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# Mechanism of Wear-Out of Sounding Pipes in Ship Ballast Tanks

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**Abstract**: During the operation of ships in the global commercial fleet, measurements of the current ballast level in ballast tanks are taken under various cargo and ballast conditions. As a result of repeated measurements, the structure at the bottom of the sounding pipes is damaged. The main cause is the impact of the weight at the end of the measuring instruments on the bottom of the pipe. Once the bottom of the pipe is destroyed, the impact is transferred to the hull or double bottom of the ship. In some cases, if timely measures are not taken to limit this phenomenon, the watertight integrity of the ship's hull is compromised. The article examines a possible mechanism of wear of the measuring pipes during the ship's operation. Repairing this type of wear takes a significant part of the ship's repair time and is accompanied by many associated tasks, the cost of which exceeds that of the repair itself. Approximate estimates of the time required for this type of wear to occur have been made. Measures to reduce this adverse effect are proposed.

**Keywords:** Ballast tanks, Sounding pipes, Wear, Ship repair

## Introduction

Sounding refers to the measured height of a fluid from its surface to the bottom of the tank. Ullage is the empty space in the tank, measured from the top of the tank to the upper surface of the fluid. Ullage is typically measured when the tank's contents are highly viscous or when the tank is filled to its maximum capacity (Chopra, 2021). A sounding pipe is installed within the tank. These pipes extend slightly above the top of the tank, allowing for safe and easy measurement without needing to open any manhole covers. They are equipped with protective caps that can be opened during measurement. The bottom of the sounding pipe is open, enabling the liquid to fill the pipe and match the fluid level within the tank (Chopra, 2021).

The wear and tear of measuring pipes in ship ballast tanks is a common problem. The main cause of this is the repeated impact of the measuring tape on the bottom of the pipe. When the bottom of the pipe is completely damaged, the impacts are transmitted to the double bottom lining and the bottom of the ship. In some cases, this can lead to a breach in the watertight integrity of the ship's hull. The IMO has certain requirements for measuring pipes on ships:

- Sounding pipes diameter hasn't to be less than 32mm;
- Under open end of pipes have to be installed striking plate with adequate thickness;
- Sounding pipes material have to be of steel or other approved from classification societies material;
- Where slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

The frequency of sounding on a ship varies depending on the company, its operational policies, and the nature of the activities taking place on board. Ballast water tank and fresh water tanks should be sounded once a day (Chopra, 2021). In addition to the frequent measurement of the ballast and the impacts of the weight at the bottom of the sounding pipes, corrosion further contributes to the formation of defects.

The issue of corrosion in the elements of the ballast system of a passenger ship is presented in (Dariansyah &Arifin, 2023). The authors of the article demonstrate that the degree of corrosion depends on the salinity of the water and the duration of the elements' exposure to it. It has been found that galvanized SS304 pipes have good corrosion resistance to saltwater, making them fully suitable for ballast pipeline systems.

Proper maintenance and operation of the pipes are important for the normal functioning of the ship. Otherwise, it will carry dead weight, which will not generate profit for the shipowner. It is absolutely necessary to protect shell plating with striking plates (Regulations Govering Ballast Management, 2024).

## Mechanism for Wear-out Calculations

The procedure for ballast water measure is shown on Fig.1.

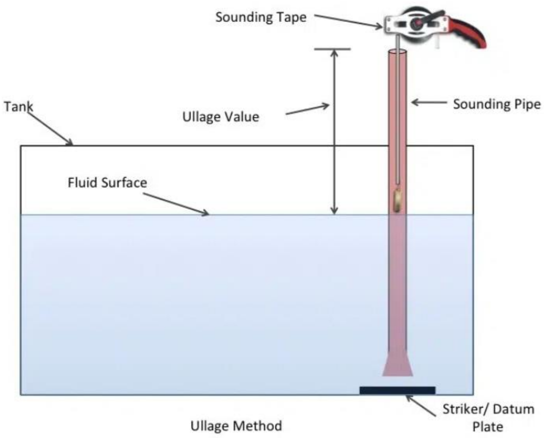


Figure.1.Procedure for ballast water measure (Wankhede, 2021)

When performing operations to determine the amount of ballast, the measuring instrument is freely lowered into the tube. The weight, attached to the end of the measuring tape, falls freely from a certain height with a specific weight onto the bottom of the measuring tube. At the beginning of the impact, i.e., at the moment of touching the bottom of the tube, the falling body has maximum speed and maximum kinetic energy. At the end of the impact, when the speed of the body becomes zero, the deformations in the body and the resulting stresses reach their maximum values. It is assumed that Hooke's law applies to the relationship between stresses and deformations, and that the forces and displacements caused by the impact are also linear, as in the case of static loading. Furthermore, it is assumed that the displacements of the body from the impact at any given moment are similar to the static displacements caused by a statically applied load of the same weight. The static stresses and displacements are determined by equations 1 and 2 (Кисьов, 1979).

$$\Delta_{st} = \frac{Pl}{EF} \tag{1}$$

Where:

- P- weigth force of the plumb bob, N;
- l- length of sounding pipe from main deck to bottom of the tank, sm;
- E- Young modulus, Pa;
- F, area of the pipe bottom, $sm^2$;
-

$$\sigma_{st} = \pm \frac{P}{F} \tag{2}$$

Where:

- P- weigth force of the plumb bob, N;
- F, area of the pipe bottom, $sm^2$;

Determining dynamic stresses is reduced to determining dynamic displacement. This is done with the help of the kinetic energy equation and the energy equation. After solving these equations, equation 3 and 4 are obtained(Кисьов,1979).

$$k_d = 1 + \sqrt{1 + \frac{2hEF}{Pl}} \tag{3}$$

Where:

- h- plumb bob falling down height, sm;
-

$$\sigma_d = k_d * \sigma_{st} \tag{4}$$

The wear caused by the impacts of the weight on the bottom of the pipe is determined by equation 5.

$$\Delta t = \frac{Ph}{\sigma_d} \tag{5}$$

According to the rules of the International Maritime Organization, the measurement of ballast is carried out once a day. It is interesting to investigate how many measurements will result in the destruction of the bottom of the pipe. A thickness of 10 mm for the bottom has been assumed. Generally, this can be determined by equation 6.

$$n = \frac{\delta}{\Delta t} * 10 \tag{6}$$

Where:

- δ- thickness of pipe bottom plate, sm;
- Δt- wear- out of thickness, sm;

## Results and Discussion

The calculations made using the dependencies presented in the previous paragraph are shown in Fig.2 and Fig. 3. The following characteristics were taken into account in the calculations: the weight of the plummet at the end of the tape measure is P=0.5 kg, Young's modulus, E=206000 Pa., the area of the pipe bottom, F=19.63 sm$^2$ and the thickness of the bottom, δ=10mm.

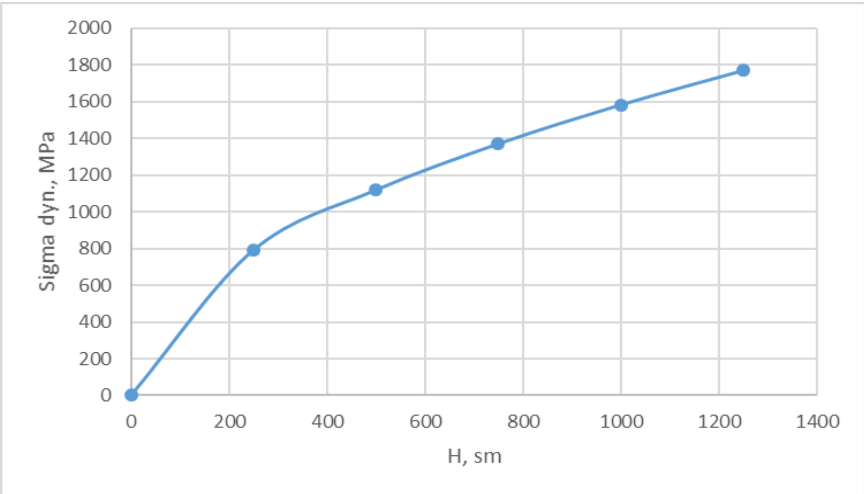


Figure 3. Dynamic stress

The dynamic stresses obtained at the end of the pipe as a result of the impact of the weight are shown in Fig. 4. It is clearly seen from there that the greater the height of the pipe, the greater the resulting stress. The wear of the pipes is more important because it is directly related to the defects in the areas around the measuring pipes. At different heights of the measuring pipes, the wear varies since the dynamic stress is different. Furthermore, the weight of the mass at the end of the measuring instrument also plays a significant role in the extent of the wear

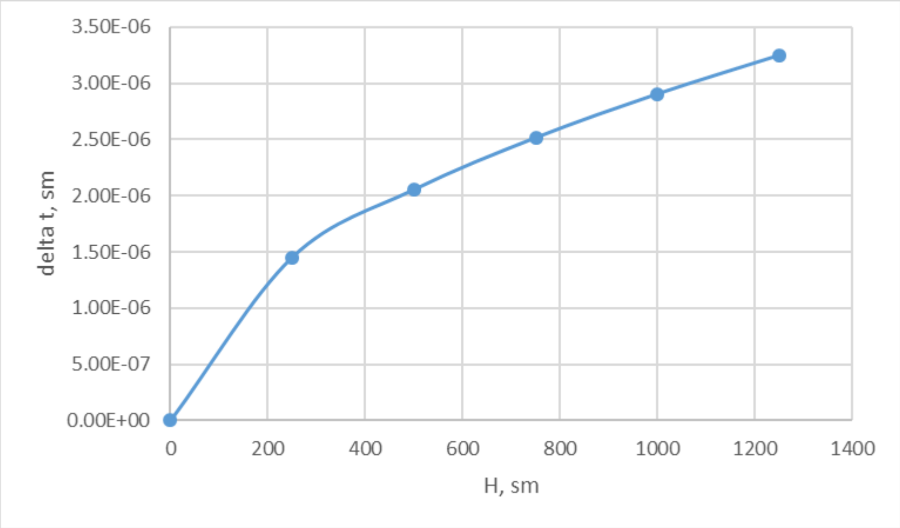


Figure 4. Wear-out the pipe bottom at every sounding time

As a result of the periodic measurement of the ballast level in the ballast tanks of the ship's hull, dynamic stresses and wear cause defects, which are mostly undesirable. The time it takes for the pipe structure to fail and for the damage to extend to the ship's hull is of particular interest. The results of the analysis for the time required for a defect to occur are presented in fig. 5. In the calculations, it is assumed that the ballast is measured once a day. It becomes clear that for longer pipes, the wear time is shorter. For example, for a pipe length of about 13.0 meters, the wear time is approximately half that of a pipe that is 2.0 meters long. The same wear for a pipe with a length of 2.0 meters occurs after approximately 7,000 measurements, whereas for a pipe with a length of about 13.0 meters, it occurs after approximately 3,000 measurements.

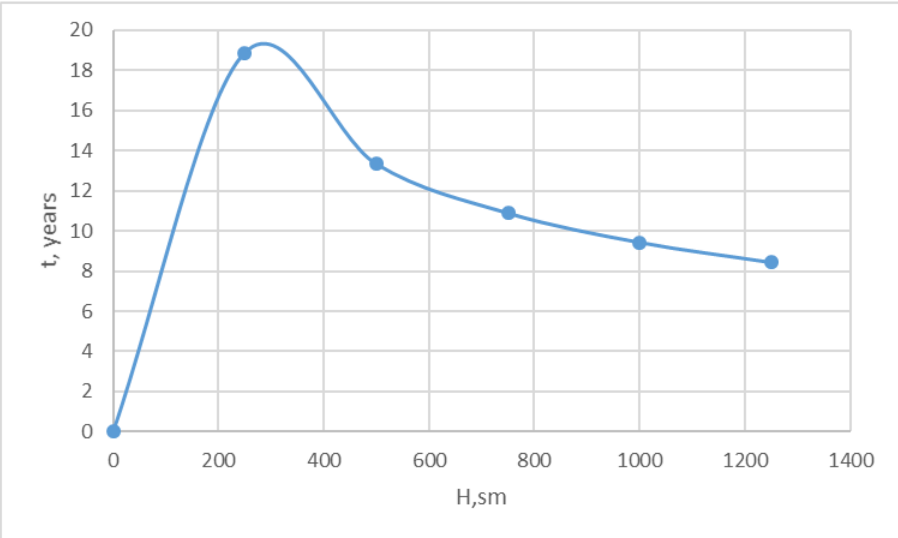


Figure 5. Time for full destruction of pipe bottom

## Conclusion

Wear on the measuring pipes of ballast tanks is a common problem in ship repair. Repairing them does not take much time, but it involves a lot of additional work to prepare the tank. The report examines the wear mechanism of the bottoms of the measuring pipes in ballast tanks. Dependencies for determining the wear and the time it takes are presented.

It is assumed that Hooke's law applies to the relationship between stresses and deformations, and that the forces and displacements caused by the impact are also linear, as in the case of static loading. Furthermore, it is assumed that the displacements of the body from the impact at any given moment are similar to the static displacements caused by a statically applied load of the same weight.

With daily measurement of the ballast and a pipe bottom thickness of 10 mm, the average number of measurements leading to its destruction is about 4500. The wear time also greatly depends on the height of the pipe and the thickness of the bottom. The analysis takes into account the most commonly encountered thicknesses and heights of pipes.

## Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the author.

## Acknowledgements or Notes

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