

INVESTIGATION REPORT

94 - 2013



**“POR DEUS
AJUDADO”**

03 July 2013



GOVERNO DE
PORTUGAL

MINISTÉRIO DA AGRICULTURA
E DO MAR



Report nr. : 094/2013

Title: “POR DEUS AJUDADO”

Ratification : 27 May 2014

Classification: Very serious

Name of vessel: POR DEUS AJUDADO

IMO nr:

Registry nr:

State substantially interested:

This report was prepared by the Maritime Accidents Prevention and Investigation Cabinet (GPIAM), which is the office of the central administration of the State that has the commission to investigate the sea accidents and events as accurate and as soon as possible, having in mind the identification of eventual causes and to disclose the related reports, to promote studies, recommendations in sea safety matters in order to minimize the sea disasters and to take part in commissions, organizations of national or foreign activities.

The current report was prepared under the norms of the International Marine Organization (IMO) and following the common procedure of the European Community.

The GPIAM investigations are independent from regulators entities, operators or other outsiders. It is not the object of an investigation to find out guilt or responsibility, therefore this report should not be used for legal actions neither can be used in court as evidence.

The safety recommendations that might result from this report cannot, under any circumstance, create a presupposition of responsibility or guilt.

The hours referred to in this report are local time and the coordinates are in *datum* WGS84.

Gabinete de Prevenção e de Investigação de Acidentes Marítimos (GPIAM)

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Description

The object of the technical investigation carried out on the accident (reversal of rotation) of the fishing vessel “POR DEUS AJUDADO”, with the identification tag “VC-295-C”, that was in the fishing activity on the Aveiro shore, between Furadouro and Torreira, on 03JUL2013, at 1315 that caused one death, is to find out the cause of the accident.

This accident is classified as a very serious sea accident, as referred to in paragraph c), nr 2, Article 3 of the Decree-Law nr 18/2012, of May 7.

Around 1215 of 03JUL2013, the fishing vessel heeled over at starboard while lifting the fishing nets about 1.25 nm from the shore. There were still around 20 nets/cloths (900 m) from a total of 5000 meters (1 cloth is around 45 meters long and 2.5 meters high). The net has a stringing (diagonal shape) of 8mm and 2 bolt-ropes.

The bottom, in the area of the accident, has a reduced plummet (sounding-lead) of about 20m and it consists generically of gravel.

Six crew members were shipwrecked, five of them were rescued with the support of another fishing vessel and one of them went missing. This last one could not swim.

The castaways were not wearing life jackets nor any other emergency floating equipment.

The refloating service maneuvers of the vessel started around 1030 of 04JUL2013 on the 40°49'.8 N 08°43.19 W, using floating balloons and towage. Later, the vessel was recovered at the port of Aveiro.

After inspection at the port of Aveiro (where the vessel was towed to), it was noticed that the vessel was floating and was completely straight, without any visible damage on the hull. It was also noticed that the supports of the hauler were damaged. One pipe that makes part of the support structure of the hauler jumped out of its place, another one broke by the welding joint and bent upwards and inwards. The fixing bolts of the support structure of the hauler jumped out.

At the time of the accident the vessel was 2 years old, was sailing at a speed of 2 knots and had a flooding alarm device that did not work (at least on the audible mode).

Timing (according to the boat swain)

Monday (02/07/2013)

- . 2200
Sailing from Aveiro
- . 2330
[Flip bucket fishing up to 0600]
- . 0600
[Finished fishing]

Tuesday (03/07/2013)

- . 1310
Start of the nets turning from the port side
- . 1315
Accident

The crew did not feel anything abnormal until the vessel started to heel over at the starboard side (SS), around 1314. At that moment, the boatswain ordered the load to be moved to the opposite board (port side – PS), however the board was quickly under water and the moving of the load did not happen. At that moment, the crew stopped hauling the nets, the winch was stuck, the engine was not stopped, the boatswain gave the alarm to the VTS Aveiro, VHF channel 74 (main channel of the port VTS) and the crew, on its own initiative, abandoned the vessel.

In order to have an understanding of the distribution of the loads on board, which can have a big role on the stability of the vessel, the crew provided the following information:

There were 7 loaded boxes of fish on the port side and 5 more (full) ahead. There would be, in total, 12 or 13 boxes of fish on board. Each box weighs around 30 kg (a total of 390 kg approximately).

There are 6 tanks at the stern of the vessel, 5 of them were already full. There was only one left to fill with the 20 nets. The net is hauled at PS.

As far as the crew is concerned, the normal position of the men during the gathering of the harness is:

- a) Boatswain on the bridge
- b) 1 man at the winch on the stem (amidships)
- c) 1 man at the stowage of the nets at the “net tanks”, at the stern (amidships)
- d) 3 men at SS passing the net

The boatswain checked the engine room the day before and did not find anything abnormal. The land mechanics had been on board about 1,5 months before the accident, for a repair on the fresh water tank. The engine was cooled with salty water (open circuit) and coolant (closed circuit).

During the investigation, it was noted that, in the engine room, there was a cooling water pipe of the engine leaking water under a cramp. As the engine had been stopped for some time (after the accident) and without internal pressure, it was noted water drips with a rate of 1-2 drips per second. That pipe had already been previously welded on the opposite side of the current holes. Two to three months before the accident, the vessel was on the shipyard, but only the sewer system maintenance was made, its pumps and valves, without any maintenance on the cooling system. Neither was requested any surveillance or test on the system at that time.

From the bottom up to the engine the piping of the cooling system is stainless steel 316. Between the engine and the clutch and a small section after one squared flange on the outlet of the cooling of the clutch, the piping is aluminum brass with 48 mm of diameter and is approximately 2 mm thick.

Then, there is a section composed by a flexible pipe and after that pipe, the 316 stainless steel piping starts again. The internal pressure is 0,5 bar.

As above mentioned, the holes appeared on the same type of aluminized brass where a previous welding had already been done – see fig. 1, because a hole had already appeared there. The previous cause had been corrosion.

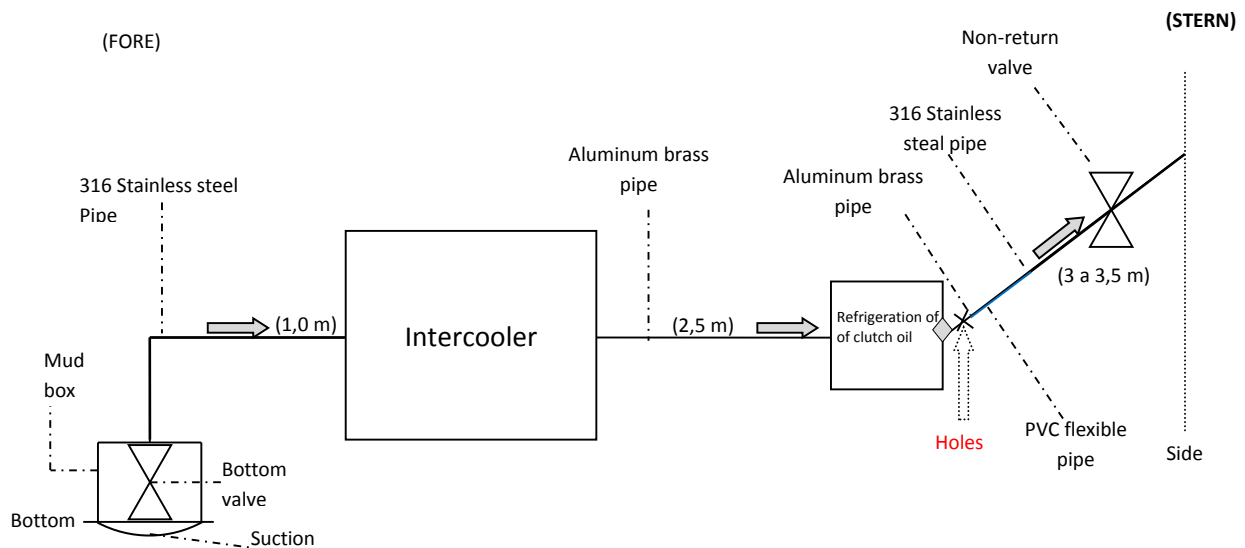


Fig. 1 – Simplified diagram of the cooling system of the vessel and where the pipe corrosion took place (see fig. 11 of the manufacturer general diagram).

The damaged piping was detected behind de engine, at the clutch cooling oil outlet, where the corrosion breaking points can be seen (holes) – see fig. 1

According to the owner, the vessel/engine should have had approximately 4300 operation hours, since it was first launched until the time of the accident.

The piping of the vessel “POR DEUS AJUDADO” was originally fitted by the engine manufacturer/ representative.

Data

I. Vessel

Name:	"POR DEUS AJUDADO"
Radio Call:	CUEU9
MMSI:	263427250
Identification Tag:	VC-295-C
Flag:	Portuguese
Registry Port:	Aveiro
Type:	Fishing
Sub-type:	Coasting
Classification:	
Gross gauging:	13,18 ton
Displacement:	55,51 ton
Gross capacity (tdw):	
Length over all:	11,95 m
Length between perpendiculars:	10,35 m
Length:	4 m
Depth:	1,70 m
Metacentric height:	GM = 0,8724 m (>0,70 m)
Draft:	
Year of construction:	2012
Shipyard:	SICNAVE
Construction site:	Vila do Conde – Portugal
Hull material:	Aluminum alloy
Type of hull:	
Main engine:	Baudouin
Power Installation:	89kW (main) +10 kW (aux.)
Nr of generators:	1
Owner:	José Carlos da Costa Craveiro
Shipowner/operator:	José Carlos da Costa Craveiro
Safety capacity/maxim:	3/9
Authorized cargo:	Diverse fresh fish

II. Weather Conditions

Sea conditions:	Hollow sea
Direction of the surge:	
Height of the surge:	1,5 m
Height of the wave:	

Wind speed:	mild
Direction of the wind:	NW
Visibility:	Good
Natural light:	Daylight

Tide:	
Period of tide:	
Current:	
Water temperature:	
Air temperature:	

III. Journey

Port of origin:	Aveiro
Ports of call:	
Destination port:	Aveiro
Type:	Coastal fishing
Segment:	During fishing
Number of days since departure:	
Commercial journey:	
Number of crew:	6
Number of passengers:	
Official language on board:	Portuguese
Nationalities:	1
Cargo:	Fresh fish, main target: sole

IV. Accident

Type:	Very Serious
Date:	03JUL2013
Time:	1315
Location:	1,25 nm off the coast, between Furadouro and Torreira
Latitude:	N40°48'.93
Longitude:	W08°43'.17
Location on board:	Engine room
Fatalities:	1
Wounded:	

Analysis

Stability and buoyancy

Generally, the flooding of a room (or rooms) inside a vessel creates two situations:

- 1 – Loss of buoyancy capacity, causing a decrease of freeboard which results on the sinking of the vessel.
- 2 – Decrease of transversal stability to a point that causes the vessel to heel over (or water boarding on the deck).

Although (eventually) the water boarding may improve the general conditions of stability, in critical conditions it might cause an insufficient freeboard to be able to endure the “roll” (transversal balance), causing the flooding of the deck and the sinking of the vessel.

Additionally to the compromised freeboard by the weight of the water, if the surface of the water in a compartment is free to move from one edge to the other, it will cause the appearance of the so called free-level (or water mirror) effect, that is always harmful to the stability of the vessel. The balance will make the surface of the liquid to run to the lower edge, causing a reduction of the straightening movements towards the several inclination points. Therefore, the vessel will be “lazier” and will have a “slower” balance.

Thus, the vessel was being operated normally under minimal navigability conditions until it reached an imbalance point, caused by the boarding of unpredictable additional water, either as in the conception project as in the operation itself of the fishing vessel “POR DEUS AJUDADO”.

According to what was determined, it was at SS that the vessel had a major concentration of cargo.

So, at starboard side, the vessel had a concentrated weight equivalent to 1% of the total displacement (cargo + crew): 0,21 ton of fishery (7 boxes) + 0,18 ton of crew (3) = 0,39 ton.

Therefore, the total weight on deck, plus the stability evidence conditions, would be: 0,39 ton of fishery (13 boxes) + 0.48 ton of crew (6) = 0,87 ton, i.e. approx. 3% of total displacement.

The bulk (cargo + equipment + crew) were spread, as shown in fig. 2, which *per se* is not in accordance with the metacentric height, i.e., the location of the points to define the balance of a floating device (see fig. 3), considering that it would be approximately only 3% of its total displacement. It should be noted that the displacement at the moment of the accident would have been approximately 33, 51 ton, which corresponded to about half cargo.

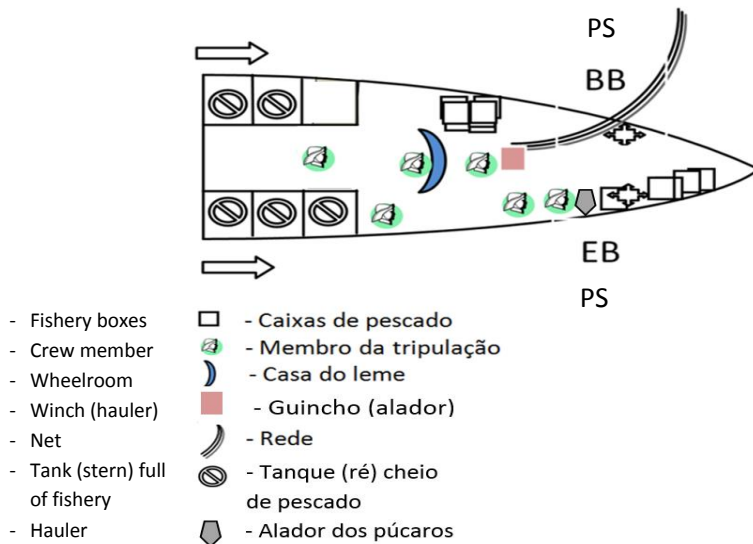


Fig. 2 – Vessel diagram representing the several fishing equipment, the crew members' position, the fishery boxes and the stern tanks.

Thus, and having in consideration the water flow that was coming out from the piping and the pressure on the engine rotations and subsequently from the associated pumping system, a flooding certainly caused changes to the previously referred metacentric height on the vessel "POR DEUS AJUDADO".

Therefore, if the engine room was flooded with water coming from the damaged pipe up to the top level of the fuel tank on the foreside, the flooding would cause a metacentric height (GM) minimum reduction of 0,03 m. The effect of the water mirror phenomena in the engine room would contribute even more to this reduction. On the other hand, if the flooding would exceeded the top of the foreside tanks, then there would be a minimum reduction of 0,05 m GM. For information only, it should be noted that, in order to ensure a stable balance, the gravity center (G) must be on the vertical center of the displaced water or the *Carena* Centre (CC) [**body of the vessel below waterline**] and from a distance upwards not too much high to ensure a stable balance (see fig.3)

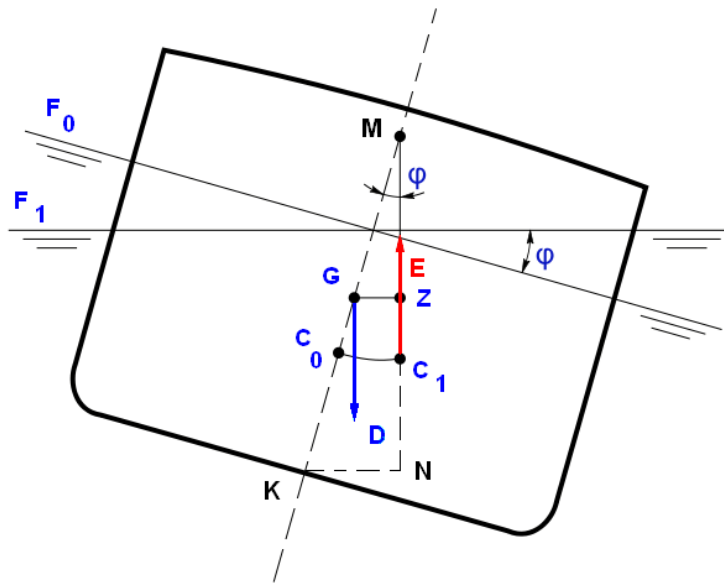


Fig. 3 – Metacentric height, defined by segment GM. The vessel became unstable when segment KM (variant that depends on the relative positions of G and C ($C_1; C_0$) and the stability branch, which, on the other hand, depends on each vessel cargo condition, i.e., the condition of a cargo at a considered point in time) was minor to the segment KG (gravity center ordinate). G – Gravity center; C_0 – Gravity center of the displaced water; M- Transversal metacenter; Φ - Inclination angle; GZ – Stability branch; ME – Straightening moment.

It would have been possible that the vessel was exposed to a force caused by the hauling or by the nets stuck to the bottom because the board of the heeling was exactly the opposite to the one on the hauling, except if, by a remote possibility, a net got stuck at the bottom and quickly got unstuck, which would have caused a heeling over at SS (the opposite side of the hauling), increased by the water mirror/free surface phenomena caused by the boarding water in the engine room. However, there were no reports of something abnormal happening with the fishing gear or of the vessel heeling over at PS, even for brief moments, prior to the accident.

Therefore, during the 16 hours that the engine room was without surveillance, the accumulation of water inside reached such values that put the stability of the vessel at jeopardy (possibly even during less time), due to, not only the increase of the displacement, but also to the consequences that the water-mirror effects had on the stability of the vessel. Thus, when the vessel was subjected to an external disruptive force, like a higher and stronger wave (heeling over at SS), she did not have the capability to return to the right/initial position in time to avoid water boarding through the edge, causing a subsequent inclination movement strong enough to, with the sudden increase of displacement, capsize the vessel.

Engine cooling system

As far as the vessel cooling system is concern, the main engine (model 6W126) is equipped with two cooling circuits see fig. 11;

- 1 – Closed circuit that carries the coolant fluid and cools the block and the head of the cylinder.
- 2 – Open circuit that carries the sea water and cools the charge air cooler, the coolant fluid of the engine and the clutch oil, if necessary.

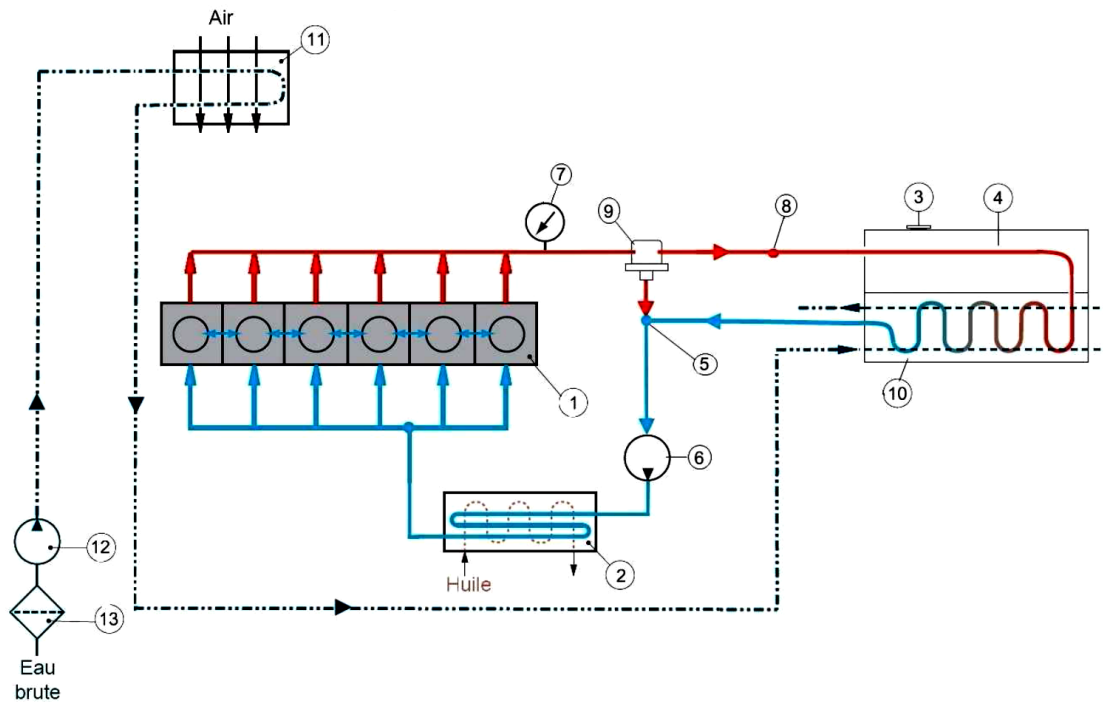


Fig. 11 – General diagram adapted from the operation principle of the engine cooling system of the vessel “POR DEUS AJUDADO” (open and closed). 1 – Block and head of the cylinder; 2 – Engine oil cooler; 3 – Pressurized cover of the fresh water container; 4 – Expansion tank; 5 – Return central heat circuit; 6 – Water pump; 7 – Fresh water temperature sensor; 8 – Central heat feeding circuit; 9 – Thermostat Valve; 10 – Fresh/sea water heat exchanger; 11 – Supercharged air heat cooler; 12 – Sea water pump; 13 – Sea water filter; 14 – Clutch oil cooler . Source: *Moteurs Baudouin*.

In an open circuit, the cold sea water may cause thermal stress, mainly in the pipeline, that is why the corrosion there is inevitable high.

On the fig. 1, three types of different materials are identified, they make the cooling piping system: Stainless steel 316, aluminized brass and PVC.

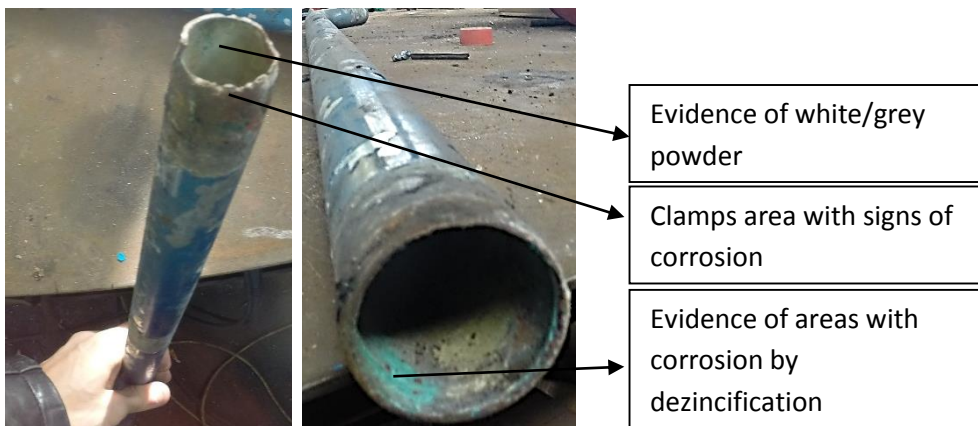
The aluminum brass and cupronickel pipes 90/10 are especially indicated to operate in corrosive and salty environments. However, under determined circumstances, they are likely to corrosion phenomena, such as dezincification (see explanation and examples below).

After repair , the investigation team noted that the pipes were reviewed and those made of aluminum brass were replaced by stainless-steel 316 of 48mm diameter and 3,2 mm thick, which gives a greater safety in terms of protection from corrosion, having in consideration the pressures, salinity and other features of the cooling system of this vessel.

It was not possible to submit the pipes to a proper scientific analysis due to the fact that they had already been removed, therefore one can only guess (through empirical analysis) the type of corrosion that damaged them. It should be noted that it has not been possible yet to assess exactly whether the first welding was accurate , however it was noted that the weld used was the indicated for alloys of zinc and copper (BROX Saf-FRO NF A81-361; DIN 1733; AWS A5.8B/SB Cu 60 Zn Si 870-900 L-Cu Zn 40 Rb Cu Zn A).

The pipes that were installed at the time of the accident showed signs of visible corrosion, it was noted empirically that on these pipes (that were installed on the vessel in 2012) the corrosion was more visible at the tie-ins, clamps and curves areas, which indicates a gap corrosion through a differential ion concentration action, cavitation phenomena and turbulence.

Also, it is possible a corrosion under stress situation, where the stresses do not need to be very high in relation to the limit of the material flow and can be due to cargo and/or residual effects of manufacturing process, such as welding or folding, namely when these pipes, with high stress levels are used in chloride rich environments (such as sea water).



Photos 1 (left) and 2 (right) – Cooling system of the vessel “POR DEUS AJUDADO” oxidation on the aluminium brass. The white/grey (photo 1) and green (photo 2) areas indicates evidence of corrosion products.

However, the corrosive process that occurs on zinc alloys used on cooling systems as the one on “POR DEUS AJUDADO” is called corrosion by dezincification where the anode materials in this case is zinc, remaining the copper and the consequent corrosion products (see photo 2). This corrosion is more evident in brasses with high zinc content like aluminium brass (76% Cu, 22% Zn and 2% Al) and yellow brass (67% Cu and 33% Zn), but can be seen even on more resistant alloys like red brass (85% Cu and 15% Zn).

Normally the austenitic stainless-steel forms a cathode in a bimetal pair (*brace*) and do not corrode. One exception is the brace with copper that should be normally avoided, except in favourable conditions. The contact between austenitic stainless-steel and zinc or aluminium may result in some additional corrosion of the latter metals. The evidence of white/grey powder may also be a sign of corrosion (see photo 1). It should be noted, as a reminder, that the aluminium brass was present on the same line as the stainless-steel 316.

Conclusions

The vertical reduction of the metacentric height due to the water mirror effect plus the transversal displacement of the gravity centre (caused by the lateral displacement of the cargo), worsen the GM reduction.

Cause of the accident found:

Water entering through two holes of 2mm (diameter) each, on the pipes that carried the sea water to the engine cooling system. In other words, it was possible that there was enough water boarding the vessel during those 16 hours (or less), to sink the vessel.

Contributory factors:

1. Installation of piping made by materials and thicknesses more prone to corrosion.
2. Faulty piping maintenance due to a lack of strict procedure on each intervention on board.
3. Faulty surveillance on the engine room.
4. The flooding alarm did not go off in time, it was ignored or it was not noticeable.
5. Lack of optimization in the distribution of the cargo and crew on board.

It is important to point out that, generally, an open cooling system like this one, which was installed in 2012 on this vessel, involves high risks of reliability and corrosion. It should be noted that since 2012 the system had two similar corrosion problems on the cooling piping system. This undoubtedly exposes the serious problems that an open cooling system has, even when operating simultaneously with a closed circuit and with the installation of corrosive saline environments resistant materials.

Safety Recommendations

In view of the conclusions reached by this report, the GPIAM recommends the shipowner (José Carlos da Costa Craveiro) that:

- 094-2013.1** - A written procedure should be implemented to be carried out on the vessel fleet, in order to improve the engine room surveillance.
- 094-2013.2** - To proceed with the repair or the installation of a flooding alarm in the engine rooms of all the fleet, where an effective audible and visual signal should be guaranteed.
- 094-2013.3** - After the 094-2013.1 and 094-2013.2 have been carried out, he should proceed with training and education of all the fleet crews, using simulators in case of flooding of the engine room and where the importance of wearing life jackets (and others floating devices) is obvious in every-day life on board. During those training courses it should also be taught to the crews the optimized and safer way to distribute cargo and people on board of the fishing vessel.

To Sociedade Vítor, Lda and to Baudouin – Société Internationale des Moteurs Baudouin :

- 094-2013.4** - A recommendation should be issued immediately to all their clients who use similar engine cooling systems on their vessels, in order to replace all the aluminium brass; yellow; red and/or cupronickel pipes by more corrosion resistant pipes submitted on this technical report (for example, Stainless-steel 316).
- 094-2013.5** - If that is not available, and after the implementation of the Safety Recommendation# 094-2013.4, it should be sent to all operators/shipowners/builders/shipyards who operate or intervene in vessels with open cooling systems (only open systems or combined simultaneously with closed systems) installed by Sociedade Vítor, Lda and/or by Baudouin, preventive maintenance manuals and refitting of those systems where the welding procedure should also be included.

Abbreviations

AMN – Autoridade Marítima Nacional / **National Maritime Authority**

ACT – Autoridade para as Condições do Trabalho / **Work Conditions Authority**

BB – Bombordo / **Port side (PS)**

Cl. – Classe / Degree

DGAM – Direção-Geral da Autoridade Marítima / **Maritime Authority General Directorate**

DGRM – Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos / **Natural Resources, Safety and Maritime Services General Directorate**

EB – Estibordo / **Starboard side (SS)**

EMSA – Agência Europeia de Segurança Marítima / **European Maritime Safety Agency**

EPI – Equipamento de Proteção Individual/ **(PPE) Personal Protection Equipment**

IMO – Organização Marítima Internacional / **International Maritime Organization**

INEM – Instituto Nacional de Emergência Médica / **National Institute of Medical Emergency**

IPMA – Instituto Português do Mar e da Atmosfera / **Sea and Atmosphere Portuguese Institute**

PTM – Instituto Portuário e dos Transportes Marítimos / **Port and Maritime Transport Institute**

ISN – Instituto de Socorros a Náufragos / **Life-Saving Institute**

Km – Quilómetro / **Kilometer**

kW – Quilowatt / **Kilowatt**

Lff – Comprimento fora-a-fora / **Length over all**

Lpp – Comprimento entre perpendiculares / **Length between perpendiculars**

LT – Hora local / **Local Time**

m – metro / **meter**

Mi – Milha náutica / **(nm) Nautical mile**

Kts – Nós / **knots**

N/A – Não aplicável / **Not applicable**

SHST – Saúde, Higiene e Segurança no Trabalho / **OHS - Safety, Health and Welfare at Work**

STCW – Convenção Internacional sobre Normas de Formação, de Certificação e de Serviço de Quartos para os Marítimos / **International Convention on Standards of Training, Certification and Watchkeeping for Seafarers**

STCW-F - Convenção Internacional sobre Normas de Formação, de Certificação e de Serviço de Quartos para os Marítimos para Tripulantes de Embarcações de Pesca / **International convention on training and certification for fishing vessel personnel**

Vis – Visibilidade / **Visibility**