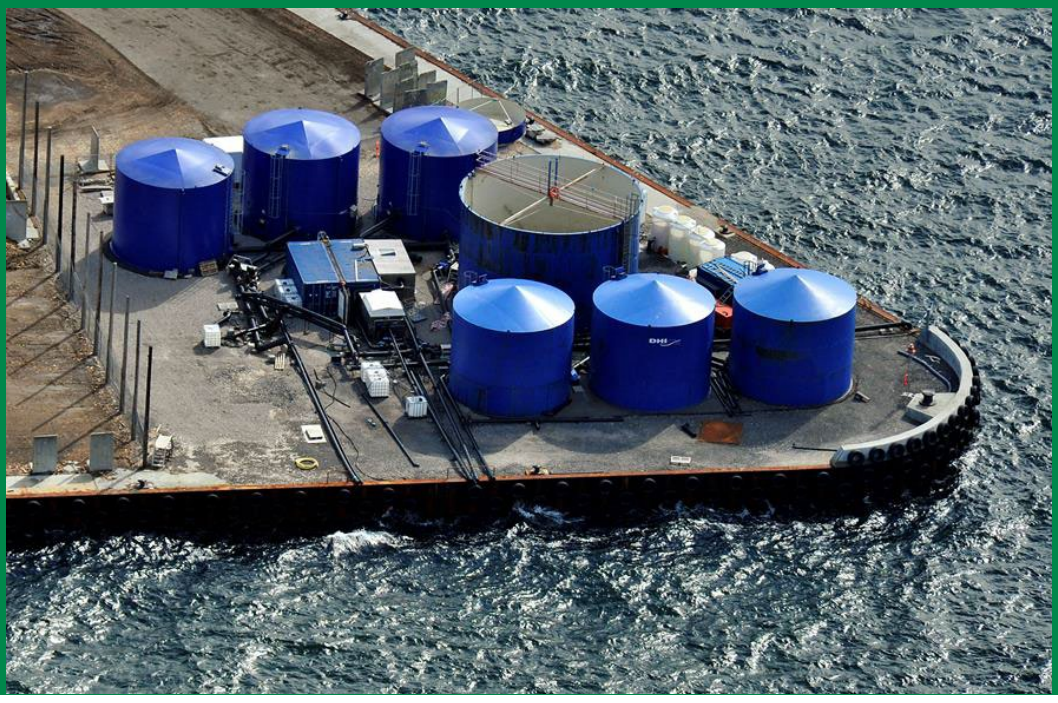
Ministry of Environment
of Denmark
Environmental
Protection Agency

Scientific investigation of ballast water discharge

Random checks on ships in autumn – winter 2022

Environmental Project
no. 2271

June 2024



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1. Executive summary

During the period from 8 November to 19 December 2022, DHI conducted an anonymized scientific investigation in Greenlandic and Danish ports to test if the Ballast Water Management Systems (BWMS) installed on board eight different vessels were in compliance with the D2 discharge standard. According to the D2 standard the number of organisms ≥50 µm shall be less than 10 organisms/m^3, and the number of organisms ≥10 and <50 µm shall be less than 10 organisms/mL.

All BWMS were treating ballast water with filtration and UV. The installation date and Treatment Rated Capacity (TRC) of the BWMS varied.

While five out of eight tests showed compliance with the D2 standard, two tests did not, and another two tests had operational issues. One test was interrupted due to sampling difficulties. The investigation showed that there was no correlation between performance efficiency and installation date or TRC.

During the investigation, it was noted on several occasions that crew members awareness of the Operation Maintenance and Safety Manual (OMSM) and the Type Approval Certificate and their education in operating the BWMS were weak. While most of the BWMS investigated had easily accessible sampling points, one system had a sampling point being inaccessible. The filter was a weak point for some systems, as clogging and resulting low flow rates were observed. Additionally, alarms occasionally sounded during BWMS operation without clear instructions on what to do.

2. Introduction

The Danish Environmental Protection Agency (DEPA) is in the process of ensuring the control that the discharge of treated ballast water in Danish harbours fulfils the D2 discharge standard. DEPA has therefore asked DHI to perform a scientific investigation including collecting a representative sample of the ship's ballast water followed by biological analysis to clarify whether the ship complies with the D2 discharge standard.

DHI provides independent performance evaluation of ballast water management systems (BWMS) for the type approval process. DHI is not involved, intellectual or financial, in the mechanics, design or marketing of the products and technologies that are being evaluated. To ensure that DHI's tests are uncompromised by any real or perceived individual or team bias relative to test outcomes, DHI's test activities are subject to rigorous quality assurance (QA), quality control (QC) and documentation. DHI's quality management system is certified according to ISO 9001.

DHI is conducting biological performance evaluation tests of BWMS in accordance with the following rules, standards, and guidelines:

- United States Coast Guard. Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters /1/
- United States Environmental Protection Agency, Environmental Technology Verification Program. Generic Protocol for the Verification of Ballast Water Treatment Technology /2/
- International Maritime Organization (IMO). International Convention for the Control and Management of Ships' Ballast Water and Sediments /3/
- International Maritime Organization (IMO). Code for Approval of Ballast Water Management System (BWMS code). Resolution MEPC.300(72) /4/
- Marine Environment Protection Committee (MEPC). Procedure for Approval of Ballast Water Management Systems That Make Use of Active Substances (G9). Resolution MEPC.169(57) /5/
- IMO Guidance for the commissioning testing of ballast water management systems (BWM.2/Circ.70/Rev.1) /6/
- Guidance on ballast water sampling and analysis for trial use in accordance with the BWM Convention and Guidelines (BWM.2/Circ.42/Rev.2) /7/

This report describes the outcome of a scientific investigation including sampling and biological analyses of treated ballast water from 8 ships in Danish and Greenlandic ports in the period from 8 November to 19 December 2022.

To the extent possible the following sampling and analysis procedures were performed on each ship:

- A representative sampling was performed during the full discharge period
- Indicative and detailed analysis were performed according to requirements described in BWM.2/Circ.42/Rev.2

Danish Shipping together with DHI coordinated the selection of the ships for the scientific investigation. Throughout the project period weekly update meetings were held with the project group where the progress of the project was discussed. The project group consisted of:

- Danish Environmental Protection Agency (DEPA)

- Danish Maritime Authority (DMA)
- Danish Shipping
- Danish Maritime
- DHI

3. Selection of ships for inspection

Danish Shipping selected a list of shipowners with ships calling Danish and Greenlandic ports. Based on this list a total of eight Danish shipowners were contacted on 11 October 2022 by DEPA with a supporting letter describing the aim of the project (Appendix A). All eight shipowners responded positively on the request.

After initial connection with the ship owners DHI continued the communication and secured the logistics around the tests. This included making sure that the relevant information on the selected ships was available in due time.

A total of five shipowners had the possibility to contribute with ships on which de-ballast operations could be performed in Danish or Greenlandic ports during the life span of the project. Some of the shipowners contributed with more than one ship which made it possible to include eight ships in the investigation.

Before initiation of any of the tests DHI received the following information from the shipowner:

Information on the vessel:
- Vessel
- Vessel IMO number
- Location for scientific investigation
- Date for scientific investigation

Information on the BWMS:
- Manufacturer
- Technology (e.g., UV or electrolysis)
- Type Approval and Certificate No.
- Model No.
- Date of installation of BWMS
- Treatment rated capacity, TRC

4. Description of the ballast water management systems

The study investigated BWMS from three different manufacturers located in three different countries. All the BWMS investigated utilized filter and UV technology.

Installation dates varied from as far back as April 2014 to as recent as September 2022.

Treatment Rated Capacity (TRC) ranged from 300 m^3/h to 1000 m^3/h.

5. Sampling procedures

Sampling was performed in accordance with standard procedures described in DHI Standard Operation Procedure (SOP) 30/1775. To the extent possible the following sampling and analysis procedures were performed on each ship:

- A representative sampling performed during the full discharge period
- Indicative and detailed analysis according to requirements described in BWM.2/Circ.42/Rev.2 /7/

5.1 Representative sampling

A sample was collected during the corresponding ballast water discharge after the full treatment had been applied. Samples were taken in accordance with the Guidelines on ballast water sampling (G2) [Resolution MEPC.173(58)].

Compliance with the D2 standard was evaluated in samples of ballast water discharge collected as near to the point of discharge as practicable.

Sampling was performed in accordance with standard procedures described in DHI SOP 30/1775. Two sequential samples for enumeration of organisms ≥50 µm, each with a volume of minimum 500 L, were randomly collected during discharge at least 5 min after start of discharge and at least 5 min before the end of discharge with at least 5 min between samples. One sample (approx. 10 L) was collected for enumeration of organisms ≥10 and <50 µm.

5.2 Parameters recorded during sampling

The following parameters were monitored during sampling:

TABLE 1.

	Parameter	Organisms ≥50 µm	Organisms ≥10 - <50 µm
Sampling of treated ballast water	Volumes of samples collected		
	Were the samples concentrated before analysis? (Y/N)		
Analysis of treated ballast water	Number of subsamples analysed		
	Time (hours) after sampling for completion of analysis		
	Were the entire volume of the sample analysed? (Y/N)		

5.3 BWMS operation

In connection with the scientific survey and during operation of the BWMS and the sampling process the following BWMS operation parameters were monitored:

- Holding time
- Flow rate (m^3/h)

- Total volume de-ballasted (m^3)
- UV Intensity reading (W/m^2)
- BWMS performance claim
- If the self-monitoring equipment indicated correct operation (Yes/No); if not, then the alarms that occurred during de-ballast operations were described

6. Analytical methods

The tests were evaluated as successful, if the analyses indicated that the treated ballast water did not exceed the D2 standard at discharge, and the self-monitoring equipment of the BWMS indicated correct operation.

The methods described below were used for analysing the samples for the parameters in the D2 standard:

TABLE 2.

Parameter	Analysis	DHI SOP
Organisms ≥50 µm	Detailed analysis, Microscopy	30/1700
Organisms ≥10 - <50 µm	Indicative analysis, FastBallast	30/1778

The applied methods are included in the Guidance on ballast water sampling and analysis for trial use in accordance with the BWM Convention and Guidelines [BWM.2/Circ.42/Rev.1], and the procedures are detailed in DHI SOPs. The methods are briefly described below.

Organisms ≥50 µm

Compliance with the D2 standard was verified by direct counting of live organisms in the size class by use of a stereo microscope and a counting chamber. Live organisms were enumerated by use of standard movement and response stimuli technique. The analysis was all completed on location within six hours from the end of the sampling.

Organisms ≥10 - <50 µm

Compliance with the D2 standard was verified by analysis with FastBallast, indicative compliance monitor for organism size class ≥10 and 50 µm. The analysis was all completed on location within six hours from the end of sampling.

7. Results

All results related to performance of the BWMS and compliance with the D2 standard have been anonymised by DHI. The anonymisation ensures that the results cannot be associated with specific ships or specific BWMS.

There was no correlation between performance efficiency and installation date or TRC (see Chapter 4).

Compliance with the D2 standard was fulfilled in five out of eight tests: Numbers of organisms ≥50 µm were less than 10 organisms/m^3, and numbers organisms ≥10 - <50 µm were less than 10 organisms/mL:

- For the organism size class ≥50 µm the numbers of organisms in the discharge water ranged from 0 – 1 organism/m^3
- For organisms in the size class ≥10 - <50 µm the numbers of organisms in the discharge water ranged from 0.2 – 2 organisms/mL

In two out of eight tests compliance with the D2 standard was not fulfilled: Number of organisms in the size class ≥50 µm were greater than 10 organisms/m^3; while organisms in the size class ≥10 - <50 µm were less than 10 organisms/ml:

- For the organism size class ≥50 µm the numbers of organisms in the discharge water ranged from 70 - 138 organism/m^3
- For organisms in the size class ≥10 - <50 µm the numbers of organisms in the discharge water ranged from 3.4 – 3.7 organisms/mL

In two out of eight tests operational issues were observed:

- Clogging of filters
- Extreme low flowrates due to clogging filters resulting in double operation times during ballast operations
- By-pass of the BWMS for safety reasons caused by clogging of filters and resulting low flow rates

In one out of eight tests the sampling operation was not possible:

- the sampling point was not accessible
- due to cargo operations the ballast tanks appointed to the scientific operation were de-ballasted before sampling could be organised and the operation was thus interrupted

In two out of eight tests performed challenges with the BWMS operations, including control and alarm systems, and challenges with maintenance were observed:

- Crew not aware of the Operation Maintenance and Safety Manual (OMSM) and the Type Approval Certificate
- Weak education of crew how to operate the BWMS

8. Conclusion

All BWMS investigated were treating ballast water with filtration and UV.

While five out of eight tests showed compliance with the D2 standard, two tests did not, and two tests had operational issues. One test was interrupted due to sampling difficulties. Operational issues were observed on some occasions.

Alarms occasionally occurred without clear instructions on how to proceed. It was a concern that crew members were not always familiar with the system. The crew's awareness of the Operation Maintenance and Safety Manual (OMSM) and the Type Approval Certificate and their education in operating the BWMS were in some cases found to be weak.

9. Acknowledgement

Considering the short project period and the logistic challenges for the selection of the ships and the arrangement for the testing, it was with the great help from Danish Shipping and the Danish shipowners involved possible to carry out the scientific investigation efficiently and very successfully.

10. References

1. United States Coast Guard. Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters. 33 CFR Part 151 and 46 CFR Part 162. Federal Register, Vol. 77, No. 57, March 23, 2012.

2. United States Environmental Protection Agency, Environmental Technology Verification Program. Generic Protocol for the Verification of Ballast Water Treatment Technology (ETV protocol). EPA/600/R-10/146, September 2010.

3. International Maritime Organization (IMO). International Convention for the Control and Management of Ships' Ballast Water and Sediments. London. International Maritime Organization, 2004.

4. International Maritime Organization (IMO). Code for Approval of Ballast Water Management Systems (BWMS Code). Resolution MEPC. 300(72). Adopted 13 April 2018.

5. International Maritime Organization (IMO). Procedure for Approval of Ballast Water Management Systems That Make Use of Active Substances (G9). MEPC.169(57). Adopted 4 April 2008.

6. IMO Guidance for the commissioning testing of ballast water management systems (BWM.2/Circ.70/Rev 1). Adopted 9. December 2020

7. Guidance on ballast water sampling and analysis for trial use in accordance with the BWM Convention and Guidelines (BWM.2/Circ.42/Rev.2). Adopted 9. December 2020

Appendices

Appendix A – DEPA Supporting Letter

Ministry of Environment of Denmark
Environmental Protection Agency
Marine & Aquatic Environment
J.nr. 2022 - 54007
Ref. RAAHK
Den 14. oktober 2022

Scientific investigation of ballast water discharge 2022

Introduction

The Ballast Water Management Convention will be revised in the coming years, with that the experience building on verification of compliance, is crucial to the work ahead. In order to gain experience the Danish Environmental Protection Agency will conduct a scientific investigation on the discharge of ballast water by sampling and analysing treated water, as well as lessons learned from vessels crew on their experience with the operation of the treatment systems.

The present project includes scientific investigations including sampling and biological analyses of treated ballast water from up to 10 ships in Danish and Greenlandic ports in the period 15 October to 31 December 2022 and the aim of the investigations is to verify whether the ships comply with the requirements of discharge standard D2 in the ballast water convention. **All results achieved during the project will be anonymized and there will be no penalization in case of non-compliance with the D2 discharge standard requirement.**

The Danish Environmental Protection Agency (DEPA) will be overall responsible for the project and DHI A/S will be the executing party – meaning performing the sampling, analytics on board the ships and delivering a report at the end of the project period. Besides DEPA and DHI, a project group is connected to the project; overall the project group consist of:

- Danish Environmental Protection Agency (hereafter DEPA)
- Danish Maritime Authority (hereafter DMA)
- Danish Shipping

- Danish Maritime
- DHI

Danish Shipping Companies

Sampling and analysis

To the extent possible, the following sampling and analysis procedures will be performed on each ship:

- A representative sampling performed during the full discharge period
- Indicative and detailed analysis according to requirements described in BWM.2/Circ.42/Rev.2 (Guidance on ballast water sampling and analysis for trial use in accordance with the BWM Convention and Guidelines (BWM.2/Circ.42/Rev.2). Adopted 9. December 2020)

A sample will be collected during the ballast water discharge after the full treatment by the BWMS has been performed during a ballast operation applied during normal operation of the ship. Samples will be taken in accordance with BWM.2/Circ.42/Rev.2..
Compliance with the ballast water discharge standard (D2) will be assessed at ballast water discharge as near to the point of discharge as practicable.
If possible, the selection of ships should be based on a criterion of performing random spot checks of as many different types of ballast water treatment systems as possible. A close collaboration within the project group is expected to sufficiently secure the selection of different ballast water management systems (BWMS). In connection with the scientific survey and during operation of the BWMS and the sampling process the following BWMS operation parameters will be monitored by DHI:

Holding time	Time ballast water is held in ballast tank(s) prior to de-ballasting' (hour)	
BWMS operating parameters (de-ballasting)	Flow rate (m^3/h)	
	Total volume de-ballasted (m^3)	
	UV Intensity reading (W/m^2) or TRO reading (ppm)	
	BWMS performance claim	
	Did the self-monitoring equipment indicate correct operation (Yes/No) If not, please describe the alarms that occurred during de-ballast operations	

Sampling will be performed in accordance with standard procedures described in DHI standardized procedures (DHI-SOP 30/1775). Two sequential samples for enumeration of organisms ≥50 µm, each with a volume of minimum 500 L, will be randomly collected during discharge at least 5 min after start of discharge and at least 5 min before the end of discharge with at least 5 min between samples. One sample (approx. 10 L) will be collected for enumeration of organisms ≥10 and <50 µm.

The following parameters will be monitored during sampling:

	Parameter	Organisms ≥50 µm	Organisms ≥10 - <50 µm
Sampling of treated ballast water	Volume of samples collected		
	Were the samples concentrated before analysis? (Y/N)		
Analysis of treated ballast water	Number of subsamples analysed		
	Time (hours) after sampling for completion of analysis		
	Were the entire volume of the sample analysed? (Y/N)		

All results related to performance of the BWMS and compliance with the D2 standard will be anonymized by DHI. The anonymization will ensure that the results in the test report cannot be associated with specific ships.

Outcome of the project

- Brief descriptions on the different types of ballast water management systems tested
- Brief description of the experimental design and the applied methods for sampling and analysis
- Anonymized results of the analyses and conclusions on whether the D2 discharge requirement was fulfilled
- Data on operational parameters
- Overall conclusion of the scientific visits including the most important 'lessons learned'

It is the intention that the report will form a part on the work to revise the Ballast Water Management Convention, as far as possible.

Best regards

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Scientific investigation of ballast water discharge
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All BWMS were treating ballast water with filtration and UV. The installation date and Treatment Rated Capacity (TRC) of the BWMS varied.

While five out of eight tests showed compliance with the D2 standard, two tests did not, and another two tests had operational issues. One test was interrupted due to sampling difficulties. The investigation showed that there was no correlation between performance efficiency and installation date or TRC.

During the investigation, it was noted on several occasions that crew members awareness of the Operation Maintenance and Safety Manual (OMSM) and the Type Approval Certificate and their education in operating the BWMS were weak. While most of the BWMS investigated had easily accessible sampling points, one system had a sampling point being inaccessible. The filter was a weak point for some systems, as clogging and resulting low flow rates were observed.

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