

GUIDE FOR

BALLAST WATER EXCHANGE JULY 2010

Guide to Color Coding Used in Online Version of the Guide

The following summarizes the colors corresponding to Rule Changes, Corrigenda items and editorial changes in the Guide files which are available for download.

Rule Changes:

NOTICE NO. 1 – October 2010 (effective 20 October 2010)

Corrigenda:

CORRIGENDA/EDITORIALS – 22 February 2016

Editorials:

Editorial Changes



GUIDE FOR

BALLAST WATER EXCHANGE

JULY 2010 (Updated February 2016 – see next page)

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the State of New York 1862**

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February 2016 consolidation includes:

- October 2010 consolidation includes:**

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Foreword

The inadvertent transfer of harmful aquatic organisms and pathogens in a vessel's ballast water has been determined to have caused a significant adverse impact to many of the world's coastal regions. The international maritime community, under the auspices of the International Maritime Organization (IMO) has developed several documents, including the "International Convention for the Control and Management of Ship's Ballast Water and Sediment, 2004," (Ballast Water Management Convention), which are aimed at preventing the introduction of unwanted aquatic organisms and pathogens through the discharge of ballast water and sediments.

The Ballast Water Management Convention will apply to vessels registered in a country which is party to the Convention and to those vessels registered in other countries when operating in the waters of a country which is party to the Convention.

One of the strategies incorporated into the Ballast Water Management Convention is Ballast Water Exchange (BWE). Ballast water exchange is the process of exchanging coastal water, which may be fresh water, salt water or brackish water, for mid-ocean water. During the exchange process, biologically laden water taken on in the last port of call is flushed out of the ballast tanks with open ocean water, typically 200 nautical miles from the nearest land. Scientists, specifically Marine Biologists, have determined that marine organisms and pathogens are, in general, less numerous in the open ocean and, due to changes in the water's chemistry, temperature and salinity would be less likely to survive once they are discharged into the near shore receiving waters.

While the vast majority of vessels are capable of conducting ballast water exchange, and the procedures do not typically require any special structural modifications to most of the vessels in operation, it does present challenges for designers, builders, owners and operators. These challenges include over-pressurization or under-pressurization of tanks, longitudinal strength and transverse stability concerns, as well as maneuverability issues.

To assist the marine industry, ABS issued the "Advisory Notes on Ballast Water Exchange Procedures" in October 1999. This Advisory described the implications associated with ballast water management and ballast water exchange using fourteen typical vessels as examples. While the findings contained in the Advisory focused on existing vessels, many of the conclusions could also be applied to assist in the development of new buildings. However, it is to be noted that the details provided in the Advisory are vessel-specific and that the information contained therein was to be viewed as typical, and provide representative values that might be obtained for any single vessel and are highly dependent on the vessel's design and structure, which may vary greatly from one vessel to another.

This *Guide for Ballast Water Exchange* is provided for the use of designers, builders, owners, and operators of vessels classed with ABS and specifies the requirements for obtaining the optional classification notation Ballast Water Exchange (**BWE**). The **BWE** notation identifies a level of compliance with the applicable regulations contained in the IMO "International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004", as well as those IMO Guidelines referenced in the Convention addressing ballast water exchange.

While the Convention has not yet entered into force, many port States, such as Brazil, Canada and the United States have established national regulations mandating the exchange of ballast water, together with evidence to support that the exchange has taken place (ballast water records).

This Guide is to be used in conjunction with other Rules published by ABS and IMO guidelines.

Users of this Guide acknowledge and agree that ABS is not responsible for a vessel's operation pertaining to ballast water exchange and shall bear no liability for such operations. This Guide references relevant international regulations and guidelines that are considered to be applicable. While it is the intent of the Guide to be consistent with these relevant regulations and guidelines, it is the ultimate responsibility of the users of this guide to refer to the most recent text of those regulation and guidelines.

ABS appreciates the receipt of comments and suggestions, as well as technical and application questions for the improvement of this Guide. Users are also advised to check with ABS to verify that this version of the Guide is current. For this purpose, enquiries can be submitted electronically to either rsd@eagle.org or to the Rules & Guides Section of eagle.org.

The effective date of this Guide is the first day of the month of publication



GUIDE FOR BALLAST WATER EXCHANGE

CONTENTS

CHAPTER 1	Introduction	1
	Section 1 General	2
	Section 2 Definitions	4
	Section 3 Basis of Notation	5
	Section 4 Classification Symbol and Notation	6
	Section 5 Classification Procedures	7
CHAPTER 2	Ballast Water Exchange Requirements.....	9
	Section 1 Ballast Water Exchange Standard and Requirements	10
	Section 2 Ballast Water Exchange Methods.....	12
	Section 3 Ballast Water Exchange System Design and Construction.....	20
CHAPTER 3	Ballast Water Management Plan	23
	Section 1 General Information	26
	Section 2 Cover Page	27
	Section 3 Preamble.....	28
	Section 4 Introduction	29
	Section 5 Vessel Particulars	30
	Section 6 Crew Review Record/Revision History	31
	Section 7 Table of Contents.....	32
	Section 8 Introduction – Intent and Purpose of Ballast Water Management and Management Plan.....	33
	Section 9 Ballast Water System Drawings and Data.....	35
	Section 10 Ballast Water Sampling Points	38
	Section 11 Operational Guidance	39
	Section 12 Safety Procedures for the Vessel and Crew.....	42
	Section 13 Operational or Safety Restrictions	43
	Section 14 Description of the Method(s) Used Onboard for Ballast Water Management and Sediment Control	44
	Section 15 Procedures for the Disposal of Sediments	46
	Section 16 Methods of Communication	47
	Section 17 Duties of Designated Ballast Water Management Officer and Vessel's Master.....	48

Section 18	Ballast Water Record Book and Reporting Forms.....	50
Section 19	Crew Training and Familiarization	52
Section 20	Supporting Documentation	53
APPENDIX 1	Ballast Water Reporting Form	54
APPENDIX 2	Ballast Water Record	58
APPENDIX 3	International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004.....	62
APPENDIX 4	IMO Resolution A.868 (20)	66



CHAPTER 1 Introduction

CONTENTS

SECTION 1	General	2
1	Application	2
3	Objective/Scope	2
	FIGURE 1 Scope of this Guide	3
SECTION 2	Definitions	4
SECTION 3	Basis of Notation	5
SECTION 4	Classification Symbol and Notation	6
1	Systems Built under Survey	6
3	Systems Not Built under Survey	6
SECTION 5	Classification Procedures	7
1	Engineering Review	7
3	Initial Survey	7
5	Surveys After Construction	7
7	Governmental Regulations	8



CHAPTER 1 Introduction

SECTION 1 General

1 Application

The requirements in this Guide apply to vessels that are designed, equipped and intended to conduct ballast water exchange at sea in accordance with the “International Convention for the Control and Management of Ships’ Ballast Water and Sediments, 2004”, the associated IMO Guidelines and national regulations addressing ballast water exchange. At the request of the owner, those vessels intended to conduct ballast water exchange which comply fully with the requirements of this Guide and the applicable Rules and have been constructed under survey by ABS Surveyors may be assigned the **BWE** classification notation as specified in Chapter 1, Section 4 of this Guide.

Within this Guide, ABS refers to relevant international regulations and guidelines that are considered to be applicable. While it is the intent of this Guide to be consistent with the regulations and guidelines, it is recommended that the users of this Guide refer to the most recent text of those regulations and guidelines.

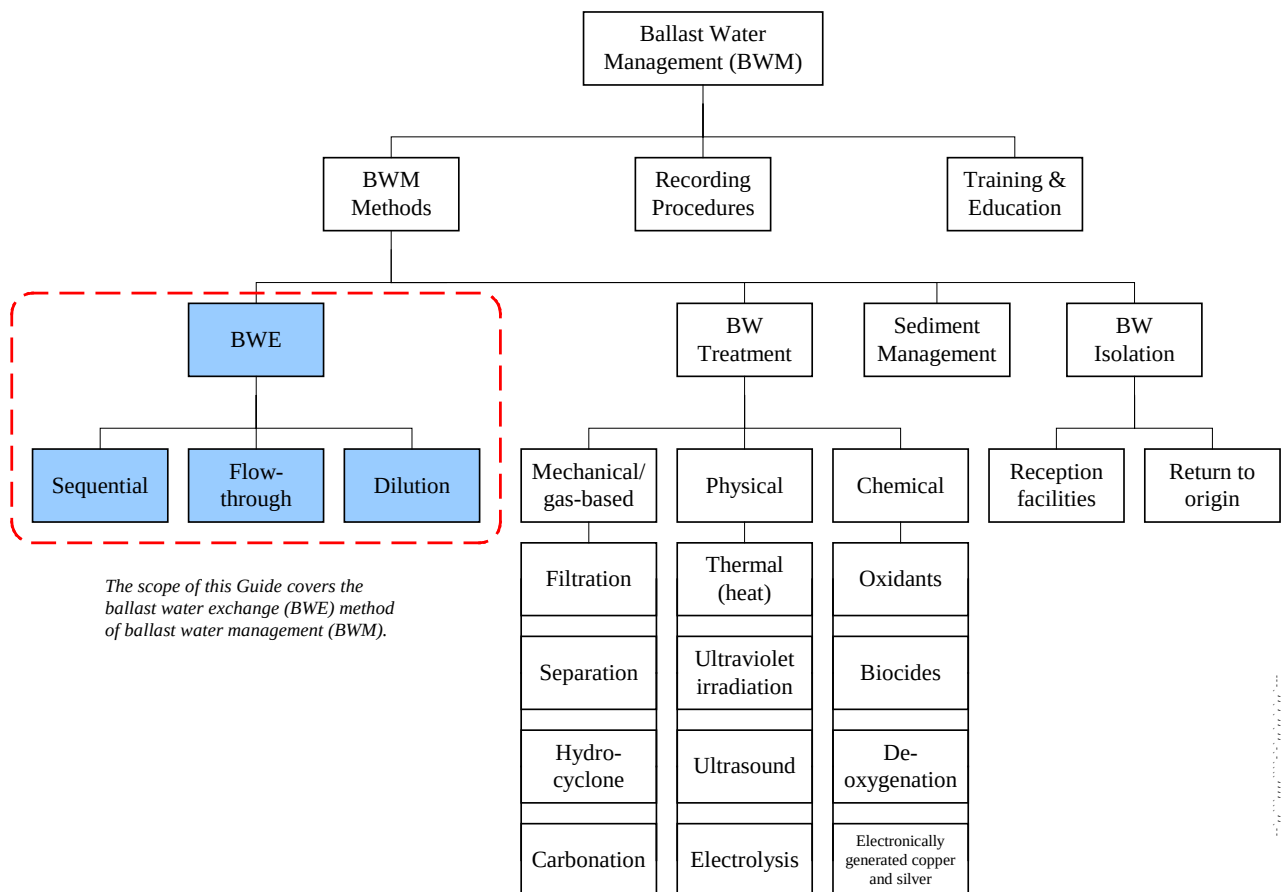
3 Objective/Scope

The objective of this Guide is to provide supplementary requirements regarding ballast water exchange at sea that generally are not addressed by other ABS Rules or Guides. Ballast water exchange at sea presents numerous challenges related to the operation of vessels, specifically vessel structure, stability and machinery systems. Owners/operators that have elected to conduct ballast water exchange at sea as a means to control and manage ballast water pending the implementation of the IMO regulations mandating the installation of an approved ballast water management system, may experience increased structural and mechanical equipment failures unless the vessel’s design, construction and operation have considered the potential hazards associated with ballast water exchange at sea.

It is recognized that vessels conducting ballast water exchange may have unique operating characteristics for which the requirements in this Guide may not be applicable. For such cases, ABS is prepared to consider alternative arrangements, provided that substantiating information and/or a risk analysis is submitted for review.

As indicated in 1-1/Figure 1, BWE is one of the accepted ballast water management methodologies provided for within the Convention which is available for selection by the owner.

FIGURE 1
Scope of this Guide



CHAPTER 1 Introduction

SECTION 2 Definitions

Administration is the Government of the State under whose authority the vessel is operating. With respect to a vessel entitled to fly a flag of any State, the Administration is the Government of the State. With respect to floating platforms engaged in exploration and exploitation of the sea-bed and subsoil thereof adjacent to the coast over which the coastal State exercises sovereign rights for the purpose of exploration and exploitation of its natural resources, including Floating Storage Units (FSUs) and Floating Production Storage and Offloading Units (FPSOs), the Administration is the Government of the coastal State concerned.

Ballast Water is the water with its suspended matter taken onboard a vessel to control trim, list, draft, stability or stresses of the vessel.

Ballast Water Exchange (BWE) is a process involving the replacement of water in a ballast tank using either the sequential, flow-through, dilution or other exchange methodologies recommended or required by IMO.

Ballast Water Exchange Plan is the procedures and advice to safely and efficiently exchange ballast water in accordance with applicable structural and stability requirements.

Ballast Water Tank is any tank, hold or space used for the carriage of ballast water.

Ballast Water Management (BWM) means mechanical, physical, chemical, and biological processes, either singularly or in combination, to remove, render harmless or avoid the uptake or discharge of harmful aquatic organisms and pathogens within ballast water and sediments.

Ballast Water Management Plan is the plan for the handling or treating of ballast water onboard a vessel to minimize the transfer of harmful organisms or pathogens in the vessel's ballast water and sediment.

Convention is the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004.

Gross Tonnage is the gross tonnage calculated in accordance with the tonnage measurement regulations contained in Annex I to the International Convention on Tonnage Measurement of Ships, 1969 or any successor Convention.

Harmful Aquatic Organisms and Pathogens are aquatic organisms or pathogens which, if introduced into the sea, including estuaries, or into fresh water courses, may create hazards to the environment, human health, property or resources, impair biological diversity or interfere with other legitimate uses of such areas.

Rules are the ABS Rules for Building and Classing Steel Vessels (*Steel Vessel Rules*) or the ABS Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length (*Under 90m Rules*), as appropriate.

Sediments are the matter settled out of ballast water within a vessel.

Ship is a vessel of any type whatsoever operating in the aquatic environment and includes submersibles, floating craft, floating platforms, Floating Storage Units (FSUs), and Floating Production Storage and Offloading Units (FPSOs).

Treatment is a process or mechanical, physical, chemical or biological method to kill, remove or render infertile harmful or potentially harmful organisms within ballast water.



CHAPTER 1 Introduction

SECTION 3 Basis of Notation

This Guide contains the provisions for ballast water exchange systems and for the optional classification notation **BWE** for vessels classed with ABS. This Guide is intended for use in conjunction with the appropriate Rules found in the *ABS Rules for Building and Classing Steel Vessels* or *ABS Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length*, as appropriate. Ballast water exchange systems designed and installed in accordance with this Guide will also comply with the International Maritime Organization (IMO) Regulations and Guidelines listed below:

- The International Convention for the Control and Management of Ship's Ballast Water and Sediments, 2004.
- IMO Resolution MEPC.124 (53), "Guidelines for Ballast Water Exchange (G6)", adopted on July 22, 2005.
- IMO Resolution MEPC.127 (53), "Guidelines for Ballast Water Management and Development of Ballast Water Management Plans (G4)", adopted on July 22, 2005.
- IMO Resolution MEPC.149 (55), "Guidelines for Ballast Water Exchange Design and Construction Standards (G11)" adopted on 13 October 2006.
- IMO Resolution MEPC.150 (55), Guidelines on Design and Construction to Facilitate Sediment Control on Ships (G12)", adopted on 13 October 2006



CHAPTER 1 Introduction

SECTION 4 Classification Symbol and Notation

1 Systems Built under Survey

Where requested by the owner, vessels designed, constructed, and surveyed in accordance with this Guide, may be assigned the notation **BWE**.

3 Systems Not Built under Survey

Vessels which have not been constructed under survey in accordance with the requirements of this Guide may obtain the optional **BWE** notation, provided the vessel's arrangements have been determined to comply with the design and construction criteria contained in this Guide. The operation of the ballast water exchange system is to be demonstrated to ABS, or documentation confirming the successful performance of ballast water exchange for a period of one year is to be submitted to ABS.

CHAPTER 1 Introduction

SECTION 5 Classification Procedures

1 Engineering Review

Vessels having the **BWE** notation are required to be provided with certain design features. These design features are addressed in Chapter 2 of this Guide.

Prior to the issuance of the **BWE** notation, the following plans or documentation are to be submitted electronically by the manufacturer, designer or shipbuilder to ABS. However, hard copies will also be accepted.

- i) Arrangement showing the location and capacity of the ballast tanks and pumps
- ii) Booklet providing the standard construction details for the ballast piping system, including vents and overflows, valve arrangement and controls, and the means for determining the level in the ballast tanks
- iii) The location of ballast water and sediment sampling openings
- iv) Ballast Water Management Plan
- v) Calculations demonstrating the adequacy of the vents and overflows to prevent over- or under-pressurization of the ballast tanks
- vi) Loading Manual and Trim & Stability Booklet

The ballast water record book is to be developed and retained onboard the vessel.

3 Initial Survey

The ballast water exchange system, alarms, shutdowns and control equipment are to be tested under working conditions to the satisfaction of the attending Surveyor. Vessels complying with the requirements in Chapter 2 and confirmed by survey are eligible to receive the **BWE** notation.

5 Surveys After Construction

An Annual Survey is to be conducted to retain the **BWE** notation status. At each Annual Survey, the ballast water exchange system is to be examined. The survey is to include the following, as applicable:

- i) A general, external examination of the controls and piping systems (including pipes, valves, pipe supports, etc.)
- ii) *Operation and Maintenance Records*: The Surveyor is to review the ballast water exchange records and the ballast water exchange plan to confirm that activities, including sampling of the ballast water, associated with the exchange of ballast water have been properly recorded and that the exchange plan is current.
- iii) *Alarm and Safety Devices*: The Surveyor is to verify the operation of applicable alarms and safety devices, using simulated conditions where necessary.

In conjunction with the Special Periodical Survey, the ballast water exchange system is to be examined and placed in satisfactory condition to retain the **BWE** notation. The mechanical and electrical components are to be examined, including but not limited to valves, seals, pumps, control panels, vents, air pipes and monitoring sensors. When possible, the operation of the ballast water exchange system is to be demonstrated to the satisfaction of the attending Surveyor. At the discretion of the Surveyor, the vessel's entire ballast water exchange system (including ballast tanks, pumps, valves and controls) is to be examined as part of the Special Periodical Survey.

7 Governmental Regulations

Several national administrations have in place additional requirements pertaining to the management of ballast water for vessels operating in their territorial waters. These requirements may address additional vessel features, equipment, reporting, and record keeping that are not included in this Guide. Owners/operators are encouraged to remain current with these national administration requirements.

CHAPTER 2 Ballast Water Exchange Requirements

CONTENTS

SECTION 1	Ballast Water Exchange Standard and Requirements	10
1	Ballast Water Exchange Standard	10
3	Where Ballast Water Exchange is to be Conducted	10
5	Ballast Water Management Implementation Schedule	11
	TABLE 1 Summary of Convention B-3 Compliance Schedule	11
SECTION 2	Ballast Water Exchange Methods	12
1	General	12
3	Sequential Method	13
3.1	Stability	13
3.3	Longitudinal Strength	13
3.5	Sloshing	14
3.7	Wave-induced Hull Vibrations	15
3.9	Over- and Under-pressurization of Tanks and Holds	15
3.11	Free Surface Effects	15
3.13	Forward and Aft Drafts	15
3.15	Propeller Immersion	15
3.17	Bridge Visibility	16
3.19	Data, Tables and Forms to be Included	16
5	Flow-through Method	18
7	Dilution Method	19
	TABLE 1 Log of Ballast Water Exchange Method(s)	12
	TABLE 2 Summary of Ballast Water Exchange Sequences	17
SECTION 3	Ballast Water Exchange System Design and Construction	20
1	General	20
3	Ballast Piping	20
5	Ballast Pump	20
7	Ballast Valve Arrangements	21
9	Sea Chests and Shipside Openings Intended for Ballast Water Exchange	21
11	System Arrangements	21
13	Control Features	21
15	Ballast Tanks	22
17	Sampling	22

CHAPTER 2 Ballast Water Exchange Requirements

SECTION 1 Ballast Water Exchange Standard and Requirements

1 Ballast Water Exchange Standard

Owners/operators that have elected to operate with BWE as the method of BWM are to meet the following requirements:

- i) Vessels performing ballast water exchange must achieve a 95% volumetric exchange of ballast water.
- ii) In order to achieve 95% volumetric exchange, vessels utilizing the flow-through or dilution methods, as defined in 2-2/1, must pump through three times the volume of each ballast water tank.
- iii) If a vessel utilizing the flow-through or dilution method is able to complete at least 95% volumetric exchange in pumping less than three times the volume, documentation consisting of detailed studies confirming this capability is to be submitted for review and is to be attached as an annex of the BWM plan.

3 Where Ballast Water Exchange is to be Conducted

Exchange of ballast water in deep ocean areas or open seas offers a means of limiting the probability that coastal aquatic species will be transferred in vessels' ballast water. A vessel conducting ballast water exchange to meet the BWE standard is to:

- i) Conduct ballast water exchange at least 200 nautical miles from the nearest land and in water of at least 200 meters in depth.
- ii) If a vessel cannot conduct ballast water exchange in accordance with 2-1/3i), the exchange is to be conducted as far from the nearest land as possible, but at least 50 nautical miles from the nearest land and in water depth of at least 200 meters.

The location, volume and depth of the water where the exchange is conducted is to be recorded in the Ballast Water Record Book. (See Chapter 3, Section 18 and Appendix 2 of this Guide.)

A port State, in consultation with adjacent or other States, may designate areas where ballast water exchange may be conducted if there are locations of operation where the distance from nearest land and water depth do not meet the requirements of 2-1/3i) or 2-1/3ii). Owners and operators are encouraged to consult with the port State authorities to confirm the presence and location of such designated areas.

In extraordinary conditions, such as adverse weather or equipment failure, the Master may make the decision not to perform ballast water exchange if he/she reasonably determines that in doing so the vessel's stability or safety of the vessel its crew or passengers may be threatened.

If a vessel is not able to perform ballast water exchange in accordance with the requirements of Chapter 2, Section 1, a notation with explanation for the variance is to be made in the Ballast Water Record Book.

5 Ballast Water Management Implementation Schedule

The implementation schedule for vessels to meet the ballast water management requirements is provided in Regulation B-3 of the Convention and is summarized in 2-1/Table 1, where D-1 and D-2 refer to Regulations D-1 and D-2 of the Convention, respectively.

TABLE 1
Summary of Convention B-3 Compliance Schedule

Ballast Cpty (m3)	Build Date	® First Intermediate or Renewal Survey, whichever occurs first, after the anniversary date of delivery in the respective year									
		2009	2010	2011	2012	2013	2014	2015	2016	2017	
<1500	< 2009	D1 or D2								D2 ®	
	in 2009	D1; D2 by "2 nd Annual but not beyond 31 Dec 11" or EIF , whichever is later (Note)									
	>2009	D2 (at delivery or EIF, whichever is later)									
≥1500 or ≤5000	< 2009	D1 or D2						D2 ®			
	in 2009	D1; D2 by "2 nd Annual but not beyond 31 Dec 11" or EIF , whichever is later (Note)									
	>2009	D2 (at delivery or EIF, whichever is later)									
>5000	< 2012	D1 or D2								D2 ®	
	≥ 2012	N/A			D2 (at delivery or EIF, whichever is later)						

Note: Advice is to be sought from Signatory States with respect to the delayed D2 enforcement date recommended by A.1005(25).

CHAPTER 2 Ballast Water Exchange Requirements

SECTION 2 Ballast Water Exchange Methods

1 General

Three methods of ballast water exchange have been evaluated and determined to be acceptable to IMO; viz the sequential method, the flow-through method and the dilution method. A description of these methods is as follows:

- i) *Sequential method* – A process by which a ballast tank intended for the carriage of water ballast is first emptied and then refilled with replacement ballast water to achieve at least a 95% volumetric exchange.
- ii) *Flow-through method* – A process by which replacement ballast water is pumped into a ballast tank intended for the carriage of water ballast, allowing water to flow through overflow or other arrangements. At least three times the tank volume is to be pumped through the tank.
- iii) *Dilution method* – A process by which replacement ballast water is filled through the top of the ballast tank intended for the carriage of water ballast with simultaneous discharge from the bottom at the same flow rate and maintaining a constant level in the tank throughout the ballast exchange operation. At least three times the tank volume is to be pumped through the tank.

The flow-through method and the dilution method are often referred to as “pump-through” methods.

Each ballast water exchange method has particular associated aspects that are to be considered when selecting the method(s) to be used on a specific type of vessel, as discussed in the following Subsections. The degree to which a vessel is suited to the sequential method, the flow-through method, or the dilution method is dependent on its design and age.

Any other method of ballast water exchange will be subject to special consideration by ABS.

After the ballast water exchange methods for a vessel have been determined, and the ballast water exchange system requirements have been met, the pertinent sequencing or pump-through operational information is to be documented, together with safety considerations, in the Ballast Water Management Plan as outlined in Chapter 3 of this Guide. The Ballast Water Management Plan is also to include a summary of selected exchange method(s), similar to 2-2/Table 1 below.

TABLE 1
Log of Ballast Water Exchange Method(s)

<i>BWE No.</i>	<i>BWE Method</i>	<i>Description of Conditions</i>	<i>Date</i>	<i>Approved By</i>

The vessel’s loading conditions for the selected ballast water exchange method or methods are to be developed and calculations submitted to show that the loading conditions satisfy the applicable requirements for ballast capacity, trim, stability, longitudinal strength, and local strength. These conditions are to be submitted for approval and then placed in the vessel’s Loading Manual or Trim and Stability Booklet. The vessel operators are to use the approved ballast water exchange loading conditions from the Loading Manual or Trim and Stability Booklet when performing ballast water exchange operations.

3 Sequential Method

The sequential method entails completely emptying ballast tanks of the coastal waters and refilling with open-ocean water. Emptying of certain tanks may lead to significantly reduced stability, higher vessel structural stresses, high sloshing pressures and/or reduced forward drafts which may then increase the probability of bow slamming.

Margins are to be provided for stability and strength for all seagoing conditions, as specified in the vessel's approved trim and stability booklet and the loading manual. The loading conditions for the selected ballast water exchange method or methods are to be taken from the approved loading manual or trim and stability booklet. The following items are to be evaluated when the sequential method is selected for ballast water exchange.

3.1 Stability

3.1.1 Intact Stability

The intact stability requirements contained in 3-3-1/3.1, "Intact Stability", of the *Steel Vessel Rules* or 3-3-1/3.1 of the *Under 90m Rules*, as applicable are to be satisfied. These requirements are to be met at every stage of the ballast water exchange under all loading conditions. The results of the intact stability calculations demonstrating compliance with the intact stability requirements during ballast water exchange are to be included in the stability booklet and submitted for review and approval.

When calculating stability, the free surfaces in all tanks are to be set to maximum.

3.1.2 Damage Stability

The damage stability requirements contained in 3-3-1/3.3, "Subdivision and Damage Stability", of the *Steel Vessel Rules* or 3-3-1/3.3 of the *Under 90m Rules*, as applicable are to be satisfied. Compliance with limiting GM/KG curves, which may be based partly on applicable damage stability criteria, is to be maintained at all times.

3.3 Longitudinal Strength

3.3.1

The longitudinal strength for each stage is to be within the allowable seagoing limits, as prescribed in the *Steel Vessel Rules* or the *Under 90m Rules*, as applicable. This is to be demonstrated by printouts for each stage as developed by the ABS-approved loading program or by the approved Loading Manual.

3.3.2

At any longitudinal location, a typical output of longitudinal strength includes the following:

- Calculated still-water bending moment (SWBM) and still-water shear force (SWSF)
- Maximum and minimum values of SWBM and SWSF
- Calculated still-water torsional moment (SWTM), where applicable
- Maximum permissible value of SWTM, where applicable
- Calculated SWBM and SWSF in flooding conditions, where applicable
- Maximum permissible values of SWBM and SWSF in flooded conditions, where applicable

3.3.3

Under each loading condition, the calculation of longitudinal strength is to be conducted for each stage of ballast water exchange.

3.3.4

If, in any stage, the seagoing limits are not met and cannot be met due to the vessel's/tank configuration (this must be demonstrated by the designer), special consideration may be given to the implementation of operational procedures such as weather condition limitations or enhanced watch keeping procedures.

3.5 Sloshing

3.5.1

In general, sloshing is unavoidable for a vessel using the sequential method. However, it can be controlled to within acceptable limits by restricting the sea state in which the ballast water exchange operations are conducted. Where necessary, an approach is to be proposed, subject to the approval of the Flag Administration, to establish a maximum sea state or significant wave height for partial filling of ballast tanks where sloshing occurs. Documentation for the ballast water exchange is to include where applicable:

- An assessment of the potential for liquid resonance in the tank as a function of the ballast water filling height. For low filling levels (less than 25%), the resonance in general is not a concern. However, confirmation is required. For filling levels greater than 50%, resonance can be an issue that may require a sea state limitation during ballast water exchange sequences.
- For those vessels having a **SH** or **CSR** notation or where the tank is less than 0.01L and 0.056B, sloshing is not a concern. However confirmation is required.
- A ballast water sequence stop (i.e., temporary "hold" or permanent completion of a ballast water exchange operation stage) will not be permitted in the filling range associated with resonance, or if physically checking for resonance during actual operations.
- A check of the impact pressure at partial filling.

3.5.2

The maximum sea state or the significant wave height is to be limited such that the impact pressure is less than or equal to the pressure permitted by the *Steel Vessel Rules*.

The sloshing check may be exempted under the following locations/conditions where extensive internal structure is provided:

- Double side or double bottom tanks for all vessels.
- Topside tanks for bulk carriers in the heavy ballast conditions.
- A forepeak tank fitted with a centerline wash bulkhead or a centerline ring structure or horizontal ring structures.
- Wing ballast tanks of single hull oil tankers fitted with transverse ring web structures.

3.5.3

For ballast holds of bulk carriers, sloshing must be considered where there is resonance due to partial filling. For this reason, partial filling of ballast holds of bulk carriers is to be avoided.

3.5.4

Partial filling of ballast tanks of single hull tankers is to be avoided, especially in light ballast conditions, unless the tanks are designed for unrestricted filling levels for the ballast condition under consideration.

3.5.5

In cases when the sloshing action is to be considered, the sloshing calculations are to be submitted. The Ballast Water Management Plan is to identify the stages of the exchange where sloshing may be of particular concern and a footnote assigned to the relevant stages for justification of their elimination. The footnote may read as follows:

“Exchange of ballast in tanks may impose significant structural loads generated by sloshing action when the level of the water in the tank is between ...% and ...%. Accordingly, the procedure is to be carried out only in favorable sea and swell conditions such that the risk of structural damage is minimized.”

3.7 Wave-induced Hull Vibrations

Ballast water exchange is to be carried out so as to prevent wave-induced hull vibrations in both favorable and swell conditions.

3.9 Over- and Under-pressurization of Tanks and Holds

Venting calculations are to be conducted to determine the maximum pressure in each tank and hold during the filling phase and the minimum pressure during the de-ballasting considering the maximum pumping rates of the ballast pump. The results of these calculations are to confirm that the tanks and holds will not be subjected to pressure or vacuum in excess of that for which the tank or hold has been designed.

These sets of calculations are to be submitted for review by ABS.

3.11 Free Surface Effects

When using the sequential method, the free surface moments of all tanks are to be set to the maximum for stability and strength calculations.

3.13 Forward and Aft Drafts

3.13.1 Forward Draft

In all sequences of ballast water exchange, the forward draft of the vessel is to be greater than the prescribed minimum forward draft as shown in the Trim and Stability Booklet. If, for a transitory period or in a specific sequence, the minimum forward draft can not be satisfied, the Ballast Water Management Plan is to identify the stages of the exchange process that do not meet the criteria for minimum forward draft, and a footnote documenting this is to be assigned to the relevant stages. The following is an example of such a footnote:

“Exchange of ballast in tanks is to be carried out in favorable sea conditions such that the risk of forward slamming is minimized (Beaufort Force less than or equal to 7).”

3.13.2 Aft Draft

Full propeller immersion is assumed as the minimum requirement for the aft draft.

3.15 Propeller Immersion

The aft draft of the vessel in each sequence of ballast exchange shall be adequate to fully immerse the propeller. If, for a transitory period or in a specific sequence, 100% propeller immersion can not be satisfied, the sequence is to be identified in the Ballast Water Management Plan with a footnote documenting this limitation. The following is an example of such a footnote:

“At this stage of the ballast water exchange operations, the full immersion of the propeller is not possible. This may be considered satisfactory provided the ballast water exchange operations are undertaken in fair weather and sea conditions – such that the Master will be satisfied with the control of the vessel’s maneuverability, and that there is sufficient ballast capacity available at all stages of the voyage to enable propeller immersion in a reasonably short period of time should weather and sea conditions begin to worsen.”

3.17 Bridge Visibility

3.17.1

For vessels built on or after 1 July 1998, the requirements of 3-6-1/1.1.1(a) and (c), 3-6-1/1.1.2(a) and 3-6-1/1.1.3 of the *Steel Vessel Rules* or 3-6-1/1.1.1 (a) and (c) and 3-6-1/1.1.2(a) and 3-6-1/1.1.3 of the *Under 90m Rules*, as applicable are to be met during the stages of ballast water exchange.

3.17.2

For vessels built prior to 1 July 1998, the requirement of IMO MSC/Circ. 403 and SOLAS Regulation V/22.2, is to be met.

Note: For vessels built before 1998, this visibility limit was not mandatory and is not to be invoked simply because ballast water exchange is being implemented.

3.17.3

In all sequences of ballast water exchange, the bridge visibility required for the vessel is to be satisfied. If, in a specific sequence or during a transitory period, the bridge visibility requirements can not be satisfied, the Master is to determine that it is safe to conduct the ballast water exchange taking into consideration the increased blind sectors or reduced horizontal fields of vision resulting from these sequences or period. The vessel's Ballast Water Management Plan is to include a footnote to alert the vessel's Master. The following is an example of such a footnote:

"The Master is to be aware of the fact that the forward bridge visibility is impaired in sequences and accordingly additional measures (such as an enhanced navigational watch will be maintained, including where necessary an additional lookout forward with adequate communications with the navigation bridge) to provide for navigational safety have been established."

The commencement and termination of the enhanced navigational safety measures taken during ballast water exchange operations are to be recorded in the vessel's record of navigational activities.

3.19 Data, Tables and Forms to be Included

For the sequential method, the following information is to be provided to assist the evaluation of safety considerations entailed in 2-2/3.1 through 2-2/3.17:

- Initial vessel condition data listed in the trim and stability booklet
- Summary of the stage-by-stage ballast water exchange sequences (see 2-2/Table 2 below)
- The printout results of stability criteria calculation at each stage
- The printout results of longitudinal strength calculation at each stage
- Specific instructions entailed in 2-2/3.1 through 2-2/3.19.

The following table is an example of the summary of the ballast water exchange sequences at every stage under a certain loading condition listing the status of each tank and items to be checked for comparison. Such summary table is to be required for each loading condition under consideration, and is to be provided with the Ballast Water Management Plan outlined in Chapter 3 of this Guide.

TABLE 2
Summary of Ballast Water Exchange Sequences

Ballast Water Exchange Sequence Table

Voyage: _____
From: _____
To: _____
Date (dd/mm/yr): _____
Weather Conditions: _____

Sequence	A.P.T.		Tank No.		Tank No.		Tank No.		Tank No.		Tank No.		Tank No.		F.P.T	F.O./L.O./F.W. (Mt)	Draft Aft (M)	Draft Fwd (M)	Trim (M)	GM/KG (M)	BM %	SF %	Propeller Immersion %	Bridge Visibility (M)	Time Estimation (hr.)	Remarks
	P	S	P	S	P	S	P	S	P	S	P	S														
Initial Condition																										
Step 1																										
Step 2																										
Step 3																										
Step 4																										
Step 5																										
Step 6																										
Step 7																										
Step 8																										
Step 9																										
Step 10																										

- Notes:
- 1) Master to be notified when the propeller will not be fully immersed
 - 2) Master to be notified that bridge visibility forward will be reduced
 - 3) Master or Ballast Water Management Officer to confirm that the tanks indicated as empty or filled are in that condition
 - 4) Noting difficulties to confirm tank levels of the vessel at sea, where a step results in the partial filling of a tank, additional conditions of $\pm 10\%$ of the partially filled tank level are to be assessed. (Steps resulting in partially filled tanks are to be avoided)

5 Flow-through Method

The flow-through method involves pumping replacement ballast water into the bottom of a full ballast tank, forcing existing ballast water out through an overflow or other arrangement. Ballast water equal to approximately three times the tank capacity must be pumped through the tank to achieve 95% effectiveness in eliminating aquatic organisms.

The flow-through method does not typically alter stability, hull girder stress and vessel attitude. It therefore eliminates concerns of exceeding shear force and bending moment limits and concerns related to shallow forward and aft drafts and extreme trims. As with all methods, the Ballast Water Reporting Form provided in Appendix 1 is to be completed and transmitted to the next port where ballast water is discharged.

In those instances where the flow-through method alters stability, hull girder stress or vessel attitude, a ballast water summary sequence table is to be submitted demonstrating that adequate strength and stability has been maintained.

As the flow-through method is not suitable for all tanks, in addition to the design requirements of Chapter 2, Section 3 of this Guide, the following items are to be evaluated on those vessels utilizing the flow-through method:

- i) Safe pumping procedures are to be provided for ballasting and de-ballasting operations that take into account additional vessel structural stresses that may be involved with conducting ballast water exchange.
- ii) The size of the fixture designated for the overflow is to be verified such that over-pressurization of a ballast tank or pumping equipment, which may lead to structural damage, is prevented. Under-pressurization created by a large drop in pressure due to rapid change in the volume of the contents of the tank is also to be avoided by verifying air vent pipes are open and properly sized prior to discharge. Hydraulic calculations verifying the proper sizing of the fixtures are to be submitted for review.

Calculations confirming that the capacity of the ballast water tank and the ballast piping are capable of providing ballast water exchange by the flow-through method without the risk of being subject to a pressure greater than design are to be submitted for review.

Ballast water carried in double bottom tanks is to be exchanged by the sequential method, unless calculations confirming that pump pressure generated in raising the necessary head of water does not cause excessive internal pressure leading to damage to the vessel.

- iii) Charts and/or tables are to be provided to show the pumping rates, volumes, and time required to exchange ballast water in each tank. In addition, the charts and/or tables are to identify the openings used for release of water from the tank, together with overboard discharge arrangements.
- iv) Arrangements for the examination by the vessel's crew of sounding pipes, vent pipes and non-return devices involved in ballast water exchange are to be provided. Cautionary procedures to be taken regarding the use of air pipes that are not designed for continuous ballast water flow, and weathertight closures (e.g., manholes) which are to be re-secured after flow-through ballast water exchange, are to be provided within the Ballast Water Management Plan and on the charts and/or tables required in item iii) above.

The Ballast Water Management Plan is to contain a note similar to the following example:

"Tank lids or other openings to be used during the flow-through operation are to be specified. Opening of tank lids or manholes, even in fair weather and sea conditions, can compromise deck watertight integrity. The authority as well as the responsibility for this action rests with the Master, and prudent seamanship is to be used. A procedure is to be followed for confirming they are closed after work is completed."

- v) The circumstances and conditions under which ballast water exchange is not to be undertaken due to adverse weather, design limitations, equipment failures, loss of power or other extraordinary circumstances that could threaten human life or safety of the vessel are to be detailed.
- vi) A flow-through method that has water flowing on the deck is not recommended. The use of collecting pipes, internal overflow pipes or interconnecting pipe/trunk arrangements between tanks is to be used to avoid water flowing on the deck.

- vii) The cautionary procedures related to flooding of deck areas and icing during cold weather conditions are to be identified (for example, the flow-through method is not to be performed in low temperature weather conditions that would result in icing).
- Where the effect of icing on deck has not been taken into consideration, the Ballast Water Management Plan is to indicate, *“The flow-through method is not to be performed in weather conditions that would result in icing.”*
- viii) For the flow-through method, it is recommended that the inlet and outlet piping connections be located as remotely from each other as practicable. Aft and fore peak tanks are to be provided with additional pipe work to improve the mixing conditions, unless documentation can be provided to demonstrate adequate mixing. The total cross sectional area of the ballast water discharge pipes on the upper deck is not to be less than two times that of the cross sectional area of the filling/suction pipe. To optimize the ballast water exchange, the ballast water discharge pipes serving the same tank are to be of a different diameter. The discharge pipe located closer to the filling/suction pipe is to have a smaller diameter than the other discharge pipe located further away from the filling/suction pipe. For illustration purposes and as an example, where the filling suction pipe has a diameter of 250 mm, the discharge pipes may be of 200 mm and 300 mm diameter, respectively.
- ix) Where topside and lower hopper side tanks are not interconnected, the scantlings of the hopper and double bottom tanks are normally derived using the head to the top of the tank or two-thirds the distance to the top of the overflow, whichever is the greater. Traditionally, ballast tanks are filled until ballast water overflows. The water pressure at the tank bottom drops immediately due to entrapped air, which reduces the water level in a small diameter overflow pipe. However, the flow-through method will result in a constant high pressure during the long periods required to complete the exchange. Therefore, for flow-through ballast water exchange where topside and hopper side tanks are not interconnected, the scantlings of the tank boundary structure are to be verified using a tank head equivalent to the full distance to the top of the overflow plus the generated back pressure at the maximum flow rate.
- x) The installation of additional air pipes, access hatches (as an alternative to deck manholes), internal overflow pipes (to avoid overflowing on the deck), or interconnecting pipe/trunk arrangements between tanks, where applicable and possible, may be considered.

7 Dilution Method

In the dilution method, replacement ballast water is filled through the top of the ballast tank and simultaneously discharged from the bottom at the same flow rate while maintaining a constant level in the tank throughout the ballast exchange operation. As with the flow-through method, ballast equal to approximately three times the tank capacity must be pumped through the tank to achieve 95% effectiveness in eliminating aquatic organisms.

The dilution method has the advantages of the flow-through method with regard to maintaining the stability and strength and other similar benefits. By discharging water from the bottom of the ballast tanks, sediments are more easily removed. This method avoids the use of air vent pipes and the removal of manhole covers to discharge water over the deck.

In addition to the design requirements of Chapter 2, Section 3 of this Guide, the following safety precautions are to be taken and noted in the Ballast Water Management Plan if the dilution method is chosen:

- i) Arrangements are to be made to automatically maintain the ballast water level in the tanks at a constant level.
- ii) High and low water level alarms are to be provided where maintaining a constant level in a tank or hold is essential to the operational efficiency of the vessel during the ballast water exchange.
- iii) The arrangements are to include the provision of a manual emergency stop for any operating ballast pump in case of valve malfunction or incorrect control actions.

As with all methods, the Ballast Water Reporting Form provided in Appendix 1 is to be completed and transmitted to the next port where ballast water is discharged.