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Components Testing: The Quieter Side of the BWMS Discussion

BY WALTER POGGI, PRESIDENT, RETLIF TESTING LABORATORIES

Ballast Water Management Systems have dominated industry news for years, with millions of words generated on developing regulations, the approvals process, as well as on international interpretation and implementation. Additional volumes have been authored on USCG interpretation and implementation of compliant systems. Amid this ongoing typhoon of words, another area often gets lost in the shuffle because of its stability and consistency, but is no less important in the grand scheme of things: Electrical and environmental simulation testing and compliance of BWMS components.

In 2016, when Retlif Testing Laboratories became the first "Sub Lab" approved by the USCG for environmental simulation testing related to BWMS, the industry was becoming aware of the growing undercurrent of both process and protocol. Retlif, which currently has working relationships with five of the USCG designated Independent Laboratories (IL), led the way.

"As we all know, maritime operating conditions constitute a harsh and unforgiving environment." Richard Reitz, Retlif Director of Engineering said. "The acute and cumulative effects of vibration, inclination, not to mention the extremes of temperature, directly impact the performance of maritime equipment performance from Voyage Data Recorders to simple deck winches. The components of a BWMS are no exception. And unpredictable voltage variations can further impact the proper operations of such components."

To address these concerns, the USCG defined specific test criteria in 46 CFR 162.060-30 that BWMS system components

TABLE 1

Parameter	Condition	Duration
Sinusoidal Vibration	Sinusoidal Resonance Sweep 2 to 13.2 Hz: ±1mm 13.2 to 80 Hz: : ±0.7g Resonance Frequency Dwells Selected by the test engineer	at least 1 Octave per minute 4 hours per dwell
Temperature – Environmentally Controlled Spaces	Min: 0°C Max: +55°C	2 hours 2 hours
Humidity	90% RH at +55°C	2 hours
Voltage Variation	Voltage Variation ±10% Voltage, ±5% Frequency Voltage Transients ±20% Voltage, 10% Frequency	Long enough to check operation 3 seconds between transients
Static and Dynamic Inclination	Static Inclination ±15 degrees Roll and Pitch Dynamic Inclination ±22.5 degrees, Roll ±7.5 degrees, Pitch	Long enough to check operation

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FIGURE 1

FIGURE 2

must meet, related to environmental simulation and voltage variation. Table 1. to the right, shows these requirements.

In order to better understand the scope of this type of testing, Retlif engineers designated a critical First Step.

"The issue of interpretation regarding approval of BWMS is an often discussed topic." Reitz said. "While specifications are reasonably defined, the systems are complex, involving multiple parts and multiple modes of operations." This leads to the key question:

"How are the system and its components actually tested?"

Effective science-based testing, codified in a test plan is the smartest route to compliance. In this analogy, the lack of a test plan is like building a ship without a rudder. It means a potential loss of focus and direction, a serious enough void that could turn the effort into what the testing world euphemistically terms, "a misguided science experiment."

Nor is the lack of a test plan what the customer wants. Customers want the most economic testing program that will demonstrate compliance with the specifications, and ultimately result in market access. "Both the customer and the laboratory want a defined, cost effective testing program, that for the customer assures marketplace access a.s.a.p. The laboratory wants well defined scheduling of personnel and test instrumentation, because that provides the most efficient operation," said Scott Poggi, Retlif Director of Operations.

And this is anathema to regulators and approving bodies. They want to review a test report that is technically complete and "technically clear." An acceptable test report must convey how each test was performed and how the equipment under test (EUT) was set up, operated and monitored.

Understanding the Test Plan

To address such concerns before they become realities, the first step of a BWMS test program is the development of a test plan. The process is not simple, requires a meaningful amount of time, but will result in a lengthy but essential document. There are four basic steps involved.

- **Initial Documentation Review:** The laboratory will have technical documentation which it used in the generation of the quotation for the needed testing. Once an order is received to perform testing, an engineering team typically composed of one electrical and one mechanical test engineer will review the documentation. This is done to better understand the equipment to be tested and to begin strategizing the testing approaches for each of the test methods.

- **Customer's Manufacturing Facility Visit:** Next, the laboratory's engineering team will visit the customer's manufacturing facility. This visit is normally completed over two days, during which the laboratory engineering team interfaces with the customer's in-house engineering. During these meetings issues such as modes of operation and test setups are discussed and defined. These meetings are invaluable. The laboratory team sees the equipment for a better understanding of how it can be setup, energized and operated during testing, and the customer's engineering group gets a much fuller understanding of the actual testing that will take place.

- **Test Plan Generation:** Armed with the information gathered during the onsite visit, the laboratory's engineering team oversees the generation of the test plan. This process normally takes about two weeks and results in a document of approximately 175 to 200 pages. The document addresses test setups, modes of operation, monitoring technics and pass/fail criteria in detail.

• **General Approval:** After the test plan document is completed by the laboratory, it is then circulated to both the customer and the IL for the approval and sign off. Clearly at this point there can be give and take with slight modifications made. However, the end result is a document that is both customer and IL-approved which provides very defined and clear direction for the test program.

Environmental Sim & Voltage Variation Testing

Now let's look at the basics of the environmental simulation and the voltage variation testing that are performed on the component parts of a BWMS.

• **Sinusoidal Vibration**

The purpose of this test method is to determine the ability of BWMS system component or Equipment Under Test (EUT), to withstand expected dynamic stresses due to vibration and to ensure that performance degradations or malfunctions will not be produced by the in-service vibration environment. During this testing, the EUT will be operating in its appropriate Mode of Operation(s) while mounted onto a vibration test machine. (See Figure 1) Vibration Testing will consist of first a Resonance Search followed by Resonance Frequency Dwells in each of the 3 orthogonal axes.

Actual testing is actually broken up into two parts. First a Resonance Search is performed at a rate sufficiently low so as to permit resonance detection over a frequency range of 2 to 80 Hz.

The typical rate for a resonance searches is 1 octave per minute. Utilizing the data obtained (any resonant frequency(s) in the resonance searches, the test engineer will select the frequencies to perform vibration testing. (Resonant frequencies are defined as response peaks greater than twice the input acceleration amplitude). If no resonances have been found, the EUT will be vibrated at a frequency of 30 Hz with and acceleration of 0.7 g peak. Each resonant frequency dwell testing is applied for a minimum of a (4) hour period per axis. During each 4 hour test the EUT is monitored for any physical or mechanical damage for proper operation in the mode of operation selected.

• **Temperature – Environmentally Controlled Spaces**

The purpose of this test method is to determine the ability of the EUT to withstand the expected stresses due to extreme temperature conditions at in-service locations, and to ensure that performance degradations or malfunctions will not be produced in such environments. For this testing the EUT is placed inside a test chamber and setup in its operational configuration with all the necessary cabling connected and/or fittings engaged. (See Figure 2).

Prior to the start of the test, EUT operational status is determined to be in compliance. The EUT is then returned to its non-operational configuration with no pressure and/or electrical energy applied. With the EUT non-operational, the chamber temperature is adjusted to 0°C and once stabilized that temperature level is maintained for a period of 2 hours.

At this point the EUT is again energized and its proper opera-

TABLE 2

Test	Levels	Length of Test
Voltage Variation	+ 10% Voltage +5% Frequency	Long Enough To Check Operation
	+ 10% Voltage -5% Frequency	Long Enough To Check Operation
	-10% Voltage +5% Frequency	Long Enough To Check Operation
	-10% Voltage -5% Frequency	Long Enough To Check Operation
Voltage Transients	+20% Voltage +5% Frequency	3 Seconds Between Transients
	+20% Voltage -5% Frequency	3 Seconds Between Transients
	-20% Voltage +5% frequency	3 Seconds Between Transients
	-20% Voltage -5% Frequency	3 Seconds Between Transients

tion again confirmed. The EUT is then made non-operational, and the chamber temperature is adjusted to 55°C. After this temperature has stabilized, it is maintained for a period of 2 hours after which the EUT is once again energized and its proper operation confirmed.

The temperature chamber is then returned to lab ambient conditions/temperature, and once again the proper operation of the EUT confirmed.

- **Humidity**

The purpose of this test method is to determine the ability of the EUT to withstand the expected stresses due to potential high humidity conditions that can be experienced at in-service locations, and to ensure that performance degradations or malfunctions will not be produced in such an environment.

For this testing the EUT is placed inside the test chamber and setup in its operational configuration with all the necessary cabling connected and/or fittings engaged. (See Figure 2).

Prior to the start of the test, EUT operational status is determined to be in compliance. The EUT is then returned to its non-operational configuration with no pressure and/or electrical energy applied. With the EUT non-operational, the chamber temperature and humidity are adjusted to a temperature 55°C, with 90% Relative Humidity. This temperature/humidity level is then maintained for a period of 2 hours, after which the EUT is once again energized and its proper operation confirmed. The chamber is then returned to lab ambient conditions/temperature/humidity and once again the proper operation of the EUT confirmed.

- **Voltage Variation**

This test is performed to determine the ability of the EUT to withstand the expected stresses ue to simultaneous power fluctuations in voltage and frequency that may occur in use, and to ensure that performance degradations or malfunctions will not be produced by such service power fluctuations environment.

For this testing the EUT is powered by a programmable power source capable of powering the EUT and producing the variations and transients shown in Table 2. Prior to the start of the test, the EUT is place in its appropriate Mode of Operation and proper operation is confirmed.

Proper operation is again checked at each of the test levels shown in Table 2, and at the conclusion of the testing.

- **Static and Dynamic Inclination**

This test method is performed to determine the ability of the EUT to withstand the expected stresses due to static and dynamic inclination conditions that can occur at sea, and to ensure that performance degradations or malfunctions will not be produced by the in-service static inclination environment.

During this test, the EUT is placed in the appropriate Mode of Operation and subjected to both static and dynamic inclination test conditions, as shown in Table 1. Inclination is applied about the vertical axes in both directions. To perform this testing the EUT is placed on the Incline Table and oriented to the Inclination Machine table top as it would typically be aboard a ship.

The Static Inclination test consists of six test steps. With the EUT positioned on the inclination machine and with the machine set at 0° Pitch and 0° Roll position, the EUT is operated in its defined mode of operation and proper operation confirmed. The machine is then adjusted to the following positions and at each one, proper operation of the EUT is confirmed, +15° Pitch and 0° Roll position, -15° Pitch and 0° Roll position, 0° Pitch and +15° Roll position, 0° Pitch and - 15° Roll position, and finally back to 0° Pitch and 0° Roll position. After Static Inclination is completed Dynamic Inclination is performed. For the Dynamic

Inclination testing the inclination machine is set to operate simultaneously at ±22.5° Roll, ±7.5° Pitch. During this testing, the EUT is monitored for proper operation. The inclination machine is then returned to the 0° Pitch and 0° Roll position and proper operation is again confirmed. The length of both the Static and the Dynamic testing is not set to a defined time, but rather “long enough to check operation”.

Conclusion

While it is highly likely that flux and more millions of words will be written re: Ballast Water Management Systems areas, the USCG environmental simulation and voltage variation requirements for system components are very well defined and have been tested to on a dailybasis for quite some time. The test methods used are based on and rooted in recognized national or international consensus standards. When applied to BWMS components the test methods provide assurances for proper operations when such equipment is place into a marine environment.