Report on the investigation of

a fatal accident

during a vertical chute evacuation drill

from the UK registered ro-ro ferry

P&OSL Aquitaine

in Dover Harbour

on 9 October 2002

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Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999

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

EU	-	European Union
FRB	-	Fast rescue boat
IACS	-	International Association of Classification Societies
IMO	-	International Maritime Organization
IT	-	Information technology
kg	-	kilogram
LSA	-	Life saving appliances
m	-	metre
mm	-	millimetre
MAIIF	-	Marine Accident Investigators’ International Forum
MCA	-	Maritime and Coastguard Agency
MES	-	Marine evacuation system
MOR	-	Means of rescue
N	-	Newton
P&OSL	-	Prefix to ships’ names of the company P&O Stena Line Ltd.
ro-ro	-	Roll-on roll-off (ferries)
SOLAS	-	Safety of Life at Sea Convention
sweeper	-	A person designated to clear blockages in vertical chutes
UTC	-	Universal Co-ordinated Time
Wheel Mark	-	Mark of approval under European Marine Equipment Directive

SYNOPSIS

At 1319 UTC on 9 October 2002, a fatal accident occurred during an evacuation drill from the UK registered ferry *P&OSL Aquitaine.* The drill was being held in Dover harbour, using an RFD manufactured Marin-Ark marine evacuation system. P&O Stena Line's marine safety manager informed the MAIB of the accident that day.

The marine evacuation system, consisting of two vertical chutes leading into two large, fully reversible liferafts, was deployed at 1233. Once the evacuee receivers, assistants, observers and manufacturer's representatives were in place, the evacuation began.

After 124 people had gone down the chute and entered the liferafts, a female volunteer, Mrs McCabe-Jones, began her descent. Nine seconds later she shouted for help; the chute controller, stationed at the top, shouted to her to wriggle, but she replied that she could not. A chute sweeper, who was one of the ship's officers, then went down the chute in a controlled manner and found the volunteer stuck in a back down piked position (hands and feet above her head) inside one of the elasticated socks in the descent sections.

Her lifejacket and jacket had come off and were near by. The sweeper tried to pull her up, but was unsuccessful. However, she slipped through the sock but retained the same piked position in the next sock down. The sweeper tried again to pull her up, but then realised she was no longer talking to him. He called out to the chute controller and to the receivers that she was not responding, and asked for someone to cut her out. She slipped through the sock and, yet again, retained the same position.

The chute was then cut to allow her to descend in a controlled manner into the liferaft, where she arrived, unconscious, some 10 minutes after the start of her descent. First-aid was administered and was continued while she was evacuated ashore by a fast rescue boat, which had been standing by. She was then airlifted to hospital where she was pronounced dead.

As there were no witnesses to Mrs McCabe-Jones's descent, and she was unable to tell the sweeper what had happened, it is impossible to determine exactly how she assumed the position in which the sweeper found her. However, it is probable that the initial mechanism which caused Mrs McCabe-Jones to become stuck, was her lifejacket riding up and her legs being raised in such a way that she assumed a piked position in the sock below.

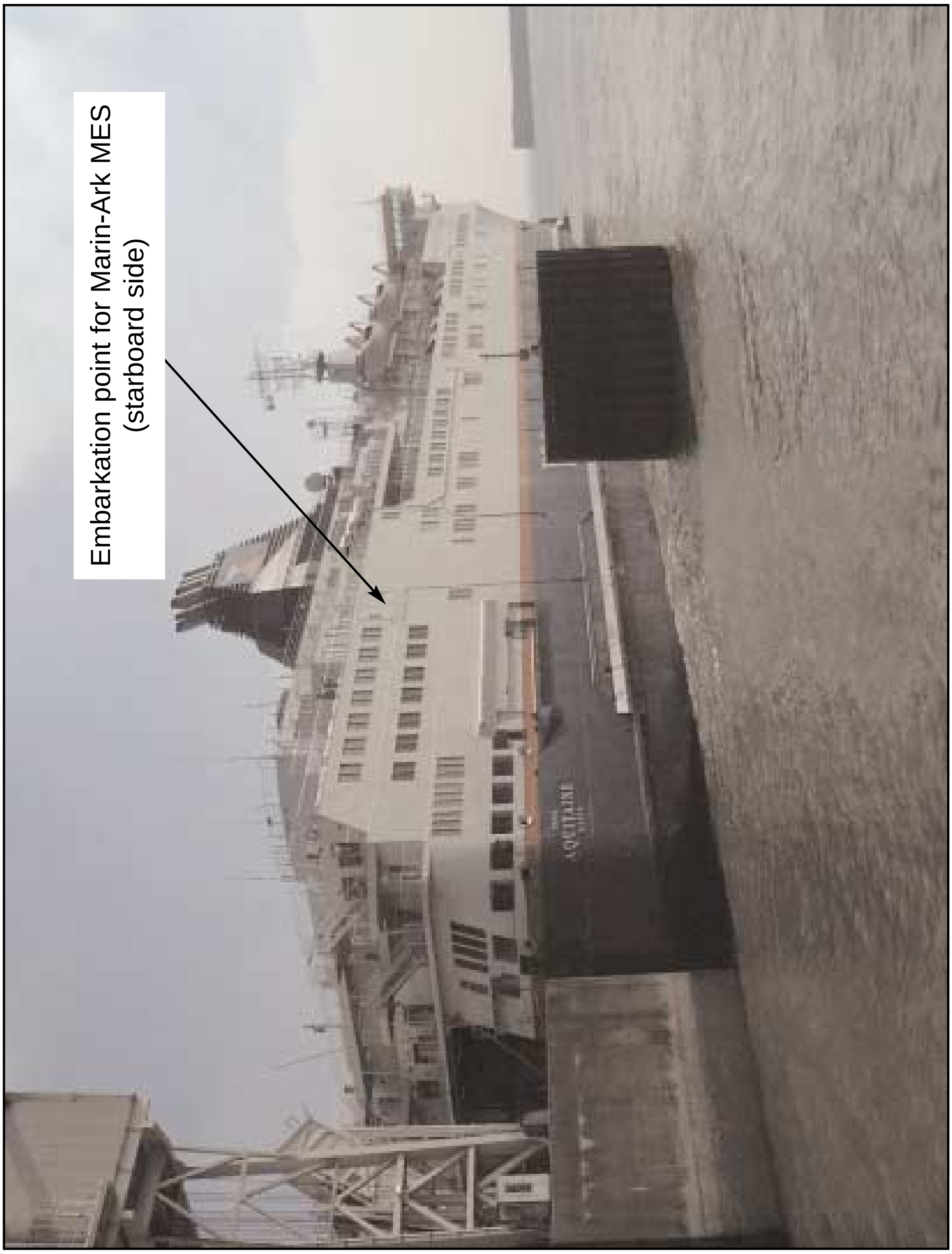
Safety recommendations have been made to:

- Shipping companies, to revalidate their risk assessments for drills, with regard to selecting suitable personnel and limiting the number of people in a chute to one at a time. They should also revalidate their risk assessments and safety cases, with regard to the adverse effects of blockages during an actual emergency.

- The Maritime and Coastguard Agency (MCA), to ensure that only lifejackets suitable for safe descent with the specific MES installed are used. It should also take forward to the IMO, recommendations on the approval of lifejackets for specific MESs and that a reporting method should be set up for accidents involving MESs.

- The MES manufacturers, to remove any possible causes of blockages in chutes.

Photograph 1



P&OSL Aquitaine berthed in Dover

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *P&OSL AQUITAINE,* THE CHUTE AND THE ACCIDENT

All times are UTC.

Vessel details

Registered owner	:	Stena Ferries Ltd
Chartered by	:	P&O Stena Line Ltd
Port of registry	:	Dover
Flag	:	UK
Type	:	Ro-ro car ferry
Built	:	Temse, Belgium in 1992
Classification society	:	Lloyd's Register of Shipping
Length overall	:	163.4m
Gross tonnage	:	28,833
Passenger capacity	:	1850

Chute details

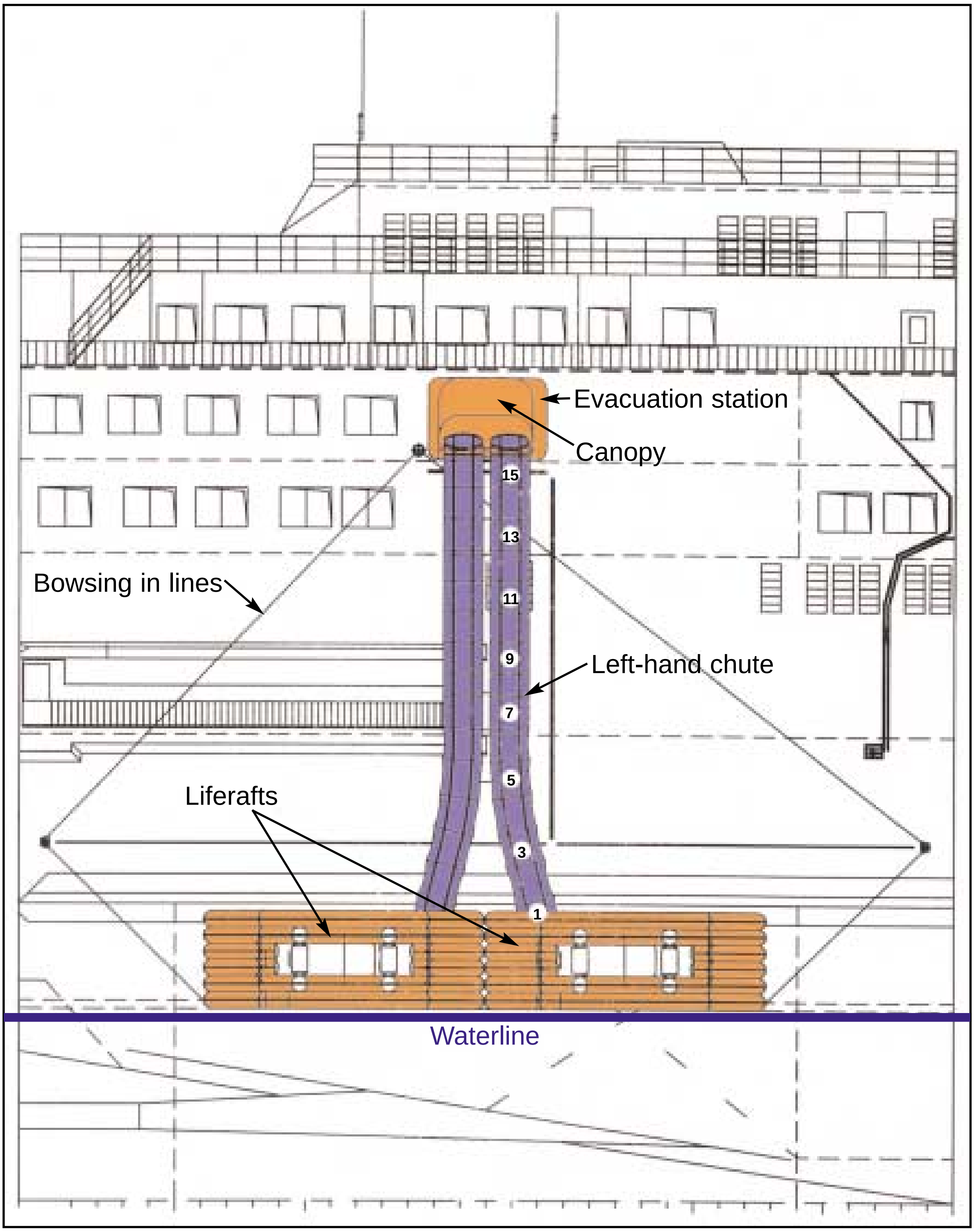
Type	:	Marin-Ark Marine Evacuation System
Approval	:	By MCA in December 1997
Manufacture	:	Chute number 106 by RFD in August 2000
First installation	:	October 2000 on board *P&OSL Provence*
Material	:	Woven nylon and warp knitted polyamide fabric with a polyurethane coating
Height of chute	:	About 14m
Number of cells	:	15
Number and capacity of liferafts	:	2 x 106 (deployed on 9 October 2002)
System deployment time	:	In less than 3 minutes

Accident details

Time and date	:	1319 on 9 October 2002
Location of accident	:	Alongside Cruise Terminal, Western Docks, Dover

Weather and wind force	:	Cloudy, fine and clear, wind east-north-east force 4 to 5
Injuries/fatalities	:	One fatality

Diagram 1



The Marin-Ark MES deployed from a high sided ferry

1.2 BACKGROUND - THE MARIN-ARK MES

1.2.1 RFD

Manufactured by RFD, the Marin-Ark MES provided a dry-shod, totally enclosed method of evacuating passengers and crew from a ship in distress into launched inflatable liferafts **(see diagram 1)**. RFD Ltd was founded by Reginald Foster Dagnall in 1920.

During its existence, the company has traded in the field of marine and aerospace safety and survival equipment. The factory is situated in Dunmurry (near Belfast) in Northern Ireland and manufactures survival systems with design and quality standards in accordance with ISO 9001.

In 1932, RFD invented the first inflatable liferaft, and in 1979 the company invented the first MES. RFD produces a number of types of liferafts including the Marin-Ark MES, and is part of the Survitec group of companies.

1.2.2 Inception, development and approval of the Marin-Ark MES

RFD developed the Marin-Ark MES to meet the IMO SOLAS requirements to provide a “dry shod evacuation” system for ro-ro ferries. This requirement arose from recommendations made after the sinking of the Baltic ferry *Estonia* in 1994 **(see Section 2.9.1)**. The system was developed over a 2½ year period up to 1997, and was brought on to the market the following year. To date, about 120 systems have been installed on more than 50 vessels, over a range of about 23 ferry and cruise ship operators.

Previously, RFD had manufactured and installed a limited range of marine evacuation systems using inflatable slides of different lengths, to evacuate passengers to a platform and into a series of 50-person liferafts. This type of MES was difficult to operate, needing large numbers of trained crew; it was also prone to slide and platform distortion and movement in rough seas and strong winds.

The Marin-Ark MES was designed to:

- Be less complex to install.
- Be simpler to operate by fewer crew.
- Be easier to use, by removing any exposure of passengers to the weather during the evacuation process.
- Incorporate a fully reversible liferaft capable of immediate use upon inflation - whether as part of the evacuation system or as a float-free alternative.

(In practice it has been found that the Marin-Ark system is easier to operate when the vessel is heeling and trimming.)

After the initial concept, design and development trials, and following the successful completion of a heavy weather trial, the system was approved by the MCA in December 1997.

The approval process was carried out and witnessed at all times by MCA surveyors and, occasionally, by other national maritime authorities. In 1999, under the EU Marine Equipment Directive, Lloyd's Register of Shipping granted the Wheel Mark, based on MCA type approval, and the audit of the quality assurance of the manufacturing process, to the Marin-Ark MES.

In its current configuration, the Marin-Ark MES is suitable for conventional passenger ships and high-speed craft with freeboards of between 8 and 23.5 metres. It is considered suitable to be used by a full cross-section of untrained passengers, except for the aged, the disabled, and infants less than 5 years old.

As well as providing a dry-shod evacuation, the Marin-Ark MES was designed so that evacuees could not see outside the canopy at the head of the evacuation station and during descent **(see photograph 2)**. This was in case they became frightened of the height of the descent, and refused to go down.

Photograph 2

An evacuee prepares to descend the left-hand chute

1.2.3 Description and operation of the Marin-Ark MES

The Marin-Ark system consisted of two vertical telescopic chutes from the evacuation station into two, three or four, 106- or 109-person liferafts. These were enclosed and were fully reversible, in that they could float either way up. Each vertical chute comprised a series of cells, each of which had an internal, helical slide path into an elasticated sock. This provided evacuees with a controlled rate of descent.

Evacuation stations could either be installed in a between-deck space, such as on *P&OSL Aquitaine*, or on an open deck.

Deployment of the system was initiated by the release of compressed gas, which operated hydraulic rams. These pushed the stowed liferafts out of their housing. On reaching the outer limit of the rams, the stowed liferafts would tilt over, dropping the liferafts into the water, while the two chutes unfolded behind them. The liferafts then inflated automatically within three minutes.

The liferafts were held into the side of the ship by bowsing lines, which could be controlled from the evacuation station **(see diagram 1)**.

The evacuation team consisted of:

- The chute controller, who acted as the system operator and was in overall control, at the head of the chutes.
- The chute controller's assistant.
- Receivers, at the exit of each chute.
- Two seamen, who secured the bailers and the liferafts together, and helped in guiding evacuees.

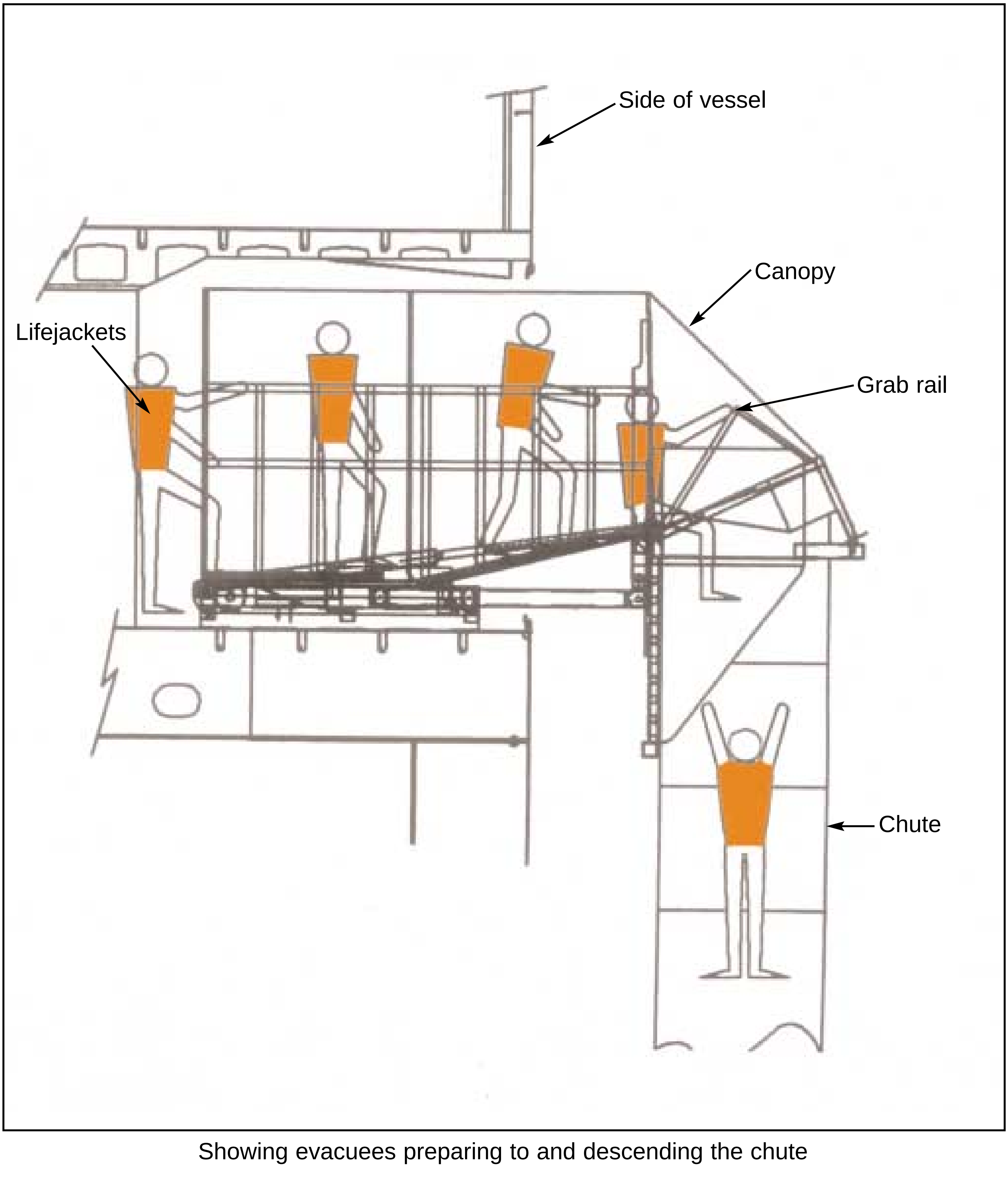
Additionally, a trained crew member, waiting to descend the chute, acted as the sweeper.

Evacuees descended feet-first, wearing lifejackets, but with their shoes and spectacles removed to avoid damaging the chute. They were instructed to keep their feet and knees together, legs slightly bent, and their arms above their heads during the descent **(see diagram 2)**.

It was compulsory for evacuees to don their lifejackets in the relatively safe environment of the ship so that they were already prepared when they reached the liferaft near the waterline.

In the event of anyone stopping in a chute, the crew's first action was to instruct the evacuee to "wriggle". This would usually be sufficient to help them on their way. If this did not work, the evacuee would be considered stuck and a sweeper would be sent down the chute to assist in freeing the person to allow their descent to continue.

Diagram 2



Showing evacuees preparing to and descending the chute

1.2.4 Risk assessment for Marin-Ark MES drills

Under the Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 (SI 2962) Regulation 7, the owners and operators of ships have certain general duties, including the preparation of risk assessments as stated below:

(1) *A suitable and sufficient assessment shall be made of the risks of the health and safety of workers arising in the normal course of their activities, for the purpose of identifying-*

(a) groups of workers at particular risk in the performance of their duties; and

(b) the measures to be taken to comply with the employer's duties under these Regulations.

and any significant findings of the assessment and any revision of it shall be brought to the notice of workers.

(2) *This assessment shall extend to the risks to the health and safety of other persons on board ship in so far as they may be affected by the acts and omissions of the employer.*

To comply with the above, P&O Stena Line completed a generic fleet risk assessment on drill deployment of the Marin-Ark MES in October 2000.

On 16 October 2000, a SOLAS required deployment of one of the *P&OSL Aquitaine*'s Marin-Ark MES units was used as a crew training exercise. During this drill, which used both right and left-hand chutes, one person sustained a torn ligament and another suffered concussion.

Both these injuries were a result of the individuals exiting the right-hand chute and making heavy contact with the inflated tubes of the liferaft wall. The left-hand chute exited into the open inner part of the liferaft. However, the right-hand chute's exit pointed towards the relatively close liferaft wall. As a result of these accidents, the risk assessment was reviewed in October 2001 **(Annex 7)**.

The October 2001 assessment was again formally reviewed for use in the drill on board *P&OSL Aquitaine* in October 2002, and was considered suitable in light of the knowledge at that time.

The risk assessment identified hazards and persons at risk, and provided control measures to minimise risk.

Six hazards to the personal safety of crew, shore staff, contractors and others were identified. These were:

No.	Hazard	Rationale
1	Working at height	Units are located 15 – 21 metres above the waterline
2	Descent from height	Evacuation is by vertical chute down the ship’s side
3	Sticking in chute	It is possible to become stuck in the chute, blocking the descent of others
4	Friction contact in chute	Clothing can be lifted, lifejackets pulled off and lifejacket lights can be damaged by friction contact with chute material. Exposed light parts can cut evacuees’ faces
5	Chute exit to raft	The catcher cell can cause evacuees to be tipped headfirst into the raft. In right-hand chute, there is inadequate room for safe exit from the chute. If evacuees are too close together in the chute they can land on each other
6	Slip hazard	Immediately post deployment, rafts are wet inside. Flooring is smooth and flexible

The respective control measures to the above hazards were identified in the risk assessment as:

1. Units set in enclosed spaces or behind deck railings. On deployment, a canopy gives edge protection.

2. Chute is designed to restrict descent speed by a series of funnel shaped socks (cells) which grip evacuees as they descend. Descent time is about 6 seconds. Each person receives simple instructions as they enter the chute.

3. Shoes are removed before descent. Chute design minimises chance of sticking. Simple instructions provided. Use of sweeper to free stuck evacuee.

4. Training lifejackets provided without lights and with leg straps. Participants advised to wear trousers or boilersuits.

5. Right-hand chute forbidden for use in drills. Trained staff assist at exit. Raft design minimises contact hazards. Drills restricted to one person in chute at a time.

6. Trained staff to guide evacuees. Movement around raft edge avoids water. Equipment available in raft to remove water. No sharp edges present in raft.

Overall: Ship's staff are trained in the deployment and use of Marin-Ark by attendance at shore-based courses, and by use of onboard training materials. The system is designed for use by untrained persons in the event of an emergency evacuation from a ship.

The assessment of the level of residual risks with the identified control measures in place is given in the following table:

Hazard No.	**Likelihood of event**	**Degree of harm**	**Level of risk**
1	Highly unlikely	Extremely harmful	Moderate
2	Highly unlikely	Extremely harmful	Moderate
3	Highly unlikely	Harmful	Tolerable
4	Likely	Harmful	Substantial
5	Unlikely	Harmful	Moderate
6	Unlikely	Slightly harmful	Tolerable

To reduce the substantial risk identified for hazard 4, an additional control measure was identified, which recommended the replacement of ship's lifejackets with training lifejackets. That is, without lights and with leg straps.

After the first deployment drill using the Marin-Ark MES from a P&OSL ferry, it was identified that some lifejackets were riding up and causing minor injuries to evacuees. The level of risk during drills was assessed as being substantial. Therefore the company ordered 100 Seadog Shipshape 2 lifejackets to be fitted with leg straps, and to be used solely for training drills in the fleet. They were not part of the LSA for any of the ships. By a cost benefit analysis, the number of these lifejackets was considered to be sufficient for training purposes, as it was not envisaged that more than this number would descend the Marin-Ark MES during a drill.

On the day of the accident, 215 people were designated to descend the chute. The training lifejackets and the ship's normal lifejackets were distributed among the evacuees. This was purposely done to give a realistic trial, and to compare the effectiveness between lifejackets with, and without, leg straps.

No additional control measures were identified for the moderate risks assessed for hazards 1, 2 and 5.

An additional hazard identified on the risk assessment was that of psychological stress. The control measure for this was to check for and recognise symptoms such as hesitation, and allow persons to not descend the chute.

Neither the risk assessment as a whole, nor its significant findings, were brought to the attention of the evacuees before the drill on 9 October 2002. This contravenes Regulation 7 of SI 2962 as stated above.

The approval of the MES by the MCA implied that it could be used by any fit person, except the disabled, infants and the aged, for which alternative means of evacuation would be provided. As none of the personnel used on the day of the accident were in the latter categories, there was no formal vetting system by P&O Stena Line on the suitability of evacuees for the drill of 9 October 2002.

1.2.5 History and description of the chute used in the drill

Chute number 106 was manufactured in August 2000 at the RFD factory in Dunmurry, Northern Ireland. It was installed on board *P&OSL Provence* in October 2000 and deployed the same month. It was serviced by RFD in Dunmurry and in the RFD service station in Calais, and repacked for March 2001, when it was installed on board *P&OSL Aquitaine*. A year later, the chute had its annual dry service and was deployed for the drill in October 2002. The service and deployment intervals are governed by SOLAS requirements. These are quoted in **Annex 3**. The servicing did not find a manufacturing fault in the glide path in cell 4 **(see Annex 1)**.

The chute was made up of 15 cells. Each cell had a series of wide loops arranged around the top and bottom, to which the outer cell walls were attached. There was also a mid-height hoop, which was held in place by six encasing sleeves. The blue material of the outer cell walls and the tapered slide paths were made of woven nylon. The sock was made of two panels of the blue nylon material and an orange elasticated material made up of a warp knitted polyamide fabric with a polyurethane coating on one side.

A ‘traffic light' system indicator was installed in the chute to indicate to the chute controller, at the head of the chute, if anyone had become stuck or had stopped during their descent. It also prevented the chute controller from sending further evacuees down. Four sensors, situated in each of the chute's four lower cells, operated the indicator unit. The sensor was attached to the outside of the blue half of the lining in each cell, forming a pleat in the fabric. As the evacuee passed through the cell, the pleat straightened out, thereby opening the sensor.

If this happened, the appropriate sensor light on the indicator would momentarily show red. As the evacuee cleared the cell, the pleat contracted, closing the sensor, and the indicator light would show green. If an evacuee stopped in the cell, the sensor would remain open and the appropriate sensor would remain red. After several seconds, the main red light would illuminate indicating a blockage.

1.3 NARRATIVE

Times quoted are UTC, and are from two MCA video recordings taken from the top and the bottom of the chute.

On 9 October 2002, over 250 evacuees and observers gathered on board *P&OSL Aquitaine* to take part in a Marin-Ark evacuation drill. The ship's FRB was in attendance as safety cover and to prove its ability to tow two loaded rafts. Also in attendance was a boat with St John's Ambulance first-aiders on board who could attend to any evacuee who might become injured during the drill.

At about 1233, the Marin-Ark MES unit on the port side aft was deployed, after which eight people (RFD, MCA, and ship's staff) descended the chute into the liferafts. Once in the liferafts, some of the ship's staff secured the bailers and the two liferafts together, while the others took up their positions by the exit to receive the evacuees.

The traffic signal system was found to be not working. This was overcome by use of hand-held radios by the chute controller's assistant and the receiver's assistant at the top and bottom of the chute respectively. Only the left-hand chute was being used for the drill. Once an evacuee had reached the liferaft, the receiver's assistant used the radio to inform the controller's assistant that the chute was "clear". The chute controller's assistant then tapped the chute controller's back and he sent the next evacuee down.

At 1248, after confirmation to proceed from the master on the bridge, the first of the evacuees was sent down, and the drill continued without any major delays. At about 1252, as one female evacuee approached the head of the chute, she hesitated and was immediately dismissed by the chute controller and his assistant. At 1312, 12 paratroopers descended the chute in quick succession to test the capacity of the chute.

At 13:18:09, the person preceding Mrs McCabe-Jones let go of the grab-rail at the top of the chute. During that person's descent, Mrs McCabe-Jones, who was wearing a Seadog Shipshape 2 lifejacket, moved forward to the head of the chute and, as she was doing so, the chute controller told her:

> "*Next one, sit on seat, hold on the rail, do not go down until told. When you go down, keep your legs together, arms above head. If you become stuck, wriggle*."

Mrs McCabe-Jones was reported to be co-operative while waiting in the queue at the top of the chute **(see photographs 3(a) and 3(b))**.

At 13:18:17, the person ahead of her reached the chute's exit and entered the liferaft.

At 13:18:19, the "clear" signal was given to the chute controller's assistant, who then tapped the chute controller. The chute controller said "go". Mrs McCabe-Jones let go of the grab-rail at 13:18:21 and began her descent. At 13:18:30 Mrs McCabe-Jones shouted, "Help". The chute controller replied, shouting, "Wriggle, wriggle". At 13:18:35, she replied, "I can't" and was told by the chute controller, "Move, shake your body". Again, she replied, "I can't", in a raised voice. The chute controller shouted, "Don't panic, don't panic, you'll be all right". The receivers, in the liferaft below, were informed by radio that someone was stuck in the chute. The chute controller moved the next evacuee away from the entrance and, again, shouted for her to wriggle, after which he heard muffled sounds. At 13:19:01, the chute controller called for a sweeper.

The sweeper, who was an evacuee and one of the ship's first officers, moved forward from the queue and, at 13:19:16, he let go the grab-rail and began his descent down the chute. He moved down slowly in a controlled manner, by keeping his arms and legs extended. He could hear Mrs McCabe-Jones calling, and he replied that he was on his way down.

He found her stuck in one of the socks, with her arms and legs above her body in a back down, piked position **(see diagram 3)**. Her lifejacket had come off and she handed it to him. He also found her day jacket, unbuttoned and off, in the cell. The sweeper noted that she was rational, able to follow instructions and was able to give him her hand. Her breathing did not seem laboured, although she did complain of having difficulty in doing so. Having moved the lifejacket and jacket out of the way, he took hold of her hand and tried to pull her up, but she could not move. He told her to bend her legs, and he pulled on her hands in an attempt to get her feet to go down first. Mrs McCabe-Jones then slid through the sock. The sweeper followed her down to the next cell but, again, found her still stuck in the same position. He tried to pull on her hand again, but was unable to move her.

The sweeper then realised that Mrs McCabe-Jones was not responding or talking to him, and he thought she had lost consciousness because she had been complaining that she could not breathe properly. He placed both of his feet on to hers and held one of her hands and tried to pull her up by holding on to an outer hoop of the chute. While trying to push her feet down, he called out to the chute controller and the receiver that she was not talking. She then slipped down to the next cell.

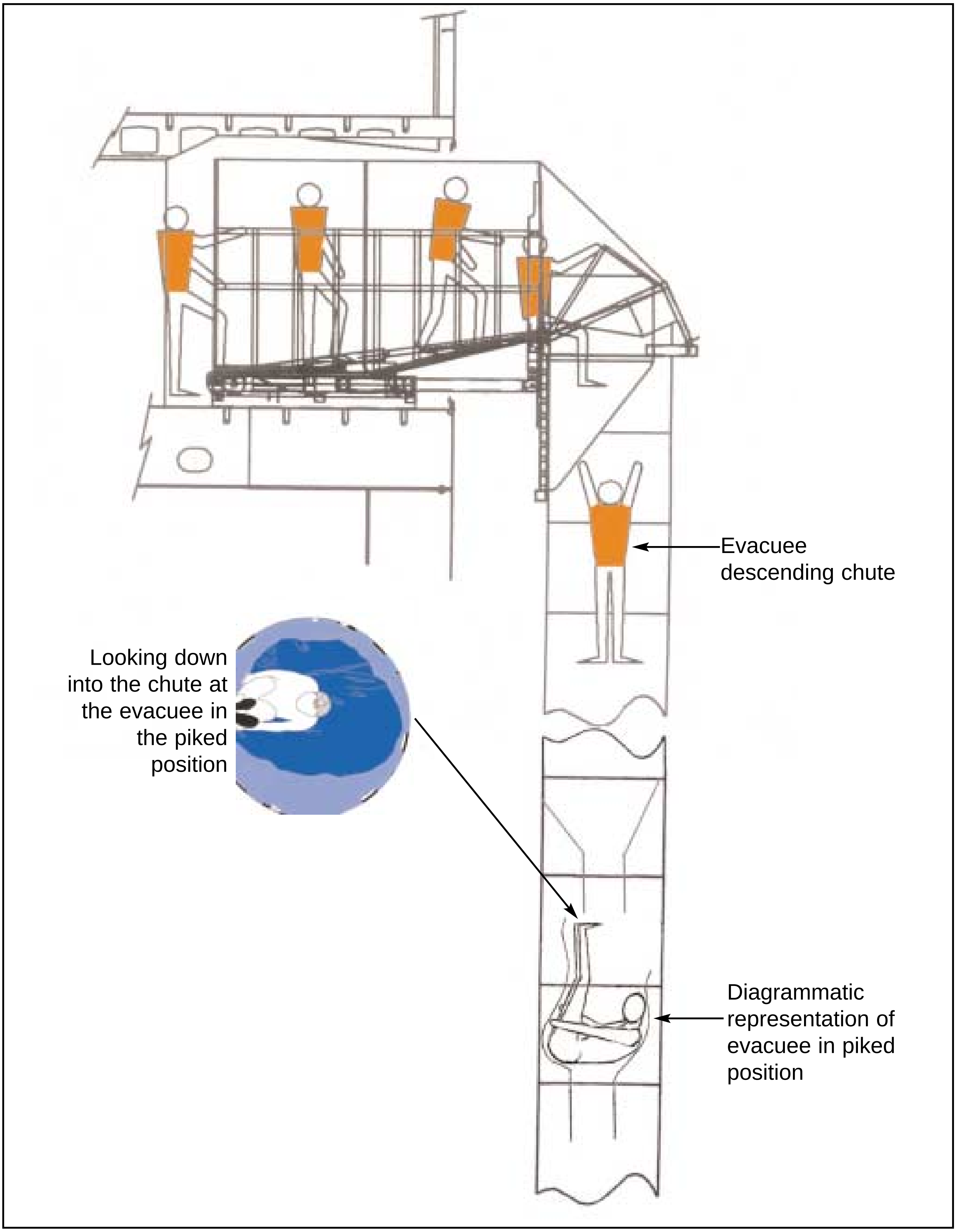
Photographs 3a and b

Notice difference in height of strap

Mrs McCabe-Jones waiting in the queue near the top of the chute

Lifejacket light

Photographs courtesy of MCA and Mr B McCabe-Jones



Showing evacuees descending the chute and in the piked position

When the sweeper found Mrs McCabe-Jones again, he looked out through the gaps in the chute's outer wall and saw that they were well down the side of the ship, and near the top of the liferaft **(see photograph 4)**. He called for someone to cut Mrs McCabe-Jones out of the chute.

The receiver, below, went up and out on to the liferaft's roof to investigate the reason for the blockage, and saw an abnormal bulge in one of the cells. He shouted for the person to straighten his/her legs and to wriggle, and began shaking the chute. He then heard the sweeper say that the woman was stuck and was not responding to his commands. The receiver relayed this message to the two RFD representatives in the liferaft who had been pulling on the bottom of the chute in an attempt to free her. As this appeared to have no effect, at 13:23:25, one of the RFD representatives decided to climb up the inside of the chute.

After he had climbed up several cells, he found a large bulge of a person in one of the socks of the cell above him. He called out to the person, but received no response. He then widened the elasticated part of the sock and put his head up to see if he could release the person, and saw Mrs McCabe-Jones's bottom. He tried to push her up from underneath, but was unsuccessful. He then reached into the sock and tried to pull her out, but was unable to move her. During this

Photograph 4

Looking down from the assembly station to the top of the liferafts time, he found that the evacuee was unresponsive. He decided to cut the sock (actually the two socks of cells 3 and 4) with a knife and, on doing so, she went past him through to the last cell above the liferaft.

From inside the liferaft at the exit, the second RFD representative could see Mrs McCabe-Jones above him. She was in a foetal position, with her knees clutched to her chest. He then pushed his shoulder up against her body. A P&O Stena Line employee joined him and, with one pushing and the other pulling on her legs, she finally entered the liferaft at 13:30:17.

Mrs McCabe-Jones arrived in the liferaft unconscious and blue in the face. Resuscitation techniques were carried out by the St John's Ambulance representative and continued throughout her evacuation to hospital.

At 1333, ship's time, the bridge staff called for an ambulance with paramedics. She was placed on the stretcher, and taken out of the liferaft on to the FRB, which then took her ashore at 1334 **(see photograph 5)**. At 1339, the Kent Ambulance service received a call for an ambulance and, shortly afterwards, two ambulances were activated and in transit to Western Docks. At 1340, Mrs McCabe-Jones was landed ashore with St John's Ambulance representatives in attendance.

Photograph 5

The fast rescue boat and lifeboat standing by alongside the liferaft

An air ambulance was also activated, and was in transit at 1340. At 1351 the road ambulances arrived, but were not used as the air ambulance was due on-scene. The air ambulance arrived at 1402 and Mrs McCabe-Jones was evacuated at 1409 to the Kent and Canterbury hospital, where she arrived shortly after. She was pronounced dead at 1425.

No more evacuees were sent down the chute after the accident. At 1344, the P&O Stena Line marine safety manager made an announcement to the remaining evacuees on board the ship that the drill had been stopped because the chute had been cut, and this could cause a risk of injuries if more evacuees descended it.

Later, the chute was taken to a P&O Stena Line warehouse for safe keeping. With the agreement of the investigating police officers, it was later decided to take the chute to a police station for the coroner's safe keeping.

Two days later, the result of a postmortem examination at Buckland hospital was that the cause of death was inconclusive.

1.4 MRS MCCABE-JONES

Mrs Lynda Susan McCabe-Jones lived near Ashford in Kent. She was 53 years old, 1.68m in height and weighed about 100kg. She had been employed by P&O Stena Line's IT department for about 3 years. Before that, she was a senior lecturer at West Kent College in Tonbridge for 15 years, teaching IT and accounts to 17 to 18 year-old students. She was a skilled first-aider.

1.5 REASON FOR DRILL ON *P&OSL AQUITAINE*

P&O Ferries has introduced the *Darwin* class of ship to its fleet on the cross-channel routes. It has done this by converting two existing freight ro-ro vessels, of 200-passenger capacity each, into passenger ro-ro ferries, each of 2000-passenger capacity. For the first time in the marine industry, the company has fitted these ships exclusively with the Marin-Ark MES, which means the carriage of conventional lifeboats is not required. The vessel also carries eight 25-person, self-righting, davit-launched liferafts, one FRB, three rescue boats, and one 12-person MOR.

The Marin-Ark provides lifesaving evacuation appliances for 2780 passengers and crew on each ship. This gives a 25% excess capacity.

The evacuation of disabled adults and infants less than 5 years old, including their guardians, is by the eight 25-person liferafts. Passenger statistics indicate that this is sufficient capacity for these individuals, even allowing for specific occasions when the number of disabled passengers may be significant.

To allow this proposal to be approved, the MCA has granted an exemption from Merchant Shipping Regulations, which require lifeboats, on the grounds that the Marin-Ark MES provides an equivalent lifesaving capability. This is detailed by Regulation 2.1 of SOLAS Chapter 3.

To support the case for granting an exemption, the MCA requested a trial evacuation of 215 persons as half of a Marin-Ark system capacity. In addition, the MCA wanted to witness a successful in-service deployment of the Marin-Ark system, as several deployments had not been completed satisfactorily. During one deployment, a number of injuries were sustained because of the proximity of the exit of the right-hand chute to the side wall of the liferaft. When another deployment took place, it was found that a chute was twisted to render it unusable.

The objectives of the evacuation drill on 9 October 2002 were to prove:

- The assembly system by using one assembly station as a representative sample.
- The carousel counting system. This was a procedure developed by P&O Stena Line to count passengers, issue lifejackets and can be used to identify passengers who may be unable to descend the chute.
- The segregation of infants and infirm who cannot evacuate via the Marin-Ark MES.
- Controlled movement of passengers from the assembly station to the chute head.
- Controlled movement of infants and the infirm to MOR.
- Deployment of the system.
- The control of the chute head.
- Evacuation via the chute.
- Times for assembly, carousel counting and evacuation.
- Ability to tow a pair of Marin-Ark liferafts with an FRB.
- Whether the *Darwin* Class of ships need specialist lifejackets.

The following was the plan for the evacuation drill:

- Deployment of two inboard liferafts, the two outboard rafts being disconnected for the purposes of the drill.

- *P&OSL Aquitaine* was chosen as the most similar ship to *Darwin* Class, using the port side MES of the two Marin-Ark evacuation assembly stations.

- *P&OSL Aquitaine* withdrawn from service and proceed to the Cruise Terminal berth.

- Line managers on board *P&OSL Aquitaine* were responsible for co-ordination of the drill on the day, following detailed planning in conjunction with Fleet Department managers.

- Drill held on a crew change day to assemble 215 staff from both watches.

- Ship's staff to be augmented by cadets, other sea staff volunteers, office staff and volunteer military personnel and industry guests.

- Staff should wear trousers and long sleeved shirts, or boilersuits, no shoes or glasses.

- Drill and deployment to be controlled but not timed, the clock can be stopped as required for safety and operational issues.

1.6 THE EVACUEES

The majority of the evacuees were *P&OSL Aquitaine*'s staff, from all departments on board the ship. The drill was planned for the day when the personnel changed shift on board, to maximise the number of evacuees.

Management staff and personnel from other company ships, including senior officers, were also used as evacuees. To increase the number, 50 paratroopers from the First Battalion Parachute Regiment were also asked to take part. Before Mrs McCabe-Jones made her descent, 12 of the paratroopers went at 3-second intervals to test the capacity of the chute.

A person from the company's IT department had requested permission from the marine safety manager to take part in the drill, for his own interest in the activities on board. As there was a likelihood of a shortfall in the numbers of evacuees required by the MCA, this request was granted. Later, the IT staff member asked if two of his colleagues could attend, to which the marine safety manager agreed. On the day of the drill, the three IT staff members attended with three others from their department, including Mrs McCabe-Jones, and their names were added to the guest list, on which they signed their names.

About 15 other office workers from various organisations either descended the chute, or were in the queue to descend, at the time of the accident.

1.7 TRAINING OF SWEEPERS

The sweeper, who descended the chute to assist Mrs McCabe-Jones, was 33 years old, fit, experienced and had a good knowledge of the Marin-Ark system. He had attended P&O Stena Line's Marin-Ark MES familiarisation training courses with other ships' staff in October 1999, March 2001 and March 2002.

There was no specific practical training to act as a sweeper. However, during this training, he and all course members were given verbal instructions using an illustration in the RFD training manual, on how to act as a sweeper.

The difficulties of descending the chute under control, and trying to lift someone in the chute, were recognised, as was the difficulty and practicability of simulating a blockage. The company had no record of anyone becoming stuck in the chute (only those who had stopped in it), and there was no warning of this possibility from RFD.

The P&O Stena Line training manual was basically that supplied by RFD with some company-specific amendments.

The P&O Stena Line crew training manual gave the following instructions for a blocked chute:

> *Infrequent though they are, 'hang ups' usually occur in the lower four cells of the chute. Being close to the liferaft, voice communication and physical contact is possible. If the blockage occurs higher up the sweeper will clear a chute in the following manner. Descend under control until the person blocking the chute is reached. Brace each foot on the sides of an adjacent chute ring. Reach down, bend the knees and grasp the person's lifejacket at the shoulders. Straighten up, lifting the person clear, then releasing him/her, having advised as to the position of arms and feet.*
>
> *The sweeper continues down to the raft.*

1.8 SUMMARY OF THE INSPECTION OF THE CHUTE

An inspection of the chute was carried out in the Cruise Terminal at Dover on 18 December 2002. The coroner's officer delivered the chute from police storage to the site.

Three MAIB inspectors, their LSA expert, the coroner's officer, the coroner's expert, a scenes-of-crime officer and representatives from P&O Stena Line and RFD were present at the inspection.

The purpose of the inspection was to report on the chute's condition, to find any faults which might have played a role in the accident, and to establish if it was manufactured in compliance with RFD's specifications.

The chute was laid out on the floor for external inspection. It was then suspended by a crane so that each of the lower cells could be inspected in turn, before and after being detached from the one above **(see photographs 6 & 7)**.

The following were the key observations from the inspection:

- Vertical cuts were found in the external walls of cells 1 and 2. These were made by one of the RFD representatives during the rescue attempt.
- Cuts were also found in the elasticated sections of the socks in cells 3 and 4. These were also made by a rescuer.
- A vertical tear was found in the whole vertical length of the sock in cell 14, which is very near the top of the chute.
- The top of the slide path section in cell 4 had not been completely stitched during manufacture, and was not in compliance with RFD's specifications.
- Fraying of the woven nylon material at the bottom of a number of socks was found, but only at cell 1 was a stirrup[1] found.
- The inside of the chute was in good condition.
- The stitching of a number of the yellow mid hoop supports had partially, or totally, come undone.

The full inspection report is in **Annex 1**.

1.9 SUMMARY OF THE RECONSTRUCTION OF THE ACCIDENT

Following the accident, it became clear that a reconstruction would be necessary to investigate the possible causes of how the deceased attained the position in which she became stuck in the chute. Therefore, after the detailed inspection was completed, the reconstruction was planned to incorporate the findings.

The initial meeting for the reconstruction took place at RFD's factory in Dunmurry, attended by two MAIB inspectors, the RFD marine systems design manager, and the P&O Stena Line sweeper who tried to free Mrs McCabe-Jones.

The attendees determined that Mrs McCabe-Jones was found in cell 6, and that the lifejackets used in the drill (not including the 32 lifejackets used which had leg straps) did not have the side belt for the restraining strap. The lifejacket, which the sweeper had brought with him, was fitted with a side belt.

RFD had created a four-cell section chute suspended from a scaffolding frame. The chute was open at the top so that participants of the reconstruction could see down into the first cell **(see photographs 8 & 9)**.

[1]Formed from the frayed edges of the socks.

Photograph 6

The actual chute used in the drill hoisted up by crane for the inspection

Photograph 7

Top hoop

Mid hoop

Bottom hoop (removed)

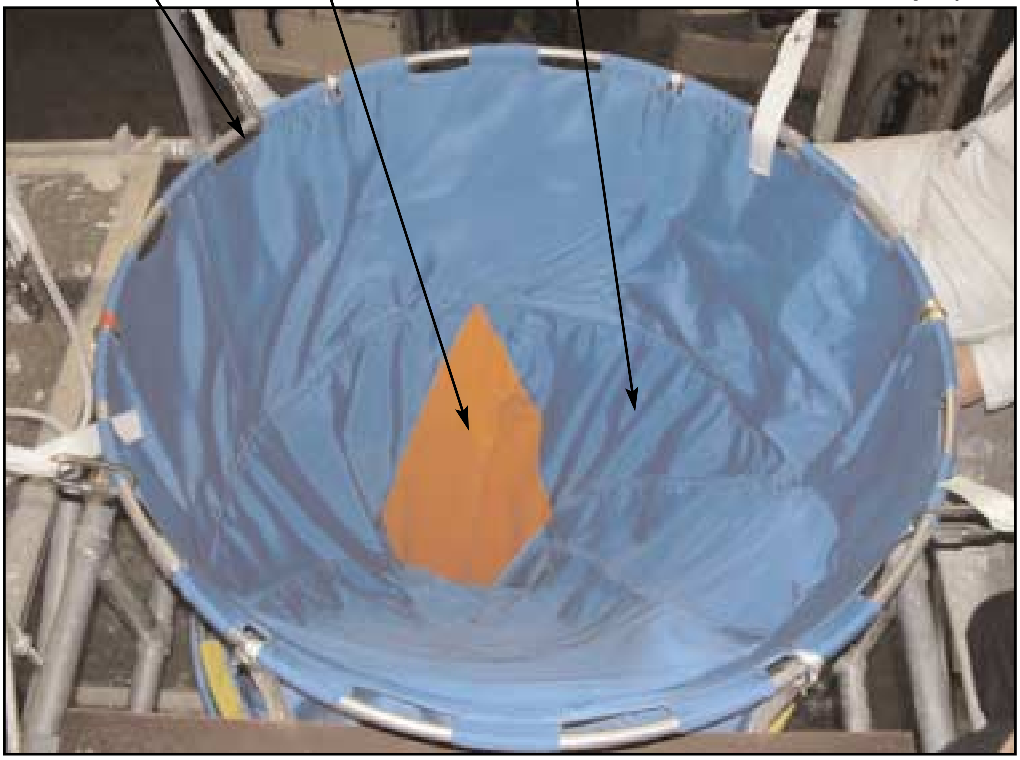
Sock

Showing one cell of the chute

Photograph 8

Four cells rigged up in RFD's factory for the reconstruction

Photograph 9



Looking down into a cell during the reconstruction

During the first day, each of the participants recreated (with the aid of a harness and a knotted line) the position in which Mrs McCabe-Jones was found. With growing confidence, the participants were able to assume quickly the same position, without great discomfort. Then the participants were able to explore different possible reasons as to how she assumed the piked position. The second day carried on with the latter work until a possible scenario was derived **(see photograph 10)**.

The main findings of the reconstruction were as follows:

- In an ideal condition, if an evacuee is able to maintain the required posture during the descent, it appears to be impossible to become stuck in the piked position.
- To attain the piked position, the evacuee's legs and feet had to be raised, for what ever reason, to allow the upper body to overtake the lower body.
- The riding up of the lifejacket was probably a contributing factor in initiating the actions taken by Mrs McCabe-Jones, and in her becoming stuck in the chute.
- The actual accident occurred in more dynamic circumstances than those which could safely be conducted in the reconstruction.
- Stirrups caused by the fraying of the bottom edge of some of the socks were easily broken under the weight of a person.
- The full reconstruction report is in **Annex 2.**

1.10 STUDY OF VIDEO RECORDINGS OF THE DRILL

During the drill on 9 October 2002, for research purposes, two MCA video cameras were in continuous operation: one at the top and one at the bottom of the chute. From the analysis of the MCA video recordings, which included audio enhancement, a spreadsheet was produced giving information on the descent of the 116 evacuees who went before Mrs McCabe-Jones. This is shown in **Annex 4**.

The analysis showed that 61 evacuees entered the liferaft face-forward, and with the lifejacket in place **(see photograph 11)**. Thirty four exited on their left sides, right sides, with bent knees or backwards but with their lifejacket in place. Therefore, 95 evacuees had their lifejackets in place when they exited the chute, which is 82% of the total. Descent time for these two groups varied from 6 seconds to 26 seconds, with an average time of 11 seconds.

Photograph 10

A participant of the reconstruction sitting in a sock in the piked position

Last sock

Photograph 11

The exit from the chute into the liferaft

Twenty one of the evacuees had displaced lifejackets (18% of the total), either at the front or back or both. Again, their times of descent varied from 6 seconds to 26 seconds, with an average time of 11 seconds. Those who had displaced lifejackets and could be identified, were contacted and accounts of their experience during the descent were obtained. These included the following points:

- Some lifejackets rode up from the bottom, causing the evacuee to stop in the chute, occasionally more than once.
- Some found it necessary to move their arms down to rearrange the lifejackets and wriggle before they continued their descent.
- Some received minor injuries to the face as a result of the lifejacket-light hitting them during their descent. Others, aware of the dangers presented by the light, disconnected theirs and put them in their pockets.

Before Mrs McCabe-Jones, 16 female evacuees descended the chute, of which seven arrived at the exit face-forward and with their lifejackets in place. Four females arrived on their left sides, right sides, with bent knees or backwards, but with their lifejackets in place. Therefore, 11 of them had their lifejackets in place, which is 69%. Descent time for the two groups varied from 6 to 18 seconds, with an average time of 11 seconds.

Five females arrived at the exit with displaced lifejackets, with their descent times varying from 6 to 14 seconds and an average time of 10 seconds.

However, two of the females set the fastest time of descent at 6 seconds. Seven males had descent times of 7 seconds.

Observations from the videos identified 25 evacuees of both sexes who were greater than the average build. Fifteen of these evacuees' lifejackets were in place, the rest arrived at the exit with their lifejackets displaced. Therefore, the lifejackets of 30% of the people within this category displaced; higher than the overall 18%. This group had descent times varying from 7 to 26 seconds, giving an average time of 12 seconds, which is slightly longer than the other groups.

Thirty two of all the evacuees were wearing lifejackets with thigh/leg straps, none of which was displaced as they entered the liferaft.

1.11 RESULTS OF QUESTIONNAIRES FROM DRILLS

After the abandon-ship drill on *P&OSL Aquitaine*, P&O Ferries sent a questionnaire to the fleet to gain information on the use of the Marin-Ark MES.

The received reports referred to 100 descents, 48% of which occurred during the drill on 9 October 2002. All but two of these descents were with Seadog Shipshape 2 lifejackets, as used by most of the evacuees on the day of the accident.

Riding up of lifejackets in front of the wearers occurred during 22 descents; some said this caused them to stop in the chute. Twenty four people, or about one in four, reported they had become stuck/stopped in the chute, but they were able to wriggle free and had completed the descent.

Two comments were made that training had helped in their descents. General comments ranged from "..the whole experience was uncomfortable and unpleasant.." and "very disorientating and it was a surprise when I got to the bottom of the chute.." to "..this was a good system…far superior to the (slide) MES, more efficient, a lot easier to use, easier for staff to understand.."

To gain experience of descending the Marin-Ark MES, two MAIB inspectors attended a drill on board P&O Irish Sea Ferries' *European Ambassador* on 5 January 2003 in Birkenhead, when about 40 crew members descended the chute with the inspectors.

During the drill, one person suffered a sprained ankle during descent. Another suffered concussion from being hit by the next evacuee after becoming stuck in the chute, probably by displacement of one of the traffic light sensor cables.

Following this drill, P&O Irish Sea Ferries issued a questionnaire to the crew members, and received 34 responses. Of these, 11 evacuees stopped in the chute, four of whom mentioned catching a foot, and three mentioned straddling a "wire". Six evacuees reported landing on other evacuees during descent. Observations and comments were similar to those made in the responses to P&O Ferries' questionnaire, with the addition that there seemed to be a lack of control of the speed of an evacuee's descent.

1.12 INTERNATIONAL QUESTIONNAIRES

Shortly after the accident, the MAIB sent questionnaires to classification societies, certain national maritime authorities, and ship owners and operators which had the Marin-Ark MES installed on their ships.

The responses from the ship owners and operators showed that:

- Most deployments, with or without evacuees, occurred in sheltered waters of harbours or shipyards;
- Risk assessments had not been made for about half of the deployments;
- In the majority of cases, very few people became stuck/stopped, very few people were injured, and no significant problems were experienced with the variety of lifejackets used.

However, one drill carried out on a high-speed craft in Australia produced two serious accidents, during which one person suffered a broken ankle, and another suffered a neck injury, resulting in confinement to a wheelchair.

There has been one account from Denmark of an evacuee becoming stuck in another manufacturer's vertical chute MES using a different glide path to Marin-Ark. Wearing a lifejacket, this evacuee began her descent normally, but the toe of her right shoe (evacuees are allowed to wear shoes in this system) caught on the fabric inside the chute and became stuck. She called out to say that she was stuck when she heard the chute controller telling the next evacuee to "go". She was pushed down the chute by the following evacuees landing on top of her, and was pressed down in a doubled-up position. Eventually, she arrived at the bottom of the chute face-down. During the time she was stuck, she felt hot and had difficulty in breathing as a result of the pressure of the people on top of her.

The evacuee had made no unusual movements during her descent, and had obeyed the instructions given to her and shown in the illustrations in the reading material given to her beforehand.

To improve evacuees' safety, the chute manufacturer made the following changes:

- Every evacuee to wear overshoes, to minimise and equalise friction during descent;
- The receiver to use a signalling horn to indicate to the chute controller that an evacuee has arrived in the liferaft;
- The exit to the chute was improved to decrease speed of the evacuee in the later stages of descent and to ensure a steady flow so that evacuees can move away from the landing zone.

1.13 POST-ACCIDENT RESEARCH

In addition to the work of the LSA expert who assisted the MAIB in its inspection of the chute, the MAIB placed the following three contracts for research during the investigation.

1.13.1 Medical opinion

Assessment of the histology slides, taken during Mrs McCabe-Jones's postmortem examination, her medical history and the video taken during her descent.

These were assessed by Professor W R Roche, an honorary consultant pathologist at Southampton General Hospital. The closing comments of this assessment were:

Positional asphyxia is usually associated with flexion of the neck, and/or compression of the chest. The appearance of the evacuation tube in the video suggest that the structures would allow a person in the horizontally supine *position with the limbs in a jack-knife position to experience forces producing flexion of the neck and restriction of the respiratory movements of the chest and abdomen.*

Having read the clinical records and viewed the video recording, I am of the opinion still that death was due to positional asphyxia.

1.13.2 Positional asphyxia

QinetiQ Centre for Human Sciences was contracted to carry out a study titled "An investigation into the role of positional asphyxia in the death of a volunteer taking part in a trial of a maritime mass-evacuation system."

The conclusions of this study were as follows:

The victim died because of a combination of rare events.

The present study supports the views of the two pathologists conducting and reviewing the victim's post mortem examination, that the victim died of positional asphyxia.

The present study also shows that designs for future dry-shod mass evacuation systems should pay particular attention to:

1. *Providing some means of preventing evacuees getting into bottom first or back first presentation positions.*
2. *Providing some means of mechanical purchase, with appropriate instructions, to help extricate evacuees, should they get stuck in these positions.*
3. *Considering the problems of claustrophobia and how this can be minimised by appropriate instructions to evacuees before descent.*
4. *Re-examining the wisdom of using leg-restraint straps of front-mounted lifejackets as these might increase the risk of subjects being inextricably trapped should they get into bottom-first or back-first presentation positions.*

1.13.3 Audio analysis

Avenca Ltd was contracted to carry out an audio analysis of the MCA video tapes taken during Mrs McCabe-Jones's and the sweeper's descent.

Four specific sections of the audio were analysed in an attempt to clarify conversation with Mrs McCabe-Jones during her descent. The results of this analysis have been used in the narrative of this report.

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.

The investigation has been given high priority because of the global implications it may have for vertical chute MESs, the mass evacuation of passenger ships in an emergency, and the use of volunteer evacuees in drills.

2.2 THE ACCIDENT

2.2.1 The evidence

From the information given by the ship owners and operators, and the questionnaires received by the MAIB, it would seem that the frequency of becoming stuck (as opposed to stopping) was rare. As there were no witnesses to Mrs McCabe-Jones's descent, and she was unable to tell the sweeper what had happened, it is impossible to determine exactly how her jacket and lifejacket came off, and how she assumed the piked position in which the sweeper found her. For this reason, an inspection and reconstruction was carried out to understand the mechanics of how Mrs McCabe-Jones became stuck, and to discover whether or not it was caused by a defect in the chute.

From an analysis of the rescuers' statements, and the evidence of the cuts in the chutes and the socks, it is probable that the sweeper found Mrs McCabe-Jones stuck in cell 6. (Cell 1 was the first cell above the top of the liferaft and cell 15 was the first one down from the head of the evacuation station.) There were two significant faults in the chute above and below cell 6; the tear to the sock at cell 14 and a manufacturing fault in cell 4.

The inspection concluded that the initial tear had occurred on deployment, when, for some reason, the elasticated fabric became caught either on a grub screw in the top hoop, or on one of the bungee rope shackles. The passing of evacuees during descent would probably have elongated this tear. This sock is very close to the top of the chute, where the evacuees would not have gathered momentum, and would probably not have noticed that the elasticated part was torn and ineffective. Very careful consideration was given as to what effect this tear could have had on the accident. The considered opinion of the MAIB and the LSA expert **(see Appendix 1, Conclusions)** was that, although there was a slight possibility that the tear could have had some bearing on the accident, in all probability it did not have any effect on Mrs McCabe-Jones's descent, or cause her to become stuck a further seven cells down.

The top of the slide path in cell 4 had not been stitched during manufacture. During the rescue attempts, the sock in cell 5 was well down into cell 4 because of the combined weight of Mrs McCabe-Jones and the sweeper. Therefore, when she fell from cell 5 into cell 4, she passed directly from one sock to another, without touching the tapered slide path and the hole made by the defect at the top of the slide path. The defect in cell 4 could not have affected the accident.

The cells between 14 and 4 had no significant defects, which could have caused Mrs McCabe-Jones to become stuck in the chute.

The reconstruction proved that it was difficult for a person's feet to be tripped up by catching on the hoops, as they were on the outside of the smooth nylon walls of the chute and the slide path. However, the RFD rescuer, who climbed up the chute during the recovery of Mrs McCabe-Jones, must have used the outer hoops as steps and/or as supports.

The inspection showed that the bottom of a number of socks had frayed edges to the nylon material, which could cause stirrups and the possibility of evacuees' feet becoming caught in them. However, during the reconstruction, these stirrups were easily broken as the threads, made up of very thin strands, came apart easily under a person's weight.

The analysis of the top video tape audio signal, using a filter system, identified a further conversation between the sweeper and Mrs McCabe-Jones. The sweeper said he was on his way down to help, and he asked where she was situated. After that, the analysis could extract no more meaningful information.

2.2.2 The descent

The reconstruction showed that, over about 20 descents, the participants had difficulty in deliberately trying to get caught, and this suggested that the cause of Mrs McCabe-Jones becoming stuck was unusual. If an evacuee was able to maintain the required posture during descent, it appeared in the reconstruction to be impossible to become stuck in the piked position; however, it should be remembered that the reconstruction had been conducted using limited dynamic motions. In reality, the accident would have been far more dynamic, with a greater speed of descent and, hence, greater momentum.

The following two scenarios have been devised to explain the causes of Mrs McCabe-Jones becoming stuck in the piked position within the chute:

Common initial events

Mrs McCabe-Jones entered the top of the chute with the front of her lifejacket projecting out, because of the type of lifejacket she was wearing and also her body shape. The video recording shows the webbing restraining strap secured quite high up towards her neck compared with other people **(see photographs 3a and 3b)**.

As she descended the chute with her legs together and arms up, the friction of her descent caused her smooth, lined jacket together with her lifejacket, to ride up until the lifejacket's webbing strap was under her arms.

The quickest descents were of 6 seconds, the average time of descent was about 11 seconds and Mrs McCabe-Jones made her first call of help 9 seconds after she had let go of the grab rail at the top of the chute. Because she was found more than half way down the chute, her descent time to that position was, compared with other descent times, not unusual. This left little time for delay or stoppage during her descent.

<u>Scenario 1</u>

Her projecting lifejacket then caught the stitched seam, where the chute slide path narrows into the sock **(see photograph 12)**. The front part of the lifejacket flipped up into her face, causing her to become wedged momentarily in the sock of cell 7, in a very uncomfortable and distressing manner **(see photograph 13)**. Unable to move her arms, and the webbing trying to ride up, she raised or spread her legs to try to push herself up to reach a more comfortable position. As she did so, she slipped out of her jacket. This was lined and, therefore, could have slipped off relatively easily. The lifejacket would have come off with the jacket. Since her legs were not directly below her, she fell back-first into the next cell, and into the piked position, with the jacket and lifejacket falling loosely on top of her.

<u>Scenario 2</u>

As the lifejacket rode up uncomfortably in her face, she tried instinctively to pull it down (the lifejacket light might have also irritated her). Because of the disorientation of descent, and the distraction in adjusting her lifejacket, she inadvertently moved her legs out of the recommended position for descent and, in doing so, her feet momentarily touched on something in the chute, causing her body to trip. At the same time her jacket and lifejacket came off. With the momentum at which she was travelling, her upper body overtook her legs which had been slowed down by the tripping mechanism, allowing her attitude of approach to the next sock to be unorthodox, and causing her to assume the piked position.

The reconstruction showed that when the participants attained the piked position with their bottoms down, it was not life threatening to them. However, it was impossible to recreate the accident precisely, without risk of injury to those involved.

Once in the piked position, it was almost impossible for the sweeper to release Mrs McCabe-Jones. There was no reference in the company's training manual on how to release an evacuee from the piked position, as the occurrence had not been foreseen.

Photograph 12

Stage 1 - Lifejacket rode up

Photograph 13

Stage 2 - Lifejacket rode up

The sweeper was unable to lift her up physically so that she could push her legs down into the sock, allowing her to continue her descent in the correct attitude. She slipped from one cell to another, but retained the same piked position. The sweeper needed some sort of apparatus to help him lift her out of the piked position. The QinetiQ report also concluded that sweepers should be provided with some means of mechanical purchase in assisting evacuees if they became stuck in the chute.

The decision to send down a sweeper was taken quickly and without hesitation. However, the rescue took about 10 minutes to release Mrs McCabe-Jones, because, initially, those at the top and bottom of the chute were unable to see the blockage (the chute controller thought she was near the top) and the position she was in. If they had been able to see her, or had the sweeper been equipped with a radio set, they would have had a better awareness of the situation.

2.2.3 Traffic light system

In a number of deployments, the traffic light system has not operated properly. Although, on the day of the drill, radio communications overcame the malfunction, this only allowed one person in the chute at one time (apart from the military personnel). The traffic light malfunction slowed the ideal rate of the evacuation in the drill, which would also happen in an emergency. The unreliability of the traffic light system did not contribute to the accident.

During the *European Ambassador* evacuation, and during another evacuation in Norway, several evacuees reported being stopped in the chute when they were near the bottom. On investigation, this was found to have been caused by excessive slack in the traffic light system wire.

RFD has subsequently retracked the sensor cable so that it will not form a loop, which could hinder an evacuee.

2.3 LIKELY CAUSE OF DEATH

During the investigation, two possible causes of death were considered: did Mrs McCabe-Jones die of positional asphyxia or for medical reasons?

An investigation was made into her medical condition, by sending a copy of the postmortem examination report, the histology slides taken during the postmortem examination, her medical case-notes and details of the accident to a consultant pathologist. He reported that there was no physical evidence to sustain death as a result of her medical condition. The review of her case-notes did not reveal any immediate life-threatening illness.

However, there was other physical evidence that suggested Mrs McCabe-Jones died from asphyxia.

QinetiQ's studies showed that back-first, rather than bottom first, presentation threatened successful transit through the sock. In the back-first presentation, the head was inclined forcibly on to the chest, making breathing difficult. In that position, it was extremely difficult for the subject to attain any effective purchase on the slippery sides of the sock.

Volunteers who had been trussed up in a semi-piked position halved the size of the biggest breath they were able to take at one time. This procedure was repeated by exposing each volunteer to a further two episodes of 10 minutes over an artificially enlarged abdomen. This reduced the maximum breath that they could take somewhat further, but did not impede breathing while they were relaxed and at rest. It became obvious that it would impede breathing significantly if the subjects panicked or struggled to free themselves.

QinetiQ believed that Mrs McCabe-Jones died of positional asphyxia, which was also the opinion of both the pathologist who carried out the postmortem examination, and the consultant pathologist at Southampton General Hospital.

2.4 LIFEJACKETS

The reconstruction established that the initial mechanism, for causing Mrs McCabe-Jones to stop and become stuck in the chute, was probably the riding up of her SeaDog Shipshape 2 lifejacket. A number of evacuees who had suffered lifejacket displacement during their descent stated that the lifejacket had caused them to stop in the chute.

Lifejackets are generally made to fit all sizes of adults, and are designed to support a person in the sea in the correct position for survival, not specifically for descending vertical chute escape systems. All authorities, whether classification societies or flag administrations, require that all evacuees must wear a lifejacket when descending a vertical chute during a drill. RFD designed the elasticated socks to take into consideration the wearing of lifejackets by evacuees. The response from the ship owners and operators, which had the Marin-Ark MES on board their ships, showed that many types and makes of lifejackets were being used in evacuation drills. The lights on the lifejackets were catching people's faces during descent of the chute, causing minor injuries. Actions have been taken to recess the lights into the lifejacket.

However, during the drill on *P&OSL Aquitaine,*18% of the evacuees arrived in the liferaft with their lifejackets displaced. Some lifejackets had ridden up at the front, causing added resistance to evacuees' descent and, in some cases, stopping them.

The analysis of the video recordings shows that all the evacuees who were wearing leg straps had no problems with their lifejackets, and most exited the chute normally. However, QinetiQ concluded that leg straps would cause extra problems to evacuees in the piked position. Also, in an emergency, leg straps could pose difficulties for passengers in donning lifejackets and they would need additional supervision from crew members.

This aspect was criticised in the *Estonia*[2] report, as passengers under stress had difficulties in understanding how to don lifejackets and the instructions were neither looked for, found, read, nor understood correctly. The type of lifejacket used in the drill on the day of the accident had been designed for ease of donning, with only a push-fit clasp to secure the strap at the front of the lifejacket; the strap can then be tightened by pulling on the loose section of the strap. The video recordings show that the lifejackets, issued to the evacuees, did not have a small webbing belt at its side, through which the restraining strap could be passed.

The female evacuees had a slightly higher rate of lifejackets riding up than the males, which could be explained by the difference in physique. Had the small webbing-guides or leg straps been fitted to the lifejacket worn by Mrs McCabe-Jones during the drill, it might not have come off.

It is essential that, no matter which type of lifejacket is used, it is fastened as tight as possible so that it cannot ride up or come off, and possibly lead to a blockage in the chute. However, lifejackets are not specifically designed for descent down vertical chutes in the Marin-Ark MES, although some are better than others in this respect.

Therefore, the MCA must ensure that through the EU Maritime Equipment Directive, a lifejacket, which is safe for descent, easy to don, and does not increase the likelihood of evacuees becoming stuck, is used during evacuations. The MCA should also progress this internationally, via the IMO.

A safety recommendation has been made to the MCA, that all lifejackets onboard vessels equipped with MESs within the MCA's jurisdiction, are suitable for safe descent with the specific MES installed, and this should also be taken forward to the IMO.

During the implementation of this recommendation, the MCA should advise owners of the findings of this investigation and inform them that any vessels fitted with a Marin-Ark MES should carry lifejackets which do not ride up on a person's body during descent of the MES.

[2]Report on the capsizing on 28 September 1994 in the Baltic Sea of the ro-ro passenger vessel mv *Estonia* published by The Joint Accident Investigation Commission of Estonia, Finland and Sweden

2.5 ISSUES ARISING FROM THE CHUTE INSPECTION

The aim of the detailed inspection was to establish if any obvious cause for the accident could be determined from the chute itself, and whether any defects were present.

It was established that the chute had been constructed to the approved drawings, except for the unstitched deflector panel in cell 4. A tear was found in the elasticated section of cell 14.

MAIB's LSA expert made four recommendations as a result of the inspection. These were to:

- Investigate the effect of the stirrups on a person's descent;
- Investigate the effect of a turned-up hem on the bottom of the sock;
- Improve the quality control of manufacture of the system to ensure the chute is constructed correctly;
- Improve the quality control at the service stations, to ensure systems are serviced and packed correctly.

These issues have been addressed as follows:

- A detailed study by RFD of the breaking behaviour of the strands of a stirrup (and the reconstruction testing) established that the strands would not impede an evacuee's descent, because the strands would break easily under load.
- The manufacturers considered a turned-up hem to be more likely to cause problems as it may form an even stronger stirrup. The results of the first recommendation also partially negated the need for this recommendation.
- RFD has taken steps to improve the quality control process, as detailed in Section 4, to cover the last 2 recommendations from the MAIB LSA expert.

In light of the defects found in this examination, it would be good practice for the inside of the chute to be inspected as soon as it is deployed for a drill, and before the first evacuee makes a descent.

2.6 DESCENDING IN THE MARIN-ARK MES

The design of the internal path of descent for evacuees, was a compromise between speed of descent and safety. The speed of descent had to be fast enough for the required time to evacuate passengers and crew from the ship, but not too fast as to cause injuries and problems to the evacuees. To meet the required evacuation time for high-sided vessels, it is proposed to have up to three evacuees in the Marin-Ark chute at any time. The rate of descent is controlled by the friction of the elasticated section of the sock, and by orientating each sock at 90° to the one above, causing the evacuee to turn during descent.

The responses to the questionnaire, after the drill on board *European Ambassador*, showed that many of the evacuees found the rate of descent alarming, and they instinctively spread their arms out to slow themselves down and, on occasion, they stopped in the chute. This would probably explain the different times of descent during the drill of 9 October 2002, and why people stopped in the chute and had to wriggle to free themselves.

There is a certain amount of confidence in the safety of the system, as shown by drills in Canada and Norway, in which many evacuees, of all ages and sizes, including children as young as 6 years old, have been involved without injury.

However, it must be remembered that these systems are intended for use in times of an emergency, when the degree of control will not be the same as during drills. Large numbers of people, in different states of panic, will have to evacuate passenger ships and descend the chutes. They will be placed in an unfamiliar environment; with stress-related narrowing of consciousness and perception. Therefore, it is more likely that, in the situation of an actual emergency, people will become stuck and/or injured. It is essential, therefore, that sweepers have effective means at their disposal to clear blockages to enable the evacuation to continue as quickly and effectively as possible.

Although the recovery arrangement provided for the sweeper has been further developed, there still remains the possibility of a similar accident occurring again, unless the manufacturers of the Marin-Ark MES address the problem of blockages occurring. However, RFD has commissioned a risk assessment and hazard analysis to determine which areas of the product may be improved so as to minimise the risk of this and other types of accidents occurring. A safety recommendation has been made to remove any possible causes of blockages in chutes, by redesign and/or other means.

2.7 LIVE DRILLS

Passenger ships, including *P&OSL Aquitaine*, are required by SOLAS to carry out emergency training and drills. These are overseen by the Flag State Administration, or its delegated organisation (for *P&OSL Aquitaine,* the MCA was the overseeing authority). These drills are to improve crew's familiarity with the safety equipment, and to practice abandoning the ship. Details of drills are required to be recorded. Administrations also require full live evacuation drills to satisfy themselves that the MES will operate effectively, so that the required number of people are evacuated in the required time. However, most drills are carried out by shipping companies, which take the opportunity to train ship's staff during the SOLAS-required deployment of an MES.

The drill on 9 October 2002 was a demonstration of the evacuation system proposed for the *Darwin* class of passenger ferry in P&O Stena Line's fleet. The MCA requested an MES evacuation drill, using a similar chute to the 12 chutes to be fitted on the *Darwin* ships. The drill took place on 9 October 2002 on board *P&OSL Aquitaine*, during which this fatal accident occurred. Critical stages of the drill were timed for information only; the whole drill did not have a time limit.

Over 120 Marin-Ark units have been installed on a number of ships worldwide since 1998, and more are being installed at the present time. There have been several deployments, using over 5,000 evacuees to descend the chutes; this is the only recorded death to have occurred. QinetiQ's report concluded that Mrs McCabe-Jones died because of a combination of rare events.

Some of these other deployments have used over 400 evacuees at a time. There has been a number of injuries to evacuees, ranging from sprained ankles to a more severe case of a neck injury, which confined the person to a wheelchair. The number of injuries has not been significant compared with the total number of people using the chutes. However, they still do happen, even in the controlled environment of a drill. On the day of the accident, the drill was very well controlled, because the communication system between the chute controllers and the receivers allowed only one person in the chute at a time, (except when the 12 paratroopers descended the chute).

Other drills did not have the same level of control, allowing more than one person in the chute so that evacuees who had stopped, for whatever reason, were injured by the following evacuees landing on top of them. Therefore, some injuries were not sustained as a result of the mechanics of the chute itself, but by the lack of control on the timing of the evacuees' descents.

A safety recommendation has been made to ensure that, during drills, the chute is clear before the next evacuee descends.

There is a conflict between having realistic drills, using different shapes, sizes, ages and experience of evacuees, and a shipping company's duty of care not to expose their personnel to risk of injury and death. However, there needs to be a level of confidence, not only for the authorities, but also for the ship owners, operators, their staff and passengers, that the operation of the MES is safe and effective.

At least three different types of vertical-chute marine evacuation systems have been approved and installed on various vessel types since the mid-1990s. Fortunately, none of these systems has yet been used in a real emergency. But this does mean that all the lessons to improve the safety of these chutes can only be learned from live drills.

Very few accidents occur during drills involving vertical chute MESs. However, there is no specific worldwide accident reporting method in place on this subject. To address the issue of reporting accidents involving MESs, the MCA has been asked to take forward a recommendation to the IMO on reporting of accidents involving MESs.

2.8 RISK ASSESSMENT

The risk assessment for the drill on 9 October 2002, which P&O Stena Line developed, was dated 15 October 2001 **(see Annex 7)**. It had been renewed and modified following previous incidents, and had been formally reviewed for use in this particular drill.

The risk assessment recognises the possibility of psychological stress on the evacuees. As a control measure for this it states:

Check for and recognise symptoms. Allow person to not descend chute.

Although no guidance was given to assist in the recognition of symptoms, evacuees who were uncertain, hesitant, or who in any way appeared afraid, were allowed to step aside and not take part. Indeed, at 1252, one evacuee showed hesitation and was dismissed.

The risk assessment identified and assessed the level of risk for six hazards:

- Two were assessed as being of tolerable risk. That is, the identified control measures were adequate.
- Three were assessed as being of moderate risk and, on consideration, no further control measures were considered necessary.
- One was assessed as being a substantial risk. To reduce this risk, it was recommended that training lifejackets, without lights and with leg straps, were used for the drill. In light of the main hazard being seen to be the lifejackets coming off, not that of stopping in the chute, this was not done. However, the 100 lifejackets that had been purchased for use by P&O Stena Line's training section, were interspersed with the ship's lifejackets for this drill.

It was established during the reconstruction that the initial mechanism for causing Mrs McCabe-Jones to become stuck in the chute was probably the riding up of her lifejacket. It is a matter of conjecture as to whether the accident would have occurred had Mrs McCabe-Jones been wearing a lifejacket fitted with leg straps, as recommended by P&O Stena Line's risk assessment. However, had the lifejacket she was wearing been fitted with leg straps, it is unlikely that it would have ridden up during her descent.

When identifying control measures in formal risk assessments, it is essential that these measures are clearly stated and actioned. Recommending the replacement of lifejackets on board is not a control measure. The action of actually replacing the lifejackets on board for those without lights, and with leg straps, would have been a control measure.

Under SI 2962[3], Regulation 7, as stated in section 1.2.4, P&O Stena Line was required to bring to the attention of all evacuees in a drill, the significant findings of the relevant risk assessment. This was not considered necessary on 9 October 2002.

One control measure identified in the risk assessment was to restrict one person to a chute at a time. This is to ensure that evacuees do not land on each other. Although the risk assessment was formally reviewed for use in this drill, no additional control measures were identified on the risk assessment, such as to ensure the safety of the 12 paratroopers who descended the chute at 3-second intervals. Given that the fastest descent during the drill was 6 seconds, this control measure was not in place for these evacuees. However, just before the drill, the planned rapid group descent of the paratroopers was discussed with their commanding officer. The paratroopers were considered to be trained for actions such as this rapid group descent, so no added control measures were considered necessary.

In its approval of the Marin-Ark MES, the MCA suggest that it can be used by any fit person. Although there is no suggestion that any of the evacuees on 9 October 2002 were not fit, it would be prudent to ensure that the medical health of volunteers for drills is vetted for future drills. This could be a useful control measure in future risk assessments.

In view of the above, a safety recommendation has been made with regard to risk assessments for drills.

This accident has illustrated that a person can, as a result of a combination of rare events, become stuck for some time in the chute, the consequences of which can be fatal. Compared with a drill, it is conceivable that, in an emergency situation, the likelihood of people becoming stuck in a chute will increase, and other evacuees could pile up on top of the blockage, if more than one person is descending the chute at a time.

The time taken for the sweeper to clear the blockage could then be significant, bearing in mind that the sweeper has to pass the people in the chute. It could also be dark and the weather could be bad, causing a lot of movement in the chute. This scenario would stop the descent of passengers down that particular

[3]The Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997

chute, and might, depending on the number of passengers being evacuated, increase the time taken for evacuation. This could severely reduce the effectiveness of vertical chute MESs, especially where it is the major means of escape, such as in P&O Stena Line's *Darwin* class.

There is currently no requirement in SOLAS for any sort of risk assessment for an emergency evacuation, so the risk assessment was only conducted for drills. However, before the accident, no consideration within the ship's safety case was given to the adverse effect of possible blockages in the chute during an emergency evacuation. This accident demonstrates that a chute can become blocked and inoperable for some time. This fact should be incorporated in the safety case and/or risk assessment when it is made or revalidated. A safety recommendation has been made to this effect.

To spread this safety message to an international level, MAIB will take the findings of this investigation to IMO for its consideration and action.

2.9 FITTING OF THE VERTICAL CHUTE MES

2.9.1 Reasons for the introduction of vertical chute MESs

The Marin-Ark MES was designed and developed to evacuate a large number of passengers and crew from high-sided vessels into large reversible liferafts. This is accomplished without people being exposed to the weather, in the quickest possible time and with ease of deployment, using the least number of crew.

The reasons for the instigation of such MESs by manufacturers are mainly twofold: the safety record of lifeboats and their launching systems, and the recommendations from the *Estonia* accident.

1. Lifeboats

   In 2001, MAIB published its *Review of Lifeboat and Launching Systems' Accidents*. This set out some of the changes to lifeboat-based evacuation systems which have followed marine accidents. These have included the introduction of large, 150-person capacity lifeboats and on-load release gear for their suspension hooks.

   However, it also considered some of the accidents involving these systems; many of which were fatal. It concluded that the causes of these accidents had their roots in the complexity of the systems, which do not have the confidence of the user, the seafarer. These factors were compounded by poor instruction and training material.

2. Capsize of *Estonia*

The ro-ro ferry *Estonia* foundered in the Baltic Sea in 1994, with the loss of 852 lives. There were 137 survivors. The crew did not manage to launch any of the 10 lifeboats, largely as a result of the rapidly increasing list and the lack of time for organising the crew. The vessel carried 63 inflatable liferafts, 12 of which were capable of being launched by davits. The rest were launched by dropping them into the sea from their storage spaces.

Liferafts were useful in the rescue of people but there were serious deficiencies, which lessened their effectiveness in heavy seas. These included capsizing; those on capsized liferafts were thrown into the sea when they righted; accumulation of water in the liferafts, and the liferaft's black underside making them difficult to be seen by rescuers.

The report into the investigation of the accident recommended that:

> *All existing passenger vessels should be reassessed with regard to evacuation and all reasonable measures taken to increase the time available and possibilities for evacuation.*

2.9.2 Move towards MESs

Vertical chute MESs, including the Marin-Ark system, have demonstrated in drills that the requirement to evacuate large numbers of people quickly, and without exposure to the elements, has been met.

The passenger trade of the worldwide shipping industry has been fitting the Marin-Ark MES, not only to existing vessels, but also to new buildings. The Marin-Ark MES had not been a replacement for lifeboats on conventional ferries, the carriage of which is a SOLAS requirement. Nevertheless, MESs are the only means of evacuation from high-speed craft. The *Darwin* ferries have been introduced without lifeboats, instead they have been fitted with six Marin-Ark stations, providing 12 chutes, all of which include a 25% extra passenger capacity as a safety margin.

The *Darwin* project is setting a precedent, and it is possible that other ferry companies will follow suit, therefore bringing about a movement away from the carriage of traditional lifeboats. Vertical chute type MESs are relatively new and, as lessons are being learned, improvements in safety and efficiency are being made.

SECTION 3 - CONCLUSIONS

The following are the safety issues which were identified as a result of the investigation. They are not listed in any order of priority, but are listed in the order in which they appear in the analysis section:

1. It was concluded that the frequency of becoming stuck (as opposed to stopping) in MESs was rare in drills. [2.2.1]

2. It is probable that the sweeper found Mrs McCabe-Jones stuck in the sock of cell 6. [2.2.1]

3. The defects found during the chute inspection did not contribute to Mrs McCabe-Jones becoming stuck in the chute. [2.2.1] [2.5]

4. The reconstruction of the accident proved that it was unlikely for a person's feet to be tripped up on the outer supporting hoops. [2.2.1]

5. Stirrups, formed in the frayed edges of the socks, did not contribute to the accident, as they came apart easily under a person's weight. [2.2.1]

6. The reconstruction showed that the riding up of Mrs McCabe-Jones's lifejacket either stopped her in the chute or slowed her down such that she spread out her legs. [2.2.2]

7. Mrs McCabe-Jones probably raised or spread her legs and the momentum of the descent caused her to assume the piked position. [2.2.2]

8. The decision to send down a sweeper was made quickly and without hesitation. [2.2.2]

9. The sweeper needed some sort of apparatus to help him lift Mrs McCabe-Jones out of the piked position. [2.2.2]

10. The unreliability of the traffic light systems did not contribute to the accident. [2.2.3]

11. Positional asphyxia was the most likely cause of Mrs McCabe-Jones's death. [2.3]

12. It is probable that the initial mechanism for causing Mrs McCabe-Jones to become stuck, was the riding up of her lifejacket. [2.4]

13. 18% of evacuees had their lifejackets displaced during descent. This could have caused added resistance and instability to the evacuees' path down the chute. [2.4]

14. The reconstruction showed that the piked position was not life-threatening for those carrying out the tests. [2.2.2]

15. On board ships there are many types and makes of lifejackets, some of which have a tenency to ride up during the descent of MES chutes. [2.4]

16. There is a need for the approval, both in the UK and internationally, of suitable lifejackets, which provide a safe descent for MESs. [2.4]

17. The chute was designed to give evacuees the necessary rate of descent to comply with a required speed of evacuation and to minimise the risk of injury. [2.6]

18. The speed of descent varies because some evacuees possibly find the rate at which they descend alarming and instinctively slow themselves down. [2.6]

19. Sweepers need more effective means to clear blockages, especially during an emergency, when it is essential to keep the chute operational at all times. [2.6]

20. RFD has further developed the recovery arrangements for evacuees who are stuck in the chute. However, no modifications have, at the time of publication of this report, been made to the Marin-Ark chute to prevent this type of accident recurring. [2.6]

21. There is a conflict between administrations wanting as close to a realistic drill as possible, and shipping companies' duty of care to their evacuees. [2.7]

22. During the many Marin-Ark evacuation drills that have been completed, involving over 5,000 evacuees in vertical chutes, very few of them have been injured. [2.7]

23. Most of the injuries that have occurred during drills, were caused inside the chute when evacuees collided with each other. [2.7]

24. To the MAIB's knowledge, to date, vertical escape chutes have not been used during a real emergency. [2.7]

25. Although very few accidents occur during drills, there should be a specific worldwide accident reporting method to the IMO which can collate the evidence. [2.7]

26. P&O Stena Line's risk assessment considered only the evacuation drill, as there is no requirement under SOLAS to complete a risk assessment for emergency evacuation, and the safety case did not make reference to a blocked chute in an actual emergency. [2.8]

27. If the risk assessment's recommendation for of all evacuees to wear lifejackets fitted with leg straps had been adhered to, it is unlikely Mrs McCabe-Jones's lifejacket would have ridden up. [2.8]

28. In an emergency situation, stopping the evacuation of passengers to clear a blocked chute would reduce rate of evacuation. [2.8]

29. The installation of Marin-Ark MESs, instead of lifeboats, on conventional ferries, is setting a precedent within the marine industry. [2.9]

30. Development work on all types of vertical chute MESs is in progress to improve their safety and efficiency. [2.9]

SECTION 4 - ACTION TAKEN

Since the accident, a number of risks have been identified, and actions have been taken to reduce them.

4.1 P&O STENA LINE (NOW P&O FERRIES)

The company has selected an alternative lifejacket for use on its project ships: the Cosalt Premier. A sister company reports no problems with this jacket in Marin-Ark chutes. It cannot be pulled off the wearer. Existing Marin-Ark evacuation assembly stations will have lifejackets replaced with this type during 2004. In any drill deployment for which Cosalt Premier lifejackets are not available, modified SeaDog Shipshape 2 lifejackets with leg straps will be provided.

A Fleet Directive has been issued requiring the provision of a briefing at General Emergency before evacuation, to explain to passengers what will happen, how to use the chute and how to free oneself if stuck in the chute. This briefing will be practised during regular emergency drills and will bring the significant findings of the relevant risk assessment to the attention of those concerned.

Further fleet directives have been issued requiring the provision of a tail block and line at each Marin-Ark set for use by a sweeper if necessary. Also UHF radios are to be used by chute control and raft personnel, both in drills and emergency evacuations, to ensure clear and unambiguous communications.

Further changes will be made to the use of the Marin-Ark evacuation system once the findings of MAIB’s and RFD’s investigations are finalised.

These include:

The provision of trained sweepers at each Marin-Ark set.

The provision of suitable equipment (harness, lines, straps, knife, torch and radio) for the use by the sweeper.

The risk assessment for drill deployment has been revalidated and, among other new control measures, now requires the selection of fit and healthy evacuees **(see Annex 8)**.

The safety case, on the adverse effects of possible blockage in chutes at the time of the evacuation in an emergency, has been revalidated **(see Annex 9)**.

4.2 RFD

All internal paperwork, regarding inspection of chutes following a deployment, has been amended to include a detailed inspection of the interior of the chute. A Service Bulletin has been prepared and is currently being issued to the relevant RFD service stations.

An internal review of the quality procedures for the Marin-Ark chute has been completed, with all persons involved being reminded of their responsibilities.

The ‘yellow’ mid hoop support is currently being reviewed to improve durability and to aid repair during service.

The crew instruction is being reinforced regarding the donning of a lifejacket correctly and tightly, and in that any loose clothing must be secured e.g. jackets zipped closed, jackets buttoned.

‘Cut Here’ information has been generated, and is currently being reviewed, where instructions aid a person entering the chute from outside to assist somebody stopped in the chute.

A Recovery Arrangement is being developed, where equipment is provided for a sweeper to descend the chute and aid the passenger in their descent. At this stage it consists of a harness, haul line, strops and radios.

A more robust chute sensor system assembly has been introduced and the sensor cable has been retracked so that it does not form a loop, which could hinder an evacuee.

<u>Outstanding actions</u>

A database of lifejackets that are currently in use by Marin-Ark owners and a recommended list of lifejackets for use with the Marin-Ark MES will be prepared.

A reminder placard, to hang from chute entry grab-rail, will be provided for all Marin-Ark sets in use.

The company has placed a contract to identify possible areas for development of the MES by conducting a further independent risk assessment /hazard analysis of the chute.

4.3 MAIB

On 14 February 2003, the MAIB issued a Safety Bulletin, the contents of which are at **Annex 6**. Copies were sent out internationally to all shipping companies with Marin-Ark MESs installed on board their ships.

SECTION 5 - RECOMMENDATIONS

Shipping companies which have, or are intending to have, vertical-chute marine evacuation systems installed on their ships, are recommended to:

<u>For drills</u>

1. Prepare or revalidate their risk assessments, with particular emphasis on: selecting suitable personnel, inspecting the inside of the chute and ensuring that the chute is clear before the next evacuee is allowed to enter. [3.26]

<u>For actual emergency</u>

2. Revalidate their safety cases and risk assessments on the adverse effects of possible blockages in chutes at the time of the evacuation. [3.26] [3.28]

The Maritime and Coastguard Agency is recommended to:

3. Ensure that all lifejackets on board vessels equipped with MESs within MCA's jurisdiction, are suitable for safe descent with the specific MES installed. [3.16]

4. Take to the European Union for action with regard to the Marine Equipment Directive and forward to the IMO the requirement that all lifejackets on board vessels equipped with MESs worldwide, are approved for use with the specific MES installed. [3.16]

5. Take forward to the IMO that a reporting system should be set up, to gather reports of all accidents involving MESs. [3.25]

Manufacturers of all vertical-chute marine evacuation systems, and the authorising bodies, are recommended to:

6. Remove any possible causes of blockages in MES chutes by redesign and/or other means. [3.20]

Marine Accident Investigation Branch
July 2003

ANNEX 1

Inspection report on the chute

Inspection of RFD Ltd Marin-Ark Chute Serial No. 00106, Part No. 44219011 at the Cruise Terminal, Dover on 18th December 2002

Background:

During the full-scale evacuation drill of 215 passengers from *P&OSL Aquitaine,* one evacuee became lodged in the escape chute and subsequently died. The accident happened in Dover on 9 October 2002. The escape chute was an RFD Marin-Ark Marine Evacuation System (MES), located on the port side of the vessel. MAIB decided to investigate the accident.

MAIB employed me as an expert in the investigation. I have 33 years experience in inspection and survey with the Department of Transport. I have spent the last 12 years being involved with the type approval of existing and novel LSA equipment, such as lifeboats, rescue boats, fast rescue boats and all types of inflatable liferafts. These have included self-righting and reversible liferafts, and slide and chute MESs. This involved examination of manufacturers' quality and production procedures - from specifications to prototype testing, both in the UK and overseas.

Facts:

As part of the MAIB investigation into the fatality, I was requested to attend at the cruise terminal, Dover, on 18th December 2002. My task was to inspect and report on the condition of the RFD Ltd., Marin-Ark chute Serial No. 00106, Part No. 44219011, this being the chute in which the incident occurred.

The chute was delivered to the cruise terminal by Kent Police, who were responsible for its safekeeping. The chute, in its assembled state, was laid out along the floor for a detailed external inspection. It was then raised vertically for further extended inspection. Each cell was inspected as part of the chute, **see photographs A1/1, A1/2 and A1/3,** and then detached for close individual inspection, before being marked and placed in separate bags for continued storage and reassembly, if required.

Photograph A1/1

Photograph A1/2

Photograph A1/3

The escape chute consists of 15 cells, each having an external tube made from blue RFD 1037 nylon. Each section has a series of wide loops arranged around its top and bottom. These enable the cells to be joined together with hoops. There is also a mid-height hoop, held in place by six encasing sleeves made from lengths of plastic-coated fabric, situated between the vertical bungee and the tape strap.

The inner part of the cell forms the cone-shaped slide path, constructed of the same material. This leads into a parallel spout, or sock, to one side, but has an orange, sideways stretch-elasticated panel. The sock of each cell leads into the sock of the cell below. The cells are joined with the socks offset by 90 degrees to each other, forming a rotational descent path.

A traffic light system is fitted in the chute. This has sensors in the lower cells, which indicate that the descending evacuee is about to exit the chute. This was not working on the day of the drill **(see photographs A1/4 and A1/5)**; an alternative means of communicating with the top of the chute was being used.

Photograph A1/4

Photograph A1/5

The inspection of the chute, and of each cell, showed the following (the lowest cell being No.1):

Cell No.1 The lower end of the external section connects around the opening in the liferaft. There is a 94cm vertical slit between bungee positions 3 and 4.

The blue fabric has frayed at the bottom of the sock, with the cross-threads forming a stirrup, and in another area where the threads have possibly formed a stirrup but then parted at one end, **see photographs A1/6 and A1/7.**

Photograph A1/6

Photograph A1/7

Cell No.2 There is a 55cm vertical slit between bungee positions 3 and 4.

The mid-height hoop attachment, between bungees 4 and 5, is partially damaged.

Cell No.3 There is a vertical slit in the sock between bungee positions 3 and 4 **(see photograph A1/8)**.

The mid-height hoop attachment, between bungee positions 3 and 4, is completely detached. Between bungee positions 2 and 3 it is 90% detached, and between bungee positions 1 and 6 it is 30% detached (**see photograph A1/9)**.

Photograph A1/8

Photograph A1/9

Cell No.4 There is a vertical slit in the lower 60% of the sock between bungee positions 3 and 4 **(see photograph A1/10)**.

The mid-height hoop attachment between bungee positions 2 and 3 is 98% detached. Between bungee positions 1 and 2 it is completely detached, and between bungee positions 1 and 6 it is 50% detached **(see photograph A1/11)**.

In the cone section, the top of a doubling panel has not been stitched along 50% of its length. **Photographs A1/12, A1/13 and A1/14** show this panel has not been correctly stitched.

Photograph A1/10

Photograph A1/11

Photograph A1/12

Photograph A1/13

Photograph A1/14

Cell No.5 Minor fraying to the blue fabric at the bottom of the sock.

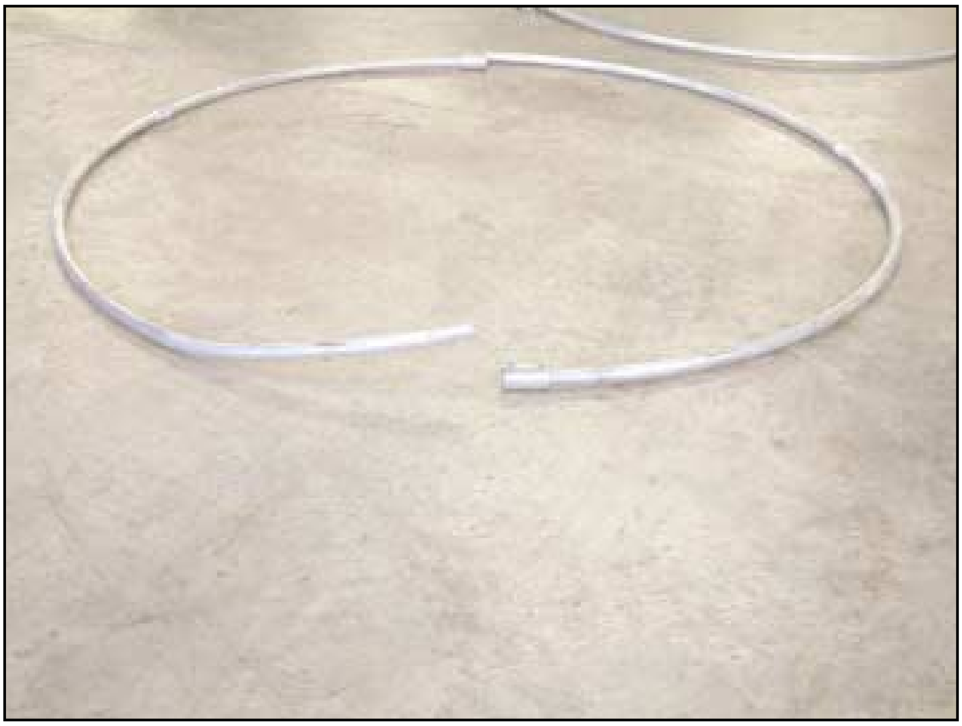
Cell No.6 The mid-height hoop attachment between bungee positions 4 and 5 is 20% detached.

There is the start of fraying to the blue fabric at the bottom of the sock that forms a stirrup **(see photograph A1/15)**.

After dismantling, it was noted that there is a 10 to 15 degree set at one end of a section of the upper joining hoop **(see photograph A1/16)**.

Photograph A1/15

Photograph A1/16



Cell No.7 The mid-height hoop attachment between bungee positions 3 and 4 is 10% detached, and between bungee positions 1 and 2 it is 99% detached.

There is fraying across 60% of the blue fabric at the bottom of the sock where the threads might have formed a stirrup, before becoming detached at one end **(see photograph A1/17)**.

Cell No.8 The mid-height hoop attachment between bungee positions 2 and 3 is 10% detached.

No. 1 bungee guide loop is detached at one end **(see photograph A1/18)**.

There is minor fraying of the blue fabric at the bottom of the sock.

Cell No.9 The mid-height hoop attachment between bungee positions 2 and 3 is 10% detached, and between bungee positions 3 and 4 it is 75% detached.

The No. 3 bungee guide loop is detached at one end **(see photograph A1/18)**.

There is minimal fraying of the blue fabric at the bottom of the sock.

Photograph A1/17

Photograph A1/18

Cell No.10 The mid-height hoop attachment between bungee positions 1 and 2 is 30% detached, and between bungee positions 6 and 1 there is a small tear.

The No. 4 bungee guide loop is detached at one end **(see photograph A1/18)**.

There is fraying of the blue fabric at the bottom of the sock, with the cross-threads only attached at one end **(see photograph A1/19)**.

Cell No.11 The blue fabric at the bottom of the sock has started to fray.

Cell No.12 The mid-height hoop attachment between bungee positions 1 and 2 is 10% detached. Between bungee positions 3 and 4 it is 10% detached, and between bungee positions 1 and 6 it is 100% detached **(see photograph A1/20)**.

Photograph A1/19

Photograph A1/20

Cell No.13 The mid-height hoop attachment between bungee positions 3 and 4 has a 15% tear.

The No. 4 bungee guide loop is detached at one end **(see photograph A1/18)**.

Cell No.14 The chute valise was around this cell and had minor damage **(see photograph A1/21)**.

There is the start of fraying of the blue fabric at the bottom of the sock.

The orange elasticated fabric has a vertical tear 3 to 4 cm from the seam. This starts at the bottom of the sock and extends up its length to a point just below the rounded top of the panel **(see photograph A1/22)** where there is a jagged sideways tear (**see photograph A1/23)**. It then continues vertically up to, and then follows, the line of stitching **(see photograph A1/24)**.

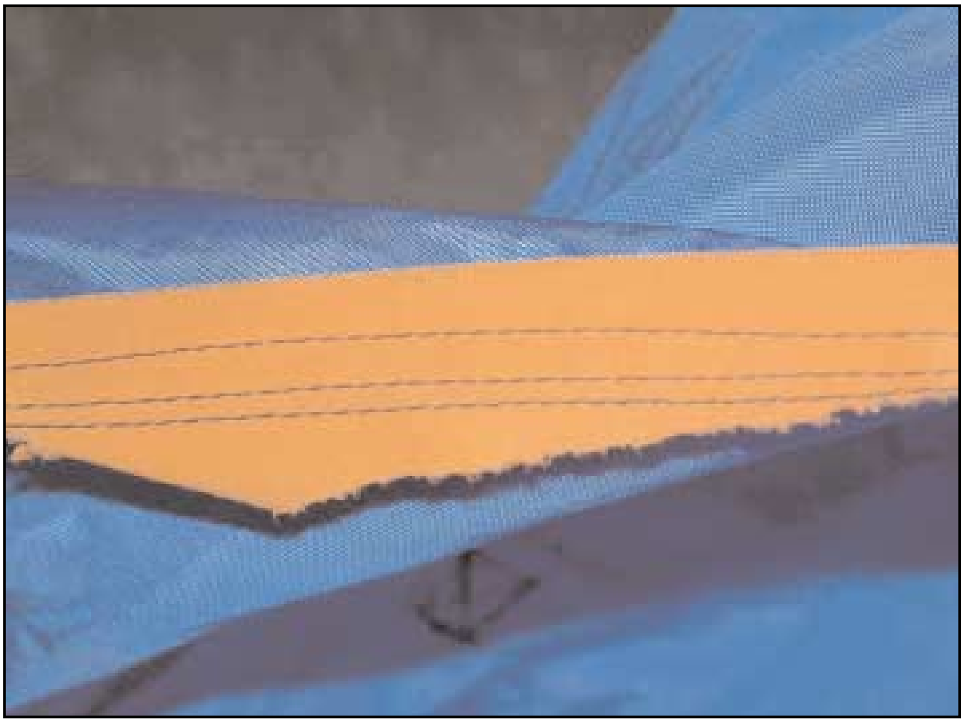
One of the attaching loops had not been threaded on to the joining hoop next to the hoop-joining sleeve.

Photograph A1/21

Photograph A1/22

Photograph A1/23

Photograph A1/24



Cell No.15 The mid-height hoop attachment between bungee positions 5 and 6 is 100% detached. Between bungee positions 6 and 1 it is 5% detached at one end, and has a 10% tear in the middle.

There is fraying at the bottom of the blue fabric restraining panel, fitted over the elasticated panel. This is the only cell fitted with such a panel in the sock, and it is designed to take the initial shock load when an evacuee enters the chute **(see photograph A1/25)**.

One end of the hoop had either not been engaged in the joining sleeve, or had become disengaged **(see photograph A1/26)**.

Top Adapter Although heavily soiled, it was not damaged.

Photograph A1/25

Photograph A1/26

Analysis

The vertical slits in the external tubes of cells 1 and 2 were made by the rescuer, when gaining access to the evacuee, who was lodged higher up in the chute. The descent path was not affected by the damage to both the bungee guide loops and the mid-height hoop attachments. Likewise, the fact that the suspension hoop sleeve was not secured, and was external to the chute, had no effect on the descent path.

The slits in the socks in cells 3 and 4 were also made by the rescuer and were below the portion where the evacuee initially became stuck.

The vertical tear in the orange elasticated fabric in cell 14 could have been caused by deployment of the system. The jagged part of the tear in the sock could have been the starting point of the tear having become fouled with the bungee shackles, or joining sleeve, during assembly or packing. The tear would not have impeded the descent of any of the evacuees.

Where fraying across the blue fabric at the bottom of the socks has been referred to as either starting, minor, or minimal, the cross-threads had pulled clear of the weave, leaving only the ends of the vertical threads. In other cases, the cross-threads were broken along their length, but were either still attached at the ends, or were attached at one end only.

The only remaining instance of the cross-threads at the bottom of a sock not having broken and forming a stirrup, in which a foot or feet could become entangled, is at the bottom of cell No.1.

Generally, the inside of the chute was in good condition, except for fraying at the ends of the socks.

Conclusions:

The external damage to the chute is superficial, and could have been caused either during deployment, through contact with the ship during the drill, or in its handling during removal from the ship or in subsequent handling in storage and delivery to the terminal.

The doubling panel, which was not stitched in the upper part of cell 4, would not have impeded any of the evacuees. This is because the area involved is in the top part of the cone of cell 4, and the bottom of the sock from cell 5 above, which is designed to be entered from the top of the sock of cell 4.

The vertical tear in the orange elasticated fabric in cell 14 could have been caused by the deployment of the system. The jagged part of the tear in the sock, could have been the starting point of the tear having become fouled with the bungee shackles, or joining sleeve, during assembly or packing. The tear would not have impeded the descent of any of the evacuees; their time in the chute might have been reduced by less than one second, from the average time of eleven to fourteen seconds.

The cross-threads in the fraying at the bottom of a sock, if of sufficient number, could have formed a loop/stirrup large enough for an evacuee’s foot, or feet, to have become caught. This would have caused the body to continue past the feet - into the piked position - the threads either parting or pulling free at their ends during the event. This scenario must be investigated further, so I have included this as one of my recommendations.

There is a possibility that, for some reason, an evacuee’s feet could become spread, or pushed forward, and become engaged through the sock. The rim of the sock below this could have the same effect as catching the feet in a loop.

Recommendations:

Investigate the impact stress on stirrups formed by the cross-threads formed 1, 2, 3, 4 and 5 mm of weave from the blue chute fabric and establish the possible amount of fraying necessary to cause an evacuee to become stuck in the piked position, such as occurred to the casualty in this incident.

The only descent-path wear is in the form of fraying across the blue fabric at the bottom of the socks. Therefore, the effect of a single turn-up hem on the outside of the chute might be investigated.

The quality control during manufacture, assembly, and packing should be improved to ensure that all components, chutes and systems are finished and installed to specification. (This need is indicated by the incomplete stitching of a doubling panel in one of the cells, the damage to the sock in cell 14 could have been initiated during packing and the non-engagement of one of the joining hoop ends into the joining sleeve.) The monitoring of the quality control system at RFD Ltd., under the MED wheel-mark approvals, would be Lloyd's Register, which now issues the certificates of approval.

The quality control at the RFD Ltd. service station should be improved, to ensure that during servicing, all components, chutes and systems are fully inspected, and correctly re-packed and installed. (This need is indicated by the fact that a manufacturing fault had not been detected, the damage to the sock in cell 14 could have been initiated during packing and the non-engagement of one of the joining hoop ends into the joining sleeve.)

T R F L Clark

C/Eng. MRINA

30th December 2002

ANNEX 2

Report of reconstruction of *P&OSL Aquitaine* Marin-Ark MES accident, conducted at RFD Ltd, Dunmurry, N Ireland, 13-14 January 2003

Background

The purpose of the reconstruction was to investigate the likely events leading up to Mrs McCabe-Jones becoming stuck in the position in which the sweeper found her. Present at the initial meeting were two MAIB inspectors, the P&O first officer who acted as the sweeper on day of accident, RFD's marine system design manager and the Survitec group operations director, who was not involved with reconstruction itself.

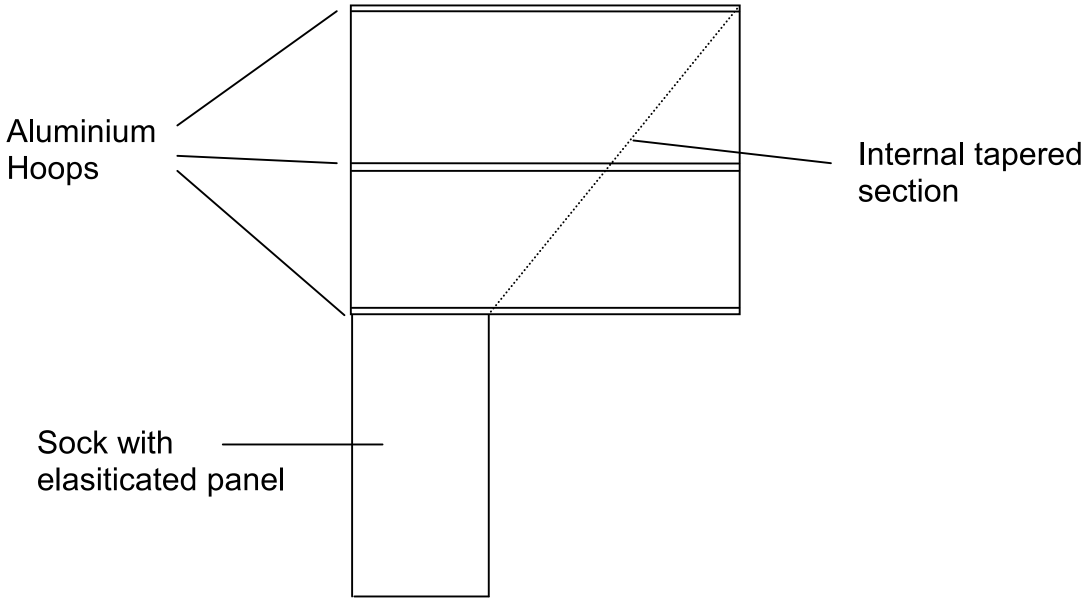
RFD had erected a small section of the escape chute, to enable various scenarios to be explored. **(See photograph A2/1.)** Discussions also took place, including reviewing video footage of the accident, which was taken by MCA on the day.

Photograph A2/1

Chute description

The *P&OSL Aquitaine* escape chute had 15 cells, each with a tapered section and a sock with an elasticated panel. Figure A2/1 shows a schematic elevation drawing of one cell.

Figure A2/1



The cells were joined together by the aluminium hoops at the top and bottom of the cells. The cells were attached to each other but rotated through 90 degrees so that there was a spiral descent path down the chute. The chute was 1.2 m in diameter. The mid hoops (seen passing through the yellow sleeves in **photograph A2/1**) were only required to assist the chute in keeping its shape. The cells also had six elastic 'bungee' cords around their circumference. The chute to allow flexibility for ship/liferaft motion when the system is deployed at sea.

Known facts of the incident 9 October 2002

The sweeper found Mrs McCabe-Jones stuck in a 'piked' or 'jack-knife' position with her back down into the sock of cell 6; her thighs were tucked up towards her chest and her legs were up.

Her jacket and lifejacket had come off, the lifejacket resting on top of her. After several attempts to free her she dropped through to the next sock, cell 5, but still in the same position. The sweeper followed her through to the next cell. She was still conscious at first but then fell unconscious before she fell through to the next sock, cell 4. At this time the sweeper realised he could see the ship's belting through a gap in the chute. As this was near the bottom of the chute he asked the RFD staff, who were outside the chute to cut the sock to get her out as soon as possible. As the socks of cells 3 and 4 were overlapping considerably under the weight of two people in the cell 4, the socks of both 3 and 4 were cut at the same time. Mrs McCabe-Jones fell into the lower sock and was eventually released into the liferaft.

Mrs McCabe-Jones was approximately 100 kg and 1.68 metres tall and was between sizes 18 to 22.

Reconstruction

The escape chute was erected on the premises of RFD Ltd and was 4 cells high with an inflatable cushion at the bottom. It allowed controlled descents of the chute and was rigged with a safety rope hung down its length. A helicopter rescue harness was also available to allow a person to be pulled back up and avoid getting into a hazardous position.

The first task was to recreate the position in which Mrs McCabe-Jones was found. After a couple of positions, the sweeper agreed the most likely position adopted was that shown in **photographs A2/2 and A2/3**, as he could not remember precisely. The sweeper adopted the piked position himself without the safety harness but with the safety rope in position. Although the piked position was uncomfortable, it did not cause any undue concern for those who tried it.

Photograph A2/2

Photograph A2/3

The likely options that would lead to a person assuming the piked position were then pursued. If a person was stuck such that the knees were brought up to the chest, it appeared impossible for the person to move the feet above the waist. **(See Photograph A2/4.)** The person could become stuck in this position but by leaning forward the person starts to slide down feet first.

Photograph A2/4

Chute supporting hoops

The approximate position of the hoops, which support the chute, were measured from a video taken on the day of the accident from a boat away from the side of the vessel. As the cells were connected by elasticated cord, when unloaded, the spacing between top and bottom of the cells was 720 mm, when fully extended, it was 1320 mm. Estimates from the video indicated a spacing of 905 mm. The reconstruction tried all these spacings to see if a particular position of the hoops could cause an obstruction to catch a person's feet on. The reconstruction participants found that it was possible for their feet to catch on one of the hoops if the legs were straightened and kept rigid at the right time. However, by keeping the legs flexible during the descent, a person's feet will glance off the hoop and carry on down. The spacing of the hoops was not a factor. As the hoops are on the outside of the chute it is impossible to catch your feet without some effort by the evacuee.

Stirrups in sock end

The inspection of the actual escape chute, in Dover, after the accident had highlighted the possibility of stirrups of material threads at the exit of the socks. It may be possible that an evacuee's feet could become stuck in the stirrup. A stirrup of 4 threads was formed in the reconstruction since cell 7 in the inspection had been found with 4 loose threads on it. **(See Photograph A2/5.)**

Photograph A2/5

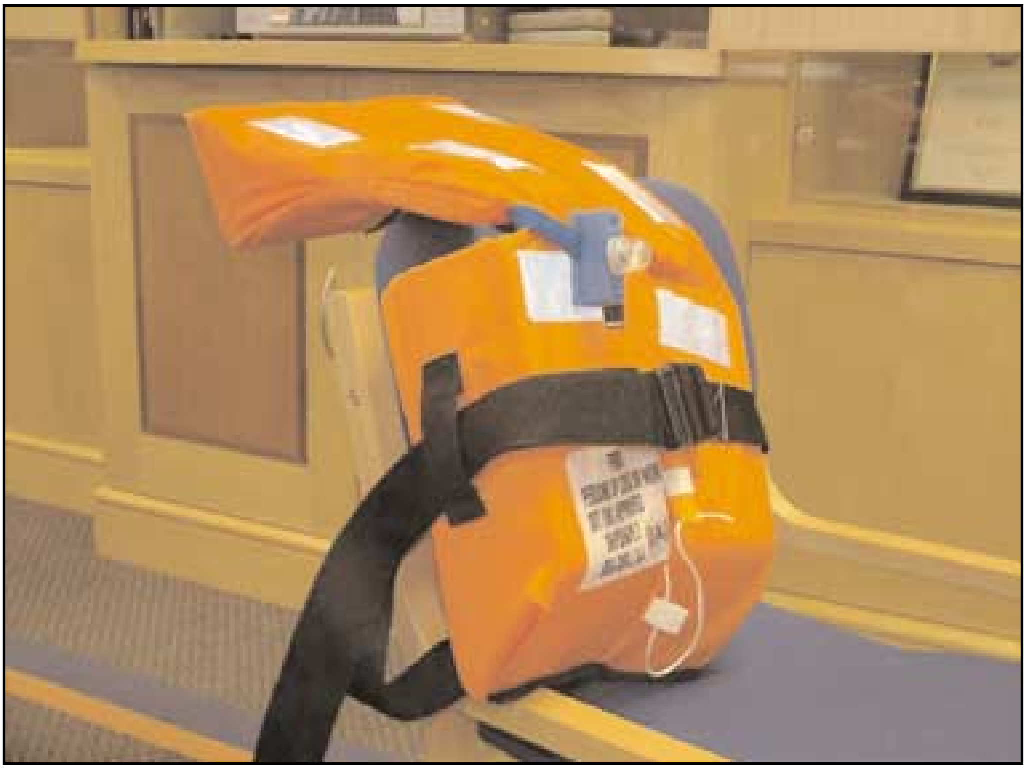
During the reconstruction, it was found that, on catching a foot in this stirrup, it was broken easily under the weight of a person. **(See Photograph A2/6.)** Additionally, by the very design of the chute, the exit of the sock was hanging well into the next sock below, making it impossible to attain the piked position when a person's feet become caught in a stirrup.

Photograph A2/6

Lifejacket issues

The type of lifejacket used in the evacuation trial had been a ‘Seadog Shipshape 2’. P&O Stena Line supplied such a lifejacket for the reconstruction, but it became apparent after studying video footage that it was not identical to those used in the evacuation trial on *P&OSL Aquitaine*. Unlike the lifejacket shown in **Photograph A2/7**, the lifejackets used in the evacuation trial had no webbing guide loops on the side.

Photograph A2/7



After some trials it was found to be relatively easy for the lifejackets used in the *P&OSL Aquitaine* drill to ride up, while going down the chute. Female evacuees had a slightly higher incident rate than males **(see Section 1.9)** of lifejackets riding up, possibly because in some cases their lifejacket projects further out. It is quite conceivable that, while descending the chute, the bottom of the lifejacket would have become caught, because the chute narrows into the sock and effectively the lifejacket would have folded up around the wearer’s head. **(See Photograph A2/8.)**

This was very uncomfortable for the wearer, and it was easy for the lifejacket to pass over the head at this point. If the wearer also had their hands above their head, as instructed, while descending the chute, the lifejacket webbing would simply ride up the wearer’s back and come off. **(See Photograph A2/9.)**

In the case of Mrs McCabe-Jones, both her jacket and lifejacket came off. The material of jacket may have made the process of losing the lifejacket even easier. If the lifejacket worn at the time of the accident had the small webbing guides present, or had leg straps, her lifejacket might not have come off.

Photograph A2/8

Photograph A2/9

Probable cause of adopting piked position

From the work described above, the following probable scenario was developed. Mrs McCabe-Jones entered the top of the chute with the front of her lifejacket projecting out as a result of her body shape. From the video, the restraining strap was made fast relatively quite high up towards the neck compared with other people. As she descended the chute with her legs together and arms up, her jacket and webbing of the lifejacket could have ridden up her back until the webbing was under her arms. If the projecting lifejacket then caught the stitched seam, where the chute narrows into the sock, the front part of the lifejacket might have flipped up into her face and she may have become wedged in the sock of cell 7 in a very uncomfortable manner. This may have been when she first called for help. With her arms unable to move with the webbing trying to ride up, she may have pushed out with her legs to try and push up to get more comfortable, and to remove the lifejacket. As she did so, she may have suddenly slipped out of her lifejacket and jacket, because her legs were not directly below her, and fell bottom first into the next cell, the lifejacket falling loosely on top of her.

Findings

From the reconstruction, it seems almost impossible to become stuck in a piked position in the chute if the required body posture, instructed at the top of the chute, is maintained. The critical factor appears to be when the evacuee's feet rise, for whatever reason, above the waist, as at this time a person's bottom will lead first. However, to get your feet above your waist requires effort on the part of the person in the chute. The evacuee most probably has to stop and adjust themselves in some way to result in a bottom-leading position.

It is also clear that the lifejacket must have been a contributing factor in the lady becoming stuck in cell 6. In the process of coming off, the lifejacket would have certainly caused some discomfort. This may have initiated the actions of the lady to try and stop and relieve herself of the discomfort by feeling around below her with her feet to gain some purchase to lift herself up.

It must be remembered that this reconstruction has been conducted using fairly limited dynamic motions. In reality, the accident would have been far more dynamic, with a greater speed of descent and, hence, greater momentum involved. It will be impossible to precisely recreate the accident further without a greater risk of injury to those involved with such a reconstruction.

SOLAS requirements

SOLAS requirements

The IMO's International Convention for SOLAS states that:

> *Every inflatable liferaft, inflatable lifejacket and marine evacuation system shall be serviced:*
>
> > *at intervals not exceeding 12 months, provided where in any case this is impracticable, the Administration may extend this period to 17 months; and*
> >
> > *at an approved servicing station which is competent to service them, maintains proper servicing facilities and uses only properly trained personnel.*
>
> *In addition to or in conjunction with the servicing intervals of marine evacuation systems required by the above, each marine evacuation system should be deployed from the ship on a rotational basis at intervals to be agreed by the Administration provided that each system is to be deployed at least once every six years.*
>
> *All survival craft required to provide for abandonment by the total number of persons on board shall be capable of being launched with their full complement of persons and equipment within a period of 30 minutes from the time the abandon-ship signal is given.*

Spreadsheet on results of video recordings taken at top and bottom of chute

Results of video recordings taken at top and bottom of chute								
	Time let go	Time at bottom	Elapsed time	Gender and approx build	Clothing	How arrived at exit	Lifejacket and clothing	Remarks
1	11:47:58	11:48:06	8	M - medium build	cap, hi vis jacket jumper & trousers	face down & then twisted round	Lj up @ front	disorientated cap still on
2	11:48:11	11:48:20	9	M - medium build	padded jacket and trousers	feet and body across exit	OK	
3	11:48:23	11:48:34	11	M - heavy build	nylon jacketcargo pants	on left side	OK sweat shirt up	
4	11:48:37	11:48:56	19	M -medium build	chef's clothes and apron	face forward - slow to arrive	OK	Wiggle
5	11:49:59	11:49:08	9	M - medium/heavy build	chef's clothes	face forward	OK - shirt up at back	
6	11:49:12	11:49:08	10	M - slight build	shirt and trousers	face forward	OK	
7	11:49:26	11:49:38	12	F - slight build	top and trousers	face forward	OK	Hurt mouth from light
8	11:49:42	11:49:56	14	M -medium/heavy build	jumper and trousers	face forward	OK	
9	11:49:58	11:50:10	12	M - medium/heavy build	boiler suit and hi vis jacket	face forward	OK	
10	11:50:12	11:50:19	7	M - medium build	jacket and trousers	face forward	Lj up @ front over face, shirt up	
11	11:50:21	11:50:32	11	M - heavy build	jacket and trousers	on left side	OK - both shirts up to strap	
12	11:50:35	11:50:46	11	M - medium build	Boiler suit	face forward	OK	
13	11:50:49	11:50:57	8	M - heavy build	chef's shirt and trousers	on right side	Lj twisted -shirt up to strap	
14	11:51:00	11:51:12	12	M - very heavy build	chef's shirt and trousers	on left side	Lj and shirt ridden up at front	
15	11:51:13	11:51:24	11	M - medium build	chef's shirt and trousers	face forward	OK - shirt up	caught left foot at bottom
16	11:51:28	11:51:34	6	F - medium build	top and trousers	face down	OK	
17	11:51:41	11:51:47	6	F - medium build	top and trousers	face forward holding Lj	Lj over head nearly off only held by strap	
18	11:51:52	11:52:06	14	F - heavy build	top coat and trousers	crouched up	Lj at front over face	Wriggle help to stand up (lady turned away
19	11:52:10	11:52:17	7	F - medium/heavy build	sweat shirt trousers	left side	Lj and shirt ridden up	
20	11:52:22	11:52:29	7	F - medium buld	nylon top and trousers	face forward	OK	Lost a sock
21	11:52:32	11:52:39	7	M - medium build	jacket and jeans	face forward	OK - jumper up at front	
22	11:53:00	11:53:09	9	M - medium/heavy build	jumper and trousers	face forward	OK - shirt up to strap	
23	11:53:14	11:53:22	8	M - medium build	jacket and jogging trousers	face forward	OK	
24	11:53:25	11:53:39	14	F - very heavy build	top and trousers	feet up and sideways	Lj infront of face shirt ridden up	Wriggle - squeals x 2
25	11:53:45	11:53:55	10	M - medium build	shirt and jogging trousers	face forwards	OK - shirt up to strap	Wriggle
26	11:53:59	11:54:11	12	M - military	military	slowly stopped at bottom	OK	
27	11:54:15	11:54:25	10	M - military	military	crouched - face forward	OK	
28	11:54:27	11:54:36	9	M - military	military	face forward	OK	
29	11:54:40	11:54:49	9	M - military	military	face forward	OK	
30	11:54:51	11:55:00	9	M - military	military	left side	Lj up in front of face	
31	11:55:03	11:55:14	11	M - military	military	crouched left side	OK - trousers ridden up	Wriggle
32	11:55:17	11:55:25	8	M - military	military	face forward	OK	
33	11:55:28	11:55:39	11	M - military	military	face forward	Lj over back of head and face sunken in	As he got up Lj went over from back to front
34	11:55:43	11:55:54	11	M - military	military	face forward	OK	Wriggle
35	11:55:58	11:56:05	7	M - military	military	right side but then faced forward	OK	
36	11:56:08	11:56:17	11	M - military	military	face forward	Lj up a bit	
37	11:56:21	11:56:32	11	M - military	military	face forward	OK	
38	11:56:36	11:56:46	10	M - military	military	right side but then faced forward	OK	
39	11:56:49	11:56:59	10	M - military	military	right side but then faced forward	OK	Short delay for "clear"
40	11:57:22	11:57:33	11	M - military	military	left side but the faced forward	Lj up in front of face	
41	11:57:37	11:57:50	13	M - military	military	face forward	OK	
42	11:57:54	11:58:11	17	F - medium/heavy build	boiler suit and hat, hi vis jacket	left side and face down	OK	Slow to let go, Wriggle x 2, disorientated
43	11:58:15	11:58:28	13	M - medium build	boiler suit	nearly bottom first across exit	OK - leg straps	disorientated
44	11:58:34	11:58:46	12	M - medium build	top and trousers	face forward	OK - jumper up to strap leg straps	
45	11:58:53	11:58:09	16	M - medium build	boiler suit	right side	OK - leg tsraps	
46	11:59:14	11:59:23	9	M - medium build	boiler suit & hi vis jacket	face forward	OK - leg straps	
47	11:59:26	11:59:36	10	M - heavy build	jumper and trousers	face forward	OK - leg straps	
48	11:59:41	11:59:48	7	M - medium build	top and trousers	face forward	OK - leg straps	
49	11:59:51	12:00:05	14	M - medium build	boiler suit	face forward	OK - leg straps	
50	12:00:07	12:00:20	13	M - medium build	boiler suit	face forward	OK - leg straps	
51	12:00:23	12:00:52	19	M - medium build	boiler suit	left side	OK - leg straps	
52	12:00:56	12:01:07	11	M - heavy build	jumper and trousers	face forward	OK - leg straps	
53	12:01:22	12:01:36	14	M - medium/heavy build	boiler suit	face forward	OK - leg straps	
54	12:01:40	12:01:52	12	M - medium build	boiler suit	face forward	OK - leg straps	
55	12:01:56	12:02:07	11	M - medium build	jumper and trousers	face forward	OK - leg straps	
56	12:02:11	12:02:26	14	M - medium build	boiler suit	face forward	OK - leg straps	Wriggle
57	12:02:29	12:02:39	10	M - medium build	boiler suit & hi vis jacket	face forward	OK - leg straps	
58	12:02:43	12:02:50	7	M - medium build	boiler suit & hi vis jacket	face forward	OK - leg straps	
59	12:02:53	12:03:09	16	M - medium build	boiler suit	face forward	OK - leg straps	
60	12:03:12	12:03:22	10	M - medium build	boiler suit & hi vis jacket	face forward	OK - leg straps	
61	12:03:25	?	?	M - medium build	Trousers and jumper	?	OK - leg straps	Exited fast - Camera turned away
62	12:03:40	12:03:49	9	M - medium build	boiler suit & hi vis jacket	face down	OK - leg straps	

63	12:03:52	12:04:03	11	M - medium build	boiler suit	right side	OK - leg straps	
64	12:04:07	12:04:16	9	M - medium build	boiler suit	face down and then faced forward	OK - leg straps	
65	12:04:20	12:04:32	12	M - medium build	boiler suit	face forward	OK - leg straps	
66	12:04:37	12:04:48	11	M - medium build	boiler suit	face down and then faced forward	OK - leg straps	Slow in letting go, came out quickly
67	12:04:52	12:05:01	9	M - medium build	boiler suit	face forward	OK - leg straps	
68	12:05:04	12:05:14	10	M - medium/heavy build	boiler suit	face forward and then rolled out	OK - leg straps	
69	12:05:17	12:05:26	9	M - medium build	boiler suit	face forward	OK - leg staps	
70	12:05:29	12:05:40	11	M - medium build	boiler suit	face forward	OK - leg straps	
71	12:05:43	12:06:00	17	M - medium build	nylon jacket and boiler suit	face forward	OK - leg straps	
72	12:06:24	12:06:34	10	M - medium build	boiler suit	face forward	OK - leg straps	Wriggle
73	12:06:38	12:06:47	9	M - medium build	padded jacket and boiler suit	face down and then faced forward	OK - leg straps	
74	12:06:51	12:06:59	8	M - medium build	top and trousers and his vis jacket	bunched up on left side	OK - leg straps	
75	12:07:03	12:07:13	10	F - medium build	boiler suit and his vis jacket	face forward	Back of Lj around face	Fell forward on getting up
76	12:07:19	12:07:37	18	F - heavy build	boiler suit and top	face forward	OK	Screamed when she let go at top
77	12:07:34	12:07:55	21	M - medium build	top and trousers	face forward	OK	Hands touched the entrance - Wriggle
78	12:08:00	12:08:10	10	F - medium build	top and trousers	face forward	OK	Asked if go fast? Flopped onto floor
79	12:08:28	12:08:43	15	M - slight build	trousers and white shirt	face forward	Front of Lj in face, strap over shoulder and arm	Put arm back thro' strap when he got up
80	12:08:48	12:08:57	9	M - medium/heavy build	top and jogging trousers	face forward	OK	
81	12:08:59	12:09:08	9	M - medium build	jumpers and jeans	face forward	OK	
82	12:09:11	12:09:19	8	M - medium/heavy build	boiler suit	face forward	OK	
83	12:09:22	12:09:40	18	M - medium build	top and trousers	Slowly face forwards	OK	Wriggle
84	12:09:43	12:09:51	8	F - medium build	top and jeans	face forwards	OK	
85	12:09:56	12:10:07	11	F - medium build	nylon top and jeans	left side, across chute & crouched	OK	
86	12:10:10	12:10:21	11	F - medium build	top and jeans	face down	OK	Feet hit bottom and fell backwards onto floor
87	12:10:27	12:10:42	15	M - medium build	top and trousers	face forwards	OK	wriggle from top(could see him4s) and bottom
88	12:10:49	12:10:57	8	M - medium build	top and trousers	face down and then faced forward	OK	
89	12:11:01	12:11:14	13	M - medium build	top and jeans	face forward and hands near face	OK	Put hand up to face when standing up
90	12:11:17	12:11:29	12	F - medium build	top and jeans	face forward	OK	Coms para's coming down at 3 sec intervals
91	12:12:08	12:12:07	9	Military	Military	face forward - right leg tucked under	OK	
92	12:12:11	12:12:19	8	Military	Military	face forward	OK	
93	12:12:14	12:12:21	7	Military	Military	?	OK	
94	12:12:16	12:12:23	7	Military	Military	face forward	OK	
95	12:12:20	12:12:33	13	Military	Military	face forward trousers uo to knees	OK	
96	12:12:22	12:12:39	17	Military	Military	left side and helped out of exit	OK	
97	12:12:24	12:12:43	19	Military	Military	?	OK	
98	12:12:29	12:12:44	15	Military	Military	face forward - pulled out of exit	OK	
99	12:12:31	12:12:47	16	Military	Military	face forward	OK	
100	12:12:34	12:12:49	15	Military	Military	?	Lj came forward over head	
101	12:12:37	12:12:51	14	Military	Military	left side	OK	
102	12:14:04	12:14:13	9	M - heavy build	Military	face forward	Lj at front over face	
103	12:14:16	12:14:42	26	M - heavy build	boiler suit	Slowly face forwards	Back of Lj over face, front up, strap ridden up to neck	Wriggle x 2
104	12:14:48	12:15:14	26	M - medium build	jumper and trousers	face forward	OK	Wriggle x 2
105	12:15:19	12:15:32	13	M - medium build	boiler suit	face forward	OK	
106	12:15:35	12:15:46	11	M - medium build	boiler suit and hi vis jacket	right side and across exit	OK	
107	12:15:48	12:15:56	8	M - medium build	boiler suit	right side but then faced forward	Lj front in face, strap ridden up to arm pit	
108	12:16:00	12:16:12	12	M - heavy build	boiler suit	face forward	Lj ridden up half way	Held hand to right side of face and nose
109	12:16:15	12:16:27	12	F - medium/heavy build	top and trousers	face forward	OK	
110	12:16:31	12:16:44	13	M - medium build	boiler suit	face forward	OK	
111	12:16:46	12:16:55	9	M - v heavy build	jumper and trousers	face forward	Lj up at front	
112	12:16:58	12:17:09	11	M - heavy build	nylon top and trousers	right side and slightly crouched	OK	Told to wriggle from the top
113	12:17:12	12:17:20	8	M - heavy build	jacket and trousers	?	Lj back over head and fron ridden up	
114	12:17:31	12:17:40	9	M - slight build	top and trousers	face forward	OK	
115	12:17:50	12:17:?	?	M - medium build	top and trousers	?	OK	
116	12:18:09	12:18:17	8	M - medium build	top and trousers	right side	OK	Wriggle

Spreadsheet on the responses from ship owners and operators

Responses from ship owners and operators

How many MES	Approval Authority	Deployments	Conditions	Risk assessment	Evacuees stuck?	Evacuees injured?
6 on 3 ships	MCA	3 (1 on each ship)	sheltered waters	By ship builders	No	1 minor (1 landed on another)
8 on 4 ships	Netherlands, MCA	7 all with evacuees about 30 each	in harbour up to F5	By ship builders and company	No	None
12 on 3 ships	GL, DNV, Denmark	4, 2 with evacuees	in harbour calm waters	No, but fit and healthy	Small number freed themselves	
? on 2 ships	BV and France	3	in harbour less than 25kn	?	1 wearing boots lifted by harness	None
7 on 5 ships	Norway	several with all age and weight/size	?	?	No	
2 on new buildings	LR, GL, Germany,	2 (160/120 crew and non crew)	in harbour	Yes for future pax and crew	No	None
6 on 3 ships	GL, LR, MCA	3 (20 to 100)	shipyard, calm weather	ship builders	No	None
4 on 2 ships	LR, GL, Germany,	2 (second one with about 40 crew)	harbour/drydock	No/yes generic type	No	sprained ankle/sprained ankle, concusion
2 on 1 ship	GL	2 (100 evacuees in total)	shipyard, calm weather	No but RFD, GL, USCG witness	No	None
2 on 1 ship	DNV, MCA	2 (own staff/builder's acceptance trials)	in harbour calm waters	Yes trained persons of various sizes	No	None
10 on 4 ships	MCA	4	in harbour calm waters fine	No but trained crew only	No	None
2 on 1 ship	DNV, Norway	3	in harbour	No, evacuees of both sexes and all ages	1 child stopped, CE stuck	None

MAIB SAFETY BULLETIN 1/2003

Safety Bulletin

Department for Transport

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

MAIB SAFETY BULLETIN 01/2003

Fatal accident

during a marine evacuation system deployment drill

in Dover Harbour

on 9 October 2002

Issued February 2003

MAIB SAFETY BULLETIN 1/2003

This document, containing Interim Safety Recommendations, has been produced for marine safety purposes only. It is issued on the basis of information available to date.

The Merchant Shipping (Accident Report and Investigation) Regulations 1999 provide for the Chief Inspector of Marine Accidents to make recommendations at any time during the course of an investigation if, in his opinion, it is necessary or desirable to do so.

The Marine Accident Investigation Branch (MAIB) is carrying out an investigation into the fatal accident of a volunteer evacuee during a deployment drill of a vertical-chute type marine evacuation system. The MAIB will publish its report on completion of its investigation, with final recommendations.

The volunteer evacuee became stuck in the chute and lost consciousness during the rescue. She was released and taken to hospital where she was pronounced dead. This case illustrates that blockages in vertical-chutes can occur, and this bulletin makes interim recommendations on the conduct of drills, the adverse effect of blockages in an actual emergency, and the need to remove the risk of blockages in the chutes.

Stephen Meyer
Chief Inspector of Marine Accidents

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INTERIM SAFETY RECOMMENDATIONS

Background

At about 1319 on 9 October 2002, a fatal accident occurred while an 'abandon-ship' drill, using a vertical-chute type marine evacuation system, was being conducted in Dover harbour.

After the marine evacuation system was deployed, eight people descended the vertical-chute into two large, fully reversible liferafts. These people were evacuee receivers and assistants, observers and manufacturer's representatives. After some 124 people had gone down the chute and entered the liferafts, a female volunteer began her descent. However, 9 seconds later she shouted for help; the chute controller stationed at the top shouted to her to wriggle, but she replied that she could not. A chute sweeper[1], who was one of the ship's officers, then went down the chute in a controlled manner and found the volunteer stuck in a piked position (hands and feet above her head) inside one of the descent sections. Her lifejacket and jacket had come off and were over her face and head. The sweeper tried to pull her up, but was unsuccessful. He called out for someone to cut her out. The chute was then cut to allow her to descend in a controlled manner into the liferaft, where she arrived unconscious. After first-aid had been administered, she was evacuated ashore by a fast craft, which had been standing by, and taken to hospital where, sadly, she was pronounced dead.

Comments

This tragic accident has highlighted a number of risks that need urgent attention. The volunteer who died might not have been particularly fit or healthy. Until the actual cause of death has been established, it is recommended that only fit and healthy volunteers are selected to participate in drills.

The initiator for this accident appears to have been the riding up of the volunteer's lifejacket over her face and head. It is recommended that all personnel using a vertical-chute marine evacuation system should be provided with lifejackets that cannot ride up.

It would seem that in struggling, the volunteer caught her feet, which allowed her body to continue downward. She ended up in a piked position, thus blocking the chute. Recommendations are made to ship owners and operators to take this possibility into account in their safety case/risk assessment of evacuation procedures, and also to manufacturers to remove all possible causes for such a blockage.

[1]A person trained to clear blockages in chutes.

Interim Safety Recommendations

Shipping companies, which have, or are, intending to have vertical-chute marine evacuation systems installed on their ships, are recommended to:

1. Revalidate their risk assessment for drills, with particular emphasis on selecting fit and healthy volunteers.

2. Revalidate their safety case and/or risk assessments on the adverse effects of possible blockages in chutes at the time of the evacuation in an actual emergency.

3. Ensure that all personnel using a vertical-chute marine evacuation system wear lifejackets which will not ride up during the descent of a chute.

Manufacturers of all vertical-chute marine evacuation systems, and the authorising bodies, are recommended to:

4. Take urgent action to remove any possible causes of blockages in chutes by redesign and/or other means.

ANNEX 7

P&O Stena Line's risk assessment at the time of the accident

Risk Assessment Number 61.30/56.1

DETAILED RISK ASSESSMENT

Ship: Fleet Generic **Task Type** Fleet **Dept** Deck

Current Assessment date 15/10/2001 **Last Assessment date**

Work/Activity being assessed: MarinArk - Drill deployment

Hazards - Personal Injury

1	Working at height	Units are located 15 to 20 m above waterline
2	Descent from height	Evacuation is by vertical chute down ship's side.
3	Sticking in chute	It is possible to become stuck in chute, blocking descent of others.
4	Friction contact in chute	Clothing can be lifted, lifejackets pulled off and lifejacket lights can be damaged by friction contact with chute material. Exposed light parts can cut evacuees faces
5	Chute exit to raft	The "catcher cael" can cause evacuees to be tipped headfirst into the raft. In right hand chute, there is inadequate room for safe exit from the chute. If evacuees are too close together the chute they can land on each other.
6	Slip hazard	Immediatley post deployment, rafts are wet inside. Flooring is smooth and flexible.
7		
8		
9		
10		

People at Risk

			YP	NEM	MH
1	Crew		☐	☐	☐
2	Shore Staff				
3	Other				
4	Contractors				

Hazards Environment And Property

Pollutant medium	None	
Pollutant	None	
Property	None	

Existing Control Measures For Personal injury

Hazard No

1	Units set in enclosed spaces, or behind deck railings. On deployment, a canopy gives edge protection.
2	Chute is designed to restrict descent speed by a series of funnel shaped "socks" (cells) which grip evacuees as they descend. Descent time is c.6 secs. Each person receives simple instructions as they enter the chute.
3	Shoes are removed before descent. Chute design minimises chance of sticking. Simple instruction provided. Use of "sweeper" to free stuck evacuee.
4	Training lifejackets provided without lights and with legstraps. Participants advised to wear trousers or boiler suits.
5	Right hand chute forbidden for use in drills. Trained staff assist at exit. Raft design minimises contact hazards. Drills restricted to one person in chute at a time.
6	Traine staff to guide evacuees. Movement around raft edge avoids water. Equipment available in raft to remove water. No sharp edges present in raft.
7	OVERALL: Ship's staff are trained in the deployment and use of MarinArk by attendance at shore based courses, and by use of on board training materials. The system is designed for use by untrained persons in the event of an emergency evacuation from a ship.
8	
9	
10	

Risk Assessment Number 61.30/56.1

Assessment Of Risk For Personal Injury

Degree / Likelikood	Slightly Harmful	Harmful	Extremely Harmful
Highly Unlikely	Trivial Risk	Tolerable Risk	Moderate Risk
Unlikely	Tolerable Risk	Moderate Risk	Substantial Risk
Likely	Moderate Risk	Substantial Risk	Intolerable Risk

No	Likelihood of Occurrence	Degree of Harm	Level of Risk
1	Highly Unlikely	Extremely Harmful	Moderate Risk
2	Highly Unlikely	Extremely Harmful	Moderate Risk
3	Highly Unlikely	Harmful	Tolerable Risk
4	Likely	Harmful	Substantial Risk
5	Unlikely	Harmful	Moderate Risk
6	Unlikely	Slightly Harmful	Tolerable Risk
7			
8			
9			
10			

To assess the risk arising from the hazard:

1. Select the expression for likelihood which most applies to the hazard
2. Select the expression for degree of hard which most applies to the hazard
3. Cross reference using the above table to determine the level of risk

Additional Control Measures - Personal Injury

No	Measure	Remedial Action Date	Date Completed
1			
2			
3			
4	Recommended replacement of ships lifejackets as per training L/js		
5			
6			
7			
8			
9			
10			

Health Surveillance

1	Psychological stress	Various health effects	Check for and recognise symptoms. Allow person to not descend chute.
2			
3			
4			
5			

Permits To Work

Hot Work ☐ LV Electrical Equipment ☐ Aloft / Overside ☐ Lift Shaft ☐

Enclosed Space ☐ Diving ☐ Out of Commission Form ☐ General ☐

HOD

Checked By
Dave Webb
Safety Manager

Authorised by
D.Webb
Marine Safety Manage

Assessor 1 **Assessor 2** **Assessor 3**

ANNEX 8

P&O Ferries' risk assessment following review on 8/4/03

Risk Assessment Number 38:61.30/56.

DETAILED RISK ASSESSMENT

Ship: European Highway **Task Type** Fleet **Dept** Deck

Current Assessment date 08/04/2003 **Last Assessment date**

Work/Activity being assessed: MarinArk - Drill deployment

Hazards - Personal Injury

1	Working at height	Units are located 15 to 20 m above waterline
2	Descent from height	Evacuation is by vertical chute down ship's side.
3	Sticking in chute	It is possible to become stuck in chute, blocking descent of others. There can be physical or health risks.
4	Friction contact in chute	Clothing can be lifted. Lights attached to lifejackets can break, causing cuts to evacuees faces.
5	Chute exit to raft	The "catcher cell" can cause evacuees to be tipped headfirst into the raft. In unmodified right hand chutes, there is inadequate room for safe exit from the chute. If evacuees are too close together the chute they can land on each other.
6	Slip hazard	Immediately post deployment, rafts are wet inside. Flooring is smooth and flexible.
7	Stopping in chute	Stopping in the chute is quite common. Risk increases if the stoppage is too long because following evacuees may hit stopped person.
8		
9		
10		

People at Risk

			YP	NEM	MH
1	Crew		☐	☐	☐
2	Shore Staff				
3	Other				
4	Contractors				

Hazards Environment And Property

Pollutant medium	None	
Pollutant	None	
Property	None	

Existing Control Measures For Personal Injury

Hazard No

1	Units set in enclosed spaces, or behind deck railings. On deployment, a canopy gives edge protection. Side ropes are fitted post deployment to provide additional protection.
2	Chute is designed to restrict descent speed by a series of funnel shaped "socks" (cells) which grip evacuees as they descend. Descent time is c.6 secs. Evacuees receive a briefing prior to starting the evacuation. Each person receives reminder instructions as they enter the chute.
3	Chute design minimises chance of sticking. Evacuees briefed by trained crew. Shoes removed before descent. Written and verbal reminder instructions provided at chute head. Controllers at head and foot of chute. Use of trained Sweeper and specialist equipment to free stuck evacuee.
4	Trainees required wear trousers or boiler suits. Cosalt Premier lifejacket not known to cause problems.
5	Right hand chute of unmodified MarinArks forbidden for use in drills. Trained staff assist at exit. Raft design minimises contact hazards. Catcher cell zip lip reduced to minimum. Drills restricted to one person in chute at a time.
6	Trained staff to guide evacuees. Movement around raft edge avoids water. Equipment available in raft to remove water. No sharp edges present in raft.
7	Evacuees briefed as to method of descent, transit time, means of re-starting descent if they stop in chute. Chute foot contoller to monitor evacuee gap times - if more than 30 seconds, assume stickage and act.
8	OVERALL: Ship's staff are trained in the deployment and use of MarinArk by attendance at shore based courses, and by use of on board training materials. The system is designed for emergency use by untrained persons to evacuate a ship. For drills, all evacuees must be fit and healthy. Volunteer seafarers and declared shore staff only to descend chute. Expectant mothers may not descend the chute.

9

10

Risk Assessment Number 38:61.30/56.

Assessment Of Risk For Personal Injury

Degree / Likelihood	Slightly Harmful	Harmful	Extremely Harmful
Highly Unlikely	Trivial Risk	Tolerable Risk	Moderate Risk
Unlikely	Tolerable Risk	Moderate Risk	Substantial Risk
Likely	Moderate Risk	Substantial Risk	Intolerable Risk

To assess the risk arising from the hazard:

1. Select the expression for likelihood which most applies to the hazard
2. Select the expression for degree of hard which most applies to the hazard
3. Cross reference using the above table to determine the level of risk

No	Likelihood of Occurrence	Degree of Harm	Level of Risk
1	Highly Unlikely	Harmful	Tolerable Risk
2	Highly Unlikely	Harmful	Tolerable Risk
3	Highly Unlikely	Extremely Harmful	Moderate Risk
4	Unlikely	Slightly Harmful	Tolerable Risk
5	Unlikely	Harmful	Moderate Risk
6	Unlikely	Slightly Harmful	Tolerable Risk
7	Likely	Slightly Harmful	Moderate Risk
8			
9			
10			

Additional Control Measures - Personal Injury

		Remedial Action Date	Date Completed
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Health Surveillance

1	Psychological stress	Various health effects	Check for and recognise symptoms. Allow person to not descend chute.
2			
3			
4			
5			

Permits To Work

Hot Work ☐ LV Electrical Equipment ☐ Aloft / Overside ☐ Lift Shaft ☐

Enclosed Space ☐ Diving ☐ Out of Commission Form ☐ General ☐

HOD

Checked By
Dave Webb
Safety Manager

Authorised by
D.Webb
Marine Safety Manager

Assessor 1
Dave Webb

Assessor 2

Assessor 3

ANNEX 9

P&O Ferries' Marin-Ark safety case

MARINARK MES SAFETY CASE (REVIEW)

P&O Ferries safety case (and risk assessment) of MarinArk usage has been revalidated following the publication of the MAIB Safety Bulletin 1/2003. Particular regard was paid to the adverse effects of possible blockages in chutes at the time of the evacuation in an actual emergency.

The company utilises MarinArk as an element of the ship's LSA evacuation on Prides of Aquitaine, Provence, Hull & Rotterdam and as the primary means of LSA evacuation for all on Prides of Canterbury & Kent.

Controls which reduce the risk of abandonment as a result of fire or hull damage

- Reduction in likelihood of abandonment due to structural fire protection, and installation of hi-fog in addition to mandatory fixed fire fighting installations and detection systems.
- Passenger ship stability enhancement as per SOLAS II-1: 2 compartment standard. Passenger ship survivability as per Stockholm Agreement.

RISK (1): FAILURE OF ONE MARINARK MES TO DEPLOY

Control Measures:

1. Statutory requirement is for 125% of total persons LSA capacity. As a result at least 25% redundancy exists. In practice P&O Ferries redundancy is far greater than this and loss of one MarinArk system does not result in any shortfall in LSA capacity available.
2. LSA boatage is provided for 30% of total (SOLAS II-1 : 2 compt standard) with raftage for 70% of total plus a further 25% raftage. Canterbury/Kent (Darwin Project) are equipped with all MarinArk LSA (6 systems/12 chutes/24 rafts) and 8 x 25 davit launched rafts. This results in 200 person capacity for persons who may not be able to descend a MarinArk chute. The figures are summarised in the table below:

Vessel	Total Persons	Boatage	Raftage	LSA	Less 1 M'Ark	Excess Capacity
Cant/Kent	2200	-	2780	2780	2350	150
Aquitaine	2000	600	1910	2510	2080	80
Provence	2139	724	1963	2687	2257	118
Hull	1512	600	1720	2320	1890	378
Rotterdam	1511	600	1720	2320	1890	378

3. Aquitaine is provided with 2 MES Slide systems in addition to 2 MarinArk systems.
4. Mandatory redundancy is further enhanced by the ships' trading pattern in which only 4% of sailings exceed 75% of the passenger capacity. This results in at least 50% of passenger capacity being available as LSA redundancy on at least 96% of sailings.
5. MarinArk deployment is achievable by using alternative manual release processes.

Summary: If one MarinArk MES fails completely, each ship has sufficient LSA capacity to evacuate all on board.

Assessment: Risk is acceptable

RISK (2): BLOCKAGE OF CHUTE DUE TO EVACUEE BECOMING STUCK

Control Measures:

1. Use of lifejackets that will not ride up on the wearer.
2. Briefing of evacuees by group instruction prior to abandonment, then by individual verbal instruction and pictogram at top of chute. The brief includes posture in descent and action required to resume descent if halted.
3. Assumption that a blockage has occurred if evacuee not clear of chute within 30 seconds.
4. Sweepers trained for controlled descent and clearing blockages. Sweeper will be provided with specialist equipment (belt and pouch, block and tackle (e.g. "handy billy"), radio, knife, strops, stirrups & gripline).
5. Two chutes per installation ensures that raftage is not reduced although time to evacuate will be extended as a result of a blockage should it not be quickly cleared.
6. Alternative LSA provision and redundancy (as Risk (1) above).
7. Provision of 12 chutes total on vessels with all MarinArk evacuation. A negligible risk exists of both chutes associated with one system becoming blocked at the same time.
8. Provision of multiple chutes and lifeboat options on vessels with conventional outfit.
9. Sweeper training includes written guidance on rapid clearing routines for six potential blockage situations using specialised equipment available.
10. Training of raft personnel and sweeper includes written guidance on locations in which a chute cell may be cut to assist clearing a blockage without rendering the chute unfit for further use.
11. Provision of lifeboats or davit launched rafts for persons who may not be able to descend a MarinArk chute will further reduce likelihood of blockage.
12. Carousel counting procedure at Assembly Stations will identify persons referred to in (11).

Summary: A range of measures are provided to control the risk of a chute blockage which is in any event statistically unlikely. Present data suggests that the likelihood of occurrence for single chute blockage can be considered 1:5000, so likelihood of two chutes may be 1:25,000,000.

Assessment: Risk is acceptable.

GENERAL BENEFITS OF MARINARK MES OVER TRADITIONAL LIFEBOAT EVACUATION

These benefits reduce a number of risks that arise from hazards associated with lifeboat deployment in both abandonment and training situations.

- No risk of multiple casualty due to catastrophic failure of lifeboat suspension during lowering (quick release system or fall wire failure) resulting in boat up-ending or falling from a height with 150 persons. (7 out of 12 lifeboat fatalities in the past 10 years have been due to failure or mis-operation of on-load release gear) (MAIB review refers).
- Hydrostatic release of MarinArk when immersed in 4m water. This emergency release is not available to lifeboats.
- Liferaft capacity can be exceeded (doubled) in extremis. This is much greater than possible in lifeboats, where physical constraints leave little or no room for exceeding capacity.

RSR March 2003