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**COATING GUIDANCE
FOR NAVAL FACILITIES**

by

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July 2000

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EXECUTIVE SUMMARY

This report is in response to requests received by the Naval Facilities Engineering Service Center's (NFESC) Center of Expertise for Paints and Coatings, and presents an overview of Naval Facilities Engineering Command (NAVFAC) coating guidance for Naval Facilities. Emphasis is placed on surface preparation, industrial and architectural coating specifications, maintenance painting, present coating work, and Navy coating needs. The publication is written for engineers, architects, specifiers, facility owners (private industry), corrosion and coating specialists, and maintenance personnel.

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TABLE OF CONTENTS

INTRODUCTION.....	1
SURFACE PREPARATION.....	1
NAVY COATING GUIDANCE.....	2
INDUSTRIAL SPECIFICATIONS.....	2
ARCHITECTURAL SPECIFICATIONS.....	4
COATING HANDBOOK.....	5
MAINTENANCE PAINTING.....	5
QUALITATIVE ASSESSMENT.....	5
QUANTITATIVE EVALUATION.....	5
COATING SELECTION.....	5
PRESENT COATING WORK.....	5
MOISTURE CURED URETHANES.....	5
ELASTOMERIC ACRYLICS.....	6
NAVY COATING NEEDS.....	6
CONCLUSIONS.....	6
REFERENCES AND ENDNOTES.....	7

LIST OF TABLES

Table 1: Surface Preparation Standards.....	1
Table 2: Recommended Surface Preparation.....	1
Table 3: Coating Guidance.....	2

INTRODUCTION

Located throughout the world, the Navy owns and paints a variety of structures exposed to diverse service conditions. For example: seawater immersion (sheet piles), seawater splash/spray (quaywalls), fresh water immersion (interior of water tanks), chemical immersion (interior of fuel tanks), abrasive/expansive soil (buried fuel pipes), occasional chemical exposure (maintenance shop floors), and atmospheric exposure (architectural structures, antenna towers, exterior storage tank surfaces, etc.).

This report is in response to requests received by the Naval Facilities Engineering Service Center's (NFESC) Center of Expertise for Paints and Coatings, and presents an overview of Naval Facilities Engineering Command (NAVFAC) coating guidance for Naval Facilities. Emphasis is placed on surface preparation, industrial and architectural coating specifications, maintenance painting, present coating work, and Navy coating needs. The publication is written for engineers, architects, specifiers, facility owners (private industry), corrosion and coating specialists, and maintenance personnel. The below NAVFAC Guide Specifications (NFGS) and Military Handbook (MIL-HDBK) are available from Reference [1].

SURFACE PREPARATION

The objective of surface preparation is to maximize coating adhesion and covers the removal of weak surface material, contamination removal, and substrate conditioning. Weak surface materials typically include corrosion products, mill scale, coating chalk, concrete laitance (weak surface cement), concrete efflorescence (white concrete surface salts), and unsound coatings. Surface contamination may consist of chloride salts, sulfate salts, protective surface treatments, biological growth (mildew, fungus), dirt, oils, fuels, and other contamination. Substrate conditioning can include combinations of hand tool cleaning, chemical cleaning, mechanical abrasion, water jetting, abrasive blasting, and chemical treatments.

Table 1 lists surface preparation standards used by Naval Facilities and offered by the Society for Protective Coatings (SSPC)[2] and the International Concrete Repair Institute (ICRI)[3]. Table 2 shows the recommended Navy surface preparation for substrates placed into a variety of service conditions.

TABLE 1: SURFACE PREPARATION STANDARDS

STANDARDS	DESCRIPTION
SSPC-SP 5	White Metal Blast Cleaning
SSPC-SP 10	Near White Metal Blast Cleaning
SSPC-SP 6	Commercial Blast Cleaning

SSPC-SP 7	Brush-Off Blast Cleaning
SSPC-SP 11	Power Tool Cleaning to Bare Metal
SSPC-SP 12	Water Jetting and Water Cleaning
ICRI-CSP 1	Acid Etched Concrete Texture
ICRI-CSP 2	Disk Ground Concrete Texture
ICRI-CSP 3	Light Shotblasted Concrete Texture

TABLE 2: RECOMMENDED SURFACE PREPARATION

SUBSTRATES AND SERVICE CONDITIONS	STANDARDS*
Steel	
Immersion	SSPC-SP 5, 10
Splash Zone	SSPC-SP 5, 10
Atmospheric	SSPC-SP 10, 6, 11
Tank Interior (fuel, water)	SSPC-SP 5
Tank Exterior	SSPC-SP 10
Architectural**	SSPC-SP 10, 6, 11
Galvanized Steel	
All zones	SSPC-SP 12*** and/or Phosphoric acid treatment
Aluminum	
Atmospheric	SSPC-SP 7, 12
Architectural**	SSPC-SP 7, 12
Concrete	
Floors, Decks	ICRI-CSP 3
Chemical Containment	ICRI-CSP 3
Atmospheric	ICRI-CSP 3, 2, 1
Architectural**	ICRI-CSP 3, 2, 1
Wood	
Atmospheric	Pressure washing and Sanding
Architectural**	Pressure washing and Sanding
Sound Coatings	
All zones	Pressure washing and either scuff sanding or SSPC-SP 7

*Standards are placed in order of preference. **Exterior exposure. ***Not for new galvanizing with a protective surface treatment.

Reference [4] provides a partial list of practices used to quantify chloride salt contamination. When chloride salts are not removed prior to coating, coating failures such as pinpoint rusting, blistering, and lifting may be experienced. For substrates exposed to atmospheric conditions, surface chloride contamination should be less than 5.0 $\mu\text{g}/\text{cm}^2$. For substrates immersed in seawater/fresh water, exposed to

water spray/water splash, and immersed in oils/fuels, surface chloride contamination should be less than 3.0 µg/cm².

NAVY COATING GUIDANCE

Navy coating guidance for use in coating industrial and architectural surfaces is presented in specific NAVFAC Guide Specifications (NFGS). The NFGS contains detailed guidance on: A) Structure and/or surface(s) to be coated, B) Material requirements, C) Surface preparation, D) Application procedures, E) Contractor qualifications, F) Inspector qualifications, and G) Field inspection. Table 3 lists the NFGSs for use in coating Naval Facilities. NFGS summaries are provided in the sections below entitled "Industrial Specifications" and "Architectural Specifications."

TABLE 3: COATING GUIDANCE*

PARTIAL TITLE	SPECIFICATION #
Exterior Structural Steel	NFGS-09971
Interior Steel Fuel Tank	NFGS-09970
Interior Steel Fuel Tank	NFGS-09973
Water Storage Tank	NFGS-13209
Interior Steel Water Tank	NFGS-09972
Submerged and/or Splash Zone Steel (fresh water, sea water)	NFGS-09967
Buried Steel Piping	NFGS-09974
Fuel Oil Piping	NFGS-15192
Tall Antenna Towers	NFGS-09910
Dry Shake Industrial Flooring	NFGS-09965
Thin Film Flooring System	NFGS-Draft
Epoxy Mortar Flooring System	NFGS-Draft
Paints and Coatings	NFGS-09900
Coatings for Foamed Roofs	NFGS-07572

*Specifications are available from Reference [1].

INDUSTRIAL SPECIFICATIONS

Industrial coatings are applied to the surfaces of structures requiring either protection from aggressive environments or extended performance. Aggressive environments include immersion service, the splash zone, marine service, chemical exposure, abrasion/impact service, and buried conditions. Industrial coating systems generally employ combinations of two-pack epoxies and urethanes. Summarized below are twelve NFGSs for use in coating industrial surfaces.

NFGS-09971 "Exterior Coating System for Welded Steel Petroleum Storage Tanks"

NFGS-09971 covers material requirements and installation procedures for a three-coat (four-coat Air Force) system used on exterior steel, petroleum storage tanks. The coating system consists of a zinc-rich epoxy primer (Mil-P-24441/19,

Formula 159, Type II), epoxy stripe coat (Mil-P-24441/29, Formula 150, Type IV, Green), epoxy intermediate coat (Mil-P-24441/31, Formula 152, Type IV, White, Tinted), and a topcoat of two-pack urethane (Mil-PRF-85285, Type II, White or Beige) over a near white metal blast (SSPC-SP 10)[5]. The specification is for use in either new construction or in the complete removal and reapplication of an existing system. With routine spot repair(s) of corroded surfaces and reapplication of topcoat every five to eight years, approximate service life is 20+ years. By December 2000, this specification will be converted to "Exterior Coating of Steel Structures" and will be applicable to all industrial steel structures, including fuel tanks, above ground pipelines, water tanks, and any structure with steel exposed to atmospheric conditions. The new specification will contain "one" three-coat system for use by both the Navy and Air Force.

NFGS-09970 "Interior Coatings for Welded Steel Tanks (For Petroleum Fuels)"

NFGS-09970 details material requirements and installation instructions for a three-coat system used on interior steel, petroleum storage tanks. The coating system consists of an epoxy primer (Mil-P-24441/29, Formula 150, Type IV, Green), epoxy intermediate coat (Mil-P-24441/31, Formula 152, Type IV, White, Tinted), and a Modified PTFE-Pigmented Fluoropolyurethane topcoat (White), developed by the Naval Research Laboratory, over a white metal blast (SSPC-SP 5). By utilizing the Fluoropolyurethane topcoat, performance generally exceeds that of three-coat epoxy systems (NFGS-09973). The specification is for use in either new construction or in the complete removal and reapplication of an existing system. Dehumidification is required to hold-the-blast (surface preparation) and to aid in curing during the first three days of cure. With routine spot repair(s) of corroded surfaces, approximate service life is 25+ years. NFGS-13111 "Cathodic Protection by Impressed Current" is typically used to protect the underside of tank bottoms.

NFGS-09973 "Interior Coating System for Welded Steel Petroleum Storage Tanks"

NFGS-09973, employed primarily by the Air Force, covers material requirements and installation procedures for a three-coat system used on interior steel, petroleum storage tanks. The coating system consists of an epoxy primer (Mil-P-24441, Formula 150, Green), epoxy intermediate coat (Mil-P-24441, Formula 151, Haze Gray), and an epoxy topcoat (Mil-P-24441, Formula 152, White) over a white metal blast (SSPC-SP 5). The specification is for use in either new construction or in the complete removal and reapplication of an existing system. By December 2000, this specification will be revised to parallel NFGS-09970 except for topcoat.

NFGS-13111 "Cathodic Protection by Impressed Current" is typically used to protect the underside of tank bottoms.

NFGS-13209 "Water Storage Tank"

NFGS-13209 details material requirements and placement procedures for "two" interior coating systems and "one" exterior coating system used on steel, water storage tanks. Three-coats of a National Sanitation Foundation (NSF) approved Standard 61 epoxy are used on interior potable water surfaces [6]; for use on all other non-potable water surfaces is the coating system specified in NFGS-09973. The exterior coating system consists of an epoxy primer (Mil-P-24441/1, Formula 150, Type I, Green), epoxy intermediate coat (Mil-P-24441/2, Formula 151, Type I, Haze Gray), and a topcoat of either two-pack urethane (Mil-PRF-85285) or one-pack acrylic (A-A-50570, Commercial Item Description). Interior coatings are applied over a white metal blast (SSPC-SP 5) whereas exterior coatings are applied over a near white metal blast (SSPC-SP 10). The specification is for use in either new construction or in the complete removal and reapplication of an existing system. By fall of 2000, NFGS-09971 "Exterior Coating of Steel Structures" will be used for exterior coating and NFGS-09972 "Interior Coating of Welded Steel Water Storage Tanks" will be used for interior coating. NFGS-13112 "Cathodic Protection System (Steel Water Tanks)" is generally used for tank protection below the waterline.

NFGS-09972 (DRAFT) "Interior Coating of Welded Steel Water Storage Tanks"

NFGS-09972 presents the material requirements and installation procedures for "two" coating systems used on the interior of steel, water storage tanks. Where National Sanitation Foundation (NSF) standards are required, three-coats of a NSF Standard 61 polyamide epoxy are used [6]; the coating system specified in NFGS-09973 is employed where either NSF standards do not apply or on non-potable water tank surfaces. Coatings are applied over a white metal blast (SSPC-SP 5) and dehumidification is required to hold-the-blast, and to aid in curing during the first three days of cure. The specification is for use in either new construction or in the complete removal and reapplication of an existing system. With routine spot repair(s) of corroded surfaces, approximate service life is 20+ years. NFGS-13112 "Cathodic Protection System (Steel Water Tanks)" is generally used for tank protection below the waterline.

NFGS-09967 "Coating of Steel Waterfront Structures"

NFGS-09967 provides material requirements and installation procedures for coating steel surfaces intended for service in sea water/fresh water immersion and sea water/fresh water splash zones. Two coating systems are available and consist

of either a two-coat coal tar epoxy system (SSPC-PS 11.01) or a three-coat epoxy polyamide system (SSPC-PS 13.01) over a near white metal blast (SSPC-SP 10). The specification is for use in shop-applied initial coating and is not for use in field application or maintenance painting. The specification does not identify the importance of chloride salt removal and on-site quality control. Approximate service life can be up to fifteen years. Either NFGS-13111 "Cathodic Protection by Impressed Current" or NFGS-L-13110 "Cathodic Protection by Galvanic Anodes" is generally used for coatings placed in immersion zones.

NFGS-09974 "Protection of Buried Steel Piping and Steel Bulkhead Tie Rods"

NFGS-09974 identifies materials for use in protecting steel piping and steel bulkheads, and presents partial installations procedures. Five materials are identified: A) Tape Coating System (TCS), B) Adhesive Thermoplastic Resin Coating System (ATRCS), C) Thermosetting Epoxy Coating System (TECS), D) Polyethylene-Butyl Adhesive Coating System (PBACS), and E) Mastics. For buried steel piping, either NFGS-13111 "Cathodic Protection by Impressed Current" or NFGS-L-13110 "Cathodic Protection by Galvanic Anodes" is generally used with one of the above materials.

NFGS-15192 "Fuel Oil Piping"

NFGS-15192 identifies coating materials for use on buried fuel piping, above ground fuel piping, exterior fuel tanks, and interior fuel tanks. For buried fuel piping, extruded polyethylene coating (L-C-530, Federal Specification) over a factory-applied adhesive is recommended (> 36 mils polyethylene for pipe sizes > 6 inches; > 23 mils polyethylene for pipe sizes < 6 inches). For both above ground fuel piping and fuel tank exterior surfaces (atmospheric exposure), a zinc-rich epoxy primer (SSPC-Paint 20, Type II) followed by two coats of Mil-P-24441 over a near white metal blast (SSPC-SP 10) is specified. Two coating systems are presented for use on the interior of fuel tanks over a near white metal blast (SSPC-SP 10): A) Three-coats of Mil-P-24441, and B) Two-coats of Mil-C-4556. Although interior fuel tank and exterior above ground coating systems are recommended, the preferred specifications for use in these service environments are NFGS-09970 "Interior Coatings for Welded Steel Tanks" and NFGS-09971 "Exterior Coating of Steel Structures," respectively.

NFGS-09910 "Maintenance, Repair, and Coating of Tall Antenna Towers"

NFGS-09910 covers material requirements and application procedures for use in coating tall antenna towers. If the antenna tower is steel, the coating system consists of a zinc-rich epoxy primer (Mil-DTL-24441/19B, Formula 159, Type II), epoxy stripe coat (Mil-DTL-24441/31A, Formula 152,

Type IV, White), epoxy intermediate coat (Mil-DTL-24441/31A, Formula 152, Type IV, White, Tinted), and a topcoat of two-pack urethane (Mil-PRF-85285, Type II) over a near white metal blast (SSPC-SP 10). Topcoat colors are required to be alternating stripes of international orange and white [7]. For galvanized and aluminum antenna towers, the above system is used but without a stripe coat and the zinc-rich epoxy primer. The specification can be used for new construction, maintenance painting, and in the complete removal and reapplication of an existing system. With routine spot repair(s) of corroded surfaces and reapplication of topcoat every five to eight years, approximate service life is 20+ years.

NFGS-09965 "Metallic Type Conductive/Spark Resistant Concrete Floor Finish"

NFGS-09965 covers the material requirements and installation placement of a cementitious (colored), spark resistant topping used in new concrete floor construction. The specification is primarily for warehouse, shop, and hangar floors, and is not for use in hospitals, laboratories, or other similar occupancies where sanitation is a primary consideration. The topping, referred to as "Dry Shake," is applied directly into the surface bleed water of the plastic concrete and cures to an attractive, hardening (10,000 psi compressive strength), abrasion resistant wearing surface.

NFGS-DRAFT "Thin Film Flooring System for Aircraft Hangars"

This specification presents the requirements and installation procedures for a three-coat, liquid flooring system with reflective/chemical resistant urethane topcoats, slip resistance, and joint work (polysulfide sealant). The specification is for use in coating the following concrete floors: A) New floors, B) Existing/uncoated floors, or C) Existing/previously coated floors with an unsound/failing coating system. The coating system consists of a two-pack epoxy primer followed by two coats of a two-pack urethane with non-skid grit (#60 white aluminum oxide) over a shotblasted surface (ICRI-CSP 3). At three or more year's service, coating system can be rejuvenated with additional urethane topcoats and nonskid grit. Prior to the installation of the thin film flooring system, a concrete condition assessment is highly recommended [8,9]. This specification will be available by December 2000.

NFGS-DRAFT "Epoxy Mortar Flooring System"

This specification presents the requirements and installation procedures for a five-coat, liquid flooring system (1/4" thickness) with reflective/chemical resistant urethane topcoats, slip resistance, and joint work (polysulfide sealant). The specification is for use in coating the following concrete floors: A) New floors, B) Existing/uncoated floors, or C)

Existing/previously coated/tiled floors with an unsound/failing coating system and/or tiles. The coating system consists of a two-pack epoxy primer, 1/4" sand-filled epoxy mortar intermediate coat, two-pack epoxy grout coat, and two coats of a two-pack urethane with non-skid grit (#60 white aluminum oxide) over a shotblasted surface (ICRI-CSP 3). When compared to the thin film flooring system, this system provides superior impact resistance, increased service, and enhanced aesthetics (creates a smooth surface when applied over coarse concrete). At three or more year's service, coating system can be rejuvenated with additional urethane topcoats and nonskid grit. Prior to the installation of the epoxy mortar flooring system, a concrete condition assessment is highly recommended [8,9]. This specification will be available by December 2000.

ARCHITECTURAL SPECIFICATIONS

Architectural coatings are applied to the interior/exterior of warehouses, buildings, houses, and other structures, primarily for aesthetics and moderate protection against the effects of weathering. Architectural coatings are generally required to display excellent resistance to biological growth (mold, mildew), good color stability, high resistance to dirt pickup, moderate corrosion resistance, sound adhesion, and exceptional cleanability. Summarized below are two NFGSs for use in coating architectural surfaces.

NFGS-09900 "Paints and Coatings"

NFGS-09900 presents coating guidance for exterior and interior architectural building surfaces. A combination of paints from seventeen Federal Specifications (FS), three Military Specifications (MIL), seventeen Commercial Item Descriptions (CID), and six SSPC consensus standards are identified for use in painting. Coatings include alkyds (oil-based), latexes (water-based), acrylics, two-pack epoxies, two-pack urethanes, stains, varnishes, and specialty coatings. Paints are specified as coating systems and are intended for use in coating metal, galvanized metal, cementitious substrates (plaster, concrete, stucco, etc.), and wood. Coating guidance is primarily designed for new construction: however, recommendations may be used in maintenance painting if a Coating Condition Survey (CCS) is performed. The above coatings, excluding Military Specifications, have been matched to either a Detailed Performance Specification (DPS) or an Intended Use Specification (IUS) established by the Master Painter's Institute [10]. By spring of 2000, MPI coating specifications will be integrated into this document and used by Naval Facilities.

NFGS-07572 "Coatings for Foamed Roofs"

NFGS-07572 defines material requirements and installation procedures for eight coatings used in protecting Polyurethane Foam (PUF) roofs. Coatings identified include silicone

(Type A), silicone (Type B; two-pack), aromatic urethane (Type CB; two-pack), aliphatic urethane (Type CT; two-pack), aromatic moisture-cured urethane (Type EB), aliphatic moisture-cured urethane (Type ET), hypalon (Type EH), and acrylic latex (Type D). Service life for Type D (acrylic latex) is approximately 10 years. Installation and material requirements for PUF roofing are covered in NFGS-07571 "Foamed Roofing."

COATING HANDBOOK

One Department of Defense (DOD) Military Handbook (MIL-HDBK) was developed to assist in the coating of Military Facilities. The handbook is available from Reference [1] and is summarized below.

MIL-HDBK-1110/1 "Handbook for Paints and Protective Coatings for Facilities"

MIL-HDBK-1110/1 is a comprehensive document and provides detailed information on coating composition, curing mechanisms, environmental and safety concerns, surface preparation, coating selection, coating application, inspection, and coating failure analysis. This two-hundred page handbook was written for general use by DOD personnel intending to apply either architectural paints or protective coatings to military structures fixed in place.

MAINTENANCE PAINTING

Maintenance painting is performed for corrosion protection, aesthetics, cost avoidance, and safety identification. Maintenance paint selection is determined by service conditions, existing coating system type, and Coating Condition Survey (CCS) results [11]. Key aspects of the CCS and coating selection are discussed below.

QUALITATIVE ASSESSMENT

The purpose of a qualitative coating assessment is to classify the coating system into one of three categories: 1) No coating work required (coating system is non-deterioration), 2) Minor Coating work required (coating system displays moderate deterioration), and 3) Coating requires complete removal (coating system displays significant deterioration) [12]. The qualitative coating assessment is primarily a quick visual survey and can include the following tasks.

- Assess overall condition (visual walk through)
- Identify defects [13,14]
- Identify Lead-containing coatings [15]
- Assess substrate condition below paint (identify rust, laittance, efflorescence, deterioration, etc.)
- Assess adhesion (tape test) [16]

QUANTITATIVE EVALUATION

The objective of a quantitative coating evaluation is to collect additional data for use in determining the feasibility, risk, and cost associated with maintenance painting. The quantitative coating evaluation can include the tests below.

- Identify coating system (field samples extracted and used for laboratory analysis) [17]
- Determine percentage of Lead, Chromium, and Cadmium in paint, if applicable (field samples extracted and used for laboratory analysis) [18]
- Determine percent area of defects, failures, and deterioration [19]
- Determine coating thickness [20]
- Determine coating adhesion [21]
- Determine chloride ion levels, if applicable (coating surface, substrate) [22]
- Evaluate substrate condition
- Determine risk in overcoating [23]

COATING SELECTION

Results from the Coating Condition Survey (CCS) require analysis prior to the process of coating selection. Important CCS results are: A) Coating system type (topcoat is of primary interest), B) Quantitative adhesion values (pull-off strength), C) Qualitative adhesion results (tape test), D) Coating system thickness, and E) Condition of substrate. If CCS results are favorable [24], then a maintenance paint is selected and further evaluated using a combination of manufacturer's literature, laboratory testing, field experience, and in-situ patch testing. When compared to the Existing Coating System (ECS), significant properties of the Maintenance Paint (MP) are as follows.

- MP is chemically compatible with ECS and substrate
- MP flexibility > ECS flexibility
- MP has sustainable flexibility (internally plasticized)
- MP Residual Cure Stress (stress transferred to ECS during the cure of MP) << ECS adhesion
- MP Hygrothermal Stress (MP stress transferred to ECS from changes in temperature and moisture) << ECS adhesion
- MP cohesive strength ≤ ECS adhesion

PRESENT COATING WORK

MOISTURE CURED URETHANES

A feasibility study into the use of Moisture Cured Urethane (MCU) coatings for tall antenna towers was performed [25]. A summary of laboratory results and survey findings are presented below.

- MCU coating systems are performing extremely well on coastal bridges located in Oregon
- Once substrate surface moisture is displaced, MCU coatings will produce a somewhat acceptable bond to either a damp or wet substrate
- MCU coatings form excellent bonds to both abrasively blasted steel and to MCU intercoats
- Aliphatic MCU topcoats, in general, exhibit a decrease in color retention and gloss when subjected to QUV Accelerated Weathering
- MCU application by either mitt or brush, even under controlled conditions, may produce unacceptable pinholes at a Dry Film Thickness (DFT) greater than 3.5 mils per coat
- Research from the Federal Highway Administration (FHA) concludes that MCU coatings should provide excellent barrier protection in corrosive environments: however, all MCU coatings do not perform equivalently and should be tested prior to field use
- A Relative Humidity (RH) below 30 % may produce unacceptable slow curing, whereas, a RH above 83 % may produce too fast of a cure with unacceptable carbon dioxide bubbling
- MCU coatings which employ the solvent xylene as either the principle or one of the solvent components may cause film bubbling when DFTs exceed 3.0 mils
- The use of MCU topcoats employing 100 % aliphatic resins will contain large numbers of urea links which, when compared to two-component aliphatic urethanes, give rise to lower UV resistance.
- Elastomeric Acrylics applied direct to steel resulted in significant flash rusting: however, the flash rusting neither affects adhesion nor bleeds into a topcoat when overcoated
- Elastomeric Acrylics exhibit acceptable performance when subjected to one-week immersion in tap water and one-month exposure in 95 % Relative Humidity
- Elastomeric Acrylics have displayed high performance when applied to Navy and Commercial roofs
- Elastomeric Acrylics may be suitable for use on a variety of exterior substrates located in diverse environments

Based on the above results, full-scale field demonstrations are scheduled for one galvanized antenna tower and the exterior of two previously coated steel fuel tanks.

NAVY COATING NEEDS

A partial list of current coating needs is presented as follows.

- Research into Residual Cure Stress (RCS) and Hygrothermal Stress (HS) on individual coatings and coating systems used in initial coating and maintenance painting
- Research into coatings for use in maintenance painting which exhibit low RCS, low HS, high barrier protection, excellent weatherability, moderate flexibility, and sound adhesion to existing coatings
- Develop guidance, including appropriate coating systems, for use in maintenance painting
- Develop a NFGS detailing a secondary containment coating system for areas surrounding bulk fuel storage tanks
- Develop a NFGS detailing a flexible, high build, coating system for the interior of corroded/pitted steel fuel tanks
- Evaluate software for use in predictive coating maintenance

The feasibility study concluded that MCU coatings were not appropriate for application by mitt on erected antenna towers (standard application procedure): however, MCU coatings are suitable for antenna towers when applied in a shop setting. Based on the above findings, a three-coat MCU coating system is scheduled for Navy demonstration on the exterior of a large water tank.

ELASTOMERIC ACRYLICS

A preliminary investigation into the exterior use of elastomeric acrylic coatings for Naval Facilities was conducted [26]. A summary of laboratory results and field performance findings are presented below.

- A water-based, Direct to Metal (DTM) acrylic primer followed by 20 mils dry of a water-based, Elastomeric Acrylic has provided excellent protection to steel for over 3.0 years in a coastal marine environment
- Elastomeric Acrylics developed sound adhesion to seventeen combined coated and uncoated substrates
- Elastomeric Acrylics generate low levels of Residual Cure Stress (RCS) and, when used in maintenance painting, should transfer negligible stress to existing coatings

CONCLUSIONS

In addition to Navy use, NAVFAC coating guidance and results from current Navy work may be adopted by private industry and, if properly utilized, will provide high performance.

REFERENCES AND ENDNOTES

1. www.ccb.org/
2. www.sspc.org/
3. www.icri.org/
4. The Society for Protective Coatings (SSPC). "SSPC-TU 4: Field Methods for Retrieval and Analysis of Soluble Salts on Substrates," 1998.
5. Military paint specifications are available at <http://astimage.daps.dla.mil/quicksearch/>
6. National Sanitation Foundation (NSF) International, Ann Arbor, Michigan.
7. Federal Aviation Administration (FAA), "FAA Advisory Circular Number 70/7460-1H: Obstruction Marking and Lighting," June 1991.
8. C. Dave Gaughen, "Sequential Approach to a Concrete Floor Condition Assessment: SP-2066-SHR," Naval Facilities Engineering Service Center (NFESC), March 2000.
9. C. Dave Gaughen, "Concrete Floor Condition Assessment: UG-2038-SHR," NFESC, November 1999.
10. www.paintinfo.com
11. SSPC. "Systems and Specifications: Steel Structures Painting Manual, Vol. II." SSPC, 1995 (pp. 431 – 443).
12. SSPC. "Systems and Specifications: Steel Structures Painting Manual, Vol. II." SSPC, 1995 (pp. 428).
13. NFESC, "Paint Failures – Causes and Remedies: TDS 82 - 08," June 1982.
14. Master Painter's Institute, "Maintenance Repainting: Identifiers, Defects and Failures," 1988.
15. HybriVet Systems Inc., "Lead Check Swabs," Natick MA or equal.
16. American Society for Testing and Materials (ASTM), "ASTM-D-3359," www.astm.org/
17. Fourier Transform Infrared Spectrophotometry (FTIR), "Perkin Elmer™ UV/VIS Spectrophotometer," or equal.
18. ASTM, "ASTM-D-3335, ASTM-D-3718."
19. ASTM, "ASTM-D-610, ASTM-D-660, ASTM-D-661, ASTM-D-714, ASTM-D-4214."
20. ASTM, "ASTM-D-1005, ASTM-D-1186, ASTM-D-1400, ASTM-D-4138."
21. ASTM, "ASTM-D-4541."
22. CHLOR*RID International Inc., "Chlor*Test™," www.chlor-rid.com/ or equal.
23. SSPC, "SSPC-TU 3: Overcoating," 1997.
24. C. Dave Gaughen, "Quantifying Sound Coating Adhesion: SP-2067-SHR," NFESC, March 2000.
25. C. Dave Gaughen and Theresa A. Hoffard, "Moisture Cured Urethane (MCU) Coatings for Use on Antenna Towers: A Feasibility Study (TM-2319-SHR)," NFESC, July 1999.
26. Joseph H. Brandon and C. Dave Gaughen, "Preliminary Investigation into the Exterior Use of Elastomeric Acrylic Coatings for Naval Facilities," NFESC, March 2000.