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United States Coast Guard

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[redacted]

Subj: BALLAST WATER MANAGEMENT SYSTEM (BWMS) SCALING GUIDANCE

Ref: (a) Title 46, Code of Federal Regulations (CFR) Subpart 162.060
(b) Ballast Water Frequently Asked Questions, dated April 24, 2018

Dear [redacted]:

We reviewed feedback from several sources concerning the scaling review process for BWMSs. The following guidance is provided to better explain our expectations for using scaling to demonstrate that models of a BWMS meet the requirements of reference (a). Question 12.6 in reference (b) will be updated to reflect this guidance at the next revision. This guidance is not intended to nor does it impose legally binding requirements on any party; it is intended to assist industry and the Coast Guard.

This letter will use the terms “base unit” and “scaled unit.” Base units are BWMSs that have been tested sufficiently to obtain type approval. Scaled units are BWMSs that have been modified from base units, typically to accommodate either a higher or lower treatment rated capacity (TRC), and for which sufficient empirical testing data is not available to grant type approval.

Scaling studies evaluate the effectiveness of a BWMS over a range of TRCs without requiring that every unit in the range be tested. In some cases, BWMS models with higher TRC cannot be tested under the limited conditions of a land-based facility and can only be tested on board ships. In these situations, scaling studies are used to demonstrate that the BWMS remains effective across the range of TRCs modeled. These scaling studies will be evaluated on a case-by-case basis taking into account the unique nature of each system. MSC will make the final determination on the acceptance of testing and numerical modeling during its review.

The Independent Laboratory (IL) is responsible for ensuring the test plan, including any scaling, meets the requirements for testing in accordance with reference (a). The manufacturer is responsible for completing the scaling study and submitting it to the IL. The scaling study must clearly identify the scaling of all tests (including Computational Fluid Dynamics (CFD) and mathematical models) in the Experimental Design section of the Test Plan. When reviewing the manufacturer submitted scaling study, the IL will validate all assumptions, modeling, and quality of the empirical data.

In general, a scaling study must include a thorough review of system design and performance, CFD and mathematical models, justifications, and decisions, along with the results of both the land-based and shipboard testing. It must also include all units within the BWMS product suite for which type approval is sought. The manufacturer must explicitly state the range of TRCs for which the manufacturer is seeking approval. Sufficient empirical data is necessary for the performance of the base units for the scaling review.

A comprehensive scaling study must include a complete overview of the BWMS and each individual treatment process, component, and subcomponent. An overall system/subsystem description must be included in a report introduction. Enclosure (1) is meant to provide examples of components and subcomponents that should be covered in a review for specific processes. Enclosure (1) is not meant to be exhaustive. The introduction of the report will explain the manufacturer's general approach to scaling as well as the appropriateness of this approach.

The review must also include a description of how the scaled unit is composed of the same processes, sensors, sub-components, materials, and equipment types as the base unit. Any changes, including changes to sub-components, must be documented and analyzed. Special attention must be made towards subsystems that may not scale similarly or linearly – for example, the scaling of electrode surface area in electrochlorination cells. The comprehensive scaling report must address how each individual process is subject to scaling, and how they are equivalent to the base unit.

The scaling study must include a comprehensive CFD model to validate the effectiveness of each scaled unit. An accurate CFD model plays a large role in the approving authority's decision to grant type approval. To facilitate the evaluation of the CFD model, the following information must be clearly provided: explanations of all assumptions; input and boundary conditions of all modeling components, including the element (e.g. mesh) size and quality control checks; discussion of specific models and studies (e.g. geometric models, turbulence models, and particle studies); Quality Assurance plan for and Quality Control review of the data and models, as appropriate; and any other pertinent information used to create the model.

Each model used in the scaling process must be validated using data generated from testing a physical unit, to ensure that the scaled models simulate BWMS performance in real-world conditions. If the model does not represent experimental results, then the model must be updated to better fit the experimental data. Additionally, a sensitivity analysis must be supported with conclusions on numerical model accuracy and the impact of varying parameters between the models.

Any system changes must be supported by a new CFD model to demonstrate the effectiveness of the BWMS at a new TRC. If a system employs multiple smaller BWMSs in parallel to scale up the TRC, a new CFD model must be used to demonstrate that the alternative setup will be as effective as advertised by the manufacturer (e.g. complete mixing occurs, proper flow is maintained, etc.)

The CFD model is only accurate if the assumptions used to create it are clear and supported. It is essential that all parameters of the model are clearly stated and suited for the intended operating environment. The mathematical and CFD modeling required by the scaling study must be conducted by qualified personnel. Their qualifications should include a strong background in fluid mechanics (e.g., master's degree or PhD degree with a focus in fluid mechanics and fluid dynamics calculations), system design, expertise in the software used for simulations, and/or previously demonstrated experience.

Please contact [redacted] at [redacted] with questions concerning our provided guidance.

Sincerely,

[redacted]

Lieutenant Commander, U. S. Coast Guard
Chief, Engineering Division
By direction

Encl: (1) Specific Review Considerations Table

Specific Review Considerations Table

This table is meant to provide an example of some components and subcomponents that should be covered in a review for specific processes. This table is not meant to be exhaustive. More information than listed in the table below should be included if necessary for the scaling report for a BWMS.

Process	Parameter	Examples
Separation	Type of separation technology	Screens Candle Filters Membranes Disc Filters Hydrocyclones
	Design parameters	Filter rating (nominal, absolute) Pore size Pressure drop Filtration unit rate (flow per unit area) Filter Housing Materials Filtration method (surface vs. depth filtration) Cleaning method Sensors
	Operational parameters	Design flows (filter and backwash) Operating pressure range Maximum pressure drop Filter backwash method and initiation criteria Overload response
	Scaling methods	Relationship between flow and pressure Velocity comparison across effective filtration area Filtration unit rate comparisons
Active Substances—Halogenated Oxidants	Type of halogenated active substance	Hypochlorite Chlorine dioxide Mixed oxidants

	Design parameters	Disinfectant generator technology Chemical storage requirements Power supply requirements Mixing system Hydrogen gas removal and management TRO sensor type and placement Disinfectant generator cleaning system
	Operational parameters	Design flows Disinfectant dose generation Disinfectant concentration Contact time Applied power Mixing efficiency Brine production and storage TRO concentration Utilities needed (such as compressed air or freshwater)
	Scaling methods	Generator capacity comparisons Applied power comparisons TRO residual comparisons CFD modeling (for chemical mixing efficiency) Comparing contact time with disinfection agent
Active Substances—Non-Halogenated Oxidants	Type of non-halogenated active substance	Sodium hydroxide Peracetic acid Vitamin K
	Design parameters	Chemical storage requirements Chemical delivery and mixing system Sensor type and placement
	Operational parameters	Design flows Disinfectant concentration Contact time Mixing efficiency Neutralization chemical dose Neutralization contact time

	Scaling method	Chemical residual comparisons CFD modeling Contact time comparisons Effectiveness of chemical in different temperatures
Neutralization of Active Substances	Design parameters	Neutralization chemical storage Chemical delivery and mixing system Neutralization monitoring (for example, sensors are located before and after delivery of chemical)
	Placement of disinfection monitoring sensors	Placement to ensure that readings are representative
	Neutralization process capacity	Tank capacities Flow rates Equations or algorithms (should be based on the maximum anticipated neutralization needed)
UV	Types of UV systems	Medium pressure lamps Low pressure lamps
	Design parameters	Reactor geometry Lamp type Lamp spacing and orientation Lamp power loading Sensor location Inlet/outlet configuration Power supply requirements (i.e., rectifier sizing)
	Operational parameters	Design flows UV dose UV transmittance Dose control algorithm Response to UVT change
	Scaling method	CFD modeling Particle study to track organisms route UV dosage