U.S. Department of Transportation
Maritime Administration

SHIP OPERATIONS COOPERATIVE PROGRAM

Glosten

BALLAST WATER MANAGEMENT SYSTEMS

USER GUIDE

Prepared for
Ship Operations Cooperative Program (SOCP)

File No. 20050.01

30 November 2020

Rev. -

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PREPARED: Digitally Signed 30-Nov-2020

Alan J. Orthmann, PE
Project Manager

CHECKED: Digitally Signed 30-Nov-2020

Colin J. Flynn, PE
Project Engineer

Digitally Signed 30-Nov-2020

APPROVED: Digitally Signed 30-Nov-2020

Kevin J. Reynolds, PE
Principal-in-Charge

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Revision History

Section	Rev	Description	Date	Approved
All	-	Initial release.	11/30/2020	KJR

Acknowledgements

The development of this Guide was made possible through the financial support of the US Maritime Administration (MARAD) and the Ship Operations Cooperative Program (SOCP). SOCP is a government industry organization whose purpose is to address and promote commercial operations through the identification, development, and application of new methods, procedures, and technologies. SOCP's overall objective is to improve the competitiveness, productivity, efficiency, safety, and environmental responsiveness of US vessel operations.

Special acknowledgment goes to following for their review and support of the Guide development:

- Martin Olofsson of DNV GL
- Marcie Merksamer of EnviroManagement, Inc.
- John Cappabianca of Kirby Corporation
- Captain RV Sheen of Ocean Shipholdings, Inc.

Corrections, suggestions for additional content, and BWMS program experiences provided by email to programadmin@socp.us will be considered for future updates.

Definitions and Abbreviations

Term	Definition
ABS	American Bureau of Shipping
ACS	Authorized Classification Society
AMS	Alarm and Monitoring System
Ballast water	Any water and suspended matter taken on board a vessel to control or maintain, trim, draught, stability, or stresses of the vessel, regardless of how it is carried (33 CFR §151.1504)
BWE + BWT	Ballast water exchange plus ballast water treatment
BWM	Ballast water management
BWM Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments
BWMR	Ballast Water Management Report
BWMS	Ballast Water Management System
BWMP	Ballast Water Management Plan
BWRB	Ballast Water Record Book
CFR	United States Code of Federal Regulations
COTP	Captain of the Port
DNV GL	Det Norske Veritas – Germanischer Lloyd
EC	Electrochlorination
EOS	Engineer Operating Station
ETV	Environmental Technology Verification
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HMI	Human-machine interface
IBWMC	International Ballast Water Management Certificate
IMACS	Integrated Monitoring, Alarm, and Control System
IMO	International Maritime Organization
IMO administration	IMO member state that has issued BWMS approvals
Waters under foreign jurisdiction	Waters under jurisdiction of an IMO member state
IOPP	International Oil Pollution Prevention
ISO	International Organization for Standardization
ITC	International Tonnage Convention
LCCA	life cycle cost analysis
LR	Lloyd's Register
Maker	The manufacturer or vendor of a BWMS
MEPC	Marine Environmental Protection Committee

Term	Definition
OCMI	Officer in Charge, Marine Inspection
OMSM	Operation, Maintenance, and Safety Manual
Operator	Group including the vessel crew and superintendent
Owner	Vessel owner and its representatives
NBIC	National Ballast Information Clearinghouse
NIST	National Institute of Standards and Technology
NVIC	Navigation and Vessel Inspection Circular
Project Naval Architect	Design firm hired by the owner to support any or all of the following project phases: feasibility, contract design, detail design, and construction
PSU	Practical Salinity Units
RO	Recognized Organization, granted authority by flag administration to perform certain flag approval tasks, such as statutory type approval or plan approval.
PWS	Public Water System
Statutory type approval	IMO administration type approval or USCG type approval
SOVC	Statement of Voluntary Compliance, issued by class as the ACS
STEP	Shipboard Technology Evaluation Program
TA	Type approval
TRO	Total residual oxidant
TRC	Treatment rated capacity
US	United States
USCG	United States Coast Guard
UV	Ultraviolet
UVI	Ultraviolet intensity
UVT	Ultraviolet transmission
UWILD	Underwater Survey in Lieu of Drydock
VGP	Vessel General Permit
VHS	Viral hemorrhagic septicemia
VIDA	Vessel Incidental Discharge Act
VIS	Vessel Interface System

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Overview – The Road to Compliant Ballast Water Management

Ballast water management is an operational reality for vessel owners and crew. The international Ballast Water Management Convention and USCG ballast water management regulations have fully entered into force, requiring vessel operators to develop and maintain a rigorous ballast water management (BWM) program. Vessels calling in US and foreign ports alike must have correct equipment type approvals, operate equipment in accordance with those approvals, discharge fully compliant ballast water, and comply with varying regional and local BWM requirements.

This Ballast Water Management System (BWMS) User Guide ("the Guide") simplifies the complex regulatory framework by providing step-by-step methods for integrating and operating a compliant BWMS. A successful BWM program will equally prioritize compliance with safe operations for vessels and their crew.

This Guide covers all aspects of the BWMS life cycle, in three parts:

Part A - Planning, installation, and commissioning

Part B - Maintaining compliance, monitoring, and enforcement

Part C - Training, equipment maintenance, and repair

A **Guide Navigator** is provided on the next page to help navigate the Guide and jump to the most relevant information. Use the following tips for exploring the Guide:

- Each line of the Guide Navigator is hyperlinked to a corresponding section. Click the **bold underlined text** next to the ⓘ symbol to jump to that section.
- Look for the ➢ symbol throughout the Guide to identify important takeaways.
- Most references are provided with a web link to the current document. Follow the link to access and download the document. References are located on page vii.
- This Guide is comprehensive but not exhaustive. It collects all of the major elements of building a BWMS program in one place, but it can be augmented by other ballast water guides that have more limited focus on a specific aspect of ballast water management.

The Guide is geared primarily towards ballast water management for **US flag operators** in both domestic and international trade. Foreign flag operators may still find aspects of the Guide useful for their planning, particularly if they operate vessels in US waters under the jurisdiction of the USCG.

A second release of the Guide is under development and will include several important areas of guidance: the ballast water management plan, inspections, sampling, and contingency measures. Operators and owners are encouraged to provide their soonest feedback on this Guide for consideration in the next release.

Guide Navigator

Use the following **hyperlinks** to navigate to sections most applicable to your ballast water management planning. Important takeaways in each section are identified with a ➢ symbol.

1 Applying the BWM Regulations to Your Vessel

- **Regulatory Flow Chart**: Start here if you don't know how your vessel will comply with ballast water management regulations. The Flow Chart explains regulatory outcomes for ballast water management:
  - *Exemptions, extensions, alternative compliance, and type-approved BWM.*

2 Selecting Approved Equipment

- **Factors for Down-Selection**: Quickly narrow down which BWMS systems might work using vessel characteristics, and which are nonstarters.
- **Selection Criteria**: How to develop a selection process tailored to your operation, focusing on: Is it easy to install? Is it easy to operate? Is it commercially viable? Will the installation be supportable?
- **BWMS Contracting**: Establish the contract terms to ensure the BWMS maker works for you, from purchase to supporting systems in service, and everything in between.

3 Shipyard Planning

- **Regulatory Design and Plan Review**: Focus your design on ways that check the regulatory boxes and is complete and ready for shipyard bid.
- **Shipyard Selection**: Focus on the shipyard's engineering capabilities, past BWMS install experience, and project management.
- **Strategies for Limiting Time Out of Service**: The planning doesn't stop at the shipyard contract. Consider the right level of detail design, pre-construction, riding gangs, and crew involvement that will keep the project schedule in check and on budget.
- **Shipyard Pitfalls**: There are common elements that derail most BWMS installations. Prepare accordingly, by pre-planning the complete equipment scope of supply, controls integration, tank cleaning, sampling port arrangement, and unexpected ventilation requirements.
- **Shipyard Execution Plan**: Work with the shipyard to arrange integration engineering support, a procurement plan, and owner on-site representation to oversee installation progress.

4 System Commissioning and Vessel Approval

- **Maker Attendance and Planning**: Ensure the maker's commissioning plan is available at time of equipment order, including pre-commissioning checklists, schedule, and a clear breakdown of scope of responsibility.
- **Shipyard Involvement and Acceptance Criteria**: Develop a roles and responsibility table in the commissioning plan, broken down for the maker, owner, shipyard, and class. Establish clear acceptance criteria in the contract that the shipyard must meet to complete the installation.

- **Class Requirements and Acceptance**: Work with class to determine function test requirements, and review commissioning testing guidelines in the 2019 Harmonized System of Survey and Certification.
- **Flag Involvement with Commissioning**: Review commissioning and biological efficacy testing guidelines in Annex 4 of the Harmonized System of Survey and Certification (HSSC) guidelines to understand what is expected by flag or its recognized organization.
- **Efficacy Sampling at Commissioning (IMO BWM.2/Circ.70)**: While not required for US flag vessels, many foreign flags are implementing efficacy sampling requirements in accordance with the MEPC draft amendment to the BWM Convention.
- **Class Approval**: Some vessel classes require a design assessment or appraisal, particularly for serial (multi-vessel) designs. The only type approval certificate required is the statutory certificate issued by flag (USCG for US flag vessels), or a recognized organization on behalf of flag.
- **International Ballast Water Management Certificate and Statement of Voluntary Compliance (IBWMC and SOVC)**: US flag vessels are issued a Statement of Voluntary Compliance in lieu of an international ballast water management certificate, issued by an authorized class society (ACS) on behalf of USCG. Owners are recommended to communicate with USCG early in the project, and to keep the homeport sector up to date throughout the process.
- **Contingency Extensions for Departing the Shipyard Without SOVC or IBWMC**: Departure from shipyard without flag approval should be avoided to the greatest extent possible. However, there are contingency extension and approval paths for US flag vessels and foreign flag vessels alike.

5 Maintaining Compliance

- **Crew Understanding of Type Approval**: Your crew must understand the operational limitations of the installed BWMS and its type approval, and recognize what regional limitations hold precedence. Crewmembers responsible for BWMS operation should thoroughly review the operating manual, OMSM, type approval certificate, and installation approval documents.
- **Recordkeeping**: Ballast recordkeeping is equally important to compliance with ballast water management itself. Plan your recordkeeping program in parallel with the installation design.
- **Reporting**: Include standard report submission procedures in the Ballast Water Management Plan. The crew should understand the differences between reporting in US ports and destinations, local state requirements, and reporting in international ports.
- **Understanding Pending and Proposed Regulations**: Ballast water exchange plus ballast water treatment (BWE + BWT) will become a reality in multiple regions under the Vessel Incidental Discharge Act. IMO BWMS commissioning testing does not apply to US flag vessels but may be adopted by USCG in the future.

6 Training Program

- **Crew Training by the Maker**: Training by the maker should be comprehensive and comprise several areas beyond just equipment operation. Computer-based training ahead of operation and fleetwide standardization are both proven strategies to consider with the BWMS maker.
- **Internal Training**: Develop a BWMS quick-start guide to distill operational instructions from the operating manual. Planning for training to address crew changes, especially immediately after commissioning and departure from shipyard, are key to the long-term success of the BWMS program. Establish an organizational chart defining the role of

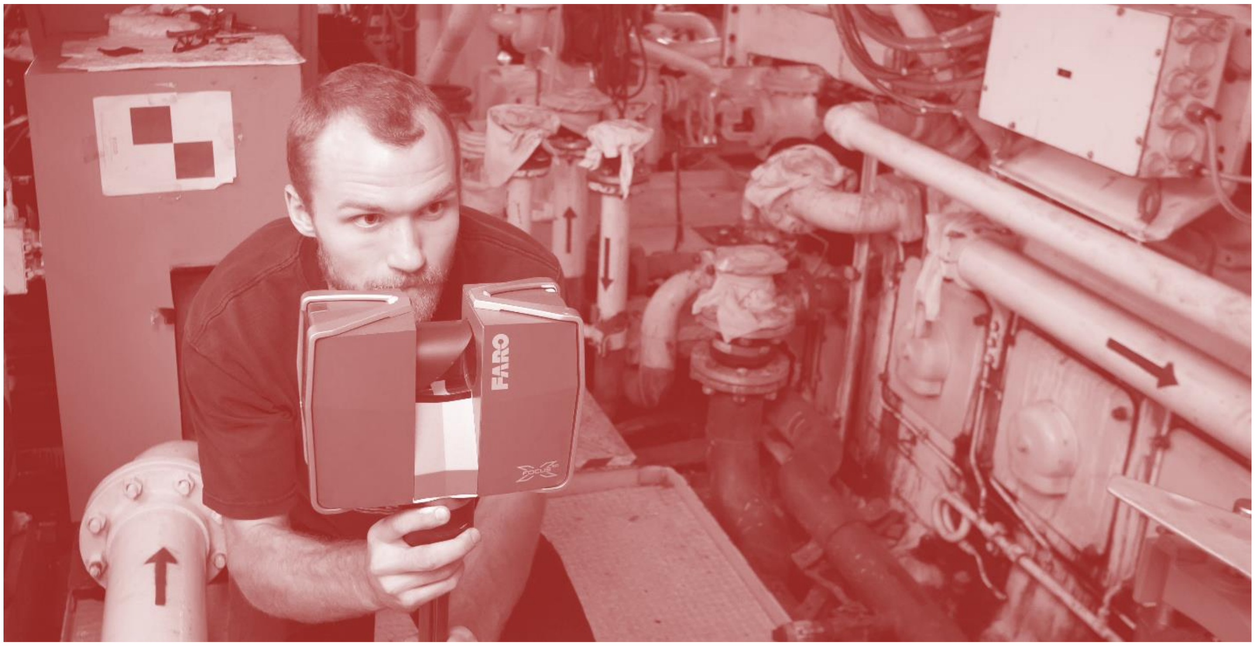
crewmembers in maintaining the vessel's BWMS program. Place special emphasis on preparing crews for inevitable equipment failures and acceptable contingency measures.

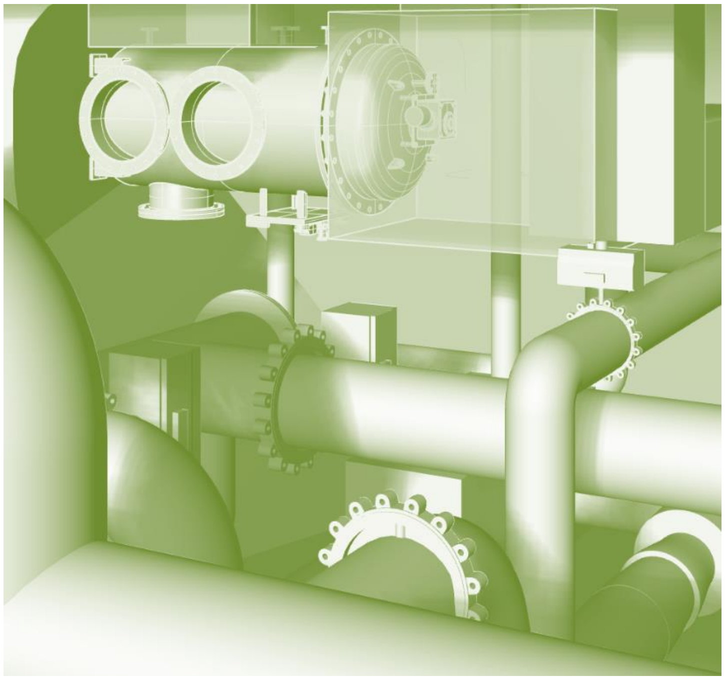
7 Equipment Maintenance and Repair

- **Standard and Redundancy Spares**: Understand how the standard spares list was developed, what failures are most common, and what additional spares are recommended by the BWMS maker to minimize system downtime.
- **Consumables Sourcing and Inventory**: Arrange supply of consumable materials for both commissioning and regular service of the BWMS. Special shipment and handling for hazardous chemicals may be necessary, and plans should be made to ensure adequate inventory is ready for when the vessel leaves the shipyard, post-commissioning.
- **Service Program and Logs for BWMS**: Use the BWMS operating manual to develop a service program. Careful logs should be maintained, especially to support potential warranty claims with the maker.
- **Planning for Maker Service Calls**: A service agreement with the BWMS maker is absolutely necessary, and you should expect to exercise it in the first few months of system operation. Understanding the terms of the agreement and how to quickly arrange support will help avoid costly delays to vessel operations.

Part A – BWMS Planning

1 Applying the BWM Regulations to Your Vessel
2 Selecting Approved Equipment
3 Shipyard Planning





1 Applying the BWM Regulations to Your Vessel

1.1 Regulatory Flow Chart

- The Regulatory Flow Chart explains regulatory outcomes for ballast water management, accounting for a vessel's ballasting status and operational elements.

Ballast water management regulations are now largely in force both internationally and domestically in the United States (US). Opportunities for exemptions, extensions, and compliance alternatives have become limited as approved technologies have matured and industry has gained experience in installations and operations. At the same time, installation and commissioning does not always go to plan, which means operators may need some flexibility as they leave the shipyard refit period.

A flow chart is provided in Figure 1 to explain regulatory outcomes for a given vessel's operation. This focuses on ballast water management only. Reporting, recordkeeping, and other administrative requirements are discussed in Section 5. The flow chart covers United States Coast Guard (USCG), regional and state, and International Maritime Organization (IMO) requirements for ballast water management (BWM).

1.1.1 Flow Chart Outcomes

Applicability: Does vessel take water on board as ballast?

- NO: Vessel is not subject to BWM regulations. If the vessel does not take water onboard as ballast (and therefore does not have ballast tanks, as defined in the Code of Federal Regulations), BWM regulations do not apply.
- YES: Vessel is subject to BWM regulations. If the vessel takes water onboard as ballast, regardless of its origin or intended discharge location, BWM regulations apply.

USCG (for vessels operating in US waters): Is vessel exempt from ballast water management?

- YES: Not required to comply with BWM requirements. If the vessel qualifies as exempt, as detailed in Section 1.2, then BWM requirements for ballast carried onboard do not apply. Reporting and recordkeeping requirements may still apply.
- Eligible for extension: Submit application for extension at least 12 months before compliance date. Extensions are increasingly difficult to obtain, and the USCG now requires rigorous documentation that a compliant ballast water management system (BWMS) installation is not possible. Justifications for extension are detailed in Section 1.3.
- NO: Install USCG type-approved BWMS by next scheduled drydock. Details on Type Approval (TA) applicability are detailed in Section 2.1. Compliance alternatives include exclusive use of water from a US Public Water System (i.e. land-based municipal water), discharge of all ballast water to a shoreside facility, or installing a prototype BWMS under USCG Shipboard Technology Evaluation Program (STEP). Alternative compliance options are detailed in Section 1.4.

IMO: Does vessel operate in waters under foreign jurisdiction?

- NO: No additional BWMS compliance is required if vessel does not operate in waters under foreign jurisdiction.
- YES: Install an IMO Type-approved BWMS by next International Oil Pollution Prevention (IOPP) certificate renewal. BWMSs must be approved by a flag administration that is a member state of IMO. Generally, BWMSs with USCG TA also have IMO TA.

US Regional and State requirements:

- US regional and state requirements for BWM are in addition to USCG requirements and may require additional planning for uptake and discharge of ballast water. Regional and state requirements include ballast water exchange plus ballast water treatment (BWE + BWT), disinfection by-products, and additional reporting. These are detailed in Section 1.6.
- Foreign regional and state requirements are not widely adopted but may apply in some sovereign or local waters. Vessels on international voyages should review ballast discharge requirements for new arrival locations and verify with local authorities.

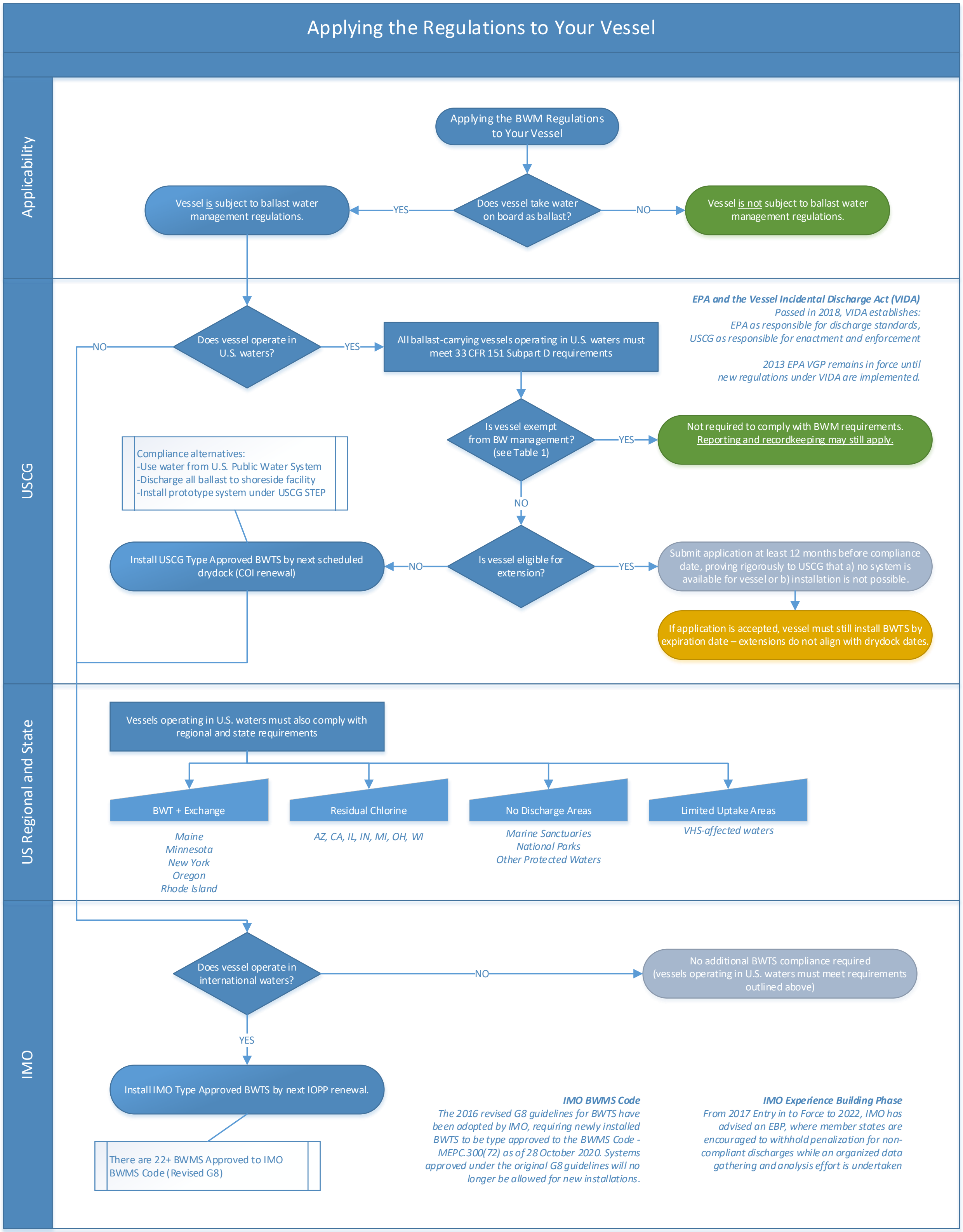


Figure 1 - Regulatory flow chart

1.2 Exemptions

USCG exemptions are defined in 33 CFR § 151.2015 and summarized in Table 1. Several vessel-types are exempt from BWM based on the locality of their operation but are not exempt from ballast water reporting or ballast water recordkeeping. It is important to note these exemptions do not reflect proposed changes under the Vessel Incidental Discharge Act (VIDA), including elimination of the exemption for crude oil tankers engaged in coastwise trade. BWM regulations in 33 CFR § 151 are not applicable to recreational vessels.

The IMO Ballast Water Management Convention provides exclusions and exemptions for BWM similar to the USCG. These are provided in Reference 10, Article 3 and Regulation A-4. Exemptions are generally at the discretion of each IMO member state, and may vary as they apply to BWM, reporting, and recordkeeping requirements.

Table 1 - USCG ballast water exemptions, adapted from 33 CFR § 151.2015

Vessel	Ballast Water Management	Ballast Water Reporting	Ballast Water Recordkeeping
Department of Defense or Coast Guard vessel subject to 46 U.S.C. 4713	Exempt	Exempt	Exempt
Vessel of the Armed Forces subject to the "Uniform National Discharge Standards for Vessels of the Armed Forces" (33 U.S.C. 1322(n))	Exempt	Exempt	Exempt
Crude oil tankers engaged in coastwise trade	Exempt	Exempt	Exempt
Vessel operates exclusively on voyages between ports or places within a single COTP Zone	Exempt	Applicable	Exempt
Seagoing vessel operates on voyages between ports or places in more than a single COTP Zone, does not operate outside of EEZ, and ≤1600 gross register tons or ≤3000 gross tons (ITC)	Exempt	Applicable	Applicable
Non-seagoing vessel	Exempt	Applicable	Applicable (unless operating exclusively on voyages between ports or places within a single COTP Zone)
Vessel operates between ports or places in more than a single COTP Zone and takes on and discharges ballast water exclusively in a single COTP Zone	Exempt	Applicable	Applicable

1.3 Extensions

Prior to the USCG issuing a large number of type approvals for BWMSs, extensions were issued widely and with minimal justification for vessels or entire fleets. With a prominent list of approved systems now established, USCG is no longer granting extensions unless the applicant thoroughly proves that their vessel cannot meet BWMS regulations. Key justifications for applying for an extension are described here, as well as recommended approach for filing an application.

1.3.1 *Justifications for Extension*

Lack of available technology is no longer a reliable justification for applying for a compliance extension. Vessels with one or multiple of the following unique characteristics may be granted an extension if it is documented and properly presented to USCG.

- **Hold time limitations**. Vessels that cannot tolerate any hold time between ballast uptake and discharge have a limited selection of USCG-approved systems. If it can be argued that a vessel's ballasting operation does not allow for mandatory hold times and that type-approved systems with no (or limited) hold time restriction are not compatible with the vessel's requirements, USCG may grant an extension.
- **Weight limitations**. Vessels that are limited to variations in weight based on draft restrictions or stability margins may be granted an extension. By documenting the estimated weight increase required for a BWMS installation and comparing it to the available weight margins, an extension may be justified.
- **Space limitations**. Space limitations alone are not a reliable justification for an extension. Proving space is not available onboard in combination with hold time, weight limitations, or another justification may strengthen an extension application.
- **End of service**. If the vessel is scheduled to end its service in the next few years, USCG may grant an extension. If the end of service is imminent (within 1-2 years of compliance date), this alone may be justification for granting an extension. If the end of service is further out, it may strengthen an extension application, but is likely not sufficient by itself to gain approval.

Contingency extensions may be granted after the vessel has entered the shipyard modification period, but it is determined that the BWMS will not be fully commissioned and approved in time for sailing. Approaches for seeking these extensions are discussed in Section 4.8.

1.3.2 *Underwater Survey in Lieu of Drydocking (UWILD)*

Vessels that qualify for Underwater Survey In Lieu of Drydocking (UWILD) may extend their drydocking date by up to 2 years. For vessels less than 15 years of age, UWILD may be requested of the OCMI prior to the next scheduled drydocking. For vessels 15 years of age or older, UWILD must be requested and permitted prior to the previous drydocking to be an accepted alternate for subsequent examinations (Reference 5).

UWILD does not qualify as a scheduled drydocking, and therefore does not trigger a vessel's USCG compliance date.

1.4 Alternative Compliance

Several alternative methods to ballast treatment are accepted by USCG to meet BWM requirements. For most vessels and their operating regions, these alternative methods will not be practical. They may, however, be adapted for unique vessel operations.

1.4.1 *US Public Water System (PWS)*

- ➢ Only vessels that exclusively take on ballast in port may consider using municipal water from a PWS.
- ➢ IMO does not recognize PWS or municipal water as a compliant BWM method, so exemption from IMO member administrations would be necessary for discharges in foreign waters.

A vessel may perform ballasting operations and discharges exclusively with water taken from a US PWS. PWSs are generally municipal water supplies that have been certified by a US state or the federal Environmental Protection Agency (EPA) in accordance with the Safe Drinking Water Act.

A vessel looking to use PWS as ballast must do so exclusively, therefore requiring the vessel to only take on ballast while in port where a PWS source is available. No ballasting at sea, such as for fuel burn compensation, would be allowed as it would not be sourced from a PWS.

If a vessel can use water exclusively from a PWS for ballast, records of all PWS procurement must be kept, as well as records of ballast tanks being cleaned or never containing ambient water (Reference 4).

At present, the USCG does not have an approval path to using potable water generated onboard, via evaporators or reverse osmosis units, for ballast.

IMO does not recognize water sourced from a municipal system, US or foreign, as a compliant BWM method. A vessel would have to receive exemption from the IMO member administration of any foreign locations where water would be discharged.

1.4.2 Discharge to Shoreside Facility or Treatment Vessel

- There are presently no shoreside or vessel-based treatment facilities operating in North America.

Vessels may alternatively discharge all ballast water to a shoreside facility or another vessel for the purposes of treatment. At present, there are no operating shoreside or receiving vessel treatment facilities in North America. Until a shoreside or vessel treatment facility becomes available, this is not a viable BWM solution.

1.4.3 Enroll Vessel in Shipboard Technology Evaluation Program (STEP)

A vessel may enroll in USCG’s STEP program to meet BWM requirements. STEP allows an experimental BWMS to be installed and operated onboard vessels for testing and evaluation purposes. A vessel enrolled in STEP is granted equivalency with USCG BWM regulations and must follow operational and reporting requirements in Navigation and Vessel Inspection Circular (NVIC) 01-04 in lieu of USCG BWM regulations.

STEP has become a niche method of compliance and is generally only accepted for development and testing purposes. Given the maturity of the BWMS industry, few STEP approvals from USCG are expected going forward.

1.4.4 Elimination of Ballast Water or use of Locked-In Freshwater System

While not suitable for most vessels, the owner should consider whether complete elimination of ballast water or modification to a locked-in freshwater system is feasible. These approaches could eliminate the need for a BWMS installation if determined practical.

1.5 Management with a Type-Approved System

The most widely adopted path to achieve BWM compliance is to install and operate a type-approved BWMS. As detailed in the regulatory flow chart, a vessel may be required to install a BWMS type-approved by USCG, an IMO member administration, or both.

The approach for planning, installing, commissioning, and maintaining a compliant BWMS is the subject of this Guide.

1.6 Regional and State Requirements

1.6.1 Ballast Water Exchange plus Ballast Water Treatment (BWE + BWT)

- Five states require ballast exchange in addition to treatment with a BWMS.
- BWE + BWT should be incorporated into the Ballast Water Management Plan (BWMP) and confirmed with vessel strength and stability limitations. Safety issues should be carefully reviewed and understood before carrying out any BWE + BWT operations.
- Vessel owners should consult with the BWMS maker to determine if multiple treatment cycles are required for BWE + BWT procedures.

Several US states require ballast water exchange in additional to federally required treatment (Reference 15). These states are:

- Maine
- Minnesota
- New York
- Oregon
- Rhode Island

The Vessel Incidental Discharge Act (VIDA) passed in 2018 and is expected to result in entry-into-force of new regulations in 2022 or 2023. VIDA will expand BWE + BWT requirements in the Saint Lawrence Seaway and the Pacific Region (Pacific Coast Region, Alaska Region, and Hawaii). This is further discussed in Section 5.4.

For vessels operating in the waters of any of these states, the operator should review the state's requirements and incorporate in the vessel's BWMP.

As with any exchange-only operations, BWE + BWT procedures should take into consideration concerns with vessel stability, trim, and list. <u>Practically, performing exchange plus treatment presents the ship operator with significant logistics and safety issues</u>. Any BWE + BWT operations should be incorporated in the BWMP, confirmed in stability calculations (manually or with the vessel's onboard strength and stability program), and coordinated with the BWMS maker.

Research on the practicality of BWE + BWT operations is detailed in Reference 14.

Where BWT is required federally, and exchange is additionally required locally, a vessel may need to undergo two ballast treatment cycles: treatment on uptake of water ambient to the origin location, and treatment on uptake of water used for mid-ocean exchange. Type-approved BWMSs have generally not been tested for a BWE + BWT operation, so there is no assurance the discharge standard is being achieved without treating at both steps.

If a vessel is planning to perform BWE + BWT to meet state requirements, the US vessel owner should consult with the BWMS maker for operational instruction. Systems requiring treatment on discharge, such as UV, or neutralization on discharge, such as electrochlorination (EC), may not be able to accommodate flow-through ballast exchange in parallel with treatment.

Transport Canada has proposed BWE + BWT for vessels discharging in Canadian waters, but these requirements have not been adopted or entered into force.

1.6.2 Discharge Standards

Biology discharge standards are uniform for all states and international locations. California, which proposed more stringent biology discharge standards in a phased approach, has delayed any adoption until 2030 at the earliest.

Residual chlorine is measured in micrograms per liter (µg/L). The international and federal limit is 100 µg/L, which is the limit which most chlorine-based BWMSs are configured to meet. Different regions and states have implemented residual chlorine limits for ballast discharge that are more stringent than federal requirements. These states and their discharge limits are provided in Table 2.

For vessels installing a chlorine-based BWMS and planning to discharge in any of these state waters, the owner should consult with the BWMS maker for operational instruction. More rigorous neutralization procedures may be necessary.

Table 2 - Residual chlorine discharge limits by state

Region	Discharge Limit (µg/L)
Federal and International Ports	100
Arizona	19
California	60 19 (inland/freshwater)
Illinois	19 (acute) 11 (chronic)
Indiana	20
Michigan	38 (>160-minute discharge) 200 (<160-minute discharge)
Ohio	38 (>160-minute discharge) 200 (<160-minute discharge)
Wisconsin	38 (daily instant maximum)

1.6.3 Discharge-Limited Areas

Ballast discharges are limited or restricted in National Marine Sanctuaries, National Parks, and other federally protected areas. For vessels operating in or near these areas, the operator should review the applicable regulatory restrictions and incorporate in the BWMP. A complete list of federally protected areas is provided in Reference 15, and restrictions specific to Marine Sanctuaries as well as sanctuary boundary definitions are provided in Reference 3. A map of protected Marine Sanctuaries is provided in Figure 2, and detailed maps of each sanctuary are available on NOAA's sanctuary website, here: https://sanctuaries.noaa.gov/about/maps.html

For foreign voyages, particularly to new locations, the US vessel owner should consult with local authorities in advance of arrival to determine if any discharge-limited areas are in effect.

Figure 2 - Map of federally protected Marine Sanctuaries

1.6.4 Limited Uptake Areas

The Vessel General Permit (VGP) provides general guidance about where to avoid ballast uptakes, repeated here:

- Areas known to have infestations or populations of harmful organisms and pathogens (e.g., toxic algal blooms).
- Areas near sewage outfalls.
- Areas near dredging operations.
- Areas where tidal flushing is known to be poor or times when a tidal stream is known to be turbid.
- In darkness, when bottom-dwelling organisms may rise up in the water column.
- Where propellers may stir up the sediment.
- Areas with pods of whales, convergence zones, and boundaries of major currents

The only region in the US with specific uptake limitations are those waters known to be affected by viral hemorrhagic septicemia (VHS). The state of New York requires water taken aboard in areas affected by VHS be kept to a minimum to prevent spread of the disease to unaffected areas. Maps of areas affected by VHS can be found through various online government resources, such as the National Park Service website, here: https://www.nps.gov/piro/learn/nature/vhs.htm

2 Selecting Approved Equipment

After it is determined that a type-approved BWMS is necessary to achieve vessel compliance, a feasibility review of available technologies and their suitability for a specific vessel is recommended.

An overview of technology types and their applicability are provided in the 2019 ABS Advisory (Reference 18).

2.1 Factors for Down-Selection

Prior to performing a feasibility review, several vessel characteristics will help quickly down-select from the type approval (TA) lists. Each down-selection step should shorten the list of systems remaining for further review.

Step 1: Operating Region

Does the vessel operate in US waters?

- Yes – The BWMS must be type-approved by the USCG. A list of USCG type-approved systems is hyperlinked in Reference 1. Consider only BWMS from the approved list.

Does the vessel operate in waters under foreign jurisdiction?

- Yes – The BWMS must be type-approved by an IMO administration. The hyperlinked list provided in Reference 1 has been annotated for IMO type-approved[1] systems in accordance with the BWMS Code[2] (Reference 9).

Does the vessel operate in both waters under US jurisdiction and under foreign jurisdiction?

- Yes – create a list of systems common to the USCG and IMO type-approved lists. Not all USCG type-approved systems have been confirmed for compliance with the BWMS Code.

Step 2: TA Certificate Review

Prior to proceeding with the next down-selection step, collect and examine applicable TA certificates (issued by USCG and/or an IMO administration).

The TA certificate is a necessary resource for down-selecting BWMSs. Every USCG type-approved system is issued a certificate with key information about the system's capabilities and limitations. TA certificates from IMO administrations vary by the administration, but the DNV GL certificate issued on behalf of Norwegian Maritime Authority is a representative example. All certificates issued under the BWMS Code are standardized in accordance with that document. The majority of BWMSs approved in accordance with the IMO BWMS Code were issued a certificate through DNV GL on behalf of Norwegian Maritime Authority.

Table 3 summarizes certificate key data critical to the down selection process, and each item is related to where the relevant information is located on the example certificates provided in Figure 3 and Figure 4.

[1] IMO does not issue type approvals. 'IMO type-approved' refers to approvals issued by an administration that is a member state of the IMO, e.g. Norwegian Maritime Authority.

[2] As of 28 October 2020, all systems installed on vessels operating in waters under jurisdiction of states party to the BWM Convention must be approved in accordance with the BWMS Code or Revised Guidelines (G8), Reference 9.

Table 3 - USCG certificate key data, critical to down selection

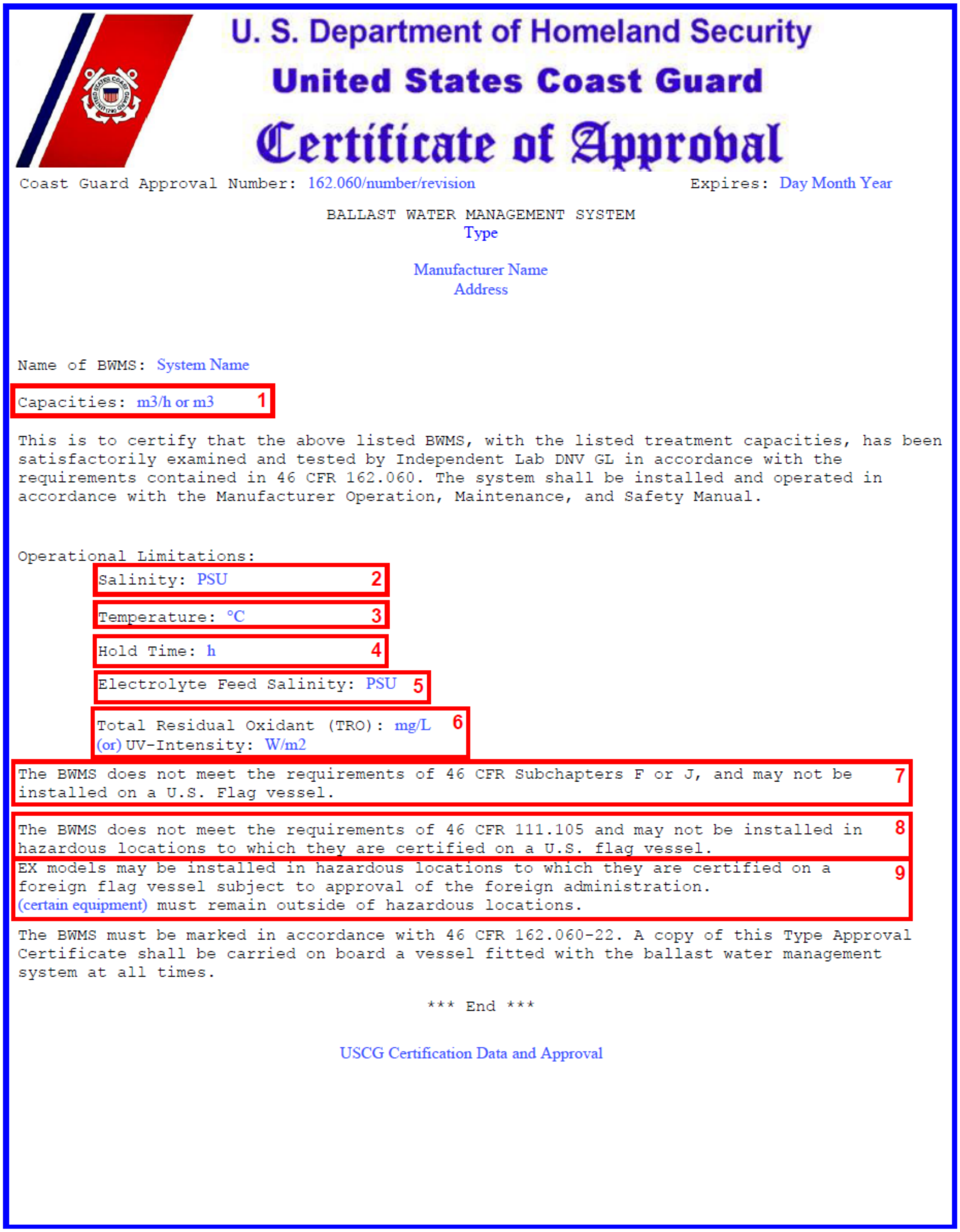
Key Data	Down Select Critical	Limitation	Explanation
1 - Capacity	Yes	m^3/h	Flow rate capacity, treats during ballast uptake/discharge
		m^3	Volume capacity, treatment takes place in-tank
Operational Limitations			
2 - Salinity	Yes	Not applicable (or)	No limitation on ballast salinity
		PSU range/limits	Acceptable range or limit on ballast salinity
3 - Temperature	Yes	Not applicable (or)	No limitation on ballast temp
		°C range/limits	Acceptable range or limit on ballast temp
4 - Hold time	Yes	Not applicable (or)	No hold time limitation
		h	Hours required between treatment and discharge, should be considered against vessel's shortest voyage/ballast cycle
5 - Feed salinity (EC only)[1]		Not applicable (or)	No limitation on feed salinity
		Practical Salinity Unit (PSU) range/limits	Acceptable range or limit on feed salinity
6 - UV intensity[2], Total Residual Oxidant, other	Varies	Required treatment	Potential operational impact, see Figure 5 and related discussion
Approval Limitations			
7 - US Flag Vessels	Yes	Does not meet 46 CFR Subchapters F or J (or)	Cannot be installed on any US flag vessels
		no statement/meets subchapter F and J	Can be installed on US flag vessels
8 - US Flag with hazardous areas	Yes	Does not meet 46 CFR 111.105	Cannot be installed in hazardous locations on US flag vessels
		Meets 46 CFR 111.105	Can be installed in hazardous locations on US flag vessels
9 - Foreign Flag with hazardous areas	Yes	Not intended for hazardous areas	Cannot be installed in hazardous locations on any vessel
		May be installed in hazardous areas	Can be installed in hazardous locations with flag approval

[1] Seawater feed is required for electrochlorination (EC) treatment. EC systems can generally treat low-salinity ballast but require a stored source of high-salinity water for generating chlorine if the ballast water is below a certain salinity.

[2] Ultraviolet intensity (UVI) does not correlate to system's ability to treat in low UV transmission (UVT) water. Intensity at the point of treatment is inversely proportional to the water's UVT, so systems with higher UVI are more impacted by turbid water.

USCG Certificate

An example USCG TA certificate is provided in Figure 3.



U. S. Department of Homeland Security

United States Coast Guard

Certificate of Approval

Coast Guard Approval Number: 162.060/number/revision   Expires: Day Month Year

BALLAST WATER MANAGEMENT SYSTEM
Type

Manufacturer Name
Address

Name of BWMS: System Name

Capacities: m3/h or m3 1

This is to certify that the above listed BWMS, with the listed treatment capacities, has been satisfactorily examined and tested by Independent Lab DNV GL in accordance with the requirements contained in 46 CFR 162.060. The system shall be installed and operated in accordance with the Manufacturer Operation, Maintenance, and Safety Manual.

Operational Limitations:

Salinity: PSU 2

Temperature: °C 3

Hold Time: h 4

Electrolyte Feed Salinity: PSU 5

Total Residual Oxidant (TRO): mg/L 6
(or) UV-Intensity: W/m2

The BWMS does not meet the requirements of 46 CFR Subchapters F or J, and may not be installed on a U.S. Flag vessel. 7

The BWMS does not meet the requirements of 46 CFR 111.105 and may not be installed in hazardous locations to which they are certified on a U.S. flag vessel. 8

EX models may be installed in hazardous locations to which they are certified on a foreign flag vessel subject to approval of the foreign administration. 9
(certain equipment) must remain outside of hazardous locations.

The BWMS must be marked in accordance with 46 CFR 162.060-22. A copy of this Type Approval Certificate shall be carried on board a vessel fitted with the ballast water management system at all times.

*** End ***

USCG Certification Data and Approval

Figure 3 - Generic USCG TA certificate with key information highlighted

Examine each certificate for the data provided in Table 3. Data critical to down-selecting available systems is identified, with explanations on the limitations defined in the certificate. If both USCG and IMO TA are required, a review of the USCG certificate should be adequate for the down-selection.

IMO Administration Certificate

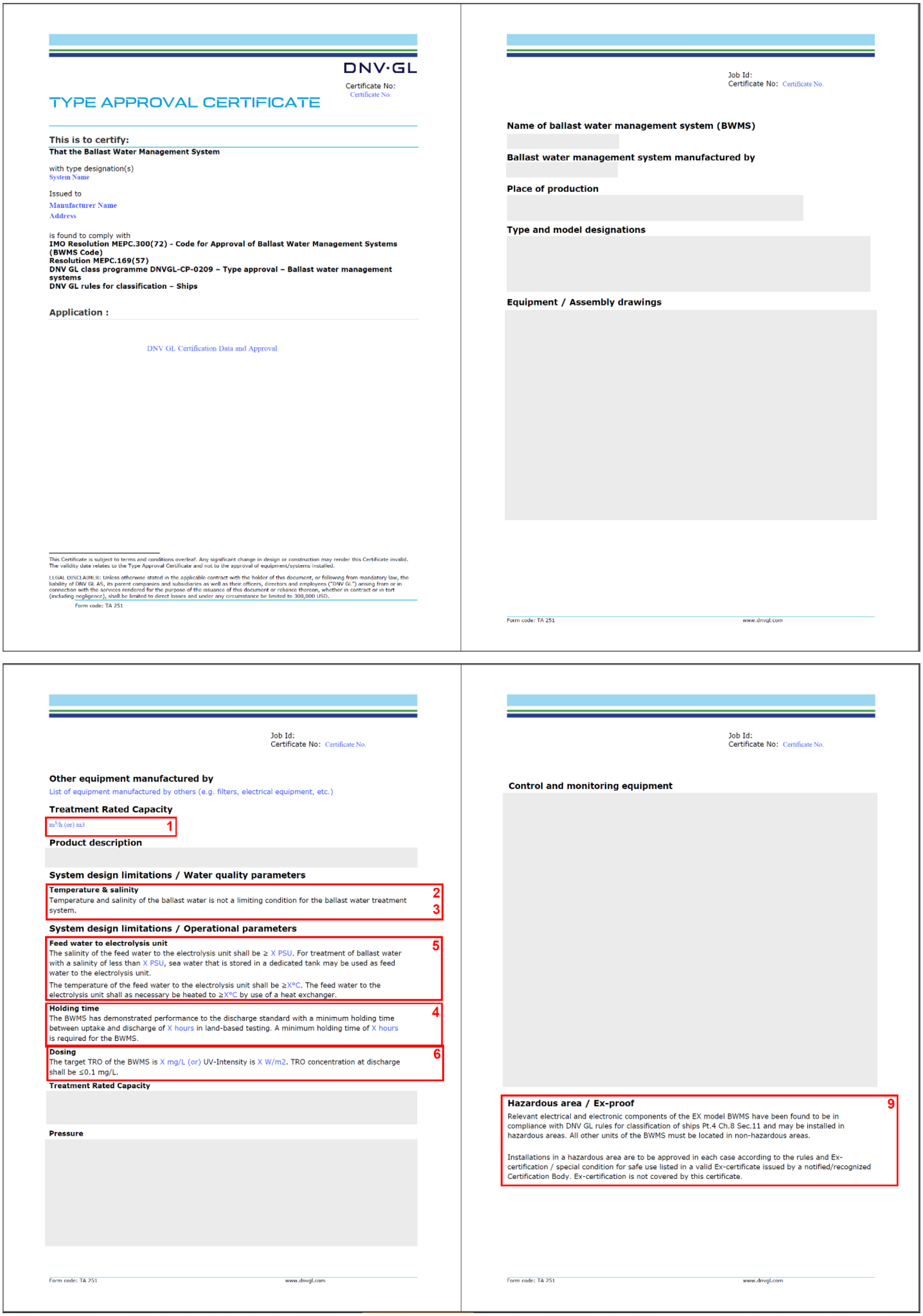
IMO administration TA certificates are typically more detailed and variable between systems than the USCG certificate but contain similar key information on limitations.

An example IMO TA certificate is provided in Figure 4. Data critical to down-selecting available systems is identified in the example certificate and can typically be found on page 3 onward. Non-critical sections are grayed out for clarity. Key data 7 and 8 related to US flag are not included in the IMO certificate as IMO does not check for compliance with US regulations.

If needed, examine the IMO TA certificate for the data provided in Table 3.

Complete IMO type approval certificates with detailed information on the approval are available to the public through IMODOCS at docs.imo.org. A user login must be created to review informational papers at Meeting Documents > Committee > MEPC.

For convenience, a collection of type approval information packets from MEPC 75 are provided in Reference 8 (linked here).



DNV·GL

TYPE APPROVAL CERTIFICATE

Certificate No:
Certificate No.

This is to certify:
That the Ballast Water Management System

with type designation(s)
System Name

Issued to
Manufacturer Name
Address

is found to comply with
IMO Resolution MEPC.300(72) - Code for Approval of Ballast Water Management Systems (BWMS Code)
Resolution MEPC.169(57)
DNV GL class programme DNVGL-CP-0209 – Type approval – Ballast water management systems
DNV GL rules for classification – Ships

Application :

DNV GL Certification Data and Approval

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV GL AS, its parent companies and subsidiaries as well as their officers, directors and employees ("DNV GL") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.

Form code: TA 251

Job Id:
Certificate No: Certificate No.

Name of ballast water management system (BWMS)

Ballast water management system manufactured by

Place of production

Type and model designations

Equipment / Assembly drawings

Form code: TA 251 www.dnvgl.com

Job Id:
Certificate No: Certificate No.

Other equipment manufactured by
List of equipment manufactured by others (e.g. filters, electrical equipment, etc.)

Treatment Rated Capacity
m^3/h (or) m3 1

Product description

System design limitations / Water quality parameters

Temperature & salinity 2
Temperature and salinity of the ballast water is not a limiting condition for the ballast water treatment system. 3

System design limitations / Operational parameters

Feed water to electrolysis unit 5
The salinity of the feed water to the electrolysis unit shall be ≥ X PSU. For treatment of ballast water with a salinity of less than X PSU, sea water that is stored in a dedicated tank may be used as feed water to the electrolysis unit.
The temperature of the feed water to the electrolysis unit shall be ≥X°C. The feed water to the electrolysis unit shall as necessary be heated to ≥X°C by use of a heat exchanger.

Holding time 4
The BWMS has demonstrated performance to the discharge standard with a minimum holding time between uptake and discharge of X hours in land-based testing. A minimum holding time of X hours is required for the BWMS.

Dosing 6
The target TRO of the BWMS is X mg/L (or) UV-Intensity is X W/m2. TRO concentration at discharge shall be ≤0.1 mg/L.

Treatment Rated Capacity

Pressure

Form code: TA 251 www.dnvgl.com

Job Id:
Certificate No: Certificate No.

Control and monitoring equipment

Hazardous area / Ex-proof 9
Relevant electrical and electronic components of the EX model BWMS have been found to be in compliance with DNV GL rules for classification of ships Pt.4 Ch.8 Sec.11 and may be installed in hazardous areas. All other units of the BWMS must be located in non-hazardous areas.

Installations in a hazardous area are to be approved in each case according to the rules and Ex-certification / special condition for safe use listed in a valid Ex-certificate issued by a notified/recognized Certification Body. Ex-certification is not covered by this certificate.

Form code: TA 251 www.dnvgl.com

Figure 4 - Generic IMO TA certificate with key information highlighted

Step 3: Flag

Is the vessel US flagged?

- Yes – The BWMS must be USCG type-approved in accordance with 46 CFR subchapters F and J for marine engineering and electrical engineering. Systems that are not approved in accordance with subchapters F and J are clearly indicated on the USCG TA certificate.
- No – The BWMS approval does not need to be approved in accordance with subchapters F and J. It may be type-approved by the USCG or an IMO administration, depending on the operating region.

Many USCG type-approved BWMSs are not approved to meet the requirements of equipment installed on US flag vessels. The USCG list in Reference 1 (linked here) has been annotated for systems that do and do not meet requirements for US flag vessels.

Step 4: Operating Profile

The duration for which a vessel is expected to hold ballast between uptake and discharge will impact which BWMSs are suitable for its operation.

Does the vessel ever hold ballast for less than 72 hours between uptake and discharge?

- Yes – Carefully review the TA certificate for minimum required hold time. Any system that requires a hold time longer than the vessel's shortest anticipated voyage should be excluded from the down-selection.
- No – All but one of the current USCG type-approved BWMSs have a minimum hold time of 72 hours or less, so would not inhibit the vessel's ability to stay on schedule.

Step 5: Limitations and Crew Input

- Vessels often ballasting in turbid water and planning to use a UV system should carefully compare the UV transmittance typical for those locations with the UVT allowed by the BWMS maker.
- Filters are also impacted by very turbid water and may be clogged during operation, impacting ballasting operations. Oversizing BWMS filters and incorporating high and low seachests may prevent filters from becoming overloaded.
- Electrochlorination can only generate a biocide for treatment when sea water is available. For ballast uptakes in low-salinity water, reserve sea water must be stored onboard.

Different BWMS technologies have limitations in effectiveness in different waters. The vessel operator can offer important insight to unique characteristics of ballasting that may otherwise not be considered early in the BWMS selection process.

Water Quality

- Consult with the vessel operator (crew and/or superintendent) whether very turbid waters are experienced in ballast uptake locations.
- For UV systems, evaluate TA certificates for systems with reduced treatment rated capacity (TRC) at reduced UV intensity values. Consider against commercial impacts of decreased ballasting rates in challenging water.
- For electrochlorination (EC) systems, evaluate TA certificates for systems with low TRO dose, particularly dose-on-uptake. These systems may lack adequate dosing margin to treat turbid water with high oxidant demand.

TA testing for BWMS is carried out under a standard set of challenge water conditions. Some systems may have to de-rate their through-put capacity or TRC if water conditions are particularly challenging.

The water quality used during TA testing is challenging, but not universally representative of the most challenging port locations. The UV transmission (UVT) in actual conditions may be much lower, preventing a UV system from penetrating and completely treating water on uptake. Oxidant demand due to total suspended solids (sediment), and particulate and dissolved organic carbons may be significant, possibly negating lower doses of chlorine or total residual oxidant (TRO) from electrochlorination or chemical injection. A general correlation of turbidity to UV transmission and oxidant demand is shown in Figure 5. It is important to note that some constituents in water, such as dissolved organics, do not impact turbidity or color but do decrease UVT. Turbidity and UV absorption (the inverse of UVT) are not directly proportional in all waters.

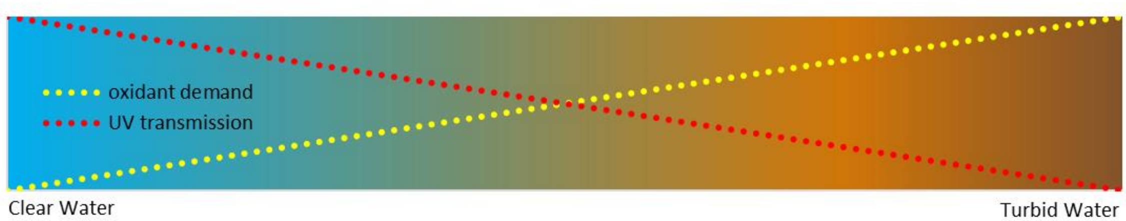


Figure 5 - Turbidity correlated with UV transmission and oxidant demand (credit: Glosten, Inc.)

When considering a UV system, consult with the operator about which uptake port locations have a notably turbid water appearance. Rivers and their estuaries where the substrate is mud or clay will typically have water with higher turbidity and lower UVT (Figure 6). Where reliable information is not available, collect ballast samples in potentially problematic ports and send the water to be tested for UVT.

If a UV system is being considered that may have a reduced TRC in water with low UVT, ask the crew or port engineer whether reduced ballast rates will have commercial impacts for the vessel and its schedule. For vessels where cargo operations drive the time at the dock, it is less likely to be an issue, and a reduced ballast rate in turbid waters may not impact the schedule. Where ballasting (uptake or discharge) drives the time at the dock, or where ballasting cannot be carried out in parallel with cargo ops, reduced ballast rates may have significant schedule and commercial impacts.

Chlorine-based systems, electrochlorination or chemical injection, are impacted by other aspects of water quality. Solids and other dissolved substances in the water may increase oxidant demand and the amount of treatment chemical reacted away prior to effectively treating the water. Systems with low applied TRO doses are more energy-efficient in clean water but may not be able to apply adequate doses in waters that have significant non-biological reactants with the applied chemical.

Filters can also be impacted in very turbid and sediment-loaded waters. The automatic backflushing system may not be able to keep up with sediment removal, triggering an alarm and possibly a system shutdown. These sorts of delays can have major impacts on ballasting and cargo operations. The following measures can be taken to ensure filters remain operational in most water conditions:

- Oversize the filter to a higher flow rate than recommended by the BWMS maker. Impacts on arrangement where filters are to be installed should be considered.
- Install high and low seachests if not already present. This maximizes operator flexibility in various port conditions.

Figure 6 - Ballast water may have low UV transmission or high oxidant demand, Shanghai shown here

https://www.maritime-executive.com/editorials/ballast-water-treatment-at-muddy-water-ports

Fresh Water Considerations

- Consult with crew for frequency of ballasting in fresh water for impacts on electrochlorination treatment and hold time.
- EC systems are not practical for vessels operating primarily in fresh water.
- Bulk chemical systems that are oxidant-based can still treat in fresh water without additional measures being taken.

Freshwater ballasting has impacts on both UV and EC systems. Treatment of fresh water generally requires longer hold times, especially with UV, as the freshwater species tend to be more robust against treatment than brackish and seawater species. If hold time limitations laid out in the TA are complied with, BWMSs should generally perform as expected.

EC is uniquely challenged by ballasting in fresh water. While EC is an effective method of treating fresh water, it requires a seawater source to generate the chlorines and bromines that disinfect the ballast water. For vessels that exclusively operate in sea water, the EC process has a reliable source for generating disinfectants. For vessels that uptake in fresh water, onboard seawater storage must be considered.

Criteria no. 5 from the certificate data (Table 3) defines the minimum feed salinity for EC systems. The higher the minimum feed salinity, the more dependent the system is on having a reliable seawater source.

The vessel's crew and superintendent (or port engineer) can provide information on how frequently the vessel operates in fresh water. If the vessel occasionally takes up fresh water (or low salinity brackish water), and does not have a practical way to ensure sea water or salt-augmented water is consistently stored onboard, EC systems should be excluded from the down-selection process.

EC systems that have a very low feed salinity requirement (1-3 Practical Salinity Units, PSU) may be able to uptake in most brackish/freshwater ports without using onboard seawater storage.

Bulk chemical systems utilizing oxidants such as chlorine dioxide and bulk sodium hypochlorite can treat ballast in fresh water without the treatment process being impacted. Treatment efficacy may still require longer hold times, which can be reviewed in the TA certificate.

Bulk Chemical and Consumables Storage

- Bulk chemicals can be required for both treatment and discharge neutralization, the chemicals of any BWMS being considered for down-selection should be reviewed and understood.
- Vessels that do not visit ports with established chemical supply chains should closely review whether a bulk chemical-based BWMS (or system requiring chemical neutralization) is feasible to support for all vessel voyages.
- Depending on volume of ballast treated and ballast treatment cycles between chemical replenishment, large onboard areas for chemical storage may be required.

Several type-approved systems use bulk chemical for disinfection or onboard disinfectant generation. Useful data on a BWMS's chemical use is not included in most TA certificates, so more front-end research may be required for vessels that are sensitive to chemical storage and use. Vessels with the following characteristics may want to investigate the practicality of chemical use as part of the down-selection process:

- Vessels with limited access to ports with established chemical supply chains.
- Vessels with very large ballast volumes but limited space to safely store bulk chemicals onboard. The amount of storage required depends significantly on the vessel's expected port call locations and frequency of ballast treatment cycles. As part of the down-selection process, review remaining eligible systems for the specific chemicals that are required for normal operation. The use of chemicals may not be a down-selection criterion for many vessels but is important process information to understand before moving to the formal BWMS selection.

Owners of vessels with these characteristics should perform the down-selection considering the following overview information on bulk chemicals:

- Sodium hypochlorite: Also known as bleach, sodium hypochlorite is used by some systems to achieve active substance treatment without the necessary seawater supply or power consumption for EC. Sodium hypochlorite is a very common chemical to procure globally, but may not be available at remote port locations that do not already support a hypochlorite demand.

  US-flagged vessels using sodium hypochlorite must source chemicals that are registered with the EPA to be compliant with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This is not common for most hypochlorite makers, so setting up a reliable supply chain, especially in non-US locations may be challenging.

- Neutralization chemicals: Includes sodium thiosulfate, bisulfite, and metabisulfite, these chemicals are used to bring residual chlorine in treated ballast below discharge standards prior to discharge. Most all active substance-based BWMS use neutralization chemicals to ensure ballast is compliant for discharge.

  These chemicals are less available than sodium hypochlorite, but supply chains can be established through most industrial chemical distributors.

- Other consumables: process chemicals, such as acid for equipment cleaning or TRO reagent and buffering solutions, are common to most BWMS, regardless of treatment method. Special attention should be payed to systems that use hazardous acids, and the vessel owner should consider whether the associated risks and precautions are reasonable for the vessel's operation.

Other process consumables like reagent are often supplied by the maker, and do not present notable challenges to crew health or storage. These chemicals are typically critical to the treatment process and carry a limited shelf life, so procurement should be planned carefully.

Step 6: Available Space and Power

- Perform review of available space and power onboard a vessel and compare to published data for remaining down-selection systems. If published space and power approaches vessel's availability, the BWMS is likely not suitable for the vessel.
- Research beyond published documents is likely required to get useful footprint and power data. Publicly-available data might underrepresent actual values, and not include ancillary equipment and loads, piping in-line installations, and peak operating conditions.

Technologies and makers vary significantly in required footprint and power. Some makers publish basic footprint and power data for their range of treatment capacities. This data should be interpreted conservatively and not taken at face value. Advertised values are not typically comprehensive of the installed system requirements:

- Advertised footprints do not include power and control cabinets, interconnecting piping, and ancillary equipment outside the maker's scope.
- Advertised power requirements may represent nominal operating power rather than peak power and will not typically include all of the ancillary systems required to support the system's operation.

In order to use published footprint and power data to down-select systems, perform the following preliminary exercise:

1. Use the vessel general arrangement/machinery arrangement to select two cursory locations where primary BWMS equipment could be installed. Determine the available square area of each location.
2. Review the most recent vessel load analysis to determine available power for the following operating conditions: in-port, cruising underway. If ballasting is required during any other operating condition, determine available power for these conditions also.
3. Locate published data for remaining BWMS options. Find the closest capacity for the remaining BWMSs and corresponding footprint/power consumption.
4. Compare published footprint and power consumption data to the available square area and available power (at all applicable operating conditions) and determine if either of the published parameters approaches the available amount. If either of the published parameters approaches 75% or more of the available amount, the system is likely not suitable for the vessel.

2.2 Selection Criteria

- A robust, owner-specific selection process should be developed to suit the owner's priorities and commercial position.
- Is it easy to install? Complexity, size, and electrical loads are key factors for selection. Service and maintenance envelopes should be solicited from BWMS makers in addition to basic footprints to inform the evaluation.
- Is it easy to operate? Reliability and operational limitations should factor into the selection process.
- Is it commercially viable? A life cycle cost analysis (LCCA) will inform the owner of the relative financial impacts of each BWMS being evaluated. Commercial terms and lead time can inform whether the maker's plan suits the vessel's compliance schedule.

- ➢ Will the installation be supportable? Readiness of maker to actively support the project and life cycle of the system is important, including design, construction, commissioning involvement, service agreement, and establishment of a service network.

The appropriate model and capacity of each system that advances through the down-selection process should be verified for accuracy with the maker. Once this list of maker models is established, the selection process can proceed.

The selection process cannot be distilled to a standardized method that is universally applicable to all vessels. Each vessel's unique machinery and ballasting arrangements, and each owner's unique commercial factors should drive a custom selection process that prioritizes key selection criteria appropriately. The selection process should use quantitative metrics for rating each system, even if some data inputs are qualitative. A quantitative approach allows for an objective analysis, mitigating biases within the selection team from having an appreciable impact on the process. This section summarizes the key criteria that an owner should build into their selection process and weight appropriately.

Some key documents are necessary from the maker to proceed with system evaluation and selection:

- TA Operation, Maintenance, and Safety Manual (OMSM)
- Equipment arrangement drawings
- Equipment list
- Power consumption data
- Preliminary piping and electrical schematics, specific to vessel
- Example points list from similar project
- Price quote with maker scope of supply and terms

Is the system easy to install?

2.2.1 System Complexity

Type-approved BWMS technologies vary significantly in both the complexity of equipment being installed, and the complexity of operating the system during ballasting procedures. Each system being considered should undergo the following review of complexity, and be scored accordingly in the selection process:

- Equipment arrangement. The equipment arrangement for each BWMS should be reviewed in 3D space, against a laser scan point cloud if possible, to identify whether the equipment can reasonably fit in existing machinery spaces. Service/maintenance envelopes should be solicited from each BWMS maker and incorporated in the equipment arrangement evaluation. Identifying additional space required is critical to a complete assessment of the equipment arrangement.
- Integration with existing ship's systems. A review of each BWMS's required services from existing ship's systems will help address the complexity of the installation itself. Services such as compressed air, ventilation, cooling (freshwater or seawater), and potable water, are common for BWMS integration. A system that minimizes impacts on these ship's systems may have a more streamlined installation process.
- Electrical and piping schematic review. The owner should review preliminary schematics developed specifically for the vessel by the maker. These schematics, while typically not comprehensive at preliminary stages, give an indication of how much cable and piping is required to be routed and interconnected. Systems that have significant auxiliary system interfaces, or many devices with power, control, and feedback wiring, should be scored accordingly during the selection process.

- Operating procedures. The generic TA OMSM for each system being considered will outline procedures for ballasting, de-ballasting, and some routine service operations. The vessel operator should participate in this aspect of system selection, as they can provide insight to how each system's operating procedures will impact vessel operations such as ballast sequences and cargo loading/offloading.
- Major issues preventing successful operation. Technical aspects of some systems may make it infeasible for installation on a particular vessel. For example, a BWMS that requires significant storage of bulk chemicals may not be well-suited for a vessel with extremely limited storage space onboard. A thorough understanding of each BWMS's integration needs is necessary to tease any nonstarters out.

2.2.2 Electrical Loads

The down-selection process should have eliminated any systems requiring more power than available from the electrical plant. Electrical load contributes to the LCCA, described below, but also indicates whether the BWMS may have the following electrical impacts:

- Additional power management. If the BWMS load approaches the available plant power, the crew may be required to actively manage loads during ballast treatment that they would not otherwise. For in-line BWMS, this power management may occur during cargo handling, which are burdened by other existing vessel operations.
- Electrical modifications. The extent of modifications to the existing power and distribution systems will be dictated by the size and type of electrical load required. Even where loads do not approach the available plant power, they may be significant enough to add new distribution hardware, such as switchgear, panels, and transformers.

Systems with electrical loads that will minimize impacts to plant management as well as modifications to the distribution system should be rated as preferred to other systems. Inland and coastal vessels, including barges, which typically have little spare electrical capacity, may be especially challenged to integrate a BWMS without major modifications to the electrical plant. If it appears a repower will be necessary to support BWMS operations, the owner should start planning for these modifications as soon as the need is identified.

Is the system easy to operate?

2.2.3 Reliability

Reliability is a difficult criterion to quantify, particularly during the selection phase before detailed technical information is available. There are some particular aspects of BWMS design that can be reviewed to inform a reliability score:

- Use of standard marine components vs. custom-built equipment. Many makers build their kit from components already well-known and reputed in the maritime industry.
- Redundant configurations. Most major BWMS-specific components of a system are unlikely to be fully redundant due to their size and cost. Within these components, however, redundant configurations are preferred to single points of failure. A system that can operate at partial capacity when a sub-component fails should receive a higher score for reliability. Examples include multi-bulb vs. single-bulb UV chamber configurations, and multi-electrode vs single-electrode EC configurations.
- Points list size. A system's points list directly corresponds to its control complexity. Simpler control systems tend to be more reliable, while complex systems introduce more potential points of failure. The owner should request an example points list from each maker that is representative of the vessel being considered. A review and quantification of each points list can serve as a high-level indicator of system reliability.

2.2.4 Operational Limitations

Operational limitations are provided in the USCG and IMO TA approval certificates and detailed in Section 2.1.

While the down-selection process should have eliminated any systems with limitations not suitable for the vessel, the remaining systems should be evaluated according to the permissible operating ranges of salinity (ballast and feedwater), temperature, hold time, and other parameters.

- Salinity: Most BWMSs allow treatment of all salinities in ballast. Feedwater salinity for EC-based systems, however, is an important operating parameter that may dictate planning for treatment in low salinity. Systems with a lower low-end salinity of feedwater are less likely to require onboard seawater storage, and should be rated as preferred to systems with a higher low-end salinity.
- Temperature: Limitations on temperature only need to be considered after the down-selection if a vessel is expected to operate in extreme water climes, such as the Arctic (cold water), and the Red Sea or Persian Gulf (hot water). Hot water operations may impact the BWMS's ability to cool equipment if it relies on sea water to maintain low temperatures. Seawater temperatures for cooling are not typically included in the TA certificate but are detailed in the OMSM.
- Hold time: BWMSs with shorter hold times in water types applicable to the vessel should be rated as preferable to BWMSs with longer hold times. The owner should carefully consider all potential transits and minimum voyage times and compare them to the hold times required by each BWMS being evaluated.

Other parameter limitations may be discussed in the maker's OMSM, including conductivity, UV transmission, and pressure. Strict throughput limitations should also be considered, especially for vessels like tankers and bulkers where time at the dock is dependent on the ballasting rate on uptake and/or discharge.

Is the system commercially viable?

2.2.5 Life Cycle Cost Analysis (LCCA)

The preceding selection criteria focus on system physical characteristics. An LCCA uses the physical characteristics of each BWMS to develop a comprehensive evaluation of the estimated cost to the owner. The level of detail to build into the LCCA should depend on the owner's financial position, project funding, and the commercial status of the vessel. Some degree of LCCA is recommended for all BWMS selection processes. The National Institute of Standards and Technology (NIST) Life-Cycle Costing Manual (Reference 23) is a useful resource for building the LCCA, and provides a method for calculating **present value** of each BWMS installation over the life of the project. The LCCA for a BWMS installation should integrate the following cost considerations at a minimum:

- Capital investment. The one-time cost of equipment, engineering, class involvement, construction, commissioning, administration, and other factors to complete a compliant BWMS installation.
- Earnings loss. Loss of earnings for out-of-service time due to BWMS installation. This should be distinguished from out-of-service time already expected for projects separate from the BWMS installation.
- Fuel oil cost. Operational cost of fuel to account for increased power consumption by the BWMS and its support systems.
- Chemical expenses (where applicable). Operational cost of supplying chemicals required for the BWMS process.

- Operation, maintenance, and replacement expenses. Operational cost of operating and maintaining the system, including additional labor, training program, spare parts, service, sampling, and end-of-life component replacement.

The owner should develop investment terms and assumptions in coordination with their financial department to ensure LCCA results reflect the company's financial strategy and objectives. Considerations should also be made on the savings of adapting one make of BWMS for several vessels or fleet-wide, where practical for each vessel's operation.

At the completion of a preliminary LCCA, a sensitivity analysis should be performed to understand how each cost factor impacts the outcome, and help the owner understand the relative impact of different assumptions made.

2.2.6 Lead Time and Commercial Terms

Lead time is a key factor for most projects in determining whether a specific BWMS can realistically be installed. If BWMS selection occurs far enough in advance, this should not be a concern for most BWMS makers. If schedule is condensed, lead time should be a deciding factor in the selection process: can each maker deliver on time, or not?

The standard commercial terms offered by each maker can lend insight into the level of service and support the owner should expect throughout the project. While perhaps not a heavily-weighted factor in the selection process, knowing the commercial terms can help set the owner's expectations for the maker and help in planning design and construction phases accordingly.

Would the installation be supportable?

2.2.7 Maker Support of BWMS Life Cycle

BWMS makers have varying degrees of standard and available support a) prior to and during the sale of the system, b) after the sale and throughout the design and installation period, and c) after commissioning of the system. The maker's willingness to participate in the overall BWMS project should be considered as an important factor in the selection process.

Some key elements of maker support to consider are:

- Responsiveness, cooperation, and transparency during the sales process. These traits can be indicative of the amount of support to be expected post-sale and through the life of the installation.
- Planned involvement in design, construction and commissioning phases of project. Solicit each maker for their planned level of support for each of these phases.
- Service agreement. What options for service agreement can the maker provide? The owner should consider these for each maker against their expectations.
- Service network. An established network for providing remote troubleshooting, repair services, supply chain for spare parts and consumables, etc.

2.3 BWMS Contracting

- ➢ Scope of supply versus the overall equipment required for the installation. Determine who is supplying equipment not part of the maker's standard scope prior to purchasing the BWMS.
- ➢ Adequate commissioning time included by the maker contractually. Request commissioning schedules from previous projects and compare with maker offer for on-site support.

- Pre-commissioning support from the maker to ensure smooth transition from construction to commissioning.
- Spares kit in the initial purchase contract.
- Dedicated training provided by maker, administered on-site with crew. Work with the maker to also provide a desktop training course to facilitate crew changes.

Once a BWMS maker and system is selected, contracting can proceed. Contracting should generally proceed according to the following steps:

1. Owner sends requirements to maker, including any details developed during the selection process.
2. Maker returns budget or full quote for equipment and services.
3. Owner and maker engage in question-and-answer discussions until owner is comfortable with all aspects of the quote and scope.
4. Owner performs diligence review of commercial terms and conditions.
5. Commercial terms are negotiated between owner and maker.

2.3.1 Scope of Supply

The maker's proposed equipment scope of supply should be reviewed closely with the project naval architect and compared with equipment indicated in piping/electrical schematics and the OMSM. Many makers seek to limit their scope to only equipment that was included in the TA, reducing the cost and increasing the profit margin of each sale.

Ancillary equipment outside the TA is often required for successful operation of the system, and the maker has the best knowledge for specifying the correct equipment. Some common equipment that is not included in the maker's standard scope of supply but critical to operation:

- Electrical transformers for converting ship's power to power suitable for the BWMS equipment.
- Auxiliary pumps, such as filter backflush pump, cooling loop pump, and eductor pumps.
- Heat exchangers.
- Ballast discharge sampling port.

The owner has two options for procuring additional equipment:

1. Lower risk/higher initial cost: request the maker to include some or all of the additional equipment required for the BWMS installation.
2. Higher risk/lower initial cost: specify additional equipment in the shipyard's scope of supply, minimizing the maker's scope.

The project naval architect can assist in evaluating which equipment could be readily procured by the shipyard, and which should be included in the maker's scope. The best approach is often a balance of some equipment outside the TA being supplied by the maker, and some being sourced and supplied by the shipyard.

The owner should have one maker-recommended spare parts kit included in the scope of supply. If the recommended spares kit seems insufficient to the owner, additional spares should be requested for incorporation in the maker's scope.

- Treatment dose monitoring equipment, such as a TRO monitor for chlorine-based systems, is highly recommended to be included as spare with the main scope of supply. This equipment is critical to successful BWM, prone to fail if not installed, operated and maintained exactly as specified, and often carries long lead times for replacement.

Ordering of some spares can be reduced if the maker verifies that critical components and equipment are kept in their inventory for warranty or owner-responsibility replacements.

2.3.2 Commissioning

Many makers include a standard commissioning line item in their overall price. The standard commissioning may not be suitable for a specific vessel installation and should be reviewed with the project naval architect to determine if any scope modifications should be made. The total duration of commissioning requiring technician attendance from the maker is not usually less than one week.

A major issue encountered on many BWMS installations is the lack of installation readiness when the maker's commissioning team arrives for commissioning. To avoid this circumstance, the owner can contract the maker to attend during the pre-commissioning period when the shipyard is completing the construction and pre-testing procedures for new and modified systems. Maker technician attendance during pre-commissioning allows the technician to identify any critical issues early and gives the shipyard and owner access to the technician for answering questions and surveying the installation.

Maker commissioning does not include IMO efficacy sampling at commissioning, which is pending adoption by IMO under BWM.2/Circ.70 (Reference 11) and already required by some flag administrations. Efficacy sampling at commissioning is solely the responsibility of the owner, unless explicitly contracted with the maker in addition to standard commissioning.

Details on implementation of commissioning efficacy sampling by flag are provided in Section 4.5, and planning for all vessels flagged under BWM convention signatories and contracting states is discussed in Section 5.4.

2.3.3 Shipping Terms

Shipping terms are typically linked to international standards such as Incoterms 2020. Within such standards, there are specific options and terms that affect responsibility and scope of relationship between the seller and buyer. Depending on where the BWMS is manufactured and packaged, the responsibilities of the US vessel owner and the maker can have significant impacts on cost to the owner to complete delivery. Unless the shipyard is known at the time of contracting with the BWMS maker, most makers will only offer Ex Works (EXW) or Free on Board (FOB), leaving the majority of shipment risk with vessel owner.

If the owner has its own shipping division or uses a reliable ship manager to make shipping arrangements, EXW or FOB from the maker is generally acceptable. If the owner has limited experience procuring equipment from overseas (where many BWMS are manufactured), it should consider contracting the maker to make additional shipping arrangements after shipyard planning is more mature.

2.3.4 Warranty

Few BWMSs on the market have been installed broadly enough for owners to be assured that their system will operate reliably and without some degree of immediate malfunction. As such, the maker warranty is critical to ensuring success of the project after the vessel leaves the shipyard.

Many makers are offering one-year warranty for repair/replace/refund of any damaged parts due to material, design fault, or workmanship, and extended warranty for specific components that are more difficult to replace. The owner should pursue similar terms at a minimum but determine if other makers' guarantees can be used to negotiate better terms with the selected maker.

2.3.5 Life Cycle Support

After-delivery services are key to ensuring a BWMS maintains compliant operation past commissioning. The owner should request all details on field services provided by the maker and verify that the maker has representatives in the vessel's planned regions of operation. This should include contact information, and the owner is encouraged to reach out to likely service representative to understand service capabilities.

A service period may also be included in the warranty to ensure the BWMS can be serviced at minimal cost to the owner for a period after installation.

2.3.6 Maker Training

Prior to commissioning, training is generally administered by the BWMS maker. The maker holds the most relevant expertise for preparing the crew for successful operation of the system once the maker has turned the system over to the vessel crew. Operation of the BWM for IMO commissioning testing and sampling, for example, is to be carried out by the crew.

Crew training should be included in the contracting for the system purchase. The owner should confirm that the maker will perform adequate training on-site for the crew that is present during the shipyard period and commissioning. Training days should be accounted for separately from commissioning days, as attention to training may otherwise be compromised to ensure a successful commissioning.

Many operators struggle to prepare crew changeouts for operation of the new BWMS. For crewmembers on leave during installation and commissioning, they may have a limited opportunity understand operating procedures and safety concerns. To support training beyond the on-site program administered in the shipyard, the owner should work with the maker to set up a desktop training course as part of the contract. A desktop training course can be made available for all of the vessel's crew changes, making use of video conferencing and virtual simulation of the BWMS controls system. Crewmembers will be better prepared to understand and operate the system when they arrive onboard.

Details for maker-provided crew training, as well as sustained internal training by the owner, are provided in Section 6.

3 Shipyard Planning

“Spend as much time preparing as possible as the systems are so complex and impact so many areas of the ship. It is imperative to achieving on time installation in the shipyard.”

-SOCP Member, on shipyard planning

Prior to any planning of the BWMS installation, a timeline should be established to ensure all critical-path efforts start and finish in-line with the project needs. An example timeline is provided here:

18 months prior to installation:	Concept development and BWMS down selection process.
12 months prior to installation:	Detailed vessel survey and 3D scanning. BWMS final selection.
6-8 months prior to installation:	Order BWMS, plan pre-fabrication of piping/structure.
4-6 months prior to installation:	Proceed with pre-fabrication of piping/structure.
3 months prior to installation:	Completion of detailed design and review with selected shipyard.

3.1 Regulatory Design and Plan Review

- Class requirements for BWMS design submittals are provided in each class’s BWMS guide.
- The planned submittal list should be introduced to class prior to the design proceeding to identify any required documents missing from the design.
- Manage class review by specifying which documents are for review or information only.
- The regulatory design submittal serves as basis for shipyard contracting and should be developed in conjunction with a detailed work specification.

Design plans must be approved by the vessel’s class as part of class certification, but the design should be submitted for plan review well in advance of the shipyard period. Each class society has a list of required design documents. In addition to drawings specific to the BWMS install, class will generally require an update to the lightship weight estimate, and any potential impacts on vessel stability.

A typical list of documents required by class and a corresponding submittal list is provided in Table 4. The owner should verify their vessel’s class drawing list prior to planning the BWMS installation design.

This list of design documents, considered the regulatory design, should also serve as the minimum design package included in the shipyard contract. The project naval architect should additionally develop a detailed work specification for the shipyard to fully scope the project, providing any information not included in the drawing package.

The importance of developing a detail design for piping and structural elements is discussed in Section 3.3.

Table 4 - Example ABS list of required documents and corresponding submittal documents

ABS Required Document	Satisfying Submittal Document
General arrangement drawings of the BWMS	BWMS Equipment Arrangement Drawing, including locations
Arrangement and capacity of ballast tanks and pumps	Vessel ballast system drawing and capacity plan drawing, provided by way of reference
Ballast piping system drawings	Piping and Instrument Diagram (for approval) and Piping Arrangement & Detail Drawing (information)
Location of ballast water sampling facilities	Piping and Instrument Diagram
Electrical circuit drawings and main power cable drawings	Electrical One-Line Diagram (for approval) and Interface System Block Diagram (information)
Power calculation document	Electrical Load Analysis and Short Circuit and Circuit Breaker Coordination Review
Hazardous area installations and hazardous area plan	Updated vessel hazardous area plan, if applicable
Control, monitoring, and safety system documentation	*Provided by BWMS Maker:* TA OMSM and vessel-specific OMSM
Documentation in accordance with Section 4-9-3 *Marine Vessel Rules*	↓
Local instrumentation arrangement plan	Piping and Instrument Diagram
Structural plans	Structural Modifications Drawing
Storage tanks and day tanks containing chemicals and preparations used to treat ballast water	*Provided by BWMS Maker:* TA OMSM and vessel-specific OMSM
Safety documentation for hazardous chemicals	↓
Leakage detection system and safety features associated with the generation of toxic or flammable gases	↓
Safety assessment documentation, where applicable	↓
Personnel Protection Equipment arrangements	↓
Firefighting measures	General Equipment Arrangement Drawing
Ballast water management plan	Vessel-specific Ballast Water Management Plan (In accordance with MEPC 127 (53)
BWMS operating and safety manual	*Provided by BWMS Maker:* TA OMSM and vessel-specific OMSM
Shipboard function test plan for sea or quay trial	↓
Ballast water record book	Vessel-specific Ballast Water Record Book (information)
BWMS maintenance book	*Provided by BWMS Maker:* vessel-specific OMSM

It is key for class review to remain focused on the BWMS installation itself. Because most installations impact many aspects of the design, class may seek out an expanded scope to review other aspects of the vessel's design against rules. To avoid unnecessary review by class, the following steps should be made in coordinating with class:

1. Provide project introduction letter clearly communicating what documents are to be submitted, and which documents are for review versus which documents are provided as information only.
2. Align document titles with class-required lists as closely as possible and show whether drawing is for approval or for information.
3. During submittal, communicate aspects of the vessel that are not impacted by the BWMS install, including:
    a. Vessel stability if aggregate weight change is less than 0.5% of lightship.
    b. Portions of reference vessel drawings that are shown for context but not involved in the install. Examples include electrical load analysis, electrical one-line, auxiliary piping systems.
    c. Hazardous area plans, if applicable.

3.1.1 NVIC 10-82 Review

- ➢ NVIC 10-82 allows ABS review and approval of BWMS installs on behalf of USCG. For vessels classed ABS, review under NVIC 10-82 can be requested from the USCG sector where modifications are planned.
- ➢ Foreign flag vessels typically rely on vessel's class society for installation oversight.

USCG accepts ABS review of BWMS installs under NVIC 10-82. During BWMS installation design and prior to contracting for plan submittal, the US vessel owner's naval architect should submit a request to the USCG sector where modifications are planned to take place. If the location of modifications is not known prior to plan submittal, the vessel's homeport Sector may approve NVIC 10-82 review.

3.1.2 Optional Class Notation

Classes offer additional ballast water treatment notations such as BWT or BWT+ (ABS) or BWM(T) (DNV GL) that cover design and practices above and beyond what is required by regulation.

These notations are at an owner's option. Guidance information for gaining additional class notations can be found in References 17 and 20.

3.2 Shipyard Selection

BWMS installation projects are complex, impacting a diversity of systems and areas throughout the vessel. For many shipyard periods involving a BWMS install, it may be the most significant modification occurring during construction and may drive the total duration of the out-of-service period.

If a BWMS installation is treated as a standard repair, with the shipyard selected based on conventional repair requirements, the BWMS installation may not be successful. The BWMS installation period should be approached similarly to a major conversion, with shipyard review and selection being the critical first step to a successful project.

The capabilities of the shipyard are a critical consideration in not only shipyard selection, but in the owner's preparation. This is true for any shipyard, whether based in the US or internationally. Some shipyards will have highly capable engineering, planning, and purchasing teams that can execute a basic/contract design. Other shipyards have no engineering capability and can only purchase basic piping and structure materials. While it is possible to have a successful project at either end of these capabilities, they each demand very different levels of design, owner-furnished equipment and materials, planning, and on-site support.

3.2.1 Shipyard Engineering Capabilities

- Select a shipyard that retains in-house engineering or can demonstrate past success working with an engineering contractor on complex projects.
- Alternatively, provide all detail and production-level design details to the shipyard, and provide owner/engineering on-site support throughout construction.
- Determine on-site support level based on the shipyard's capabilities.

A BWMS installation, when done in a precise and timely manner, requires multiple levels of design that includes concept, contract/regulatory, detail, and in some cases production. It is now common practice to provide a single integrated package of all of these aspects that one can flip through like a book. This 'book' is often integrated with a detailed specification that has 3D images of the envisioned 'as-built' arrangement for the installation team. This serves multiple purposes:

- The vessel class (or other recognized organization, RO) survey uses these plans to verify key details and check-off open 'survey' comments.
- The purchasing team uses the equipment list to procure equipment and materials, and plan lead times that could impact schedule.
- The installation team uses the details and production drawings to perform the installation.

Therefore, the owner-delivered engineering package must either include 100% of the necessary details, or the selected shipyard must have the capability and the contractual obligation to provide them. In the selection process, the shipyard should be provided with the intended level of engineering from the owner. All engineering expected from the shipyard must be explicitly stated in the construction contract and sample engineering and standard details should be received and considered.

Many shipyards have reduced their engineering department capabilities in recent decades, leaning on contractors for developing detailed design drawings or simply forgoing a formal detail design process. A shipyard should be selected based on their engineering capabilities, their demonstration to carry out complex projects successfully with support of engineering consultants, or both.

3.2.2 BWMS Install Qualifications

- Past performance on BWMS installs is critical to the selection process.
- Customer feedback specific to BWMS installs should be solicited and incorporated in the selection process.
- Shipyards with established piping and electrical departments streamline construction.

Prior experience with a BWMS installation project is not mandatory, but strongly advised when selecting a shipyard. Shipyards undergo substantial lessons learned on their first couple of BWMS installations, and a number of shipyards, US and foreign, have proven their ability to execute. Experience with the same make and model is an added benefit, though more difficult to align with other shipyard selection factors. The owner should request examples of past BWMS installs, as well as feedback from past customers on those projects.

Shipyards with established piping and electrical departments also can contribute to the success of a project. If a shipyard does not have these capabilities, it should be established contractually that approved subcontractors will be hired to supplement the work force. Where this is the case, the owner should consider increased on-site support to maintain oversight of the construction and all involved contractors.

3.2.3 Project Management

- BWMS installations require a dedicated project manager from the shipyard, and benefit from the shipyard having a dedicated planning department.
- A detailed construction schedule, specific to the BWMS installation, should be developed by the shipyard and approved by the owner.
- Communication between the owner's naval architect and the shipyard should be supported throughout shipyard planning and construction.
- Pre-bid shipcheck from shipyard representatives gains commitment from the shipyard and introduces unique challenges of the project.

The shipyard must treat a BWMS installation as a high-priority project for it to be successful and avoid major delays. A project manager dedicated to the BWMS installation is necessary. Despite the complexity of BWMS installs, they are often treated as a routine modification by the shipyard. While other major modifications, such as propulsion, are viewed as greater schedule risks, a BWMS has been found to introduce at least equal schedule risk to a shipyard period, and often greater risk due to both owner and shipyard inexperience with BWMS installations. Some shipyards carry a dedicated planning department, which offers an advantage in their ability to carry out a BWMS installation.

The owner can contractually require a dedicated project manager. Further, the owner should require a detailed construction schedule be provided and maintained specific to the BWMS project. The construction schedule can be an early identifier of whether the shipyard has adequately planned all aspects of the project and understands the extent of the work required. While the schedule is useful for tracking the project's progress, it is fundamental for identifying any major shipyard planning issues at the project's outset, especially conflicts with other repair work under contract with the shipyard.

It is also recommended to formalize communication between the BWMS project naval architect and the shipyard to facilitate quick resolution of technical issues. This can also be established contractually by requiring a project communication plan from the shipyard and hiring the naval architect for remote shipyard construction support. On-site support by the naval architect is not typically required if the owner can provide adequate support by its own staff.

While not a necessity, the owner can arrange pre-bid shipchecks with shipyard representatives to ensure each shipyard understands unique aspects of the project and vessel. This will be more practical for some vessel trades than others. A shipyard's willingness to participate in a shipcheck can also be in an indication of their commitment to being a successful partner on the project.

3.3 Strategies for Limiting Time Out of Service

3.3.1 Class Approval Planning

- Complete regulatory design for class plan approval well in advance of detail design and construction to ensure adequate time to resolve all technical comments before major design changes are required.
- Close all technical comments before shipyard contracting proceeds.
- Establish a plan and lead person for resolving surveyor comments. A project naval architect with past BWMS installation experience will have established methods for tracking and resolving comments and is suitable for this role.

- Prepare all equipment manufacturer approvals and certificates that are required by class in advance.

Ahead of all construction, the US vessel owner should complete a clean regulatory design that minimizes technical and surveyor comments. If technical comments are outstanding during detail design, and a clear plan has not been established for resolving surveyor comments prior to construction, completion of construction and commissioning are likely to be delayed.

Of particular importance is understanding any modifications to the electrical plant that may be necessary to accommodate the BWMS operation. In some circumstances, the plant size may need to be increased where there is not sufficient spare capacity during ballasting and deballasting operations. Replacement of ship service generators and the potential impacts on emissions certification (such as upgrading to EPA Tier 4/IMO Tier III) should be planned in parallel with the BWMS installation design. A repower could require a higher engineering burden than the BWMS installation itself.

The successful execution of BWMS class plan approval and eventual survey approval requires the regulatory design to be submitted well in advance of detail design and shipyard solicitation, and the ownership of managing all class comments to be clearly defined. The project naval architect is usually suitable for this responsibility, having developed the regulatory design and knowing the class review process. A project naval architect with past BWMS installation experience will have established methods for tracking and addressing class comments, ensuring issues are resolved well before construction proceeds.

Beyond class requirements for the BWMS installation, class or flag typically require type approvals, certificates, and other documentation for equipment part of the install to meet class rules (e.g. overboard shell valves). A list of the equipment requiring such documentation should be developed as part of the regulatory design and provided to the shipyard to be included in their procurement process.

3.3.2 Detail Design

- Developing complete piping and structure details prior to the shipyard period avoids schedule delays and change orders. Accurate modeling of valves and large instruments is necessary to ensure interferences are identified and resolved.
- Detail design provides opportunity for maker and engineer to review construction plan and identify any misconceptions of the BWMS and its TA.
- 3D laser scanning is recommended to support detail design for most installs to mitigate unforeseen issues and schedule delays during construction. Performing the laser scan survey between concept and regulatory design will further reduce risk on the project.
- A transport plan ensures routing and landing major equipment into place has been reviewed and confirmed feasible with the vessel's existing hatches and machinery spaces.

US vessel owners that have completed one or multiple BWMS installations have agreed on a universal aspect of a successful project: performing detail design of the installation. Detail design that is focused on piping arrangements and structure assemblies ensures that the contract design can be implemented as planned, mitigating the risk of unknown complexities that will arise during construction. Electrical and controls design are of equal importance, as these often fall outside the shipyard's capabilities. Controls design and integration are detailed in Section 3.4.

3D laser scanning is now used during planning on most successful BWMS projects and can significantly reduce unforeseen issues during construction. The upfront cost for performing a laser scan survey will prevent many added costs and schedule delays during the construction period.

Detail design should proceed prior to shipyard contracting so that the production details can be included as contract documents for shipyard bid. If the detail design proceeds after shipyard contracting, it still facilitates a smooth and timely construction period, with major conflicts being resolved during the shipyard's planning period.

3.3.2.1 Piping

Piping installations should be modeled in 3D, using CADMATIC, Rhino, ShipConstructor, or similar software, and imported to laser scanning point clouds to identify physical interferences and impacts on service/maintenance access. Large piping (4" and above) is necessary, but smaller piping (1" – 3-1/2") is recommended to have a complete design model of the planned modifications.

A key element of piping modeling is accurately representing in-line piping components and instruments. Valve operators and powered actuators are often an overlooked or underestimated aspect of piping arrangements and can cause a complete re-work of a production design if not adequately accounted for. Pipe hangers and supports must also be considered, as mounting of a 3D route can be challenging if not planned in advance. In spite of compact spaces for retrofits, changes in pipe direction should be kept as gradual as possible to reduce turbulence and air entrapment. Further, high-point vents and low-point drains should be planned for maintenance and shutdown activities, as well as freeze protection for piping exposed to weather.

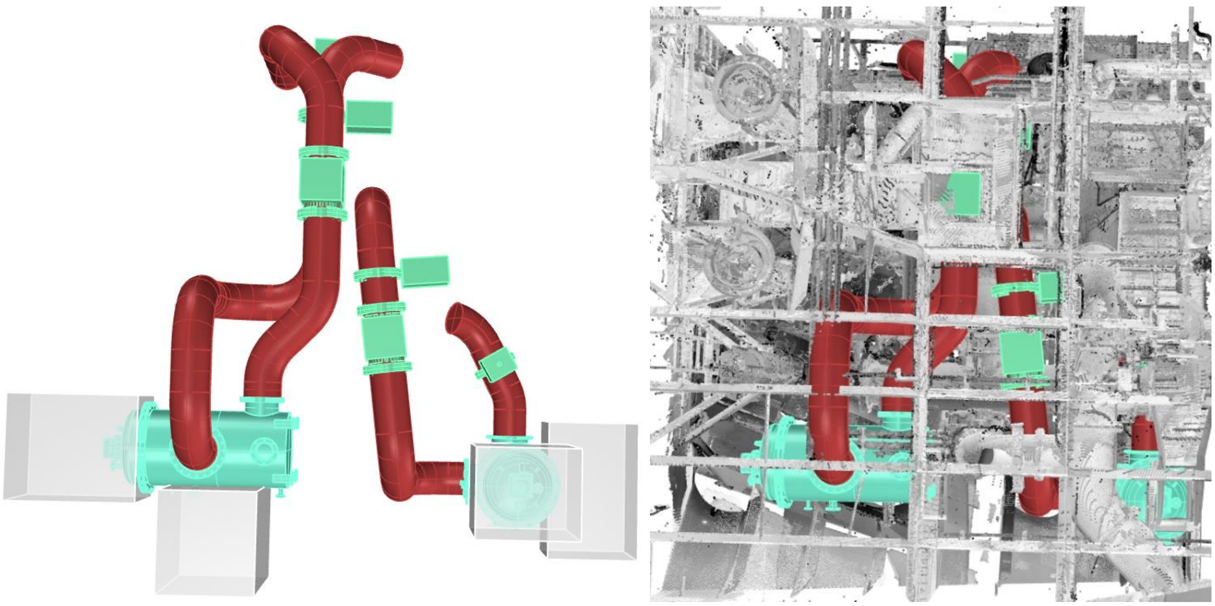


Figure 7 - Detail piping design, shown isolated on left and integrated in 3D laser scan on right

3.3.2.2 Structure

The required structural foundations for equipment will establish the exact location of the equipment, which can vary from what is originally planned during feasibility and contract design. Designing foundation details ahead of construction will ensure several key risks are avoided with equipment installation.

- Design efficiency: shipyard foundations are typically over-designed, requiring more structure and space than an optimized design. If the foundation is developed in advance, a minimal amount of structure can be used, using tools like finite element analysis (FEA) to predict loads and stress, and the foundation can be designed to accommodate the best location for accessing and servicing the equipment. This is especially important for equipment that has a control interface, requires monitoring of instruments, or loading of consumables for the treatment process.

- Interface points: without detail design of foundations and other supporting structure, the interface with existing structure usually cannot be finalized. With BWMS equipment often having to be installed in limited locations where space is available, the nearest structure may not be simple for building a foundation from. Shipyards may be challenged to come up with a solution without experienced 3D structure design and FEA analysis for verification. This could result in the shipyard requiring a modified or alternative location that will complicate the installation, and likely have cost and schedule implications.
- Transport Plan: an exercise often overlooked during detail design is the procedure for loading major equipment into its final location. Hatch openings, rigging arrangements, and conveyance route through machinery spaces must be verified during detail design. If a feasible conveyance route cannot be achieved without risking damage to BWMS or vessel equipment, the shipyard must plan alterations to ship structure and interferences in advance of loading equipment onboard. Addressing the transport plan during detail design reduces delays and costly modifications during construction.

3.3.3 Pre-Construction on Piping and Structure

- Detail design allows for prefabrication of piping and structure in advance of the vessel arrival.
- Shipyard periods for BWMS installs can be condensed significantly if piping and major foundations are prefabricated for quick installation.
- The owner should plan to have oversight of pre-fabrication efforts.

If detail design is completed well in advance of the scheduled shipyard period, a shipyard can proceed with prefabricating large piping and foundations. It is possible for prefabrication to proceed at a facility separate from the intended project shipyard. When built near an arrival port, the finished parts can be loaded on the vessel to accompany underway. This can facilitate construction to start for the BWMS installation prior to the final shipyard selection, as fabrication is independent from the shipyard location.

The owner should plan to have reasonable oversight of prefabrication efforts and regular meetings with the fabricator, which will help mitigate rework when the shipyard period starts. Interface drawings and dimensions of BWMS equipment should also be provided by the maker to the pre-fabrication contractor to ensure fit-up is correct at full system install.

3.3.4 Riding Gang Installation

- Riding gang installation does not require detail design to be completed as long as effort is closely coordinated between installer and the project naval architect.
- Similar to pre-construction, shipyard periods can be condensed with the use of riding gangs, and risk of unforeseen delays can be mitigated.
- Labor groups trained for BWMS installations are available for riding gang work and should be targeted if riding gangs are to be used.

Riding gang installation occurs *in situ*, on the vessel while it is underway and operating in its trade. Riding gangs can be contracted globally and have been trained to specialize in BWMS installations. The labor rate for riding gangs is often lower than shipyard rates, both in the US and internationally, as they don't bear the overhead burden of conventional shipyard workers.

The only limits to riding gang installation are very large piping or structural members that cannot be safely handled and fitted, and the availability of BWMS equipment for final fit-ups. If delivery of BWMS equipment can be arranged in advance of the shipyard period, further riding gang work can be completed.

If a riding gang is selected for advance construction, the outfit should be verified to have BWMS installation experience. The nature of the work is different enough from normal underway repair work, and there is now an established riding gang work force that can be utilized.

3.3.5 Owner On-Site Support

- The owner should plan for an on-site representative to maintain oversight of the project and coordinate communication between all involved parties.
- The on-site representative should be well-versed in the design package and BWMS details specific to the vessel.
- Additional on-site support from the project naval architect and BWMS maker may be necessary given the nature of the install. At a minimum, remote construction support from both parties should be planned, and contracted as necessary.

Most successful BWMS installations have required some level of on-site representation by the owner to maintain oversight of the construction, and coordinate efforts and communication between the various parties necessary to carry out the project.

As discussed in Section 4, the owner (or its representatives) should take the lead on coordinating communication between the shipyard, BWMS maker, and class. This requires complete review of the design package being implemented by the shipyard, understanding of the BWMS TA certificate and OMSM, and specific characteristics of the BWMS for the subject vessel.

In some cases, the owner should coordinate on-site support from the project naval architect, as well as a maker pre-commissioning representative, to augment their duties and ensure all aspects of the project are being monitored. This added support is particularly important for very complex designs, such as multiple systems installed on one vessel or heavy integration with existing vessel controls, or installations where the maker has few completed projects with their BWMS.

The BWMS maker will typically be available for remote support of construction at a minimum. If the owner determines that no on-site support from the project naval architect is required, they should still contract some level of remote support to aid with shipyard questions, class surveyor comments, and any unplanned engineering tasks that arise.

3.3.6 Continued Crew Involvement

- The crew can identify arrangement and engineering issues that the owner or project naval architect are not aware of.
- As-built conditions vs. drawings for piping and electrical systems need to be verified with crew before designs are finalized.
- **Important**: a crew member, preferably a member of the engine department, should be assigned to manage the BWMS installation during the shipyard period.

Crew involvement in BWMS planning should not stop at BWMS selection, or even completion of contract design. The crew is especially valuable during detail design discussions, where their in-depth knowledge of the vessel arrangements and systems cannot be substituted by vessel drawings or even laser scans.

Some of the most valuable input from the crew will come during discussions on piping and electrical arrangements and electrical modification details. Electrical systems are the most likely aspect of an installation to differ from expected conditions, and variances can cause unexpected delays late in the installation process if not identified early. The crew can verify the actual availability and rating of panels and breakers, determining whether more significant electrical modifications need to be planned.

After the vessel arrives in the shipyard for the installation phase (or completing the installation, in case of pre-construction or use of a riding gang), an on-site crew member should be assigned to the BWMS install, to coordinate with the shipyard's manager and the owner's on-site representative. The assigned crewmember and on-site representative should be different individuals to ensure the BWMS installation is receiving adequate oversight throughout the installation.

3.4 Shipyard Pitfalls

Many potential pitfalls of the BWMS shipyard installation are common to other shipyard projects, but many are unique to ballast water treatment or exacerbated by the complexity of the BWMS design. The most common BWMS shipyard pitfalls and strategies for prevention are provided here.

3.4.1 Scope of Supply: Owner-Furnished vs. Shipyard-Furnished

- The owner should fully understand the extent of the maker's equipment scope.
- Create a list of all equipment uniquely specific to the BWMS and not furnished by the maker. Verify requirements for this equipment.
- Determine which BWMS-specific equipment should furnished by the shipyard and which should be furnished by the owner.
- Explicitly detail equipment designated for shipyard scope to ensure material, performance, and regulatory characteristics are met, and emphasize lead time and schedule requirements to the shipyard when coordinating their equipment list.

Most BWMS makers have limited their standard scope of supply to the basic set of equipment that was verified during the TA process. Any equipment that was not reviewed by an independent lab as part of the TA is typically excluded from the scope of supply, minimizing the cost to the maker of supplying the BWMS. Similarly, shipyards will seek the least expensive option for shipyard-furnished equipment that meets the specifications as written.

Despite not being included in the maker's scope of supply, many pieces of equipment are critical to the treatment process and allow little variability for characteristics or arrangement. In some cases, no substitution or modification is possible due to regulatory requirements (such as a class-approved gas detector).

To ensure all equipment is properly specified and delivered by a capable party, the owner should follow a standard process for reviewing equipment lists and managing scope of supply:

1. Develop a *project equipment table* from the BWMS equipment list and documentation. Verify equipment list with BWMS drawings and identify any disparities or omissions.
2. Consult with maker on disparities or omissions between the BWMS equipment list and drawings. Categorize all equipment items as furnished by maker or furnished by others. Detail material, performance, and regulatory requirements for each piece of equipment furnished by others.
3. Return *project equipment table* to maker for verification of scope and details of equipment furnished by others. Update *project equipment table* with maker.
4. Define equipment furnished by others as either owner-furnished or shipyard-furnished. Consultation with the project naval architect can ensure equipment is appropriately assigned.
5. Review *project equipment table* with each revision or update to the maker document package and update in accordance with any changes. The maker's scope of supply can change dramatically from order to delivery, and changes can create gaps in the owner and shipyard's defined scopes of supply.

When the *project equipment table* is completed, incorporate in the shipyard contract specifications to clearly specify the equipment being supplied by the shipyard. If the owner has preference for make and model of additional equipment being supplied by the shipyard, these details should be included in the contract specifications.

3.4.2 Controls Integration

- A vessel interface system (VIS) is necessary for compliant operation but is outside the BWMS maker's scope.
- A separate work scope defining controls integration should be developed and contracted, preferably as a direct contract with vetted automation engineer.
- The automation engineer should be contracted both for VIS design and fabrication as well as pre-commissioning testing of all electrical and controls hookups.
- A hook-up list with termination details is necessary to ensure successful, timely completion of electrical systems.
- Remote shutdown for the BWMS is recommended and may be required by class.

BWMSs are required by USCG and IMO rules to be automated, requiring little crew interaction after the treatment process has initiated. The BWMS may control existing ship's equipment such as pumps, valves, and ventilation. Further, the BWMS is required by regulation to interface with the vessel's alarm and monitoring systems (AMS), including manual and automatic shutdowns, and must be monitored from a staffed location such as the Engineer Operating Station (EOS). A vessel interface system (VIS) is necessary to complete these controls and monitoring interfaces but is not well-defined by makers due to the unique needs of each vessel's design. The VIS, typically living between the vessel's existing control infrastructure and new dedicated hardware, requires design and planning of similar complexity to the physical BWMS install.

A separate work scope should be developed for defining controls integration of the BWMS. The number of control devices can number in the hundreds, and input/output (I/O) points in the thousands for a typical BWMS installation, requiring careful planning and understanding of how the BWMS interfaces with existing ship's systems and new equipment separate from the BWMS. Any hardware required to complete the VIS must not only function as intended, but also meet all class and flag requirements. A competent automation engineer should be contracted early in the project to be informed on the design development and to plan the controls integration accordingly. It is recommended for the owner to contract with an automation engineer directly to allow oversight and close coordination with the project naval architect. Similarly, the automation engineer can be contracted through the naval architect, ensuring seamless transfer of design information.

In addition to electrical drawings required for class submittal, a hookup list should be developed between the naval architect and the automation engineer, with all cables and termination details provided. This document should be included in the shipyard contract to establish the completion criteria for electrical installations.

The BWMS should be integrated with a remote shutdown in the case of an emergency or hazardous situation. The remote shutdown can either be integrated into the Integrated Monitoring, Alarm and Control System (IMACS) at the EOS, or as a physical shutoff switch at the EOS. The method should be based on the level of integration with the vessels IMACS or AMS system.

Class may require a shutdown depending on the potential hazards associated with the BWMS, so planning this modification in advance can avoid a comment-relayed delay in completing commissioning.

3.4.3 Tank Cleaning

- Unless explicitly exempted by the BWMS maker as part of the TA, ballast tank cleaning is advised for all BWMS installations. Tank cleaning should be included in the shipyard scope and construction schedule.
- Tank cleaning should be completed prior to the function test but after any pre-commissioning ballasting. After pre-commissioning, raw water ballasting should be limited to sea-to-sea until the commissioning test is performed.

As discussed further in Section 4, tank cleaning is a critical path to the BWMS installation completion, and should be included in the shipyard contract and built into the shipyard schedule. Not all BWMS makers require tank cleaning but may advise it to ensure compliant discharge. This is especially true for systems that treat on uptake only. Tank cleaning requirements should be coordinated with the selected maker for incorporation in the shipyard work scope.

The timing of tank cleaning must also be coordinated with the rest of the installation work and pre-commissioning testing. Once clean, no untreated ballast can be sent to the tanks (unless an in-tank treatment process is being used), so any raw ballast uptake for pre-commissioning testing should occur before tank cleaning. Preferably, any ballasting performed before the BWMS is fully functional should be conducted in a sea-to-sea flushing arrangement.

3.4.4 Sampling Port Planning

- Detail design should incorporate sampling port location, including access from the deck plate or grating.
- A sampling port and pitot detail drawing, in accordance with ETV and ISO requirements, should be included in the shipyard contract.

Overboard sampling ports are required by USCG and IMO and must meet certain specifications for their arrangement and location. Class approval requires location of the sampling port to be submitted, as detailed in Section 4.6.

USCG requires in the CFR (Reference 4, § 151.2075, Reference 6, § 162.060-28) that the sampling port be:

> As close as practicable to the BWMS overboard outlet prior to the discharge point to determine concentrations of living organisms prior to discharge.

Sampling port arrangements are specifically defined in the ETV Protocol (Reference 16) and the ISO standard for ballast water discharge sample ports (Reference 22). In addition to a piping diagram showing the location of sampling ports schematically, the detail design should include the specific location to ensure access for service and sampling procedures is possible. The sampling port should be located so that it is accessible from deck plate or grating, or a new access platform should be fabricated.

A sampling detail drawing should be provided as part of the shipyard contract to ensure the port and pitot meet both ETV requirements and the ISO standard. An example sampling port taken from the ISO standard is shown in Figure 8 and sampling pitot is shown in Figure 9. There are other acceptable alternatives provided in Reference 22, as well as details on allowable dimensions.

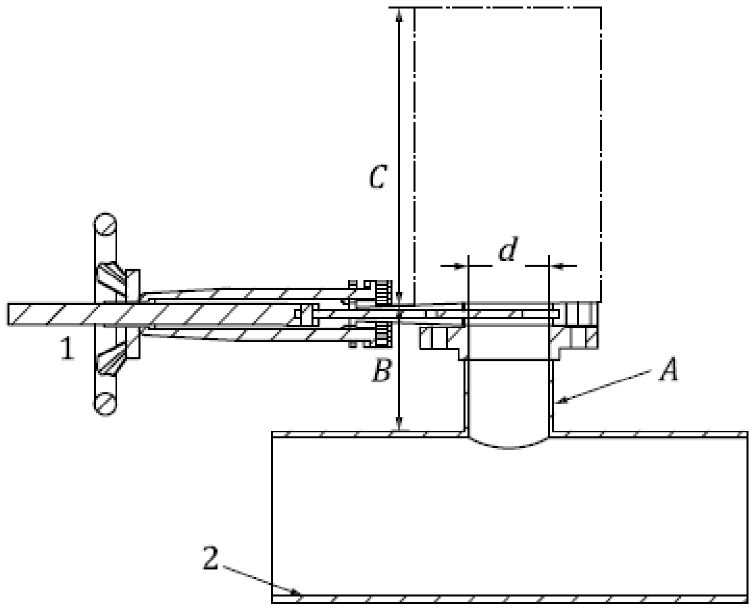


Figure 8 - ISO in-line sampling port configuration, per Reference 22

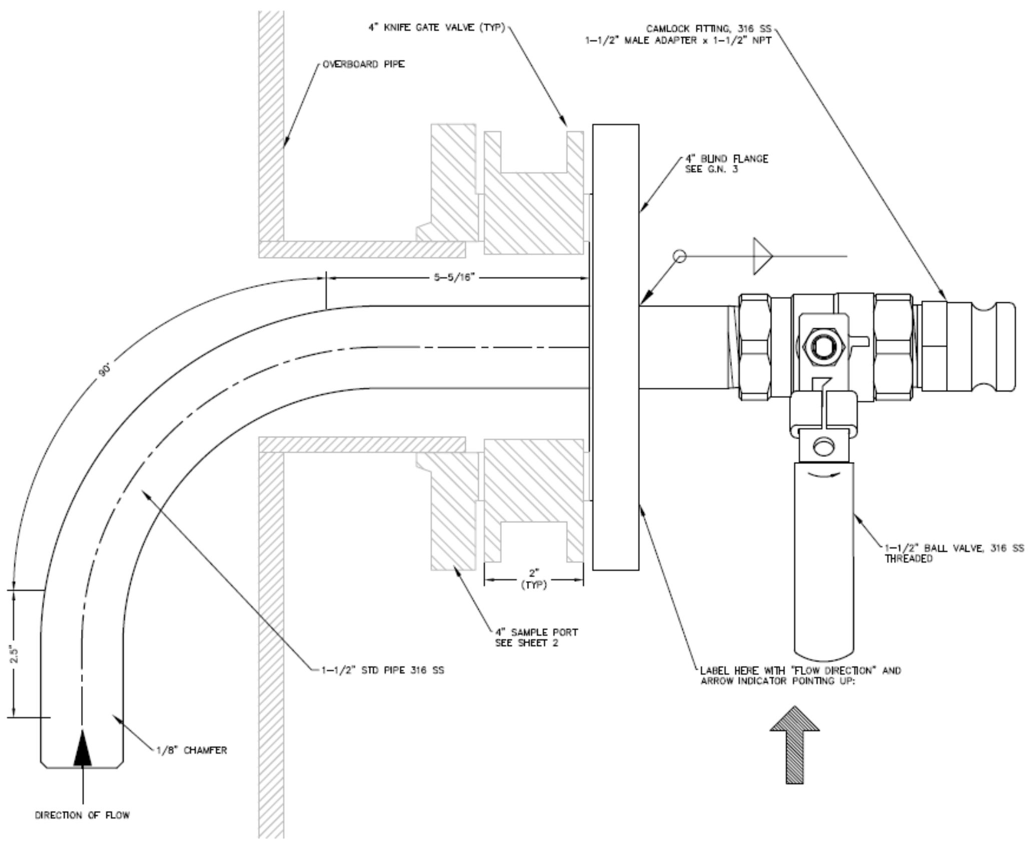


Figure 9 - Sampling port and pitot detail (image credit: Glosten, Inc.)

A sampling pitot should only be mounted to the port when ballast sampling is planned. It should be removed and replaced with a blind flange the remainder of the time, avoiding corrosion, damage, or the build-up of biofouling.

3.4.5 Ventilation

- Supplemental ventilation may be required for adequate cooling, depending where equipment is installed.

- ➢ Systems using hazardous chemicals or generating hazardous gases may require additional ventilation to meet air change requirements.

BWMS equipment is limited in where it can be installed in the vessel, either due to required proximity to ballast piping, or size of units that must be located remote from other machinery. As a result, some equipment may not be adequately served by existing machinery space ventilation, resulting in overheating and shutdowns if not addressed properly. For any air-cooled BWMS equipment with significant power consumption, the owner and project naval architect should review the available ventilation in the selected location to determine if it is adequate for supporting the equipment design temperature.

Where dedicated ventilation is required, it should be incorporated in the regulatory and detail design phases to ensure proper execution during construction.

Systems generating hazardous gases, such as hydrogen gas with EC, may have additional ventilation requirements to comply with the BWMS TA. These additional requirements should be thoroughly reviewed with the BWMS maker and incorporated in the regulatory and detail design phases.

3.5 Shipyard Execution Plan

- ➢ Integration engineering support ensures the functional design is carried out properly.
- ➢ Procurement planning ensures all equipment materials arrive in time for installation, and necessary specialty training is not overlooked.
- ➢ Owner on-site representation is key to overseeing the project and identifying potential delays before they become reality.

A detailed shipyard execution plan is vital for a successful installation. BWMSs are big, complicated, and integrate with many parts of a vessel. For a large vessel, 30 days is a common target for a BWMS installation, independent of other repair projects. Smaller vessels with simpler BWMS installations may need less time. The owner must determine the target time based on their vessel and the specific installation.

Many vessels spend up to twice the target duration, however, and this is most often due to poor planning. The following sections describe some basic components of a proper shipyard execution plan.

3.5.1 Integration Engineering Support

Most BWMS will require integration engineering support. The US vessel owner can use the following checklist to ensure readiness for the shipyard:

- Vessel survey and 3D scanning complete
- Regulatory drawings/documents complete and approved by class, including:
    - Ballast Water Management Plan
    - Weight Change Evaluation
    - Structural Modifications
    - Piping and Instrumentation Diagram, including ballast system and any changes to ballast tank arrangement.
    - Electrical Power Systems Diagram
    - Control System Block Diagram
- Construction Drawings complete and supplied to the yard, including:
    - Major equipment list

- Piping drawings and materials list
- Electrical drawings and materials list
- Structural drawings and materials list

Integration engineering is either supplied by the owner (if in-houses capabilities exist) or is provided by a 3rd party. Ensure the outside group has BWMS integration experience and request their qualifications and project examples. The following three groups are common choices:

- Naval Architecture Firm

  Benefit: Naval architecture firms specialize in equipment integration on vessels and interfacing with class societies and other regulatory groups. A select group of firms have established broad experience with BWMS installations.

  Drawback: Introduces a new group that must be managed, increasing the necessity for good communication. Additional communication challenges may be avoided if integration engineering is provided by the project naval architect.

- Shipyard

  Benefit: Using the shipyard for integration engineering limits the number of parties involved and consolidates shipyard responsibilities, potentially avoiding conflicts.

  Drawback: Most shipyards focus on detailed design and often lack technical and regulatory expertise.

- BWMS Maker

  Benefit: Using the BWMS maker for integration engineering limits the number of parties involved and consolidates BWMS maker responsibilities, potentially avoiding conflicts. Integration engineering services are sometimes subcontracted to a third-party naval architecture firm, managed by the maker.

  Drawback: Most equipment suppliers are focused on their equipment and may not have extensive experience with vessel integration.

3.5.2 Procurement and Planning

3.5.2.1 Specialty Materials and Equipment

Some BWMSs require specialty equipment that are challenging for a shipyard to source. This may include BWMS equipment, auxiliaries with long lead times, and specialty piping. These items are best sourced by the owner in advance and delivered to the yard.

To avoid delays, it is vital that all materials are available to the shipyard by vessel arrival, and preferably in advance.

3.5.2.2 Specialty Installation Training

Some parts of the installation may require certified installers that are not available at the shipyard. The owner must identify these items and plan accordingly. Certified technicians may be required for the following items:

- Plastic piping
- Vessel alarm and monitoring system modifications
- Remote control valve system modifications
- Integration with vessel satellite communication or GPS system

3.5.2.3 Shipyard Questions and Clarifications

If the shipyard did not perform the integration engineering design, then expect questions before construction begins. The owner should plan to connect the project naval architect directly with the shipyard to answer questions and clarify intent.

3.5.3 On-site Installation Support – Electrical and Mechanical

On-site representation at the shipyard is essential. Best practice is to have at least two people dedicated to the BWMS installation, one mechanical supervisor and one electrical supervisor. These team members are typically coordinated by the vessel superintendent and in close communication with the integration engineer. The US vessel owner should plan to hire the integration engineering team for on-site support if this service was not provided by the shipyard. Members of the vessel crew may also serve as BWMS supervisors but must be dedicated to this role without other general vessel modification responsibilities.

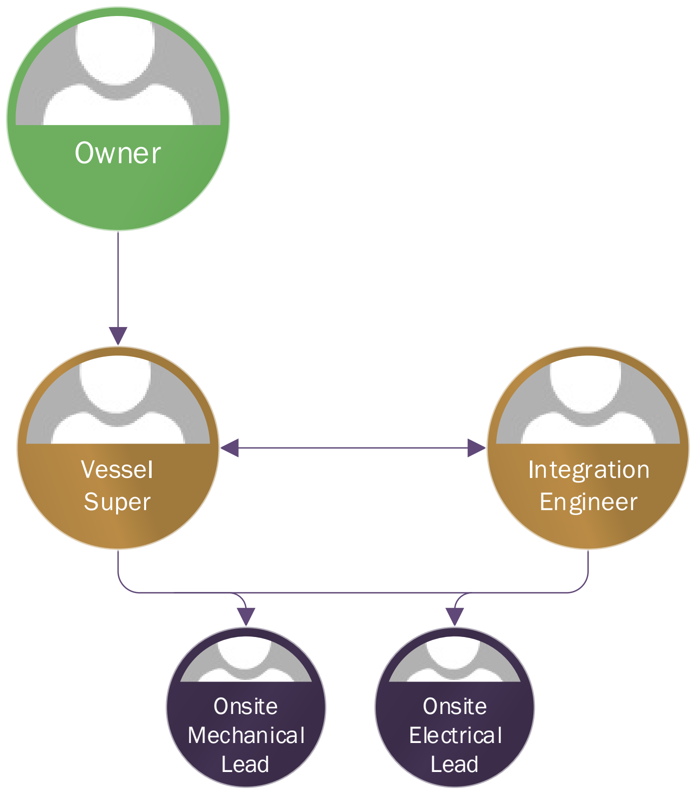


Figure 10 - Installation support team organizational chart

3.5.4 The Importance of Pre-Commissioning

Pre-commissioning is the process of completing the owner's and shipyard's responsibilities prior to the BWMS maker joining the vessel for commissioning of the entire treatment plant. A detailed pre-commissioning checklist is a good way to delineate these responsibilities and communicate what has been completed.

It is typically the shipyard's responsibility to complete pre-commissioning, with owner support, and the BWMS maker's responsibility to get the treatment plant operational after that. The pre-commissioning checklist should include, at minimum, the following items:

- Electrical and controls systems:
    - Cables installed and properly secured
    - Insulation tested

- Supply voltages verified at major equipment
- Communication between BWMS controls and all field devices

- Mechanical systems:
  - Piping installed and pressure testing complete
  - Pumps run and pressures verified
  - Remote controlled valves operated and feedback verified
- Class surveyor comments closed

3.5.5 Commissioning Team

The BWMS maker will typically include commissioning attendance in the equipment contract for a specified number of days. Five days is a common baseline with additional days billed to the owner, if required. It is the owner's responsibility to coordinate attendance of the commissioning team.

Best practice is to keep at least one onsite supervisor through the end of the shipyard period, to support the BWMS maker and shipyard if issues arise.

3.5.6 Regulatory Interface - Class and Flag

The final step is acceptance of the installation by both class and flag. In most cases, flag acceptance is carried out by the class society as a recognized organization (RO). The on-site installation support team should serve as primary liaison with regulatory bodies, monitoring status of surveyor comments, and updating timelines for inspections and commissioning. Class and flag involvement, and the role of each for US flag vessels, is detailed in Section 4.

The shipyard execution plan should include a list of 'pre-testing' required by class prior to commissioning, e.g. piping hydrostatic testing. This list should be coordinated with class and incorporated into the project schedule.

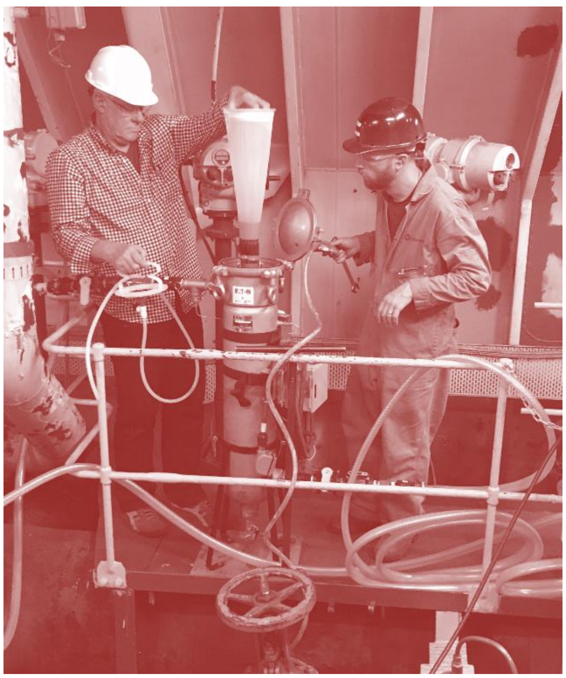
Part B – Compliance, Monitoring, and Enforcement

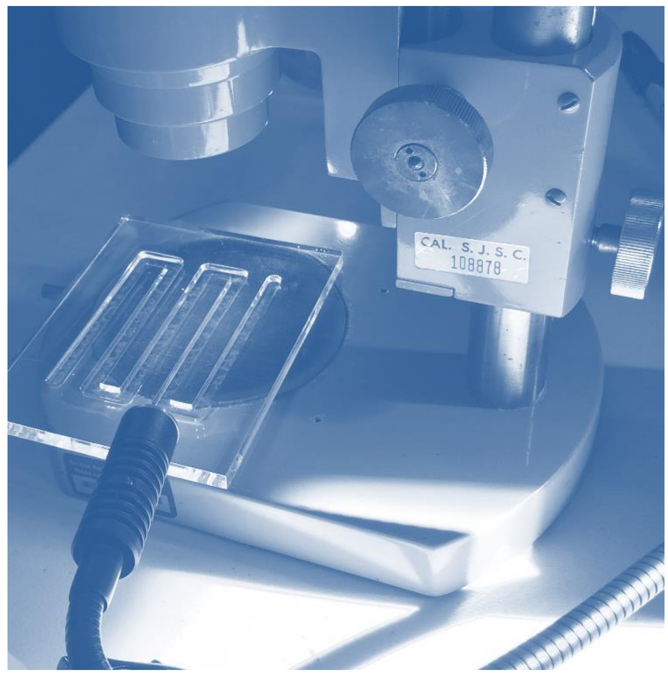
4 System Commissioning and Vessel Approval

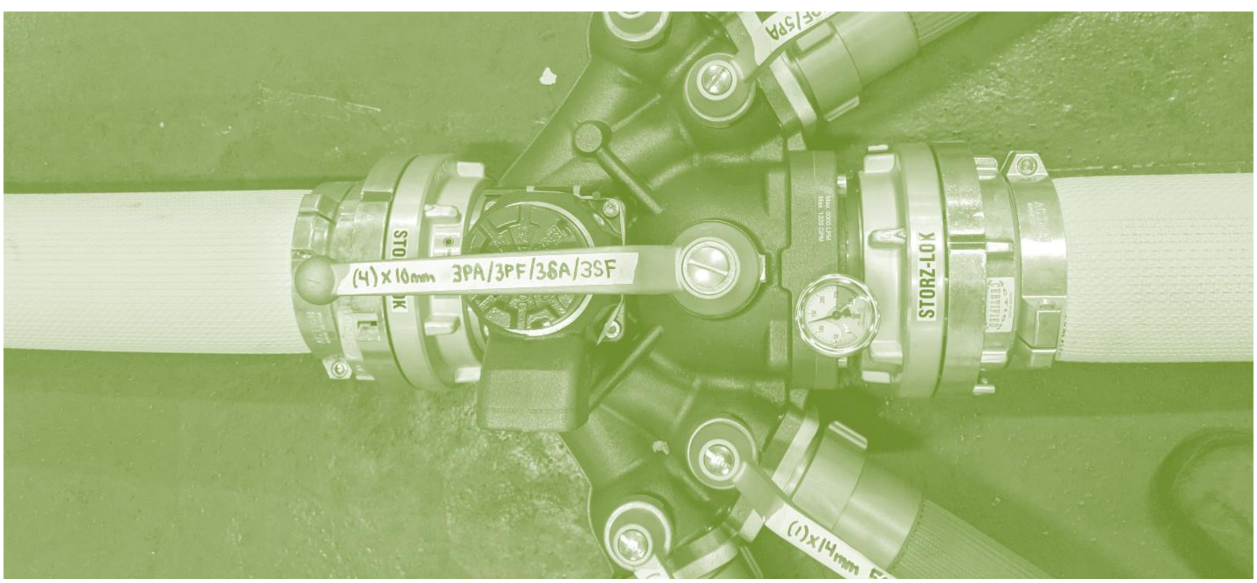
5 Maintaining Compliance

Sections planned for forthcoming BWMS Guide revision:

- Ballast Water Management Plan
- Inspections
- Sampling
- Contingency Measures







4 System Commissioning and Vessel Approval

Commissioning is the final step to gaining approval for a BWMS installation. The success of commissioning hinges not only on the success of the installation itself, but also the thorough planning of the commissioning and all of the parties required to carry it out. An important predecessor is execution of the pre-commissioning checklist. This list is developed by the maker and is to be carried out primarily by the shipyard.

Each system and vessel have unique aspects that determine the exact commissioning plan, but all installations have key commissioning aspects that require attention prior to and during installation.

4.1 Maker Attendance and Planning

As discussed in Section 2.3, commissioning support from the maker should be coordinated during contracting, in parallel with determining the equipment scope and conditions of the order. For commissioning to be successful, the maker should take the leading role for planning and executing the commissioning procedures. The US vessel owner or its representative should coordinate communication between all involved parties.

4.1.1 Maker's Commissioning Plan

- ➢ Maker should provide a vessel-specific commissioning plan and update the plan to align with the installation design.
- ➢ The commissioning plan should include the details provided here to facilitate a successful commissioning.

At the time of order, it is essential that the maker provide a preliminary commissioning plan, specific to the vessel. The commissioning plan should include the following details:

- Pre-commissioning shipyard checklist. All items required to be completed by the shipyard, with support from the owner, prior to commissioning proceeding.
- Pre-commissioning maker checklist. All items required to be completed by the maker prior to commissioning proceeding.
- Schedule. Daily breakdown of pre-commissioning and commissioning events, covering the complete process for the specific vessel.
- Scope of responsibility. Clear breakdown of responsibilities for the required parties: maker, shipyard, owner (or owner's representative), and class.
- Commissioning procedures. Step-by-step instructions for carrying out the commissioning process.
- List of required materials. Any consumables, tools, testing equipment required for commissioning that are not being provided by the maker.

4.1.2 Commissioning Duration

- ➢ If BWMS installation is not thoroughly planned, significant margin should be allowed in the schedule for commissioning and unplanned troubleshooting.
- ➢ Commissioning typically occurs dockside, so must wait until the vessel is re-floated to proceed.

The commissioning duration is highly variable based on the BWMS selected and the vessel specifics. Commissioning presents the highest risk to shipyard schedule, as it is contingent on all aspects of the installation being complete and successful, and typically occurs just prior to the vessel departing the shipyard. For vessels where IMO commissioning testing and sampling is required (Section 4.5), additional time should be allotted in the schedule. In most cases, commissioning must be carried out dockside, where water is available for ballasting and de-ballasting. As a result, commissioning cannot be moved up in the shipyard schedule while the vessel is still in drydock. A well-planned installation can reduce the commissioning period, in some cases to 2-3 days. However, it is better to plan a long commissioning period in advance, that is realistic for a given BWMS and vessel, than to scramble extra days right before vessel departure.

4.2 Shipyard Involvement and Acceptance Criteria

4.2.1 Scope of Responsibility: Maker, Shipyard, Crew, Owner, Class

- The role of each party should be clearly communicated as part of commissioning planning. Recommended responsibilities are provided here.

Clearly defined roles in the commissioning plan will ensure all parties are aware of their responsibilities and plan accordingly. Communicating these roles during the shipyard planning period also provides the opportunity for clarification and adjustment to roles as needed for a given installation.

Recommended commissioning responsibilities are provided in Table 5.

Table 5 - Commissioning responsibilities

Responsibility	Maker	Owner[1]	Shipyard	Class
Develop commissioning plan and schedule	Lead	Support		
Coordinates communication between all parties		Lead		
Resolves all class technical comments	Support	Lead		
Approves all technical comment responses				
Provides pre-commissioning checklist				
Provides commissioning procedure				
Approves commissioning procedure				
Schedules maker attendance of pre-commissioning and commissioning dates				
Approves pre-commissioning checklist				
Provides oversight of pre-commissioning progress				
Completes all items on pre-commissioning checklist				
Completes contracted work scope				
Resolves all class surveyor comments		Support	Lead	
Approves surveyor comment responses				
Tests all new and affected ship's systems, including piping, power, ventilation, etc.				
Confirm all ship's systems are operable prior to commissioning				
Arranges logistics for ballast water supply, feedwater as required				

Responsibility	Maker	Owner[1]	Shipyard	Class
Arranges process consumables for commissioning, such as bulk chemicals, if applicable	Maker	or Owner	or Shipyard	
Arranges maker-provided consumables				
Administers required BWMS operator training				
Completes required BWMS operator training				
Leads step-by-step commissioning procedures				
Attends commissioning (at discretion of class)				
Operates BWMS equipment during commissioning	Lead	Support		
Operates all ship's systems supporting commissioning				
Approves commissioning				
Conducts IMO commissioning testing and sampling[2]				
Issues IBWMC on behalf of flag[3]				Typical

[1] The owner includes the vessel crew and any on-site or technical support team, including the project naval architect.

[2] As applicable, see Section 4.5.

[3] A statement of voluntary compliance (SOVC) is issued by an authorized class society (ACS) on behalf of USCG for US flagged vessels. The SOVC takes the place of the IBWMC.

4.2.2 Shipyard Acceptance Criteria

➢ The criteria to accept the shipyard's installation must be formalized in the contract to have clear metrics for commissioning to proceed.

The following at a minimum must be completed by the shipyard in advance of commissioning:

- Complete contracted work scope. Every item within the shipyard's scope must be completed prior to commissioning proceeding.
- Complete maker's pre-commissioning checklist. The maker's pre-commissioning checklist is specific to the BWMS and vessel, and it should be incorporated as a contractual requirement for the shipyard to complete.
- Close all class surveyor comments. The shipyard is responsible for addressing all surveyor comments, but it may require support from the owner and its project naval architect.
- Provide arrangements for ballasting. Commissioning includes the full function test of the BWMS. The shipyard must make arrangements for water to be available for uptake to the ballast system. This must be coordinated with the vessel's drydock schedule, as commissioning generally cannot proceed while the ship is out of the water. For BWMS where salt feedwater is required, the shipyard is also responsible for sourcing if such water is not locally available.

4.3 Class Requirements and Acceptance

Each class society has its own requirements for approving a BWMS install, mostly tied to a survey of the installation and a witness of a functional test. Class is primarily tasked with confirming the installation and operation of the BWMS conforms with the BWM Convention.

4.3.1 *Function Test*

- ➢ The function test is carried out as a sub-procedure of commissioning and is generally required by class. Execution by the vessel's crew is often required.
- ➢ Function test consists of a normal ballast cycle, including ballasting, de-ballasting, and stripping (if applicable).
- ➢ The 2019 HSSC Survey Guidelines (Reference 12) recommends the function test include verification testing of biological efficacy compliance.

The function test is generally a sub-procedure of the maker's official commissioning procedure and should be performed as part of commissioning. The test procedure will vary based on BWMS and vessel specifics. At a minimum, the function test should represent a normal ballast operational cycle (Reference 11):

- Ballasting
- De-ballasting
- Stripping, where a dedicated stripping system exists

Due to the function test focusing on an actual ballast cycle and operation of the ballast piping system, crew participation will help facilitate the process. Crew participation may be required by the class surveyor to demonstrate the crew's understanding of the BWMS operation and how it impacts ballasting operations.

The 2019 Survey Guidelines under the Harmonized System of Survey and Certification (HSSC, Reference 12) recommends that the operational test be carried out in accordance with the commissioning procedures, and includes verification of the treated discharge to be in compliance with regulation D-2 of the BWM Convention (Reference 10) for biological efficacy.

4.3.2 *Requirements by Class*

- ➢ Class may require witness of the function test to grant approval of the BWMS install.

Below are the current requirements by prominent class societies for BWMS function tests:

- ABS requires a function test with surveyor in attendance (see ABS BWT Guide, Reference 17).
- DNV GL advises that the commissioning procedure should be carried out with surveyor attendance, but does not require it (see DNV GL guide, Reference 19).
- Lloyd's Register rules align with the BWMS Code (Reference 9), which does not require surveyor attendance of a function test or commissioning procedure (see Lloyd's Register approval guide, Reference 21).

Vessels under class societies not listed here should review that class's rules for function tests and related surveyor attendance.

4.4 Flag Involvement with Commissioning

- ➢ Annex 4 of the HSSC Survey Guidelines (Reference 12) should be reviewed by the owner to ensure a complete understanding of what is to be expected from the survey by flag or the recognized organization (RO).

The vessel flag typically relies on a recognized organization (RO), such as the vessel's class society, to provide oversight and acceptance of the commissioning process. A class society may still carry out oversight on behalf of flag for vessels that are not classed. Complete guidance for the RO to survey the BWMS installation and commissioning (as part of the HSSC) is provided in Annex 4 of Reference 12. The owner should review the Annex 4 guidelines as part of planning for the BWMS commissioning, as it provides insight to what should be expected from the RO's survey.

In the case of US flag vessels, a statement of voluntary compliance (SOVC) is issued by the vessel's class society, serving as the ACS, on behalf of USCG. The SOVC serves as a substite for the IBWMC

4.5 Efficacy Sampling at Commissioning (IMO BWM.2/Circ.70)

- US-flagged vessels are not currently subject to the requirements of IMO efficacy sampling at commissioning.
- Vessels under several foreign flag administrations, including Australia, Cyprus, Greece, and Singapore, must perform efficacy sampling at commissioning, ahead of global entry into force of IMO requirements.

A draft amendment to the Ballast Water Management Convention, Regulation E-1, was presented at the Marine Environmental Protection Committee (MEPC) 74 and adopted at the MEPC 75 in November 2020. Global entry into force is expected 1 June 2022.

Some foreign flag administrations have chosen to implement the amended Regulation E-1 in advance, with biological sampling required for vessels under those flags at BWMS commissioning. The flag administrations where this applies are detailed below.

Vessels of all flags anticipating BWMS installs 2022 and onward should plan biological efficacy sampling and testing at commissioning. This aligns with 2019 HSSC Survey Guidelines (Reference 12) for verifying the treated discharge is in compliance with regulation D-2 for biological efficacy. Specifics for commissioning testing and sampling are to be detailed in a forthcoming revision of the Guide.

4.5.1 US Flag

No sampling at commissioning is presently required for US flag vessels and will not be required until the US establishes its own commissioning sampling protocols or becomes party to the BWM Convention. The latter is unlikely. However, commissioning testing on US flag vessels is recommended to verify that the BWMS is operating as expected, and prepare the owner for eventual requirements.

4.5.2 Foreign Flag

Several foreign flag administrations have elected to implement the amended Regulation E-1 requirement for commissioning testing and sampling ahead of global entry into force. The specifics of each flag's requirements at the time of publishing are provided here.

Table 6 - Foreign flags with early commissioning sampling regulations

Flag	Commissioning Sampling	Reference
Australia	Required	DoA Circular No. 01 of 2019 (Reference 24)
Cyprus	Required	SDM Circular no. 20/2019 (Reference 25)
Greece	Required	GRC 2323.3-2 (Reference 26)
Singapore	Required	MPA Circular No. 09 of 2019 (Reference 27)
Bahamas	Recommended	BMA Bulletin No. 165 (Reference 28)
Panama	Recommended	PMA Circular MMC-345 (Reference 29)

Commissioning testing and sampling regulations are in a state of dynamic change, with new flag requirements being released or updated frequently. Additional foreign flags may implement the requirement for commissioning sampling ahead of global entry into force. For vessels under flags not listed here, flag administration announcements regarding ballast water treatment should be followed closely, and owners should revisit requirements as they approach the shipyard period.

4.6 Class Approval

4.6.1 Design Assessment and Class Type Approval Certificate

- Class-specific TA certificate is not required, statutory (USCG or IMO) TA certificate only.
- Design assessment or appraisal may be required, depending on class.

All BWMS installed must have the applicable statutory TA certificate, issued by USCG (US flag), the flag administration or its RO (IMO). The applicability of USCG and IMO TA certificates are discussed in Section 2.

Class societies do not require that the statutory TA certificate be issued by the vessel's class, only by the vessel's flag administration or that flag's RO. Alternatively, the class society may request the flag administration to accept a TA certificate by another administration or its RO. Written acceptance by the flag administration serves as equivalent to a TA certificate issued by that administration.

A design assessment or appraisal is recommended or required by some classes to confirm the BWMS conforms with class rules:

- ABS: <u>recommended</u> - Product Design Assessment in addition to statutory TA (required for optional BWT or BWT+ notation, Reference 17).
- DNV GL: <u>formal assessment or appraisal not required</u> – DNV GL performs additional review during plan review for BWMS not approved under their independent lab type approval testing program. BWMS type-approved by DNV GL on behalf of Norway are verified to conform with class rules during the approval process.
- Lloyd's Register: <u>required</u> - Machinery General Design Appraisal in addition to statutory TA (Reference 21).

The BWMS should be verified to hold the design assessment or appraisal applicable to the vessel's class. A standard design for multiple vessels may also be reviewed by class for safety and class rule conformance, expediting the subsequent plan review for individual vessels. The individual review will forgo safety and class rule requirements and focus on vessel interfaces only. This approach is recommended for multiple vessels in a series or with similar ballast arrangements that are being fitted with the same BWMS model.

In the case that a BWMS has not undergone an assessment by the vessel's class, an individual design appraisal may be permitted. A design appraisal can also serve to expedite the plan review process. Class fees should be expected for an individual appraisal.

The BWMS statutory TA is a requirement for systems installed on all vessels, regardless of class. Some class societies may provide additional voluntary certification services in addition to statutory TA, but these are not required to meet US or IMO BWM requirements.

4.6.2 Plan Review

In conjunction with surveyor acceptance and completion of the function test, design plans must be approved by the vessel's class before the installation can be class certified and the international ballast water management certificate can be issued. Class requirements for plan review are detailed in Section 3.1.

4.7 International Ballast Water Management Certificate and Statement of Voluntary Compliance

- Approval by class (or a flag's RO) is required for the flag state to issue the international ballast water management certificate. The IBWMC is the key document to fulfill IMO BWM requirements (Reference 12). In the case of US flag vessels, the ACS issues a Statement of Voluntary Compliance on behalf of USCG.

The international ballast water management certificate (IBWMC) is issued by the flag state, and typically requires survey and approval of the installation by an RO of that flag. For most vessels, the applicable RO will be the class society. Class approval requires review and approval of design documentation and may require attendance of a functional test and commissioning, as discussed below.

Once approval is granted by the flag, or an RO acting on its behalf, the flag state will issue the IBWMC. For US flag vessels, USCG relies on class as the ACS to perform inspection to verify compliance with the BWM Convention (Reference 10). A SOVC is issued by the ACS on behalf of USCG, and serves as substitute for the IBWMC (Reference 7). Owners of US flag vessels will benefit by involving USCG in the project early and keeping the homeport sector up to date throughout planning of installation and commissioning.

4.8 Contingency Extensions for Departing the Shipyard Without SOVC or IBWMC

- US flag: USCG extension application during the shipyard period if BWMS installation will not be completed before return to service.
- US flag: USCG extension application prior to shipyard period if vessel enters shipyard ahead of statutory shipyard date.
- Foreign flag: IOPP extension up to 6 months if BWMS installation will not be complete before return to service.
- Foreign flag: Temporary IBWMC if installation largely finished with limited items to complete BWMS install outstanding.
- Foreign flag: Receive certificate but operate under BWMP contingency measure until BWMS is fully operational.

USCG and ROs for foreign administrations have issued extensions for vessels to sail prior to class acceptance and certificates being granted under some circumstances. All efforts should be made to complete the installation and commissioning while in the shipyard, as re-deploying maker technicians is expensive and requires logistical coordination with the trade of the vessel. Further, access to necessary labor outside the shipyard is challenging if any last-minute repairs to the BWMS and the associated installation become necessary.

Several contingency extension paths exist to allow a vessel to sail without class acceptance or issuance of a SOVC or IBWMC, and these have been exercised on various installations. The owner should review these options during the planning period to understand what may be exercised in the event of major delays to project completion.

4.8.1 US Flag

1. Apply for extension during shipyard period. If it is determined that a BWMS installation will not be completed and approved prior to vessel departure, the US vessel owner may submit an extension application to the Office of Operating and Environmental Standards. Key elements should be included in the application to improve likelihood of acceptance:
    a. Submit letter summarizing request for extension.

b. Document reason for vessel leaving shipyard prior to BWMS installation being complete.

c. Document reason for BWMS not completing on time, emphasizing factors outside control of owner/operator.

d. Outline plan and timeline for completion BWMS installation.

2. Apply for extension ahead of the shipyard period. If the vessel is entering shipyard prior to its drydock due date, for commercial or other reasons, the US vessel owner may submit an extension application to the Commandant.

    a. Submit letter summarizing original compliance date and advance shipyard date.

    b. Request extension to allow grace period after shipyard to recognize owner's decision to enter into shipyard early.

These contingency extension approaches are outside the USCG's clearly defined instructions for applying for extensions and are thus not guaranteed to be approved.

4.8.2 Foreign Flag

1. Request IOPP extension from flag administration RO for up to 6 months to complete commissioning and sort out installation or BWMS operational issues.
2. Request temporary IBWMC from RO, on condition that limited outstanding BWMS install items be completed within set time period.
3. Request full IBWMC with recognition that vessel will exercise approved contingency measures laid out in the BWMP until the BWMS is fully operational. This approach bears compliance risk, as it requires destination port states, in a case-by-case basis, to accept contingency measures in lieu of ballast water treatment.

The tolerance of ROs representing various flag administrations for accepting compliance extensions is difficult to predict. Owners of foreign flag vessels should consult with the RO, typically the vessel's class society, during the project planning period to determine what contingency extension options may be accepted.

5 Maintaining Compliance

5.1 Crew Understanding of Type Approval

With few exceptions, the BWMS must be installed, maintained, and operated within the specific limits of its type approvals, and in accordance with the OMSM. Most systems may have multiple approvals between class and flag, but generally the set of limits applicable to the region of operation shall hold precedence. In some cases, an operator might switch between ‘international’ and ‘US’ mode to maintain compliance with the USCG type approval for the system while operating in US waters. This is particularly true for some UV-based systems.

The crew should be familiarized with the BWMS’s TA and the conditions of the installation approval. The designated Ballast Water Management Officer (BWM Officer) is responsible for thoroughly understanding all aspects and disseminating information to the rest of the crew appropriately.

5.1.1 Operating Manual

Two manuals exist for a BWMS: the TA Operation, Maintenance, and Safety Manual, (OMSM), and the vessel-specific operating manual, which should be included in the Ballast Water Management Plan (BWMP).

The TA OMSM is a regulatory document that generically defines the overall BWMS and how it meets regulatory requirements as type-approved equipment. It also gives installation instructions, which are not immediately useful to the operator after the system is in full operation. The vessel-specific operating manual contains information specific to the installed BWMS and vessel specifics. All operating procedures are included in the vessel-specific operating manual, making it a critical document for the operator to understand.

The operator should thoroughly understand the following information in the operating manual, as it is the guiding document for defining compliant BWMS operation:

- Operating parameters for the BWMS
- Specific operating procedures for the BWMS
- Valve lineups for different operations
- Hazards associated with the BWMS
- Shutdown switches and locations
- Chemical handling procedures, where applicable
- Active substance discharge concentration limits (see Section 1.6.2)
- Alarm lists and troubleshooting procedures
- Maintenance schedule for the BWMS equipment
- Spare parts list and repairs that can be carried out by the crew
- Repairs that require maker or service rep attendance
- Data retrieval for BWMS logs

5.1.2 Equipment Type Approval and operational limitations

- Crew should thoroughly understand the operational limitations (USCG) and system design limitations (IMO) laid out in the Type Approval certificates.
- The OMSM is part of the BWMS Type Approval, and the Operating Manual is part of the class plan review and approval. The crew should understand how both documents limit the operation of the BWMS.
- The best method to ensure compliance with operational limitations is to plan all ballast operations in advance, with each ballast event cross-checked with each limitation.

The BWMS Type Approvals, both USCG and IMO, define at a high level the limitations of the BWMS for operational use. The master, BWM Officer, and any crewmembers tasked with operating the BWMS should thoroughly understand the operational limitations of the system (USCG certificate), and system design limitations (IMO certificate), as described in Section 2.1. The limitations defined in the TA certificates are most significant for the operator to understand. A summary of these limitations and guidance for handling operations outside the limitations is provided in Table 7. The best method of ensuring compliance is to plan all ballast operations in advance, and to cross-check each planned ballast event with each TA limitation to ensure limits are not exceeded or deceeded.

Table 7 - Operational limitations

Limitation	Impact	Guidance for Exceeding/Deceeding Limitation
Salinity and temperature	Informs where the operator can uptake ballast for proper BWMS operation, and whether an uptake point may be outside the TA certificate limitations.	Low salinity: - Delay uptake until favorable tide increases salinity. - Reposition vessel to higher salinity location on minimal ballast, <u>verifying compliance with the vessel's strength/stability program</u>. Low temperature: see last row.
Hold time	Informs the operator how long treated ballast water must be held onboard to ensure a compliant discharge.	- Delay discharge until hold time is achieved. - Discharge ballast only from tanks that have achieved hold time, <u>verifying compliance with the vessel's strength/stability program</u>.
Feedwater salinity (EC systems)	Saline water of a certain concentration must be available for generating the disinfecting chemical. Operator needs to understand relationship of seawater density, salinity measured in parts per thousand (ppt), and salinity measured in practical salinity units (PSU), the latter being the unit that defines limits for most EC systems.	- Plan in advance: store highly saline water onboard to substitute for ambient water (e.g. aft peak storage). - Without saline water storage: see guidance above for low salinity.

Where operational changes cannot be made to comply with the limitations (such as temperature below minimum limit), the operator can consider the following contingencies:

- Minimize the ballast volume loaded or discharged until the operational limitation can be met (e.g. limit/delay discharge if minimum hold time is approaching, while continuing cargo operations).
- Exchange any ballast not treated within operational limits once suitable water is available (e.g. open ocean with reasonable salinity and temperature.
- Document any ballast operations outside the TA limitations in the narrative record of unusual events (BWRB, see Section 5.2) and include details in the appropriate report.

5.1.3 Installation Approval

Every aspect of the BWMS installation is reviewed by class to confirm compliance with class rules. Class provides an approval based on the condition of the installation at the time of completion.

Any changes by the crew to the piping, instrumentation, or BWMS equipment could compromise the class approval, the IBWMC (if applicable), and bring the vessel out of compliance. The operator should consult with the BWMS maker prior to modifying any aspect of the installation after leaving the shipyard.

5.2 Recordkeeping

Recordkeeping and reporting are often overlooked during the planning and shipyard periods, leaving the operator unprepared to maintain vessel compliance with BWMS requirements. Both elements are equal in importance to the BWMS operation itself. Most regulatory violations and fines stem from an owner's noncompliance with recordkeeping and reporting requirements.

All recordkeeping and reporting requirements for a specific vessel are to be documented in the BWMP, which is a document required to be submitted during class plan review of the installation. All considerations for recordkeeping and reporting should therefore be understood by the crew and implemented into vessel policies prior to the vessel departing from the shipyard.

5.2.1 Ballast Water Record Book

The Ballast Water Record Book (BWRB) is required by IMO for international vessels (BWM Convention, Reference 10), and can serve as an organized method for meeting USCG requirements for record keeping (33 CFR § 151.2070, Reference 4). The BWRB should be comprised of the following documents:

- Form of BWRB, as linked in and in accordance with Reference 10.
- Record of ballast water operations (ballast water handling log), documenting each activity defined in the Form of BWRB. The record of ballast water operations should have a signature field for officer in charge for each operation, and a summary signature field for the master for each page.
- Form for narrative record of unusual events, to also be used for recordkeeping of sediment handling and removal.
- Copies of all submitted Ballast Water Management Reports (BWMRs, for US ports), Ballast Water Reporting Forms (for international ports), and any applicable local or regional reports, satisfying the requirements of References 10 and 4.

The BWRB may be a written record, standalone electronic record system, or be integrated into the vessel's general recordkeeping system.

All ballast water records shall be maintained onboard for a minimum of two years. For international vessels, records must further be kept in the owner's control for an additional three years in accordance with Regulation B-2 of Reference 10.

The vessel's ballast water records should be accessible and readily available for examination by applicable Port State authorities at all reasonable times. They may be stored as digital media that is viewable during an inspection.

5.3 Reporting

The quick and effective communication between the vessel, USCG or international Port State Control, and local authorities regarding the discharge of ballast water is a significant component of ballast water management. For vessels entering US waters and port locations, the operator must transmit a BWMR. For vessels entering international ports, the operator must coordinate reporting requirements with the relevant Port State authority. The procedures for submitting reports are described in this section.

5.3.1 Ballast Water Management Report (BWMR) for US Ports and Destinations

A Ballast Water Management Report[3] must be submitted to the National Ballast Information Clearinghouse (NBIC) no later than six (6) hours after arrival at the port or place of destination, or prior to departure from that port or place of destination, whichever is earlier.

Forms must be submitted as follows:

- Web App BWMR Form: This form remembers static information and auto-populates fields when a user starts a new report for the vessel. Users can access previously submitted forms.
- Electronic submission: Use the electronic (PDF) version of CG-5662. Complete the form on a computer. Click the button "Send form by e-mail". The form will automatically create a PDF data file and attach it to an e-mail message addressed to the NBIC.

Both options are available online at the following web address: http://invasions.si.edu/nbic/submit.html

5.3.2 Ballast Water Reporting Form for International Ports

The Ballast Water Reporting Form is generally used for international port arrivals. Each Port State planned as a destination should be contacted in advance, preferably prior to departure from the previous port, to verify required reporting procedures, forms, and timing.

An example Ballast Water Reporting Form is linked here (Reference 13):

MEPC.288(71) Appendix

5.3.3 Reporting to Local Authorities at US Ports

Several US states have implemented their own reporting requirements, separate from the national requirements described above. These states include California, Oregon, and Washington. Most of these states use the same BWMR that is submitted to NBIC but require a copy of the report be submitted to the local agency.

Several of these US states also have their own deadline for BWMR submittal <u>prior</u> to vessel arrival. California, Oregon, and Washington all require report submission no later than 24 hours prior to arrival in state waters or port destinations, depending on the state. Other states may have similar requirements.

[3] Reporting form: CG-5662, OMB Control Number 1625-0069.

The reporting requirements of each US state planned as a vessel destination should be verified with local authorities at that destination prior to departure from the previous port.

5.4 Understanding Pending and Proposed Regulations

5.4.1 Vessel Incidental Discharge Act (VIDA)

VIDA reorganizes the way that BWM regulations are established and enforced in the US. Under VIDA, the EPA is required to establish updated discharge standards by December 2020, followed by USCG implementing a plan for vessel compliance and enforcement of those standards two years later. The full implications of VIDA execution are not fully known, but the establishment of additional BWE + BWT requirements should be understood by owners:

- VIDA establishes exchange requirements for vessels carrying low-salinity ballast (less than 18 parts per thousand salinity) into low-salinity locations of the Pacific Region (Pacific Coast Region, Alaska Region, and Hawaii). An exception is permitted for vessels treating ballast to a more stringent standard than those currently established.
- VIDA also establishes exchange requirements for vessels entering the Saint Lawrence Seawater via the Saint Lawrence River.

These requirements expand the US regions requiring BWE + BWT significantly, and owners operating vessels in the Pacific Region and Great Lakes will have to plan BWM accordingly. Under VIDA, states may also apply for no-discharge zones within state waters, which could also have operational impacts for some owners.

5.4.2 IMO BWMS Commissioning Testing and Sampling

- ➢ Vessels under foreign flag installing BWMS 2022 onward should plan for commissioning testing and sampling in accordance with IMO amendments.
- ➢ Vessels under Australia, Bahamas, Cyprus, Greece, and Panama, and Singapore should plan for commissioning testing and sampling for all BWMS installations.

As discussed in Section 4 on commissioning, amendment to Regulation E-1 of the BWM Convention will not enter into force until 1 June 2022. At entry into force, vessels under all flag states party to the Convention will be required to conduct treatment performance sampling at commissioning for new BWMS installations. This <u>does not apply to US flag vessels</u>, as the US is not party to the Convention.

Australia, Cyprus, Greece, and Singapore have issued circulars requiring commissioning sampling, and sampling is proceeding on vessels flagged with these Member States. Bahamas and Panama have also committed to voluntarily proceed with commissioning sampling but have not implemented detailed sampling requirements to date.

5.4.3 State and Port Proposed Regulations

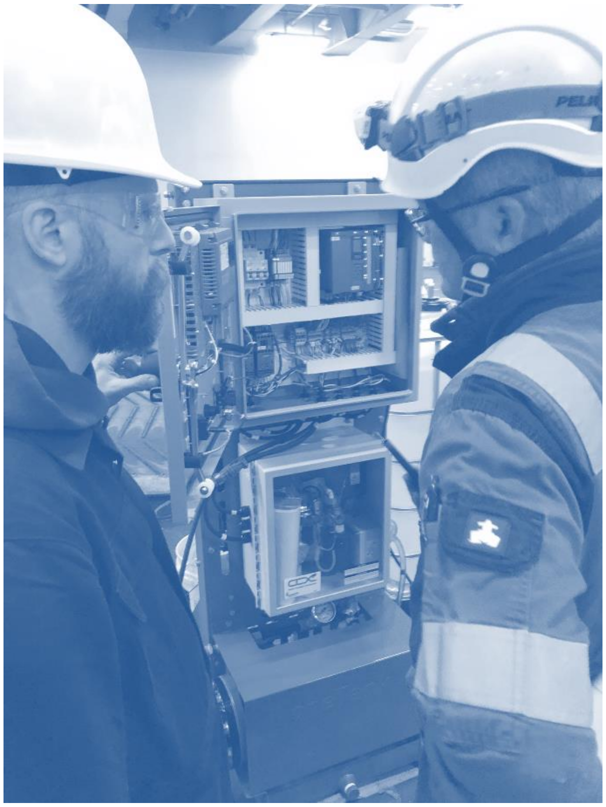
California is presently the only US state with proposed requirements that exceed the national BWM regulations, but the implementation of these requirements has been delayed until at least 2030.

Some international Port States have begun to implement BWM requirements in addition to the requirements of the BWM Convention. The BWM regulations of any Port State or region planned as a vessel destination should be verified with local authorities well in advance of vessel's anticipated arrival.

Part C – BWMS Life Cycle

6 Training Program

7 Equipment Maintenance and Repair



6 Training Program

6.1 Crew Training by the Maker

- Training is comprised of documentation review, computer-based training, a safety briefing, installation walkthrough, commissioning, Port State Control procedures, and first treatment cycle preparation.
- Arrange computer-based training for both the vessel's commissioning crew and subsequent changeout crews.
- For fleets, once a BWMS is installed, train other crews on that vessel to introduce operations and challenges in advance of the next installation.
- Ask the BWMS maker about remote connectivity options and look to coordinate this device with the vessel's existing satellite communication network. Any interaction with the vessel's network should be verified for compliance with the ISM Code requirements for cyber security, taking effect 1 January 2021.
- Development of an internal training program ensures long-term success of the BWMS operation.

As part of commissioning, the BWMS maker should provide training to the crew. If accounted for appropriately during contracting and planning, the training program and specific training requests will go a long way towards guaranteeing the first few ballast cycles are successful. Shipyard periods are a busy and often hectic time and scheduling training requires careful planning and coordination between the shipyard, maker, and owner.

Step 1: Documentation Review

- Ensure that all documentation for the system is in order and reviewed by the vessel crew.
- Communicate system limitations (salinity, hold time, sediment loads, etc.).

☐ **Next up: Documentation Review**

The owner must ensure that all documentation is in order. It is generally preferred to have both electronic and hard copies, with hard copies secured in a single binder for easy reference. A checklist of *minimum* documentation requirements is provided here:

- Vessel-Specific Operating Manual
- Ballast Water Management Plan
- General Arrangement Drawing
- Piping and Instrumentation Diagram
- Electrical One Line Diagram
- Control System Block Diagram

✋ Participants: Captain, Chief Mate, Chief Engineer, 1st Engineer, Electrical Engineer

The crew should review documentation ahead of the maker's training sessions. This gives the crew a solid background on the system operation and the chance to ask questions during the training session. The documentation package used for review should be fully approved by vessel class.

Step 2: Computer-Based Training of Control System

- ➢ Request computer-based simulation training of the control system and human-machine interface (HMI).

☑ **Previously completed by crew:**

1. Reviewed all relevant documentation.

☐ **Next up: Perform mock treatment cycles using computer mimic screens**

Computer-based desktop training allows for crew interaction with the system in a controlled setting before commissioning. This can be done in a conference room away from busy parts of the vessel during the shipyard period. The maker should have simulations available using mimic HMI screens on a laptop computer, with computer and software provided by the maker for use during training. Remote learning for the first changeout crew is also recommended, ensuring transfer of knowledge on the BWMS happens smoothly at crew change.

✋ Participants: Captain, Chief Mate, Chief Engineer, 1st Engineer, Electrical Engineer

Topics to be covered during computer-based training:

- Review of HMI screens:
    - Overview screen and major equipment icons
    - System sub screens
    - Current alarms and alarm history
    - Passwords and login credentials
- Typical ballast uptake sequence
- Typical ballast discharge sequence
- Downloading ballast treatment log files

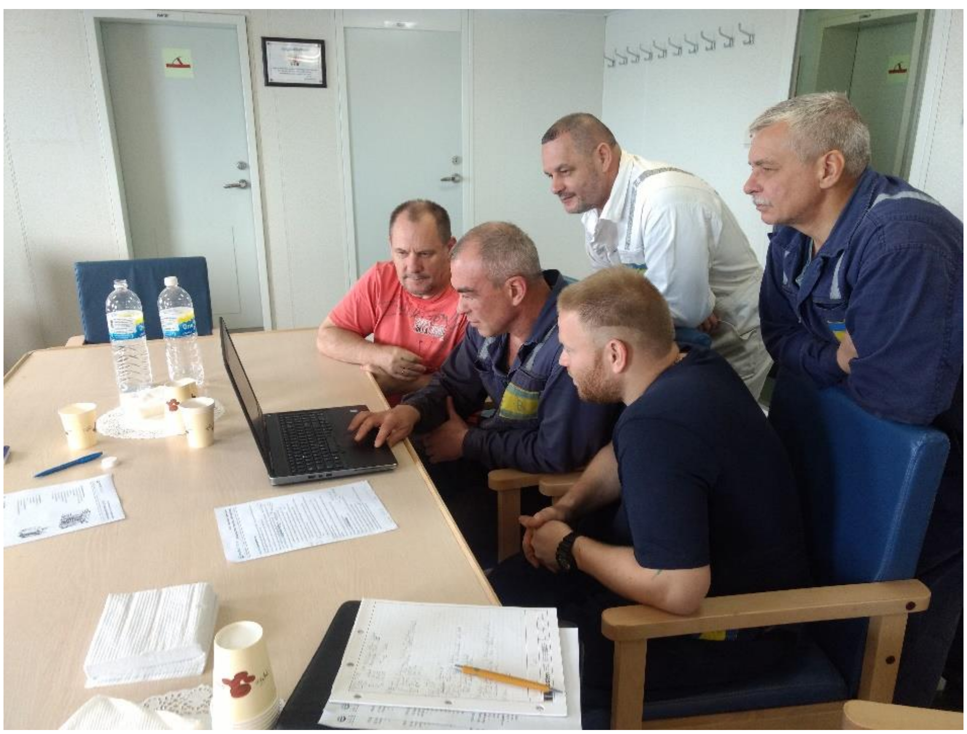


Figure 11 - Computer-based training with vessel crew using control system HMI mimic screens prior to commissioning of new BWMS

Step 3: Safety Briefing

☑ **Previously completed by crew:**

1. Reviewed relevant documentation.
2. Completed computer-based training with mock treatment cycles.

☐ **Next up: Briefing on safety and required personal protective equipment**

Before interacting with the new ballast water management equipment, the crew must be properly trained on safety procedures, such as for electrical systems and high voltage, chemical handling, and explosive environments in the presence of hazardous gases.

Participants: Captain, Chief Mate, Chief Engineer, 1st Engineer, Electrical Engineer.

- Electrical systems:
    - High voltage panels, power disconnect locations, panels with multiple power sources.
- Chemical storage and handling:
    - Proper personal protective equipment for handling (gloves, goggles, gowns, etc.).
    - Safety data sheets and identified hazards.
- Explosive gases:
    - Monitoring equipment locations, alarms and maker recommended actions, dilution vent outlets, possible leakage points.
- Vessel stability:
    - Impacts to vessel loading plan, changes to ballast tank volumes during treatment cycles (in tank systems), changes to ballast piping/pumping arrangements.
- Other potential hazards outlined in the maker's operating manual.

Step 4: Installation Walkthrough

☑ **Previously completed by crew:**

1. Reviewed relevant documentation.
2. Completed computer-based training with mock treatment cycles.
3. Received a briefing on safety and required personal protective equipment.

☐ **Next up: Completed installation walkthrough**

The BWMS maker should do a thorough walkthrough of all newly installed equipment with the crew. Equipment locations will vary depending on the type of vessel, but common locations might include the Engine Room, Steering Gear Flat, Cargo Pump Room (tank vessels), Main Deck, and remote HMI panel locations, such as the Engineer Operating Station (EOS).

Participants: Captain, Chief Mate, Chief Engineer, 1st Engineer, Electrical Engineer.

- Treatment plant (electrolytic unit, bulk chemical storage/dosing, UV reactors, etc.):
    - Maintenance access points, instruments, and common procedures.
    - Naming conventions.
- Chemical/oxidant monitoring equipment (if fitted, disinfectant systems only).
- Neutralizing plant (if fitted, disinfectant systems only).
- Ballast filters (if fitted, most slipstream or full-flow in-line systems).
- Ballast water sample points (Port State Control inspections).
- Equipment connected to vessel auxiliary systems and auxiliary demands (seawater, freshwater, compressed air, steam, hydraulic, etc.).
- Other maintenance access points and standard procedures.
- Remote HMI panels for system operation.

Figure 12 - Maker's guided walkthrough of new BWMS system equipment

<u>*Step 5: Crew Commissioning Participation*</u>

☑ **Previously completed by crew:**

1. Reviewed relevant documentation.
2. Completed computer-based training with mock treatment cycles.
3. Received a briefing on safety and required personal protective equipment.
4. Inspected the completed installation with a walkthrough.

☐ **Next up: Commissioning participation**

Near the end of commissioning (see Section 4), the maker should involve the crew in active treatment cycles and the operation of BWMS equipment. This allows the crew to see the equipment in operation and note normal operating parameters. It is best to wait until the end of the commissioning period to ensure equipment is running near normal and most installation issues are corrected to avoid confusion.

✋ Participants: Chief Mate, Chief Engineer, 1st Engineer.

Topics:

- Ballast uptake & discharge procedures.
- Observe the treatment plant in operation.
- Oxidant monitoring (disinfectant systems only).
- Common warning alarms and troubleshooting.
- Standard operation parameters (pressure, temperature, flow rate, timing, etc.).

Step 6: Spare Parts, Service Procedures, Regular Maintenance Items

☑ **Previously completed by crew:**

1. Reviewed relevant documentation.
2. Completed computer-based training with mock treatment cycles.
3. Received a briefing on safety and required personal protective equipment.
4. Inspected the completed installation with a walkthrough.
5. Participated in final commissioning efforts.

☐ **Next up: Spare parts, service procedures, regular maintenance items**

As arranged during contracting, the BWMS should come with spare parts for failures and scheduled replacement, and will require periodic maintenance. The maker should provide training on the specific maintenance requirements of the BWMS.

Participants: All members of the engine department.

Topics:

- BWMS maker to go through all supplied spare parts, describe their significance, discuss common failures, and discuss how to make replacements if a failure occurs.
    - Many makers have instructional videos or supplemental service documents that accompany the operating manual, and the owner should ensure these are available to the crew.
- Discuss all regular maintenance items and schedules, as described in the operating manual.
    - This will include basic equipment maintenance: inspections, cleaning, greasing, gasket/seal replacements, and may include additional specialty items noted by the maker (e.g. UV bulb or electrolytic cell replacement).
- Understand what the crew is able to service and what must be serviced by a maker's representative.

Step 7: Port State Control Preparation

☑ **Previously completed by crew:**

1. Reviewed relevant documentation.
2. Completed computer-based training with mock treatment cycles.
3. Received a briefing on safety and required personal protective equipment.
4. Inspected the completed installation with a walkthrough.
5. Participated in final commissioning efforts.

6. Reviewed spare parts, basic service procedures, and regular maintenance items.

☐ **Next up: Port State Control preparation**

Upon arrival at a ballast discharge port, local Port State Control may board the vessel and request documentation proving successful ballast water treatment. In some cases, the authorities will require ballast water samples be taken to perform chemical and biologic testing. The crew should be well-versed in documentation requirements and ballast water sampling procedures. Sampling will be further detailed in a forthcoming revision of the Guide.

Participants: Captain, Chief Mate.

Topics:

- Downloading ballast treatment log files and cycle documentation from the BWMS.
- BWRB and ballast log requirements related to the BWMS.
- Planning for demonstrations of equipment operation and an installation walkthrough.
- Sample port location(s), sampling pitot installation where applicable.
- How to run the system to ensure sample port is properly filled and flowing.
- Supporting the external sampling team.

Step 8: First Ballast Water Treatment Cycle

☑ **Previously completed by crew:**

1. Reviewed relevant documentation.
2. Completed computer-based training with mock treatment cycles.
3. Received a briefing on safety and required personal protective equipment.
4. Inspected the completed installation with a walkthrough.
5. Participated in final commissioning efforts.
6. Reviewed spare parts, basic service procedures, and regular maintenance items.
7. Reviewed possible Port State Control requirements.

☐ **Next up: First ballast water treatment cycle**

On the first ballast voyage leaving the shipyard, the crew must run the newly installed treatment plant on their own for the first time. It is common to experience issues on this first trip and the owner should plan accordingly.

Establishing a remote connection to the BWMS for maker support can save time and money. Alternatively, or in addition, the owner may consider asking the maker to be on-site during the first treatment cycle.

The first few ballast voyages are typically challenging due to the following:

- BWMSs are typically the last to be commissioned during a yard period and often insufficient time is left for testing. This leaves problems to be discovered during the first few voyages.
- Commercial pressure towards the end of the shipyard period may limit testing time, particularly if the vessel is delayed. Margin time built into the shipyard specification and schedule is key to ensuring commissioning can be completed.
- Crew changes immediately following a yard period are common and unfamiliar crews are left to run the first treatment cycle. Plan for this in the training program.

The owner should exhaust every option to complete commissioning and the function test, including a full ballast cycle with the BWMS, prior to leaving the shipyard. The cost and operational impacts of a malfunctioning or incomplete BWMS cannot be understated. Considerable time, expenditures, and resources are needed to resolve issues once the vessel has returned to its trade, and schedule impacts should be expected.

The installation of an industrial virtual private network (VPN) gives the maker access to their equipment remotely and allows quick, seamless troubleshooting while underway or in port. These devices are typically installed in the bridge and use ethernet to connect the BWMS controller to either the local cellular network (while dockside) or the vessel's Very Small Aperture Terminal (VSAT) system (while at sea). These devices can reduce vessel downtime and limit service engineer visits. It is critical, however, to verify that any communication technology adapted by the BWMS maker is in compliance with IMO's revised ISM Code and its requirements for cyber security. These new requirements take effect 1 January 2021 and may limit the possible formats for connecting a remote communication device to the BWMS.

Participants: Owner, Captain, Chief Mate.

Topics:

- Prepare remote or on-site support from the maker to enhance problem solving abilities during this first cycle.
- Plan contingency measures (see Table 8 below) in case problems occur that cannot be quickly solved.
- Operate the BWMS as per training and system operating manual.

6.2 Internal Training

6.2.1 Internal Quick-Start Guide

A BWMS maker will provide an operating manual and documentation for the specific installation. This documentation may not capture all the nuances of the vessel integration, however, as all vessels are different, and knowledge of a specific vessel is kept with the crew. This is particularly true for retrofit projects where some auxiliary vessel systems are aging and require specific attention.

The owner should establish an internal training program or set of documents to capture vessel-specific operating details of the new BWMS. A quick-start guide is a good way to retain and pass on this knowledge. The quick-start guide contains a subset of the maker's operating manual and includes notes on specific vessel parameters and operations.

<u>Quick-Start Guide Checklist:</u>

- Start Up
  - Login credentials.
  - Manual valve lineups.
  - Ship service diesel generator requirements for specific vessel operations.
  - Auxiliary system requirements: seawater pumps, air compressors, ventilation fans, hydraulic power units, etc.
  - Typical BWMS menu navigation on HMI screen.
- Shutdown
  - Print or display regulatory information for Port State Control inspection.
  - View alarm logs.

- Logout sequence.
- Secure manual valves.
- Secure auxiliary systems.
- Typical BWMS menu navigation on HMI screen.

- Maintenance and Troubleshooting
  - Summary of maintenance schedules and procedures.
  - Common alarm list with troubleshooting guidance.

6.2.2 Planning for Crew Changes

BWMSs are often complicated and will require operator experience before everything runs smoothly. During crew changes, the incoming crew now has an additional system to learn. The owner should plan sufficient overlap time for this knowledge transfer with the outgoing crew, in addition to all other commitments. Computer-based training in advance for the changeout crew is crucial to preparing them for success. Development of the above quick-start guide will also ease this process and enhance new crew member understanding.

Owners who have completed several BWMS installations recommend deploying a crewmember, experienced with BWMS operation, to either meet the new vessel crew in port or to ride along for the first treatment cycle. The experienced crewmember can assist the crew in the BWMS operation and ensure the newly trained crew understands key aspects of operation, maintenance, and the type approval.

6.2.3 Failures and Planned Contingency Measures

➢ Ensure the new ballast water management plan (BWMP) includes a robust section on contingency measures.

At some point, all BWMSs will experience a failure. Planning for such events and documenting contingency measures in the approved BWMP will limit commercial disruptions. A list of typical contingency measures is given below. Each will depend on the specific situation. The crew should be familiar with the approved measures and know when to use each.

Table 8 - Sample contingency measures for BWMS failure, additional measures should be considered depending on vessel type and operation

	Contingency Example	Use Case	Commercial Impact
1	Repair at ballast loading port	Crew has spare parts onboard and can repair with local or remote support from maker.	Delay
2	Repair during sea passage	Crew has spare parts onboard and can repair with remote support from maker.	Limited or no impact
3	Ballast water exchange (BWM Convention regulation D-1)	Crew does not have spare parts or problem is sufficiently large to disrupt BWMS long-term. Problem is identified with sufficient time to perform exchange.	Limited or no impact
4	Exchange inside designated exchange area	Limited use case based on geographic area, problem cannot be resolved, and ballast discharge is not possible at the terminal.	Delay
5	Retain ballast water onboard (no discharge)	Problem cannot be resolved, and ballast discharge is not possible. Vessel does not plan to load cargo.	Major impact if cargo cannot be loaded

	Contingency Example	Use Case	Commercial Impact
6	Partial discharge outside 12nm (USA only)	Limited use case based on geographic area, problem cannot be resolved, and partial ballast discharge is acceptable.	Delay

6.3 Owners of Knowledge and Duties

The owner must establish roles and responsibilities for the new BWMS to ensure operation of the system is according to the maker's TA and to limit compliance issues. It is recommended that the owner develop a simple organizational chart to outline the roles. A sample chart is given in Figure 13 below.

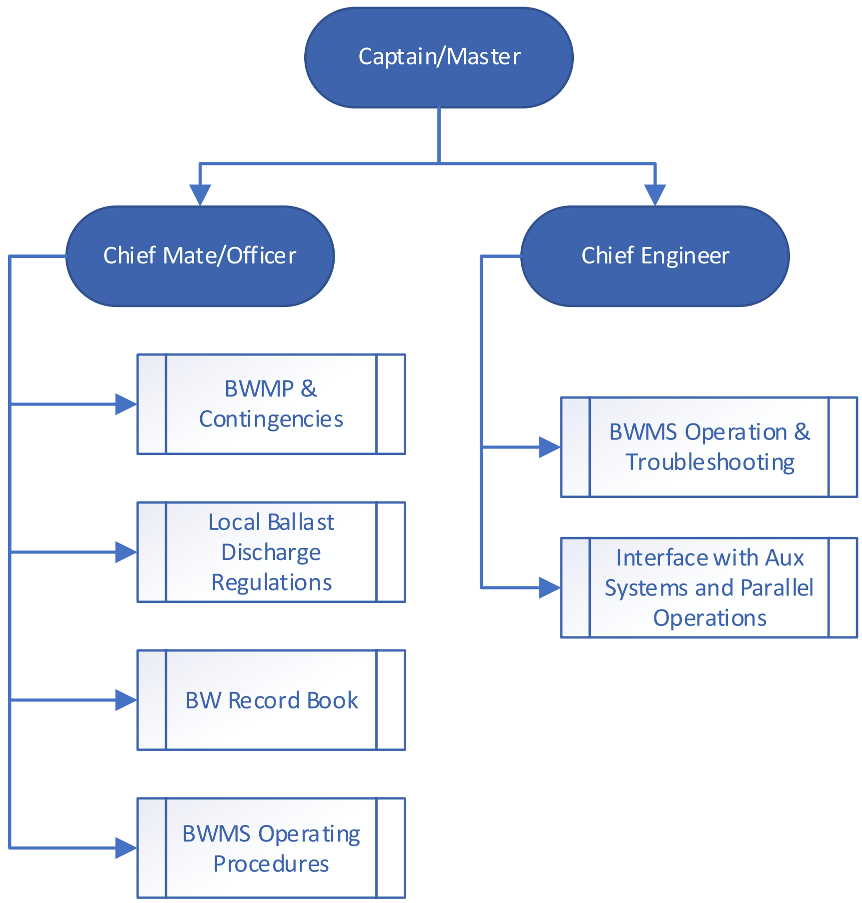


Figure 13 - Vessel Crew Responsibilities Overview

7 Equipment Maintenance and Repair

7.1 Standard and Redundancy Spares

- Request the maker's spare parts justification, such as a failure mode and effects analysis (FMEA) or similar, to ensure a robust yet cost effective list has been provided.
- A vessel-specific FMEA by the owner will help the crew understand how to prioritize their inspections and identify early indicators of malfunction or failure.
- Additional spares for possible failures during commissioning should be consulted with the BWMS maker.

With 1) crew understanding of the Type Approval and BWMS manuals, and 2) completion of maker and internal training, the final key element of the BWMS life cycle is 3) a robust spares and maintenance program. The critical importance of all three elements to an owner's BWMS program is represented as the legs of a stool, as shown in Figure 14. All three are necessary to ensure sustained, smooth BWMS operation on any vessel.

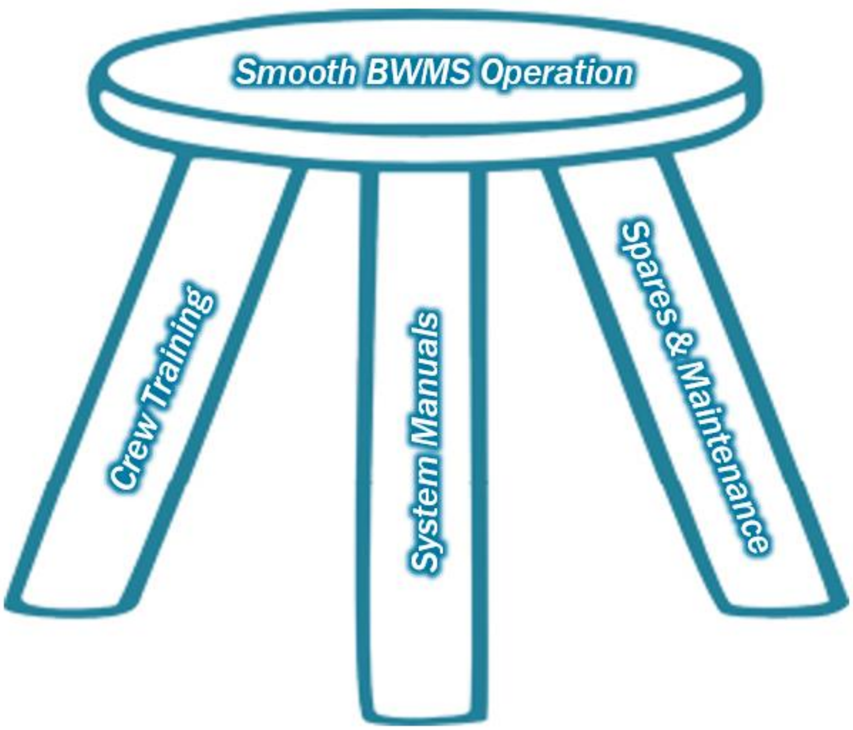


Figure 14 - Key elements supporting smooth BWMS operation

The maker's operating manual should list both standard and recommended redundancy spare parts for high risk items. A FMEA approach is recommended when considering spare parts. Most BWMS makers can provide an FMEA that was developed as part of the type approval. The owner would further benefit from carrying out a vessel-specific FMEA to identify where failures for a given installation are most likely and have the greatest consequences. With this information, the owner can design a vessel-specific inspections and maintenance plan, ensuring consistent operation of the BWMS and minimizing downtime. Table 9 shows a sample spare parts rate with a basic failure rate/impact approach to determining spares planning.

Table 9 - Sample spare parts list using failure mode and effects analysis; failure rate rated A-E (low-high) and impact rated 1-5 (low to high)

ID	Name	Failure Rate	Impact	Standard	Redundancy
A0001	Centrifugal 1 stage 316SS pump	C	5	1	0
A0002	Sensor Transmitter Pressure, UL, 3/4" NPT, Relay	B	2	0	0
A0003	Sensor Transmitter, UL, 3/4" NPT, Catalytic Bead	B	2	0	0
A0004	Valve Actuator	D	5	1	1
A0005	Transmitter, Flow Meter	B	5	0	1
A0006	Flow Indicator	E	4	1	0
…	…	…	…	…	…

7.2 Consumables Sourcing and Inventory

Many BWMSs have consumables that must be stocked regularly. There are two considerations for consumable supplies, as described below.

7.2.1 Commissioning

Some of the consumable chemicals will likely be needed for commissioning. This supply is sometimes provided by the maker alongside the equipment, but the owner must verify this during initial inquiries and contracting. Often, it is best to supply consumables locally rather than purchasing from the equipment maker. Two reasons drive this decision:

1. Many treatment-related chemicals are common, so shipping and duties can be avoided.
2. Some chemicals are considered hazardous and may be difficult to transport, particularly by air freight.

Examples of hazardous chemicals commonly used for BWMS are as follows:

- Bulk dosing system oxidants.
- Electrolytic and UV system cleaning acid.
- Paint, glue, solvents, etc.

7.2.2 Regular Service

Replenishment of consumables used during commissioning should be planned ahead of vessel sailing. This is especially important for materials that are solely supplied by the BWMS maker or not readily available from local suppliers.

Operating experience over time will provide the best indication of the replenishment schedule for consumables; however, the maker should provide a conservative estimate of consumption for the first several ballast cycles.

Some chemical consumption rates will vary based on environmental conditions and may be different from commissioning. Bulk dosing oxidant chemical consumption varies with organic demand of the local water, for example. A higher organic demand requires a higher chemical dose. It is important to maintain a conservative supply onboard the vessel to ensure smooth operation and minimize impacts to the vessel's other operations.

7.3 Service Program and Logs for BWMS

The owner must develop a service program for the BWMS in accordance with the maker's guidance. Guidance should be listed in the system operating manual. Careful logs should be maintained to keep the crew on schedule for all maintenance needs, and to support potential warranty claims, when appropriate. A sample service schedule is given in Table 10 for reference, assuming an electrolytic installation. The actual schedule and requirements should be tailored for each vessel and individual BWMS.

Table 10 - Sample service schedule for an electrolytic chemical-based system

Frequency	Requirement	Repair/Service	
As prompted by control system	Replace EC unit cleaning solution	Capacity: -- kg/hr[1] -- kg/hr -- kg/hr	Replace every: -- cycles -- cycles -- cycles
	Replace oxidant sampling unit reagent	Approx. every -- hours of unit run-time	
	Replace oxidant sampling unit buffer reagent	Approx. every -- hours unit run-time	
Weekly	Confirm treatment system is powered and no unresolved alarms exist.	Check breakers and disconnect switches are energized	
		Check for alarms.	
Monthly	Clean all strainers	Pump 1 suction	
		Pump 2 suction	
Every 90 Days	Inspect/service oxidant sampling unit	Replace indicator reagent	
		Check and clean internal strainer	
		Inspect glass cuvette for debris and replace as necessary	
Every 6 Months	Download data log from control panel	Backup data and store for a minimum of -- months onboard vessel	
	Calibrate Gas Detectors	Calibrate in accordance with maker manual and described in this section	
Every 1 Year (annually)	Service oxidant sampling unit	Replace pump tubes	
		Replace buffer reagent	
	Maker authorized personnel inspection and service	Inspect electrical connections, generator cell(s), performance data in digital logs	
Every 5 Years	Maker authorized personnel inspection and overhaul	Inspect system, performance data in digital logs	
		Service control valves	
		Replace electrolytic cells and inspect electrical connections	
		Inspect and service power supply heat exchanger	

[1] Kilograms per hour

7.4 Planning for Maker Service Calls

A service agreement and written contract must be part of commercial negotiations with the BWMS maker. A good service contract will avoid confusion and possible delays when help is needed. Important points to consider in a service contract are listed in the following checklist.

Service Contract Checklist:

- Warranty period and coverage:
    - Standard warranty options.
    - Extended warranty options.
- Service contact details and availability:
    - Ensure the maker has a service representative available 24/7/365.
    - What are the contact details and how should an issue be documented and reported?
- Spare parts availability, cost, and logistics:
    - Compare the maker's spare parts network to typical vessel operating locations.
    - How soon can spare parts be dispatched and what are the logistics? Consider downtime for coordination with the maker as well as any customs clearance that may be required.
- Service engineer availability and attendance:
    - Compare the maker's service network to typical vessel operating locations.
    - How soon can a service engineer be dispatched?
    - Document standard cost for days waiting and days working.

Remote support availability and costs.