Discussion on Current Guidance for Scaling of Ballast Water Management Systems

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Abstract

Ballast water management systems (BWMS) undergo testing in accordance with detailed procedures to receive type approval by an Administration. Most of the type approval testing has been conducted on models with treatment rated capacities (TRC) approximating 250 m^3/h (suitably rated for smaller bulkers, car carriers, cruise ships, shuttle tankers, etc.). A review of published test information indicates that land-based testing has not been conducted above 500 m^3/h and shipboard testing has been conducted at 1000 m^3/h or greater TRC for only a few BWMS.

International Maritime Organization's (IMO) Guidance on scaling of ballast water management systems provides recommendations for scaling of BWMS. IMO states "the most vulnerable model should be tested according to the requirements for shipboard tests." However, the term "most vulnerable" is not clearly defined in the Guidance and no administration has published clear scaling guidance. A review of 47 type approval certificates provided to IMO by Administrations indicates only two BWMS have type approvals specifying a greater flow rate for scaling. The IMO Correspondence Group for revision of the Guidelines for Approval of Ballast Water Management Systems (G8), has identified the need to improve the reporting of scaling conducted.

This paper incorporates discussions with shipowners about their experiences with operating BWMS; some revealed higher incidence of operational issues for systems with TRC more than 1500 m^3/h. This paper identifies patterns between operational hurdles with higher flow rate systems and scaling variables. The paper also provides suggestions for model validation used to support BWMS scaling.

Key Words: MEPC, Ballast Water Management, scaling, Guidelines (G8), D-2 standard, BWM Convention

Introduction

The International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) developed two guidelines for the approval of ballast water management systems (BWMS) to comply with the D-2 performance standards of *The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (Ballast Water Management (BWM) Convention): *Guidelines for Approval of Ballast Water Management Systems (G8)* (MEPC.174(58)) and *Procedure for Approval of Ballast Water Management Systems that make Use of Active Substances (G9*) (MEPC.169(57)). The Guidelines (G8) state that the BWMS should be "tested at its rated capacity" for land-based testing and that "[t]he amount of ballast water tested … should be consistent with the normal ballast operations of the ship and the BWMS should be operated at the treatment rated capacity for which it is intended to be approved" for shipboard testing. The Guidelines (G8) also defines shipboard testing as "a full-scale test of a complete BWMS." Even though the need for testing at normal ballasting operations is consistently mentioned, the only scaling provisions in the BWM Convention and the Guidelines (G8) are for

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downscaling of a BWMS to support physical limitations of land-based testing facilities. Subsequently, IMO has agreed to two circulars on the scaling of BWMS (BWM.2/Circ.28 and BWM.2/Circ. 33) which mention the need for both up and down scaling. However, and no firm requirements have been established.

This paper discusses problems with the scaling and subsequent approval of BWMS with treatment rated capacities (TRC) 1000 m^3/h or greater. These larger TRC BWMS (suitable for Suezmax tankers, Aframax tankers, larger bulk carriers, etc.) should be given more consideration when approving BWMS models than is evident from a review of available type approvals due to the flow rates and duration of operation required.

Current guidance for scaling BWMS

BWM.2/Circ.33 (*Guidance on scaling of ballast water management systems*) recommends that shipboard testing be used to verify assumptions (i.e., mathematical model and/or calculations) in scaling the system. Additionally, the Circular suggests, where all discrete models are land-based tested, the "most vulnerable model" should be shipboard tested to demonstrate the ability of the BWMS to operate in normal ships' conditions. Although BWM.2/Circ.33 does not define "most vulnerable model", earlier sub-committee submissions provide some insight on the use of this term by providing an example of a larger filter (IMO, 2010).

To type approve a BWMS beyond its currently approved TRC without additional land-based testing, BWM.2/Circ.33 provides the following guidance:

- Key performance parameters, physical/environmental conditions, dosage considerations and design parameters should be identified,
- Validated mathematical model and/or calculations should be used to predict key performance parameters will be achieved in the scaled unit and that the fundamental operating mechanism is not changed,
- Shipboard testing should be used to verify the key performance parameters from the model and/or calculations, and
- Modeling should address efficacy and environmental impact and actual analysis for disinfection by-products should be performed (where necessary).

BWM.2/Circ.33 also recommends that "[a] representative number of scaled systems capacities, taking into account the treatment technology, should be tested according to the requirements for shipboard tests."

Concerns for improperly scaled BWMS

The BWM Convention will be one of first shipboard environmental requirements where port state control may conduct sampling for compliance. Owners and operators are the responsible parties that may have to demonstrate compliance with the ballast water discharge standards. While Resolution MEPC.252(67) *Guidelines for Port State Control under the BWM* Convention only envisions sampling in the third or fourth stage, the sampling decision is at the discretion of port state control. There is concern that a ship with a system that is otherwise operating normally may fail compliance testing. In such a case the shipowner/ operator may not understand the complete reason when non-compliance is due to insufficient scaling of the BWMS.

As the parties responsible for appropriate testing, Administrations and vendors should develop appropriate scaling criteria and make all scaling documentation publicly-available when shipowners are

evaluating BWMS for their vessels. Once the BWM Convention has entered into force, special consideration could be provided to these "early movers" with larger TRC BWMS.

Review of available type approval documentation

Administrations have submitted type approval documentation to the IMO Marine Environment Protection Committee (MEPC). A review of Administration submittals for 47 BWMS revealed most of the type approval testing has been conducted on models with TRC's approximating 250 m^3/h and only two BWMS have approvals specifying a greater flow rate for scaling.

A review of the publicly-available test information indicates that land-based testing has not been conducted above 500 m^3/h and shipboard testing has been conducted at 1000 m^3/h or greater TRC for only a few BWMS. Many of the type approvals list TRC models significantly greater than land-based and shipboard tested models with no scaling information in the publicly-available test reports.

In a recent BWM Program update presentation, the USCG summarized the status of Alternate Management Systems (AMS) by reporting that 56 AMS acceptances from 14 foreign Administrations have been granted. The USCG also observed that scaling was not conducted per the Guidelines (G8) for approximately 80% of systems (USCG).

It appears that IMO scaling guidance has not been taken into account for many type approvals.

BWMS operational experience

In early 2016, 15 shipping companies met at ABS World Headquarters to discuss lessons learned as early movers of ballast water management regulations. These shipping companies had more than 150 BWMS installed. The majority of these were operational and being utilized. Case studies were discussed to review lessons learned and problems encountered. The case studies covered various types of vessels, both retrofit and new construction projects, and a wide range of TRC. While each experience was unique to the individual vessels and system types, common issues included filter problems, piping leakage, prefabricated piping errors, sensor failures, software problems, major component failures, and insufficient electrical power for auxiliary systems. Shipowners were only able to report reliable operation of two installed BWMS.

Information was also gathered on the technical characteristics of the BWMS (e.g., type of technology, TRC) to identify possible trends. An important point of the information from the shipowner's meeting is that approximately two-thirds of the BWMS installed have TRC greater than or equal to 1000 m^3/h.

Generally, BWMS with lower TRC (< 1000 m^3/h) have achieved greater operational success. BWMS with capacities greater than 1000 m^3/h have limited success (i.e., commissioning delays, extended time required after vessel delivery to achieve operating status). Shipowners have been concerned with getting the equipment to operate on a routine basis. The ability to demonstrate the D-2 ballast water performance standards was not the major concern.

During MEPC 67, the IMO agreed to a study on the implementation of the D-2 performance standard. Responses to the study are contained in the *Final report on the study on the implementation of the ballast water performance standard described in regulation D-2 of the BWM Convention* (MEPC 69/4/4). In the D-2 study, Track 1 looked at the similarities/differences in testing and certification and Track 2 looked at the BWMS operational performance.

In Track 1, Administrations, other Government agencies and recognized organizations were asked "How do you evaluate and certify BWMS for multiple units in a model series, sizes, and/or flow rates (system scaling)?" The responses included:

.1 in accordance with BWM.2/Circ.33;
.2 CFD analysis and mathematical modelling;
.3 use of land-based testing as minimum and shipboard testing as maximum for scaling systems;
.4 manufacturer calculations.

The analysis of this study question indicated that some Administrations rely on their recognized organizations to deal with scaling with no indication on how type approval certificates are issued for the scaled units. Some responses indicated that certain Administrations deviated from the approach in BWM.2/Circ.33 in their evaluations.

Track 2 of the D-2 Study focused on Operational Performance of BWMS and asked about the most common failures or problems. The responses identified the main problems were failures and mechanical malfunctions with sensors, controls, piping/valve systems, and filtration. These responses align with information from the ABS-facilitated shipowner meeting.

The MEPC Correspondence Group on the review of the Guidelines (G8) also discussed the need for improved scaling of BWMS. In the *Report of the Correspondence Group on the review of the Guidelines (G8)* (MEPC 69/4/6), it was noted that guidance for scaling is already available in BWM.2/Circ.33 and agreement was made on a need for the circular to be reviewed to ensure that it remained relevant. Additionally, suggestions were made for the whole of the text (BWM.2/Circ.33) to be transferred into the revised Guidelines (G8). The correspondence group observed, in part, that the details of the process and methods for scaling decisions should be communicated to the Administration. The majority of correspondence group favored validation of modeling through full-scale shipboard testing. Further discussion on scaling is to be included as next steps for the correspondence group.

Suggested BWMS scaling improvements

From the information presented, the BWM Convention should identify a means to ensure a consistent scaling approach by Administrations. Scaling of a BWMS should be supported by the treatment equipment manufacturer's modeling (i.e., mathematical calculations, computational fluid dynamics, performance related parameters, etc.). If sufficiently detailed, the modeling can provide an understanding of the technologies sensitivity to disturbances and non-optimum operating conditions. The Administration reviewing the BWMS type approval and modeling documentation should thoroughly evaluate the vulnerabilities of each technology used.

Validation of scaling may not always require full-scale testing (i.e., land-based and/or shipboard testing). Some design criteria data may be validated using pilot plant and/or bench tests where the performance parameters can be sufficiently adjusted and manipulated to determine the treatment technology responses. Multiple bench/pilot tests could be run to validate the technology responses to changes in performance parameters.

Some examples of performance parameters that can be validated using bench/pilot plant testing include:

- Ballast water temperature, salinity, UV transmittance, dissolved and particulate organic carbon (technologies can be evaluated to determine the minimum and maximum of parameters),

- Pre-treatment filters (standard methods similar to ISO 16889-2008, *Hydraulic fluid power – Filters - Multi-pass method for evaluating filtration performance of a filter element* could be adapted and used to determine follow-on disinfection technology vulnerabilities to the differences between filter screens) and
- UV lamp output spectrum (outputs should be analyzed for potential changes in efficacy within and between organism size classes).

Where bench/pilot plant testing cannot adequately validate the design criteria, the Administration should require full-scale validation (i.e., shipboard testing). The number and TRC of models requiring shipboard testing should cover the full range of the proposed type approvals. The extremes of the TRC range should be tested and several models in-between tested to demonstrate correlation to the modeling predictions (i.e., whenever practical, interpolation should be used in favor of extrapolation). Where testing results for mid-range BWMS models does not correlate with the modeling predictions, the design criteria and performance parameters should be reviewed and corrections made. This may require additional bench/pilot and/or full-scale testing to re-validate the revised modeling.

Some examples of performance parameters that should be validated by full-scale shipboard testing:

- Sizes and types of ships (changes to installation elevations, piping sizes and lengths, side-stream and neutralization mixing efficiencies, etc.),
- Total Residual Oxidant (TRO) monitors (longer distances between ballast piping and TRO monitors for potential variations in true TRO values and control system time delays) and
- Extended total holding time on active substance depletion (especially where re-treatment upon discharge is not included in the treatment process due to larger vessels having much longer voyage times than the 5 day G8 hold times for type approval testing).

Based on available information, the scaling guidance for BWMS can be improved to ensure BWMS are operable for larger TRC systems and that all model sizes are able to provide compliance with the D-2 performance standards for in-services vessels. The scaling requirements should not be overly burdensome due to the time and cost for BWMS testing, but key components for scaling needs to be clearly identified and included in the requirements for BWMS testing. Transparent scaling of BWMS will be provide shipowners and Administrations more confidence for shipboard compliance.

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