Report on the investigation of

the flooding and loss of the fishing vessel

Aurelia (BF15)

78 miles west of St Kilda

13 August 2001

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Regulations 1999

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

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

BS	-	British Standard
DTLR	-	Department for Transport, Local Government and the Regions
DTp	-	Department of Transport (now replaced by the DfT)
EPIRB	-	Emergency Position Indicating Radio Beacon
ETA	-	Estimated Time of Arrival
FRC	-	Fast Rescue Craft
FV	-	Fishing Vessel
kHz	-	kilohertz
LED	-	Light Emitting Diode
MF	-	Medium Frequency
mm	-	millimetres
MRSC	-	Maritime Rescue Sub-Centre
RT	-	Radio Telephony
SFPV	-	Scottish Fisheries Protection Vessel
UTC	-	Universal Co-ordinated Time

SYNOPSIS

The UK-registered, twin-rig stern trawler *Aurelia*, BF15, sank 78 miles west of St Kilda, at approximately 0015 on 13 August 2001. The MAIB was notified that morning and an investigation began immediately.

Aurelia was 23.79m long, built by Macduff Shipyards and completed in February 1998.

While on passage to the St Kilda edge fishing grounds, *Aurelia* suffered extensive flooding of her engine room, which went unnoticed until the main engine began to surge because it was three quarters submerged.

Although *Aurelia* was fitted with a bilge alarm, it did not operate in this instance.

The cause of the flooding is uncertain, but its speed indicates a failure of the main engine sea water cooling system; much of which was already submerged by the time the flood was noticed. Either the failure of the aluminium brass pipework, or an expansion coupling in the system, is considered to be the most likely source of the leak. The pipework condition had not been monitored, and there was evidence of misalignment of pipes and poor construction methods in the pipework.

No extended spindles were fitted to the main sea water inlet valves. This meant that since the flooding was at an advanced stage when it was discovered, the crew were unable to shut them.

The crew endeavoured to pump out the engine room, but power to the electrically-driven bilge pumps was soon lost. The hand bilge pump had a negligible effect on a leak of that size. Had an engine-driven salvage pump been available on board, more could have been done to save the vessel.

While the crew were monitoring the level of the flooding in the engine room, its aft escape door became blocked open by fishing nets, which were being washed across the then submerged after deck. Also, the engine room bulkhead was not watertight, and other doors were left open when *Aurelia* was abandoned. These conditions increased the rate and extent of the downflooding, which eventually sank the vessel.

The five crew had to retrieve lifejackets from their cabins below deck, before they could be donned. Both liferafts were launched successfully, and *Aurelia* was abandoned without injury. The fast rescue craft (FRC) from the SFPV *Norna*, which was in the vicinity, picked up all five crew about 25 minutes after *Aurelia* sank.

The issues raised as a result of the investigation are largely covered by the publication of MSN 1770, The *Code of Safe Working Practice for the Construction and Use of 15 metre (LOA) to less than 24 metre (RL) Fishing Vessels*, which became regulation on 23 November 2002.

One recommendation has been made to the Maritime and Coastguard Agency for it to advise owners, operators, and builders of fishing vessels to take into account that flooding of the engine room can lead to rapid submersion and, hence, inaccessibility of the sea inlet and discharge valves.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *AURELIA* BF15 AND ACCIDENT

Vessel details

Registered owner	:	Denholm Fishselling
Port of registry	:	Banff
Flag	:	United Kingdom
Type	:	Twin-rig stern trawler
Built	:	February 1998, Macduff
Construction	:	Steel
Registered length	:	23.79m
Length overall	:	25.93m
Gross tonnage	:	337
Engine power and/or type	:	437kW Caterpillar 3512

Accident details

Time and date	:	2212 UTC, 12 August 2001 (Time of "Mayday" broadcast)
Location of accident	:	57° 53.3N 011° 04.7W
Persons on board	:	Five
Injuries/fatalities	:	None
Damage	:	Total loss of vessel

1.2 BACKGROUND TO VOYAGE

Aurelia was the third vessel of that name to be owned and run by Ian Scott and his family. She was designed by Macduff Ship Design, built by Macduff Shipyards in 1997, and completed in February 1998.

Two regular crews operated *Aurelia* on a trip on/trip off basis. She was a twin-rig trawler and fished for white fish out of Lochinver. A typical trip took her to Rockall and lasted 10 days. She made sufficient money to meet both pay-back commitments and provide good wages for her crews. There was no difficulty in finding good crew members.

Since a routine dry dock, 2 months before the accident, she had continued to operate without problems until her final voyage. During the dry dock, some evidence of electrolysis was noticed in the hull. This was attributed to a faulty fuel monitor which was subsequently disconnected.

The sea water pipe, between the engine-driven pump and the jacket water cooler, had to be replaced when *Aurelia* was about 3 months old; a spare had been carried on board since, but was not used. More recently, the pipework connecting the port and starboard electrically-driven bilge and ballast pumps to their respective sea water inlet valve chests, had been repaired by welding.

Two years before the accident, *Aurelia* ran aground, but there was no damage as a result. Since then, and before the accident, she suffered minor damage when she collided in port with another fishing vessel.

1.3 SEQUENCE OF EVENTS

(All times are Universal Co-ordinated Time plus 1 hour (British Summer Time))

Aurelia sailed from Lochinver at about 2200 on Tuesday 7 August 2001, to trawl for white fish on the Rockall bank fishing grounds.

Towards the end of her second haul, an expansion joint, in the vicinity of the main engine fresh water heat exchanger, failed. Consequently, the fresh water cooling header tank low level and the bilge alarms sounded.

A replacement coupling was found ashore and carried out to *Aurelia* by fv *Maranatha III*. Meanwhile, to enable the main engine to be run, a makeshift replacement coupling had been made on board and fitted.

The new coupling was fitted immediately. The broken coupling was very difficult to replace – first by a temporary one, and then by the new one – because of misalignment either side of it. *Aurelia* resumed fishing at about midday on Saturday 11 August.

The following morning, after three poor hauls, the skipper decided to sail for the St Kilda edge grounds, where the fishing was reported to be better.

At the time, *Aurelia* was loaded with about 4 tonnes of fish, 3 to 4 tonnes of ice, full fresh water tanks and about 55 tonnes of fuel.

At about 2230 that night, the watchkeeper, who was the vessel's engineer, noticed that the main engine was surging and its exhaust very smoky. He went down into the engine room to investigate and found it to be flooded, with the main engine three-quarters submerged. *Aurelia*'s bilge alarm had not sounded.

Immediately, the watchkeeper told the skipper, who was in bed, before returning to the engine room to pump out the bilges.

Aurelia was fitted with electrically-driven centrifugal bilge and ballast pumps. Both had been set up for normal routine operation. This was:

- The port pump for deck washing.

- The starboard pump for pumping bilges overboard.

The watchkeeper set both pumps to pump the engine room bilges. He started the pumps and then primed them using the four-way open bottom cock on the suction side of each. This allowed the suction to be taken from the sea, the ballast tanks, or the bilges via a valve chest.

Figure 1 shows the four-way open bottom cock in the same position on a similar vessel.

In his haste to change the discharge of the port pump from deck wash, the watchkeeper dropped the changeover spanner for the three-way pump discharge cock into the bilge. This pump, therefore, remained on deck wash.

Figure 2 shows a cock similar to this three-way cock on another vessel.

The watchkeeper then went up on to the deck to secure the deck wash hose so that it discharged water directly overboard. He then returned to the wheelhouse. At that point the main engine stopped.

All five crew were mustered and they donned lifejackets. The skipper noted the vessel's position from the GPS. He instructed two of the crew to operate the engine room bilge hand pump, located on the starboard side of the aft main deck.

Figures 3 and 4 show a hand pump of the same type, on a similar vessel, both on its own and being operated.

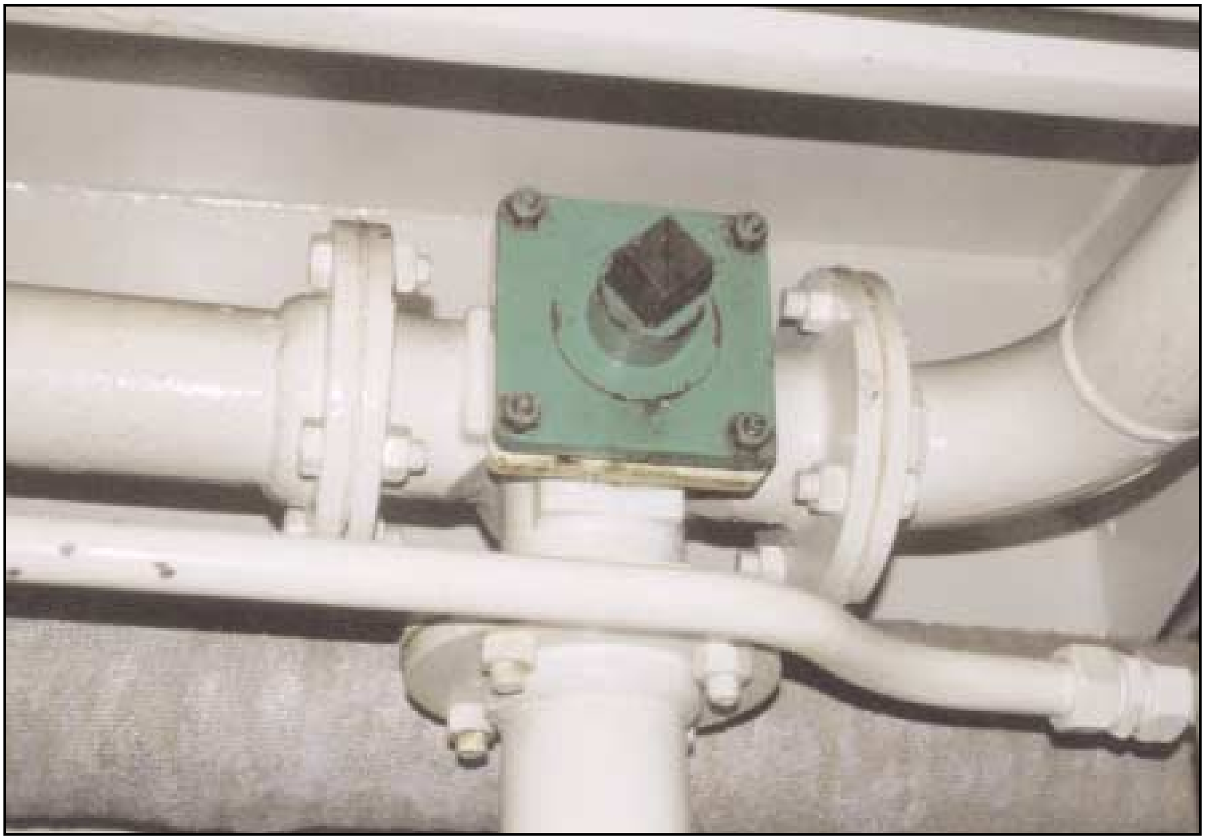
The skipper checked the extent of the flooding through the vessel, but other than a wet carpet at the foot of the accommodation ladder, he found all the remaining spaces dry. Meanwhile, the watchkeeper tried unsuccessfully to find the source of the flooding in the engine room.

Figure 1

Four way bottom cock

Bilge / ballast system

Figure 2



Three way pump discharge cock

Figure 3

Engine room bilge hand pump on aft working deck

Figure 4

Engine room bilge hand pump on aft deck being operated

Figures 5 and 6 show the sea water valves on a vessel similar to *Aurelia*. The restricted access to these valves is clear.

At about 2300, the auxiliary generator, supplying the vessel's electrical power, shut down. Consequently, the emergency lighting came on and electrical power to the bilge and ballast pumps was cut.

Emergency power to the GPS, in the event of main electrical power failure, is dependent on its internal batteries. In this case, when main electrical power was lost, the GPS signal was also lost, indicating the possibility that the GPS internal batteries were not charged.

As a precautionary measure, the skipper instructed two of the crew to launch the lee side (starboard) liferaft. Once launched, this was towed round the vessel and made fast to her stern, making it easier to board, if necessary.

By then, the water level in the engine room was 1 metre above the tank tops, and the engineer could no longer remain. To maintain a watch on the flooding, the aft engine room escape door was left open.

After consulting the skipper, one of the crew broadcast a "Mayday" at 2312 on MF 2182kHz, giving the position noted by the skipper. MRSC Stornoway received the broadcast and spoke to the skipper, who confirmed *Aurelia*'s position and the extent of the flooding. He also told them that the crew was abandoning to the liferaft.

The cook was becoming increasingly nervous, since he could not swim. The skipper decided to put him and another crewman into the liferaft, along with the EPIRB, which had not been activated. The motion of the vessel was putting a lot of strain on the liferaft painter mounting point so, fearing that it might break, the remaining liferaft was launched. This also was towed round to the stern, where the crew of the first liferaft tied the two together.

The *SFPV Norna*, which was in the vicinity, was contacted on VHF channel 16. This vessel gave an ETA of 0035 at the position given by *Aurelia*. *Aurelia* informed her that two liferafts had been launched, and that two of the crew were already in one of them. The skipper checked again for flooding but, other than the wet carpet in the accommodation, the rest of the vessel was still dry.

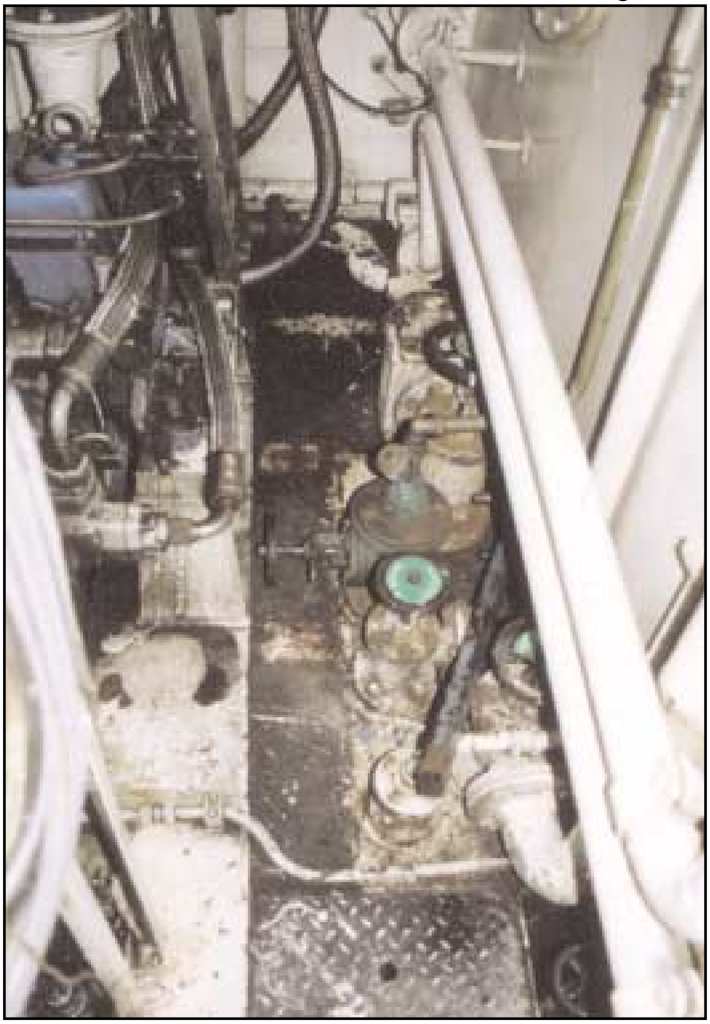
The engine room had by that time flooded to within 650mm of the deckhead, and the vessel was listing to port. Water, which had shipped aft, had pushed the port net into the open aft engine room escape door, preventing its closure. **Figure 7** shows the aft engine room escape door on a similar vessel.

A third crew member entered the liferaft, leaving the skipper and the engineer on board *Aurelia*. After a final look around the vessel, they, too, embarked a raft and the painter was cut. During embarkation, the hand-held VHF used by the skipper to contact *Norna*, was lost overboard.

Figure 5

Sea water inlet valves - port side main engine well

Figure 6



Sea water inlet valves - starboard side main engine well

Figure 7

Aft working deck

At this stage, the aft engine room escape door, the aft deck to accommodation door, and the hatch up to the bridge from the accommodation, were all open. It is unclear whether the door through to the fish room was open, but the small fish chute hatch to the fish store was.

The weather hampered the crew as they tried to paddle away from *Aurelia*. They first drifted down the port side, and on to the bulbous bow, before they managed to paddle about 6 metres clear. About 8 minutes after cutting the painter, *Aurelia* went down stern first, taking about 15 seconds to disappear. As her wheelhouse entered the water, the windows could be seen blowing out.

Among the debris left floating was one lifebuoy, six or eight fish bins and possibly some nets.

Aurelia's crew could see *Norna*'s lights, so they set off a distress flare. She was seen to stop about half-a-mile from the rafts and lower her FRC. It approached the rafts slowly, looking for anyone in the water and to avoid becoming entangled in the floating debris. One of the crew lit a hand-held flare to help guide them in and, when close enough, shouted to the FRC crew that everyone was accounted for.

About 25 minutes after *Aurelia* sank, her crew was picked up by the FRC. The transfer from the rafts to the FRC, and the return and transfer to *Norna*, was quick, efficient and without incident.

MRSC Stornoway had sent out a helicopter. This reached *Norna* about 5 minutes after *Aurelia*'s crew had been taken onboard. The crew was winched immediately on board in twos; the skipper went up last, with the winchman.

After being in the air for about 55 minutes, they arrived in Stornoway at about 0430. An ambulance and the superintendent of the Fisherman's Mission met them. No one needed hospital treatment.

1.4 BILGE ALARM

The bilge alarm system on board *Aurelia* was made by Electronic Devices Limited, and known as the Two Zone Bilge Water Alarm. It is accepted by the MCA, and uses float switches (type ED 735) approved by UK DTp and Classification Societies. The system allows two separate compartments, or zones, to have bilge high level alarms connected to the bridge control unit.

The system has two separate functions:

1. It detects high water levels in the two zones fitted with level switches. Any number of level switches can be fitted on each zone. When a level switch is operated by water in the bilge, an audible alarm sounds on the control unit, and the LED for that zone is lit. The audible alarm is silenced using the

accept button on the control panel. Once the water level in the bilge is reduced to below the level switch, the alarm resets itself and the LED for that zone goes out. There are adjustable timers, which can be set to ensure the system does not reset and alarm with the movement of the water in the bilge as the vessel rolls.

2. The system is also capable of automatically starting a bilge pump of up to 5-amp capacity for each zone, when a high water level is detected. Additionally, it has an override function, which allows these bilge pumps to be operated from the control unit. However, *Aurelia* did not use this automatic bilge pump operating facility. The bilge and ballast pumps were not connected to the bilge alarm system.

The control panel has an LED, an alarm accept button and a test/override switch for each of the two zones. The manufacturer's recommended method of operating this unit is as follows:

1. When a bilge alarm sounds, the LED lights up for the relevant zone.

2. The alarm cancel button is pressed, this stops the alarm sounding, but the LED remains lit.

3. Once the space has been pumped out, either automatically or manually, the LED goes out and the alarm resets automatically after a few seconds.

4. Where the bilge pumps are connected to the control unit, the test/override switch allows the bilge pumps to be operated from the bridge if either the float switch, or the electronics of the control system, fail. Where no bilge pumps are connected, this switch serves no practical purpose and should not be used. However, operating the test/override switch will silence an existing alarm and/or prevent that zone from alarming until the switch is returned to the off position.

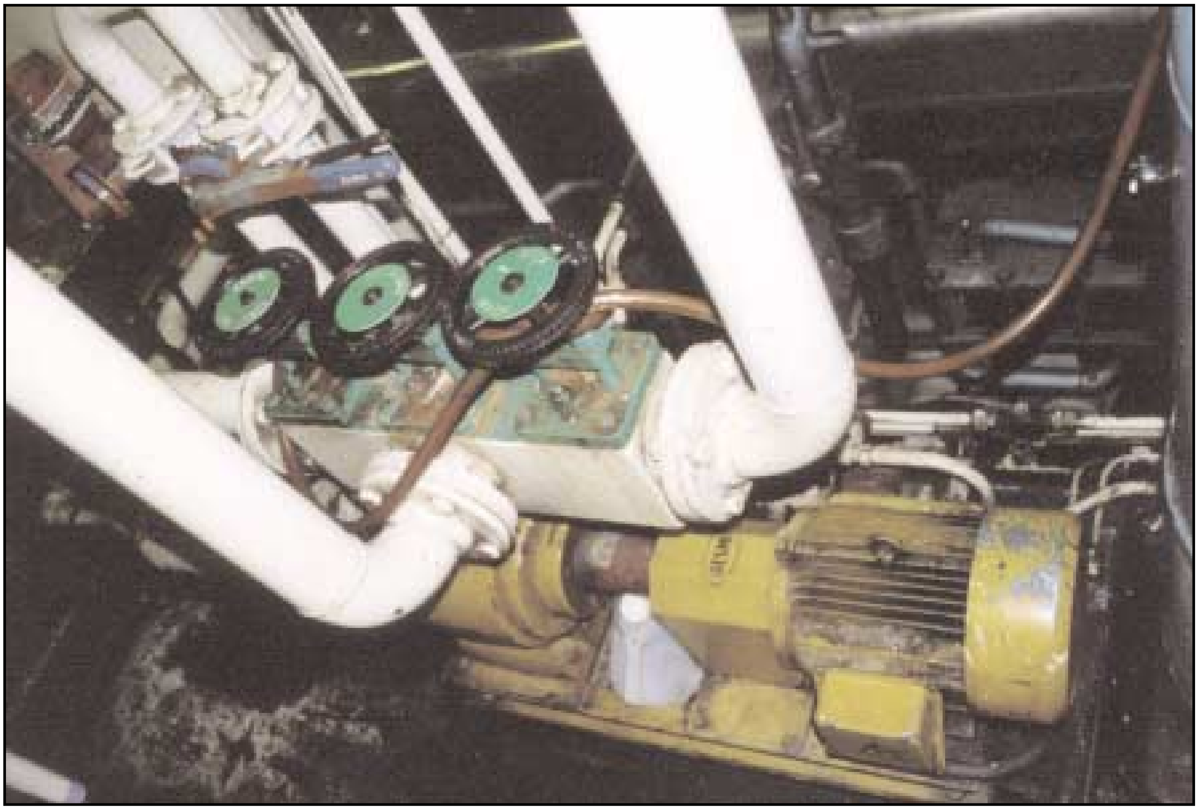
1.5 BILGE PUMPING ARRANGEMENTS

Aurelia was fitted with two electrically-driven Desmi Type S70 50 175 centrifugal bilge and ballast pumps. **Figure 8** shows the same make and model of pump on board a vessel similar to *Aurelia*. Each pump was theoretically capable of pumping up to 50 m^3/hour. In practice, this would be reduced to around 30 m^3/hour in the case of the port pump, because of the restricting effect of the deck wash system. A typical deck washing connection can be seen in **Figure 9**, and shows the restriction.

The diagram 'Bilge and Ballast System Schematic' in **Figure 10** shows the layout of this system, together with the changeover cocks referred to in the sequence of events.

A hand pump was also available. This was capable of pumping up to 5m^3/hour. A similar pump is shown alone, and being operated, in **Figures 3 and 4**.

Figure 8



Centrifugal bilge and ballast pump

Figure 9

Typical deck wash connection

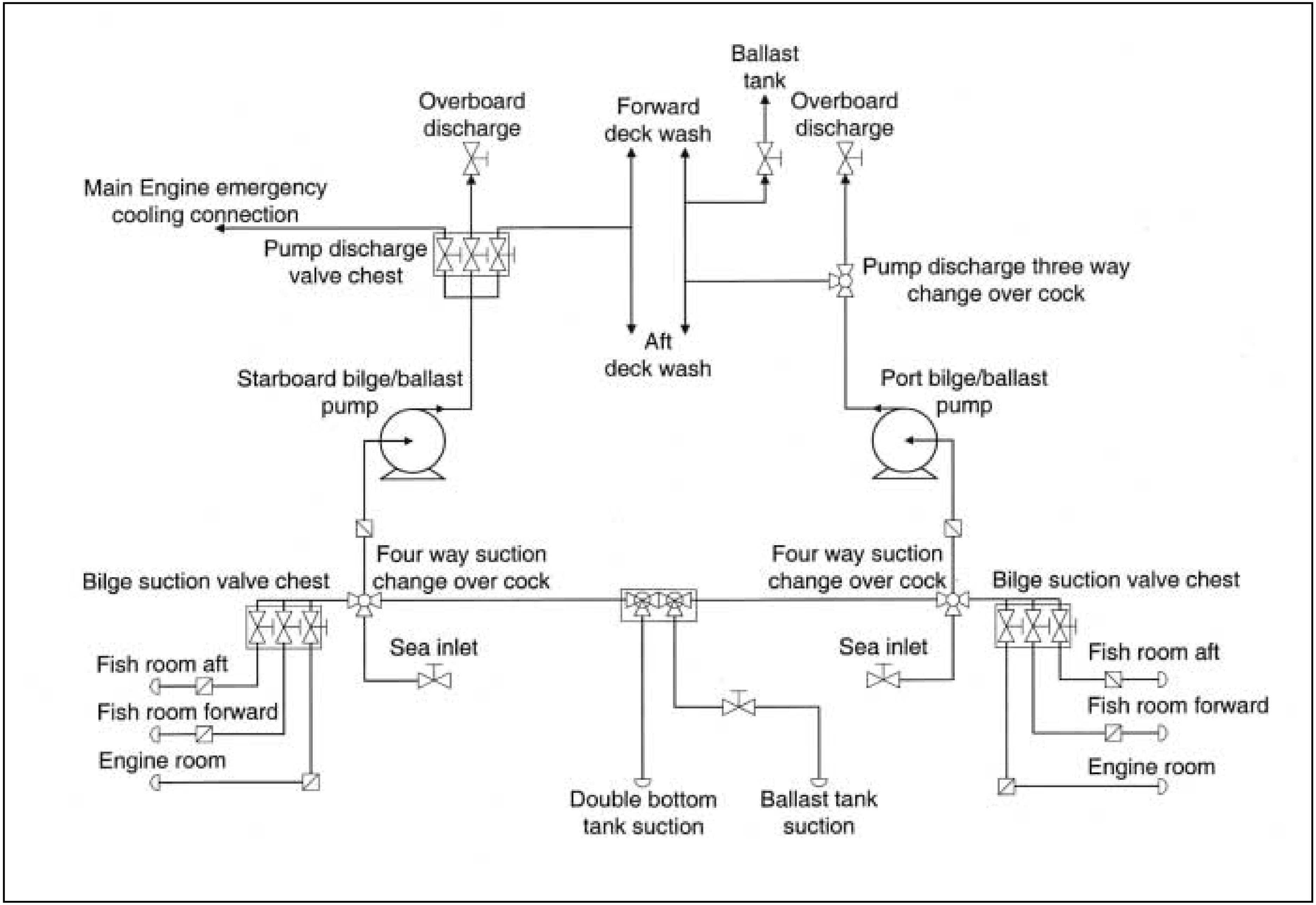


Figure 10

Bilge and ballast system schematic

1.6 SEA WATER COOLING SYSTEM

The sea water cooling pipework for the main engine was 75mm diameter aluminium brass (BS2871 CZ110), a copper alloy (76 - 78% copper) which is resistant to corrosion in sea water. The "Main Engine Sea Water Cooling System Schematic" in **Figure 11**, shows the layout of this system.

1.7 EXPANSION COUPLINGS

The expansion couplings, or joints, fitted to *Aurelia* were Teguflex joints manufactured by Trelleborg. **Annex 1** shows some of the key factors of these expansion joints. The couplings fitted were capable of withstanding up to 30mm of compression, or 20mm of elongation or 20mm of lateral displacement (misalignment).

1.8 WEATHER

On the day of the accident, seas were slight with a moderate swell, force 4 to 5 westerly wind, dark but with good visibility.

1.9 CREW

Aurelia sailed with an experienced crew of five.

Ian Scott, the 46 year old skipper, co-owned the vessel with the rest of his family. He had fished since leaving school at the age of 16. He had served as skipper since he was 20 years old, and had been on this, the third *Aurelia*, since she was built in 1998. He held a Deck Officer Certificate of Competency (Fishing Vessel) Class 2 and a restricted RT Certificate.

Derek Taylor, 41, was the engineer on board at the time of her loss, and had served in this capacity since May 1998. He held an Engineering Certificate of Competency (Fishing Vessel) Class 2, in addition to basic sea survival and advanced fire-fighting certificates. He had been at sea for 20 years, on a variety of fishing vessels.

David Wiseman, a 31 year old ex-fisherman with a Deck Officer Certificate of Competency (Fishing Vessel) Class 1, basic sea survival and fire-fighting certificates. He was on leave from his present job, and was filling in for one of the regular crew who was on holiday. He had 15 years fishing experience.

Kevin Wiseman, aged 21, had been at sea for 5 years. He joined *Aurelia* in January 2001, and was studying for his Deck Officer Certificate of Competency (Fishing Vessel) Class 2. He held basic sea survival and fire-fighting certificates.

Robert Annand, aged 49, was the cook on board, and had sailed with Ian Scott for the last 13 years.

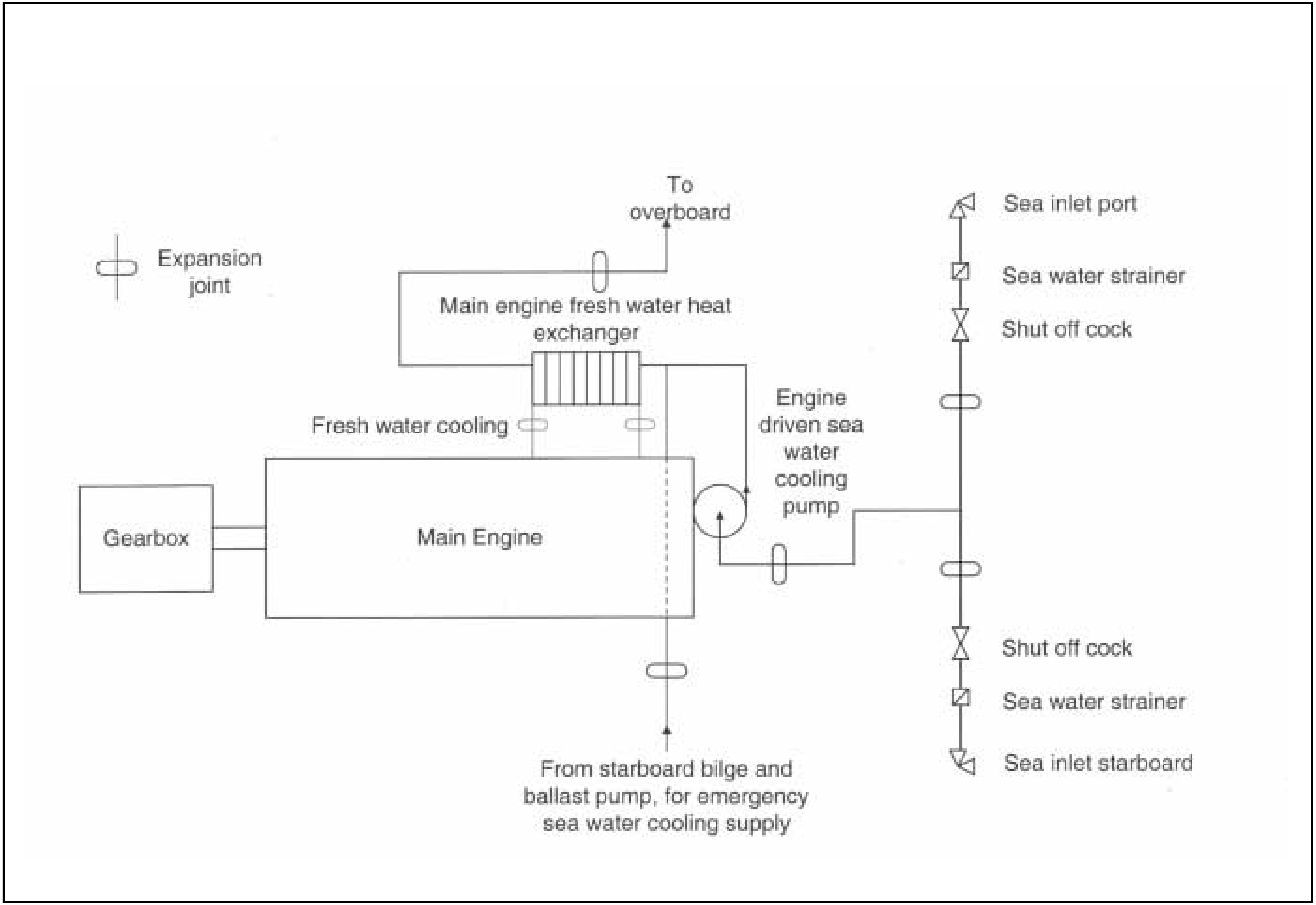


Figure 11

Main engine sea water cooling system schematic

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 in the future.

2.2 BILGE ALARM

On 12 August 2001, the bilge alarm did not operate when the engine room flooded. Thus, the sea water ingress into the engine room went unnoticed until it was at a dangerously high level.

Although the bilge alarm had operated the day before, during the failure of the expansion joint on the fresh water system, it had not been tested that day. In the view of the MAIB, bilge alarms should be tested before the start of every voyage, and daily where possible.

The facility to operate a bilge pump automatically was not in use. Instead, the bilge pump had to be started manually. It was normal practice for some watchkeepers to use the test/override switch to silence the bilge alarm, and to return it to the off position once the space had been pumped out. The day before the accident, the alarm operated when fresh water leaked into the engine room. It is possible that the alarm was not reset to its “off” position, which would explain why it did not operate when the engine flooded the next day.

The alarm might not have been reset because of the crew’s lack of knowledge of the system, coupled with the fact that using the test/override switch to silence the alarm would have stopped its continuous sounding in the event of the vessel rolling. Previous MAIB investigations have found that bilge alarms have been silenced, but not reset, for this reason, and this might have been the case on board *Aurelia*.

Although there was a reset timer within the control system to prevent this happening, it might not have been adjusted correctly.

2.3 SOURCE OF THE FLOODING

By the time the flooding was discovered, the water was three quarters of the way up the side of the main engine. This means there was approximately 1 metre of water over the bottom plates submerging the sea water inlet valves. The water was also deep enough to cover the source of the water ingress, thus making it impossible to ascertain precisely the source of the leak.

It is therefore a matter of speculation as to the cause of the flooding of the engine room. There are many possible reasons for leakage.

Four of them are considered below:

1. The stern tube

Sea water leakage through the stern tube was improbable. There was no history of leakage problems and, in any case, the flooding rate was far in excess of what was possible with a major stern tube leak.

2. A hole or crack in the hull

Damage caused by grounding is ruled out because *Aurelia* was in deep water. Also, there is no report of any noise or motion which might have indicated an impact to the hull. Further, because she was less than 4 years old, and her hull was reported to be in good condition, its structural failure was unlikely.

3. Failure of an expansion coupling in the sea water pipework

Total failure of a 75mm (3-inch) expansion coupling, in the main engine sea water cooling pipework, could create a leak consistent with the reported rate of flooding.

The day before the accident, a fresh water cooling system expansion joint had failed. There was misalignment in the pipework either side of this coupling, which might have led to its failure. Although the coupling on the sea water pipe was of a different size and specification to those on the fresh water system, and was operating under different conditions of temperature and pressure, the mechanism of failure as a result of misalignment was the same for any expansion coupling of this type.

The expansion couplings fitted to the sea water pipework were designed to withstand misalignment of up to 20mm. However, misalignment greater than this is not unusual in sea water systems.

4. A hole or crack in sea water pipework

Pipework failure was another possible source of the flooding. Failure of the 75mm (3-inch) diameter main engine sea water cooling pipework, could also create a leak consistent with the reported rate of flooding.

Three recognised modes of failure are associated with copper and copper alloy pipes:

a. Fatigue fracture

Ineffective pipework mounting and/or support can cause residual loading and excessive vibration of the pipes, which can result in their fatigue fracture. Residual loading will also be the result of any misalignment in pipework. It was known that in way of the previously failed expansion coupling on the fresh water cooling system, misalignment existed.

Fatigue fracture will lead to a rapidly spreading crack in the material, usually starting at a point of raised stress, such as a flared flange or weld.

b. Erosion corrosion

An aluminium brass pipe owes its long-term corrosion resistance to the protective effect of a thin, adherent film of corrosion product, which forms during the early life of the pipe. This film forms a barrier between the material of the pipe and the corrosive environment; sea water in this case. However, turbulence in the flow will produce localised areas of high velocity water at the protected metal surface, and this can lead to removal of the protective film, exposing the bare material. This will result in localised thinning, and eventual failure of the pipe. Turbulent flows are found downstream of valves or elbows in pipes.

c. Galvanic corrosion

This can be caused by two different materials - such as aluminium brass and steel - being coupled together in the same piping system. The rate of corrosion will be increased by incorrect earthing or short circuits.

Galvanic corrosion also leads to localised thinning of the material, and eventual failure of the pipe.

The main engine sea water cooling pipeline ran from the port and starboard main sea valves, at the bottom plate level, to the engine-driven main engine sea water pump (**Figures 5 and 6** show the main sea valve on a similar vessel).

There were three expansion couplings in this section.

The pipework ran from the pump to the main engine fresh water heat exchanger, and via an expansion joint to the overboard ship's side valve.

This pipework had not been inspected internally, or ultrasonically, since *Aurelia* was built, so it is impossible to know precisely its condition. However, there is evidence to suggest that it was subject to conditions which could have led to a combination of any, or all, of the failures of the pipes or expansion couplings described above.

These conditions were:

- The pipework had three expansion couplings between the ship's side valve and the engine-driven pump. This is more than would normally be fitted to this pipeline and might have been fitted in an attempt to make good some misalignment in the pipework. This may indicate the presence of residual stresses in the pipework, possibly leading to fatigue cracking or failure of an expansion coupling caused by misalignment.

- The difficulty experienced in refitting the expansion coupling to the fresh water cooling pipework, in way of the fresh water cooler, might well have caused the cooler to be moved slightly on its mounting. This would have led to additional stresses and misalignment in the sea water cooling pipework attached to this cooler. This could have resulted in rapid fatigue crack propagation, or failure of an expansion coupling because of misalignment.

- Although the water velocity through the sea water pipework was within the limits for the aluminium brass used, the pipes were constructed by joining straight sections to elbows. These elbows and joins set up localised areas of turbulence which could lead to erosion corrosion. (**Figure 12** shows a section of pipe immediately downstream of the starboard sea water inlet strainer on board a similar vessel to *Aurelia.*)

- There is anecdotal evidence of galvanic corrosion being seen at *Aurelia*'s last dry dock. This was thought to have been caused by the earth fault on the fuel monitor, which was then disconnected. However, it might not have been associated with this earth fault, and could have been a result of the use of dissimilar materials. Either way, galvanic corrosion could have caused localised thinning of the pipe material.

Figure 12

Main engine seawater cooling system

2.4 PUMPING ARRANGEMENTS

The use of both electrically-driven bilge pumps had no visible effect on the rate of flooding of *Aurelia*. Since the rate of pumping achieved by these pumps, even allowing for reduced efficiency, is in excess of ten times that theoretically achievable using the hand pump, the use of the hand pump on that occasion was futile.

Crew members who manned this pump found it extremely tiring to use. Had they found it necessary to swim or to paddle the raft for a longer period, to escape the sinking vessel, their tiredness would have had an adverse effect on their chances of survival.

A full understanding of the capabilities of hand pumps might have made them aware of their limitations. Consideration might then have been given to the carriage of an engine-driven salvage pump, which could have continued running after the electrical power had been lost to the main bilge pumps.

2.5 DOWNFLOODING

When *Aurelia* was abandoned, the aft engine room escape door, the aft deck to accommodation door, and the hatch up to the bridge from the accommodation were all open. It is unclear whether the door through to the forward working deck was open or not, but the small fish chute hatch to the fish room was open.

Safety at Sea Ltd, at the University of Strathclyde, modelled the damage stability of *Aurelia*, based on the available information and assuming that the engine room bulkheads were watertight.

The findings of its initial study show that because of the design of the engine room, total flooding of that compartment would induce a significant list to port. This would cause substantial flooding of the aft working deck, further reducing the vessel's buoyancy. However, the water would not reach the aft deck to accommodation door unless the flood had spread beyond the engine room.

It is possible that there was further leakage of sea water into one of the aft spaces of *Aurelia*. For example, through the door on the aft working deck into the steering space/store below. However, the wet carpet at the foot of the accommodation ladder, and the findings of Safety at Sea Ltd, indicate that there was leakage into the space beneath the accommodation passageway from an early stage. This is most likely to have come through the aft engine room bulkhead and was sufficient to lower *Aurelia* in the water, bringing the open aft deck to accommodation door closer to the sea.

When *Aurelia* was abandoned, waves were already washing over the aft working deck with sufficient force to wash some nets into the open engine room escape door. With unabated flooding of the engine room spreading into the accommodation, it was only a matter of time before downflooding into the accommodation and, finally, the fish hold, led to *Aurelia* sinking. In the event, this took no more than ten minutes.

2.6 ABANDONMENT AND RESCUE

All *Aurelia*'s crew members donned lifejackets as soon as they were alerted to the flooding, although this was delayed because they had to return to the lower deck to retrieve them from their cabins.

The crew's abandonment of *Aurelia* was achieved successfully. No one entered the water, and there were no injuries. The two liferafts were deployed correctly and both operated successfully.

Although the EPIRB was not activated, it was available on board the first liferaft. Radios were not available on both rafts, although sufficient hand-held VHF radios were available on board. Only the skipper carried one during the incident and, unfortunately, this was lost when he embarked the liferaft.

Aurelia sank very soon after she was abandoned. Once the generator had failed, there was no more power available to run the bilge and ballast pumps, and the situation was beyond the crew's control. They could have abandoned as soon as the first liferaft was launched and the "Mayday" had been broadcast and received. However, they thought it safer to stay on the vessel as long as possible; only abandoning her when they realised she had started to sink rapidly.

Once in the tethered liferafts, the difficulty in paddling them away from *Aurelia* quickly became apparent, and there were concerns that they might be dragged down with the sinking vessel.

The crew did not appreciate how quickly the vessel was going to sink.

2.7 ACCESSIBILITY OF SEA INLET VALVES

Aurelia's engine room was unmanned, so the bilge alarm was the crew's first line of defence against possible catastrophic engine room flooding.

Had the bilge alarm been working correctly, it is probable the crew would have discovered the engine room flooding in time to find the source of the flooding and close the main engine sea water cooling inlet valve, thus preventing the vessel from sinking.

In any case, if extended spindles had been fitted on the sea valves, they could have been closed despite being submerged.

Regulations and advice encourage the industry to ensure that sea valves are easily accessible.

The *Fishing Vessels (Safety Provisions) Rules 1975* state that sea inlet and discharge valves shall be readily accessible. Also, the *Code of Safe Working Practice for the Construction and Use of 15 metre (LOA) to less than 24 metre (RL) Fishing Vessels (MSN 1770)* advises that each inlet should be fitted with a positive means of closure from an accessible position. Further, MGN 165 *Fishing Vessels*: *The Risk of Flooding*, advises that sea inlet valves should be able to be closed without having to lift floor plates.

However, this advice does not fit the situation on board *Aurelia*. On this vessel, the sea valves were above the floor plates but were rendered quickly inaccessible because the small free space in the main engine well, where they were located, was the first area to flood.

During the design and construction of fishing vessels, when considering the accessibility of sea inlet and discharge valves, the possibility of rapid flooding of the engine room and submersion of these valves should be taken into account.

2.8 THREE WAY PUMP DISCHARGE COCK

Electrical power, and the use of the bilge pumps, was lost within about half an hour of the discovery of the engine room flooding.

The port bilge pump discharge had been directed to the deck wash main by the pump's three way discharge cock, thus restricting this pump's discharge capacity.

The operating spanner was not attached to the cock and, while trying to alter the discharge to overboard, the spanner was dropped into the flooded engine room.

Because the bilge pumps were immobilised at an early stage, the restriction to the port pump's capacity, owing to it discharging through the deck wash hose, is not considered to have had a significant effect on the water level in the engine room.

However, there is a lesson to be learned, in that operating spanners for change-over cocks on bilge and ballast pump valves, should be attached permanently to the cock.

SECTION 3 - CONCLUSIONS

3.1 CAUSES AND CONTRIBUTORY FACTORS

On 12 August 2001, the bilge alarm did not operate when the engine room flooded. Thus, the sea water ingress into the engine room went unnoticed until it was at a dangerously high level.[2.2]

Control of the sea water ingress into the engine room was lost, because the main sea water suction valve was rendered inaccessible, because it was submerged, so could not be closed. [2.7]

3.2 OTHER FINDINGS

1. The main sea water cooling pipework had not been inspected internally, or ultrasonically, since *Aurelia* was built, so it is impossible to know precisely its condition. [2.3]

2. The sea water pipework was misaligned in places, causing residual stresses in it and additional stresses in the flexible couplings. [2.3]

3. The construction of the sea water pipework led to areas of turbulent flow within the pipe. [2.3]

4. The aluminium brass material used in the construction of the sea water pipework is prone to both erosion and galvanic corrosion. [2.3]

5. When the vessel was abandoned, no specific checks were made to ensure that all the watertight doors were secured shut. [2.5]

6. When the main electrical supply was lost, the GPS was also lost, indicating the possible failure of its internal batteries. [1.3]

7. Once embarked in the liferafts, no VHF radios were available. [2.6]

8. The crew did not appreciate how quickly the vessel was going to sink. [2.6]

9. The difficulty in paddling the tethered liferafts clear of the sinking vessel was not appreciated until it was attempted. [2.6]

10. The electrically-driven and hand-operated bilge pumps were ineffective in pumping out the water in the engine room. [2.4]

11. The crew members who worked the hand-operated bilge pump found it extremely tiring. [2.4]

12. The donning of lifejackets was delayed as a result of them being stowed in the cabins. [2.6]

SECTION 4 - RECOMMENDATIONS

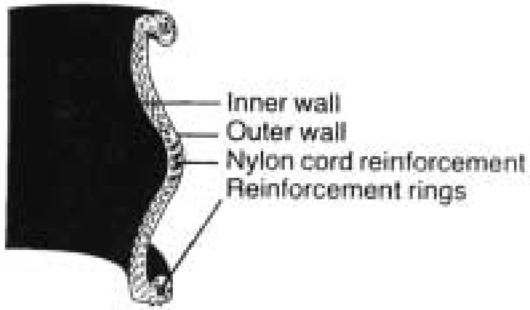
The Maritime and Coastguard Agency is recommended to:

1. Advise owners, operators, and builders of fishing vessels that when considering the accessibility of sea inlet and discharge valves, the possibility of rapid flooding of the engine room, and submersion of these valves, should be taken into account.

Marine Accident Investigation Branch
December 2002

Structure

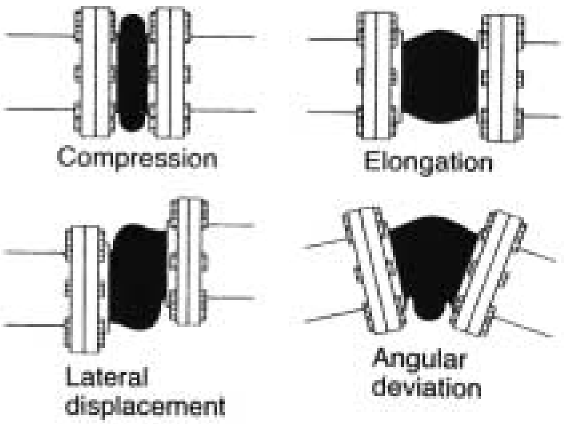
The joint is reinforced with heavy-duty nylon cord anchored in the reinforcement rings on the collars at each end.



In general, the following maximum values apply: Compression 30 mm, elongation 20 mm, bending 35° and lateral displacement ±20 mm.

Movement

Teguflex expansion joints are subject to the following movements:



Note: Maximum values do not apply simultaneously. Expansion joints are not designed to compensate for torsion.

An expansion joint is not a pipe support!

To absorb loads, use appropriate fittings such as Trelleborg Novibra pipe supports.