# Engineering and Technical Services for Joint Group on Pollution Prevention (JG-PP) Projects

# Joint Test Report
# S-98-OC-010

# For Validation of Alternatives to New Paint Coating Technologies for Seawater Ballast Tanks

# October 3, 2001

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## PREFACE

This report was prepared by the Chief of Naval Operations Pollution Prevention Branch on behalf of, and under guidance provided by the Joint Group on Pollution Prevention (JG-PP) through the Joint Pollution Prevention Advisory Board (JPPAB). The structure, format, and depth of the report's technical content were determined by the JPPAB, Government contractors, and other Government technical representatives in response to the specific needs of this project.

We wish to thank the participants involved in the creation of this document for their invaluable contributions.

This Joint Test Report (JTR) documents the results of testing performed in accordance with the *Joint Test Protocol* MIL-PRF-23236, Validation of New Paint Coating Technologies for Seawater Ballast Tank. This JTR will be made available as a reference for future pollution prevention endeavors by other U.S. Department of Defense (DoD), National Aeronautics and Space Administration (NASA), and industry organizations to minimize duplication of effort.

## EXECUTIVE SUMMARY

The Naval Sea Systems Command (NAVSEA) Materials Engineering Office and the Joint Group on Pollution Prevention initiated a program in FY-99 to expand on previous successful Navy efforts to implement the use of solvent-free coating systems on Department of Defense (DoD) ships, boats, and small-craft. The program identified edge-retentive, solvent-free ballast-tank coating systems that comply with all current Federal, state, and local environmental regulations and exhibit a service life approximately four times longer than that of current Navy tank coatings. The objectives were to evaluate and approve alternate coatings for use in ballast tanks containing seawater, and to develop and install 20-year service life high solid, low edge-retentive tank coating systems.

The study initially evaluated one product, but as the governing specification was revised, additional products were evaluated on an as received basis. Products not meeting all phases of the test flow were deleted from further testing. Results of the testing are not subjected to interpretation, but were used to determine if the product meets the requirement or not, respectively. Pot life was changed from a finite time limit to an ID Characteristic to allow for the products with a very short pot life. These products were applied with plural component spray apparatus.

This joint test report (JTR) can be applied in situations where corrosion protection of ferrous metal tanks exposed to seawater immersion or partial immersion is a requirement. Currently, formal testing is not required, however further testing can be conducted on an as requested basis at any time.

The use of solvent-free coatings can prevent 94% of the life-cycle air pollution generated from tank coating operations. This can be accomplished by extending the interval for tank painting from the current periodicity of once every 1-7 years to a periodicity of once every 20 years with the solvent-free systems, which can also inherently reduce the solvent content of the paints. Once fully implemented in the fleet, the extended service life of these new solvent-free coatings will allow the Navy to avoid over $236M of maintenance costs over the next 20 years.

# 1. INTRODUCTION

The Joint Logistics Commanders (JLC) and Headquarters National Aeronautics and Space Administration (NASA) co-chartered the Joint Group on Pollution Prevention (JG-PP) to coordinate joint service/agency activities affecting pollution prevention issues identified during system and component acquisition and sustainment processes. The primary objectives of the JG-PP are to:

- Reduce or eliminate the use of hazardous materials (HazMats) or hazardous processes at manufacturing, remanufacturing, and sustainment locations; and
- Avoid duplication of effort in actions required to reduce or eliminate HazMats through joint service cooperation and technology sharing.

JG-PP projects typically involve at least one original equipment manufacturer (OEM) producing multiple systems for more than one of the Services or NASA, as well as at least one facility, such as a Department of Defense (DoD) depot, maintaining one or more of the systems. For each project, JG-PP technical representatives select at least one target HazMat for reduction or elimination. This target HazMat(s) is a material used in production or sustainment processes that is known to create environmental and/or worker health concerns. Project participants then identify alternative technologies or materials for evaluation.

For each project, a Joint Test Protocol (JTP) is written, containing the critical requirements and tests necessary to qualify potential alternatives to selected target HazMats and processes for a particular application. The required tests for this project are documented in *Joint Test Protocol for Validation of New Paint Coating Technologies for Seawater Ballast Tanks* dated October 2000, hereafter referred to as JTP. The tests are summarized in Section 2.

During each project, the participating technical representatives select candidate alternatives that will be tested in accordance with the JTP. A PAR for this project was not conducted because the project stakeholders had already identified potential alternatives. The alternatives are provided in Section 3.

The testing was executed after the project participants defined the tests to be performed and the alternatives to be tested. This Joint Test Report (JTR) documents the results of the testing, describes any test modifications made during the execution of testing, and identifies technically acceptable alternatives to the baseline process. Any test procedure modifications documented in this JTR have been agreed upon by the project technical stakeholders.

For the Validation of Alternatives to New Paint Coating Technologies for Seawater Ballast Tanks Project, volatile organic compounds (VOC) as found in coating materials (primers and topcoats) were identified as the target HazMat to be eliminated or reduced. The identified process was painting. The identified application is corrosion control. The

substrates are metals, primarily steel. Table 1 summarizes the target HazMat, process and material, applications, current specifications, affected programs, and candidate parts/substrates.

**Table 1. Alternative Seawater Ballast Tank Coating Target HazMat Summary**

| | |
|---|---|
| **Target HazMat** | Ozone via Reduction of VOC |
| **Current Process/ Material** | Epoxy Coating Compounds |
| **Applications** | Primers, Topcoats and Complete Systems |
| **Current Specifications** | MIL-PRF-23236 |
| **Affected Programs** | All Where Corrosion of Steel is to be Prevented |
| **Candidate Parts/Substrates** | All Metals, but Primarily Steel |

## 2. TESTING REQUIREMENTS

A joint group led by the Joint Acquisition Pollution Prevention Activity (JASPPA) and consisting of technical representatives from Marine Coating Manufacturers, the affected system program offices, the sustainment community, and other government organizations identified engineering, performance, and operational impact (supportability) requirements. These requirements were identified for VOCs in epoxy marine coatings applied to ships' metal (primarily steel) seawater ballast tanks. This group then reached consensus on tests with procedures, methodologies, and acceptance criteria to qualify alternatives against these technical requirements. These tests were identified for a number of application categories. Failure in any test does not necessarily disqualify a candidate alternative for use in all possible applications. For example, failure to comply with the JTP at the low temperature range will not necessarily disqualify the coating when tested to the JTP requirements at ambient temperatures.

Tests were conducted in a manner that eliminated duplication and maximized use of each test specimen. For example, where possible, more than one test was performed on each specimen. The amount and type of tests that were run on any one specimen were determined by the destructiveness of the test.

Table 2 and Table 3, respectively, list the common and extended engineering and testing requirements identified by the JG-PP project participants for Validation of Alternatives to New Paint Coating Technologies for Seawater Ballast Tanks. Common tests are required by all affected programs listed in Table 1. Extended tests are required by at least one of the programs, but not all. The listings in Table 2 and Table 3 also include acceptance criteria and the references, if any, used for developing the tests. Each of the tests is fully described in the JTP.

**Table 2. Common Engineering and Testing Requirements**

| Engineering Requirement | Test | JTP Section | Acceptance Criteria | References |
|---|---|---|---|---|
| Sea Water Resistance | Immersion | 3.2 | No Film Failure | All MIL-PRF-23236 |
| Intercoat Compatibility | Recoatability | 3.3 | 50% Adhesion to Original Paint | |
| Adhesion of Original Paint | Adhesion | 3.4 | 70% Adhesion to Substrate | |
| HAZMAT | VOC | 3.5 | VOC 340 grams/Liter | |
| Personnel Safety | Toxicity | 3.8 | Non-Toxic; Non-Hazardous | |
| Corrosion Resistance | Edge Retention | 3.9 | 70% Coating Retention on Edges | |
| Flammability | Flash Point | Table 5 | Flash Point $100^0$ F | |
| Application Characteristics | Pot Life | 3.1 | As Per Manufacturers Data Sheet | |
| Insert Requirement | Dry Time | Table 5 | Maximum 24 Hours/Coat; Maximum of 7 Days for System Until Service | |
| ID Characteristics | Certification | Table 5 | Technical Review | |

Note: VOC levels are expected to be lowered to 250 grams/Liter in the near future.

**Table 3. Extended Engineering and Testing Requirements***

| Engineering Requirement | Test | JTP Section | Acceptance Criteria | References | Programs Requiring Test |
|---|---|---|---|---|---|
| NONE | | | | | |

* Considering sea water ballast tanks, any program that will use coatings that pass the JTP requirements must use coatings that pass all the requirements. There are no situations where any program would require only partial testing.

To save testing cost and to avoid long-term tests on products that may not meet minimum requirements, the testing can be performed in phases illustrated in Figure 1 with the phases described in Table 4. After the completion of each phase, the technical representative of the authorizing agency can determine which candidate alternatives to eliminate and which to test further.

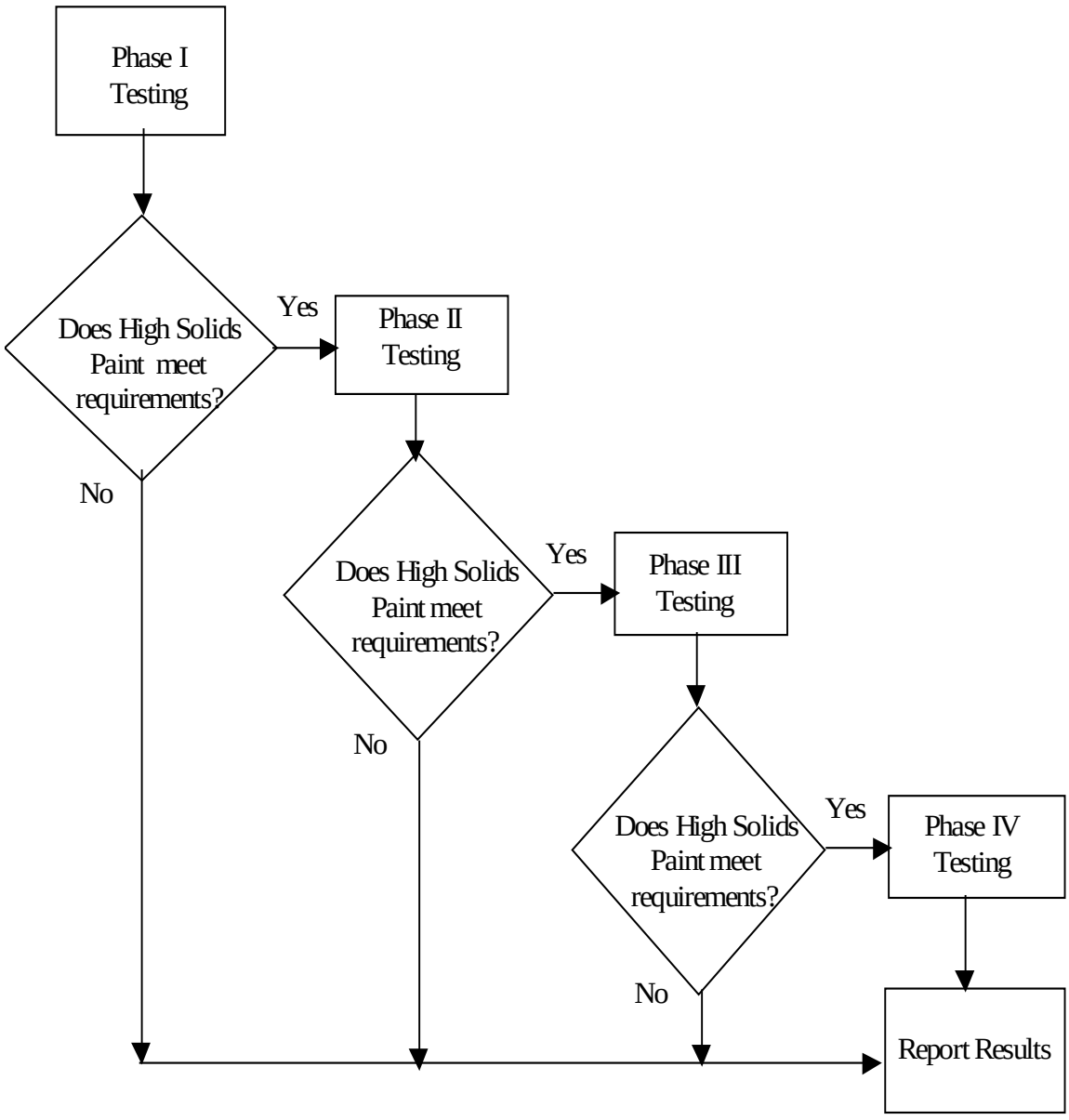


**Figure 1. Example Test Flow**

The tests in each testing phase are listed in Table 4. Table 4 also shows the relationships between application categories and the tests performed.

**Table 4. Test Phases for Sequential Execution**

| Testing Phase | JTP Section | Test Name | Application Categories | | | |
|---|---|---|---|---|---|---|
| | | | Component | Mixed Primer | Mixed Topcoat | Coating System |
| Phase I | Table 5.0 | ID Characteristics | X | X | X | |
| | | Chemical Type of Coating | X | X | X | |
| | Table 5.0 | Material | X | X | X | |
| | 3.5 | Solvent Content (VOC) | | X | X | |
| | Table 5.0 | Color | | X | X | |
| | 3.5 | HAZMAT Cert. | | X | X | X |
| | Insert | Mass per Gallon | | X | X | |
| Phase II | Table 5.0 | Condition in Container | X | | | |
| | 3.1 | Pot Life | | X | X | |
| | Table 5.0 | Flash Point | | X | X | |
| | Table 5.0 | Dry Time | | X | X | X |
| | Table 5.0 | Application Characteristics | | X | X | X |
| Phase III | 3.2 | Immersion Resistance | | | | X |
| | 3.9 | Edge Retention | | | X | |
| | | | | | | |
| Phase IV | 3.4 | Adhesion | | X | X | X |
| | 3.3 | Recoatability | | | X | X |
| | Insert | Service Test | | | | X |

All of the above tests are described in the JTP and have not been modified with the exception of the pot life requirement. With the advent of solventless epoxy paints, the requirement for a four hour pot life is not achievable, thus pot life is no longer a requirement, but rather an ID Characteristic as per the manufacturer's data sheet and certification.

## 3. ALTERNATIVES TESTED

The alternatives tested are products either requested by NAVSEA or offered to NAVSEA as conforming to specification requirements. The vendor submits preliminary Identification Characteristics as required by the specification and is deemed either acceptable or not for further long-term testing.

The FY-99 JG-PP/NAVSEA solvent-free tank coating program technical approach was based on working closely with coating vendors to identify commercial tank coatings that could satisfy Navy needs. Coatings were evaluated regarding their ability to help the Navy prevent pollution both by having no added solvent (as compared with current Navy tank coatings that have a solvent level of from 100 gm/l to 340 gm/l) and by having an ability to extend the tank service life.

Based on the pollution prevention and performance criteria described above, NAVSEA selected five coating systems for testing. Table 5 presents the coating system test matrix.

**Table 5. Solvent-Free Tank Coating Test Matrix ***

| Product | Application |
|---|---|
| Sigmaguard BT 7541 | Ballast Tank |
| Duraplate UHS | Ballast Tank |
| Interguard THA 180 | Ballast Tank |
| Jotun 591 | Ballast Tank |
| Sigma Edgeguard | CHT Tanks |

*Note: It should be noted that not all of the coatings listed in Table 5 are approved. For example, the Jotun 591 coating has had difficulties with MSDSs and satisfying VOC levels. To find out if new coatings that meet the VOC requirements have been added to the list above, please contact the project points of contact on the JG-PP website: http://www.jgpp.com/

## 4. TEST RESULTS

The performance of the commercial coatings described in Table 5 was initially screened using laboratory tests. Laboratory test panels were prepared in accordance with the manufacturer's instructions. Application guidelines usually required a thin “wetting primer” coat to flow into the surface profile, a “stripe coat, “ and then two edge-retentive topcoats. The stripe coat is an extra layer of paint applied only over the edges of stiffeners or supports in tanks to minimize edge breakdown. Because the coatings are solvent free, they are typically applied in relatively thicker layers than current Navy solvent-bearing paints on a per-coat basis. For example, the Sherwin Williams Duraplate and the Sigmaguard BT topcoats were applied at 8-10 mils per edge-retentive topcoat, while the current, solvent-bearing MIL-P-24441 paint is applied at 3-5 mils per coat.

For any product tested or proposed to be tested there will be no approval granted if the following tables are not successfully completed;

- Table 4
- Table 2

Since the specification covering the products is a performance specification, many test values are manufacturer provided. The JTP is intended to verify the vendors "fingerprint" and further stress the coating through the tests in the JTR.

## 5. SUMMARY AND RECOMMENDATIONS

- The target HAZMAT is the VOC and hazardous air pollutants (HAPS) in the paint. These VOCs act as solvents to allow the paint to be applied.
- The project was conducted to verify that there exist coatings with little or no added solvents which will, when applied properly, provide corrosion protection in marine ballast tank service.
- The testing and subsequent ship application of the paints verified that such products exist.
- Benefits generally accrue to the vessel owner in that ballast tank maintenance painting can be avoided at least through four cycles of inspections (12 to 15years) versus previous life times of three to five years.

FY-99 program accomplishments include demonstration and approval of two ballast-tank coating systems, demonstration and implementation of plural component spray equipment, and development of coating application process control documents. FY-00 program plans include transitioning the solvent-free coating technology to other services for marine and shore-based tanks; qualifying new solvent-free coating systems for use in fuel and petroleum service; and tracking the performance of already approved coating systems to verify life-cycle cost savings.

## 6. REFERENCE DOCUMENTS

The documents listed in Table 6 were referenced in the descriptions of tests defined in this JTR. (not previously defined in the JTP). References used for defining the tests contained in the JTP are included in the JTP.

**Table 6. Reference Documents for JTR Test Descriptions**

| Reference Document | Title | Date | JTP Test | JTP Section | Applicable Section(s) of Reference Document |
|---|---|---|---|---|---|
| TT-N-95 | Naphtha; Aliphatic | Notice of Validation 11/05/91 | D 1296 | Table 5.0 | |
| TT-T-548 | Toluene, Technical | Notice of Cancellation 9/9/97 Replaced by A-A-59107 Toluene, Technical, 9/9/97 | D 1296 | Table 5.0 | |
| PPP-P-1892 | Paint, Varnish, Lacquer, and Related Materials; Packaging, Packing, and Marking of | Notice of Cancellation 11/21/97 No Replacement | | | |
| FED-STD-141 | Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing | Change No. 1 12/10/93 | Brushing Properties Test Method #4321.2<br><br>Spraying Properties Test Method # 4331.1 | 3.6<br><br>3.7 | |
| FED-STD-313 | Material Safety Data Sheets Preparation and the Submission of | Change No. 1 3/21/00 | | | |
| D 93 | Standard test Methods for Flash point by Pensky – Martens Closed Tester (DoD adopted) | D93-1999B 7/10/99 | Supercedes FTMS No. 141 # 4293 | Table 5.0 | |

**Table 6. Reference Documents for JTR Test Descriptions - Continued**

| Reference Document | Title | Date | JTP Test | JTP Section | Applicable Section(s) of Reference Document |
|---|---|---|---|---|---|
| D 522 | Standard Test Method for Elongation of Attached Organic Coatings with Conical Mandrel Apparatus (DoD adopted) | D 522A-1993 9/15/93 | Supercedes FTMS No. 141 # 6222 | Table 5.0 | |
| D 523 | Standard Test Method for Specular Gloss (DoD Adopted) | D 523-1983 (R99) 3/31/89 | | Table 5.0 | |
| D 562 | Standard Test Method for Consistency of Paints Using the Stormer Viscometer (DoD Adopted) | D 562-1981(R97)e1 10/30/81 | Supercedes FTMS No. 141 # 4281 | Table 5.0 | |
| D 846 | Standard Specification for ten-Degree Xylene (DoD Adopted) | D 846-84 03/30/84 | | | |
| D 1208 | Standard Test Methods for Common Properties of Certain Pigments (DoD Adopted) | D 1208-1996 10/26/84 | Supercedes FTMS No. 141 # 5261 | Table 5.0 | |
| D 1210 | Standard Test Method for Fineness of Dispersion of Pigment-Vehicle Systems (DoD Adopted) | D 1210-1996 9/19/96 | | Table 5.0 | |
| D 1296 | Standard Test Method for Odor of Volatile Solvents and Dilutents (DoD Adopted) | D 1296-1993 (R96) 06/22/90 | Supercedes FTMS No. 141 # 4401 | Table 5.0 | |
| D 1475 | Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products (DoD Adopted) | D 1475-1998 10/10/98 | Supercedes FTMS No. 141 # 4184 | Table 5.0 | |

**Table 6. Reference Documents for JTR Test Descriptions - Continued**

| Reference Document | Title | Date | JTP Test | JTP Section | Applicable Section(s) of Reference Document |
|---|---|---|---|---|---|
| D 1729 | Standard Practice for Visual Evaluation of Color Differences of opaque Materials (DoD Adopted) | D 1729-1996 2/12/90 | Supercedes FTMS No. 141 # 4249 | Table 5.0 | |
| D 2196 | Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield) Viscometer (DoD Adopted) | D 2196-1999 4/10/99 | | Table 5.0 | |
| D 2369 | Standard Test Method for Volatile Content of Coatings (DoD Adopted) | D 2369-1998 11/10/98 | Supercedes FTMS No. 141 # 4041 | Table 5.0 | |
| D 3359 | Standard Method for Measuring Adhesion by Tape Test (DoD Adopted) | D 3359-1997 11/10/97 | Adhesion | 3.4 | |
| D 3828 | Standard Test Methods for Flash Point by Small Scale Closed Tester (DoD Adopted) | D 3828-1998 11/10/98 | | Table 5.0 | |
| E 308 | Standard Method for Computing the Colors of Objects by Using the CIE System (DoD Adopted) | E 308-1999 6/10/99 | | Table 5.0 | |
| F 718 | Shipbuilders and Marine Paints and Coatings; Product/Procedure Data Sheet (DoD Adopted) | F | | | |
| | National Ambient Air Quality Standards (NAAQS) | | | | |