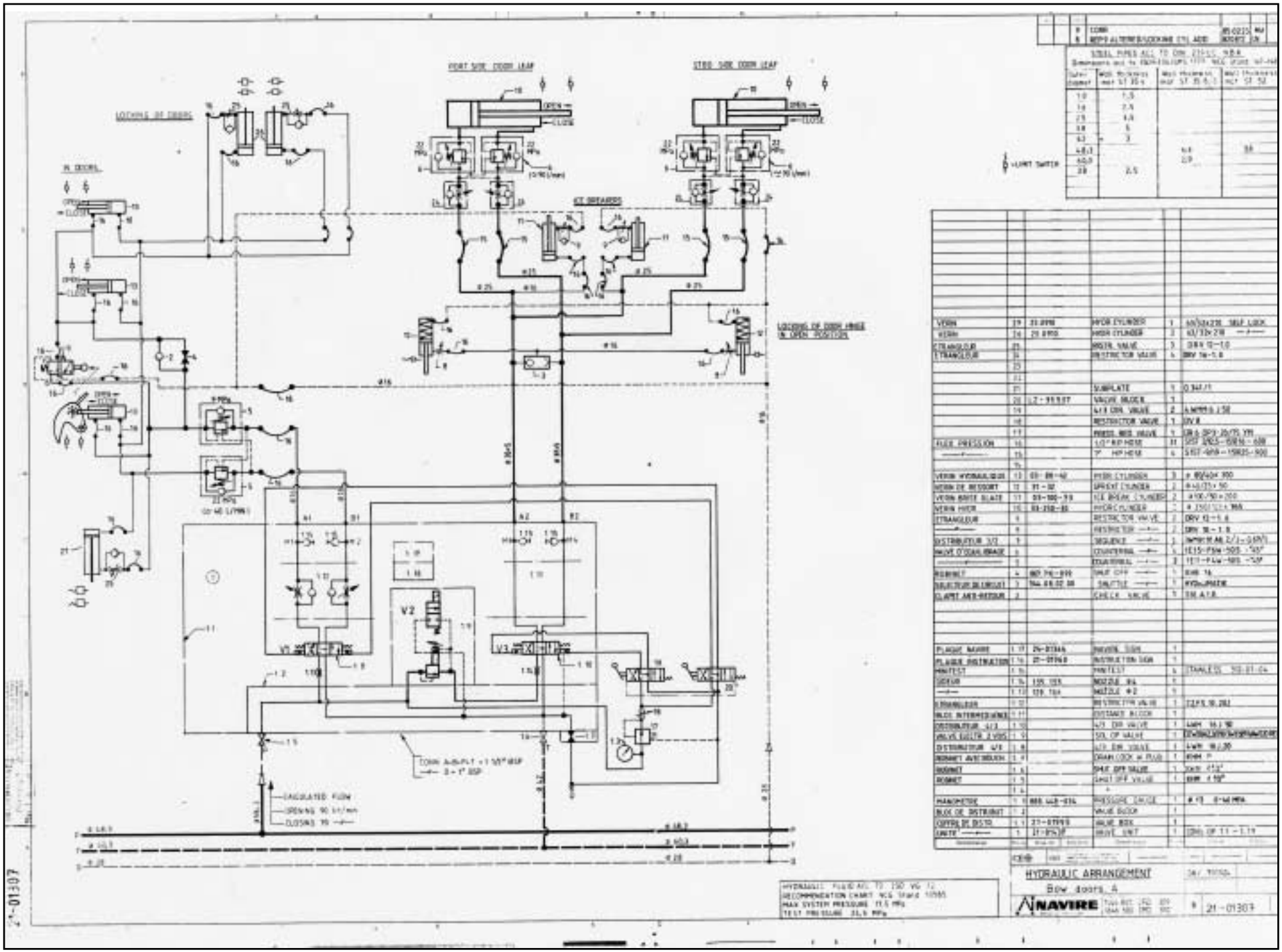


Figure 6

Diagram of outer bow doors hydraulic arrangement

Underside of deck
5 vehicle ramp

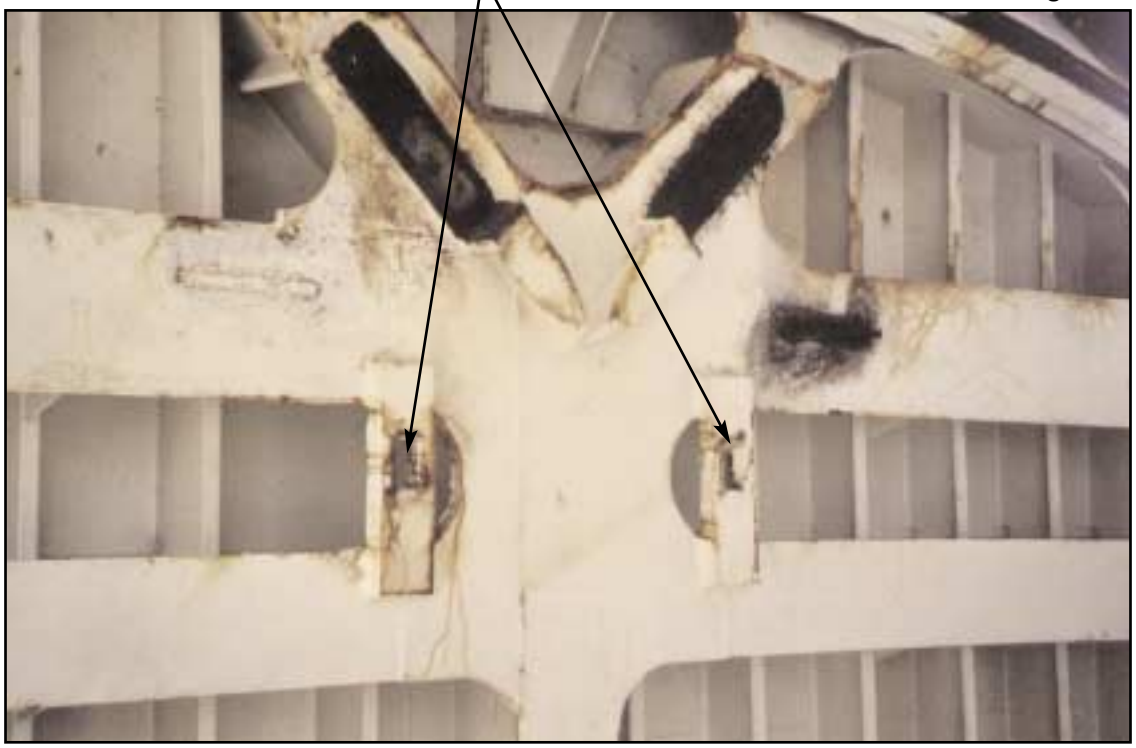
Sockets for original locking wedges

Figure 7

View of outer bow door space deckhead showing port door in open position

Sockets for original locking wedges

Figure 8



Outer bow door space deckhead showing sockets for original locking wedges

The doors are fitted with rubber seals, approximately 95mm x 60mm cross-section, within a groove at the door periphery, for a weathertight rather than a watertight seal. The design compression of the seal is in the order of 8mm.

1.7 EXTENT OF DAMAGE

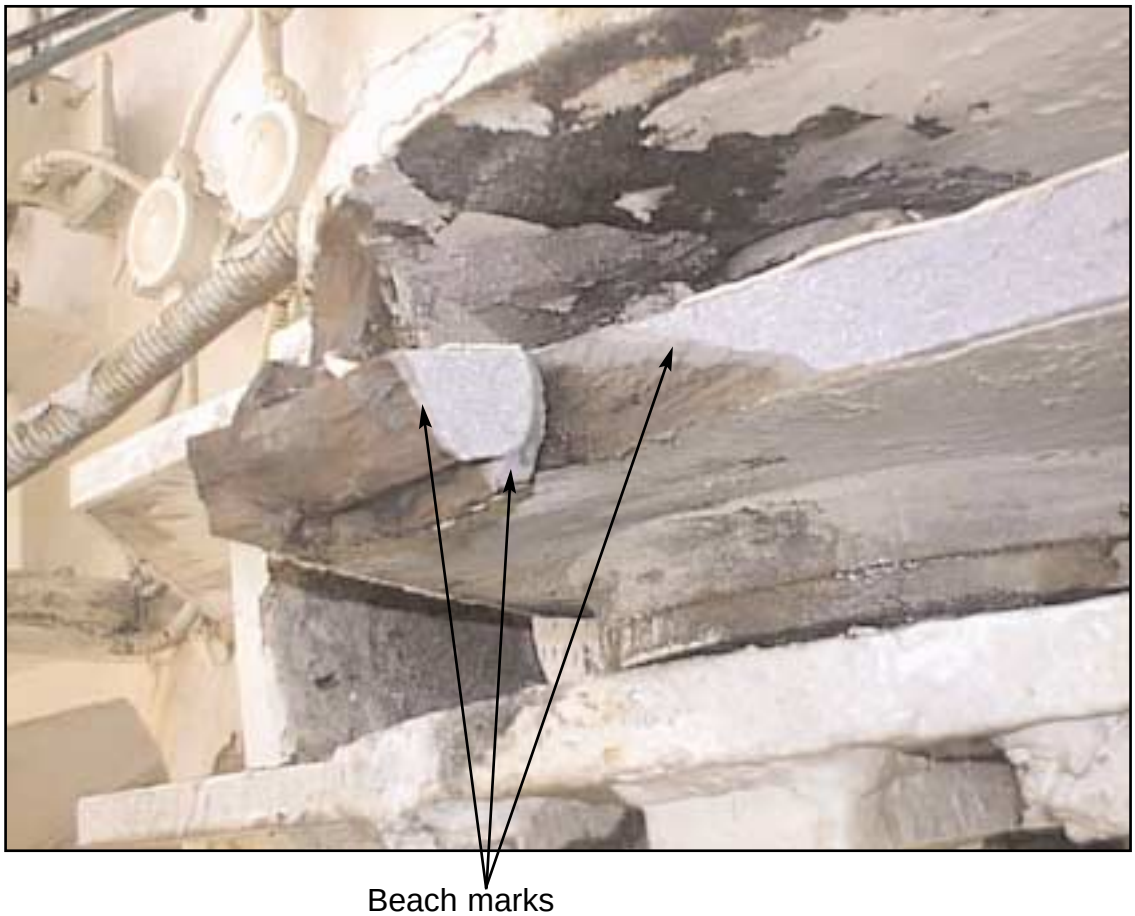
The upper hinge assembly on the starboard bow door connects the hinge arm, which is attached rigidly to the door, to the hull of the vessel. The upper hinge plate had fractured horizontally through the hinge plate, and vertically through the hinge plate stiffener **(Figures 9 & 10)**. The darker, corroded areas, which can be seen adjacent to the fresh 'clean' fractures, indicate previous cracking.

The hydraulic hoses for the centreline cleats were severely stretched **(Figure 11)**; the adjacent stainless steel hydraulic pipework was also damaged.

Electrical wiring for the door locking pin proximity switches was severely stretched.

Lesser damage was also sustained to minor brackets and other areas of the steelwork surrounding the starboard bow door.

Figure 9

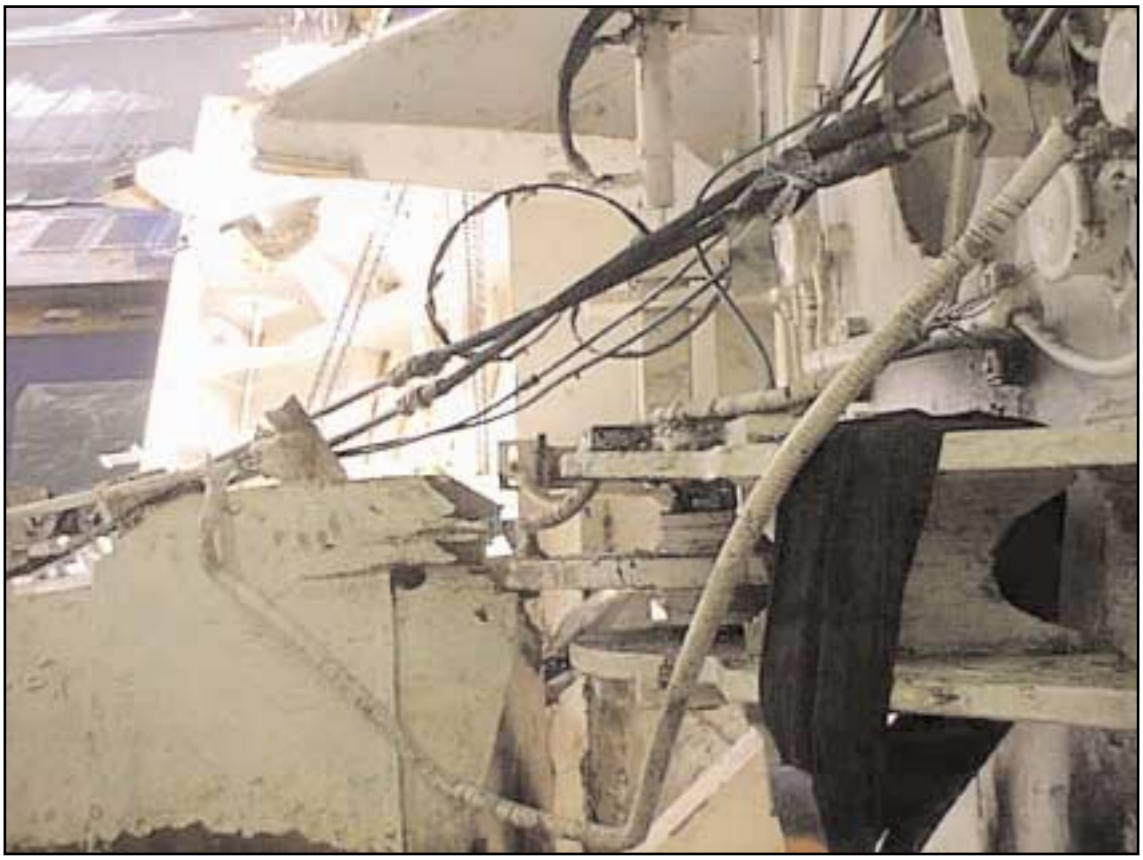


Photograph of starboard upper hinge plate failure

Figure 10

Starboard upper hinge

Figure 11



Photograph showing stretched hydraulic hoses and damaged fittings

1.8 REPAIRS

The upper hinge assembly, which suffered the greatest damage, was totally renewed. The design of the new assembly was based on the port bow door upper hinge, effectively the original design with the addition of two stiffeners on the upper hinge plate. The material used was Lloyd's Grade A steel, as specified in the original construction drawings. Other work carried out included:

- Overhauling the lower hinge assembly.
- The operating cylinder being overhauled.
- Reconditioning and refitting the lower centreline cleat.
- Hydraulic hoses, pipes, electrical wiring and minor steelwork damage being renewed as required.
- Renewing the door seal.

Unfortunately, P&O Ferries Ltd did not ask the shipyard to retain the damaged upper hinge components, nor were they requested to do so by Lloyd's Register. The components therefore could not be analysed as part of the investigation into the cause of the structural failure.

The vessel was returned to service on 6 March 2004.

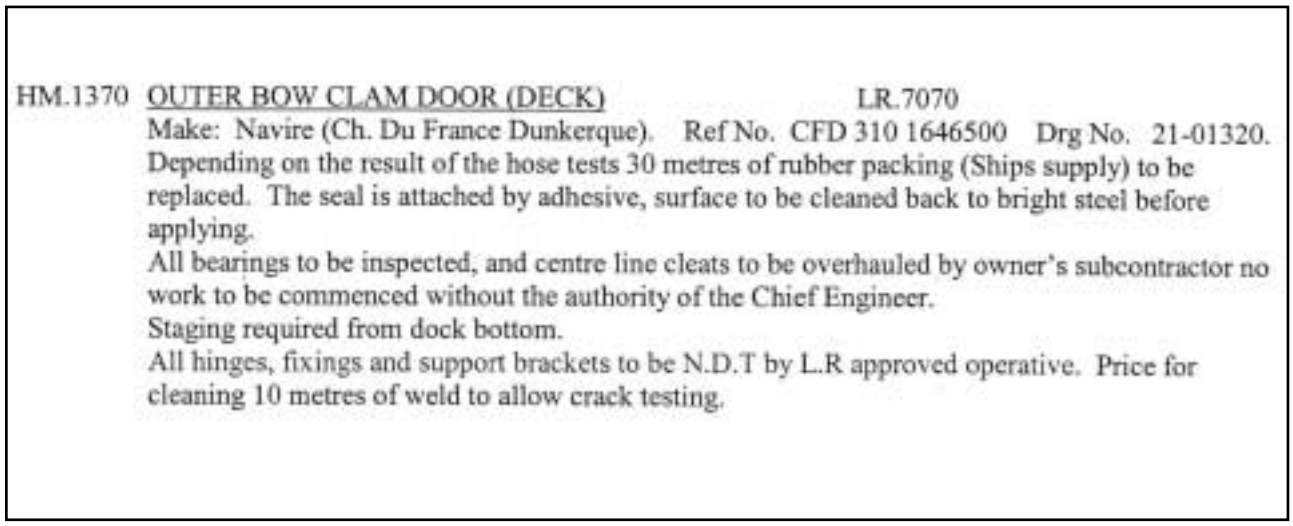
1.9 VESSEL REFIT

Pride of Provence had annual refits, which were carried out at ship repair yards in the UK. The most recent refit occurred between 22 December 2003 and mid January 2004 at A&P Tyne.

During the voyage north to the shipyard, the vessel was subjected to gale and storm force weather conditions. The bridge log records a north-westerly wind between force 7 and 10. The sea conditions were recorded as very rough with a heavy swell that necessitated a speed reduction to reduce damage from violent pitching.

This heavy sea loading on her bow resulted in considerable water leakage through the bow doors, which could be seen by the CCTV camera located between the vehicle ramp and bow doors. Renewal of the starboard door seal and Non-Destructive Testing (NDT) of the "cowcatcher" mounting points to the hull were included in the refit specification before the voyage to the shipyard **(Figure 12)**.

Figure 12



HM.1370 OUTER BOW CLAM DOOR (DECK) LR.7070
Make: Navire (Ch. Du France Dunkerque). Ref No. CFD 310 1646500 Drg No. 21-01320.
Depending on the result of the hose tests 30 metres of rubber packing (Ships supply) to be replaced. The seal is attached by adhesive, surface to be cleaned back to bright steel before applying.
All bearings to be inspected, and centre line cleats to be overhauled by owner's subcontractor no work to be commenced without the authority of the Chief Engineer.
Staging required from dock bottom.
All hinges, fixings and support brackets to be N.D.T by L.R approved operative. Price for cleaning 10 metres of weld to allow crack testing.

Extract from refit specification detailing work to be carried out on the bow door equipment

The sub-contractors employed by A&P Tyne encountered a degree of difficulty during the fitting of the starboard door seal. The inability to achieve a weathertight seal when the closed doors were subjected to water hose tests, meant that a rubber spacer seal, varying between 10mm and 15mm thick, was added between the main seal and the recess. The face of the main seal was greased to facilitate smooth closing of the door lip onto the seal. Ship's staff estimated the resultant compression on the main seal with the starboard door closed was 40mm. No record of this spacer seal appears to have been made, and P&O was not informed of the addition.

Every year, the refit specification included NDT of hull fixtures and fittings, including the supporting structure for the bow doors, although this was not a Class requirement.

A&P Tyne employed a specialist sub-contractor to undertake this work, and the method commonly used was Magnetic Particle Inspection (MPI). This technique employs a thin coat of white paint containing iron filings covering the area of interest. A large magnet is held over the area and any surface irregularity shows up as a concentration of iron filings.

The incident on 22 February, prompted P&O Ferries Ltd to investigate why the hinge had failed. This investigation established that NDT of the bow door support structure had not been carried out, as it should have been, during the most recent refit.

The shipyard quality control system, information feedback to P&O during the daily meetings, and onboard inspection by ship's staff, did not identify this oversight.

Work that was undertaken on the bow doors and associated structure during the refit included:

- Hinge bearing replacement on both doors;
- Alignment check on both doors;
- Strengthening the cheek plates for the starboard forward ram pivot due to ovality of the original cheek plates, and renewal of the hinge pin **(Figure 13)**;
- Overhauling the rams including new spherical bearings on the starboard ram;
- Overhauling the hydraulic system, including the locking cleats;
- Non-destructive testing of the “cowcatcher” mounting points to the vessel’s hull.

During the refit, the bow doors had remained in the open position apart from when they were closed briefly for hose testing.

Technical staff on board the vessel considered that frequent hinge bearing renewal was necessary during the refits because of the number of door operations that were carried out on the Dover to Calais route.

Figure 13

Lower side doubler plate welded to original bearing cheek plate (matching arrangement on upper side)

Starboard operating cylinder for door attachment pivot bearing

1.10 EVENTS LEADING TO THE FAILURE

Shipboard engineers had discovered cracks in the starboard upper hinge plate on 16 February, during an investigation of a fault on the bow doors. Ship's staff estimated the cracks, which had propagated through the stiffener and part of the hinge plate, to be about 1mm wide **(Figures 14 & 15)**.

P&O, the MCA and Class (Lloyd's Register of Shipping) were informed and the cracks were further inspected by the company assistant technical manager and the local ship repair yard (A&P Dover).

The following day, the Class surveyor and A&P Dover inspected the cracks in the hinge plate.

1.11 THE LLOYD'S SURVEY

The senior Lloyd's Register surveyor, who attended *Pride of Provence* on 17 February, was very experienced. He had been working as a Lloyd's Register surveyor for over 20 years. Prior to this, he obtained a degree in naval architecture, followed by a comprehensive training programme with LRS. He was authorised to carry out the survey of passenger ships, and had undertaken the survey of ro-ro ferry doors on many occasions in the past.

As this was his first visit to *Pride of Provence*, he reviewed her LRS records. He ascertained that *Pride of Provence* met UR S-16, the updated IACS requirements for bow door structures and watertight integrity, and that she had recently left a refit yard. LRS records contained no evidence of cracking in the area of the bow doors. He had, therefore, no reason to inspect other areas of the bow door structure, operation or paperwork. His sole purpose was to inspect the hinge plate crack and decide the correct course of action.

Due to difficult access, he believed that it would be impossible to carry out any meaningful NDT of the cracks. The examination was therefore visual only.

The surveyor assessed the safety features of the bow doors, which included the CCTV camera between the vehicle ramp and bow doors, the bow door sensors indicating the door status, and the water detector between the ramp and inner doors. These were expected to provide adequate warning in the event of bow door failure, and the watertight integrity of the lower vehicle space was further protected by the vehicle ramp and the inner bow doors.

The Lloyd's Register surveyor could not envisage a situation where the hinge could fail once the starboard bow door was closed. Even so, he saw the master to discuss the possibility of failure. He was shown the CCTV monitor, the door sensor indicator lights and the audible water detector alarm, which were all situated on the bridge. He recalls advising the master that the bow doors should be closely monitored by these means, especially in heavy weather, until the hinge could be repaired. If failure did occur, he advised the vessel's speed

Figure 14

Starboard door upper bearing hinge arrangement

Figure 15

Starboard door upper bearing hinge in detail showing cracks

should be reduced immediately and she should be steered towards the shelter of the nearest port at very slow speed. He further recalls advising the master to avoid loading the doors excessively; if heavy weather was encountered he was asked to consider reducing speed or changing course to reduce the loading caused by wave impact. However, neither of the two masters on the vessel that day recall being given this advice. The master informed the surveyor that the weather forecast for the rest of 17 February, and the following day, was good.

The surveyor took into account the fact that the vessel had probably been operating with this crack in the hinge plate for some time.

The surveyor spent 1½ - 2 hours on board, inspecting and discussing the hinge plate crack with senior ship's staff and A&P Dover staff. It was intended that A&P would undertake the repair work. The next scheduled sailing was delayed slightly, but this was not mentioned to the surveyor, and no other pressure was put on him to get the vessel back into service.

The surveyor then visited the P&O Dover office to discuss his findings and decisions. He was informed that P&O expected to begin repairs to the door hinge within 2 days, with the work probably being completed overnight. Once the vessel was taken out of service, the plan was to strip down the hinge so that the crack could be properly inspected. A Lloyd's surveyor, not necessarily the same one, would attend the vessel at this stage to advise what repairs were necessary.

Bearing in mind all the above factors, the surveyor was content to let the vessel sail. He issued a Condition of Class **(Figure 16)** until the end of February, which allowed P&O some extra time if the plan for the repairs was delayed. The surveyor requested that ship's staff examine the cracks frequently until the hinge plate was repaired.

When he returned to his office the next day, he discussed the case with a senior colleague who agreed with the course of action taken. He also informed the Dover office of the MCA about the survey and the way that Lloyd's were handling the incident.

1.12 EVENTS AFTER THE LLOYD'S SURVEY

On 18 February, the chief engineer and A&P inspected the cracks to plan the repairs. P&O made preparations to take *Pride of Provence* out of service at the end of her last cross-channel voyage on 22 February at Dover.

The following day, the cracks were inspected and no change in them was noted. However, the starboard door seal was not fitting properly. The ferry was returned to service.

Lloyd's Register

INTERIM CERTIFICATE

COPY

Ship's Name: PRIDE OF PROVENCE
LR/IMO Number: 7907257 *Port of Survey:* Dover

Date of Build: 02/1983 *Certificate Number:* SOU 430124
Port of Registry: London *First Visit:* 17/02/04
Gross Tons: 28727 *Last Visit:* 17/02/04

I have carried out the surveys listed below. All recommendations made by me have been dealt with to my satisfaction. I am recommending that class be maintained with new records as follows.

SURVEYS HELD		STATUS	NEW RECORD
HULL			
HDAM	Hull Damage Stbd Bow Door Upper Hinge Plate	COMPLETE	

CONDITIONS OF CLASS NOW IMPOSED	DUE
Repair of STBD outer bow door upper hinge cheek plate/stiffener fracture to be specially examined and dealt with.	02/04

END

The above recommendation is made subject to any outstanding conditions of class being dealt with as previously recommended.

Signed: Lloyd's Register EMEA Southampton Office Lloyds Register

Surveyor(s) to Lloyd's Register EMEA
A member of the Lloyd's Register Group

Date: 20 FEB 2004

On 20 February, the cracks were again inspected and, again, no change in their condition was found. However, 0.6m of the lower seal packing was replaced on the starboard door.

The next day, a further inspection found no change in the condition of the cracks, but approximately 3m of the starboard door bottom seal had been dislodged and was unable to be refitted. The door also appeared to be sitting low.

1.13 *PRIDE OF PROVENCE* BOW DOOR HISTORY

Within two years of operating on the Gothenberg to Frederikshavn route, *Pride of Provence* (which was *Stena Jutlandica* at this time) suffered two incidents to her bow doors.

During a voyage between the two ports in January 1984, both doors suffered heavy weather damage that included indentation to the shell plate over an area of about 16m^2, distortion of the centreline cleats, an upper stringer and the centre line packing seal channel. In addition to the damage being repaired, reinforcement of stringers and the side shell plate was carried out.

In October the same year, the bow doors of *Stena Jutlandica* were left open during a sea crossing, which resulted in the failure of the port door upper hinge. The hinge plate was renewed. The new hinge plate was reinforced with two stiffeners welded to the upper side. Similar modifications were also carried out to the bow door hinge plates of the sister vessel *Stena Danica*.

Either at the same time or at a later date, the starboard hinge plate on *Stena Jutlandica* was also stiffened. Only one stiffener was added, probably due to difficult access. For the stiffener bracket to fit between the upper bearing cheek plate and hinge plate, the steel section had to be reduced. This was roughly flame cut, with only a small radius to dissipate the stresses at the change in section **(Figure 14)**.

Early in the vessel's life, and possibly as a result of the damage sustained in 1984, the three locking wedges were removed. Anecdotal evidence suggests that the removal of the wedges was carried out because of difficulties in opening the bow doors. The locking wedges, on the same hydraulic circuit as the centreline cleats, had tended to open after, instead of before, the cleats. This resulted in the door seal compression load being released onto the locking wedges, which then became stuck. There are no survey records that refer to the removal of these wedges.

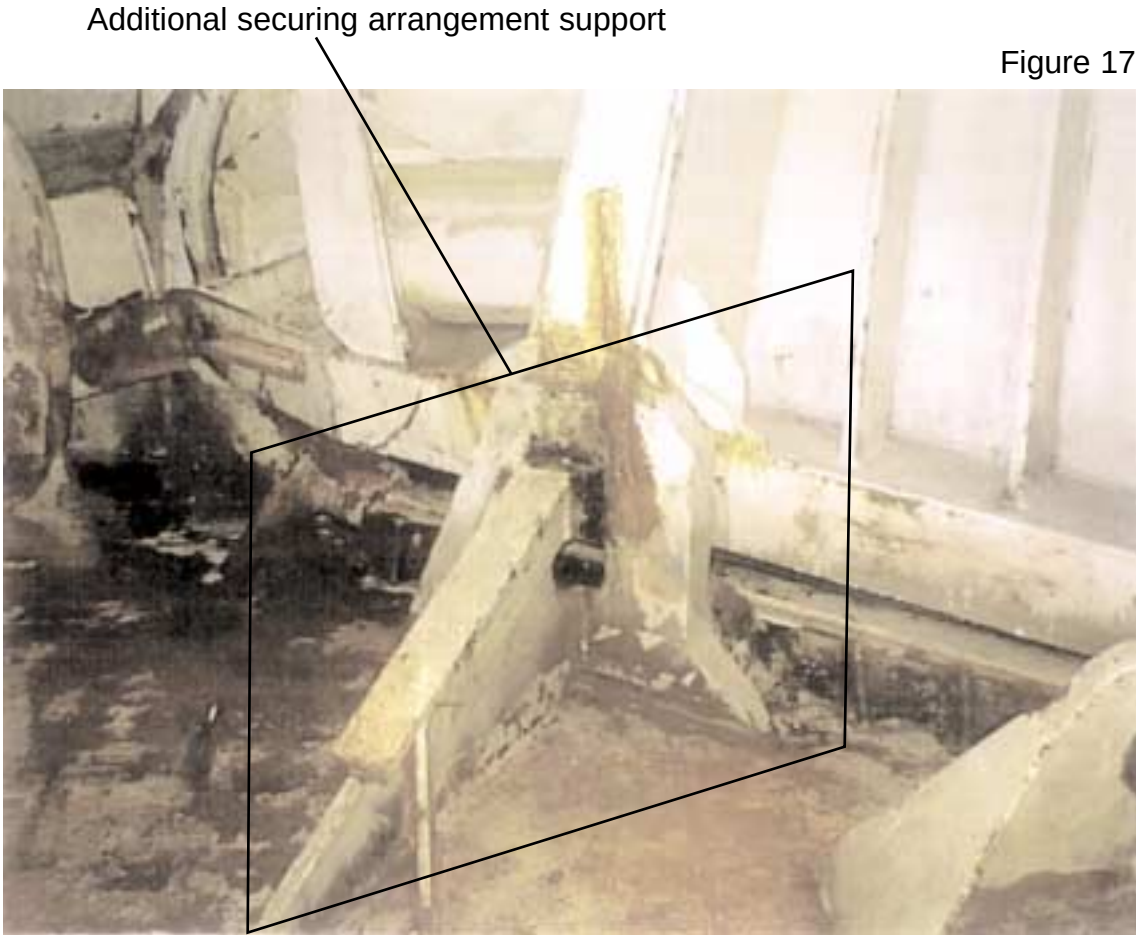
DNV approved the drawings from the bow door manufacturer, MacGregor (SWE) AB, for the reinforcement of the bow door supports to fulfil IACS Unified Requirements UR S-16 (1995) as applicable to existing ro-ro passenger vessels.

During the Bremerhaven refit in 1996, these, and various other modifications, were carried out to both comply with IACS requirements and for the new route. These modifications included:

- Inner bow doors at main deck 3 being added to comply with the requirement of the amendment to SOLAS C11/1 Regulation 10. This regulation refers, in part, to the requirement for the inclusion and siting of an inner bow door as a method of extending the collision bulkhead to the next full deck above the bulkhead deck;
- Reinforcing the bow door and ship structure, and the supports on the tanktop **(Figures 17 & 18)**, to comply with UR S-16;
- Fitting an external bow framework, known as a “cowcatcher”, which enabled the vessel’s bow to connect to the linkspan at the port of Calais;
- Various warning devices being fitted to indicate door operation and water ingress.

The DNV survey carried out during the refit, indicates that locking devices, for the door closed position, could have been in place at that time, although this conflicts with other evidence.

Figure 17



View of port bow door additional securing arrangement to comply with IACS UR S-16

DET NORSKE VERITAS

ANKOM
1996 -05- 20
Besv.

DNV

DET NORSKE VERITAS AS
Division Technology and Products

MACGREGOR (SWE) AB
BOX 4113

S-400 40 GÖTEBORG
Sweden

Att.: Pontus Dahlstrom

Your ref.	Our ref.	Date
Pontus Dahlström/RS	DTP234/RNE-12489-J-73	14 May, 1996

"STENA EMPEREUR" (ex "JUTLANDICA") Id. No. 12489
Reinforcement of Bow Door Supports

Reference is made to your letter dated 1996-04-26. Please find enclosed 3 copies of the following drawings:

Drawing No.	Rev.	Title	Code	Status
21-63319	4	Reinforcement of Bow Door Steel Structure		Approved
21-63361	B	X, Y, Z - Supports on Tanktop, sht.1		Approved
21-63361	A	X, Y, Z - Supports on Tanktop, sht.2		Approved
21-63368	A	Upper Side Z-Support		Appr. w/comm.

The drawings are approved with respect to strength with the following comments:

Drw.no. 21-63368 "Upper Side Z-Support":

The dimensions of the 200x300x15 bracket shown on "Section A-A" should be increased as indicated and a flange fitted.

One extra bracket should be fitted as indicated on the section shown on the right part of the drawing.

Extract of Classification Society approval of drawings for work to reinforce bow door supports

Maintenance records when managed by Stena Line:

Maintenance history records from 1994 provide little detail on work carried out on the bow doors and associated structure. However, the maintenance routine, which had been the same from June 1994 through to November 1997, changed in December 1997. Prior to December 1997, the routine included the instruction:

Check that the securing wedges enter its positions and tight up (sic) *the bow doors. Keep the wedges properly lubricated.*

The routine which was followed after this date did not include reference to the securing wedges.

Maintenance records when managed by P&O Stena Line:

At the vessel refit in December 1999, it was noticed that the starboard door hung lower than the port. The lower spherical bearing and pin were renewed.

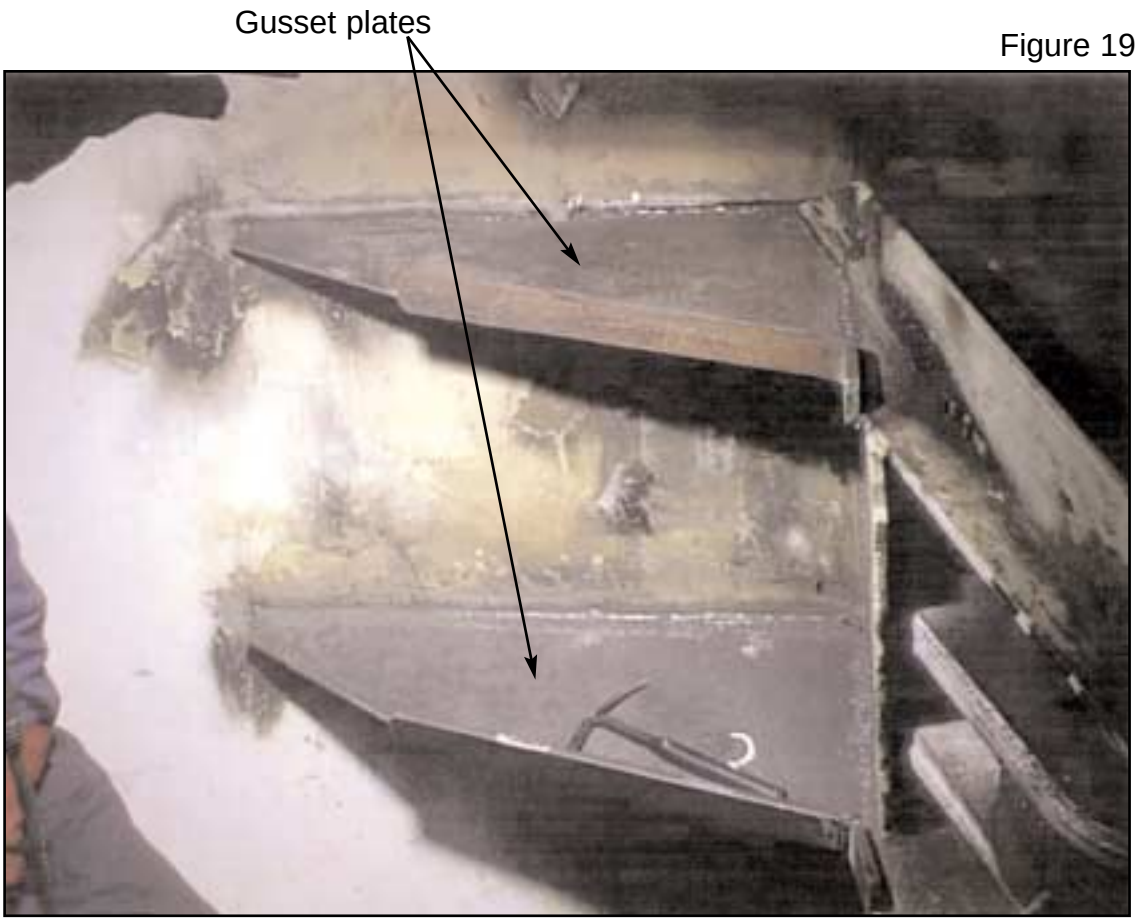
Maintenance records when managed by P&O Ferries:

Since 2002, during the vessel's ownership by P&O Ferries, ship's staff carried out regular inspections for cracks in the bow space. Cracks in the brackets supporting the starboard ram aft pivot were noted in the planned maintenance records during a general inspection in October 2002. The cracks were weld repaired and additional gusset plates were added. No cracks were found on the port side.

Further cracking of the previous weld repairs was reported on several occasions in the planned maintenance records. Further repairs to the starboard ram aft pivot support were undertaken. Whenever cracks were identified by ship's staff, they were measured, photographed and the technical department ashore was informed before the cracks were repaired by welding contractors.

No cracks were found around the starboard ram aft pivot support for over a year, but the problem reappeared after this incident on 22 February 2004. On 15 June 2004, *Pride of Provence* was removed from service, and the starboard operating ram aft pivot support structure was further strengthened and the gusset plates were renewed **(Figure 19)**.

Figure 19



Replacement gusset plates at collision bulkhead for starboard bow door operating ram

1.14 OTHER VESSELS OPERATING WITH BOW DOORS

Pride of Provence has a sister vessel, *Stena Danica*, which still operates on the route between Gothenberg and Frederikshavn and is owned by Stena AB.

In 2000, apparently after *Stena Danica* suffered heavy weather damage to her bow doors, MacGregor, the bow door manufacturer, proposed fitting four new locking wedges. These were to be fitted in different locations to the original locking wedges to produce a better securing arrangement. As with *Pride of Provence*, the original locking wedges on *Stena Danica* had been removed. This was probably because of the operating difficulties previously described in 1.13. The original locking wedges were positioned well forward on the doors supplementing the security provided by the cleats. They did not prevent the doors falling outwards at the aft end in the event of hinge failure.

The new locking wedges were of enhanced scantlings, and were positioned about half way between the forward and aft edges of the doors. MacGregor believed that they were necessary to hold the doors in place should failure of the hinges occur. They also supplemented the security provided by the cleats at the forward end. Stena AB agreed to the fitting, and DNV approved them. P&O Stena Line was not told of the relevance of this modification to the sister vessel, then *P&OSL Provence*.

In 2002, another Stena AB ro-ro passenger ferry *Stena Germanica*, also fitted with bow doors, suffered severe cracking to a door hinge arm during heavy weather. As a result of this damage, both this vessel and the sister vessel, *Stena Scandinavica,* were fitted with four locking wedges. The position of the locking wedges was similar to those on board *Stena Danica*, ie about half way between the hinges at the aft end and the cleats at the forward end. The classification society, Lloyd's Register, approved these additions.

In 2002, after the bow door incident involving *Stena Germanica*, the Swedish Maritime Safety Inspectorate (SMSI) contacted Lloyd's Register (Sweden). SMSI reiterated the concern, which had been stated at an earlier meeting, that had the hinge arm failed completely, then the door would have fallen into the sea. They also raised the issue of a possible inadequacy in the IACS Rules regarding the securing and supporting devices of bow doors. SMSI requested Lloyd's Register highlight these issues with IACS.

Lloyd's Register (Sweden) responded to SMSI and stated that the *Stena Germanica* incident was being treated with the 'gravest concern' and that a four-point plan was being initiated to take account of SMSI concerns.

The plan included the following:

- Reviewing existing vessels with side opening doors to identify areas of concern;
- Informing plan approval offices of the incident;
- Liaising with bow door manufacturers; and,
- Examining relevant IACS Rules, including their clarity.

Lloyd's Register in London also considered the concerns expressed by the Swedish Administration in a letter dated 16 April 2002 to Lloyd's Register in Sweden. It was concluded from service experience, and a review of requirements, that the Lloyd's Register Rules and IACS Unified Requirements in force at that time did not need revision. Unfortunately, this information was not promulgated to the Swedish Administration.

MAIB is not aware of any other incidents of cracking in the door support structure of vessels fitted with bow doors.

1.15 STRUCTURAL STRENGTH OF BOW DOORS

International Association of Classification Societies (IACS)

Classification societies are organisations which establish and apply technical standards in relation to the design, construction and survey of marine related structures. These standards are issued by the classification society as published rules. Classification societies perform independent research into ship design and safety for the development of appropriate rules.

Classification societies may also be involved in performing, on behalf of Marine Administrations, the statutory surveys required by international conventions. Each Maritime Administration agrees with the societies the level of delegation and the authority for the issuance of certificates. In the UK, the MCA has delegated, among other items, the hull and machinery surveys to classification societies.

For over 30 years, IACS has produced various requirements for the construction and survey of merchant vessels. The primary purpose of these requirements, which were developed by 'working groups' comprising of specialists from member Classification Societies, is to unify the requirements and procedures set by each member. The requirements produced are invariably based on past experience, professional judgment and research and development. Once a set of requirements has been agreed by a 'working group' they are presented to the IACS Council for formal adoption. After adoption, the requirements are known as Unified Requirements and, as such, are required to be incorporated into the regulations of all member societies and applied as appropriate. Any member not intending to apply any Unified Requirement must advise the IACS Council accordingly, and must also indicate the alternative arrangements they intend to use.

IACS Unified Requirements are normally recognised and accepted by the Maritime Administrations of most nations, including the United Kingdom.

- Bow Door Unified Requirements (UR)

In general terms, the structural strength of bow doors (or any door fitted in the shell plating) is required to be of equivalent strength to the adjacent area of the hull in which it is fitted.

Since 1984, however, there have been specific requirements for the construction of bow doors and visors. 'Unified Requirement – S8 (1982) – Bow Doors and Bow Doors Securings' was produced by IACS and is based primarily upon 'best past practice'. It gives both general and specific advice on the construction and strength of bow doors and how they are secured, including the design forces to be adopted and the maximum stresses permitted.

Unified Requirement S8 (1982) was applied in 1984 to the construction of all bow doors fitted in new vessels, ie vessels constructed after June 1984.

Following the tragic loss of the ro-ro passenger ferry *Estonia* in September 1994, where the bow visor was known to have been a central cause of her loss, IACS decided to review Unified Requirement S8 (1982). As a result of that review, revised requirements were issued:

- Unified Requirement S8 (1982)(Rev.2 1995) 'Bow doors and Inner Doors' and,
- Unified Requirement S16 (1995) 'Bow Doors and Inner Doors – Retrospective Application of UR S-8, as amended in 1995, to apply to existing ro-ro passenger ships'.

UR S-8 (1982)(Rev.2 1995) applies to new ships built after June 1996. Under this requirement, a slightly larger wave load was applied to the visor, as bow visors were perceived as being at greater risk than side opening doors, and more specific account was taken of the vessel's 'rake of stem' and 'flare of the bow'. The most important change introduced was in the arrangement of securing and supporting devices, so that in the event of failure of any single securing or supporting device, the remaining devices were capable of withstanding the resultant stresses without exceeding by more than 20% the stated permissible stresses.

Unified Requirement S16 (1995) applies to all ro-ro ships built and in service prior to June 1996, such as *Pride of Provence*. This requirement specifies:

1. The need to conduct a special examination of the structural condition of the bow doors and inner doors, their primary structure and securing arrangements and any defects rectified;
2. The need to provide an approved operating and maintenance manual and to ensure the bow and inner doors are regularly inspected;

3. The need to ensure that the arrangements of inner bow doors comply with stated requirements;
4. The need for redundancy in the closing and supporting arrangement;
5. In addition, as a result of measures agreed at the International Maritime Organisation (IMO), the need to provide CCTV surveillance and a water leakage detection system for the region between the outer bow doors and inner bow door.

A number of the requirements applicable to new ships also applied to existing vessels, ie those relating to the location of inner doors, securing of all doors, and the supporting structure.

Pride of Provence was modified to comply with the requirements of UR S-16, in August 1996 at Lloyd Werft, Bremerhaven, while she was classed with DNV.

Specific sections of UR S-16 and UR S-8, relevant to the hinge failure on *Pride of Provence* are:

UR S-16, item 3d states:

> *For side opening doors, the structural arrangements for supporting vertical loads, including securing devices, supporting devices and, where applicable, hull structure above the door, are to be re-assessed in accordance with the applicable requirements of S8.6 and modified accordingly.*

UR S-8.6 – Securing and supporting of bow doors, item 6.2f states:

> *The arrangement of securing and supporting devices in way of these securing devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding by more than 20 percent the permissible stresses as given in S8.2.1.*

UR S-8.1.3 – Definitions

> *Securing device*

- *a device used to keep the door closed by preventing it from rotating about its hinges.*

> *Supporting device*

- *a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the ship's structure.*

Lloyd's Register Rules and Regulations for Classification of Ships 2002, Part 4 Chapter 2, 8.5.20 states: *For side opening doors, securing devices are to be provided such that in the event of failure of any single securing device the remainder are capable of providing the full reaction force required to prevent opening of the door.*

The missing locking wedges could not be deemed to be either the securing or the supporting devices for the bow doors on *Pride of Provence*.

1.16 SURVEY AND INSPECTION OF THE BOW DOORS

In February 1997, DNV, the Classification Society for *Pride of Provence* (then Stena *Empereur*), issued a certificate stating:

> *It is hereby confirmed that the up-grading of bow doors regarding arrangement, structural strength, monitoring of closing arrangement and surveillance during voyage have been carried out in accordance with drawings approved by Det Norske Veritas for compliance with Rules for Classification of Ships, July 1995 edition, Part 7 Chpt. 1 – Sect. 1C being compatible to IACS unified requirements UR S-16 as applicable to existing Ro-Ro Passenger Ferries.*

Prior to accepting *Pride of Provence* (then *P&OSL Provence*) into Class, Lloyd's surveyors carried out surveys on the vessel between 1 and 3 March 2000. The hull survey report includes a section on the bow doors, which states:

> *General examination equivalent to annual survey now held in entirety with all items found satisfactory. Vehicle deck shell doors now hose tested and found tight. Operation, documentation and safeguards found in compliance with IACS UR S-16 and 15[1] as application. Memoranda now recommend in this respect.*

The section 'Other Survey' in the report includes the following:

> *Bow door and inner bow door examined, documentation now found on board stating DNV compliance with IACS UR S-16. Doors operated and function tested satisfactorily with satisfactory hose test on completion.*
>
> *Copy of DNV survey report for compliance with IACS UR S-8 enclosed (UR S-8 requirements for new build not existing ship more onerous than UR S-16).*

The Class Annual Survey of the bow doors, completed on 18 January 2004, was carried out while *Pride of Provence was* at the A&P Tyne refit yard. This was in the form of a checklist (Form 2100 – Appendix 1) and covered the bow, inner bow, side and stern doors. The checklist included witnessing, by the LRS surveyor, the door and ship structure, operation of the doors and associated machinery, remote operating and indicating controls and approval of the Operating and Maintenance Manual.

[1] IACS URS-15 refers to stern doors

Specifically, the checklist mentions examination of the door hinging arrangements and door locking and securing arrangements. The attending surveyor made no adverse comments on these, or any other items. The checklist does not oblige the surveyor to inspect for 'freedom of movement' of the doors.

As a result of the recommendations made in a previous MAIB report involving heavy weather damage to the bow visor of a cross-channel ferry, MGN 245 (M) Inspection of Shell Loading Doors on Ro-Ro Ferries, was introduced in September 2002.

The key points arising from this MGN are:

- Monthly inspections of shell loading doors;
- Additional inspections immediately after every voyage where heavy weather has been encountered;
- Noticeboards being posted, drawing attention to the importance of the extended portion of the collision bulkhead and the need for it to be kept fully intact at sea;
- The need for the extended portion of the collision bulkhead to be readily recognisable by crew members.

Inspections of the bow doors and associated equipment on *Pride of Provence,* before the starboard hinge failure, were divided into those held daily and those held monthly, and incorporated some of the requirements of MGN 245(M):

Daily Inspections

The deck department carried out daily inspections during the operation of the doors on arrival and departure from port. They included basic operational checks, such as checking for oil leaks, correct operation of the locking pins/cleats, operation of indicator lights, weathertight integrity of the doors and completion of a checklist **(Figure 20)**. The checklist included provision for the recording of defects found during inspection and remedial action taken.

Monthly Inspections

A member of the engineering department carried out monthly inspections, usually the engineer whose sphere of responsibility included the bow loading equipment. The inspection, normally undertaken during a vessel 'layover' period in port, was a thorough check of all aspects of door operation: mechanical, electrical and hydraulic. Defects were recorded on a defect form **(Figure 21)**, which was used to initiate remedial action and update the history records. Prior to the Tyne refit, the last monthly inspection was carried out on 30 November 2003. The next monthly inspection after this refit occurred on 6 March 2004, after the incident.

P&OSL Provence

Loading Doors Operators Checklist

Deck 3

Checklist to be completed by the nominated door operator once every 24 hours by initialling the appropriate box.

Date: 6-5-04 No: 1	clam doors		ramp		inner bow doors		stern	
Nominated Operator -	Y	N	Y	N	Y	N	Y	N
locking pins & cleats secure	JA		JA		JA		JA	
indicator light on control panels working correctly								
area inside the doors (reasonably) dry	JA		JA		JA		JA	
seals visibly intact								
doors smooth & quiet in operation	JA		JA		JA		AJ	
bottom seal clear of deck when door moving								
speed of operation normal	JA		JA		JA		JA	
locking pin indicator arms in place (cleat indication)								
area under operating arms oil free (control boxes)	JA		JA		JA		JA	
webs under locking rams oil free								
locking pin pots in deck clear of debris	n.a	n.a	n.a	n.a			n.a	n.a

comments / defects raised

signed ..... (nominated operator) date 6-5-04 time 05:35

remedial action taken

signed ..... (chief officer) date ..... time .....

above defect rectified/or action taken. Check list returned to bridge.

signed ..... (chief officer) date ..... time .....

received on bridge

signed ..... (chief officer) date 06.05 time 0730

ammendment No. 1/01 issue date 20th October 2001 prepared by J.McN approved by MJR

P&OSL **PROVENCE** Sheet 4.1

Technical Dept. - CLAM DOOR CHECK LIST

To be completed during WEEK 1 File in Door Operating & Maint. Manual

	YES	NO	REMARKS
Control Panel			
Indicator lights and alarms all in working order	✓		
Free from oil leaks	✓		
Control handles free and functioning correctly	✓		
Operating Cylinders			
Rams free from leaks	✓		
Hydraulic connections free from leaks	✓		
Flexible pipes in good order	✓		
Cylinder mountings in good order	✓		
Connecting pins greased	✓		
Pin cheek plates secure	✓		
Connections to doors and casings in good order	✓		
Connecting brackets free from cracks	✓		
Locking Pins (Doors Open)			
Indicator arms secure	✓		
Proximity switches secure and correctly adjusted	✓		
Hydraulic connections free from leaks	✓		
Pipework undamaged and corrosion free	✓		
Operating cylinders free from leaks	✓		
Sockets clear of debris and greased	✓		
Centre Line Clamps			
Cleats fully engaged with opposite door	✓		
Cleat linkages 'overcentred' when fully engaged	✓		
All pins and pivots well lubricated	✓		
Proximity switches correctly adjusted	✓		
Hydraulic pipework and flexible hoses in good order	✓		
Hydraulic connections free from leaks	✓		
Hydraulic rams free from leaks	✓		
Doors General			
Isolating cocks in operable condition with handles	✓		
Pipework in good order	✓		
Hinges well lubricated and free from metal particles	✓		
Hinge brackets free from cracks and distortion	✓		
Door seals free from significant wear	✓		
Seal securing intact and secure	✓		
Easing bars in good order	✓		
Easing bars movement smooth	✓		
Locating pins and brackets greased	✓		
Doors free from cracks and distortion inside and out	✓		
Seal landings free from significant corrosion	✓		
Door aperture free from cracks and distortion inside	✓		
Door aperture free from cracks and distortion outside	✓		
Door operation timing normal	✓		
Hydraulic power pack free from leaks, correctly functioning	✓		
Defects Noted			
Transferred to 2EO's Handover Form - No. noted above		N/A	

Signature Date 30/11/03 Engineer Officer	Signature Date 30-11-03 Chief Engineer Officer

1.17 ISM CODE

Section 9 of the International Safety Management (ISM) Code states that the onboard Safety Management System (SMS) should have procedures for reporting, investigating and analysing incidents. It should also include instructions for implementing corrective action, with the objective of improving safety and pollution prevention.

Section 10.2 of the ISM Code states that a company should report any non-conformity, with its possible cause, if known, and that appropriate action has been taken.

Section 10.3 of the ISM Code states that a company should establish procedures to identify critical systems and equipment, the failure of which may result in a hazardous situation.

Additionally, advice and guidance on the ISM Code is provided by IACS in its publication IACS Recommendation 74: A Guide to Managing Maintenance (April 2001).

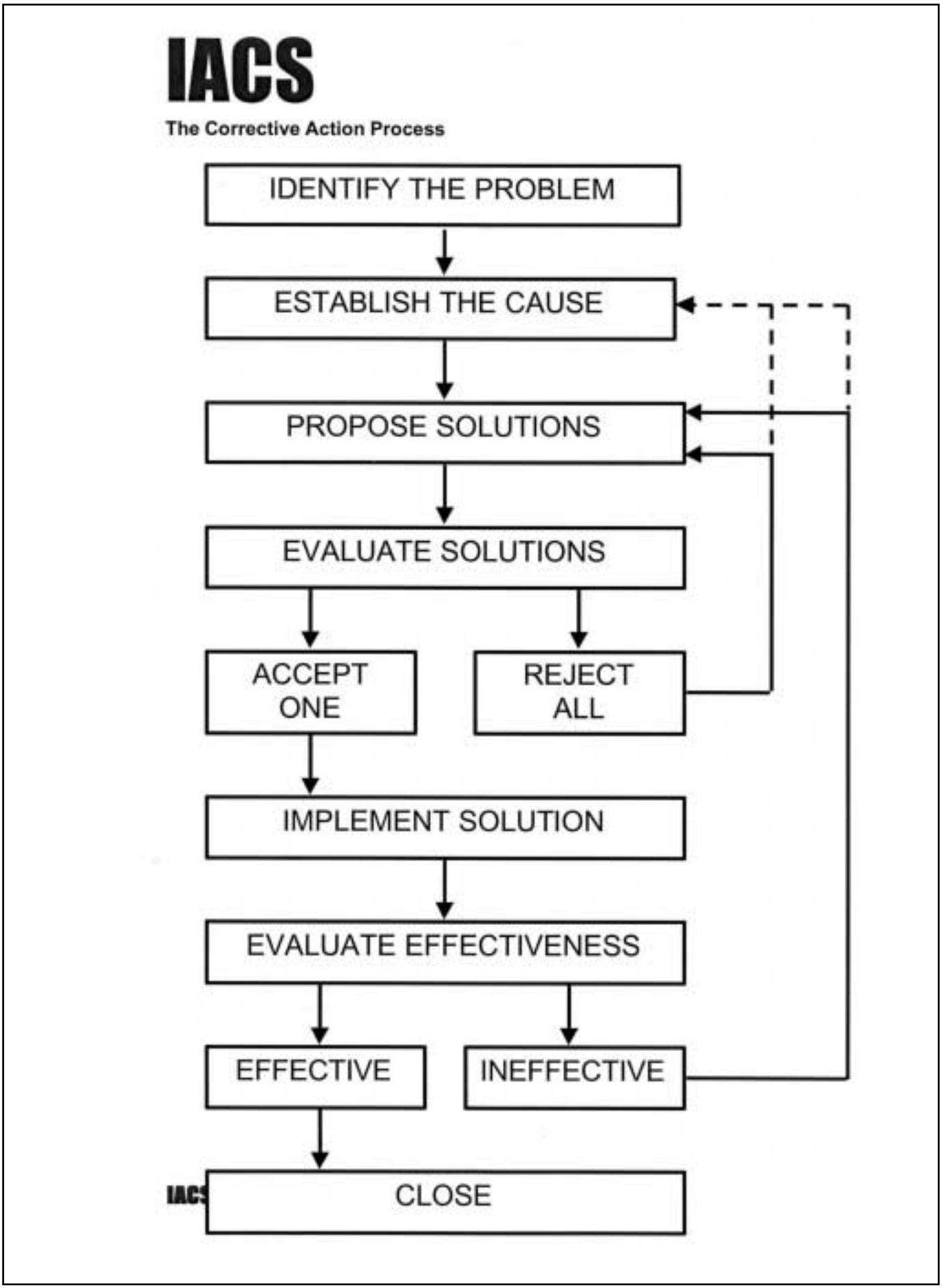
In the view of IACS, the definition of a 'non conformity' as used in section 10.2 of the Code, should be taken as a technical deficiency which is a defect in, or failure in the operation of, a part of the ship's structure or its machinery, equipment or fittings. It further states:

Problems reported may be discovered during routine technical inspections or maintenance, following a breakdown or an accident, or at any other time.

The fundamental elements of an effective defect or non-conformity investigation process are shown in the following diagram **(Figure 22)**. *Note that it is not enough simply to take corrective action. The effectiveness of such action must be verified.*

The Company should also take into account the following when developing and improving maintenance procedures:

1. *The maintenance recommendations and specifications of the equipment manufacturer;*
2. *the history of the equipment, including failures, defects and damage, and the corresponding remedial action;*
3. *the result of third party inspections;*
4. *the age of the ship;*
5. *identified critical equipment or systems;*
6. *the consequences of the failure of the equipment on the safe operation of the ship.*


IACS
The Corrective Action Process
IDENTIFY THE PROBLEM
ESTABLISH THE CAUSE
PROPOSE SOLUTIONS
EVALUATE SOLUTIONS
ACCEPT ONE
REJECT ALL
IMPLEMENT SOLUTION
EVALUATE EFFECTIVENESS
EFFECTIVE
INEFFECTIVE
IACS
CLOSE

In section 3, What Records Should Be Kept, it also states:

> *For example, the appropriate analysis of records of inspections, defects, non-conformities and corrective actions may yield information that could lead to changes in inspection and planned maintenance intervals, thereby reducing unnecessary work and the frequency of failures. The same analysis could permit the identification of trends or repetitive problems that require further investigation and longer-term solutions.*

The computerised planned maintenance systems of the previous owner, Stena AB, and P&O Ferries Ltd were incompatible, so the Stena AB system was downloaded to a printed format and kept on board prior to the introduction of the P&O system.

Several incidents of cracking of the hull structure for the bow doors were recorded in the P&O planned maintenance system, and MCA Dover was aware of a history of cracks to the bow door support structure. However, because various areas of survey and inspection had been delegated to Lloyd's Register, the MCA did not involve itself further.

The ISM certification of *Pride of Provence* was dealt with completely by the MCA, and no aspects were undertaken by Lloyd's Register.

1.18 IACS PROCEDURAL REQUIREMENTS

Transfer of Class

P&OSL Provence transferred Class from Det Norske Veritas (DNV) to Lloyd's Register (LRS) in 2000.

Before 2002, there was no requirement for Classification Societies to forward anything more than plan documents after vessels transferred Class.

However, in 2002, as a result of the *Leros Strength* incident, IACS Procedural Requirement 1A (PR1A): *Transfer of Class, Suspension of Class, Reassignment of Class and Class Withdrawal and Reporting of Changes in Class Status* – 2000, was revised. Since then, all vessel survey history can be reviewed by the gaining Society to update their records accordingly. In the case of *P&OSL Provence* this included UR S-16 compliance documentation, although it did not include on board vessel maintenance records.

In light of incidents such as *Erika,* IACS has discussed the possibility of retrospective implementation of PR1A. However, due to the range and incompatibility of history reporting systems between companies, and also between Class Societies, it was decided that this was too difficult to organise and implement.

IACS Early Warning System (EWS)

The objective of *IACS Procedural Requirements No.2: Procedure for Failure Incident Reporting and Early Warning of Serious Failure Incidents – IACS Early Warning System* – EWS 1993/Rev.3 2001 **(Annex 1)** is:

> *To improve ship safety and protection of the marine environment by providing information on incidents of* hull *failures …… which are considered to have endangered the ship, or its personnel, or posed a threat to the environment and where* sister *or* similar *ships exist that could be at risk. The information regarding such failures is to be provided to other IACS Societies, and other relevant parties as stipulated herein, with a view to reducing the likelihood of their reoccurrence.*

Lloyd's Register did not use the prescribed Early Warning System (EWS) on *Pride of Provence,* because IACS members were informed at the higher Council level and provided with a proposal to review UR S-16. The EWS was also not used after the incident to *Stena Germanica*.

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 to prevent similar accidents occurring in the future.

2.2 THE CAUSE OF THE HINGE PLATE FAILURE

The failed hinge plate was removed and disposed of after the incident; this is unfortunate, because it would have been of benefit to any investigation. That this was done without consideration for any potential investigation into what was a serious structural failure, raises questions about how the Shipping Company, and the Classification Society, evaluate and pursue such matters.

Although P&O Ferries had initiated enquiries with the door manufacturer, had MAIB not decided to investigate the incident some weeks after the event, it appears highly unlikely that any serious consideration of the causes of the hinge plate failure, and other related problems, would have occurred. Shipping companies and Classification Societies should not wait for MAIB or any other Flag Administration investigation body to initiate an enquiry when a serious, or potentially serious, incident has occurred.

2.2.1 Loading cases

In considering the possible causes of the hinge plate failure, the MAIB examined a number of loading cases, including the following:

1. Wave loading

   When the doors were closed and the vessel was underway, heavy weather would have caused loading of the doors. Supports around the bow doors were greatly increased as a result of the work necessary to comply with UR S-16. These supports were fitted to prevent the doors being pushed inwards and upwards by wave pressure. In order for the supports to work efficiently, it was necessary for the doors to sit neatly on them when closed. If there were small gaps between supports and the matching seats at the aft end of the starboard door, wave load forces could be transmitted from the doors into the hull via the hinges.

2. Compression of seals

   The doors were fitted with rubber seals around their perimeters, which were compressed when the doors were closed. Compression of up to 40mm has been reported. The door manufacturer has stated that the compression should be about 8mm. The extra compression would have caused an extra force acting to push the doors off.

3. Closing operation

   When the doors met at the end of the closing operation, the full thrust of the hydraulic rams was used to hold the doors together until the cleats were fully engaged.

4. Doors open

   The 20 tonne weight of each door hung on the hinges when the door was open. This loading would be increased and decreased in cycles, by vibration, and vessel motion. Also cycling could be caused by wash waves from passing vessels, vibration from the bow thrusters, and heavy vehicles bouncing over the treads on the ramp. Cycling could increase the effect of the door weight. The effect of wind on the open doors could also load the hinges.

5. Starboard door in contact with the "cowcatcher"

   When MAIB inspectors visited *Pride of Provence* on 26 May 2004, they noted that the starboard bow door was in contact with the "cowcatcher" when it was open **(Figure 23)**. On the port side, there was clearance between the door and the "cowcatcher". They saw no significant damage on the door or the "cowcatcher" at the point of contact, but this was not surprising as the door opened slowly.

   The "cowcatcher" prevented the starboard door from opening fully. At this point in the door opening sequence, with some travel left, the hydraulic ram was exerting its full force on the surrounding structure.

A thorough examination of these loading cases showed that the last one mentioned, case 5, involving contact with the "cowcatcher", was the only case that fitted all the evidence. The main evidence that supports this loading case is as follows:

1. The way the top hinge failed:

   The evidence indicates that the door appeared to fail at the beginning of a closing operation. The door dropped as soon as the operating lever was moved. The door was not under excessive load at that time. It is assumed that the actual failure of the top hinge did not occur at this time. The MAIB believes that it occurred when the door was opened after *Pride of Provence* arrived in Calais. The door was opened as usual, and when the hydraulic ram was nearly at the end of its travel, the door contacted the "cowcatcher". The full thrust of the ram then fractured the hinge plate. The door would not have dropped down at that time because it was resting against the "cowcatcher", and was being held there by the pressure in the hydraulic ram. The failed top hinge was only noticed at the start of the closing operation when the ram began to retract.

2. Damage to other areas around the starboard hydraulic ram:

   When the hydraulic ram exerted its full thrust, this was absorbed by the pivots at each end of the ram, the hinges, and to a lesser extent the contact between the door and the "cowcatcher". The lever between the ram and the contact point is relatively large, compared to the lever between the ram and the hinges. Cracks had been found on a number of occasions in the structure of the vessel adjacent to the starboard bow door, which supported

the aft end of the hydraulic ram. During the refit on the Tyne, it was noticed that there was ovality in the forward ram pivot, which indicated that this structure had also been overloaded. The bearing in the top hinge was known to wear quickly.

3. Port outer bow door:

   There were no similar problems with the structure surrounding the top hinge of the port door and its associated hydraulic ram. Also the top hinge bearing did not wear as quickly.

4. Metallurgical examination and structural calculations:

   A metallurgist has examined photographs of the failed hinge plate. In his opinion, the failure is consistent with a high stress, low number of cycles, fatigue failure. Structural calculations have been undertaken for the load case described; the stresses in the hinge plate are as would be expected for this type of failure.

2.2.2 The contact with the “cowcatcher”

The “cowcatcher” was added in 1996 **(Figure 1)**, some time after the vessel was built. It was therefore not considered a factor in the original design and fitting of the bow doors. The structure of the “cowcatcher” was intended to have been welded to the vessel such that it cleared the open bow doors. This was almost certainly the case on the port side, but the starboard door might have been contacting the “cowcatcher” from the time it was fitted.

A crew member recalled that the starboard door had been contacting the “cowcatcher” ever since he had been operating the doors, which was over 12 months before the incident. Another crew member recalled that the contact had been occurring since 1999.

The “cowcatcher” is attached to the upper bow structure of the vessel by fairly crude box sections, and foil sections attach the “cowcatcher” to the bulbous bow. Although these sections are of substantial construction, it would be possible for the “cowcatcher” to be distorted towards the port side if hit on the starboard side. The degree of distortion required for the bow door to make contact with the “cowcatcher” is quite small, and would not be readily apparent during visual inspection of the structure. Had any offset occurred to the “cowcatcher”, this could have been caused during a berthing operation.

It is possible that the hydraulic ram on the starboard side was changed or modified some time after 1996, such that the travel increased. This could also have caused the door to contact the “cowcatcher”.

Alternatively, the frequent operations of the bow door on the Dover/Calais route caused wear or movement in the door mechanism which, in turn, could have caused the misalignment necessary for the door to make contact with the “cowcatcher”. After the incident, the door manufacturers indicated that the frequency of the hinge bearing replacement on *Pride of Provence* was

excessive. Records indicate that the starboard door was hanging lower than the port one as far back as 1999, although it is understood that door alignment checks were carried out at the yearly refits. The door was also noted to be hanging lower the day before the hinge failure.

The first record of cracking in the structure around the aft pivot of the starboard hydraulic ram was in October 2002. Cracking would not necessarily have been immediately apparent once the starboard door started contacting the "cowcatcher", but, if these structural problems began in 2002, it is unlikely that the contact was present as far back as 1996; it is more likely to have started around 1999 or 2000. The starboard door would have been opened in the region of 7,000 times since 1999/2000, and the hinge plate would have experienced this number of stress cycles. In respect of fatigue, this is not a high number of cycles. Corrosion would have hastened the propagation of the cracks and, hence, the failure.

Figure 23 shows the starboard door contacting the "cowcatcher" on 26 May 2004, which was after the hinge plate had been repaired. Structural problems persisted with the aft pivot of the hydraulic ram until July 2004, when the stroke of the hydraulic ram was shortened.

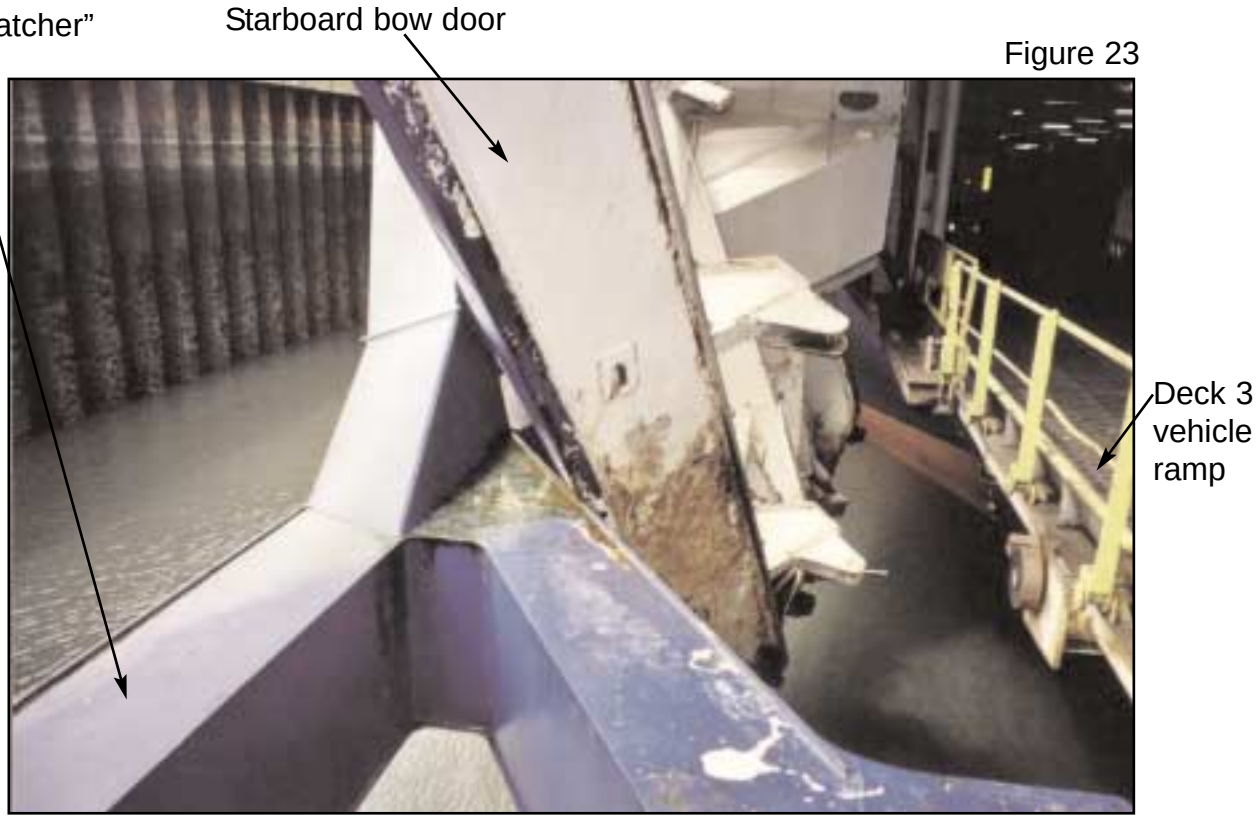


Figure 23

Starboard bow door in contact with "cowcatcher"

2.2.3 Structural calculations

A diagram of the starboard outer bow door in the closed position is shown in **Figure 24**. A diagram of the door in the open position is shown in **Figure 25**. Contact with the “cowcatcher” prevents the hydraulic ram reaching its full extension. Structure around the pivots of the ram, and the hinge plate, were overloaded in this situation. A detailed drawing of the hinge plate is shown in **Figure 26**. Referring to this figure, the image on the right is a view of the hinge plate and its stiffener looking from forward. Another detailed drawing of the hinge plate is shown in **Figure 27**. The cracking, which was the origin of the fracture, is shown; a section through the hinge plate and stiffener at this point is included.

A consultant structural engineering company compiled a finite element model of the starboard door. The hinge plate and the adjacent structure of the hinge arm were modelled accurately. The structure below this, down to the bottom hinge, was modelled fairly accurately. The rest of the hinge arm and the door were modelled with simple elements. The hinges and the point of contact between the door and the “cowcatcher” were restrained appropriately. The forces on the model from the hydraulic ram and the weight of the door were input.

Stress plots of the hinge plate and the adjacent structure of the hinge arm were produced. The highest stress is shown in red, and was located under the hinge plate next to the corner of the door arm **(Figure 28)**. The hinge plate was made from Grade A steel, which has a minimum specified yield stress of 235 Newtons per square millimetre (N/mm^2). Using the legend, the red area indicates that the stress is close to yield. The stress at the edge of the hinge plate was up to 147 N/mm^2. The results of the finite element analysis looking down on the hinge plate are shown in **Figure 29**, the stress in the radius of the stiffener was up to 74 N/mm^2.

There was also a high stress area where the forward edge of the hinge plate abuts the door arm, but no cracking had been reported there.

2.2.4 Metallurgical examination

A consultant metallurgist has examined the photographs of the cracks **(Figures 14 & 15)**, and the fracture **(Figures 9 & 10)**. He was also informed about the stress levels. His advice is included in the following description of the probable failure mechanism.

Figure 15 shows spike marks indicating that someone has attempted to chip the paint away from the cracks. The paint close to the cracks has chipped away because the paint had become separated from the steel. Corrosion of the steel is evidence of this separation. When steel is under high stress, which is less than the yield stress, it deforms elastically; such deformation would be enough to cause separation of paint coatings. The paint has separated close to the cracks, indicating that the steel in this area has suffered high stress levels.

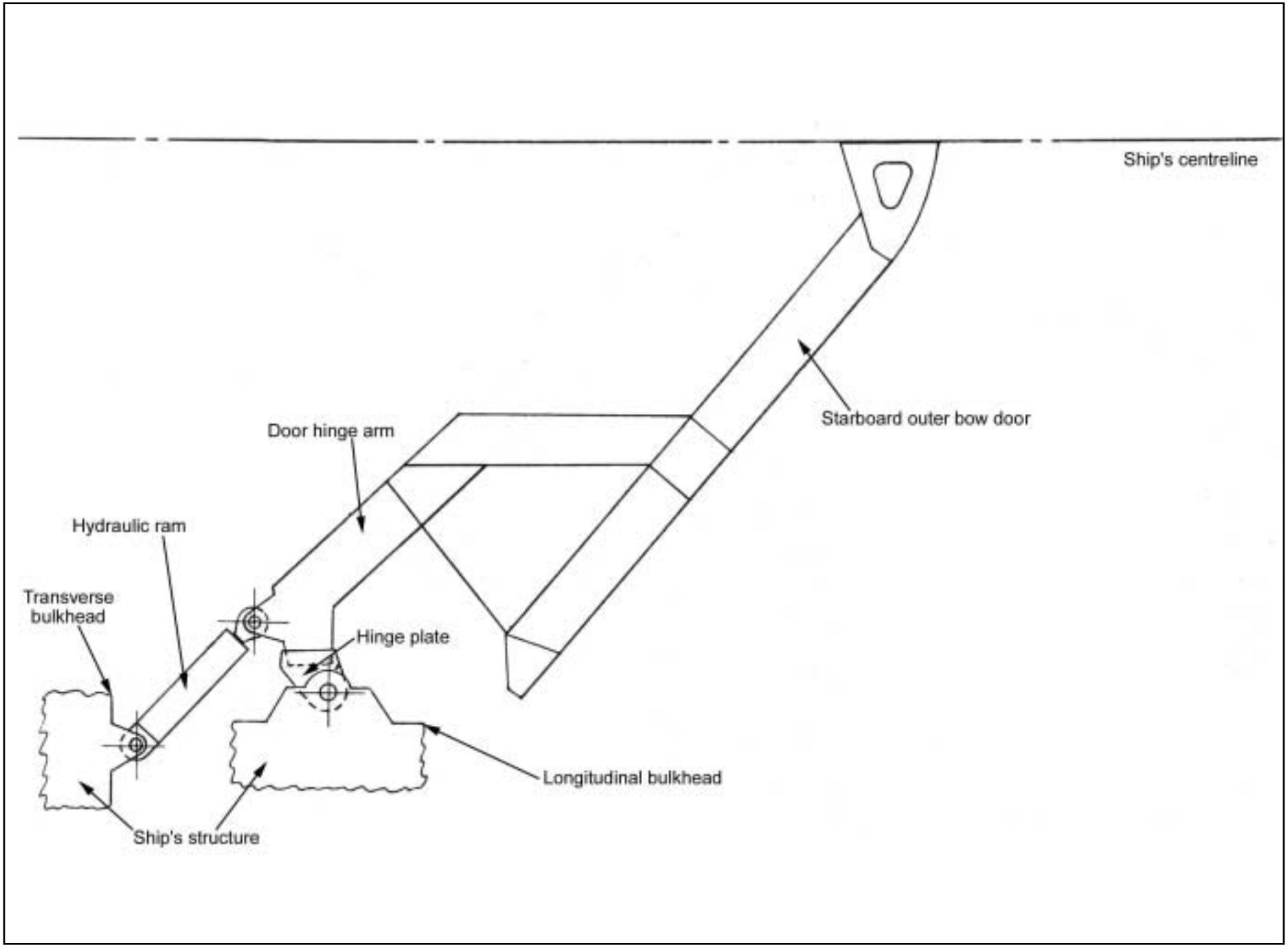


Figure 24

Diagram of starboard outer bow door looking down on top hinge - door closed

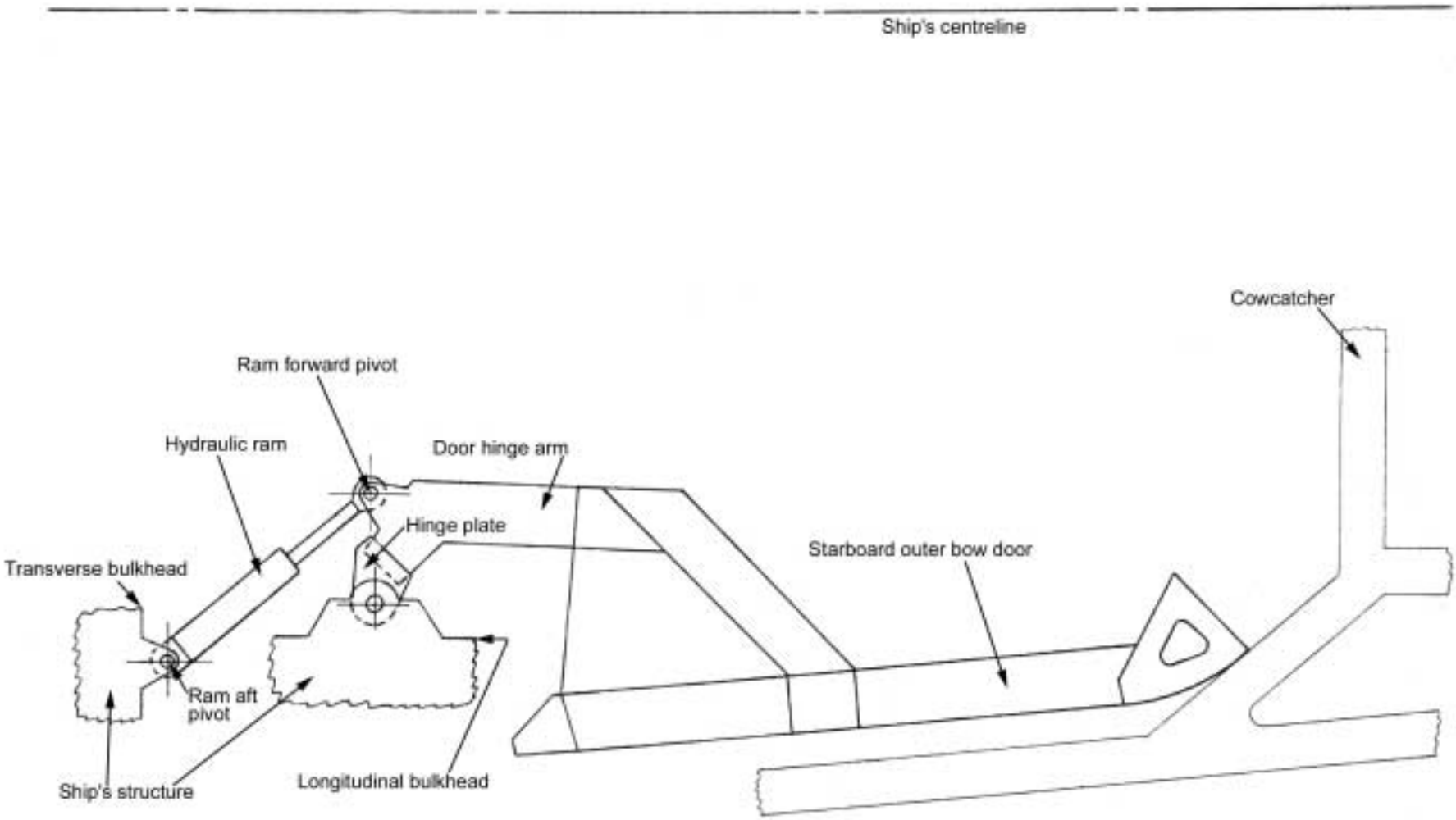


Figure 25

Diagram of starboard outer bow door looking down on top hinge - door open

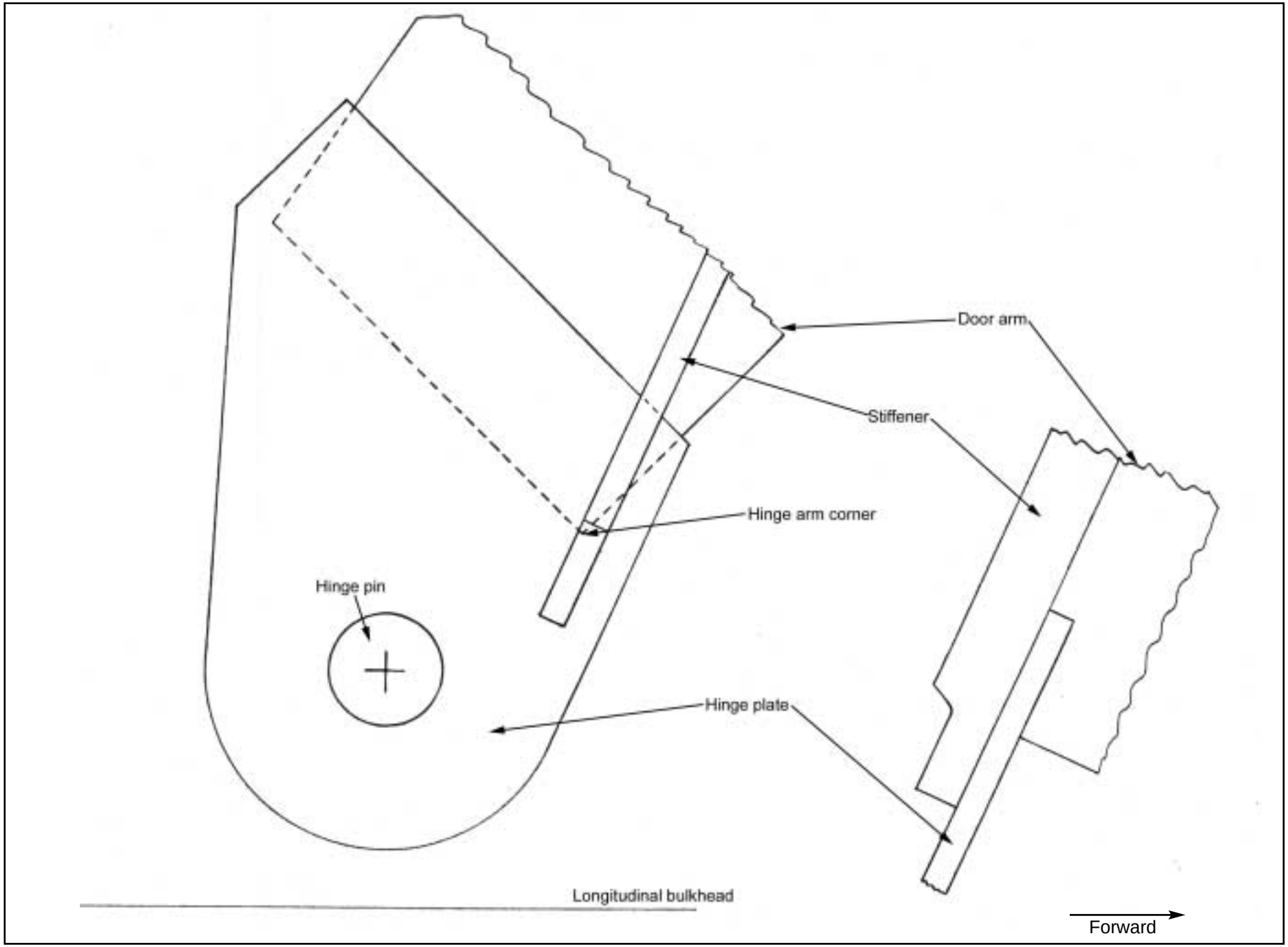
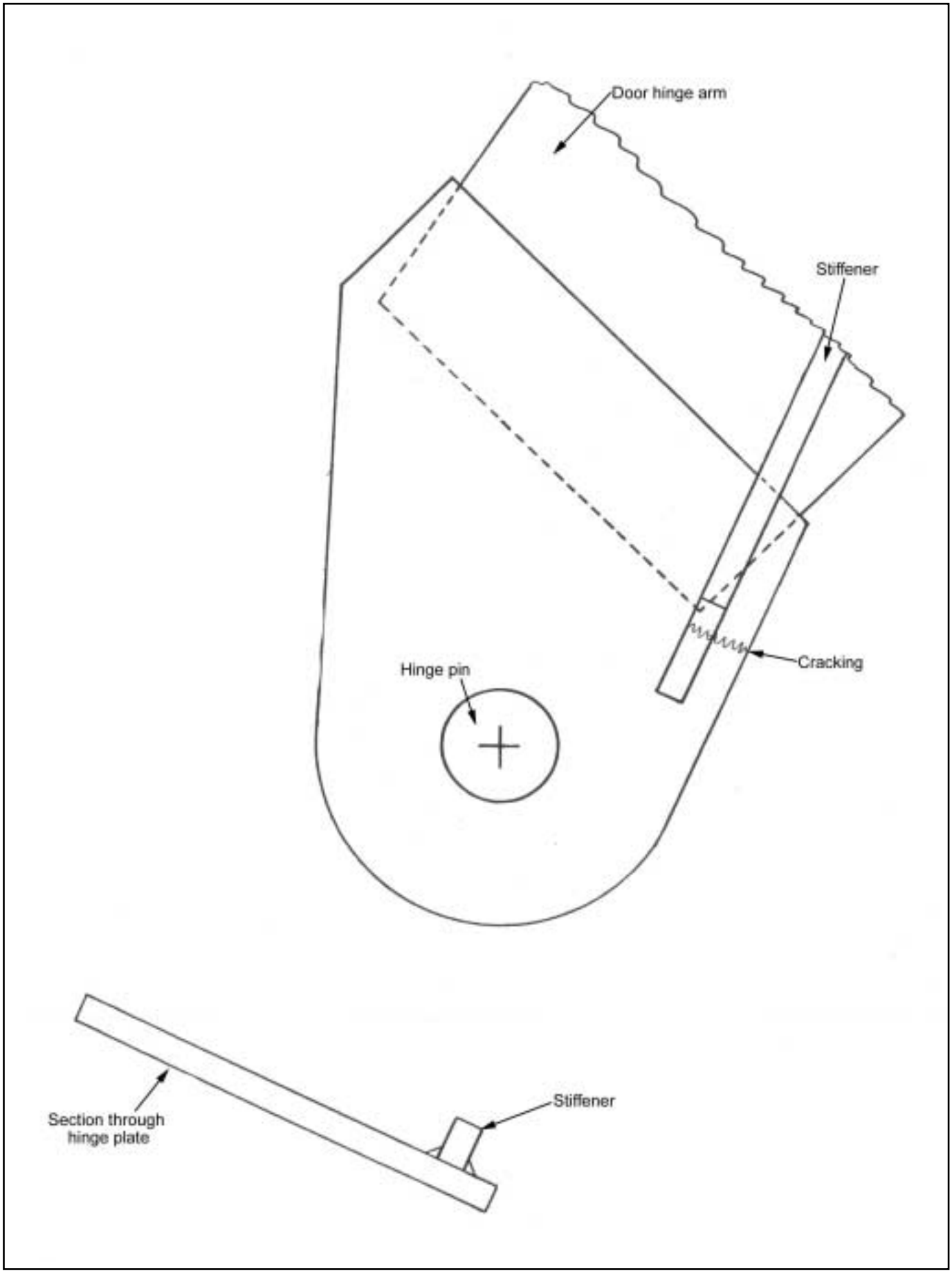
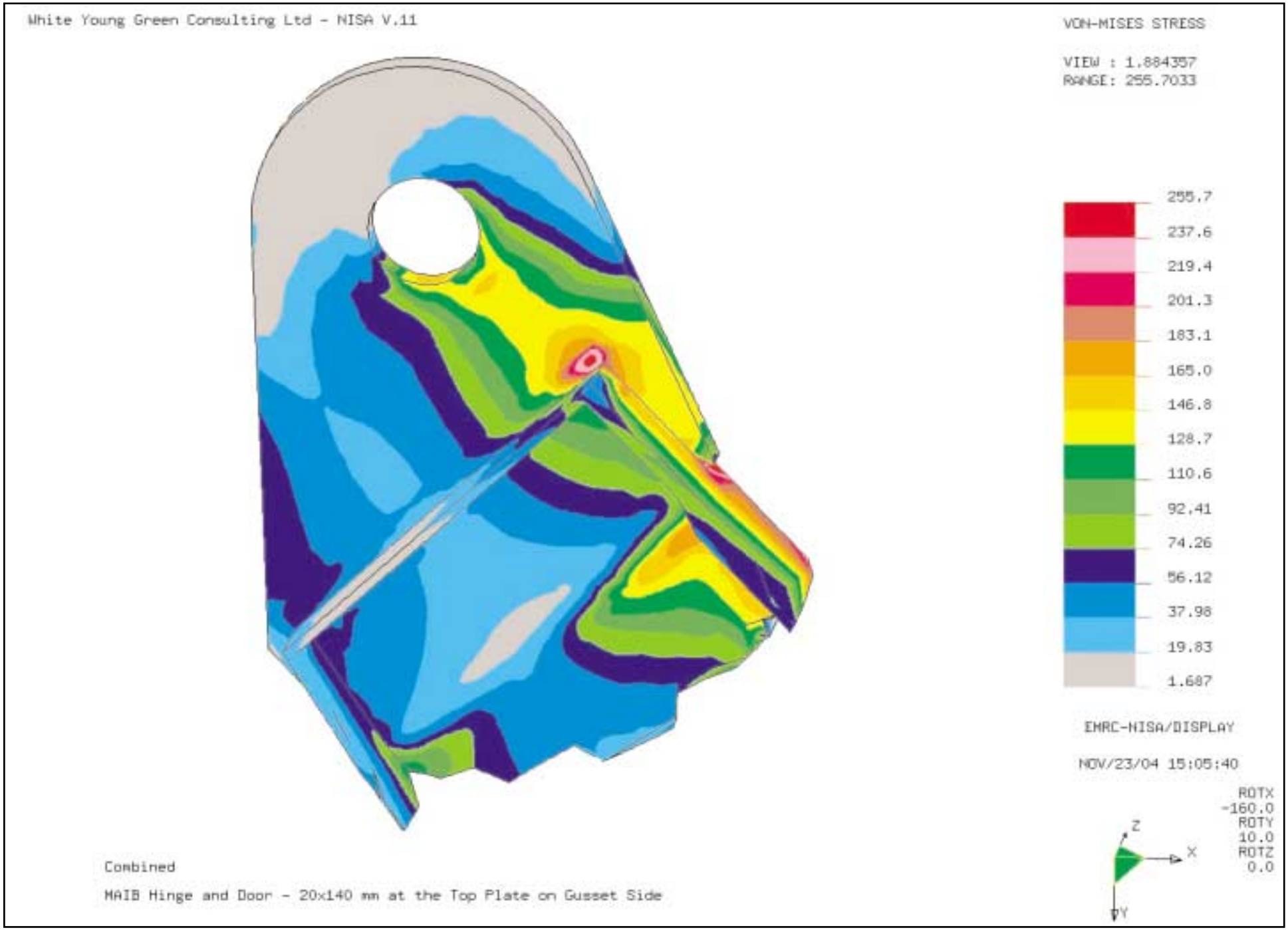


Figure 26

Detailed drawing of the hinge plate



Detailed drawing of the hinge plate



Finite stress analysis of starboard upper bearing hinge plate

Figure 28

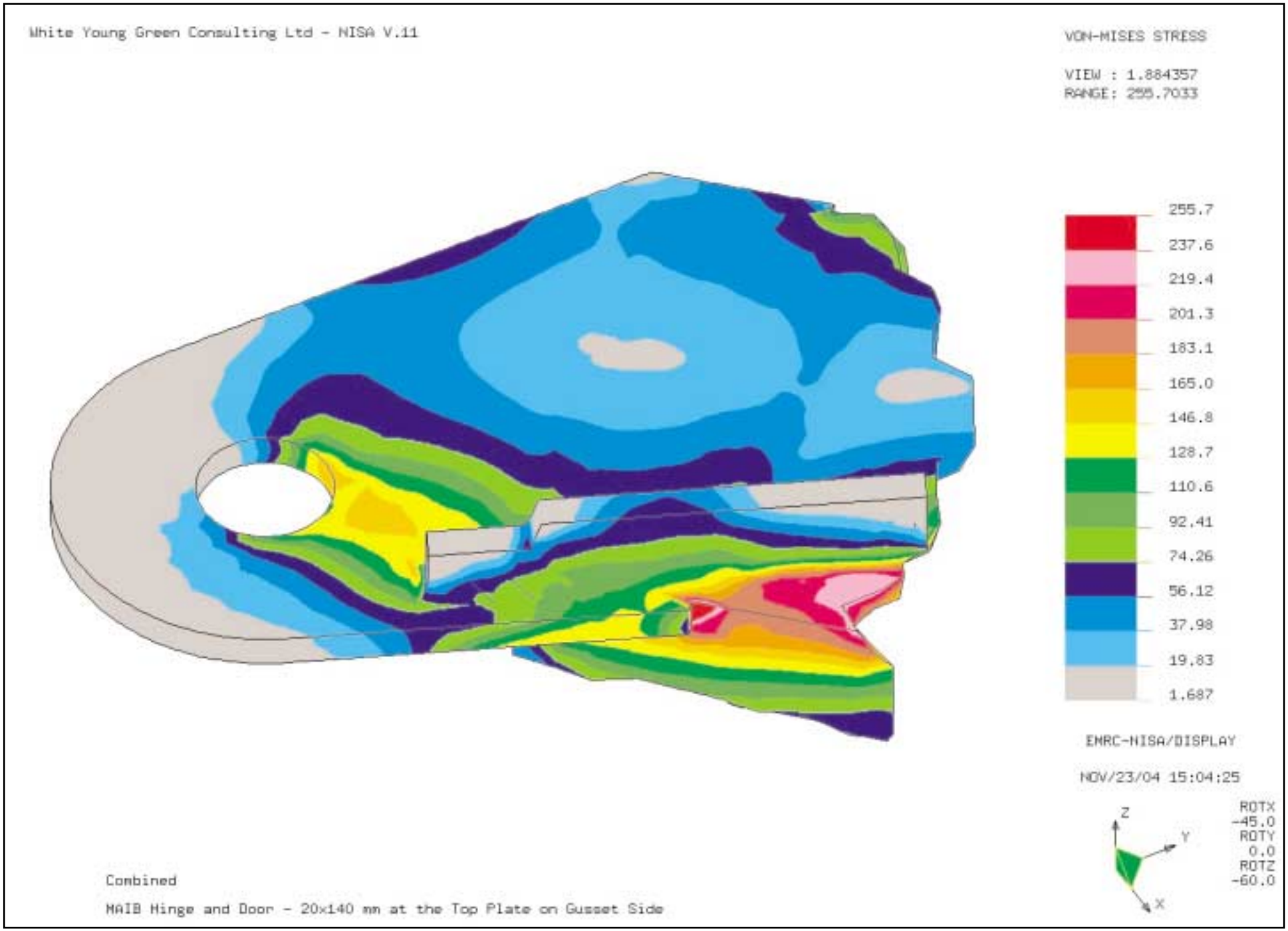


Figure 29

Finite stress analysis of starboard upper bearing hinge plate and stiffener

The silver/grey crystalline areas are the fractures **(Figures 9 & 10)**, which occurred at the time of the failure. The photograph was taken shortly after the incident, so the fractures had insufficient time to rust. The rusted areas show the cracks; these have been open for some time, allowing corrosion to occur.

Three cracks led to the fractures.

The crack on the right side of the picture is semi-circular in shape, although one side is hidden. The middle of this area is adjacent to the corner of the hinge arm **(Figure 26)**, which was identified as being subject to stress close to yield by the structural calculations. The crack began in the underside of the hinge plate, possibly in a weld defect. A stress cycle occurred each time the hydraulic ram exerted its full force on the hinge plate while trying to fully open the starboar d bow door. The stress cycles slowly spread the crack, increasing the size of its semi-circular shape. The middle of the semi-circle at the bottom is a darker brown, indicating a greater amount of rusting; the corrosion would have had more time to form in this area. The crack spread until the hinge plate was close to failure. The grey area at the edge of the semi-circle is termed a “beach mark”, which is a crack arrest or fatigue mark indicating changing loading conditions. This area shows a substantial increase in the size of the crack, probably during the stress cycle immediately before the one that caused the failure. This grey area has had insufficient time to corrode.

The underside of the edge of the hinge plate was subject to a stress level of up to 147 N/mm^2. The second crack was initiated at this position. A high stress level would be expected here because it is furthest from the neutral axis on this side of the cross-section. A crack could have started, especially if there was a notch in the edge of the plate. A notch could have been made by a steelworker’s tool for instance. The dark brown area **(Figure 10)** covering the edge of the hinge plate and spreading to the high stress area by the hinge arm corner, shows this crack. A diagonal line is apparent between the dark brown area and a slightly lighter area above.

The third crack started where the radius in the stiffener began. The radius in the stiffener was roughly flame cut; this surface showed signs of “fluting”. The grooves caused by the burning torch formed stress concentrations, which would enable a crack to initiate at a mean stress level well below the yield stress of the material. The heat input by the burning torch could also help to initiate a crack. The structural calculations indicate that the stress in this area was up to 74 N/mm^2. This crack started to spread down as shown by the dark brown area at the top of the stiffener **(Figure 10)**.

The area between the second and third cracks does not exhibit strong signs of rusting. This indicates that these two cracks converged shortly before the failure. Once these two cracks had combined, the amount of material holding the hinge plate together at this section was substantially reduced. This

combined crack met the first crack by way of the round silver/grey crystalline area in the middle of **Figure 10**. Beach marks can be seen at the edges of this round area, which probably formed during the stress cycle immediately before the incident. Once the round shaped fracture was complete, the hinge plate failed and the fracture extended across the rest of the cross-section.

2.2.5 Conclusion - the cause of the hinge failure

The MAIB believes that the starboard door made contact with the “cowcatcher” before the operating cylinder had reached its full extension. The door was prevented from opening fully, and, in this situation, the operating cylinder exerted its full operating pressure of 175 bar. In this situation, the hydraulic ram provided a thrust of about 89 tonnes, leading to excessive loading around the area of the cracking. The hinge plate was not designed to cope with this level of additional loading.

On 5 July 2004, 5 months after the incident, the stroke of the operating ram was shortened to prevent further contact between the starboard door and the “cowcatcher”.

2.3 THE FAILURE TO CARRY OUT NDT TESTS IN THE REFIT

NDT tests of the hinge plates were not included in the refit specification. However, NDT tests covering the attachment of the cheek plates either side of the hinge plate to the hull were included. Due to an oversight, this work was not carried out. Had the tests taken place, the cracks, which were nearby, might have been noticed, assuming they were present at that time.

The weaknesses in the reporting lines from the sub-contractor through A&P Tyne to P&O Ferries Ltd allowed the omission of this work to go unnoticed. Ship’s staff that were overseeing the refit failed to notice that the tests had not been carried out, despite the fact that the NDT method (MPI) employed used white paint on the components being analysed. P&O Ferries Ltd was unaware of the omission until after the failure of the hinge plate on 22 February, when requests for the NDT report for the bow door structure could not be provided.

2.4 SAFETY MANAGEMENT

Cracks were first noticed in the starboard hydraulic ram support structure in October 2002; other problems in this area were also identified subsequently. Prediction of the failure of the hinge plate could only have been made if these problems had been looked at in a holistic way, and suitable investigations initiated to determine why they were occurring.

The components around the hinge plate gave warning that stresses, beyond the design capabilities, were occurring. These included the cracking around the aft ram pivot, high bearing wear on both the hinge bearings and operating cylinder bearings, renewal of pivot pins and ovality of forward pivot cheek plates. All of these defects were noted in the planned maintenance history records on board.

Sections of the ISM Code incorporate the need not only for procedures to be in place for reporting, investigating and analysing incidents, but also the implementation of corrective action, with the objective of improving safety and pollution prevention.

If the relevant sections in the ISM Code had been followed, a report detailing the incidents of cracking and the contact between “cowcatcher” and door that had occurred over a period, would have been prepared. This might have prompted the owners to either investigate further or request the Classification Society to assist them. Corrective action might then have been implemented.

The chances of this happening would have increased if the bow doors and associated equipment had been identified as critical equipment, at the time of failure, within the meaning of the ISM Code. MAIB is concerned that cracks in the starboard ram support structure were repeatedly welded without a full appraisal of why these were occurring.

Although P&O Ferries Ltd carried out an investigation into the failure, MAIB is not aware of the depth of any investigation by Lloyd’s Register to try to identify the underlying cause of the problems surrounding the starboard bow door upper hinge. Neither Lloyd’s Register, nor P&O Ferries Ltd, carried out an in-depth investigation, even when the problems persisted after the hinge plate was repaired.

2.5 THE LLOYD’S REGISTER SURVEY ON 17 FEBRUARY

The Lloyd’s surveyor appeared to approach the inspection of the top hinge of the starboard door in a conscientious and professional manner. He prepared for the task by reading Lloyd’s records about *Pride of Provence*. If the records had contained references to incidents of cracking in the area of the bow doors, this might have influenced his decision about the course of action that needed to be taken.

The surveyor felt that no meaningful NDT testing could have been carried out until the hinge was stripped down to allow better access. However, the MAIB believes that some NDT testing should have been attempted; this might have given an indication of how far the cracks had extended.

The surveyor was of the opinion that, despite the crack in the hinge plate, there was no risk of the starboard bow door falling off once it was secured closed. He believed that UR S-16 contained adequate requirements to prevent bow doors falling outwards.

Compliance with UR S-16 meant that substantial reinforcement had been carried out to prevent the bow doors being pushed inwards and upwards. For these measures to be fully effective, the bow doors had to sit squarely on the supports fitted to the surrounding structure. However, wave loads on the doors

would be transmitted into the hull via the hinges, if there were gaps between the doors and the UR S-16 supports. In this situation, a hinge could fail under wave loading and then be able to drop out. This possibility was realised in 2000 on *Stena Danica*, and in 2002 on *Stena Germanica*, and was the reason that extra locking devices were fitted on these two vessels.

The starboard door on *Pride of Provence* was only held in place by the hinges at the aft end and the cleats at the forward end. The top hinge was therefore a critical securing device to prevent the starboard door falling off. Had the surveyor realised this, it is unlikely that he would have issued a Condition of Class allowing the vessel to carry on sailing until the end of February.

The surveyor assumed that the defect in the upper hinge could not lead to the starboard bow door failing at sea, but in the time that he had available for the survey he could not have been sure of this. With the benefit of hindsight, a better course of action would have been to have taken *Pride of Provence* out of service immediately, or to allow her to sail for one voyage only as the weather was forecast to be calm for the rest of 17 February. The surveyor could have authorised further individual round trips if he could satisfy himself that the weather was going to continue to stay calm. The other option was to temporarily weld the outer bow doors shut, and use the stern doors only.

MAIB considers that surveyors should refer significant defects in bow doors to classification society headquarters for advice and direction. Surveyors should prevent ro-ro passenger ferries from sailing if any doubt exists that a defect in a bow door component could put the vessel at risk.

2.6 MCA INVOLVEMENT

Although the MCA's Dover office were aware that the vessel had suffered some cracking problems in the bow door structure, they did not become directly involved. The MCA had delegated survey items, such as hull and machinery, to the Classification Society. As such, they were confident that the Classification Society would take appropriate measures, and were informed by Lloyd's Register that suitable action would be taken. The MCA did not visit the vessel even after the starboard bow door upper hinge failed.

Bow doors are critical items of equipment, and their failure has potentially very serious consequences. Once the failure of the hinge plate had occurred, the involvement of MCA should have been automatic, to ensure that all avenues to determine the causal factor had been exhausted, to prevent a re-occurrence.

Additionally, MCA involvement might have highlighted the need to inform other Flag states of the incident.

2.7 IACS EARLY WARNING SYSTEM (EWS)

Even if the initial cracks on the starboard door upper hinge could not be construed as a major structural failure, the failure of the hinge plate on 22 February certainly could.

Lloyd's Register did not use the Early Warning System (EWS) in this instance, as they had informed IACS Council members of the problem **(Annex 1)**. The failure was not considered to be a universal problem, and it appeared to be relevant to DNV, LRS and Stena AB only. However, it is unclear how many other vessels are operating with similar bow doors.

An earlier opportunity to use EWS, and therefore possibly clarify UR S-8 & S-16, occurred after the incident to *Stena Germanica.* Had it been implemented, this might have highlighted to the operators of *P&OSL Provence* the importance of the locking wedges that were no longer fitted.

It is considered that both these instances were of sufficient importance for the EWS to have been activated. Classification Societies should not hesitate to use the EWS when failures of critical components on bow doors occur.

2.8 LOCKING WEDGES

MAIB has been unable to determine exactly when or why the three door locking wedges were removed however, it is possible that they were removed as early as 1984 due to difficulties encountered in the operating sequence of the wedges and centreline cleats.

Before 2002, only plan drawings of a vessel were required to be transferred during a change of Classification Society. Since 2002, survey history records should be made available to the gaining Society. It appears that no record has been made of the removal of the locking wedges in DNV records, it is unclear if DNV even knew about the removal. The issue of the transfer of survey records to LRS, when the vessel changed Class in 2000, is therefore irrelevant in this instance.

The survey carried out by LRS in 2000, before accepting the vessel, does not note that the bow door locking devices were missing. As with the DNV survey in 1996, this appears to indicate that the need for redundancy in the door securing arrangements according to the Unified Requirements was not adequately applied by the attending surveyors.

The modification to *Stena Danica* in 2000, was an opportunity for the absence of the original locking wedges on *P&OSL Provence* to be highlighted. Had new locking wedges, similar to those fitted to *Stena Danica*, been fitted on *Pride of Provence*, the doors' security would have been improved. The new locking wedges would have reduced the opportunity for the door to fall off if the starboard door hinge had failed while on passage.

The two Baltic Sea vessels *Stena Germanica* and *Stena Scandinavica* were classed with Lloyd's Register and modified in 2002. Although Lloyd's Register had taken over the Classification of *P&OSL Provence* in 2000, the modifications carried out on these other ro-ro passenger ferries classed with them were not considered for *P&OSL Provence.* The decisions on these modifications appear to have been taken locally, without consideration of similar problems occurring on other similar vessels elsewhere.

The refitting of locking wedges in 2002, to *Stena Germanica* and her sistership, was a second opportunity for the lesson to be learnt.

Had the modification been carried out on *Pride of Provence* before the cracked door hinge was discovered, the reasons provided by the Lloyd's Register surveyor who attended the vessel on 17 February 2004, to allow the vessel to sail, would have been more fully justified. As it was, the vessel was allowed to sail with a fracture in a main hinge component, without any redundancy being in place should the hinge have failed while the vessel was at sea.

2.9 THE ADEQUACY OF IACS UR S-8 AND S-16

IACS Unified Requirement S-16, and its precursor S-8 for new builds, mainly consider external wave loading and measures to limit door movement while the doors are closed and locked and the vessel is at sea. Less consideration appears to be given to preventing the doors from falling outward should hinge failure occur while the vessel is at sea.

UR S-8.6.2f mentions the need for redundancy in the securing and supporting devices. Had the hinge failed on *Pride of Provence* while the vessel was at sea, it is difficult to deduce what remaining components provided the degree of redundancy to prevent the door from falling outwards.

Modifications to *Pride of Provence* (then *Stena Empereur*) in Bremerhaven in 1996 were made to comply with UR S-16. These modifications involved fitting fixed male/female reinforcements for dispersing sea load forces through to the hull structure. They do not include any specific requirement for a method to prevent the doors falling out, should the hinges or other locking devices fail. When the doors are cleated at the front and wedged top and bottom, the hinges should play no part in the door securing arrangement. However, without the locking wedges, the hinges play an integral part in retaining the doors at sea.

The bow door manufacturers, MacGregor, probably considered the issue of how effective IACS unified requirements for bow doors were in 2000 after the heavy weather damage to *Stena Danica*. It appears that this consideration was not made widely available to the ro-ro ferry industry or to IACS members. The equipment manufacturer should promulgate information about modifications carried out to critical shipboard equipment, to the owners of all vessels fitted with similar equipment and also to IACS via the relevant Classification Society.

MacGregor's view is that locking wedges are important devices to keep the doors engaged and prevent them falling out. The original locking wedges on *Pride of Provence* were not, according to MacGregor, mounted in the best position to retain the doors should hinge failure occur, compared to those refitted on *Stena Danica.* However, their inclusion would have been better than no wedges at all.

If the bow door securing arrangements contained within Lloyd's Register Rules of 2002, are interpreted as requiring more than one device to be provided to prevent the bow door from failing, then the inspections of the bow door arrangement of *Pride of Provence*, carried out by Lloyd's Register, are questionable, as *Pride of Provence* did not comply with this interpretation.

Alternatively, this could also indicate that the Lloyd's Register Rules, which almost mirror IACS Unified Requirements, are also unclear and do not give adequate guidance to surveyors.

IACS unified requirements appear to be unclear on the requirement for door securing devices to prevent the doors from falling out, should hinge failure occur, and are, therefore, open to interpretation by each Classification Society.

MAIB is concerned that UR S-16 and, by association, S-8 are not adequate in respect of the redundancy of the securing arrangements for the doors in the closed position, and believes that IACS should revisit these requirements with a view to clarifying this issue.

2.10 COMMUNICATIONS

A common thread to emerge as a result of the investigation, both into the hinge plate failure and the locking wedges, has been poor communications.

MAIB is not aware of communications between Stena AB and DNV regarding the probable removal of the original bow door locking wedges from *Stena Jutlandica* or *Stena Empereur*. As a result, drawings of the bow door hydraulic system, for example, were not updated.

MacGregor's view is that locking wedges are important. Unfortunately, this view does not appear to have permeated through the ro-ro ferry industry, flag administrations or classification societies to the extent that missing securing devices have been questioned during refit surveys or change of Class surveys.

The owners of *Pride of Provence* (P&O Stena Line subsequently P&O Ferries Ltd) were not informed of the locking wedge modifications made to *Stena Danica*, *Stena Germanica or Stena Scandinavica*.

In 2002, after the heavy weather damage suffered by *Stena Germanica*, the Swedish Maritime Safety Inspectorate was so concerned that it contacted Lloyd's Register (Sweden). The two main issues raised were the adequacy of IACS Rules for bow doors, and the possibility of bow doors falling out if hinge failure occurred.

Lloyd's Register (Sweden), in reply, took the issues seriously and listed the measures that would be implemented, including liaising with IACS on any revisions to the bow door Rules. Although Lloyd's Register in London interpreted its existing Rules as sufficient for bow door securing arrangements, this information was not promulgated to the Swedish Administration until November 2004. This inadequate transfer of information concerning a potentially severe incident was a critical failure.

Instigation of the action plan proposed to the Swedish Maritime Safety Inspectorate would have been an opportunity to highlight potential weaknesses in the Unified Requirements for bow doors. In addition, it was an opportunity to publicise the modifications carried out to ro-ro vessels with side opening doors operating in the Kattegatt.

Unless incidents such as occurred to the bow door on *Stena Germanica* and *Pride of Provence* are raised to a suitably high level within maritime organisations, the opportunities to put preventative measures in place are limited.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES

The following safety issues have been identified from the foregoing analysis. They are not listed in any order of priority.

1. The starboard outer bow door upper hinge failed because the door contacted the “cowcatcher” preventing the hydraulic operating cylinder from fully extending. This overloaded the surrounding structure, and over a period of time, resulted in the failure of the hinge plate. [2.2]

2. The failed hinge plate was removed and disposed of after the incident and could not, therefore, be analysed as part of the investigation into the cause of the failure. [2.2]

3. The starboard outer bow door probably started contacting the “cowcatcher” during the year 1999. [2.2.2]

4. The cracking in the hinge plate might have been identified if NDT of the bow door area had been undertaken during the vessel’s last refit. [2.3]

5. Problems with the structure surrounding the starboard bow door hydraulic ram provided adequate warning that overloading was taking place, but this was not recognised by ship staff or management. [2.4]

6. Neither Lloyd’s Register, nor P&O Ferries Ltd, carried out an in-depth investigation into the failure of the hinge plate. [2.4]

7. The surveyor issued a Condition of Class for the vessel on the basis that she complied with IACS UR S-16 and because she had recently undergone refit. Had he arranged for NDT of the crack he would have been better informed to make the decision on whether it was safe for the vessel to continue to operate. [2.5]

8. Although MCA was aware of the incidents of cracking to the vessel’s bow door hull structure, no involvement by the MCA occurred due to the delegation of hull and machinery surveys to the Classification society. MCA was also not involved with the survey after the failure of the door. Because bow doors are critical items of shipboard equipment, MCA should have taken a greater interest in resolving the recurrent incidents of cracking. [2.6]

9. It is possible that, had the IACS Early Warning System (EWS) been enacted after the incident to *Stena Germanica*, the operators of *Pride of Provence* might have become aware of the importance of the locking wedges that were no longer fitted. [2.7]

10. Locking wedges had been removed without the knowledge of the relevant Class Society. Subsequent surveys and inspections of the bow doors did not highlight that locking devices were missing. [2.8]

11. *Pride of Provence* had been certified as being compliant with IACS UR S-16, yet no devices were in place to prevent a bow door falling out should a hinge failure occur. Although the Unified Requirements for bow doors refer to redundancy in the event of failure of a single securing or supporting device, it does not directly specify redundancy to prevent a door falling out. [2.9]

12. Several opportunities arose, to highlight to the ro-ro ferry industry, potential weaknesses in the IACS bow door rules, and also modifications carried out to sister and similar ro-ro vessels. These opportunities were not grasped by the organisations included, due to poor or non-existent communications between them. [2.10]

SECTION 4 - ACTION TAKEN

The following actions have, or are in the process of being, carried out:

- P&O Ferries Ltd has:
  - advised the masters of *Pride of Provence* not to use the bow thrusters when the bow doors are open.
  - shortened the stroke of the starboard bow door hydraulic ram to prevent the door contacting the “cowcatcher”.
  - introduced an additional weekly inspection routine for bow doors by ship’s engineering staff.
  - liaised with Lloyd’s Register and MacGregor (SWE) AB to determine what additional locking devices are required to hold the bow doors in place.
  - included bow doors in the list of critical equipment.
  - commissioned new cleats to be supplied and fitted after being advised by MacGregor (SWE)AB of modifications to the sister vessel.
- Lloyd’s Register has:
  - carried out a survey of the bow structure of *Pride of Provence*.
  - introduced guidelines which require surveyors to report to head office any incidents involving bow doors.
  - revised survey procedures and the associated checklist to include an inspection to determine freedom of movement of bow doors.
  - proposed to IACS that a review of UR S-16 and S-8 is undertaken.
  - compiled a list of other side opening bow door ro-ro vessels classed with Lloyd’s Register to inspect their service histories for similar problems.
- The MCA has:
  - introduced guidelines which require surveyors to report to head office any incidents involving bow doors.
  - instigated discussions with the Recognised Organisations (ROs) to redefine serious conditions of class, reportable to the Agency, which will include bow door deficiencies.
  - introduced attendance at all reported incidents of failure of major components of bow doors.

- IACS has:
  - tasked a working group to collate ro-ro side opening bow door information to ascertain the type and number of damaged supporting and securing arrangements, the causes and repairs carried out to enable requirements to be proposed to avoid recurrence of similar damage and prevent serious consequences should such damage occur. Any amended requirements will apply to both existing ships and new construction. The working group will also consider whether the results from the information collated is applicable to other shell doors and, if so, propose amendments to IACS accordingly.
  - progressed a review of the practical working of the EWS.
- A&P Tyne has:
  - introduced a new Quality Assurance (QA) system in agreement with P&O Ferries Ltd.

SECTION 5 - RECOMMENDATIONS

P&O Ferries Ltd is recommended to:

2004/260 Review and amend existing ISM Code procedures to ensure*:*

- Shore-based managers are notified whenever remedial work on critical equipment is undertaken by ship's staff.

- Measures are established to record and identify trends with respect to defects affecting critical equipment.

2004/261 Establish procedures whereby detailed analysis is undertaken following the failure of any critical equipment or structure, or whenever any critical equipment or structure needs to be repaired on a frequent basis. The analysis should seek to establish the underlying root cause of the problem so that effective remedial action can be determined.

2004/262 Ensure any findings or concerns that may arise as a consequence of the analysis of any defect, or history of defects, affecting critical equipment, are promulgated to the relevant classification society.

Lloyd's Register is recommended to:

2004/263 Advise and assist ship owners and operators to carry out an in-depth investigation when they are informed about the failure of a critical piece of equipment or structure on a ship. The investigation should try to establish the underlying cause of the problem. The same course of action should be taken when informed about a critical item that needs to be repaired frequently.

The **International Association of Classification Societies** is recommended to:

2004/264 Request its members to review their current procedures to ensure that reports on bow door problems, or modifications, are notified to the respective head office so that a detailed record of bow door problems can be maintained and passed on to the succeeding classification society if the vessel transfers Class. This information should be reviewed periodically to ascertain whether further work is needed on the relevant Unified Requirements.

2004/265 Advise its members that surveys and inspections of bow doors should include an inspection of the freedom of movement of the doors to ensure that they do not come into contact with any fixed structure which might lead to excessive loading during operation.

2004/266 Reconsider UR S-16 and UR S-8, with a view to clarifying the requirements for securing devices to prevent bow doors from falling out.

2004/267 Review its policy on the use of the Emergency Warning System (EWS) in respect of bow door problems.

MacGregor (SWE) AB is recommended to:

2004/268 Ensure that the owners of vessels that are fitted with MacGregor equipment and the relevant Classification Society are advised when safety critical modifications to similar equipment are carried out on other vessels.

Marine Accident Investigation Branch
December 2004

ANNEX 1

Procedure for Failure Incident Reporting and Early Warning of Serious Failure Incidents - IACS Early Warning Scheme - EWS

No. 2 Procedure for Failure Incident Reporting and Early Warning of Serious Failure Incidents - IACS Early Warning Scheme - EWS

(1993) (Rev 1 1996) (Rev 2 1996) Corr. 1997 (Rev.3 Dec. 2001)

1 Objective:

1.1 To improve ship safety and protection of the marine environment by providing information on incidents of *hull* failures and machinery space fires and explosions which are considered to have endangered the ship, or its personnel, or posed a threat to the environment and where *sister* or *similar* ships exist that could be at risk. The information regarding such failures is to be provided to other IACS Societies, and other relevant parties as stipulated herein, with a view to reducing the likelihood of their reoccurrence.

2 Definitions: In the context of this procedure, the following definitions apply.

2.1 *Failure incident*[1)] : A *hull* failure that is known, or suspected, to be due to inadequate compliance with relevant standards for design, construction, modification or repair of the failed item or inadequacy in standards relevant to the failed item. Damage incidents caused by all other causes, including but not limited to such things as collision, grounding, improper or inadequate operation, improper loading, human error or action, natural disaster, etc. are not "*failure incidents*" within the context of this procedure.

2.2 *Serious failure incident:* A *hull failure incident* or a machinery space fire or explosion that:

- Resulted in loss of the ship, death or serious injury to the personnel on board, or severe pollution of the marine environment; or

- Endangered the ship, the personnel on board, or posed a threat of severe pollution of the marine environment.

2.3 *Sister ship*: Ships having the same hull form, dimensions and cargo tank or cargo hold configuration that have been built to the same plans, even if approved by different societies.

2.4 *Similar ship*: Ships having similar arrangement or features affected by the incident of damage or failure in question.

Note:
This Procedural Requirement applies to all IACS Members and Associates.
EWS form has been revised under Revision 2 and retitled under Revision 3.
Revision 3 (major revision): The changes introduced in Revision 3 are to be uniformly implemented from 1 July 2002.

1) In this procedure, no machinery space fire nor explosion is categorised as a failure incident . Only machinery space fires or explosions judged as a serious failure incident are reportable.

No. 2

2.5 *Hull*: Hull structure and appurtenant equipment and structure fitted on or through the hull envelope (including but not limited to such things as hatches, doors or ramps, deck equipment, ventilation and sounding pipes, rudder including steering gear, sea connections, anchors & cables, etc.)

2.6 *Incident Reporting Officer (IRO)*: The person designated by each Society to report and receive confidential information and to undertake or manage the performance of the procedure within the Society.

2.7 *Incident Data Administrator (IDA)*: The person designated at IACS Secretariat to perform the data receipt, collation, and distribution functions required to administer the procedure under Annex 2 in accordance with the requirements of section 5, Confidentiality.

3. Approach:

3.1 *Failure incidents* which are considered to be noteworthy and of possible utility for improving IACS resolutions, Societies Rules or survey procedures and guidance are to be reported[2], without identifying the particular ship involved, and addressed in accordance with Annex 1.

3.2 *Serious failure incidents* which are considered, owing to the severity of their consequences, to warrant investigation and/or action with respect to other ships which may be susceptible to such failures are to be reported and addressed in accordance with Annex 2[3]. The IDA is to establish and maintain a secure internet website (hereinafter, the "website") and a secure internet communication protocol for use in association with this procedure.

4 Exceptions:

4.1 In cases where the Builder or Manufacturer has taken the responsibility to advise Owners and the relevant classification societies of ships which may be similarly affected, the reporting of *serious failure incidents* may be limited to posting on the website sufficient details to identify the incident and a note of the action taken by the Builder or Manufacturer.

2) Considerable uncertainty may exist as to whether a particular incident is a *failure incident* or not. In deciding whether to treat an incident as a *failure incident* consideration is to be given to whether enough is known or can reasonably be expected to be learned about the particular incident to warrant treating it as a *failure incident*. Similarly, for incidents which may have been caused by inadequate maintenance of an item, consideration should be given to whether information on the incident would contribute to reassessing the periodicity of required surveys or examinations, or other aspects within the purview of classification or statutory certification.

3) In judging whether an incident should be treated as a *serious failure incident* consideration is to be given to the risk involved in terms of the probability of future occurrences resulting in severe or unacceptable consequences, as well as the likelihood of identifying and implementing safety improvements which will effectively reduce that risk.

▶

No. 2 Annex 2: Early Warning of Serious Failure Incidents

1 General

1.1 In the event of the occurrence of a *serious failure incident*, the IRO of the Society classing the ship involved, is to post information specified below on the website with notification to the IDA and the IROs of all the other Societies:

- Ship s Name and IMO Number,
- Builder s Name and Yard Number,
- Date and location of incident,
- Details of the incident (See sections 2 and 3 below),
- Any additional information considered relevant to pursuing the objective of this procedure.

1.2 To supplement the information provided by the initiating IRO (sections 2 and 3 below), the IDA is to query available databases to identify any additional *sister* or *similar ships*, as applicable and the classing societies. The IDA is also to identify other societies with which each ship was previously classed and post the additional information to the website with notification to the IRO s. The IDA may request individual member societies (which may not be the Society classing the ship involved) to assist by querying their databases to identify *sister* and/or *similar ships* and classing societies. In order to confirm that ships so identified are *sisters* (as defined), the IDA may request copies of approved plans, as necessary.

1.3 In order to determine whether the incident is one of a series of similar incidents on *sister ships* or whether it appears to be an isolated case, written feedback from the IROs of any information held on file concerning surveys, damages or repairs undertaken on the ship or the identified *sister ships* in their class or previously in their class, which is relevant to the case, is to be posted in the case file on the website as soon as possible.

1.4 Written feedback from IROs with respect to relevant follow-up information obtained during subsequent surveys is also to be posted on the website as soon as possible.

1.5 The IRO of the society initiating a case is to take a leadership role in monitoring and assessing the case information and, together with the other IROs involved, recommending any further follow-up actions considered necessary or appropriate to GPG prior to closing the case file. Such recommendations might include, but are not necessarily limited to, such things as follow-up action on a broader group of *similar ships*, or the development of IACS Resolutions with a view to minimizing reoccurrence of the *serious failure incident* in question.

2 Serious Hull Failure Incidents: In reporting these incidents the initiating IRO is also to identify any known *sister ships* and the classing Societies. In reporting the details of these incidents, the data sheet contained in Annex 3 should be used for guidance.

3 Machinery Space Fires and Explosions: Where appropriate, the initiating IRO is also to identify any known ships similarly at risk. In reporting the details of these incidents, the following should be used for guidance:

a) Incident type (e.g. fire, explosion, explosion followed by fire, etc.),
b) Extent of injury and loss of life,
c) Effect on ship (e.g. abandoned, temporarily disabled, towed, etc.),
d) Fire contained (yes/no),

▶

No. 2

e) Extinguishing method (e.g. hand extinguisher, CO2, halon, etc.),
f) Heat source,
g) Combustible material (e.g. fuel oil, lub oil, soot, gas, etc.),
h) Fault type and location,
i) Machinery component(s) involved (including manufacturer and type designation, where known).

4 Annual Review: The Society holding the Council Chair is responsible, through its IRO, for the preparation of an annual review report on Annex 2 activity for consideration by Council at its first regularly scheduled meeting of each year. The scope of the review should include:

- any difficulties regarding confidentiality considerations with respect to identification of ships or Societies involved in cases not in the public domain;
- a summary of the number and nature of cases dealt with or in process;
- identification of perceived problems with the operation of the procedure together, where appropriate, with recommendations for improvement.

▶