



A D V I S O R Y N O T E S O N

Ballast Water Exchange Procedures

O C T O B E R 1 9 9 9

our MISSION

The mission of the American Bureau of Shipping is to serve the public interest as well as the needs of our clients by promoting the security of life, property and the natural environment primarily through the development and verification of standards for the design, construction and operational maintenance of marine-related facilities.

quality & environmental

It is the policy of the American Bureau of Shipping to be responsive to the individual and collective needs of our clients as well as those of the public at large, to provide quality services in support of our mission, and to provide our services consistent with international standards developed to avoid, reduce or control pollution to the environment.

All of our client commitments, supporting actions, and services delivered must be recognized as expressions of Quality. We pledge to monitor our performance as an on-going activity and to strive for continuous improvement.

We commit to operate consistent with applicable environmental legislation and regulations and to provide a framework for establishing and reviewing environmental objectives and targets.

ABS,  **ABS SAFEHULL** and **ABS SAFENET**
are registered trademarks of the American Bureau of Shipping.





Advisory Notes on Ballast Water Exchange Procedures

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

Copyright © 1999
American Bureau of Shipping
ABS Plaza, 16855 Northchase Drive
Houston, TX 77060 USA

Cautionary Note

It should be noted that the specific ballast sequence information contained in this document is based on detailed calculations and precise tank loading scenarios. Ballast management plans and ballasting procedures need to consider actual vessel operations and the level of complexity involved in implementation.

In addition, the procedures should consider the actual capabilities of the pumping and measuring devices to be employed, the parameters of the required weather window, and the ability of shipboard personnel to perform the intended operations under a range of operating conditions.

The specific ballast sequence information contained herein clearly demonstrates that ballast exchange procedures may require that the ship be at, or near, allowable operational limits during the procedure. Ship operators are urged to exercise the utmost caution when implementing any ballast exchange procedure.



Advisory Notes on Ballast Water Exchange Procedures

Background

Beginning in 1989 governments started to institute national and regional regulations intended to minimize the introduction of unwanted organisms from the discharge of ballast water in their local jurisdictions. IMO adopted voluntary standards in 1993, and adopted guidelines for management of ships' ballast water in 1997. Further, the United Nations *Convention on the Law of the Sea* requires signatory nations to "take all measures necessary to prevent, reduce and control the intentional or accidental introduction of species, alien or new, to any part of the marine environment, which may cause significant or harmful changes thereto." Future IMO Regulations may also be looming on the horizon.

Shipboard actions necessary to address (present and pending draft) ballast water exchange requirements involve a combination of design and/or operational measures. For newbuilds it would be desirable to consider the incorporation of vessel design features that simplify/improve a vessel's ability to perform ballast water exchange operations. However, in the case of existing vessels it is generally presumed that ballast water exchange will be addressed through operational measures, but a limited number of existing vessels may require changes to their ballast system.

This advisory describes the implications of ballast water management and ballast exchange using fourteen typical vessels. The findings focus on existing vessels, yet conclusions can also be drawn with respect to desirable features for newbuilds.

It is noted that the details are vessel specific and the information contained herein should be viewed as typical, representative values, the results that might be obtained for any single vessel are highly dependent on vessel design and structure, which may vary greatly from one vessel to another. This Advisory is not intended as a substitute for vessel specific calculations and the independent professional judgement of the user.

Means to Minimize Unwanted Organisms from Ballast Water

There are several measures that can be taken to minimize the release of unwanted organisms from ships' ballast water. A summary of methods to mitigate the introduction of non-indigenous species through ballast water is as follows:

- a) Retention of ballast on board: Eliminating ballast water discharge is of course the most reliable means of preventing the introduction of aquatic organisms. Although complete elimination of ballast discharge is not always practical, in most cases proper ballast water management can minimize the quantity of ballast requiring exchange or treatment.

- b) Reducing organisms taken on board: Limiting the amount of ballast taken is the first step in an effective ballast management plan. Practices that minimize the intake of port and coastal sediment can also be effective in reducing aquatic introductions. Ballasting should be avoided in very shallow waters, in stagnant areas, in the vicinity of sewage outflows and dredging operations, in areas where target organisms or known pathogens are present, etc. Whenever practical, the loading of ballast should be delayed until the ship is in open ocean waters.
- c) Exchange of ballast at sea: Ballast water exchange is currently considered the single most practical method for ballast water management. Ballast water exchange can be accomplished by either the *sequential* empty-refill method or by *flow through* (also referred to as the *overflow* method). It has been reported that these methods are about 95% effective in eliminating aquatic organisms. Ballast water exchange operations should be performed in deep water away from coastal shelves and estuarine influences.

The *sequential* method entails completely emptying ballast tanks and refilling with open-ocean water. Emptying of certain tanks may lead to significantly reduced stability, higher stresses, high sloshing pressures, and/or reduced forward drafts. A secondary effect of reduced forward draft would be an increased probability of bow slamming.

The *flow through* method involves pumping open-ocean water into a full ballast tank. Ballast equal to approximately three times the tank capacity must be pumped through the tank to achieve 95% effectiveness in eliminating aquatic organisms. Applying the *flow through* method does not alter the stability, stress, and ship attitude.

- d) Shipboard ballast water treatment: Although ballast water treatments are currently being investigated, none has yet been shown to be practical or cost effective for general use by most ships.
- e) On-shore ballast water treatment: On-shore treatment in principle has several advantages to shipboard treatment. However, many ships do not currently have the capability in their piping system to discharge water ashore.

The information presented in this document focuses on the use of ballast water management practices and ballast water exchange (options a, b, and c), rather than treatment. The optimum solution typically involves a combination of these three methods. The information is based on the specific vessels described in the next section.

Description of Vessels Considered in the Study

ABS studied ballast water exchange procedures using fourteen vessels covering four major vessel types. A general description of the vessels used in this study is as follows:

Table 1

Vessel Type	General Description	LBP (m)	Beam (m)	Depth (m)
Single Hull Tanker	35,000 DWT	168.0	30.4	16.2
	Suezmax	261.0	50.0	25.1
	VLCC	313.0	56.6	28.6
Double Hull Tanker	40,900 DWT	174.3	32.2	19.2
	Suezmax (A)	258.0	46.0	23.9
	Suezmax (B)	289.8	46.2	25.3
	Suezmax (C)	274.0	50.0	24.5
	VLCC	317.0	58.0	31.4
Bulk Carrier	Handysize	160.3	27.2	13.6
	Panamax	215.0	32.2	18.7
	Capesize	270.0	45.0	23.8
Containership	Feeder (1200 TEU)	190.2	23.8	14.3
	Panamax (2500 TEU)	205.2	32.2	20.3
	Post-Panamax (4800 TEU)	260.8	39.4	23.6

Comments on Ballast Exchange Sequences

To gain insight on feasibility and trends, a few sequences were developed for each tanker and bulk carrier design. As will be explained later in this document, containerships were not evaluated for *sequential* and *flow through* exchange. The primary considerations in assessing *sequential exchange* scenarios focused on vessel stability, hull girder strength, propeller immersion, bridge visibility, and list angle. In addition, the effects of ballast water exchange on slamming, sloshing, and damage stability/survivability were considered. The time to execute a sequence, the number of steps, the number of tanks, the number of ballast movements, and the time to ballast to original (pre-exchange sequence) drafts were also considered as key elements in selection of viable ballast exchange options. For the *flow through* method, the time to overflow each tank individually and the time to overflow sets of tanks to reduce time are determined.

Evaluating *sequential* and *flow through* exchanges require two different methodologies. The *sequential* method requires considerable planning to ensure that the ship will remain within the accepted criteria. The *flow through* method will not normally affect the ship's condition, but it is important to assess piping and overflow arrangements to ensure that the tank will not be over-pressurized.

The venting and overflow arrangements for each tank must be reviewed to insure that *flow through* is a practical alternative. For instance, in some cases the Forepeak and Aftpeak tanks overflow into enclosed spaces, which eliminates the *flow through* option for these tanks. Precautions should also be taken to avoid over-pressurization of tanks. It may be necessary to remove manhole covers or butterworth openings to assure sufficient venting. This raises a number of concerns: the removal and replacement of covers is labor intensive, potential safety risks to personnel accessing the upper deck will limit *flow through* exchange to favorable weather conditions only, and the overflow of ballast on deck is prone to icing in cold environments. For these reasons, ballast tanks in a number of recent newbuildings have been fitted with standpipes and valves, permitting overboard discharge of ballast through the shell just above the deep ballast waterline. (See figure 1.)

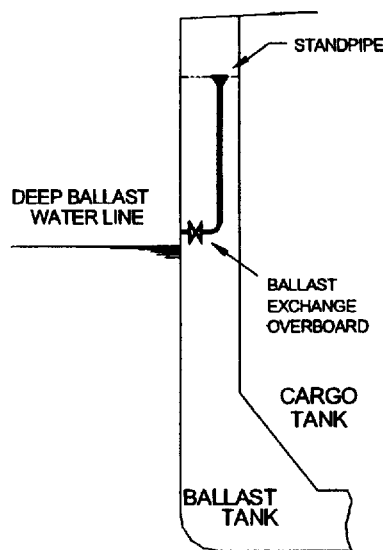


Figure 1
Standpipe to facilitate flow through

Single Hull Tankers

Three single hull tankers were evaluated using *sequential* and *flow through* exchange methods. These designs incorporate a standard MARPOL 73/78 segregated ballast tank arrangement, with ballast located in alternate wing tanks. Listed below are key findings arising from the ballast water management analysis of single hull tankers:

- Implementing the *sequential* method of exchange on single hull tankers is problematical. Due to the minimum number of ballast tanks and their distribution, it is difficult to maintain forward and aft drafts and satisfy the longitudinal strength criterion.
- Most of these exchange sequences are suitable for favorable weather conditions only. For single hull tankers, the *flow through* method is generally a more suitable alternative for exchange.
- The sequences tend to be complex, with approximately 50% more steps than there are ballast tanks. In contrast, the number of steps in the exchange generally does not exceed the number of ballast tanks for double hull tankers.

Sequential exchange

While these tankers have a similar amount of ballast volume as double hull tankers of comparable size, the MARPOL 78 tankers lack flexibility in ballast exchange because the ballast is concentrated in a small number of relatively large wing tanks. The capability to control the ship's trim, drafts and strength during the exchange process is limited. For all of the sequences studied, fore/aft diagonally opposite side tanks were emptied in pairs (e.g., No.2S & No.4P were exchanged as a set). This is a standard method for single hull tanker sequences as it helps to maintain a reasonable forward draft, reduce the maximum list, trim and bending moment, and maximize bridge visibility.

The total time involved in the ballast exchange process is as follows:

Table 2

Single Hull Tankers ShipType – Ballast condition	Time to perform exchange Sequence (hours)	Additional time to ballast to original drafts (hours)
35,000 DWT – Normal Ballast	15	3
Suezmax – Normal Ballast	29	9
– Heavy Ballast	40	10
VLCC – Normal Ballast	41	9

General trends observed when developing exchange sequences for single hull tankers are listed below:

- The forward draft tends to become very light. Due to the few, large ballast tanks the forward draft is often reduced by more than 50% during the sequence.
- Trim can be quite high. However, the large trims are not a major concern as they occur when the vessel is deep in the water.
- Propeller immersion can be difficult to maintain.
- For many ships, the fore and aft wing ballast tanks do not have identical capacities. To prevent excessive heeling, the larger wing tanks must be initially pumped down together.
- Bending moments approach 100% allowable during the sequence.
- Bridge visibility is often not sufficient during these sequences, due to the high level of trim aft. However, it is noted that this occurs in the open sea where risk of collision is less significant.
- It is difficult to satisfy all of the criteria at all times using the *sequential* method for single hull tankers. The *flow through* method may be a more suitable alternative for exchange.

Flow through exchange

For the single hull tankers, the overflow method is often a more attractive method than the *sequential* method. The *flow through* method eliminates concerns related to shallow forward and aft drafts and extreme trims. While it may take longer to carry out, there is less total “attention time” than with the *sequential* method, especially when sets of tanks are simultaneously overflowed.

The total time involved in the ballast exchange process, when performing operations in pairs of tanks, is as follows:

Table 3

Single Hull Tankers Ship Type	Volume capacity of ballast tanks (m ³)	Time to perform flow through exchange (hours)
35,000 DWT	12,900	21
Suezmax	64,100	29
VLCC Single Hull	97,800	47