

Design error 2

During the course of the Re-opened Formal Investigation into the loss of the trawler Gaul, the DfT's retained expert noted that there was an error in the draughtsman's calculation regarding the weight of waste that would operate the non-return flaps in the vessel's duff and offal chute discharges.

The draughtsman's calculation:

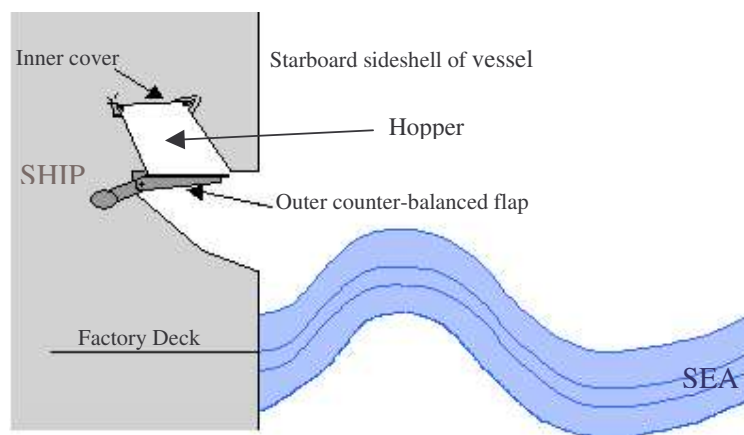
THEORY
ANTICIPATED FULL LOAD IN DISCHARGE HOPPER 130 LBS AT
STOWAGE RATE OF 45 CUFT/TON. CONSIDERED WORKING LOAD
113 LBS. COUNTER BALANCE WEIGHT BEING 162 LBS.
BY MOMENTS :- 113 LBS AT 10" LEVER = 162 LBS AT 7" LEVER.

The draughtsman calculated the weight that would be needed to cause the non-return flap plates to open automatically and discharge waste overboard, he decided that 113 lbs would be appropriate (for further details see the sketches below) This working load was approximately 85% of the maximum hopper capacity, as this lesser amount would prevent the hopper from overflowing.

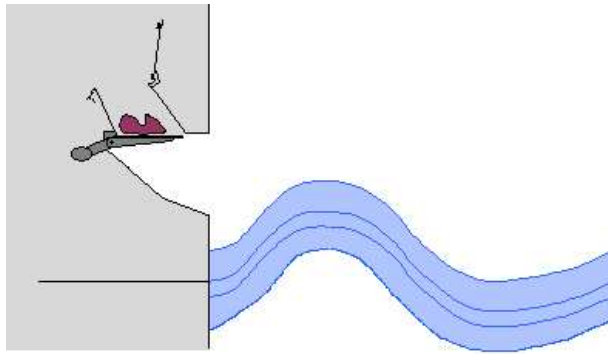
The design error

Unfortunately when carrying out this simple calculation, the draughtsman had neglected to include the weight of the steel non-return flap in the equation and, as the non-return flap was positioned on the same side of the hinge as the waste in the hopper, the weight required to open the flap was reduced. After recalculation, it was found that the weight of waste required to initiate discharge was reduced from the designed weight of 51 kg (113 lbs) to about 15 kg.

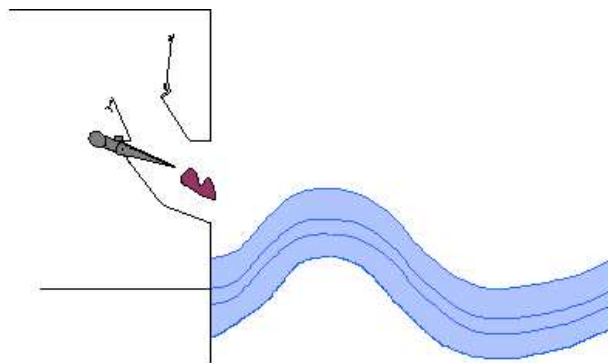
Sketch showing the arrangement of the duff and offal chute discharges, including the hinged inner cover and outer counter-balanced non-return flap - both shown in their closed positions:



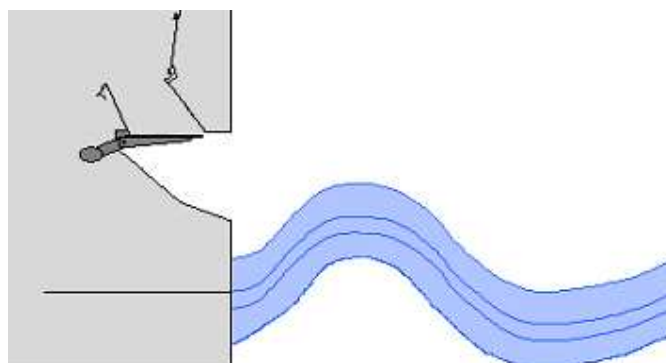
In this sketch the hinged inner cover has been opened, the outer counter-balanced non-return flap remains in the closed position and waste has been placed on the flap in the chute's 'hopper' space:



In this sketch, the weight in the hopper has exceeded the force exerted by the counterbalance weight and this has caused the non-return flap to open automatically and allow the waste to fall overboard



In this sketch, there is no waste in the hopper and the weight of the counter-balance has caused the flap to close automatically. In the closed position, the flap prevents seawater from entering the vessel.



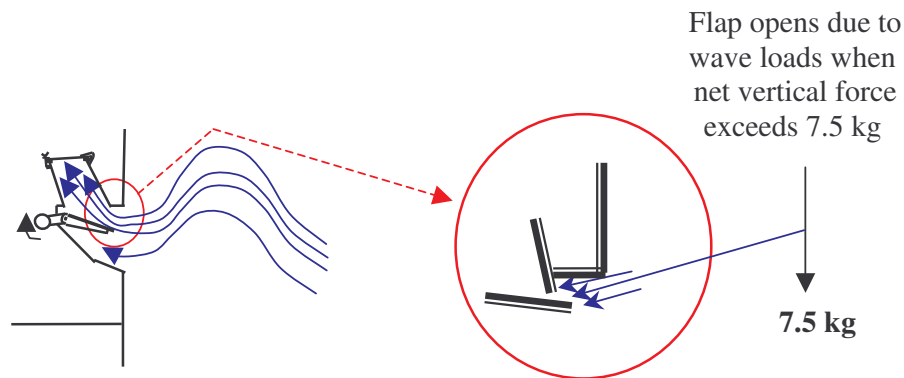
The significance of this error

The non-return flaps within the duff and offal chutes on the Gaul were designed to be the main strength barriers against the forces of the sea. However, the protection that these flaps provided was automatic in nature: the flaps were self-activating with the closing force being provided by the counterbalance weight. There was no manual over-ride and therefore the flaps could not be manually secured in a closed or safe condition. The safety of the vessel was therefore dependent in no small way on the functioning of these automatic devices.

The design of the non-return flaps was such that the force required to open the flaps was exactly equal to the force that was available to keep the flaps closed. The draughtsman's error, which has been revealed above, meant that the designed (self-closing) force was reduced from 51 kg to only 15 kg.

Additionally, this 'self-closing' force of 15 kg, which is provided by the counterbalance weight, is the force that applies at the centre of the non-return flap plate (which is also the centre point of the hopper). Simple moment and lever calculations show that the force required to overcome this 'self-closing' force will be reduced to only 7.5 kg¹ if it is applied at the outboard edge of the non-return flap plate.

*How could a force of 7.5 kg be applied at the flap's outboard edge in severe weather conditions?****



Previously it has been revealed that there was a fundamental design fault in the way that the non-return flaps were arranged in the duff and offal chutes on the Gaul. This design fault meant that the non-return flaps could not always be relied upon to operate in the 'non-return' mode. Additionally, it has been shown that the design of the chutes on the Gaul was such that the forces of the sea would be able to act upon the free edge of the flap plate - the forces generated by such action would readily overcome any 'self-closing' force that was provided by the counterbalance weight. Especially if that 'self-closing' force had been reduced by the draughtsman's error that has been revealed above.

*** A small video (3mb) showing this effect is available via:

<http://webzoom.freewebs.com/inconvenientcitizen/gaul%20flap%20movie%203%20mb.wmv>

¹ This 7.5 kg force could be reduced even further if ship motions are taken into account (the counterbalance closing force arises from gravity). The scale model tests that were carried out on the Gaul in 2003 indicated that, in severe weather conditions, accelerations as high as 0.8G could be expected at some points on the vessel. Thus, in the weather conditions in which the Gaul was lost, the force required to open the non-return flaps in the duff and offal chutes (if applied to the flap's outboard edge) could have been reduced by dynamic effects (pitch and roll) to as little as 1.5 kg.