6th IMarEST Ballast Water Technology Conference, 12-13 January 2017, London, UK
https://doi.org/10.24868/bwtc6.2017.008

Ballast Water Treatment System Integration with the Ship Alarm and Monitoring System

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ABSTRACT

Integration with the vessel Automation and Control system is a critical milestone in a Ballast Water Treatment System (BWTS) retrofit project. When completed properly, it provides for simple and intuitive operation of the BWTS and supports compliance with ballast water regulations. Integration results in seamless operation and monitoring of the ballast pumps and valves together with the BWTS at control stations in the Engine Control Room and/or bridge. It provides appropriate interlocks and alarms to ensure that the BWTS is not bypassed through ship's valves, which are not controlled and monitored by the BWTS. It also encourages and supports the required log entries in the Ballast Water Logbook. A structured approach to this integration work results in fleet wide consistency, providing maximum benefit to the owner by reducing the risk of non-compliance as well as reducing the future cost of technical support and training.

Keywords: Ballast water, BWTS, Automation, Integration, Compliance

1. Introduction

The Alarm and Monitoring System (AMS) on a modern vessel allows many separate ship systems to be controlled and monitored from screens in the Engine Control Room (ECR) or Bridge. Critical operating data, warnings and alarms generated from each system are presented through mimic diagrams, text, audible signals, allowing operators to attend multiple systems continuously and efficiently.

Ballast water operations involve starting and stopping pumps, controlling valves, and monitoring ballast tank volumes. The AMS Ballast System screen typically has a mimic representing the ballast piping and tanks, with symbols, colors, and data to indicate valve positions, pump operation, and tank levels.

New ballast water regulations coming into force will require the installation of a Ballast Water Treatment System (BWTS), a process with its own PLC control, valves, and alarms. The BWTS is directly connected to the ballast water piping and must be operated in strict coordination with the existing ballast system.

Integration of the BWTS control into the AMS allows seamless operation and monitoring of the ballast system as a whole. This can be accomplished relatively easily during new construction by providing adequate guidance and documentation to the vessel designer, shipyard, and Automation supplier during the planning stage. However, retrofitting a BWTS on an existing ship, with Vessel Automation system already in place, presents a much greater challenge.

2. The Control Integration Effort

The primary goal of control integration is to ensure that the BWTS can be efficiently operated with minimal impact to existing shipboard operations and safety, while simultaneously ensuring that operation, alarms, and logging are in full compliance with ballast water regulations, class society rules, and flag State requirements.

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This aspect of BWTS installation often does not receive sufficient attention. Guidance from Class is limited and future requirements from port State control enforcement are unclear. The integration effort is best managed by a competent and experienced Naval Architect/Marine Engineering partner with understanding of vessel operations, piping systems, class requirements, and ballast water regulations.

The level of integration required and appropriate for each vessel should be established early in the project. Consideration is given to process control requirements of the BWTS, technical specifications and limitations of the Automation System, class and flag requirements, as well as preferences of the vessel owner. A dedicated BWTS remote control panel installed in the ECR may reduce the level but will not likely eliminate the requirement for integration.

The Marine Engineer should have control integration in mind during the onboard survey and while inquiring about the current ballasting practices, valve alignments and ballast tank plan. Further documentation is prepared during the BWTS Integration Engineering phase of the project. This includes a careful analysis of the existing ballast system and tank arrangement to identify valve alignments that result in paths for untreated water to flow by gravity into the tanks or overboard.

Consideration must be given to class society rules, as well as International Convention for the Safety of Life at Sea (SOLAS), 1974 (SOLAS) and International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL) requirements based on vessel type. Cruise ships, for example, may routinely hold grey water in ballast tanks and use the ballast water overboard for discharge of grey water. This will result in contamination of pipes and tanks, which must be removed using proper flushing procedures. These procedures must be documented in the Ballast Water Management Plan (BWMP) but the marine engineer must also consider these details when preparing the installation design documents and drawings which are needed to support the reprogramming of ship's AMS.

3. BWTS Configuration

Producing a robust and compliant solution requires a clear understanding of the treatment technology, operating modes and parameters of the selected BWTS. Each BWTS incorporates process control according to treatment requirements, hold times, and design philosophy of the maker, which is reflected in the Type Approval of the system.

The BWTS may require operation during both uptake and discharge or during uptake only, with monitoring and possible neutralisation during discharge. Valves, pumps and other components required for the treatment process itself are controlled and monitored by the BWTS and are required to be logged internally. In most cases a treatment system bypass valve, to be opened in an emergency, is also monitored and logged. The ballast pump and existing valves must be operated in close coordination with the BWTS and may be monitored and logged or in some cases interlocked with the BWTS control.

The BWTS supplier should provide accurate technical specifications, drawings, and an operation and maintenance manual. They should also be prepared to provide installation guidance, including a list of the available inputs and outputs (I/O) and assistance in identifying the minimal recommended I/O for remote operation. The AMS programmer will require detailed I/O documentation and addressing to complete their work.

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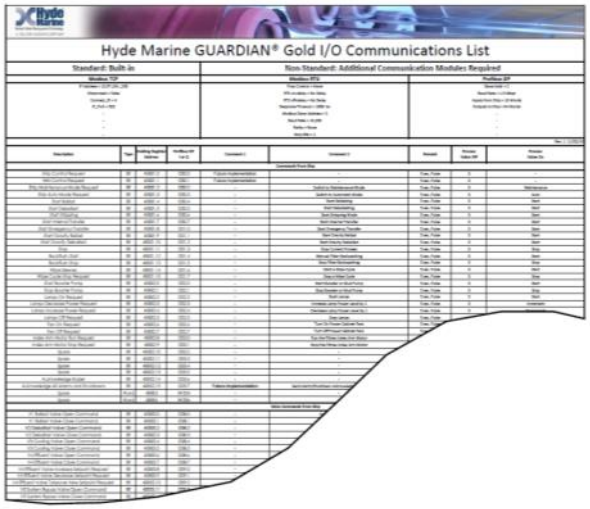
Figure 1. Documentation from the BWTS supplier specifying I/O Communication details (Hyde Marine)


Hyde Marine GUARDIAN® Gold I/O Communications List

4. Physical Integration

The BWTS will interface with the AMS via an appropriate communications protocol and cable. Examples include Modbus RTU over a single RS-485 cable and Modbus TCP over Ethernet. The most suitable protocol should be agreed upon early in the project between the BWTS and AMS suppliers. The specific communications port on the AMS will need to be determined onboard based on availability. If a spare connection is not available, an additional communications module may need to be installed in the AMS and configured as appropriate.

5. BWTS Operation and Monitoring

Communication between the BWTS and AMS is bi-directional, allowing remote operation of the BWTS by the AMS while permitting the AMS to monitor the BWTS parameters and alarms. In most cases the existing ship's ballast valves cannot be monitored or operated by the BWTS and the individual BWTS valves cannot be operated by the AMS. However, the position of the BWTS valves, BWTS parameters, and BWTS alarms are all capable of being transferred through the AMS to inform the operator. Some AMS generated alarms as described in section 6.0 must be transferred back to the BWTS for alarming and logging to meet regulatory requirements.

At minimum, the commands available from the AMS to the BWTS are operating mode selection, start, stop, and emergency BWTS bypass. In this case, all other BWTS functionality and diagnostic operation would be conducted locally from the BWTS control panel or remote control panel if installed.

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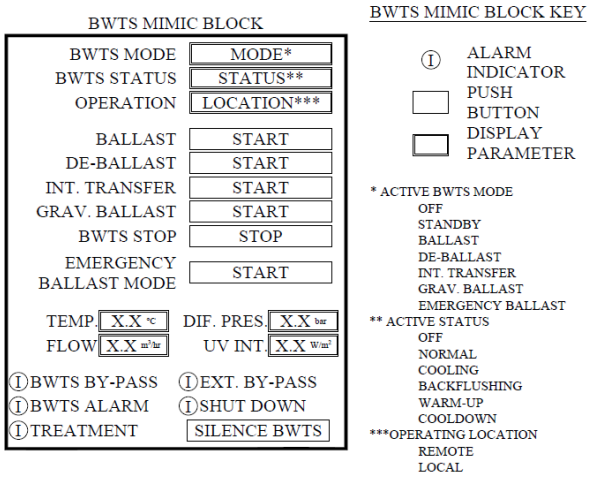
Figure 2. Guidance provided for a BWTS "Control/Alarm" block to be added to the Ballast Water Mimic Screen



Consideration must be given to what happens if the BWTS is powered off locally or loses power and/or no input signals are available to the AMS. Typically the BWTS valves will all spring return to their default safe positions without providing any valve position feedback. Under these conditions the AMS must clearly indicate that the status of the BWTS and position of all BWTS operated valves is "Unknown" on the AMS mimics.

6. External Bypass

The BWTS will generate alarms if the system operates outside of set parameters and typically monitors a BWTS bypass valve and/or ballast pump to raise a bypass alarm if water is transferred without the treatment system in operation. However nearly every existing ballast piping arrangement includes valves, which can allow water to flow by gravity into or out of ballast tanks untreated. These ship's valves are external to the BWTS and are not monitored or alarmed by the BWTS control.

Certain gravity de-ballasting operations may be allowed in accordance with the type approval of the BWTS. However, a non-complaint "external bypass" represents a considerable pollution risk. Under certain conditions, a significant percentage of the total ballast water volume of the ship can flow in or out of the ship without treatment or neutralisation. New regulations require that these activities stop and be replaced by compliant operation.

It could be argued that non-compliant external bypass events might be effectively avoided through strict operational procedures. Relying on human involvement increases the risk of unintentional bypass and since the BWTS is not monitoring these valves, proper logging would not occur. It is therefore unlikely that class and eventually port State control will allow this practice.

A solution is to program appropriate interlocks and alarms within the AMS to ensure that compliant procedures are followed. Considering that flow paths and valve combinations vary widely between ships a "Valve Alarm Logic Tree" should be developed for each project to support the necessary programming of the AMS. The table lists the valves and valve combinations that should be alarmed by the AMS and transfer back to the BWTS to be logged as a bypass of the system.

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Figure 3. Valve Alignment Table and Alarm Logic Tree

VALVE ALIGNMENT TABLE

NEW BALLAST WATER TREATMENT SYSTEM VALVES - CONTROLLED BY BWTS [1,2]

VALVE	DESIGNATION	SIZE	BALLAST		DE-BALLAST		TRANSFER		STANDBY
			POSITION	ALARM	POSITION	ALARM	POSITION	ALARM	FAILURE
V1	BALLAST VALVE	DN 200	OPEN	YES	CLOSED	YES	CLOSED	YES	CL / CL
V2	DE-BALLAST VALVE	DN 200	CLOSED	YES	OPEN	YES	CLOSED	YES	CL / CL
V3	COOLING VALVE	DN 50	INTERMITTENT	YES	INTERMITTENT	YES	CLOSED	YES	CL /CL
V4	EFFLUENT VALVE	DN 200	OPEN	YES	OPEN	YES	CLOSED	YES	CL /CL
V5	SYSTEM BY-PASS VALVE	DN 200	CLOSED	YES	CLOSED	YES	OPEN	YES	CL / OP
V6	GRAVITY FEED VALVE	DN 200	CLOSED	YES	CLOSED	YES	CLOSED	YES	CL / CL
V7	COOLING CHECK VALVE	DN 50	NOT MONITORED		NOT MONITORED		NOT MONITORED		NA
V8	BACKFLUSH PUMP ISOLATION VALVE	DN 80	NOT MONITORED		NOT MONITORED		NOT MONITORED		NA
V9	BACKFLUSH PUMP ISOLATION VALVE	DN 100	NOT MONITORED		NOT MONITORED		NOT MONITORED		NA
V10	BACKFLUSH PUMP CHECK VALVE	DN 100	NOT MONITORED		NOT MONITORED		NOT MONITORED		NA
V11	DISCHARGE VALVE	DN 200	CLOSED	YES	OPEN	YES	CLOSED	YES	OP / OP
V12	FILTER DISCHARGE CHECK VALVE	DN 100	NOT MONITORED		NOT MONITORED		NOT MONITORED		NA

1) BWTS WILL ALARM AND LOG ANY VALVE POSITION DIFFERING FROM POSITION SHOWN IN THE TABLE FOR A GIVEN OPERATING MODE. ALARMS WILL TRANSFER TO SHIP MAS.
2) AN ALARMED BWTS VALVE WOULD INDICATE A SYSTEM MALFUNCTION, BUT NOT NECESSARILY A BWTS BYPASS CONDITION. CREW MUST ASSES SYSTEM CONFIGURATION DUE TO A MIS-ALIGNED VALVE AND DETERMINE IF A BWTS BYPASS HAS OCCURRED, AND MAKE APPROPRIATE NOTATION IN BALLAST WATER LOG.

EXISTING BALLAST SYSTEM VALVES - CONTROLLED BY SHIP MAS [3]

VALVE	DESIGNATION	SIZE	STANDBY FAILURE	VALVE ALARM LOGIC TREE				
				PRIMARY CONDITION		SECONDARY CONDITON		
				VALVE	POSITION	LOGIC OPERATOR	VALVE	POSITION
V003	PUMP #2 SEAWATER SUPPLY	DN 200	CL / CL					
V004	BALLAST LINE SUCTION	DN 200	CL / CL				V0004	OPEN
V005	BALLAST LINE SUCTION	DN 200	CL / CL	V003	OPEN	AND	V0005	OPEN
V006	BALLAST LINE SUPPLY	DN 200	CL / CL			ANY OF	V0006	OPEN
V007	BALLAST LINE SUPPLY	DN 200	CL / CL				V0007	OPEN
V008	BALLAST LINE SUCTION	DN 200	CL / CL				V006	OPEN
V009	BALLAST LINE SUCTION	DN 200	CL / CL	V010	OPEN	AND	V007	OPEN
V010	PUMP #1 SEAWATER SUPPLY	DN 200	CL / CL			ANY OF	V008	OPEN
V011	BALLAST LINE SUPPLY	DN 200	CL / CL				V009	OPEN
V012	BALLAST LINE SUPPLY	DN 200	CL / CL	V066	OPEN	AND	V004	OPEN
V066	BALLAST OVERBOARD	DN 200	CL / CL	PUMP #2 RUNNING		ANY OF	V005	OPEN

3) SHIP AMS WILL BE PROGRAMED TO ALARM BY-PASS OF THE BWTS USING THE VALVE ALARM LOGIC TREE GIVEN IN THE TABLE.

External Bypass alarms also encourage and support required log entries in the Ballast Water Logbook. This can be when valves are opened for justifiable operations such as emergency bilge pumping, tank flushing, or grey water discharge at sea. The purpose is to assist operators to manage any water that may be untreated in tanks and piping and take proper corrective action as detailed in the BWMP.

7. Updating AMS Screens and Alarms

Accurate presentation of piping, valve positions, and alarm conditions within the AMS is critical to vessel safety as well as compliance. The Ballast System mimic screen will need to be updated to show new valves and piping related to the BWTS. For ships with the bilge and/or grey water systems interconnected with the ballast system, those mimic screens will also need to be updated as appropriate. Certain new alarms will need to be programmed into the AMS and BWTS control blocks will also need to be added to AMS mimics. These programming updates can be difficult to accomplish on already crowded screens.

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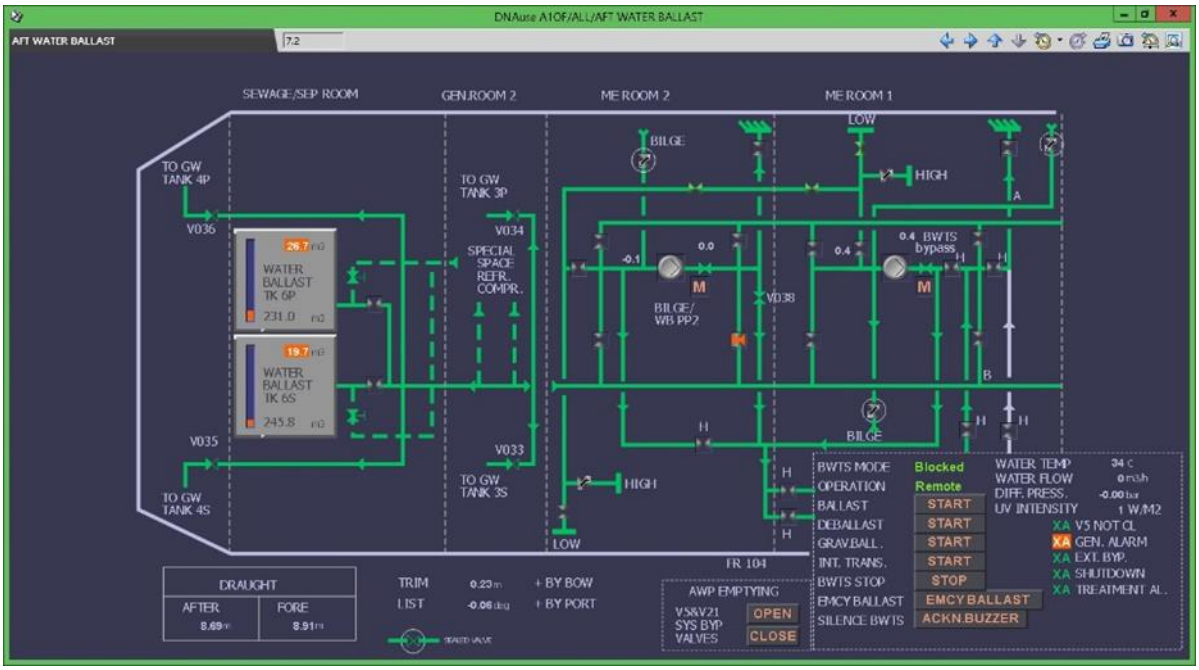
Figure 4. New Ballast Water Mimic draft layout showing updated piping, valves and BWTS Control/Alarm block (Valmet)



8. Guidance and Documentation of Integration

Clear and consistent guidance must be provided to AMS and BWTS technicians to support efficient interface the BWTS functionality and operation into the ship control system. Documentation must be specific to the vessel configuration, BWTS, AMS, and vessel class. The involvement of an experienced Naval Architect/Marine Engineer to produce a project specific documentation and coordinate the effort can greatly improve the end results of the integration work. Elements of the engineering package, which are needed for integration support include:

- BWTS piping schematic, with general notes regarding control and alarms
- Valve alignment table and alarm logic tree, with notes regarding control and alarms
- Updated Ballast Water Management Plan (BWMP)

Regulatory class has not been requiring any formal documentation of changes made to the AMS in regard to the BWTS. However, a class surveyor will verify that all of the BWTS integration with the AMS has been executed. It is recommended that all changes to the AMS be documented and retained onboard, in the event that class should request documentation of these changes.

9. Conclusion

Integration of the BWTS control with the AMS is a critical milestone in a BWTS retrofit project that should not be overlooked. A successful integration begins with a thorough understanding of the BWTS process requirements and a careful analysis of the ship's ballast system by the marine engineer. Accurate documentation and guidance is essential to support the BWTS and automation system technicians in completing their work.

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When completed properly, it provides for simple and intuitive operation of the BWTS and supports accurate ballast water logbook entries to satisfy port State control. A structured approach to this integration work results in fleet wide consistency, providing maximum benefit to the owner by reducing the risk of non-compliance as well as reducing the future cost of technical support and training.

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