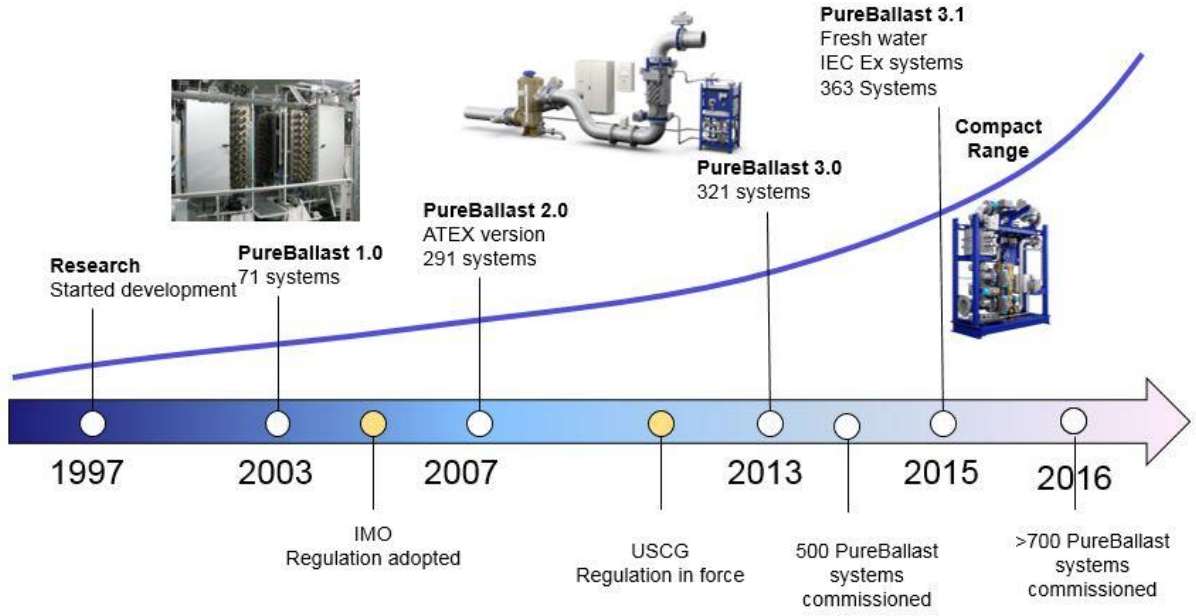
Technical Meeting — 6 September 2017

Selwyn Oliviera, Energy and Marine Division Manager with Alfa Laval Australia, gave a presentation on *Ballast Water Treatment* to a joint meeting with the IMarEST attended by 22 on 6 September in the auditorium at the Royal Prince Edward Yacht Club, Point Piper.

Introduction

Selwyn began his presentation by saying that it was exactly 100 years ago that the US Navy asked Alfa Laval to develop a centrifugal oil-cleaning separator, which was delivered in 1917. Since then, the company has become a global sales and service organisation with 100 years of experience, and an established partner in the marine industry. The company has been a pioneer in ballast water treatment systems since 2003. They have obtained compliance in all waters, with both IMO and US Coast Guard Type Approval for their PureBallast system. To date, they have 1400 systems sold, with 300 retrofitted installations.

Alfa Laval's Pure Ballast System 1.0 was developed in 2003, and then an explosion-proof version followed in 2007 for tankers. In 2012 the US Coast Guard regulations came into force. PureBallast 3.1 received Coast Guard type approval in December 2016, and the compact range was developed for platform supply vessels and the offshore industry. They can supply high-capacity systems for large vessels requiring 4–6000 L/h, or low-capacity systems for small ships requiring less than 100 L/h and fitting into a small space.



Alfa Laval's experience in ballast water treatment
(Image courtesy Alfa Laval)

Legislation

The International Maritime Organisation of the United Nations recognises the spread of aquatic invasive species as one of the four greatest threats to the world's oceans, and developed the Ballast Water Management Convention. For entry into force, this required agreement by 30 states and 35% of world gross tonnage. To date, agreement by 54 states and 53% of world GT has been achieved, and the IMO Ballast Water Management Convention was ratified on 8 September 2016, twelve years after it was written, and entered into force on 8 September 2017 to prevent the spread of invasive species via transport in ballast tanks onboard vessels. So far, 69 systems have achieved IMO type approval.

In addition, the US Coast Guard regulations entered into force in December 2013, so a ship owner/ship operator intending to deballast within US territorial waters must have a US Coast Guard-compliant BWTS. So far only four systems have achieved USCG type approval in addition to IMO type approval, PureBallast 3.1 being one of them.

Implications

From 8 September 2017 all vessels subject to the convention need to have an approved ballast water management plan on board and maintain a ballast water record book. They will have to manage their ballast water on every voyage by either performing ballast water exchange or by treating it using an approved ballast

water treatment system. They will have to undertake an initial survey and be issued with an International Ballast Water Management Certificate. Ships that are registered with flag administrations which are not yet a party to the Convention will need to demonstrate compliance and may have to undergo surveys and be issued with a document of compliance.
Newbuildings constructed after 8 September 2017 must have a ballast water management system (BWMS) installed. Existing vessels need to be equipped with a BWMS at the next International Oil Pollution Prevention (IOPP) renewal survey from 8 September 2019.
Ballast water exchange is not sufficient for vessels making ballast discharge in US territorial waters, if they do not have a granted extension, i.e. an extended compliance date. At the USCG extended compliance date, the vessel must install an USCG type approved system or install an AMS that can be used five years after the extended compliance date, even if they are yet not required to be compliant with the D-2 standard of the IMO BWM Convention.

IMO Status
IMO's Revised G8 Guidelines (for BWM system test requirements) were finalised and approved at MEPC 70 in October 2016, resulting in more-stringent test guidelines and alignment with USCG test requirements. These guidelines are mandatory and were renamed *Code for Approval of Ballast Water Management Systems*. No new Type Approval Certificate based on the old G8 Guidelines will be issued after 28 October 2018. From 28 October 2020, all BWMS installed on board must be approved under the Revised G8 Guidelines. The approval of the Revised G8 was important to clearly define the requirements for type approval testing at a stringent level.
PureBallast has the advantage of being compliant with the Revised G8 through the USCG testing. It will be one of the first systems to gain a type-approval certificate according to the Revised G8 Guidelines.

USCG Ballast Water Discharge Standard
The US Coast Guard's Standards for Living Organisms in Ships' Ballast Water Discharged in US Waters established a ballast water discharge standard (BWDS) for the allowable concentration of living organisms in ship's ballast water discharged in waters of the United States. Vessels employing a Coast Guard-approved BWMS must meet the following BWDS:

- For organisms greater than or equal to 50 μm in minimum dimension: discharge must include fewer than 10 organisms per kilolitre of ballast water.
- For organisms less than 50 μm and greater than or equal to 10 μm: discharge must include fewer than 10 organisms per millilitre of ballast water.

Indicator micro-organisms must not exceed:
(i) For toxicogenic vibrio cholerae (serotypes O1 and O139): a concentration of less than 1 colony-forming unit (cfu) per 100 mL.
(ii) For escherichia coli: a concentration of fewer than 250 cfu per 100 mL.
(iii) For intestinal enterococci: a concentration of fewer than 100 cfu per 100 mL.
The USCG's ballast water implementation schedule is already in force for all vessels.
An alternate management system (AMS) is a temporary acceptance of a treatment system based on the IMO type approval. A new bulletin released on 6 March, 2017 provides new guidance with regard to compliance date extension requests.
If a type-approved system is not available for a vessel, and compliance with the other approved ballast water management methods is not possible, then the vessel owner/operator may apply for an extension of the vessel's compliance date. Whether a type-approved system is "available" will be based on evidence submitted by the vessel owner/operator with the application for extension. The length of compliance-date extensions, when granted, are based on the availability of USCG type-approved systems and detailed installation plans.
After 6 March 2017, owners and operators should not anticipate that they will receive any further extensions to those already granted. They should plan their operations to ensure that the vessel will be in compliance with US the BWDS after the expiry date.
The message in the Bulletin is clear: the burden of proof is higher and extensions will no longer align with scheduled dry docking dates. Hence, extensions in many cases will mean that a BWMS will need to be installed in between dry-dock periods.

USCG and IMO Comparison
The US BWM regulation is not signatory to IMO BWM Convention.
Vessels discharging ballast water into the waters of the USA must comply with the requirements of 33 CFR 151 Subparts C and D.
Vessels beyond their compliance date are reminded to employ one of the following BWM methods when operating in the waters of the USA:

- Use a Coast Guard-approved ballast water management system.
- Use only water from a US public water system.
- Use an alternate management system (AMS); but note that this is only valid for 5 years from the compliance date.
- Do not discharge ballast water into waters of the USA (including the territorial sea as extended to 12 nautical miles from the baseline).
- Discharge to a facility onshore or to another vessel for purposes of treatment.

Test Methods

There are currently two test methods available for testing ballast water:

- The Most Probable Number Dilution-Culture Method (MPN method) measures the number of viable phytoplankton cells in a sample, via their ability to reproduce. It is a formal mathematical calculation based on binary scoring data from a set of dilutions, and replicates from a sample. In a ballast water management application, the binary scoring is of reproduction or no reproduction of phytoplankton, in dilutions and replicates of a ballast water sample.
- The Environmental Technology Verification (ETV) Staining Method (vital stain method) uses a combination of two fluorescein-based stains (FDA and CMFDA) to evaluate the status of organisms in the 10–50 μm size class in ballast water samples. The stains penetrate into organisms, where functional esterases convert them into fluorescent products which are retained by cellular membranes. Using epifluorescent microscopy, fluorescing organisms are enumerated as "living" individuals. Any motile organisms observed are also counted as "living."

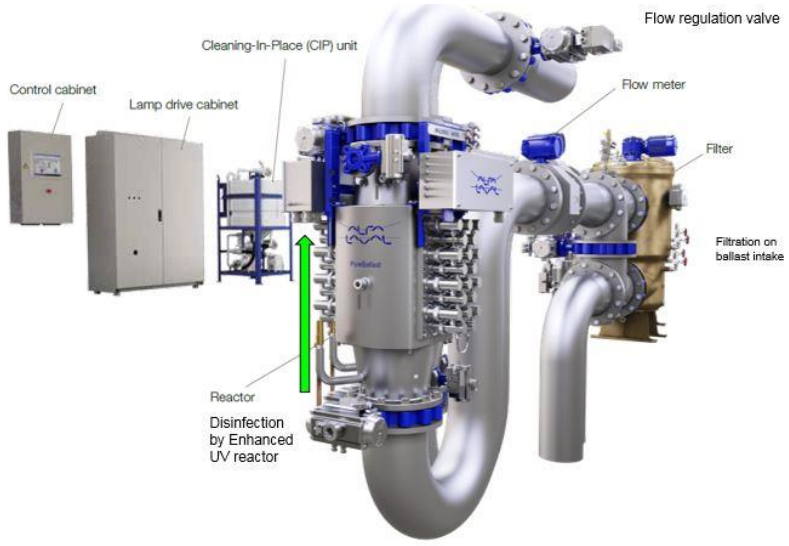
The use of an MPN-based method to evaluate mixed assemblages of organisms in ballast water is going to be validated by Environmental Protection Agency's (ETV) Technical Panel. If the panel finds an MPN method to be acceptable, the USCG will have to make a policy decision or rulemaking to incorporate the EPA-approved method.

It should be noted that MEPC 70 agreed that viable organisms mean organisms which have the ability to successfully generate new individuals in order to reproduce the species. The MPN method is designed to measure organisms' ability to generate new individuals. The MPN method will be verified in the latter half of 2017 and it is likely that it will be approved by the USCG in 2018.

PureBallast 3.1

The PureBallast 3.1 system handles ultra-violet transmittance (UV-T) down to 42% at full flow! It works in challenging waters, with no limitation on salinity or temperature. It has been tested and approved in all three water qualities: fresh water, brackish water and sea water.

The components of the PureBallast system (apart from the power supply) are shown in the diagram.



PureBallast system components
(Image courtesy Alfa Laval)

The design of the reactor has been optimised through research and real-life experience. Corrosion resistance has been ensured by manufacturing in SMO254, a high-alloy austenitic stainless steel which has been specially developed for sea-water applications and has significantly higher corrosion resistance than 316L stainless steel.
The unit uses medium-pressure lamps for higher intensity, giving 15–20 times the germicidal effect of other lamps. Used in conjunction with synthetic quartz sleeves, giving more light and at a broader wave length, thus increasing the UV dose and attacking the DNA strings at multiple places, resulting in faster disinfection and greater penetration and creating permanent DNA damage.

PureBallast filter
(Image courtesy Alfa Laval)

Equally as important as the reactor for the performance of the system is the filter. Alfa Laval uses a basket filter with 20 µm mesh from Filtrex. Noble materials are used throughout, with the filter housing being in aluminium bronze. Automatic back-flushing is incorporated, and a rotating back-flushing arm ensures that the entire filter area is cleaned with short back-flushing time. The unit is extremely compact, and works at up to 10 bar (1 MPa) pressure. It has been approved for both sea water and fresh water.
Here Selwyn showed an animation of the Filtrex filter.

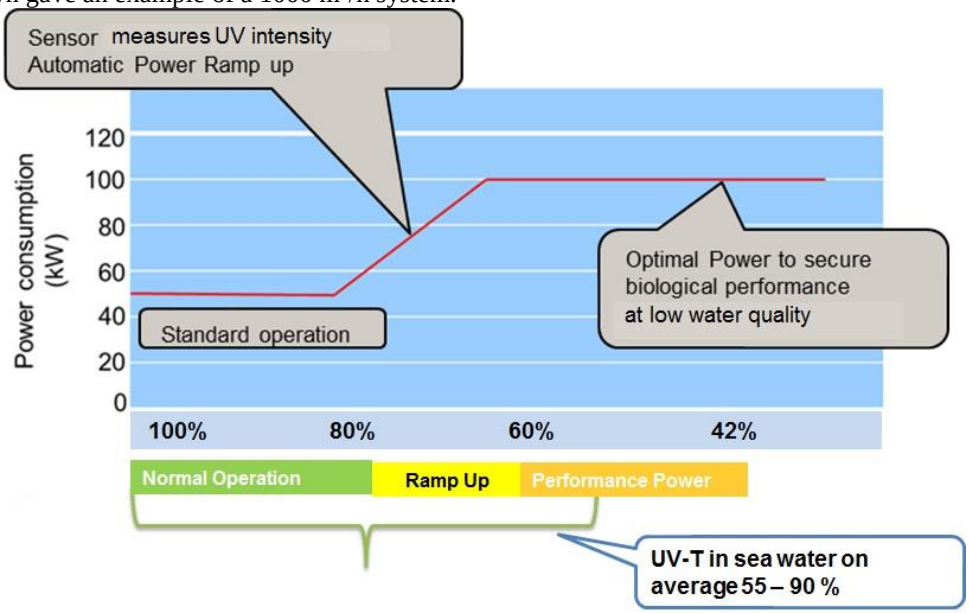
The cleaning-in-place (CIP) unit retains the same biological performance over time. It ensures fully-automatic cleaning of the reactor from scaling, removes lime deposits and metal ions, does not scratch the quartz glass sleeves, and outputs a bio-degradable liquid which can be re-used.

PureBallast cleaning-in-place unit
(Image courtesy Alfa Laval)

Over time there will be build up that cannot be removed by the solution typically used by other UV manufacturers, a wiper going back and forth which scratches the glass, further blocking the UV light and reducing the biological performance. Using the CIP unit, the same biological performance is maintained over time and, since it is gentle, the life time of the quartz sleeve is long

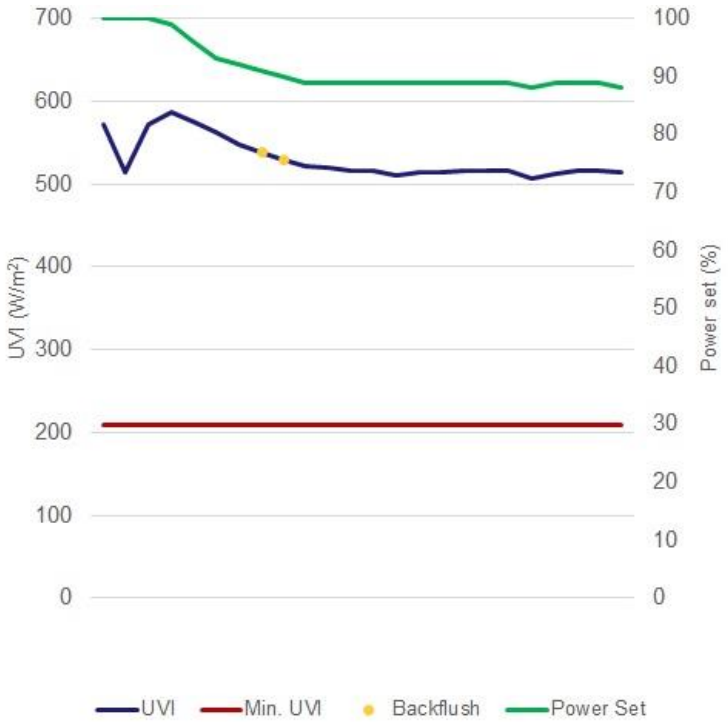
Power Optimisation

Here Selwyn gave an example of a 1000 m^3/h system.



PureBallast power optimisation
(Image courtesy Alfa Laval)

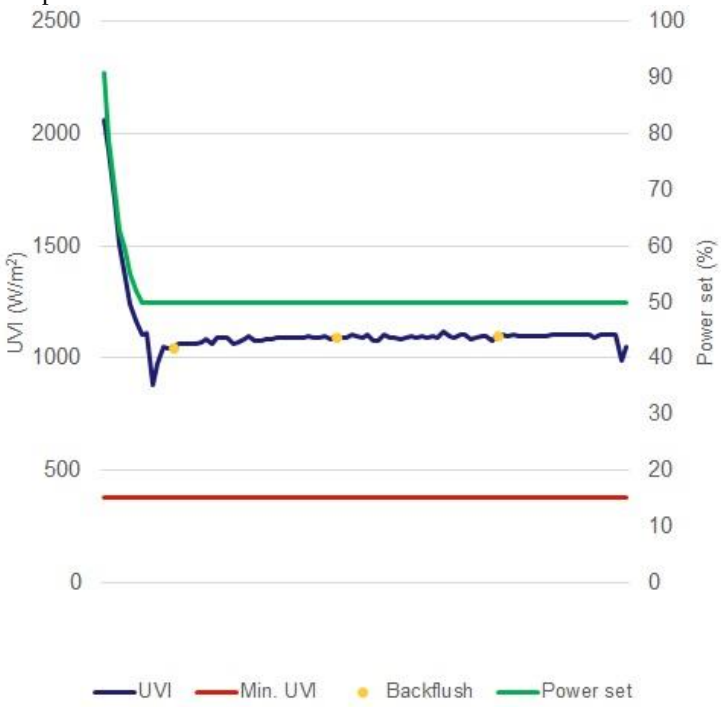
Alfa Laval has collected log files from vessels with the system installed, to analyse the performance from actual use. Nantong on the Yangtze River in China is often brought up as an example by ship owners as a challenging port but, thanks to the efficiency of PureBallast, the power consumption is less than 100%. The yellow dots in the graph show the backflush, and the conclusion is that the filter can handle the ”dirt load” without any problem, and frequent backflush



Power consumption for PureBallast 3.1

600 m^3/h system in the Port of Nantong, China
(Image courtesy Alfa Laval)

In the port of Yangshan, China, outside Shanghai, the conditions are very different. Here the performance of PureBallast becomes even more clear, the system goes down to 50% of installed power and the filter performs well, with few backflush operations.



Power consumption for PureBallast 3.
750 m^3/h system in the Port of Yangshan, China
(Image courtesy Alfa Laval)

Product Portfolio

Alfa Laval has solution sizes available to fit any vessel, operating on 400–440 V AC at 50/60 Hz.

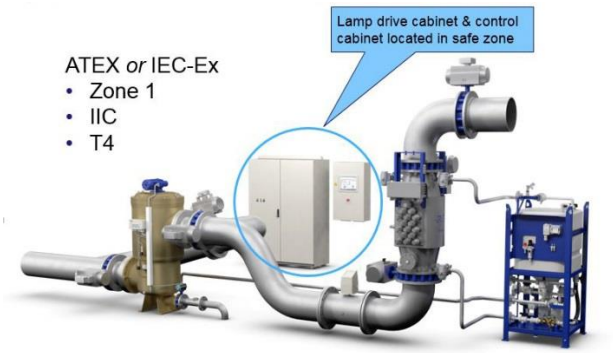
	PureBallast 170 m^3/h	PureBallast 300 m^3/h	PureBallast 600 m^3/h	PureBallast 1000 m^3/h
Lamps	6 x 3 kW	10 x 3 kW	20 x 3 kW	16 x 6 kW
Min power	11 kW	18 kW	33 kW	53 kW
Max power	20 kW	33 kW	63 kW	100 kW

PureBallast sizes available
(Image courtesy Alfa Laval)

In addition, Alfa Laval has developed an explosion-proof version, PureBallast 3.1 EX.

Two international certification schemes currently exist for hazardous areas. One scheme is endorsed in Europe under the ATEX Directives, while the other scheme is the International Electrotechnical Commission's IEC-Ex system which provides a more international but voluntary equipment certification scheme accompanied by the conformity mark licence scheme and other certification schemes for service facilities and persons.

In the PureBallast 3.1 EX system, the control cabinet can be located in the engine room, and the reactor in the pump room.



PureBallast 3.1 EX explosion-proof vesion
(Image courtesy Alfa Laval)

To cater for platform supply vessels and the offshore industry, they have developed a compact range of skid-mounted solutions which have the smallest footprints in the market: 1.4 m^2 for 170 m^3/h, or 2.2 m^2 for 300 m^3/h. They have market-leading disinfection performance, the best functionality in fresh, brackish and sea water at 42% UV-T, and reduced power consumption through UV-dosage control. The compact units are available in 85, 135, 170, 250 and 300 m^3/h sizes.

PureBallast 3.1 compact unit
(Image courtesy Alfa Laval)

Product	Max flow	Min flow	Note
PB-300S	300 m^3/h	75 m^3/h	Skid
PB-250S	250 m^3/h	65 m^3/h	Skid
PB-170S	170 m^3/h	50 m^3/h	Skid
PB-135S	135 m^3/h	42 m^3/h	Skid
PB-85S	87 m^3/h	32 m^3/h	Skid

PureBallast 3.1 compact sizes available
(Image courtesy Alfa Laval)

Life-cycle Analysis

Alfa Laval has done a cost comparison of their product with two other UV systems, one using medium-pressure lamps, like PureBallast, and another using low-pressure lamps. From a life-cycle cost perspective, for a 1000 m^3/h system, with a life of 20 years and 600 hours of ballast water operations per year, specific fuel consumption of 235 g/kWh and fuel oil at €350/t:

The single biggest impact is the material for the UV reactor, where SMO has an expected life time of four times that of 316L stainless steel. The second biggest impact is from the lamps. Despite low-pressure lamps having up

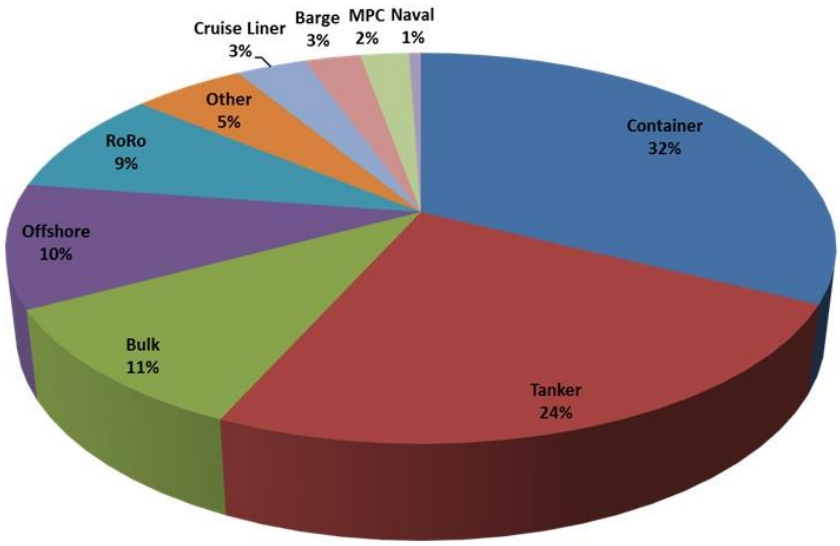
to four times longer expected life time, the large number of lamps needed, up to 15 times more than PureBallast, the cost becomes three-to-four times higher!!! Another important cost is the quartz sleeves which, thanks to the CIP unit, both maintain biological performance (keeping power consumption down), and minimise need for changing this part. For other systems, this becomes a considerable cost and, again, even more for low-pressure lamps due to the high number. The conclusion is that, over the life cycle of a system, there are important differences in operating expenditure and why investing in an efficient system, with high-quality components, quickly pays off.

Manufacturer	Alfa Laval	System A	System B
Avg kWh	51	100	60
Fuel	€ 50 337	€ 98 700	€ 59 220
# Lamps	16	18	240
Lamp Life	3 000	2 500	12 000
Lamp Replace	€ 28 800	€ 38 880	€ 108 000
Lamp Type	MP	MP	LP
Quartz Sleeve Life	15	10	10
Sleeve Replace	€ 4 256	€ 9 576	€ 127 680
Reactor Material	SMO	316L/SMO	316L
# for 1000 cu/hr	1	1	4
Reactor Life	20	15	10
Reactor Cost	€ 0	€ 172 500	€ 1 020 000
Filter Material	AlBrz	Epx Ctd Steel	Steel
Filter Life	20	12	10
Filter Cost	€ 0	€ 46 656	€ 93 312
Filter Insert	Basket	Duplex Screen	Candles
Insert Life	5	5	5
Insert Cost	€ 107 100	€ 155 520	€ 155 520
Totals	**€ 186 237**	**€ 512 256**	**€ 1 436 052**

PureBallast 3.1 cost comparison for 1000 m3/h system
(Table courtesy Alfa Laval)

Fitting PureBallast Systems

Alfa Laval has sold more than 1400 systems, with more than 1000 systems delivered, more than 700 systems commissioned and, of these, more than 300 are retrofits. PureBallast systems have been fitted to many different types of vessels owned by the majors: Maersk, CMA CGM, Mitsui OSK Lines, Bernard Schulte, NYK, Hamburg Sud, and Carnival, among others.



Vessel types fitted with PureBallast systems
(Image courtesy Alfa Laval)

Their philosophy is that no customer is the same, no ship is the same, and no project is the same, and they tailor each project to the customer, ship and project. Good project management minimises the technical complications.

Investment of time in the beginning to set up the project to:

- establish project organisation including representatives from involved parties;
- agree on responsibilities between the parties;
- involve the customer, engineering company and installation company in the specific system;
- plan the project and minimise changes in scope of supply and delivery time;
- make sure everyone has needed knowledge; and
- ensure enough time to execute the project.

The involvement of the supplier ensures:

- clear technical documentation;
- verification of engineering; and
- installation support for successful installation.

Alfa Laval has a service focus, and can provide technical support, including service agreements, re-commissioning packages, performance audits, customer competence and training, parts availability and connectivity. They can offer more than just a product, and some of the customer benefits include financial predictability, reduction and control of operational costs, optimised maintenance planning, efficient maintenance, extension of time between overhauls, increased vessel availability, Alfa Laval's presence and support, operator and maintenance training.

Conclusion

The IMO and USCG requirements for ballast water treatment are now in force, and ballast water treatment is mandatory for all newbuilds and will be for existing vessels—ballast water exchange is only an interim solution for some existing vessels. Alfa Laval has developed the PureBallast system which treats ballast water with UV radiation, and the system has been type approved as meeting both IMO and USCG regulations.

Questions

Questions time was lengthy and provided some further interesting points.

The Royal Australian Navy's LHDs, HMA Ships *Canberra* and *Adelaide*, are both fitted with PureBallast systems and, since commissioning, have had minor upgrades on the electrical system. Navies are not subject to MARPOL requirements, but the RAN has committed to compliance with the USCG requirements.

Ballast water exchange will not be permitted in the future. It can pose a stability problem for large vessels to exchange ballast water in mid-ocean, but is usually not a problem for small vessels.

The *Spirit of Tasmania* vessels use fresh-water ballast, not sea water.

In Australia, the control of ballast-water management is within the purview of the Department of Agriculture and Water Resources, not the Australian Maritime Safety Authority. Basically, Australia is playing catch-up to the IMO and USCG requirements, but hasn't yet signed the IMO BWM convention., The US Navy requires all of its vessels to have ballast-water treatment systems meeting the USCG requirements.

The USCG requirements are more stringent than the IMO requirements, so the PureBallast system now incorporates a change-over switch so that the engineer can change from IMO operation (for Europe) to USCG operation (for the USA) very easily.

It is possible to match a data logger on the PureBallast system to the ship's log to prove that the ballast-water treatment system has been run.

The vote of thanks was proposed, and the certificate and "thank you" bottle of wine presented, by Greg Hellessey.