Errors in MAIB report no.4/99 and crew error

Introduction

In 1998 the MAIB carried out its first underwater survey of the wreck of the Gaul. The MAIB investigation was later complemented by a series of model tests carried out by BMT in order to assess the vessel's behaviour in extreme waves conditions. .

In 1999, MAIB issued their Marine Accident Report No. 4/99:

> "*Report on the Underwater Survey of the Stern Trawler **GAUL H. 243** and the supporting Model Experiments*"

This report contained a comprehensive summary of the information that was collected from the wreck site together with the data derived from the BMT model tests..

The report also provided an analysis of this information and put forward a hypothetical loss scenario suggesting that the vessel had been 'knocked down' by a series of large waves, prior to foundering.

The MAIB report was submitted as evidence in the 2004 Re-opened Formal Investigation into the loss of the Gaul.

Significant errors in the MAIB report no. 4/99

The1999 report produced by MAIB may now be considered as a document that has historical rather than actual relevance to the outcome of the 2004 Gaul RFI: the loss scenario and conclusions that had been put forward within that report were subsequently overturned by the new information obtained from MAIB's second underwater survey

However, there are some important elements, within that report, which were relied upon by the experts in the 2004 RFI and which guided them to their final conclusions.

In particular, the analysis carried out by the MAIB to determine why the two large fish loading hatches had been found to be open on the wreck appears to have been taken as read by the RFI's experts when they concluded that, at the time of the loss, the hatches were unsecured and that they fell open due to gravity during capsize. The MAIB's initial analysis of this matter, however, appears to have been seriously flawed.

Report 4/99 page 79:

> ***"5.2.2 The immediate cause of the accident***
>
> *Gaul was heading with the seas broad on her port bow when her bow was pushed to starboard and a group of very large breaking waves impacted on her port beam, rolling her just beyond 90° to starboard. This action caused the fish loading hatches to fall partially open."*

The panel of experts in the 2004 RFI, building upon the MAIB's prior analysis, considered two possible causes for the fish loading hatches being open on the sea bed but went on, nonetheless, to endorse the MAIB's earlier conclusion:

> ***RFI final report paragraph 13.6.1 (page 200):***
>
> "*Accordingly, the most probable cause of the fish loading hatches being found open on the seabed is that they opened under gravity when the vessel rolled to beyond 90º during the loss.*"

Discussion

The fact that two groups of experts have examined a phenomenon, and arrived at the same conclusion as to its cause, could make that conclusion appear satisfactorily established.

However, when one group of experts makes an error during their initial examination and thus erroneously dismisses a possible cause for the phenomenon, and then the second group of experts, relying on the findings from the first group, does not examine the case properly but dismisses *a priori* that same possibility, then the error has propagated itself and the findings of both groups are unsound.

<u>The error</u>

One of the four possible mechanisms that could have opened the fish loading hatches, which had been identified, but later eliminated by MAIB, was a build up in pressure in air pockets beneath those hatches. The air pressure would increase as water rushed into the factory space.

MAIB report 4/99:

> "***3.6 MODEL EXPERIMENTS***
>
> *BMT also set out to establish whether the fish loading hatches could have been lifted by a build up of air pressure in the factory as the vessel sank…………..*
> *……….Calculations showed that the fish loading hatches could not have been opened by the pressure of trapped air in the factory as the vessel sank."*

It is understood that BMT carried out these calculations the results of which are presented on page 169 of the MAIB report:

> "*(v) The maximum air pressure acting against the underside of the fish loading hatches, assuming flooding through doors 13 and 14 was calculated to be 478 N/m². This pressure occurred when the vessel had sunk to a depth of 80m."*

The paragraph above suggests that the maximum lifting pressure on the underside of the fish loading hatches was only 478 N/m² (49 kg/m²), and that this would occur, for some unknown reason, <u>when the vessel was exactly 80m below the sea surface</u>. **This calculation is clearly incorrect**.

A simple computation can show that if the Gaul had had a trim by the head of only 5°[1] and had been submerged to merely two metres below the sea's surface, the lifting pressure on the underside of each fish-loading hatch could be of the order of 900 kg/m² (i.e. approximately 3.5 tonnes per hatch). The self-weight of each hatch was approximately 0.9 tonnes.

The conclusion must therefore be that air pressure should not have been eliminated as a possible mechanism for opening the fish loading hatches (or indeed a number of other doors and hatches that had been found open on the after part of the wreck).

The following pages suggest a different sinking sequence to the one put forward by the experts in the 2004 RFI. These pages also explain the simple calculations that need to be performed in order to evaluate the differential pressures that would be able to act at various locations on the vessel.

Hence it can be inferred that pressure forces, not human error was the most plausible reason why so many doors and hatches were found open on the wreck (i.e. the hatches and doors could have been 'burst open' by the dynamic pressure loads that would develop as the vessel sank, rather than having been all 'left open' by the crew as the RFI purported).

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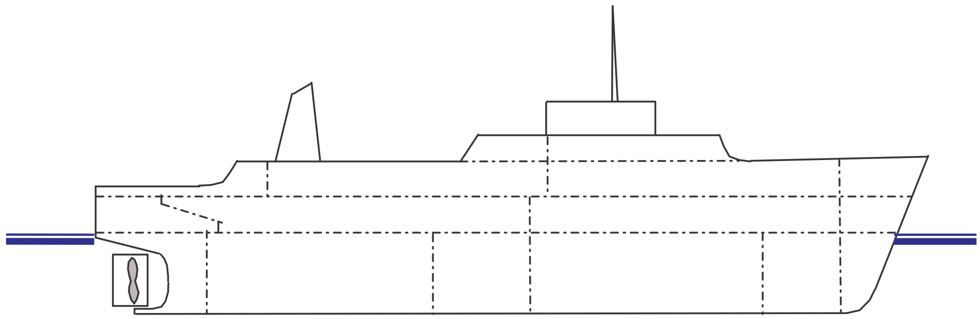
[1] Although both the MAIB and RFI experts have concluded that the Gaul sank initially and sedately by the stern. This conclusion cannot be relied upon with any degree of certainty, as it does not take into account the dynamic loads and ship motions that the vessel would undoubtedly have experienced, whilst at or near to the sea's surface and following the redistribution and loss of buoyancy that would occur as it flooded and sank. At the time of the loss the weather was extreme, with a significant wave height of circa 10m and infrequent individual waves of up to 19m in height.

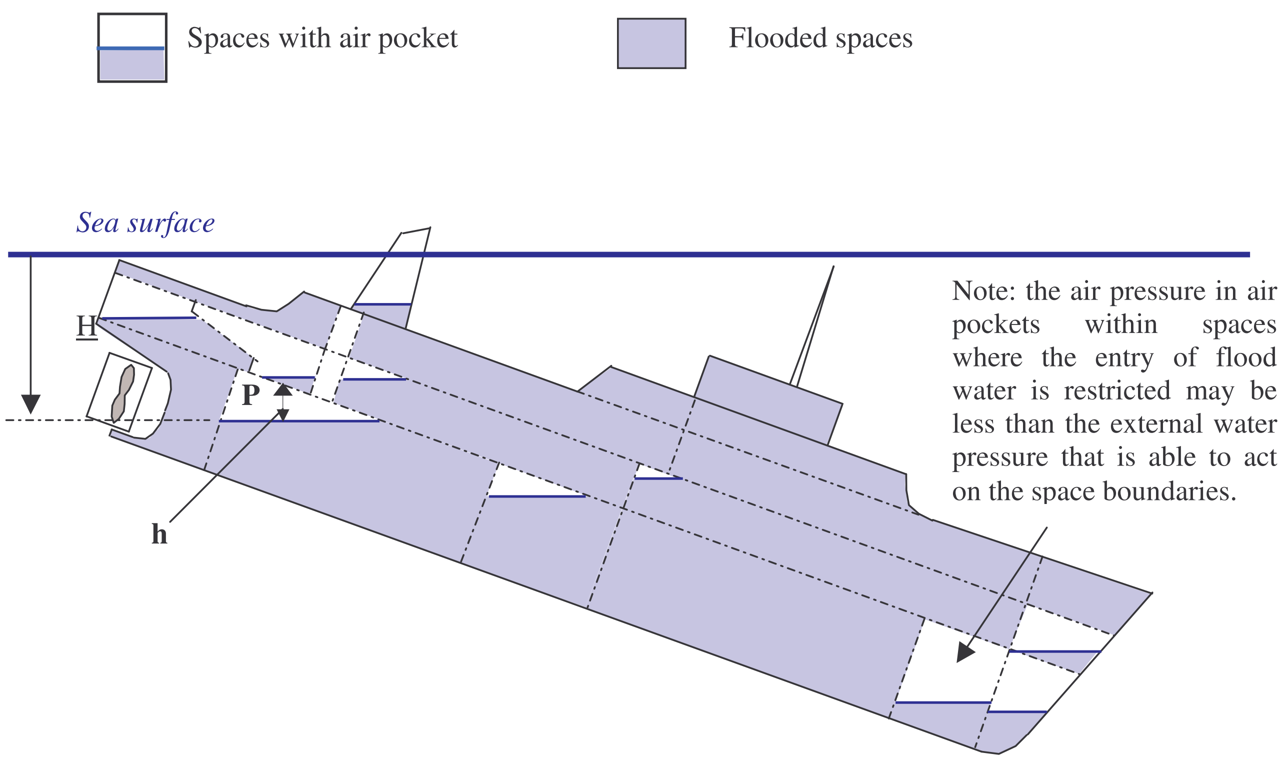
Gaul sinking sequence – implosion/explosion forces, pressure loads, crushing damage



Undamaged intact vessel

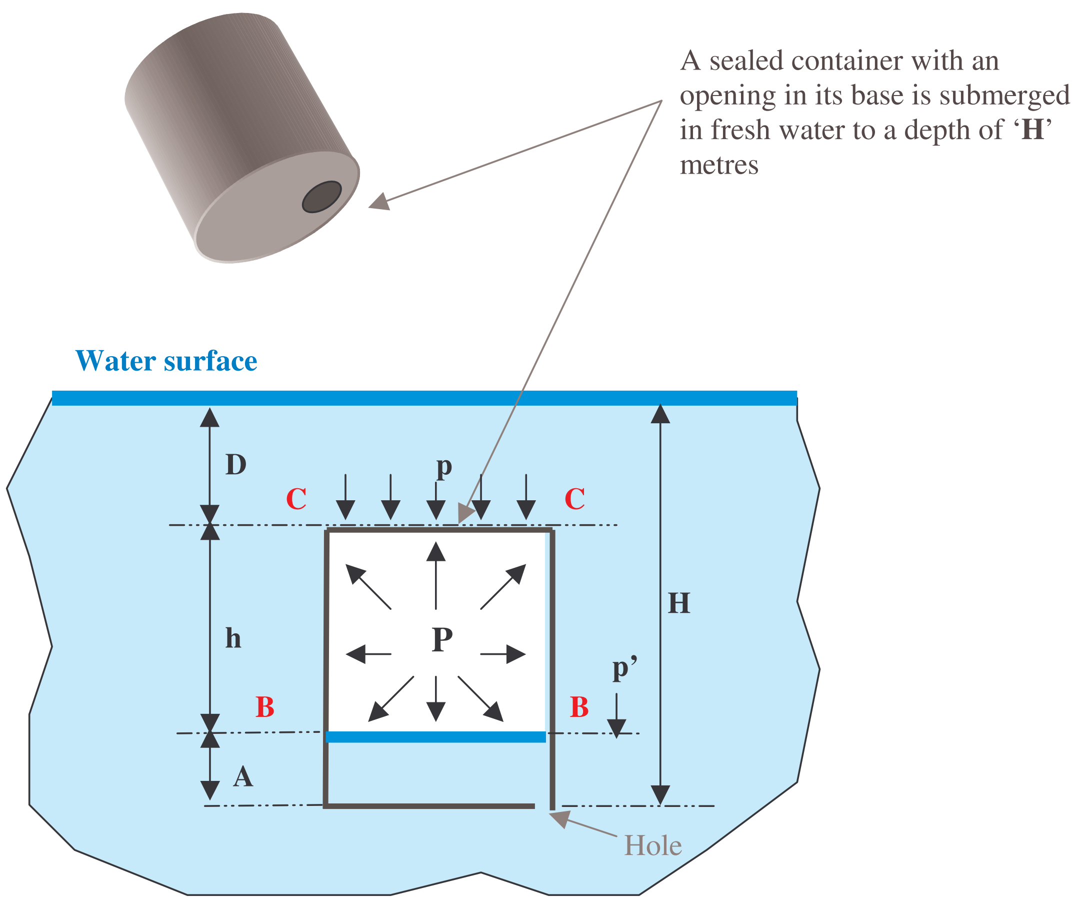
As the vessel sinks, air pockets may be formed in the upper levels of any space having watertight boundaries. In spaces where floodwater is free to enter, the equilibrium air pressure within an air pocket (**P** in the sketch below) is equal to the water pressure corresponding to the depth (below the sea surface) of its air/water interface (**H** in the sketch below).

The air pressure inside an air pocket is uniform and acts in all directions, while the external water pressure which acts upon the boundaries of the space, varies with its depth below the sea surface. An internal/external pressure differential will thus exist on the boundaries of the space, where the air pressure within the air pocket will always exceed the external water pressure. The pressure differential at a point located **h** metres above the air/water interface is equal to **h** x 1.025 tonnes/m² (density of seawater)



Vessel sinks by the head: after down-flooding has taken place and buoyancy has been lost

Elementary physics:



Cylindrical airtight container with a hole in its bottom face - submerged in fresh water

Water flows in through the hole in the container and compresses the air until its pressure **P** equalizes with the water pressure outside[2] of the container at a level corresponding to the container's air/water interface (**B-B** level at a depth of **H-A** metres in the sketch above). That is **P = p'**

The water and air pressure at **B-B** level = **P** = (**H – A**) $*$ ρ

Similarly the water pressure at level **C-C** = **p** = **D** $*$ ρ = (**H – A – h**) $*$ ρ = **P – h** $*$ ρ

It follows that the pressure differential, at level **C–C,** between the internal air pressure (**P**) and the external water pressure **P – h**$*$ ρ is equal to **h**$*$ ρ, where ρ (i.e. the density of fresh water) = 1 tonne/m3
Thus it can be said that the internal air pressure at **C-C** level exceeds the external water pressure by **{h}**[*] tonnes-force/m².

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[2] In fresh water the water pressure at a depth x metres below the water surface is equal to $\rho * g * x$ (tonnes-force/m2) where: ρ = density of fresh water = 1 tonne/m3
g = acceleration due to gravity
x = the distance below the water surface in metres

[*] {h} symbolizes the numerical value of h without its corresponding unit of measurement

The physical law outlined above is used in the design of diving bells and other similar underwater applications. Wikipedia has an entry on this:

<u>“Use of open diving bell type</u>

Diving bells and open diving chambers of the same principle were more common in the past owing to their simplicity, since they do not necessarily need to monitor, control and mechanically adjust the internal pressure. Secondly since internal air pressure and external water pressure on the bell wall are almost balanced, the chamber does not have to be as strong as a sealable diving chamber. (**Actually if *h* is the distance between a point on the side of the bell and the air/water interface at the bottom, the air pressure at that point is higher than the water on the other side by a water head pressure equivalent to *h***).**”**

http://en.wikipedia.org/wiki/Diving_chamber