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The National Transportation Systems Center

Testing and Evaluation of Experimental Shipboard Ballast Water Treatment Systems for STEP: Experience and Lessons Learned

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U. S. Coast Guard Shipboard Technology Evaluation Program (STEP)

- Program particulars
- General observations
- Lessons learned

STEP Overview – Program Goals

- Development of effective BWT systems
- Shipboard performance data and best practices for shipboard testing, for
  - USCG policy makers
  - Industry – operators and technology developers
  - Field biologists

STEP Overview – Acceptance Criteria

- Proof of performance test data - Potential to Meet STEP Treatment Criterion
- Engineering information
- Safe design and operation
- Shipboard test plan

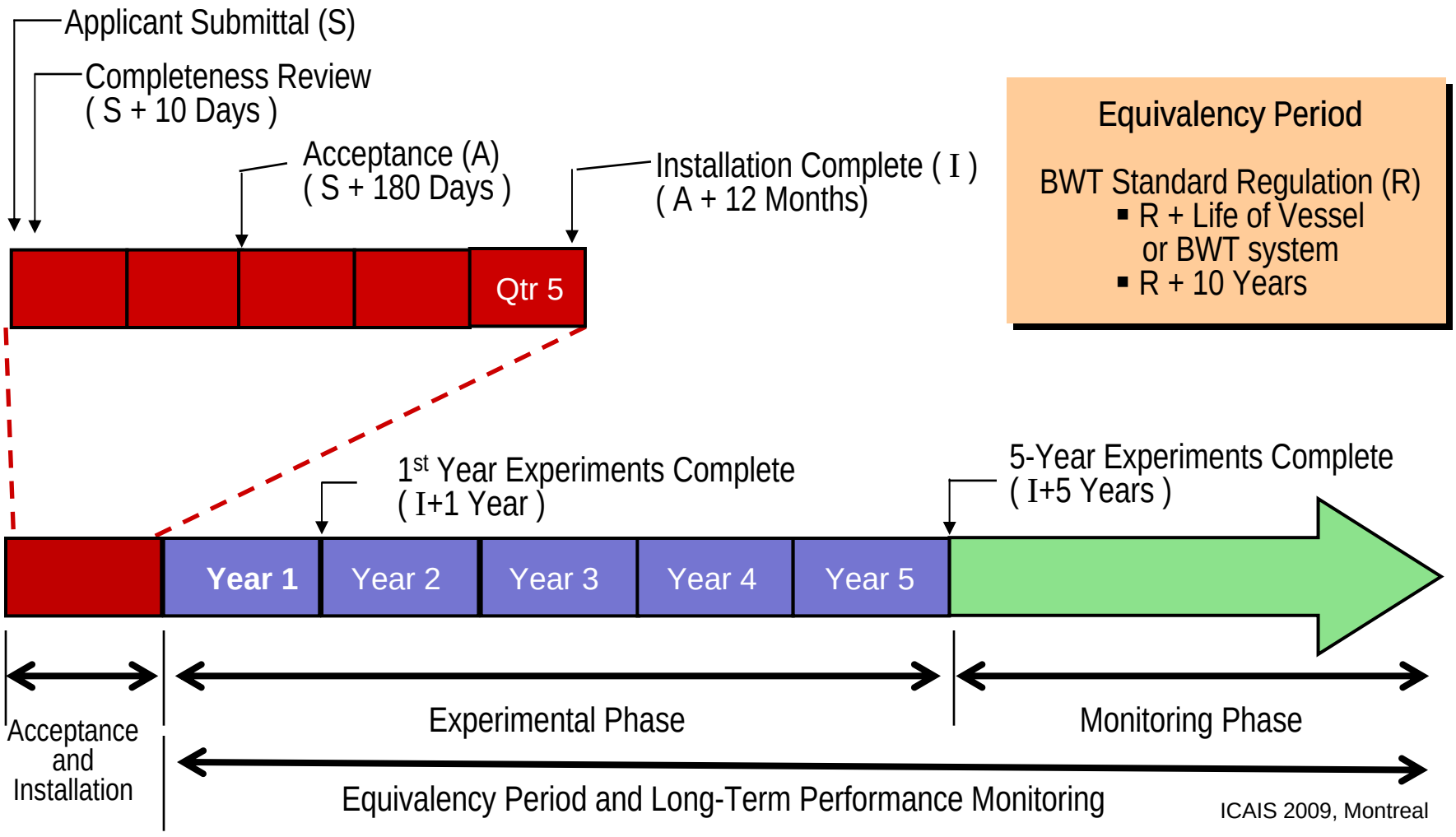
BWM Regulatory equivalence, lifetime of ship or BWT system

STEP Overview - Terms of Acceptance

Regulatory environment

- Environmental review and compliance
- "Primary" shipboard tests to confirm treatment effectiveness (Years 1 and 5)
- Performance monitoring and reports to USCG through end-of-life
  - BWT system engineering, operation, reliability
  - Treatment effectiveness

A Ship's STEP Schedule



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STEP Review Team

- Marine engineers
- Marine biologists
- Civil engineers
- Environmental scientists

STEP Review Team

- Volpe Center as technical review agent for USCG
- Advisory capacity only
- Engineers and biologists conduct:
  - Desktop application reviews
  - Shipboard observation of systems and experiments
  - Review and analysis of BWT system performance data

Application Process

- Early applications in open format to encourage innovation by scientists and engineers
- Poor quality of early applications
  - Incomplete data
  - Poorly organized format and submissions
- New, tabular format in 2006, w/better definition of USCG requirements; result: better quality applications

General Observations

- BWT - Transition of land-based water treatment technologies to shipboard
  - New environment(s)
  - New target organisms, in daunting variety
  - Variety of ship sizes, ballast system capacities, rates
  - Engineering and treatment effectiveness challenges
- Scientifically valid shipboard testing is hard, especially on commercial vessels

More General Observations

- Vendors are drivers of STEP applications, not operators
- Shipboard tests: reluctance to disrupt routine commercial operations
- Need full partnership commitment by the operator
- Shipboard needs
  - Accommodation of lab space and personnel
  - Significant departures from routine during shipboard experiments

Lesson Learned: Fully Integrate R/D & Deployment of BWT System

Application should link:

- Proof of performance tests (at different scales) logically and as an integrated test and development program leading to fielding at full scale.
- Shipboard study plan to earlier work, i.e., to validate BWT system operational parameters and treatment performance.
- Primary experiments to long term monitoring plan

Applicant's Project Organization

- Complexity of the job
  - Owner operator – operations, engineering, environmental compliance, ship's officers & crew
  - Vendor(s)
  - Biological test team
  - Laboratories
- **Applicant's** PM → authority to make decisions at both the planning and execution stages of shipboard experiments

Lessons Learned

- Proof of performance
- Ship configuration and operation
- BWT system
- Shipboard study plan
- Environmental compliance

Lessons Learned - Proof of Performance

- Some skipped tests at smaller scales
- Need for progressive scaling of experiments
  - Lab-scale on core treatment technologies – dose-response, assays
  - Pilot-scale - physical scale-up, system controls, confirm sampling/analytical protocols
- Finally, full-scale tests to confirm engineering and operations, and biological experiments

Lessons Learned - Proof of Performance

- Kill mechanism must be fully tested and characterized
  - Treatment mode of action
  - Fate/effect of treatment agents and DBPs
  - Range of anticipated operating conditions
- Fully informed review by USCG and compliance agencies
  - Treatment effectiveness
  - ALL discharge residuals, water chemistry, water quality

Lessons Learned – Ship Configuration and Operation

- Understanding the test environment: BW system configuration (tanks and piping) and operation
- Range of flow rates → maintaining dose
- Need for good ballasting data set, i.e., complete data from several voyages
- Training, and role of crew during tests and long term operation and monitoring of BWT system

Lessons Learned - BWT System Engineering

- System engineering data tables → results quite good
- Some shipboard BWT system drawings lack interface info; need “as-builts” at installation for accuracy
- Current marine safety standards don’t cover BWT technologies
- Shoreside safety standards applied: liquid/gas discharges, leak detection, safe off- gassing, HAZMAT storage/handling, etc.

Lessons Learned - BWT System

Shipboard BWT system-real world conditions:

- Confirm or modify operational parameters at full-scale, shipboard
- Confirm kill mechanism, treatment dynamics, fate and effect of treatment agents and all DBPs in anticipated environmental conditions

Lessons Learned – Shipboard Study Plan

- Characterization of in-tank conditions (chem./biol.) – need to sample multiple tanks, with spatial grid to get at stratification and “hiding” issues
- Must ensure valid challenge waters for primary experiments; **may require altering operational routine to get valid results**

Lessons Learned – Shipboard Study Plan

Study plan must:

- Account for system/treatment artifacts (e.g., sample ports & pumps)
- Ensure adequate statistical power: number of paired tanks, replicates, etc.
  - Multiple treatment/control tank pairs
  - Beyond G8 single tank pair requirement
- Specify flow proportional or incremental discharge sampling for entire tank

Lessons Learned – Shipboard Study Plan

Application should address:

- Viability assessments (i.e., zooplankton) to accurately measure treatment effectiveness
- Assays of appropriately fine taxonomic groups, as "total organisms" does not fully characterize system performance

Performance Monitoring

Long term monitoring of prototype system operation is critical:

- Proof of treatment reliability and system engineering & operations data
- Environmental compliance, especially discharge water quality
- STEP allows simplified test methods: biological or engineering parameters
  - Valid linkage to methods used in Year 1 primary experiments
  - Run simplified methods and primary experiments concurrently to establish validity

Lessons Learned – Environmental Compliance

- Importance of accurate description of ship's service (routes, frequencies, BW operations)
- STEP applications get individual NEPA analyses
- Reviews on basis of occasional BWT system use by single ship → impacts generally non-"significant"
- EPA's VGP regulation affects STEP ships and BWT systems

Lessons Learned – Environmental Compliance

- Full characterization of fate and effects
- Treatment chemicals/DBPs may behave differently in salt water; lack of
  - Toxicology data for marine organisms
  - Discharge standards for salt water
  - EPA analysis much more difficult
- STEP IS NOT type approval and marketing to industry will require new toxicology and standards

Questions

Photo: by Michael Dyer