# Eliminate Confusion in Testing Ballast Water for Invasive Species

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## Ballast: More Than Water

For more than a century, steel-hulled ships have relied on ballast water for maintaining transverse stability at sea. When a ship intakes ballast seawater, along with it comes bacteria, algae, microbes or small invertebrates. This potentially introduces non-native or invasive species into foreign biomes.

Two significant and widely recognized organizations have imposed regulations on ballast water discharge to prevent species exchange: the International Maritime Organization (IMO) and the United States Coast Guard (USCG). Their regulatory overlap, however, is causing confusion and uncertainty among those looking to meet ballast water management requirements in the most efficient way possible.

*Figure 1. Shipping moves 80% of the world's commodities, while also internationally transferring three to five billion tons of ballast water every year. Source: Hach*

## Conflicting Regulations

The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), adopted by the IMO in February 2004 and fully implemented in September 2017, provides a framework for the treatment and discharge of ballast water. The IMO identifies two performance standards.

**D1 Standard**

This establishes the appropriate volumes of ballast water exchanged. It requires ships to exchange a minimum of 95% of ballast water in the open sea. This requires pumping out the volume of each ballast water tank at least three times.

**D2 Standard**

This standard covers approved ballast water treatment systems and specifies levels of viable organisms left in the water after treatment. It requires ships to conduct ballast water treatment to decrease the amount of discharged viable organisms below the limit.

In comparison, USCG legislation applies to discharge ballast water in U.S. waters, and identifies exchange or treatment operations and sediment management guidance. The USCG's requirements are often stricter than those of the IMO. A ballast water management system that complies with the IMO may not satisfy USCG standards

Both the IMO and USCG require installing a treatment system, mitigation measures, raining requirements and a designated ballast water management officer. The USCG also requires clean, sediment-free ballast tanks and a report submitted to the U.S. authorities 24 hours before arriving at a U.S. port.

## Testing Methods

Establishing compliance relies on the ability to take ballast water samples and test them rapidly and accurately. The following are common testing methods.

### Adenosine Triphosphate (ATP)

ATP detection measures luminescence in the presence of luciferase enzyme from seawater extraction. Sampling ATP follows a three-step process:

- Extraction
- Determination
- Relative luminescence unit measurement

Several key advantages promote the use of ATP devices. It shows promising results after high-voltage electricity treatment. ATP devices can be portable and relatively affordable for the industry, and results can be calibrated to correspond only to certain organism size. Measuring total viable plankton biomass also enables the evaluation of all organism sizes. Finally, test results are obtained in less than an hour.

### Fluoresce in Diacetate (FDA)

Fluorescein diacetate (FDA) is a cell-specific identification method for cellular viability that estimates living planktonic biomass. Pulsecounting FDA, bulk FDA and Sytox FDA are the three FDA methods. Sampling involves staining, incubation and sample counting. FDA analysis enables the sampling of all organism sizes, depending on the method. The devices are also affordable for the maritime shipping industry.

Note that FDA does not necessarily stain all organisms and may be inconsistent with each sample. There is also a risk of filter damage or leakage. Staining methods may not discern between living and viable cells and staining dead or living cells may cause false positive results. The technique can also be time consuming -- incubating stained samples takes 10 to 30 minutes and FDA analysis can take one hour or more.

### Pulse Amplitude-Modulation (PAM)

PAM measures photosynthetic activity and phytoplankton biomass, which indicate viable cells. It analyzes living cells via variable fluorescence of chlorophyll in living algae. PAM fluorometry refers to the detection of photosynthetic performance parameters using fluorescing saturation pulses to stimulate species sensitive to light. The technique measures quantum yield of fluorescence, also known as instantaneous variable or maximum fluorescence.

PAM devices deliver results faster than ATP and FDA, and in some cases are also more accurate. Use requires minimal training and devices are portable and easy to handle. Costs of PAM devices range between $4,000 and $15,000.

However, PAM accuracy decreases at water turbidity greater than 20 Nephelometric Turbidity Units (NTUs). Certain organism results are also prone to reading errors. Additionally, PAM fluorometry measures only concentrations of autotrophic organisms via chlorophyll.

## The Hach BW680 Handheld Fluorometer

To stay in compliance with global regulations, ballast water testing devices need to be reliable, efficient, easy to use and cost effective.

The Hach BW680 handheld fluorometer is the optimal solution for all these concerns. It uses variable fluorescence to measure the presence of active chlorophyll in living systems (i.e., phyto-plankton) so that ship operators, port state control and flag state agents can rapidly assess ballast water compliance to the IMO D2 ballast water discharge standard.

The device takes less than three minutes to complete analysis and is easy to use, but is also highly sensitive, registering traces of chlorophyll in the parts per billion range. The device is also upgradeable, which delays the need for new systems or devices as standards or capabilities evolve. Analysis data is stored for accurate record keeping.

The BW680 is the most cost effective and easy-to-use of all ballast water instruments. Studies by Gollasch et al. (2015) and Bradie (2016) reviewed several PAM devices. While PAM devices are relatively fast, portable and easy to operate, Bradie determined that the Hach BW680 delivered the most consistency; Gollasch et al. determined that it is the easiest handheld device to use of those that did not involve filtration steps. It is also the least expensive to purchase.


*Figure 2. The Hach BW680. Source: Hach*

The past two years has been confusing to ship operators. Given the conflicts in IMO and USCG regulations, meeting ballast water requirements in a cost and time-effective manner is a daunting task.

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