6th IMarEST Ballast Water Technology Conference, 12-13 January 2017, London, UK
https://doi.org/10.24868/bwtc6.2017.006

Lessons Learned in Ballast Water Treatment Equipment Retrofit and Commissioning

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ABSTRACT

Ratification of the International Maritime Organization (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWMC)[1] has now forced the hand of operators and ship owners to comply with the BWM, and without a great deal of time to react. The need to integrate and operate Ballast Water Treatment (BWT) Systems on In-Service ships, however, is not new, and BMT have recent and relevant experience in end-to-end BWT system solutions.

In 2011 BMT Defence Services Ltd (BMT) produced the installation specification to enable A&P Falmouth Ltd (A&P) to carry out a ballast water treatment plant retrofit installation on the RFA Bay Class ships (i.e. RFA MOUNTS BAY, LARGS BAY and CARDIGAN BAY), enabling the ship to be approved and operated in compliance with the BWMC. In addition, BMT produced documentation to enable A&P to arrange, manage and perform the necessary test, trials and commissioning to prove the equipment installation and that it can be operated in accordance with the requirements of the BWMC.

The objective of this paper is to take the reader through the process of design and embodiment of a BWT system retrofit on a relatively complex (with respect to the ballast system) ship. The Bay Class ships are Landing Ship Dock (Auxiliary) ships with separate forward and aft ballast systems (to allow the ships to function in their amphibious roles by way of their stern dock), and a ship wide Ballast Stripping system. Key design and engineering considerations are discussed below and recommendations for the installation of a ballast water treatment system are also offered.

Keywords: Retrofit, technical challenge, ensuring compliance, tests and trials, stripping, sampling, BWM, ballast water treatment.

1. Introduction

The Royal Fleet Auxiliary (RFA) Bay Class Ships provide Landing Ship Dock (Auxiliary) (LSD(A)) capability to the UK fleet with their primary role being the transport of troops, vehicles, ammunition and stores as a follow-up to an amphibious assault. The class consists of three ships; RFA MOUNTS BAY, RFA CARDIGAN BAY and RFA LYME BAY from an original class of four ships (RFA LARGS BAY was sold to the Royal Australian Navy in 2011).

Although as naval platforms the UK MoD can request non-conformance/seek concessions from the Naval Maritime Regulator against the BWMC (and other statutory instruments), it is their aspiration to comply with statute where practicable. As such, in 2011, BMT were contracted by A&P Shipyard Ltd in Falmouth to provide a refit specification detailing the work required to modify the ballast systems on the Bay Class ships to integrate BWT Plant (BWTP) in anticipation of the ratification of the BWMC. BMT were also contracted to develop the test and trial documentation which would allow the customer (in this case the UK Ministry of Defence) to determine that the ballast system, and the equipment within, performed correctly providing the capability as available with the legacy system, therefore, the platforms could be operated to meet the operational and BWM requirements.

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Due to the nature of the class of ship and their role in a military context, specific performance values cannot be provided.

2. Legacy System

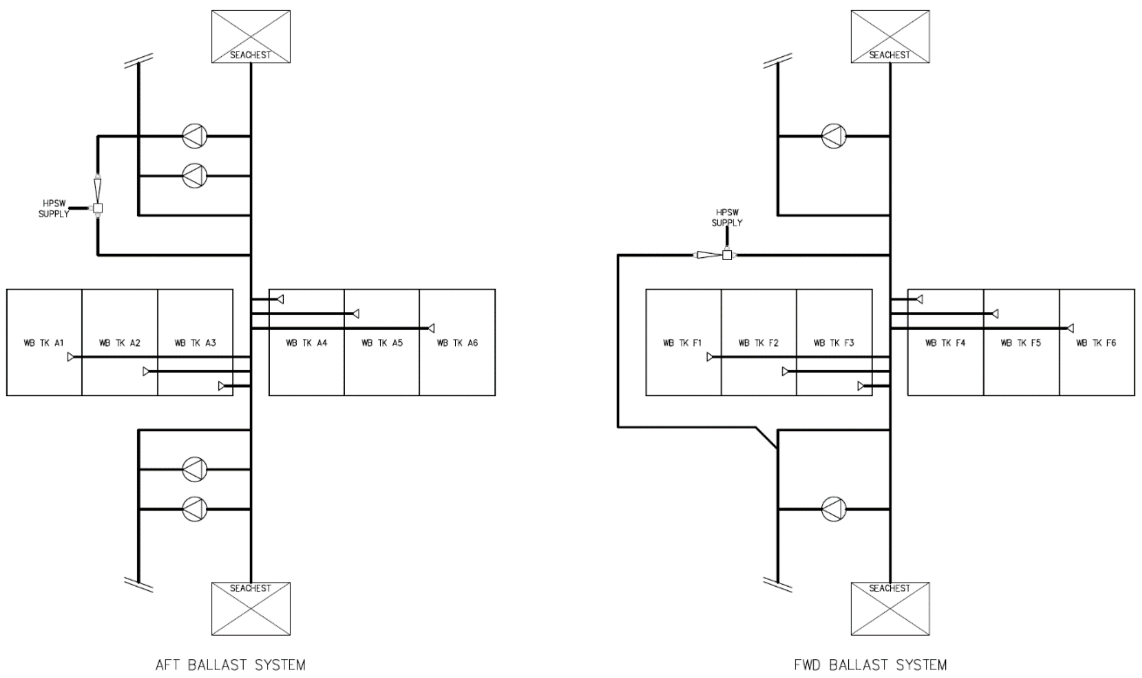
As a large amphibious platform, the Bay Class ships are required to dock down by the stern. Therefore, each ship had (and still has) two distinct and separate ballast systems on board: An aft system whose primary duty was to manage the "docking down" requirement, and a forward system that was used for more traditional ballasting duties such as taking account of changing payload and compensating for fuel burn (but still with an important role in docking down: ensuring the ship stays suitably trimmed and ballasted down for Landing Craft Utility (LCU) operations). The aft ballast system was (and is still) served by four in number equally sized ballast pumps whilst the forward system was (and is still) served by two pumps of the same capacity as the aft system pumps.

In order to ensure complete removal of ballast water when emptying the tanks, the system had a High Pressure Sea Water (HPSW) driven eductor stripping system fitted to both the forward and aft ballast systems.

Additionally, one pump in each system had (and still has) a suction line cross connection to the ship's bilge system for emergency dewatering.

A simplified representative sketch of the legacy ballast system is shown in Figure 1.

Figure 1. Legacy Bay Class Ballast System



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3. Considerations

When planning a retrofit installation of equipment such as BWTP, it is very important to capture the major considerations to be assessed through the design, which will form the foundations of the project plan / strategy, and are key markers to which assurance can be measured. A number of them that were specific to this particular project are detailed below (in no particular order):

Stakeholders

It is important to understand who the stakeholders with regard to the retrofit installation. That way, important considerations around roles and responsibilities, hierarchy, lines of communication, etc. can be determined early.

System pressure losses

In order to incorporate such major equipment as BWTP, it is necessary to conduct pressure-flow calculations to determine whether the existing system pumps are capable of working with the additional equipment in the system. Determining the system pressure loss can help ensure that the pumping system can be specified to be as efficient and well matched as possible, which may necessitate replacing the pumps.

Spatial integration

On the majority of ships, space provision for large equipment, such as BWTP will not have been allowed for when the ships were built. Therefore, the installation of relatively large BWTP local (or as close as possible) to the ballast pumps will likely necessitate reconfiguration of the space, careful thought over current, and potentially new, removal routes and/or compromises to be made. The type of space where equipment is to be fitted may also have important bearing on the type of equipment to be fitted: e.g. are there considerations around ingress protection and /or rating for use in a hazardous zone? Space around the equipment and throughout the system for control and indication plus access for sampling points (mandated by the BWM) also requires consideration.

Electrical capacity

Another important consideration is whether there is adequate electrical capacity in the existing ship's electrical system. Capacity both physically, by way of spare breakers of suitable size (or space within distribution boards for the required breakers for the new equipment), but also electrical capacity by way of unused growth margin.

Machinery Control and Alarm System (MCAS) integration

The level of integration with the ship's MCAS should be considered. The level of integration can range from no integration (with all controls either local to the plant's control panel or local with dedicated remote control) through single I/O signal indicating if there is a fault with the plant and onto full integration with all plant controls and alarms being reproduced on the MCAS.

Weight

The weight of removed and added equipment including where the weight is added and/or removed needs recording. If there is a change in the lightship displacement greater than 2% or a deviation from the lightship longitudinal centre of gravity greater than .1 % of the

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previous LCG, the ship is to be re-inclined to verify whether the changes have adversely impacted the stability of the ship[2].

System cross connections

A key consideration, specifically with respect to fitting a BWTP to meet the BWMC requirements, is whether the legacy system has any cross connections to other ship's systems. By having such cross connections, there is the potential to either introduce untreated sea after into the system or else otherwise contaminate the system, potentially impacting the effectiveness of (or even damaging) the ballast water treatment plant. This could be in contravention of the BWMC if the discharge standard is not met.

Reversionary/Emergency Modes of Operation

Are there any reversionary or emergency modes of operation that should be considered and do these have an impact on the ability of the system to meet the BWM? If so, is a dispensation required for these modes of operation?

Water in the Dock

A consideration specific to a large amphibious platform such as the RFA Bay Class ships is what to do with the water that fills the dock when the ship is ballasted down by the stern. Should this water be considered ballast and therefore be treated or is this too difficult to achieve?

4. The team

As previously stated, A&P Shipyard subcontracted BMT Defence Services Ltd to produce the refit specification for the project. The other stakeholders involved in the project can be seen in the Organisation Chart in Figure 2.

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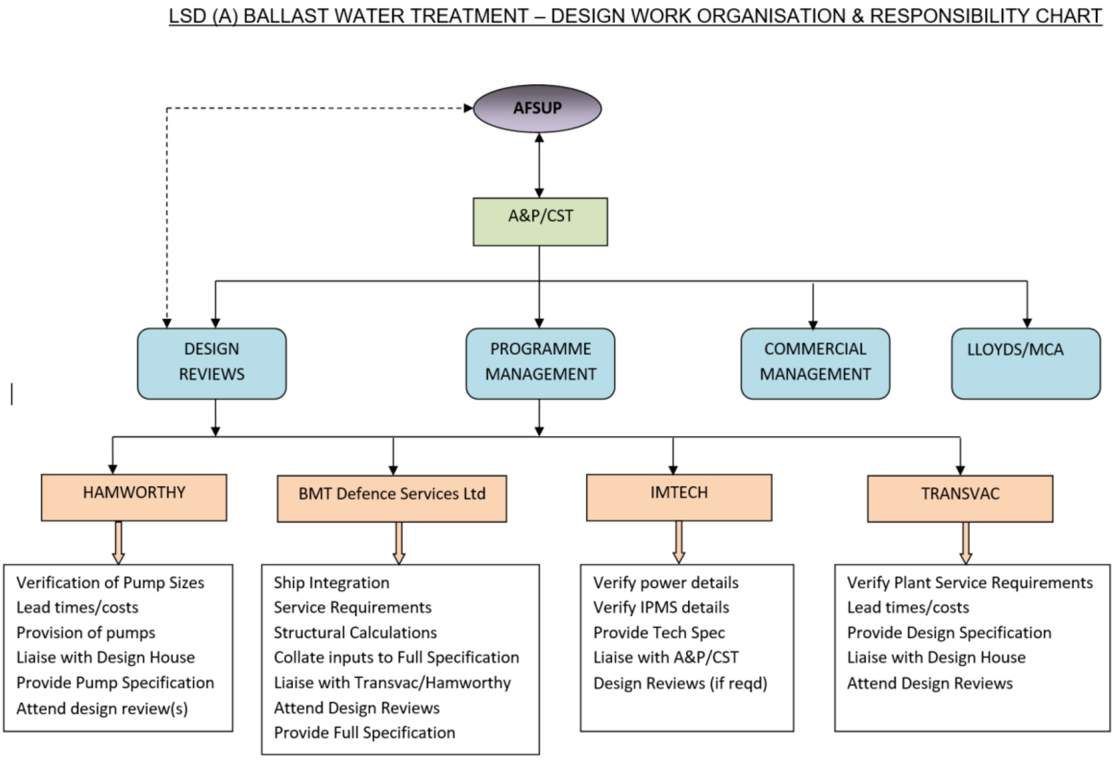
Figure 2: LSD(A) Ballast Water Treatment Design Organisation & Responsibility Chart



It can be seen in Figure 2 that for this particular project, BMT were responsible for the collation of all information into the final refit specification, however the responsibility for the electrical integration and integration with MCAS fell to Imtech. Therefore, this paper will not discuss these areas further other than to confirm that there were no issues with respect to electrical integration and that a minimal IPMS integration philosophy was taken forward: The IPMS integration included update of the ballast mimic displays to show the new system and to include alarm functions to indicate when the BWTP was not operating correctly (necessitating investigation at the relevant local control panel to interrogate the issue) and to highlight when the BWTP is being bypassed.

It can also be seen that, in this instance, A&P had responsibility for gaining Class and statute approval as required but with BMT support as necessary (there were no issues with gaining approvals for this project).

5. New System

For this project, the customer specified the Bay Class was to be fitted with 3 identical Hyde Guardian plant: two serving the aft ballast system and one serving the forward system. The Hyde Guardian plant utilises a filtration and Ultra Violet (UV) sterilisation method of BWT and has received IMO type approval.

In order to minimise system impact (and therefore cost), a policy of "minimum change" was adopted when modifying the ballast water system to incorporate the BWTP. However, a trade off of the key considerations needs to be made before the final decision on extent of change can be made.

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Pressure Loss Calculations

In order to determine whether the new system would work with the legacy ballast pumps, pressure loss calculations were carried out based on the new arrangement (including losses through existing and new pipework and through existing and new equipment). Based on these calculations, it was determined that the existing pumps were not suitable for the proposed system. Upon liaison with the preferred pump supplier (in this case the incumbent, Hamworthy, were contracted), it was determined that the best course of action was to replace the pumps with new complete pump and motor units. Fortunately these new units had the same footprint as the legacy pumps including flange to flange dimensions and therefore were a straight swap albeit with a greater power demand, heavier and with a greater height overall.

Stripping System

By far the biggest difficulty in delivering a compliant solution with the legacy system was the stripping capability, which had to be retained. This was because the eductors in the stripping system utilised motive water taken from the untreated HPSW system which would potentially contaminate the ballast system and thus likely contravene the BWMC. As such, an alternative means to strip the ballast tanks was needed. One possibility would be to use dedicated ballast stripping pumps which would use a ballast tank for the supply of motive water to the stripping eductor before passing the ballast overboard via the UV element of the BWTP. A further issue with this option would be the potential to carry over entrained air (when stripping the bottom of a tank) into the UV chamber and, due to the potential for overheating of the UV element, this would need careful consideration. An option proposed by Hyde was to reorientate the UV chamber in a vertical orientation which would help ensure a volume of water covered the element at all times. However this was not deemed acceptable as this would mean that the plant was not configured in the same way as it was when it was tested for approval with respect to the BWM. As such, BMT proposed an alternative solution where the stripping was conducted as a separate exercise to the ballast water treatment. This was done by selecting one of the ballast tanks as a dedicated stripping tank. The eductors in this solution get their motive water from the dedicated tank (which is always partially filled) via dedicated ballast stripping pumps. The water stripped from the other tanks is then discharged into this same dedicated ballast stripping tank. After all of the tank strippings have been consolidated in this way, the contents of the dedicated ballast stripping tank can then be discharged overboard via the normal ballast pumps and the BWTP UV chamber, significantly reducing the potential for entrained air reaching the UV chamber with the associated risk of overheating (which could result in BWTP damage or even fire).

Spatial Considerations

The spaces containing both the forward ballast pumps and the aft ballast pumps were very congested and there was no possibility to locate the BWT plant within the same spaces. It was therefore necessary to locate the equipment outside of the compartments containing the ballast pumps and provide additional pipework to integrate the equipment into the existing arrangements.

For the forward system, the BWT plant was installed in an auxiliary machinery compartment aft of the space containing the ballast pumps. Fortunately this machinery space had a relatively large free space that readily accepted the footprint of the new equipment. Figure 3, which shows the ballast pumps and main pipework, captures the congestion in the space containing the forward ballast pumps

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Figure 3. Forward Ballast Pump Space

For the aft system, not only was there a need to install two BWT plant but there was no real space anywhere near to the aft ballast pumps on the same level. The decision was therefore made to install these two plants two decks (~5500 mm) above the pumps in bays of the vehicle deck, either side of the ship's stern dock. By locating the aft BWT plants in these areas, it was necessary to specify Explosion proof (Ex) rated plant due to the hazardous area classification for the vehicle space. To help reduce the cost of Ex rating all equipment associated with the BWTP, the power and control panels for each plant were located on a mezzanine level directly above the plant (P&S respectively) which does not have the same hazardous area classification (as it is more than 2000 mm above the deck). Figure 4 shows how the two systems' fits were arranged physically.

Figure 4. Arrangement of BWT Plant

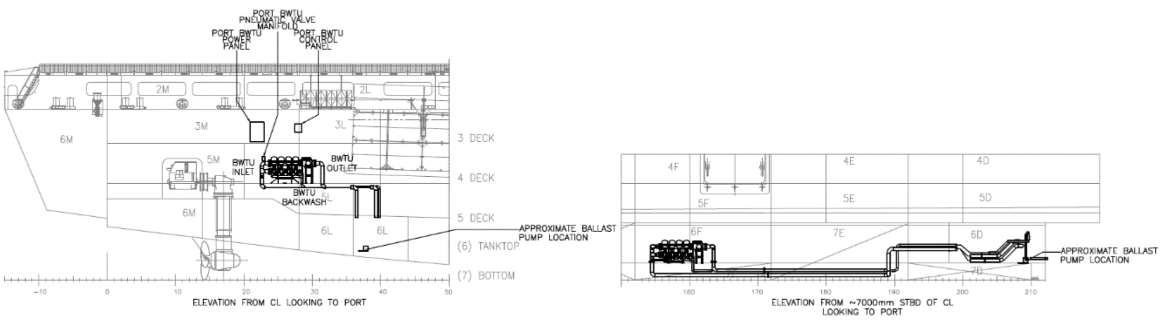

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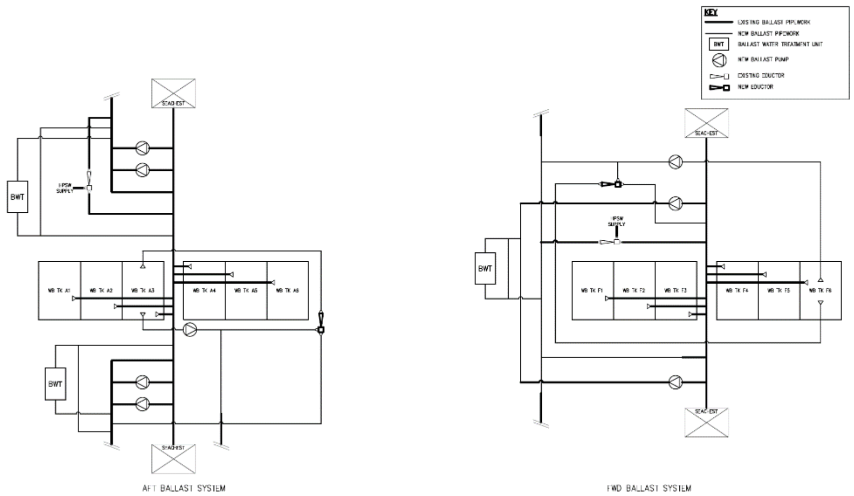
Figure 4 also gives an indication how BMT represented the routing of the new ballast pipework in 2D CAD. This was aided with annotated photographs with new pipework and indication of removals overlayed on the photos.

Figure 5 shows the final simplified schematic, and demonstrates the additional complexity and pipework required to fit the BWT system.

Figure 5. Updated Bay Class Ballast System

Test and



Once the refit specification had been accepted by all stakeholders (no issues identified by Class or the Maritime & Coastguard Agency) and the installation was approved, BMT were contracted to produce a test and trials instructions and forms that upon completion would provide the evidence required for BWM approval. The specified requirements together with completed test forms (also provided) gave assurance that: the system had been installed properly; functioned correctly (equipment and system as a whole); suitable data could be captured and recorded relating to the performance of the system; and suitable evidence was available to support acceptance of the system by the owner.

6. Conclusion

In conclusion, it can be seen that if the requirement is well defined, and a design team with access to all of the stakeholders is put together, retrofitting of ballast water treatment plant, even when in a complex ship such as a large amphibious platform, need not be too difficult. It can also be concluded that specific complexities (i.e. system interfaces/cross-connections) that could potentially impact the ability to provide a compliant solution need to be identified early so that a resolution can be sought before it is too late. A prime example of this is the stripping system design on the Bay Class. If the novel solution as developed was not detailed early there may have been issues with overheating of the UV element on the ballast water treatment plant or the need to adjust the design of the plant from that which had gained IMO approval.

The final solution provides the ability for the ship to be operated in full compliance, but maintaining the additional functionality and reversionary modes that are required by such a platform to fulfil its role as an amphibious assault support ship.

https://doi.org/10.24868/bwtc6.2017.006

Acknowledgements

Alan Scott, RFA In-Service Design & Fire Safety Co-ordinator, Commercially Supported Shipping for the permission to use the Bay Class BWT project in this paper.
Steve Walden, Cluster Design Manager, A&P Falmouth Ltd for supplying photographs and other data.
The support of BMT Defence Services Ltd is also acknowledged.
All findings, ideas, opinions and errors herein are those of the author and are not necessarily those of BMT Defence Services Limited.

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