

Report on an investigation
of a propulsion failure
and subsequent beaching of the
Class V amphibious passenger craft
Beatrice
on 31 March 2001,
opposite the River Thames Fire Station, Lambeth

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**Report No 3/2001
January 2002**

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

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

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GLOSSARY OF ABBREVIATIONS, ACRONYMS & TERMS

BST	-	British Summer Time
DUKW	-	D = year of manufacture U = utility cab or amphibian K = front-wheel drive W = rear-wheel drive, (two axles)
MCA	-	Maritime & Coastguard Agency
PLA	-	Port of London Authority
PSV	-	Public Service Vehicle
VHF	-	Very High Frequency
VTS	-	Vessel Traffic Service
WW II	-	World War II
Thames Waterman		A person who is the holder of a full licence to work as a waterman in the navigation of passenger boats on all parts of the Thames between the landward limit and Lower Hope Point.
Slipway		Inclined bed of masonry or wood, sloping towards the water.
Pontoon		Buoyant construction used as a landing place.
“A-frame”		Frame or bracket resembling the letter “A” lying on its side. The apex of the A contains a bearing when used for supporting propeller shafts.
European “Euro 2”		This is a statutory EEC requirement regarding the level and content of combustion engine exhaust emissions.

SYNOPSIS



On 3 April 2001, a passenger who had been on board the amphibious craft *Beatrice*, notified the MAIB that the craft had suffered a propulsion failure on 31 March, and had subsequently beached, opposite the River Thames Fire Station, Lambeth. The accident had been reported to MCA at Orpington the previous day, but details had not been forwarded to the MAIB.

Beatrice is one of several similar six-wheeled amphibious vehicles, owned and operated by the London Frog Company. The vehicles are based on World War II DUKWs, and take passengers on a circular sightseeing tour of London starting by road at County Hall, followed by a 30 minute cruise on the River Thames.

The craft has a Class V Passenger Certificate and is licensed to carry up to 30 passengers and two crew. The captain is a fully qualified Thames Waterman and holds a public service vehicle licence.

On 31 March 2001, *Beatrice* embarked 29 passengers and, with her crew of two, started out on the 1200 circular tour. At about 1300, having reached Vauxhall, the craft entered the river, disengaged the four-wheel drive, engaged the propeller drive, and started her voyage downriver. River conditions were good, with calm waters and good visibility. About 10 minutes later, while travelling downstream, the craft suddenly started to experience severe vibration, so the captain headed towards the nearest beach. This was on the north shore, almost opposite Lambeth fire station pontoon.

At 1315, the captain called Woolwich VTS on channel 14 and told them that he required assistance. This was followed shortly afterwards by a call to the owners. The craft had taken on some water, but was already approaching the shore. Although *Beatrice* was in the process of beaching, some of the passengers chose to don lifejackets. At 1325, the London fire brigade vessel *Fireflash* came alongside, embarked 29 passengers, and transferred them across the river on to Lambeth pontoon, where arrangements were made to transport them back to County Hall. By 1415 the company engineers were on scene and found that a large floating object had entered the propeller duct and been forced upwards between the propeller and the duct plating. Apart from causing distortion of the shafting, it had caused a rupture of the duct plating. After temporary repairs, at 1505, *Beatrice* was escorted back upriver to Lacks Dock and the slipway. By 1525 she was on the slipway and able to be returned to the company's workshop for repair.

Recommendations have been made on the provision of entry guards to the propeller duct and guidance about handling passengers in an emergency situation.



Beatrice



SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF CRAFT AND INCIDENT

Name : *Beatrice*

Official No : -

Port of registry : London

Overall length : 10.35m

Breadth : 2.48m

Maximum draught : 1.3m

Year & country where built : 1999 UK

Type : Amphibious passenger craft.
max number passengers 30
min crew 2

Main engine : Perkins Phaser 135 Ti Diesel
4 cylinder 101KkW @ 2500 rpm

Propulsion/steering : Single screw in tunnel, combined front wheel and
stern rudder

Owner : London Frog Company
The Foundry
Suite GO6
Blackfriars Road
London SE1

Date and time : 31 March 2001, about 1310

Place of incident : Lambeth Bridge, River
Thames

Injuries : None

Damage : Penetration of propeller duct
caused by debris between
propeller and duct wall

1.2 BACKGROUND

- 1.2.1 The London Frog Company operates a number of amphibious craft on circular tours starting from County Hall and then progressing across Westminster Bridge to Parliament Square, Whitehall, Trafalgar Square Piccadilly, Hyde Park Corner, Buckingham Palace, Victoria and to Vauxhall bridge before entering the Thames at Lacks Dock.

From there the craft travels downriver to the London Eye, before returning upriver to Vauxhall and Lacks Dock. The final part of the trip is back along the Embankment, past Lambeth Palace to County Hall.

The entire tour takes about 80 minutes.

- 1.2.2 The craft has a Class V Passenger Certificate and is licensed to carry up to 30 passengers and two crew. The captain is a fully qualified Thames Waterman, and the holder of a Public Service Vehicle licence.

The other crew member has responsibility for assisting the passengers and acting as a guide, giving a running commentary on the various buildings and their history as the tour progresses.

1.3 NARRATIVE

- 1.3.1 *Beatrice* embarked 29 passengers at County Hall on 31 March 2001 for the 1200 road and river cruise on the Thames. The craft, under the control of the captain, left County Hall and proceeded over Westminster Bridge on the regular route through the West End, before arriving at Vauxhall Bridge and Lacks Dock. The river slipway at Lacks Dock lies between two office blocks immediately to the east of Vauxhall Bridge, and has direct road entry from the Albert Embankment.

When *Beatrice* reached the river ramp, the captain pointed out the safety features of the craft to the passengers and told them what should be done in case of an emergency. The craft then drove down towards, and in, the river until the propeller duct became flooded and she was close to floating. The four-wheel drive was then disengaged and the propeller drive engaged. With the craft now propeller-driven, *Beatrice* started her voyage downriver.

River conditions were good, with calm waters and good visibility.

- 1.3.2 At about 1310, while travelling downstream, the craft suddenly started to experience severe vibration. Realising that the propeller drive assembly had suffered some damage, the captain decided to beach the craft at the nearest convenient point. This was on the north ashore, almost opposite the Lambeth fire station pontoon.

While attempting to manoeuvre the craft ashore, he called the PLA Woolwich VTS on channel 14 to tell them he required assistance. He supplied the name of the craft, his position, number of passengers aboard and details of the problem as far as he knew them. He followed this by telling them of his next intended action. This call was timed at 1315. He also called the owners to inform them of the incident and to arrange for their own engineering staff to attend.

By then the craft was approaching the shore and, although taking on water, was close to the point where the wheel drive could be engaged. Despite this, and reassurances from the captain, some of the passengers decided to put on the lifejackets stowed above them in the luggage racks. Shortly after this, the craft was safely beached on the north shore. The captain had beached the craft in such a way that a rescue craft could come alongside and remove the passengers to a place of safety.

- 1.3.3 At 1325, the London fire brigade vessel *Fireflash* came alongside and embarked 29 passengers. She then moved across the river and disembarked the passengers on to Lambeth pontoon, where arrangements were made to transport them back to County Hall.

By 1415 the company's engineers had arrived on scene, and had established that a large floating object had entered the propeller duct and had been forced upwards between the propeller and the duct plating. Apart from causing distortion of the shafting, it had resulted in an area of torn duct plating, about 200x100mm, allowing water to enter the hull. Temporary repairs were carried out and at 1505 *Beatrice* was escorted back upriver to Lacks Dock and the slipway. By 1525 she was beached on the slipway and able to be returned to the company's workshop for repair.

1.4 CREW PARTICULARS

Captain John Barton is 56 years old, has "Full" Waterman and Lighterman licences, both valid until 31 December 2003, and is an experienced Thames Waterman. He also holds a valid public service vehicle licence.

The second crewman, Mr Tony Merrick has had 25 years' experience on the Thames as a stevedore, is a member of St John's Ambulance, and is a member of two local historical societies.

1.5 DESCRIPTION OF CRAFT

- 1.5.1 The craft is based on World War II DUKWs, and converted to comply with Class V passenger craft requirements for the River Thames, as well as current Public Service Vehicle (PSV) standards.

The craft is essentially a lorry or coach chassis built into a steel hull. As in the original design, the single axis at the front, together with a double axis aft, has been retained, although modified up to present day standards. Buoyancy spaces are fitted forward and aft in addition to those between the hull and cabin shell. The engine compartment is separated from the passenger cabin by an "A" class steel bulkhead. The passenger cabin is on two levels, the fore part containing steel bench-type seating for 24 passengers plus two crew, while the raised part aft contains the main access and seating for a further six passengers. The forward windscreen and side windows, adjacent to the captain's and crew seat forward, are standard and comply with PSV requirements. The remaining "windows" in the passenger cabin are clear view, flexible plastic held in place by push-button studs. They are designed to be unbuttoned and rolled up to allow for additional ventilation if required. An emergency "push out" plastic window panel is fitted port and starboard, alongside the last pair of seats on the lower passenger section.

The captain occupies the front left hand seat with provision for the second crew member on his right. All controls for both road and river passage are sited in front of, or adjacent to, the driver's seat. Access to the craft is through two short, five-step access ladders fitted at the stern. Each ladder is hinged at the top and fitted for manual raising or lowering.

- 1.5.2 The craft is fitted out with a Skanti TU 1000P/P digital selection calling unit for communication between the PLA traffic control centre and other company and/or river crafts, together with an internal public address system.

The craft is equipped with 32 lifejackets, four lifebuoys and three buoyancy rafts. The float-free rafts are stowed on the roof and are of different sizes, one for 18 persons, one for 12 persons and one for 6 persons. Two of the four lifebuoys are standard issue, one on the engine bonnet and the other on the aft passenger access landing. The other two lifebuoys are fitted with lines and lights, and are mounted on the port and starboard sides aft. A grab or boarding net is also supplied. The lifejackets are stowed in luggage racks above the passenger seats with additional instructions for their use fixed to the back of a number of passenger seats in the cabin (**see Figure 1**).

- 1.5.3 The passenger cabin is fitted with two 9-litre foam extinguishers secured at the rear of the cabin, one 2-litre foam extinguisher adjacent to the captain's seat, plus a hand-held water pump and a sand bucket.

The engine compartment is fitted with a Chubb Autofoam 20 fire extinguishing unit which is under automatic or manual control.



Interior of *Beatrice* showing locations of lifejackets and instructions for use

1.6 DESCRIPTION OF STEERING AND PROPULSION SYSTEM

- 1.6.1 The craft is fitted with standard controls for road use, but has a separate clutch control lever for changing from normal road drive to propeller drive. Steering is linked to both front wheels and rudder. As the propeller and rudder are recessed into the hull, movement of the rudder while on the road does not cause any interference or danger. When operating on the river, movement of the forward wheels assists in the manoeuvring of the craft. If the linkage to the rudder head fails, emergency steering can be carried out by fixing a tiller bar on to the rudder head from the passenger cabin.

The Perkins Phaser 135 turbo-charged and air/air inter-cooled diesel engine is fitted with a gear-driven water cooling pump and a power take off for the braking system air compressor. An Alison 525 auto gearbox and clutch is fitted, with the drive shaft capable of being engaged to either the front-wheel drive or the propeller shaft. The propeller shaft drives a fixed pitch four bladed phosphor-bronze propeller through a sealed after bearing and "A-frame". The propeller rotates in a shaped propeller duct recessed in the underside of the hull, above the rear axles (**see Figure 2**).

- 1.6.2 The four-cylinder Perkins Phaser 135 Ti produces 101kW at 2500 rpm and satisfies European "Euro 2" requirements regarding exhaust emissions. It is mounted forward in the conventional road vehicle position, with the air intake mounted on a stub pipe out of the bonnet on the port side, and an elevated exhaust on the starboard side.



Rear of *Beatrice* showing propeller and rudder in recessed propeller duct

1.7 CRAFT DAMAGE

The craft suffered severe underwater damage when the propeller shaft either hit an underwater object when close to the bank, or when a large object was drawn into the propeller duct and became wedged between the propeller and the duct plating.

The actual damage report by the appointed surveyor read as follows:

The operational circumstances of the failure were summarily presented by the chief engineer. It would appear that in the course of “normal” operations, the vehicle with passengers on board is expected to deal with uneven terrain. Under given conditions where acute pitching occurs on uneven ground, the propeller assembly can be exposed to high impact compression and high side load forces. It is thought that conditions similar to those referred to here were prevalent at the time of failure.

And;

The propeller shaft “A-frame support” which appears to be a high quality forged component, had been subjected to a high compression load via the propeller which it is assumed grounded on uneven terrain. The “A-frame support” might also have been subjected to side forces at the same moment of impact. It is assumed that the vehicle then took to the water under traction. When the propeller was deployed for marine operation, the distortion of the “A-frame

support” transferred huge unbalanced torsional forces to the “A-frame” mounting, which tore out of position taking with it a sizeable part of the propeller duct skin, exposing the vehicle to the danger of rapid water ingress.

The inspecting surveyor’s report suggests that the damage to the propeller was probably caused by grounding during entry to the river.

1.8 PASSENGER RESPONSE

- 1.8.1 *Beatrice* responded normally until she entered the Thames at Vauxhall. It was only when the craft had become waterborne, the propeller engaged, and she was moving downstream under increasing revolutions, that both passengers and crew became concerned about the severe vibrations which had developed.

The master, realising that something was very wrong, notified Woolwich VTS and turned the craft towards the shore so that he could beach her at the nearest point, opposite Lambeth Pier. One of the passengers has suggested that neither the master, nor his assistant, offered information as to what was happening, nor instructed them to put on lifejackets. It appears that the passengers were aware that water was entering the craft, and expected appropriate instructions to be given. When none were given, some passengers decided that they would don lifejackets, but found this difficult as they were still “as new” with all the straps in the smallest setting. Comment was also made about the lack of readily available instruction placards on the use of lifejackets.

- 1.8.2 A passenger also alleged that no radio call was made to the rescue services. A call was made to Woolwich VTS, the agreed contact point, and recorded at 1315, presumably shortly after the master decided that the craft had sustained serious damage. The fire brigade at Lambeth advised that they were aware of the incident as they had been monitoring Channel 14; hence their quick response.
- 1.8.3 Regarding the company compliance with the Merchant Shipping (Co-operation with Search and Rescue Services) Regulations 1998, these requirements were discussed by the owner and the MCA during the early part of 2000. As a result of these discussions, the company submitted a plan covering *Beatrice* which was approved in May 2000.

1.9 OWNER’S SUBSEQUENT ACTIONS

- 1.9.1 Following this incident, the owner, after discussing with his own staff what repairs to the craft were needed, decided that it would be prudent to replace and renew the centre section of the propeller duct with a heavier gauge material as well as providing extra support within the shell and hull.

Further discussions with a consultant engineer resulted in a reinforced propeller duct. This reinforcing consisted of three additional 14 gauge rolled mild steel plates welded to the inner face of the duct with a number of 6mm rivets added for further security.

- 1.9.2 The “A-frame support” was refitted and bolted into place as before with vibration-proof nuts. New white metal bearings for the propeller shaft were also fitted.

SECTION 2 - ANALYSIS

2.1 CREW RESPONSE

- 2.1.1 When the captain became aware of the problem, he followed the agreed procedure and immediately contacted the PLA at Woolwich VTS station. He then called his employers to tell them of the problem, and what he was going to do.

From the evidence available, it does seem that in the early stages of the incident there was an element of confusion among the passengers. They were obviously aware that something was wrong, but were told nothing until the crew had made a decision about what to do. It was only after the owners were informed of the problem that the passengers were told what was happening. In the circumstances, it would have been prudent for either the captain or the other crew member to reassure the passengers before calling his employers. Given the layout of the craft and both crewmen forward, only the front passengers were able to overhear what messages were being passed to both Woolwich and the owners. With the craft obviously suffering vibration, and in some form of trouble, those at the aft end began to suffer general unease and anxiety.

It is in situations like this that the value and competence of the second crewman is critical. Passengers need to be reassured as early as possible, and then be fully briefed on the incident, once time permits. In a vessel such as this, passenger movement is restricted and every effort needs to be made to calm down the situation.

- 2.1.2 The captain's actions on beaching the craft in such a way that *Firecrest* could come alongside the stern to enable an orderly evacuation, showed competence and experience.

On the basis of the information available, the captain handled the technical aspects of the situation correctly and with a degree of confidence and professionalism, but the management should issue further guidance on handling passengers in emergency situations. When passengers can see and hear a developing emergency situation, prompt reassurance is essential. Any delay causes suspicion and doubt.

2.2 GENERAL OBSERVATIONS

- 2.2.1 The inspecting surveyor's report suggests that damage to the propeller shaft was probably caused when *Beatrice* entered the river. With the forward end afloat and the aft end still on, or close to, the riverbed, the craft pitched, possibly due to wave action, causing the stern to hit an underwater obstruction. In that event, directly the propeller shaft was engaged, severe vibrations would have been felt immediately. None were recorded until the craft was some distance downriver.

Given the shape of the propeller duct, and the apparently undamaged outer lower wings of the duct and aft wheel axle, it is considered that the damage was more likely caused through a hard floating object, such as a bulk of timber, being drawn into the propeller duct during the early part of the passage. With the propeller rotating at a relatively high speed, the sudden insertion of a solid object among the blades will cause shock loading and distortion on the blades, together with torsional shock loading on the “A-frame support”.

- 2.2.2 Such an occurrence may or may not cause the engine to stall, but at the very least it will cause the clutch to overload and result in a very noticeable noise, together with a heavy vibration. The continued operation of the propeller drive to effect a safe beaching, with a severely bent drive shaft and propeller, will give rise to heavy vibrations and possible rupture of the “A-frame support”.

The possibility of an accident caused by floating or semi-submerged objects is ever present on the River Thames. The wholesale removal of such objects from the river is not possible because of the length and size of the river and the varied requirements of its users. However, the fitting of some form of open mesh grid round the propeller duct to act as a very coarse filter might offer a partial solution, without significantly reducing the propeller’s efficiency.

- 2.2.3 A passenger reported that the captain failed to keep the passengers fully and immediately informed of the problem, which gave rise to anxiety and alarm. This aspect has been referred to earlier where, at the start of the emergency, there was a slight delay in advising the passengers what was happening. Although details of the problem might not have been passed to the passengers at that time, it needs to be borne in mind that the captain was in the process of calling Woolwich and simultaneously steering the craft to the nearest accessible riverbank. It is the duty of the crewman to reassure the passengers at this critical time, even if he did not know what the true facts of the incident were.

The entry of water into the craft would undoubtedly cause unease among the passengers and the crew needed to address these concerns at the outset. Early and positive instructions should have been given to passengers, even if the full extent of the situation was not known at the time. Once uncertainty occurs, the stronger-minded passengers will attempt to take charge. An example of this was the donning of lifejackets by some of the passengers. This action was premature and unnecessary, but it illustrates how quickly situations can degenerate into an atmosphere of fear and uncertainty. Once some started to don lifejackets, it would have been difficult to counter such a move without causing further confusion and possible panic. It is at moments like this that the second crew member needs to be assertive and to take charge of the passengers, giving the captain time to concentrate on taking corrective action.

- 2.2.4 The comment by a passenger that there were insufficient instructive notices regarding the donning of lifejackets is not considered a justifiable criticism. Not

only are instructions attached to the lifejacket itself, but several additional notices are attached to the back of a number of passenger seats.

The MCA had carried out a safety inspection of the craft before issuing the Passenger Certificate, and subsequent issue of that certificate confirms that sufficient number of instructive notices had been fitted.

SECTION 3 - CONCLUSIONS

3.1 FINDINGS

- 3.1.1 *Beatrice* complies with, and has been issued with, a valid Class V Passenger Certificate. [Ref: 1.2.2]
- 3.1.2 She was manned in accordance with the regulations, with a qualified and experienced captain, and an experienced river stevedore with first-aid qualifications as second crew member. [Ref: 1.4]
- 3.1.3 When the captain became aware of the problem, he followed the agreed procedure and immediately contacted the PLA at Woolwich VTS station. His actions in beaching the craft so that *Firecrest* could come alongside, showed competence and experience. [Ref: 2.1.1, 2.1.2]
- 3.1.4 The out-of-balance forces developed during this latter period would have exacerbated any defect which had occurred during the initial contact. [Ref: 2.2.1 & 2.2.2]
- 3.1.5 Failure of the crew member to tell the passengers early on what the problem was and what was being done about it, appears to have caused general unease, leading to some passengers donning lifejackets unnecessarily. [Ref: 2.2.3]

3.2 CAUSE

The cause of the damage to the propeller duct was the movement of the “A-frame support” under conditions of shock loading. This was caused initially by the sudden momentary seizure of the propeller while under load and, finally, by the continued operation of the propeller drive shaft while in a distorted condition.

The sudden and momentary seizure of the propeller was most probably brought about by the entry of a large solid object into the propeller duct during the early part of the passage.

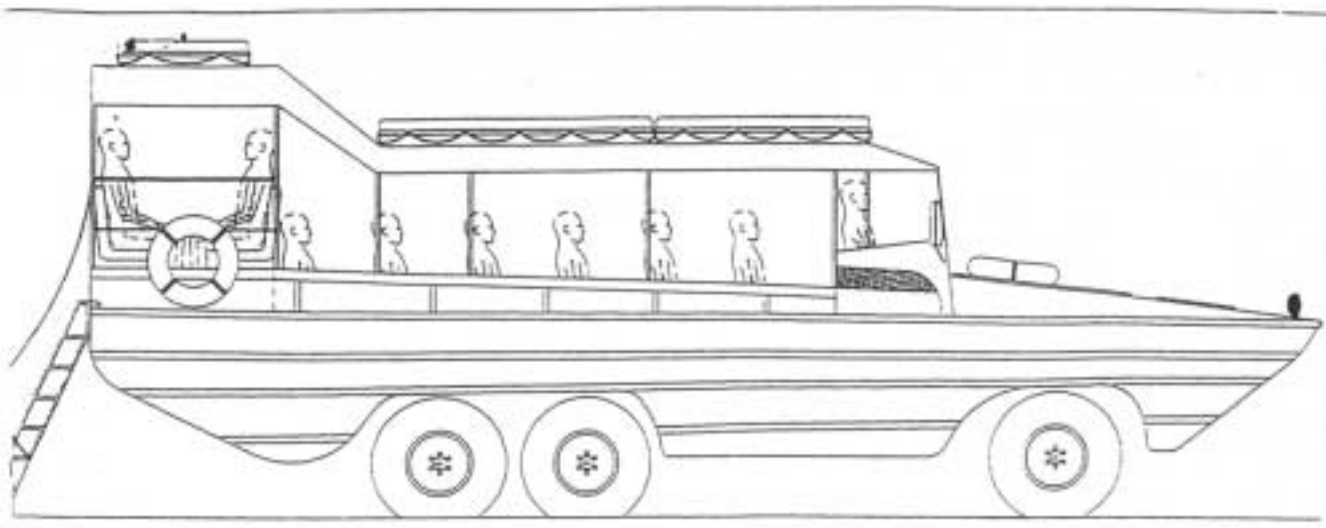
SECTION 4 - RECOMMENDATIONS

The London Frog Company is recommended to:

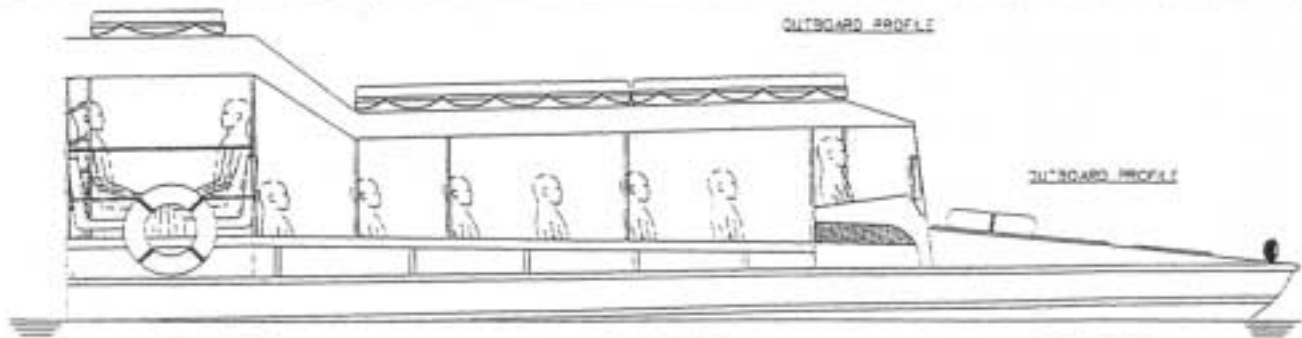
1. Consider fitting some form of open mesh grid round the propeller duct to prevent the entry of large pieces of debris, without significantly reducing the efficiency of the propeller.
2. Consider providing further guidance to operating staff and crew members on the handling of passengers during emergency situations.

**Marine Accident Investigation Branch
January 2002**

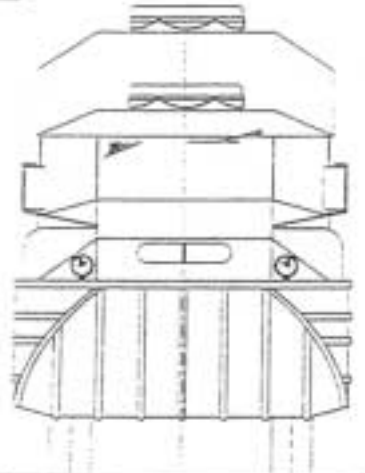
General design and layout of *Beatrice*



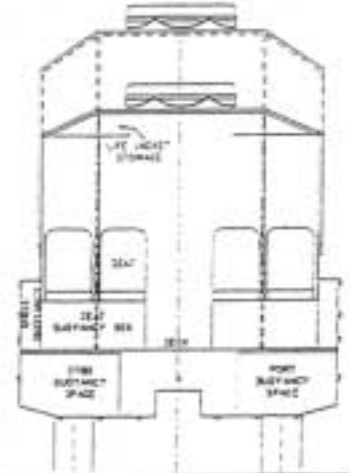
OUTBOARD PROFILE



OUTBOARD PROFILE



VIEW ON FRONT



TYPICAL SECTION THROUGH HULL
LOOKING AFT



VIEW ON TRANSM

DESIGN PARTICULARS	
LENGTH	3.30 m
BEAM	2.45 m
DRAUGHT	1.2 m
DISPLACEMENT (Estimated)	3.3 tonnes
RAZER	FOURAC, W.L.L.A
RAZOR DATE	1945
"KW	1.2 HP
FRESHWATER W.H.	3.576 m
SPEED IN WATER	5.4 KNOTS
ENGINE	DEGL.
PASSENGERS	12
CREW	2

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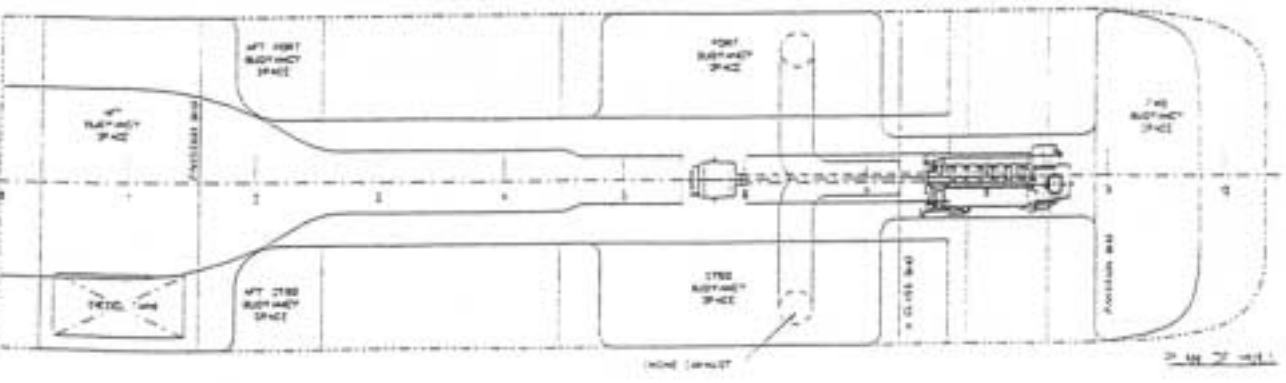
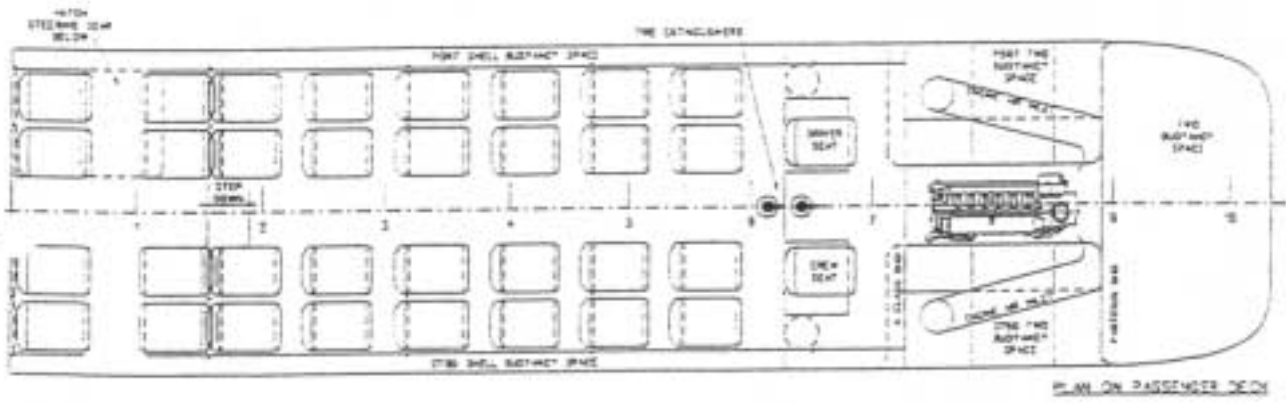
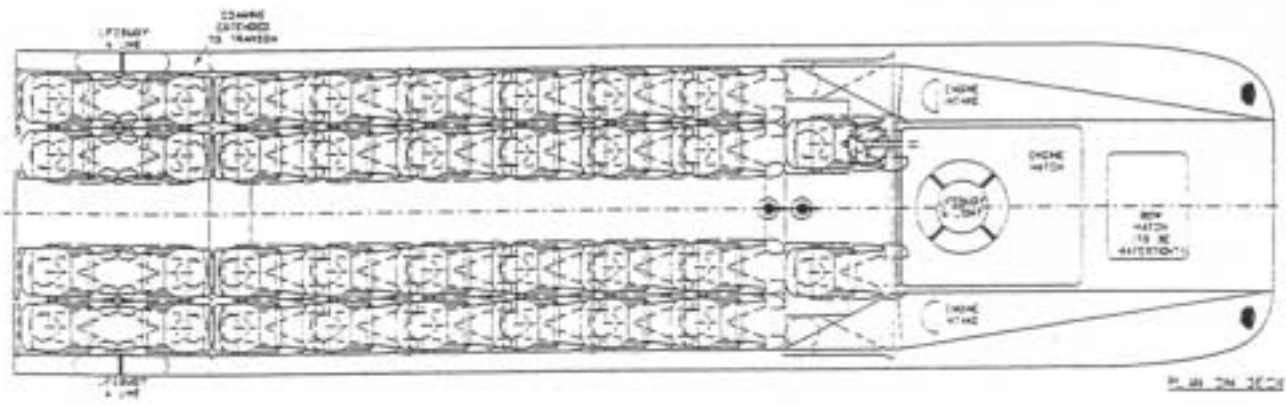
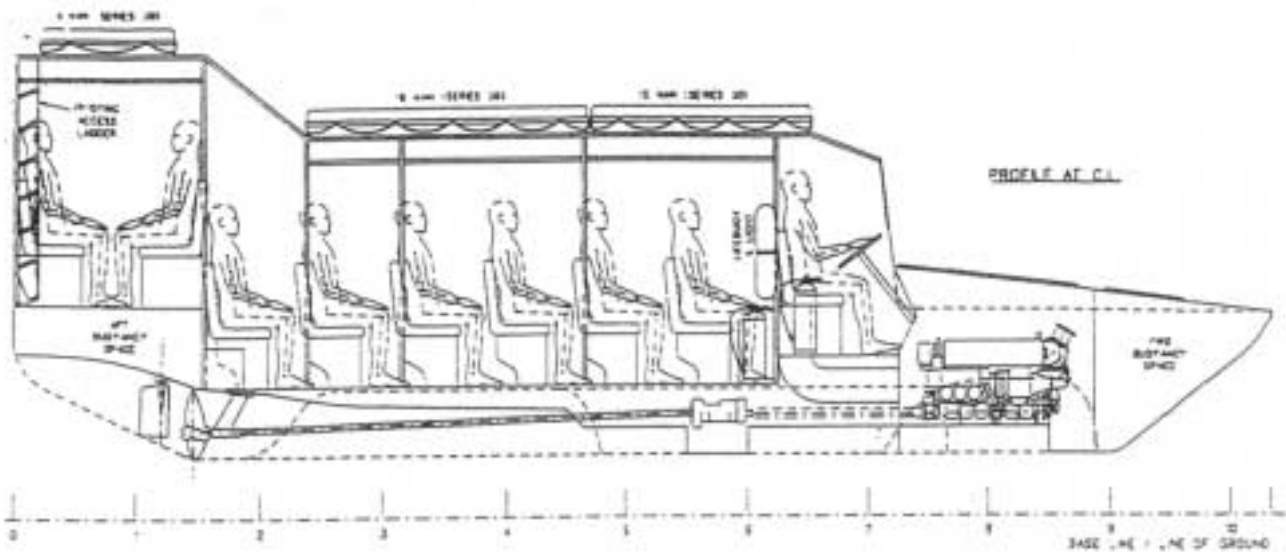
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LONDON FROG COMPANY	LONDON "FROG"
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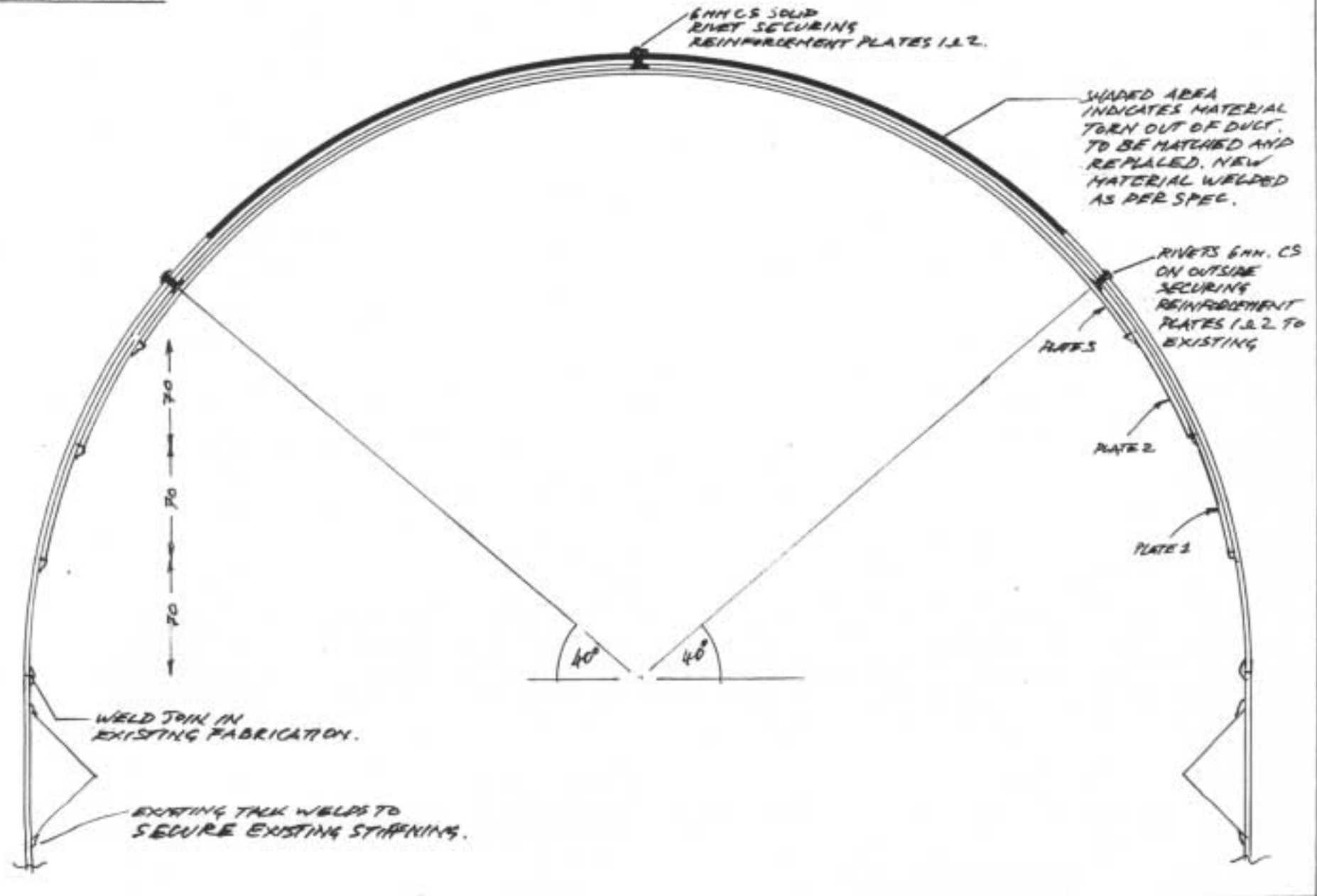
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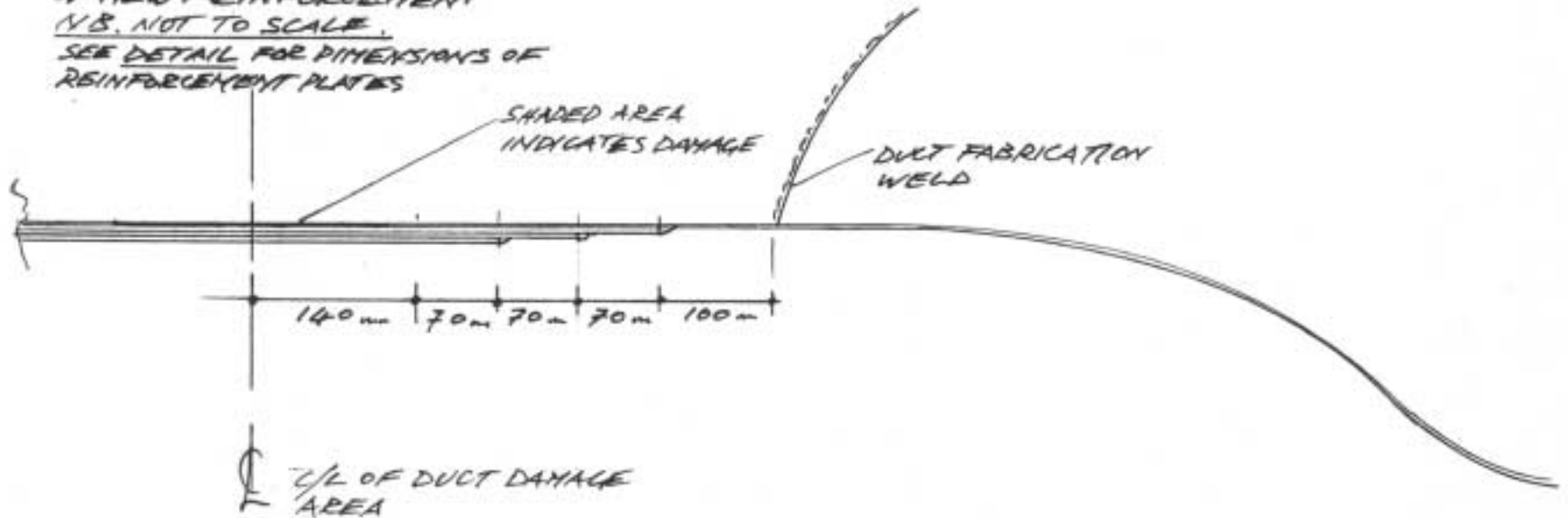
Detail of repair and strengthening of the propeller duct

DRAWING 28
NOT TO SCALE

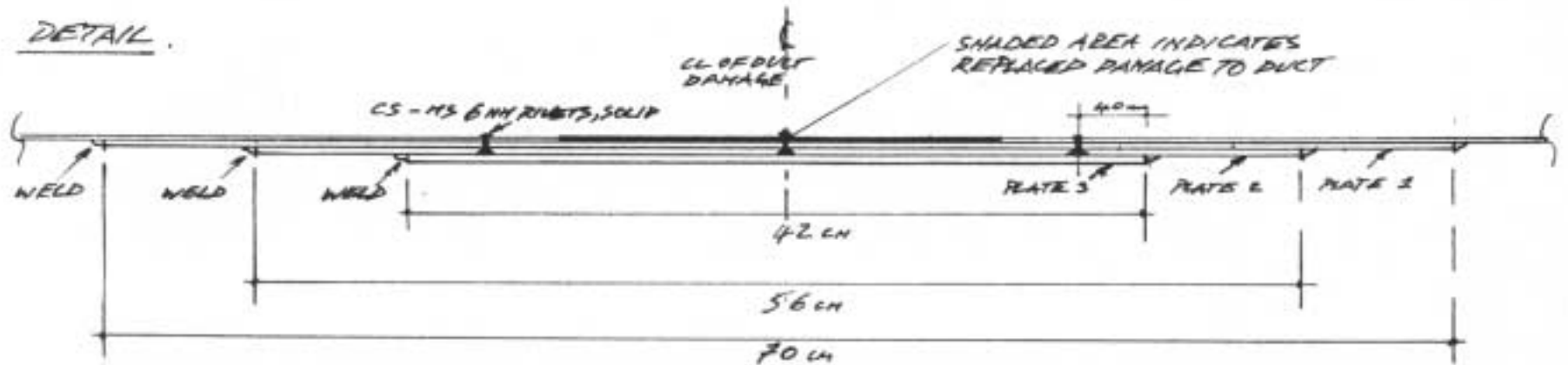


DRAWING 1 C

LONGITUDINAL SCHEMATIC DRAWING
SHOWING DIMENSIONAL POSITIONING
OF NEW REINFORCEMENT
(N.B. NOT TO SCALE)
SEE DETAIL FOR DIMENSIONS OF
REINFORCEMENT PLATES



DETAIL



DRAWING 2D - NOT TO SCALE

SCHEMATIC DRAWING SHOWING RELATIVE POSITIONS OF 6mm MS RIVETS

ALL REINFORCEMENT PLATES TO HAVE 25mm RADII AT CORNERS

TRANSVERSE C/L OF DUCT DAMAGE

