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Technical report

A new ballast water sampling device for sampling organisms above 50 micron

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Abstract

Many ballast water sampling programmes were undertaken in the past to document the number of individuals and variety of species arriving with ships. As no standard ballast water sampling tool exists various sampling devices were used during these studies. When sampling ballast water for compliance control with the Ballast Water Management Convention prepared by the International Maritime Organization a sampling device is needed which documents the number of organisms per water volume discharged. For organisms above 50 microns (in minimum dimension) less than 10 organisms per cubic meter of water are acceptable in the ballast water discharged. Further, ballast water samples need to be taken to assess the efficacy of ballast water treatment systems. As a result more than 1,000 liters of water need to be sampled – and this needs to be carried out multiple times as more than one sampling point, several replicates and various sampling occasions are required. This contribution describes a new sampling device for this ballast water sampling purpose.

Key words: ballast water sampling, IMO Convention, ballast water treatment, compliance control

Introduction

Experience has shown that sampling ships' ballast water is a challenge. For biological analysis carried out to assess the variety of organisms arriving in ballast (qualitative analysis) several sampling methods have been developed (e.g. Gollasch et al. 2002, 2003). However, these techniques are neither considered adequate when planning to sample ships for efficacy tests of ballast water treatment systems nor for compliance control sampling for the ballast water discharge standard as set forth in the International Maritime Organization (IMO) Ballast Water Management Convention (both being quantitative approaches) (IMO 2004).

According to the IMO Ballast Water Management Convention (hereafter the Convention), the IMO Guideline for Type Approval of Ballast Water Treatment Systems and the IMO Guideline on Ballast Water Sampling large amounts of water need to be sampled to proof the efficacy of treatment systems and to assess compliance of ships with standards as set forth in the Convention.

Regulation D-2 of the Convention stipulates that ships meeting the requirements of the Convention must discharge:

- less than 10 viable organisms per cubic meter greater than or equal to 50 micrometers in minimum dimension, and
- less than 10 viable organisms per millilitre less than 50 micrometers in minimum dimension and greater than or equal to 10 micrometers in minimum dimension, and
- less than the following concentrations of indicator microbes, as a human health standard:
  - Toxigenic *Vibrio cholerae* (serotypes O1 and O139) with less than 1 Colony Forming Unit (cfu) per 100 millilitres or less than 1 cfu per 1 gramme (wet weight) of zooplankton samples,
  - *Escherichia coli* less than 250 cfu per 100 millilitres, and
  - Intestinal *Enterococci* less than 100 cfu per 100 millilitres.

Especially to document the number of organisms above 50 microns is challenging as less than 10 organisms per cubic meter of water are acceptable. As a result more than 1,000 liters

of water need to be sampled multiple times as more than one sampling point, several replicates and various sampling occasions are required.

Organisms in the ballast tank may not equally be distributed, i.e. the concentration of organisms in the discharged ballast water may vary. To allow for representative sampling of the organism content in ballast water it is therefore recommended that samples should be taken during the entire discharge time which is enabled by using this new sampling device.

Another challenge is to document the volume of water which had been sampled in land-based and onboard tests. As sampling for compliance control with IMO standards may also have legal implications (in case of non-compliance) accuracy is essential.

The newly designed sampling device, developed by Hydrobios[1], one of the leading manufacturers of scientific sampling gear in Germany, allows such sampling. This sampling approach likely delivers a more representative sample of larger organism density when being discharged from a ship in both cases (a) for compliance control and (b) for efficacy tests of ballast water treatment systems.

This device consists of a flexible sampling bag with a filtering cod-end both being especially designed for this purpose. This cod-end has removable filtering panels and can be unscrewed from the sampling bag. An integrated flow-meter allows for accuracy to document the filtered volume of water.

Advantages of the Sampling Device

1. The sampling device can be hung to the ceiling, i.e. does not need a stand to be operated which is unlikely to be available on ships or is difficult to install in e.g. the ships engine room.
2. Its light weight eases transportation to and within the ship in case various sampling points need to be sampled consecutively.
3. The sampling bag can be folded, i.e. it is easier to carry which is especially an advantage when using narrow stairs in ships engine rooms – or when sampling needs to be undertaken in densely packed cargo rooms (e.g. on car carriers).
4. The device is completely independent from the ships operation (other than ballast water operations), i.e. does not require power supply etc.
5. Cleaning of the non-stick bag can easily be done by rinsing with water.
6. The filtering cod-end can be unscrewed and after cleaning of the bag the unit is ready for use immediately, i.e. several samples may be taken in a short period of time by simply sealing one cod-end and screwing on another cod-end. Sealed used cod-ends may be placed in a water tight container to avoid damage or impairment of survival of sampled organisms. Alternatively the filtering sieve of the cod-end may be replaced with a new sieve after each sampling occasion. The replaced filter sieve should be put into the sample container for later screening of organisms. This also eases the cleaning of the sieve to avoid organism contamination with future samples. As a result samples can be carried to the analysing laboratory without any further processing onboard, such as sieving at the sampling location etc. The filter sieve replacement is a matter of minutes and allows the use of only one cod-end for multiple samplings.
7. The integrated flow-meter enables a precise measurement of the water volume filtered[2].
8. Compared to using buckets a bigger water volume can be filtered as the device collects and filters the water at the same time. The limiting factor is the concentration of organism and particular matter in the water. In case the organism and particle concentration in the water is low, sampling can be "endless" when the time for filling the device equals to the time needed for water filtration through the filtering cod-end.
9. It works time efficient, i.e. up to 2.5 tonnes of ballast water were sampled in less than 30 minutes.
10. Discharge of filtered water after sampling may be carried out by dumping it in the bilge water system. In case sampling is undertaken in areas where water spillage cannot be

[1] *www.hydrobios.de*

[2] *This is difficult when using buckets, especially when the vessel to be sampled is moving, due to heavy seas or in cargo operations buckets may overflow.*

tolerated, the spillage can be minimised by directing the filtered water with a hose to a sink – or by placing a water collecting tank underneath the device which may be emptied as requested. In case the treatment system uses backwash-lines to discharge filter backwash material, this backwash line may also be used to discharge the filtered water.

11. In case the sampling procedure takes longer, organism survival may be impaired by the long sampling time. To allow optimal organism survival, the tap of the cod-end may than be opened every 10 minutes to extract sampled organisms (subsample). By doing so organism exposure to air is minimised. Organisms in all subsamples should be counted.

All these advantages will result in an efficient, timely and accurate sampling of ballast water. In addition due to the time efficient application, the number of samples or replicates taken by the sampling crew may be increased without any extra working hours.

Technical Details Inline Flow Meter

The flow meter reads the metric system with a flow indication per sampling event and a cumulative lifetime measurement (Figure 1).

Figure 1. Flow meter

Measuring range: 9 l/min (= 0,15 l/sec) up to 200 l/min (= 3,33 l/sec)
Accuracy[1]: < 96% of reading from 200 l/min to 50 l/min
Pipe diameter: 20 mm
Pressure rating: 10 bars
Hose connection: Hose nozzle for hose diameters of 25 up to 27 mm
Fluid temperature: 0°C ... +50°C
Material: Inline fitting: PVC
Paddle wheel: PVDF
Axle: Ceramic
O-Ring: FPM
Electronic housing: PC
Front plate cover: Polyester
Batteries: 2 x 9 V DC (6LR6/PP3)
Autonomy min. 2 years[2] at +20°C

Technical Details Filter Bag and Cod-end

The filter bag (Figure 2) and cod-end (Figure 3) are especially designed for the purpose of ballast water sampling. The cod-end may be unscrewed from the sampling bag after sampling (Figure 4).

Figure 2. Filter bag

Diameter: 40 cm
Length: 100 cm
Cod-end: PVC, 60 mm diameter, two side windows covered with Monyl 50 micron mesh size (diagonal dimension) filtering panels and with tap.

[1] *Further calibration experiments will be carried out shortly and will likely result in higher reading accuracy.*

[2] *Low battery charge level is automatically indicated.*

Figure 3. Cod-end with tap

Figure 4. Cod-end may be unscrewed from filtering bag

The flow meter outlet in the net is bended which results in a spiral water flow in the sampling bag. By doing so organism damage during sampling is minimised and the filtration rate of the cod-end is increased.

The filtering sieve of the cod-end may be replaced after each sampling occasion allowing for multiple samplings by using the identical cod-end. This also eases the cleaning of the sieve to avoid organism contamination with future samples.

Sample analysis

Organisms need to be analysed as soon as possible after sampling – as the IMO standards refer to living organisms, i.e. samples taken during a ships voyage need to be analysed onboard. However, analysis of larger organisms onboard is also a challenge, especially when the ship is in motion. When using Petri dishes and a stereo-microscope, organisms counting may not be accurate as the ship movement induces water movements in the Petri dish. As a result organisms may be counted twice and some may be missed out from counting. To avoid this, a Bogorov counting chamber may be used. During minimal ship movements, this chamber proved to be efficient during onboard trials. However, with increasing ship movements the Bogorov chamber looses its advantage. HydroBios therefore designed three new counting chambers which may be used during stronger ship movements. These new chambers allow for greater accuracy in counting larger organisms onboard (Figure 5).

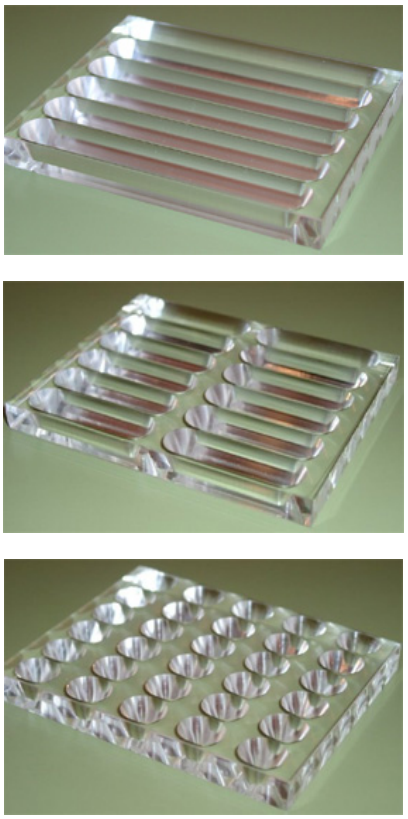

Figure 5. Newly designed zooplankton counting chambers

Sampling access point

This zooplankton sampling device may either be connected to a sampling point in the ships´ ballast water discharge line (after treatment for efficiency tests of the treatment system or in the discharge line to proof compliance with the IMO ballast water discharge standard) or alternatively a pump may be used to pump up the water from a ballast tank. In any case, the water flow should be between 10 and 200 litres a minute to allow for best accuracy of the flow meter.

Resume

This new sampling device was developed to solve the challenges encountered when sampling ballast water. Onboard tests have shown that the device is essential for timely and accurate sampling events - up to 2.5 tonnes of ballast water were sampled in less than 30 minutes. It is hoped that the use of this device enables efficient and accurate samplings to (a) test ballast water treatment systems and (b) to assess whether or not ships are in compliance with the standards as set forth in the Convention.

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