

**METRIC**

MIL-STD-2138A(SH)

**13 May 1992**

**SUPERSEDING**

DOD-STD-2138(SH)

23 November 1981

(See 6.8)

**MILITARY STANDARD**

**METAL SPRAYED COATINGS FOR CORROSION  
PROTECTION ABOARD NAVAL SHIPS (METRIC)**



AMSC N/A

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FOREWORD

1. This military standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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## 1. SCOPE

1.1 Scope. This standard covers the requirements for the use of metal sprayed coatings (aluminum) for corrosion control applications on board Naval ships. This standard covers certification of facilities, certification of operators, application procedures, metal-spray procedure, and production quality assurance (including test procedures and records).

1.2 Zinc coating material. The use of zinc material as a metal sprayed coating material has been eliminated because of excessive weight and the health and safety hazards.

1.3 Special restriction. Nuclear related applications and permanent installation of metal spray coating facilities for corrosion control on board ship require prior approval (see 6.6).

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

## SPECIFICATIONS

## FEDERAL

- BB-A-106 - Acetylene, Technical, Dissolved.
- BB-A-1034 - Compressed Air, Breathing.
- BB-O-925 - Oxygen, Technical, Gas and Liquid.
- TT-E-490 - Enamel, Silicone Alkyd Copolymer, Semigloss (for Exterior and Interior Non-Residential Use).
- TT-P-28 - Paint, Aluminum, Heat Resisting (1200 °F).

## MILITARY

- MIL-W-6712 - Wire; Metallizing.
- MIL-P-24441 - Paint, Epoxy-Polyamide General Specification for.
- MIL-M-80141 - Metallizing Outfits, Powder-Guns and Accessories.
- MIL-M-80226 - Metallizing System, Electric Arc.
- MIL-P-83348 - Powders, Plasma Spray.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, BLDG. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

#### PUBLICATIONS

DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH  
ADMINISTRATION (OSHA)  
Code of Federal Regulations (CFR)  
29 CFR 1910 - Occupational Safety and Health Standards.

(Application for copies should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)  
0655-AA-JPA-010 - Job Performance Aid for Wire Sprayed  
Aluminum Preservation.  
S9086-CH-STM-030/CH-074 - Gas Free Engineering, Volume 3.  
S9086-VD-STM-000/CH-631 - Preservation of Ship in Service (Surface  
Preparation and Painting).

(Application for copies should be addressed to the Standardization Documents Order Desk, BLDG. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)  
C 633 - Standard Test Method for Adhesion or Cohesive Strength of  
Flame-Sprayed Coatings.  
D 304 - Standard Specification for n-Butyl Alcohol (butanol)  
D 3734 - Specification for High Flash Aromatic Naphphas  
D 4417 - Test Methods for Field Measurement of Surface Profile of  
Blast Cleaned Steel.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN WELDING SOCIETY (AWS)  
A3.0 - Welding Terms and Definitions Including Terms for Brazing,  
Soldering, Thermal Spraying and Thermal Cutting.  
(DoD adopted)  
C2.1 - Recommended Safe Practices for Thermal Spraying.  
(DoD adopted)

(Application for copies should be addressed to the American Welding Society, Inc., 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

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STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SP 5 - Surface Preparation Specification No. 5, White Metal Blast Cleaning. (DoD adopted)

(Application for copies should be addressed to the Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, PA 15213.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Metal spraying terminology and definition standards. Terminology and definitions used in the preparation of drawings, spraying procedures, specifications, and correspondence related to thermal spraying shall be in accordance with AWS A3.0 except as specified herein.

3.2 Other definitions.

3.2.1 Acceptable. Acceptable items conform to the applicable standard or specification.

3.2.2 Approved (approval). Approved items under consideration have been sanctioned in writing by the Commander, NAVSEA or his authorized agent.

3.2.3 Authorized agent. An authorized agent is any Government representative specifically authorized to approve equipment, material, or procedures within the scope of this standard for NAVSEA. The authorized agent must have appropriate training and experience to implement and evaluate inspection functions of this standard. Agents are as follows:

- (a) For Government shipyards, the agent is the delegated representative of the Shipyard Commander.
- (b) For commercial shipyards, the agent is the delegated representative of the Supervisor of Shipbuilding, Conversion, and Repair.
- (c) Naval Ship Systems Engineering Station Philadelphia (NAVSSSES) is also authorized to provide field support for Naval activities.
- (d) For fleet units or activities, the delegated representative of the type Commander.

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3.2.4 Inspector. An inspector is an employee of a contractor, Naval shipyard, or Government agency designated to accept or reject materials or workmanship on the basis of the results of specified tests.

3.2.5 Certified. A certified facility or operator has been approved to the requirements of this standard.

3.2.6 Procedure. A metal spray procedure is an approved written instruction which contains all the applicable essential elements listed in this standard (see 6.6). Detailed procedures are supplied in referenced manuals.

3.2.7 Application procedure. Application procedures are the methods used to apply the metal sprayed coatings for corrosion control.

3.2.8 Blasting. Blasting is a method of cleaning and surface roughening by a forcibly projected stream of sharp angular abrasive.

3.2.9 Flame spraying. Flame spraying is a thermal spraying process wherein an oxygen-fuel gas flame is utilized as the source of heat for melting the coating material. Compressed air or gas may be used for atomizing and propelling the material to the work piece.

3.2.10 Electric arc spraying. Electric arc spraying is a metal spraying process using an electric arc as a heat source between two consumable wires. Compressed air or inert gas is used to atomize and propel the molten material to the substrate.

3.2.11 Powder metal flame spraying. Powder metal flame spraying is a method of metal spraying wherein the metal to be sprayed is in powder form.

3.2.12 Interface. An interface is the contact surface between the spray deposit and the substrate.

3.2.13 Masking. Masking is the procedure of protecting the areas adjacent to the areas to be thermal sprayed or blasted (to prevent coating adherence or surface roughening).

3.2.14 Seal coat. A seal coat is material applied to infiltrate and close the pores of a metal spray deposit.

3.2.15 Spalling. Spalling is the flaking or separation of a sprayed coating.

3.2.16 Substrate. The substrate is any material upon which a metal sprayed coating is deposited.

3.2.17 Metal spraying. Metal spraying denotes a group of processes wherein finely divided metallic or nonmetallic materials are deposited in a molten or semimolten condition to form a coating.

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3.2.18 Wire flame spraying. Wire flame spraying is a method of metal spraying where the metallic material to be sprayed is in wire form.

3.2.19 White metal surface. A white metal blast cleaned surface finish is a surface with a gray-white, uniform metallic color, slightly roughened to form an anchor-tooth pattern.

#### 4. GENERAL REQUIREMENTS

4.1 Safety precautions (personnel hazard). Personnel involved with metal spraying shall become familiar with and follow AWS C2.1, chapter 074 of NAVSEA S9086-CH-STM-030, and chapter 631 of NAVSEA S9086-VD-STM-000. Safety and health requirements shall be followed in accordance with OSHA 29 CFR 1910.

4.1.1 Metal spray gases. Chapter 074 of NAVSEA S9086-CH-STM-030 shall be used for guidance as well as the following guidelines:

- (a) Inspect all gas equipment regularly for leaks and loose connections.
- (b) Charged gas cylinders are potentially dangerous. Keep cylinders away from heat. Always secure them to keep them from toppling. Shut off gas, and place valve caps on the cylinders when they are not in use.
- (c) Do not hang a metal spray gun on a regulator or cylinder valve. Provide for portable equipment storage or permanent work station.
- (d) Provide adequate ventilation of the work area before opening any of the gas valves. No container shall be presumed to be clean or safe until proven and certified as safe by a gas free engineer.
- (e) Never point a gas hose, air hose, or other pressurized item at any part of the human body.

4.1.2 Blast cleaning. Safety precautions for abrasive blasting shall be in accordance with chapter 631 of NAVSEA S9086-VD-STM-000, as well as the following:

- (a) If fire or explosion hazards are present, precautions shall be taken before any blast cleaning is initiated. If the structure previously contained flammable materials, it shall be purged of dangerous concentrations. Prior to commencing work, the structure shall be certified safe by a gas free engineer.
- (b) While blasting, face shields with dust hoods or helmets with forced purified air shall be used to protect the eyes, face, chin, and neck from flying particles.
- (c) Safety glasses or goggles shall be worn by all persons near any blasting operation.
- (d) Blast hose shall be grounded to dissipate static charges.
- (e) Never point a blast nozzle at any part of the human body.

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4.1.3 Metal spray gun. Metal spray guns shall be used as follows:

- (a) Metal spray guns should be maintained in accordance with the manufacturer's recommendations.
- (b) Do not light the wire spray gun without having the wire in the nozzle. Without the metal in the gun, the flame can blow back through the front wire guide, damaging the nozzle, guide, drive rolls, and causing injury to the operator.
- (c) Do not use matches for lighting wire spray guns as hand burns may result; use a friction lighter, a pilot light, or arc ignition.

4.1.4 Reduction of respiratory hazards. Reduction of respiratory hazards shall be as follows:

- (a) For permanently installed shipboard (see 6.6) or shore facilities, use of a wet spray booth with a positive exhaust system is recommended for metal spraying in closed areas. To avoid the toxic or irritating effects of dust, fumes, and mists generated by metal spraying, work stations (installations on board tenders, carriers, and so forth) shall have adequate airflow and safe breathing apparatus (see 5.2.1) in accordance with chapter 631 of NAVSEA S9086-VD-STM-000 and AWS C2.1.
- (b) Breathing aluminum dust may damage the respiratory system. If signs of operator discomfort develop (dizziness or nausea) because of the dust, stop spraying at once and determine if the ventilating and exhaust systems are working properly before resuming the spraying operation.

4.1.5 Personal protection. Personal protection shall be as follows:

- (a) Never permit spray dust to enter the eyes, mouth, cuts, scratches, or open wounds. After spraying and especially before eating or handling food, wash hands thoroughly.
- (b) Finely divided metallic airborne particles can be hazardous from an explosive standpoint, and partially wet metal dust creates a hazard of spontaneous combustion. Positive exhaust systems with a wet dust collector shall be used. Ventilation shall be provided for airflow in all parts of the work space.

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4.1.6 Protective clothing. Protective clothing shall be worn, as follows:

- (a) Flame-resistant clothing and leather, or rubber gauntlets are highly recommended.
- (b) Clothing shall be strapped tightly around the wrists and ankles to keep dusts from harmful metal sprayed materials and abrasives away from the skin.
- (c) Local shipyard industrial practices shall be considered as adequate.

4.1.7 Reduction of noise hazard. Hearing protection devices shall be used, as follows:

- (a) Use hearing protectors or properly fitted soft rubber ear plugs.
- (b) Do not rely on wads of cotton for hearing protection (wads of cotton will not protect against high intensity noise).

4.1.8 Eye protection. Eye protection shall be as follows:

- (a) Helmets, face shields, or goggles shall be used to protect the eyes during all metal spraying or blasting operations. It may be necessary for metal sprayers or blasters to use goggles at all times for protection against radiation or flying particles from adjacent operations. Attendants or helpers shall be provided with proper eye protection.
- (b) While metal spraying, the helmet, face shield, or goggles shall be equipped with a filter plate to protect the eyes from excessive infrared radiation (as well as intense visible light). Shades 2 through 4 are proper shade numbers for wire flame spraying. Shades 3 through 6 are proper for powder.
- (c) While metal spraying in the open or at a lathe where ventilation is adequate to eliminate the need for additional respiratory protection, properly shaded goggles shall be worn. These should be of the eyecup type, fitted with lenses of about 50 millimeters (mm) (2 inches) in diameter, or the coverup type for those wearing corrective spectacles.
- (d) The goggles shall have indirect ventilating fins to eliminate the danger from flying particles and to reduce fogging.
- (e) While blasting, face shields or abrasive blasting helmets equipped with dust hoods shall be used to protect the eyes, face, chin, and neck from flying particles.

4.1.9 Compressed air. The following safety precautions shall be followed when using compressed air:

- (a) Never use compressed air to clean clothing. Similarly, oxygen and fuel gas shall not be used for this purpose.
- (b) Do not use compressed air for metal spraying or blasting operations at pressures other than those recommended by the equipment manufacturers.
- (c) Compressed air used for breathing shall meet the requirements of BB-A-1034.

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4.2 Equipment.

4.2.1 Abrasive blasting system.

4.2.1.1 Blasting equipment. The following types of blasting equipment may be used as specified (see 6.2), depending on the application:

- (a) Type I - Pressure blasting machines (blast generators).
- (b) Type II - Suction blast cabinets and portable units.
- (c) Type III - Centrifugal blast equipment.

4.2.1.1.1 Type I shall be used almost entirely for large area work where the blasting is done by hand. Type I shall also be used for production jobs. The nozzles may be set in any desired position. Open blast and recirculating chamber equipment are examples of type I systems.

4.2.1.1.2 Type II is less efficient than type I but may be used for small odd lot and production work that can be handled in cabinets or portable units.

4.2.1.1.3 Type III is highly efficient for blasting large volume production work. This system requires angular grit to obtain the anchor tooth pattern required for proper bonding. The grit is thrown out in a fan from a large rotating wheel. For this reason, the work must be brought in front of the wheel or wheels and rotated so as to blast all sides. Type III is only practical for a limited class of work. Additional information may be obtained from chapter 631 of NAVSEA S9086-VD-STM-000.

4.2.1.1.4 For abrasive blasting systems which reclaim grit or when reclaimed grit is to be used, a system shall be provided to classify the grit and remove excess particles (fines, contaminants, and so forth) (see 4.3.3.2). Before continual use of reclaimed grit, the equipment operator shall verify that the blasting grit anchor-tooth pattern on the blasted substrate meets the requirements of 4.4.3. If excessive time is required to obtain the proper anchor tooth, it is recommended the grit be changed out.

4.2.1.2 Air equipment. The air equipment used in the anchor-tooth pattern blasting process shall furnish air as specified in 4.2.1.2.1. The air supply shall maintain an air pressure at the blast pot of not less than 520 kilopascals (kPa) (75 pounds per square inch (lb/in<sup>2</sup>)) for angular chilled iron grit and an air pressure at the blast pot of not less than 350 kPa (50 lb/in<sup>2</sup>) for aluminum oxide grit.

4.2.1.2.1 A maximum allowed amount of 0.005 milligram (mg) of hydrocarbon contamination per liter of air shall be permitted. No separated water shall be permitted. Total water content shall be 2.0 mg per liter maximum (dew point: minus 10 degrees Celsius (°C) (14 degrees Fahrenheit (°F))).

4.2.2 Spraying system. The spraying system shall be as specified (see 6.2).

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4.2.2.1 Wire oxygen-fuel gas spray system. A wire-feed metal spray system shall consist of a source of compressed air, air drying unit, air receiver, gas control unit, oxygen, fuel gas, a reel to hold the feed wire, gauges and valves to control airflow, gas mixture, and flow, and the spray gun itself. A typical metal spray system is shown on figure 1. A typical metal spray gun is shown on figure 2.

4.2.2.2 Consumable electrode, electric arc spray system. An electric arc system shall consist of an electric arc gun, flow meter, compressed air, air cleaner, an air dryer such as a refrigerated air dryer for production work, direct current power supply unit, dual wire feeding mechanism, controls, and all necessary connecting cables and hoses. Equipment shall be in accordance with MIL-M-80226 (see 1.3).

4.2.2.3 Air equipment. The air equipment used in metal spraying shall furnish air at the gun nozzle at all times as specified in 4.2.1.2.1. The equipment shall supply air pressure to meet the operational requirements of the spray equipment.

4.2.2.4 Wire oxygen-fuel gas spray outfit. Each spray outfit shall consist of all components and accessories specified in table I.

TABLE I. Equipment and quantity.

Equipment	Quantity	
	Class 8	Class 10
Metallizing gun, complete with lubricants, carry case, tool set, and manuals	1	1
Air caps	2	4
Wire nozzles	2	4
Hose set, complete	1	1
Regulator, oxygen	1	1
Regulator, fuel gas	1	1
Flow meter, oxygen	1	1
Flow meter, fuel gas	1	1
Flow meter, air	1	1
Control unit	1	1
Wire reel and stand	1	1
Wire straightener	1	

4.2.2.5 Powder metal spray system. A powder metal spray system shall consist of powder spray gun, hoses, flow meters, fuel gas and oxygen regulators, and mechanical or aspirator feed for powder. Equipment shall meet the requirements of MIL-M-80141.

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### 4.3 Materials.

#### 4.3.1 Cleaning solvents. The following cleaning solvents may be used:

<u>Solvents</u>	<u>Specification</u>
Super High-Flash NAPTHA	ASTM D 3734, Type I
n-Butyl Alcohol	ASTM D 304

**WARNING:** Solvents are flammable and toxic. Use only in well ventilated spaces. Do not use near open flames, blasting, metal spraying work, or sources of sparks. Do not allow prolonged contact with bare skin. Read and follow precautions on container shipping labels before using contents.

4.3.2 Masking materials. Any masking material that provides adequate protection of the substrate without causing substrate corrosion or contamination may be used. Acceptable masking materials may be masking tape to protect exposed threads, gasket seats, and similar surfaces. Navy high pressure tape, metallic tape (heat reflecting), or silicon rubber tape shall be used for delicate or critical surfaces. Plastic cap-plugs or rubber stoppers may be used for small holes or openings. Hose sections may be used to cover threaded studs, stems, and protrusions. Inserts of wood, metal, or other form fitting filler may be used for masking irregular shapes such as holes, slots, keyways, or other types of recesses and for masking machined surfaces that cannot be protected with tapes or shields.

4.3.3 Abrasive blasting particles. Abrasive blasting particles used to provide the anchor tooth of 50 to 75 micrometers ( $\mu\text{m}$ ) (2 to 3 mils) during final surface preparation of the substrate shall be one of the following as specified (see 6.2):

<u>Type abrasive</u>	<u>Mesh size</u>	<u>Surface to be blasted</u>
Aluminum oxide grit	16-30	Steel or aluminum
Angular chilled iron grit	25-40	Steel

4.3.3.1 Requirements. Abrasive particles shall be clean, dry, sharp, and free of rust and excessive fines. Excessive fines are defined as greater than 25 percent fines (fall outside the specified mesh size).

4.3.3.2 Restrictions. Abrasive particles shall not contain any feldspar mineral constituents or any foreign materials that tend to breakdown and remain on the surface. Abrasive particles that have been used for cleaning heavily contaminated surfaces shall not be used for final surface preparation, even though the abrasive has been rescreened. Iron grit shall not be reused for anchor-tooth blasting. Angular chilled iron grit shall not be used for blasting of aluminum or other materials when contamination of the surface may result from the presence of iron residue. Use of iron grit on aluminum or other soft metals will result in iron bits becoming imbedded in the surface, causing corrosion under the coating

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and early failure. Iron grit shall be clean and reasonably sharp. Grit that is rusty, noticeably worn, or dull when compared with new grit under a magnification of 10X shall not be used.

4.3.4 Metal spray wire. Metal spray wire for use in corrosion control applications shall conform to MIL-W-6712. Wire surfaces shall be clean and free from scale, corrosion products, oil, or other material which will adversely affect the application, density, or adhesion of the coating. The wire shall be of uniform composition and quality, free of seams, cracks, nicks, or burrs. The wire shall uncoil readily and shall be free of bends, kinks, or slivers that would prevent its passage through the spray gun. The wire shall be stored and handled carefully to avoid bends or kinks that would prevent its passage through the spray gun.

4.3.5 Metal spray powder. Metal spray powder for use in corrosion control applications shall conform to MIL-P-83348. Metal spray powder shall be uniform in quality, condition, and color. It shall be dry, granular, free from dust and foreign material, thoroughly blended, nonagglomerated, and shall produce acceptable metal spray coatings.

4.3.6 Metal spray gases. The following gases shall be used in the metal spray process for corrosion-control applications:

<u>Gas</u>	<u>Specification</u>
Oxygen	BB-O-925
Acetylene	BB-A-106

4.3.7 Paints for sealing, barrier, and topcoat. Paints shall be as specified in 4.3.7.1 and 4.3.7.2 (see 6.2).

4.3.7.1 For temperatures above 80°C (175°F). Seal coat for components whose operating temperature is greater than 80°C (175°F) shall be heat resistant aluminum paint in accordance with TT-P-28 or equivalent seal coat approved (see 4.4.4.5.1, type I coating system).

4.3.7.2 For temperatures below 80°C (175°F). Seal coat for components whose operating temperature is less than 80°C (175°F) shall be diluted formula 150 of MIL-P-24441, followed by formula 150 or formula 156 and formula 151 of MIL-P-24441 (see 6.6 and 4.4.4.5.2, type II coating system).

4.3.8 Topcoats. Topcoats for metal sprayed components, if required, shall be as specified in the applicable contract, work order, specification, ship requirement, or Naval ships' technical manual (see 6.2).

#### 4.4 Metal spray process.

4.4.1 Surface cleaning. Areas to be metal sprayed and those adjacent thereto shall be free from grease, oil, paint, corrosion products, moisture or any other foreign material that may contaminate the surface and coating. If solvent cleaning is used, this shall be followed by washing (see 4.4.1.4).

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4.4.1.1 Solvent cleaning. Prior to any masking, blasting, or spraying, all surfaces that have come in contact with oil or grease shall be solvent cleaned. Where applicable, vapor degreasing is preferred; however, solvent washing may be used. Solvents shall not cause any detrimental attack of the substrate material and shall not leave any residue film on the substrate. Super high-flash NAPTHA (ASTM D 3734, Type I) or n-Butyl alcohol (ASTM D 304) are acceptable cleaners. Cleaning may be done by wiping, brushing, or spraying. Precautions shall be taken to protect any parts which may be attacked by the solvents.

WARNING: When using solvents:

- (a) Vapors are flammable. Keep away from heat, sparks, and open flame.
- (b) Use only with adequate ventilation. Avoid prolonged breathing of vapor. Eye irritation and dizziness are signs of inadequate ventilation and dangerous concentration.
- (c) Avoid prolonged or repeated contact with skin.

4.4.1.2 Abrasive cleaning. Preliminary abrasive blast cleaning may be used to remove heavy or insoluble deposits. An inexpensive, disposable abrasive is recommended. Dust and debris shall be removed by dry, compressed air "blow off" prior to solvent cleaning or washing.

4.4.1.3 Heat cleaning. Heat cleaning shall be used if solvent cleaning fails. If required, parts shall be heated in vented electric or gas ovens for sufficient time to remove grease or contamination remaining after degreasing cleaning process. Steel alloys shall be heated to not greater than 315°C (600°F). Aluminum alloys, except age hardened alloys shall be heated to not greater than 150°C (300°F). Caution shall be given to parts which may distort from original dimensional tolerances (for example, valve seats, and so forth).

4.4.1.4 Contaminated surfaces. Contaminated surfaces shall be cleaned with a trisodium phosphate solution, rinsed with clear, potable water, and dried after cleaning.

4.4.2 Masking. Masking shall be performed on all adjacent areas which may be affected by abrasive blasting or metal spraying. The mask shall be applied tight enough to prevent grit from seeping under the mask. When using tape, two layers shall be applied with the second layer at right angles to the first. Between abrasive blasting and metal spray processes, protective masking shall be inspected and replaced if damaged.

4.4.2.1 Special requirements. When machinery components do not require disassembly, all working and threaded surfaces shall be masked. For example, with assembled steam valves it is necessary to close the valve and apply a bead of room temperature vulcanizing (RTV) silicone rubber around the valve stem where it enters the gland strongback as indicated in NAVSEA 0655-AA-JPA-010. These procedures will prevent grit from coming into contact with threaded surfaces

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or getting inside the stuffing box. Unless otherwise noted on applicable drawings for specific surfaces, the following surfaces shall be properly masked or plugged to prevent their being damaged by abrasive blasting or sprayed metal coating:

- (a) Machined surfaces that are required to move with respect to each other, such as threads, bearing contacts, gear teeth, and slides.
- (b) Surfaces related to component alignment, proper seating, and mounting, such as flange faces, counterbores, and keyways.
- (c) Electrical assemblies, such as contacts, relays, and insulators.

4.4.3 Abrasive anchor-tooth blasting for surface preparation. Prior to metal spraying for corrosion control, the surfaces to be coated shall be prepared by abrasive blasting to provide an anchor-tooth for the metal spray.

4.4.3.1 Abrasive material. Aluminum oxide or angular chilled iron grit (see 4.3.3) shall be used to obtain the final surface preparation of the substrate (50 to 75  $\mu\text{m}$  or 2 to 3 mils). Prior to reuse, the aluminum oxide shall be screened (a grit classifier is suitable for screening grit), visually inspected for debris and oil contamination, and shall pass the following oil contamination test procedures:

- (a) Fill a clean 120 to 180 mm (4 to 6 ounce) vial or bottle half full of screened abrasive particles.
- (b) Fill the remainder of the vial or bottle with clean water.
- (c) Cap and shake vial or bottle.
- (d) Inspect water for oil sheen.

If any oil is observed, the abrasive particles shall not be used in the final anchor-tooth blasting process. After the test, clean the blasting equipment, replace blasting material, and retest.

4.4.3.1.1 For recycling grit blasting systems, the oil contamination test shall be conducted at the beginning of each shift.

4.4.3.2 Surface. The abrasive blasted surface shall be white metal in accordance with SSPC SP 5 (see 3.2.19). The anchor-tooth pattern shall have a surface profile of 50 to 75  $\mu\text{m}$  (2 to 3 mils) measured in accordance with ASTM D 4417, methods B or C. The surface, when viewed using a magnification of 10X, shall be free of oil, grease, dirt, visible mill scale, rust, corrosion products, oxides, paint, or other foreign matter. The color of the clean surface may be affected by the abrasive medium used. Photographic or other visual standards shall be used to further define the surface condition. Blasting shall not be so severe as to distort the component being prepared for metal spray.

4.4.3.3 Surface handling. Abrasive blasted surfaces shall not be allowed to come into contact with contaminated surfaces prior to completion of metal spray and sealing processes. Prepared surfaces shall be handled only with clean gloves, rags, slings, and so forth. Contact with any oil or grease such as touching with the hand will result in failure of the coating.

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4.4.4 Metal spraying.

4.4.4.1 Blast-spray restrictions. Metal spraying operations shall not proceed if there is visible moisture present on the substrate surface. Visible evidence of rust bloom or oxidation on the white metal prepared surface shall be removed by a brushoff blast. If the metal surface temperature is not greater than 5°C (10°F) above the dew point, no metal spraying shall be conducted. The substrate surface shall meet the requirements of SSPC SP 5 immediately prior to metal coating. The metal spray operation shall be started within 4 hours after anchor-tooth surface preparation for steel has been completed and shall be finished within 6 hours after anchor-tooth surface preparation. The metal spray operation on aluminum shall be started within 2 hours after anchor-tooth surface preparation has been completed and shall be finished within 4 hours after anchor-tooth surface preparation. If more than 15 minutes is expected to elapse between the surface preparation and the start of the metal spray process, or if the part must be moved to another location, the prepared surface shall be protected from moisture, contamination, and finger-marks. Wrapping with clean paper (free of newsprint) will normally provide adequate protection. When specified in the contract or other guidance documents for periods longer than 4 hours, a flash coat of metal spray (at least 25  $\mu\text{m}$  (1 mil)) shall be used to protect the surface until final metal spray can be applied. If contamination or deterioration of the surface occurs, the surface shall be reblasted as specified in 4.4.3. Under no circumstance shall the flash coated surface be allowed to stand for more than 4 hours without application of the final thickness of metal spray coating. Contamination of the substrate or flash coat shall require reblasting of the surface.

4.4.4.2 Air quality. The supplied air for blasting and thermal spraying shall meet the requirements of 4.2.1.2. Contracting and repair facilities shall ensure the specified levels of air purity through laboratory evaluations. The test method specified in BB-A-1034 for separated water shall be conducted prior to each shift.

4.4.4.3 Metal coating application. To remove invisible moisture, the local substrate surface shall receive a local preheat to approximately, but not greater than, 106.8°C (250°F) prior to applying metal coating. Surface preheating can be accomplished using the metal spray gun as a torch. The surface temperature shall be verified using a contact pyrometer. The metal coating shall be applied in multiple layers, and in no case shall fewer than two crossing passes at right angles be made over every part of the surface. The sprayed metal shall overlap on each pass of the gun to ensure uniform coverage. A type I coating system application for high temperature components (see category I of 4.4.5) shall consist of 250 to 375  $\mu\text{m}$  (10 to 15 mils) of metal sprayed aluminum plus the appropriate seal coat (see 4.3.7.1). A type II coating system application for topside equipment and interior wet spaces (see 4.4.5) shall consist of 175 to 250  $\mu\text{m}$  (7 to 10 mils) of metal sprayed aluminum plus the appropriate seal coat (see 4.3.7.2). When powder coating topcoat is specified, metal spray coating thickness shall be reduced to 75 to 100  $\mu\text{m}$  (3 to 4 mils).

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4.4.4.3.1 The spray gun shall be held 125 to 200 mm (5 to 8 inches) from the surface being sprayed (see gun manufacturer's recommendations for optimum spray distance). The angle of spray stream to the surface being coated shall be as close to 90 degrees as possible, and never less than 45 degrees. Gun accessories are available to maintain proper spray angles. When spraying complex geometric shapes, the operator shall plan for (by masking) and accomplish spraying to minimize overspray onto areas of the component where no coating is desired. Cooling during the coating operation may be accomplished by blasting clean dry air, carbon dioxide, or other suitable gas near, but not directly on the area being sprayed. The metal spray operation shall be interrupted only to measure thickness or temperature, or to permit cooling to prevent overheating. The following warning shall be observed:

WARNING: When spray metalizing:

- (a) Breathing aluminum dust may damage the respiratory system. If signs of operator discomfort develop (dizziness or nausea) because of the dust, stop spraying at once and determine if the ventilating and exhaust systems are working properly.
- (b) Never permit spray dust to enter the eyes, mouth, cuts, scratches, or open wounds. After spraying and before eating or handling food, wash hands thoroughly.
- (c) Finely divided metallic airborne particles can be hazardous from an explosive standpoint, and partially wet metal dust creates a hazard of spontaneous combustion. The greatest care shall be taken in handling them.

4.4.4.4 Cooling process. Under normal conditions, the completed work should be allowed to cool to room temperature at a normal rate prior to sealer application. If required, accelerated cooling may be accomplished with a blast of clean dry air, carbon dioxide, or other suitable gas. In any case, the air or gas shall be maneuvered to obtain a uniform cooling rate over the entire metal-sprayed area. The component shall not be quenched with liquid to accelerate cooling.

4.4.4.5 Seal coat application. Seal coats used shall be dependent on normal operating temperature of the component to be metal sprayed (see 4.3.7). Application of seal coats (see 4.4.4.5.1 and 4.4.4.5.2) shall be completed within 24 hours of metal spray operation. Seal coats shall only be applied to clean, dry metal sprayed surfaces. Presence of moisture in the metal sprayed coating pores will lead to premature coating failure. If presence of moisture is suspected, the metal-sprayed coating shall be heated to 106.8°C (250°F) to remove the moisture prior to seal coat application.

4.4.4.5.1 High temperature sealer application. Seal coat for high temperature applications (type I) (see 4.3.7.1) shall be heat resistant aluminum paint in accordance with TT-P-28 or equivalent seal coat (see 6.6). Heat resistant aluminum paint shall be applied in two separate coats of 38  $\mu$ m (1.5 mils) dry film thickness (DFT) per coat as shown on figure 3.

4.4.4.5.2 Low temperature sealer application. The seal coat for low temperature (see 4.3.7.2) applications (type II) shall be as follows:

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- (a) A seal coat of MIL-P-24441, formula 150, type I thinned after the required period of induction with an equal volume amount of super high-flash NAPTHA (boiling range 157 to 179°C (315 to 353°F)). In states and local areas where emission of solvents is controlled, the volatile organic content (VOC) of the seal coat shall not exceed local VOC limits.
- (b) One coat formula 150 or 156 of MIL-P-24441, 50 to 75  $\mu\text{m}$  (2 to 3 mils) DFT and one coat of formula 151 of MIL-P-24441, 50 to 75  $\mu\text{m}$  (2 to 3 mils) DFT. The full coat of formula 150 or 156 of MIL-P-24441, 50 to 75  $\mu\text{m}$  (2 to 3 mils) DFT shall be applied over sealer (see (a)) within 6 hours of drying of sealer. This can be a stopping point until the intermediate and topcoating can be applied. No more than 3 days shall elapse before the entire coating system must be applied.

Type II system application is shown on figure 4.

4.4.4.5.3 Polyester powder coating. The seal coat and topcoats specified in 4.4.4.5.2 can be replaced with Navy approved polyester powder at thickness of 150 to 200  $\mu\text{m}$  (6 to 8 mils) coating when the metal spray coating is reduced in thickness to 3 to 4 mils as specified in 4.4.4.3.

4.4.4.6 Topcoats. Topcoats shall be applied in accordance with ship's painting requirements over one tacky coat of formula 151 of MIL-P-24441, 50 to 75  $\mu\text{m}$  (2 to 3 mils) DFT.

4.4.5 Examples of approved applications of metal spray coatings for corrosion control. The following is a list of examples of approved applications of metal sprayed coatings for corrosion control on Navy ships. This list is for illustrative purposes and does not limit all applications of metal sprayed coating systems in areas other than those listed. Authorization by the contracting activity or type commander will be required:

- (a) Category I - Machinery space components. Aluminum coating 250 to 375  $\mu\text{m}$  (10 to 15 mils) thick may be applied to the following:
  - (1) Low pressure air piping.
  - (2) Steam valves, piping, and traps (except steam turbine control valves).
  - (3) Auxiliary exhaust (stacks, mufflers, manifold, and so forth).
  - (4) Air ejection valves.
  - (5) Diesel header and exhaust piping.
- (b) Category II - Topside weather equipment. Aluminum coating 175 to 250  $\mu\text{m}$  (7 to 10 mils) thick may be applied to the following:
  - (1) Helo tie downs.
  - (2) Coamings and bulwark.
  - (3) Steel stanchions.
  - (4) Scupper brackets.
  - (5) Deck machinery foundations.
  - (6) Chocks, bitts, rollers, and cleats.

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- (7) Steel pipe hangers and brackets.
- (8) Capstans and gypsy heads (except wear area).
- (9) Rigging fittings (block).
- (10) Fire station hardware.
- (11) Lighting fixtures and brackets.
- (12) Vent plenum.
- (13) Hatches, doors, and scuttles.
- (14) Fueling stations.

- (c) Category III - Interior wet spaces. Aluminum coating 175 to 250  $\mu\text{m}$  (7 to 10 mils) thick may be applied to the following:

- (1) Decks in washrooms and water closets.
- (2) Pump room deck and equipment support foundations.
- (3) Fan room decks and equipment support foundations.
- (4) Water heater room decks and equipment support foundations.
- (5) Air conditioning room decks and equipment support foundations.
- (6) Deck plate supports.
- (7) Machinery foundations.
- (8) Boiler air casings (skirts).
- (9) Turnstile.
- (10) Bilges and applicable wet spaces.
- (11) Well deck overheads.

4.4.6 Prohibited applications of metal spray coatings for corrosion control. Metal sprayed coatings for use in corrosion control applications are intended for selected application to steel and aluminum surfaces. Metal spray coatings for corrosion control applications shall not be used for the following:

- (a) Plastic, rubber, and painted surfaces.
- (b) Internal surfaces of components (pump casings, valves, and so forth).
- (c) Copper, brass, bronze, copper-nickel, or monel surfaces.
- (d) Stainless steels, 17-4 PH, 15-4 PH
- (e) Surfaces subject to strong acids or bases (aircraft catapult slides).
- (f) Threads of fasteners (except for body nuts and exposed portions of body studs of valves).
- (g) Valve stems.
- (h) Within 20 mm (3/4 inch) of surfaces to be welded.
- (i) Steel alloys with yield strength greater than 827.4 megapascals (MPa) (120,000 lb/in<sup>2</sup>).
- (j) Nonskid slip resistant deck coatings (except jet blast deflectors, see 6.6).
- (k) Internal portions of machinery lubricating and hydraulic systems.
- (l) Helo deck corrosion control coating.
- (m) Exterior underwater hull surfaces.
- (n) Sanitary tanks interior.

4.4.7 Maintenance and repair of metal sprayed coating systems. Any damage to the metal sprayed coating system which exposes the metal coating or exposes the substrate shall be repaired as specified in 4.4.7.1 through 4.4.7.3.

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4.4.7.1 Damage exposing the metal sprayed coating but not exposing the substrate.

4.4.7.1.1 Surface preparation, small areas. Surface preparation of small areas (less than 645 square centimeters (cm<sup>2</sup>) (100 square inches (in<sup>2</sup>)) shall be as follows:

- (a) Solvent clean as required (see 4.4.1.1).
- (b) Use 25-mm (1-inch) flexible-blade paint scraper and remove loose paint around worn or damaged area to the boundary or well bonded paint. Take care not to gouge or further damage the metal sprayed coatings.
- (c) Use a stiff handheld nonferrous bristle brush and vigorously brush away loose debris. (Do not use power tools as they will polish smooth the metal sprayed coating and may wear through the metal sprayed coating to the substrate.)
- (d) Feather a 50- to 75-mm (2- to 3-inch) collar into the undamaged area.
- (e) Lightly abrade the feathered paint area around the exposed metal sprayed coating with sand paper to provide a mechanical bonding surface for the paint primer and sealer.

4.4.7.1.2 Surface preparation, large areas. Surface preparation of large areas (greater than 645 cm<sup>2</sup> (100 in<sup>2</sup>)) shall be as follows:

- (a) Solvent clean as required (see 4.4.1.1).
- (b) Abrasive brush blast away loose paint using aluminum-oxide grit over the exposed metal spray coated area. (Use low blasting pressures sufficient to minimize abrasion and removal of metal sprayed coating, but great enough for reasonable paint removal and development of sufficient anchor-tooth pattern for sealers and topcoat paints.)
- (c) Feather a 50- to 75-mm (2- to 3-inch) collar into the well bonded paint area.
- (d) Minimize cosmetic difference between new and old paint by brush blasting or using sandpaper and repainting an area bordered by a weld bead or a structural item.

4.4.7.2 Damage exposing the metal substrate.

4.4.7.2.1 Surface preparation requiring paint touchup. Surface preparation for paint touchup shall be as follows. This procedure can be accomplished by ship's force.

- (a) Solvent clean as required (see 4.4.1.1).
- (b) Using a paint scraper, push the blade underneath the metal sprayed coating to lift off all loosely bonded metal sprayed coating until reaching a well bonded area.
- (c) Use portable disc sander with 80-mesh sandpaper and clean steel substrate to clean metal feathering 50 to 75 mm (2 to 3 inches) into the undamaged coated area.

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4.4.7.2.2 Surface preparation for metal sprayed coating system touchup.

Metal sprayed coating system touchup shall be accomplished by a certified maintenance activity as follows:

- (a) Solvent clean as required (see 4.4.1.1).
- (b) Abrasive blast area to be repaired with 16-30-mesh aluminum oxide or chilled iron grit, 24-40 to white metal in accordance with SSPC SP 5 to give a 50 to 75  $\mu\text{m}$  (2 to 3 mil) anchor-tooth.
- (c) Feather 50 to 75 mm (2 to 3 inches) into the good coating area.
- (d) Apply metal sprayed coating as specified in 4.4.4.3.

4.4.7.3 Sealing and topcoating damaged areas. When damage has exposed the metal sprayed coating or the metal sprayed coating has been replaced, sealing and topcoating shall be accomplished as specified in 4.4.4.5. When metal sprayed coating facilities are not available, replacement of paint coating by ships force shall be accomplished as follows:

- (a) Solvent clean the surface (see 4.4.1.1).
- (b) Apply 75  $\mu\text{m}$  (3 mil) DFT formula 150 in accordance with MIL-P-24441.
- (c) Apply 75  $\mu\text{m}$  (3 mil) DFT formula 151 in accordance with MIL-P-24441.
- (d) Apply top coat as required for area in accordance with TT-E-490.

## 5. DETAILED REQUIREMENTS

5.1 Certification. Prior to the utilization of the spraying procedure of this standard, Naval facilities and contractors shall obtain certification of facilities and spray operators from the NAVSEA authorized agent (see 6.3). Information submitted shall not relieve the facility or contractor of responsibility for conformance to all requirements of this standard. Contractors shall be responsible for similar qualification of all subcontractors. Certification may be terminated in the event NAVSEA or the authorized agency has evidence that all the requirements (facility, operator, and product quality assurance) of this standard are not being met. The applicable work covered by this standard may be suspended upon written notification by the authorized agency or his representative, until it has been demonstrated that such deficiencies have been corrected.

5.2 Facilities. Facilities, whether Government or privately owned, shall meet the requirements of this standard, covering working areas, abrasive blasting equipment, and metal spraying equipment (see 6.3). Fixed certified facilities that relocate their equipment to a new plant location shall be recertified in the new location. Portable facilities shall contain all equipment necessary for certification at the job site. Portable facilities may require recertification at each job site if so stated in the contract. Recertification will not be required except as described in 5.1.

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5.2.1 Working areas. Work carried out on board ship shall be conducted in accordance with chapter 631 of NAVSEA S9086-VD-STM-000 and this standard where applicable. The following minimum requirements shall be met for shore side facility working areas:

- (a) Abrasive blasting areas. If abrasive blasting is carried out in an enclosed area other than a designated blasting booth, the air in the enclosed area shall change at least once per minute. Additional safe breathing apparatus (operator's hood) shall be used.
- (b) Metal spraying areas.
  - (1) Spray booths. The wet spray booth shall be constructed with surfaces angled to deflect the metal spray blast inward and not blow dust out of the booth. The booth shall be equipped with an exhauster that will maintain airflow of at least 61 cubic meters per minute ( $\text{m}^3/\text{min}$ ) per square meter (200 cubic feet per minute ( $\text{ft}^3/\text{min}$ ) per square foot) of booth opening into the booth entrance and a wet collector.
  - (2) Shop enclosed areas. Enclosed areas shall be equipped with a waterwash dust collector with a capacity in  $\text{m}^3/\text{min}$  ( $\text{ft}^3/\text{min}$ ) at least three times the volume of the enclosed space. Air inlets to the areas shall be located near the ceiling on the side opposite the working area (bench). The air exhaust shall be located at or near the floor along the entire side of the room adjacent to the working area. The duct work shall be large enough to permit air velocities greater than 610 meters (2,000 feet) per minute. An air respirator mask shall be provided in the room. Eye and ear protection shall be provided as well.
  - (3) Field enclosed areas. Metal spraying in an enclosed space aboard ship shall only be conducted if adequate ventilation of the space is maintained. Additional safe breathing apparatus and eye and ear protection shall be provided to equipment operators as required.
  - (4) Open areas. Metal spraying in open areas shall be carried out only when eye and ear protection and an air respirator are being used.

5.2.2 Abrasive blasting equipment. The following list of equipment is the minimum required for performing abrasive blasting operations. Equipment shall be in satisfactory working order.

- (a) Blaster utilizing air free of oil and moisture (see 4.2.1.2).
- (b) Blasting table or cabinet.
- (c) Oil and moisture separator.
- (d) Air pressure regulators with pressure gauges.
- (e) Air volume indicator.
- (f) Blast nozzle equipped with a deadman valve.

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- (g) Abrasive (see 4.3.3).
- (h) Sample metal coupons.
- (i) Surface profile measurement equipment in accordance with ASTM D 4417.
- (j) Caliper or dial micrometer.

5.2.2.1 Special clothing. The following clothing is recommended when blasting operations are performed in an enclosed space:

- (a) Helmet with forced air supply.
- (b) Protective jacket.
- (c) Protective trousers.
- (d) Safety shoes.
- (e) Rubber gloves.
- (f) Protective shoe covers (for blasting horizontal or deck surfaces).

5.2.3 Metal spray equipment. The list of equipment for metal spray operations shall be as specified in 4.2.2 for the applicable spraying system. Equipment shall be in satisfactory working order.

5.2.3.1 Protective equipment. The following protective equipment shall be worn for metal spray operations:

- (a) Air respirator, if a water wash spray booth is not used.
- (b) Noise protection (ear muffs or plugs).
- (c) Eye protection (see 4.1.9).

5.2.3.2 Additional equipment. The following equipment is not required for certification, but is necessary to satisfactorily complete the thermal spray process:

- (a) Masking materials.
- (b) Surface pyrometer.
- (c) Magnetic thickness gauge.
- (d) Eddy current gauge.
- (e) Handling equipment.

5.3 Procedural process certification. Certification of the application procedure shall be given those facilities demonstrating the ability to successfully carry out the proposed procedure. The requirements set forth herein shall be met prior to obtaining certification.

5.3.1 Process procedures. Contractors and Naval activities shall have written process application procedures and perform tests, as required, to qualify these procedures (see 6.3). The written procedures shall include a description of the proposed application procedure and a listing of the processes (such as blasting, metal spraying, inspection, and sealing) performed. Record forms shall provide evidence of the performance of quality assurance examinations.

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5.3.2 Process procedure approval. Prior to the utilization of a metal spraying procedure, the contractor shall demonstrate the procedure together with the supporting test qualification data (see 6.6). Information provided shall not relieve the contractor of responsibility for conformance to other requirements of this standard. Contractors shall be responsible for similar certification of all subcontractors.

5.3.3 Certification test requirements. Operator procedure certification shall consist of a visual examination, bend test, bond test, and shape test of metal sprayed specimens prepared by an operator using the proposed procedure of 5.3. Specimens for the testing shall be prepared as specified in 5.6.1 and the written process application procedures. For the visual examination and bend test, four specimens shall be tested as specified in 5.6.2 and 5.6.3. Results of the test shall conform to 5.3.3.1 and 5.3.3.2. For the bond test, five specimens shall be prepared and tested in accordance with ASTM C 633 and shall meet the requirements of 5.3.3.3. The shape test specimens shall be prepared and tested as specified in 5.3.3.4 and 5.6.5.

5.3.3.1 Visual examination requirements. The metal sprayed coating prior to sealing shall have a uniform appearance. Surface defects of the metallized coating shall be limited to small nodules not greater than 1.1 mm (0.045 inch) in diameter and shall be not greater than 0.6 mm (0.025 inch) in height above the surrounding sprayed surface. The coating shall not contain any of the following:

- (a) Blisters.
- (b) Cracks.
- (c) Chips or loosely-adhering particles.
- (d) Oil or other internal contaminants.
- (e) Pits exposing the undercoat or substrate.

5.3.3.2 Bend test. No disbonding, delamination, or gross cracking of the coating shall occur due to bending. Small hairline cracks or alligating of the coating in the vicinity of the bend are permissible. Figure 5 illustrates acceptable and nonacceptable bend test results.

5.3.3.3 Bond test. The bond strength of the metallized coating on the individual test specimens shall be 10.3 MPa (1500 lb/in<sup>2</sup>) or greater. The average bond strength of the metallized coating on the tested specimens shall be 13.8 MPa (2000 lb/in<sup>2</sup>) or greater.

5.3.3.4 Shape test. The thickness of the metallized coating shall meet the requirements of this standard for the metal spray process and shall be 0.25 to 0.40 mm (0.010 to 0.015 inch). This test is for initial operator certification.

5.4 Certification of metal spray operators. This section provides the requirements for certification of metal spray operators. Each operator shall be certified by demonstrating, as specified herein, the ability to apply the specified coating system using the applicable spray process, and the correct and safe usage of the equipment.

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5.4.1 Responsibility. Prior to use of this standard by the applicable contract documents, each activity, contractor or subcontractor, shall establish that each metal spray operator to be employed in the use of metal spray for corrosion control applications conforming to this standard has been certified by demonstrating the ability to produce satisfactorily as specified in 5.3.3.

5.4.2 Operator certification.

5.4.2.1 Certification tests. The operator shall prepare specimens as specified in 5.6.1, which in turn, shall meet the test requirements specified in 5.3.3.

5.4.2.2 Limits of certification. Operators meeting the requirements for the certification tests shall be deemed certified operators with the coating system and spray process used in the application procedure testing.

5.4.2.3 Retest of operators. An operator failing the initial certification tests may be permitted to perform one retest for each type of test failed. If the operator fails the retest, the operator shall not be certified until completion of training or retraining and subsequent completion of certification retesting.

5.4.3 Maintenance of operator certification.

5.4.3.1 Term of certification. Operator certification shall be retained for a period of 6 months following production use of the applicable metal spray process. Production use shall be defined as performing metal spraying operations at least 8 hours in a consecutive 6-month period.

5.4.3.2 Recertification. Operators whose certification has lapsed may be recertified by satisfactorily completing the certification tests as follows.

5.4.3.2.1 Certification time lapse greater than 6 months. Certification tests of 5.3.3 shall be required if the operator has not performed metal spray processes for a period of 6 months as defined in 5.4.3.1.

5.4.3.2.2 Special. Recertification testing may also be required at any time an operator's performance is questionable as evidenced by production quality assurance.

5.5 Production quality assurance. Production quality shall be assured by certification and the maintenance of production records and an inspection system by the performing activity, contractor, or subcontractor. Production records and inspection requirements are subject to modification by the contracting activity (see 6.2).

5.5.1 Production records. The performing activity, contractor, or subcontractor shall maintain production records for lot sizes specified by the contracting activity. A production record form shall be prepared prior to commencement of work by the performing activity, contractor, or subcontractor.

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The record shall assign responsibility and provide accountability for performing work and assuring quality control. These records shall be available for review and audit by the authorized agent. The sample shown on figure 6 may be used as a guide for preparing production records.

5.5.2 Inspection system. Sampling and inspection of end items shall be as specified (see 6.2) and, at a minimum, shall consist of a comparison coupon bend test, visual inspection, and thickness measurement as directed herein. In the event of failure by a sample item during any test, the item shall be recoated by repeating the entire application procedure. Each item of the lot from which the failed sample item was drawn shall be subjected to the inspection system requirements. In the event the authorized agent suspects failure of a coating job, the knife-peel test (see 5.5.2.3) or the adhesion test (see 5.5.2.4) can be used to determine if the coating will meet the requirements of this standard.

5.5.2.1 Visual inspection. Each sample item shall be examined visually at a magnification of 10X. The coating shall have a smooth, uniform appearance. The coating system shall not contain any blisters or loosely adhering particles, nor shall it contain any cracks, pinholes, or chips which expose the metal substrate. Areas of apparent nonadherence (blistering, loose particles, cracks, or chips) shall be subjected to the knife-peel test (see 5.5.2.3). Coatings displaying any of the above discontinuities shall be removed and the coating system replaced.

5.5.2.2 Thickness measurement. Thickness measurements shall be performed on each sample item by means of a thickness gauge or by direct caliper measurement of the increased dimension. Required thickness of the coating system and tolerances shall be as specified in this standard.

5.5.2.3 Knife-peel test. The knife-peel test shall consist of a single knife cut 40 mm (1.5 inches) long through the metal spray coating to the substrate. If any part of the coating system along the cut can be lifted from the base metal using the knife, the bond shall be considered unsatisfactory.

5.5.2.4 Adhesion test. An aluminum or steel dolly (3.2 cm<sup>2</sup> (0.500 in<sup>2</sup>) surface contact area) shall be cemented to the metal sprayed surface. After curing, the dolly shall be pulled off the surface with a calibrated Elcometer adhesion tester. An adhesive failure less than 6.9 MPa (1000 lb/in<sup>2</sup>) indicates a poor metal coating and, therefore, shall not be passed. This test shall be used in a noncritical area of the job and can be recoated with the topcoat if no failure occurs.

5.5.3 Periodic inspection. Prior to commencement and once during each day's or shift's production run, a sample coupon shall be prepared by the operator and spray gun as specified in 5.6.1.1 and tested as specified in 5.6.3. The specimen shall meet the requirements of 5.3.3.2. Additional sample coupons shall be prepared for testing when multiple components are processed (that is, every tenth valve). In the event of failure, the cause shall be identified and the problem corrected. This inspection is included to identify problems which can lead to subsequent failure of a production run.

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5.6 Certification test procedures. Certification test procedures shall be as specified in 5.6.1 through 5.6.5 (see 6.3).

5.6.1 Preparation of the test specimens.

5.6.1.1 Specimens for visual and bend tests. Four panels (approximately 75 by 50 by 1.25 mm) (3 by 2 by 0.050 inches) (minimum) shall be sprayed on one of the large faces using the appropriate spraying procedure and metal substrate. The coating thickness shall be 175 to 250 mm (0.007 to 0.010 inch). The same panel may be used for visual and bend test.

5.6.1.2 Specimens for bond test. Five specimens for the bond test shall be machined and prepared in accordance with ASTM C 633 and this standard.

5.6.1.3 Specimens for the shape test. One specimen shall be manufactured in the shape of a "T" (75 by 75 by 13 mm thick by 150 mm long (3 by 3 by 1/2 inches thick by 6 inches long)). In lieu of the manufactured "T", a wide-flange I-beam section nominal size 8 by 8 or standard tee section size ST 8 WF may be used. Another specimen shall be cut from a length of 50 mm (2 inches) nominal pipe size (nps), 150 mm (6 inches) long. The specimen material shall be the applicable substrate and shall be coated using the spraying procedure specified in 5.6.1.1.

5.6.2 Visual examination. Each of the prepared specimens shall be examined under magnification of 10X. The surface appearance shall meet the requirements of 5.3.3.1.

5.6.3 Bend test. The sprayed panels shall be bent approximately 180 degrees on a 13-mm (1/2-inch) diameter rod. The coating shall be on the tensile side of the bend. The bend specimen shall be examined visually to determine conformance to 5.3.3.2. A handheld portable bend tester may be manufactured using a 13 mm (1/2-inch) diameter rod to allow reproducible bend specimens for visual examination.

5.6.4 Bond test. The bond test specimens (see 5.6.1.2) shall be tested in accordance with ASTM C 633 for bond strength and the average bond strength of the five specimens. The strength of the individual specimen bonds shall be 10.3 MPa (1500 lb/in<sup>2</sup>) or greater. The average bond strength shall be 13.8 MPa (2000 lb/in<sup>2</sup>) or greater. Examination of the test specimen shall be conducted after rupture to determine the cause of failure.

5.6.5 Shape test. The thickness of the sprayed metal coatings shall be measured in sufficient areas to determine that the coating thickness is within the required range (see 5.3.3.4) across the specimen surfaces.

5.7 Records. Records of facility, application procedure, and operator certification (including certification test results and production records) shall be maintained by each performing activity, contractor, or subcontractor. These records shall be available to the contracting activity for review and audit. The performing activity, contractor, or subcontractor shall maintain these records for a period of 6 months after completion of the contract work. Copies of the records shall be made available to the contracting activity upon request. Disposition of the records shall be as agreed upon in the contract.

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5.8 Nonconformance. In the event the contracting activity or its representative has evidence indicating that the requirements of this standard are not being met, the applicable work covered by this standard may be suspended upon written notification until the contractor has demonstrated that such work deficiencies have been corrected.

## 6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard covers the requirements for metal sprayed coating systems (aluminum) for corrosion protection and is intended for use on board Naval ships.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- (a) Title, number, and date of this standard.
- (b) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
- (c) The use of chapter 631 of NAVSEA S9086-VD-STM-000 and chapter 074 of NAVSEA S9086-CH-STM-030 in the case of shipboard work.
- (d) Type of abrasive blasting equipment required (see 4.2.1.1).
- (e) Type of metal spraying system (see 4.2.2).
- (f) Type of abrasive blasting particles required (see 4.3.3).
- (g) Type of seal coat required (see 4.3.7).
- (h) Type of topcoat (see 4.3.8).
- (i) When production records and inspection requirements are subject to modification (see 5.5).
- (j) Sampling plan required for production quality assurance (see 5.5.2).

6.3 Data requirements. The following Data Item Descriptions (DID's) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this standard is applied on a contract, in order to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

<u>Reference Paragraph</u>	<u>DID Number</u>	<u>DID Title</u>	<u>Suggested Tailoring</u>
5.1, 5.2, 5.3.1, and 5.6	DI-MISC-80678	Certification/data report	10.3.1 does not apply

The above DID's were those cleared as of the date of this standard. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

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6.4 Additional precautions. The performing activity, contractor, or subcontractor is responsible for ensuring that proper precautions are being observed to preclude personnel injury or machinery damage (including surroundings) prior to accomplishing the required operations.

6.5 Packaging. The performing activity, contractor, or subcontractor is responsible for packaging the end item in a manner that will afford adequate protection against damage during direct shipment from the facility to the receiving activity. These packages should conform to the applicable carrier rules and regulations, as required. Marking information should be provided on the exterior of the package and should include the contract or work order number, the nomenclature, facility name, and destination. This information may be modified by the contracting activity.

6.6 NAVSEA approval. Deviation from specified materials, procedures, and requirements and selection of specific alternative materials and procedures require NAVSEA approval. All nuclear related applications require NAVSEA 08 concurrence.

6.7 Subject term (key word) listing.

Certified item  
Electric arc spraying  
Metal spraying  
Oxygen-fuel gas  
Powder-flame spraying  
Wire-flame spraying

6.8 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:  
Navy - SH  
(Project MFFP-N358)

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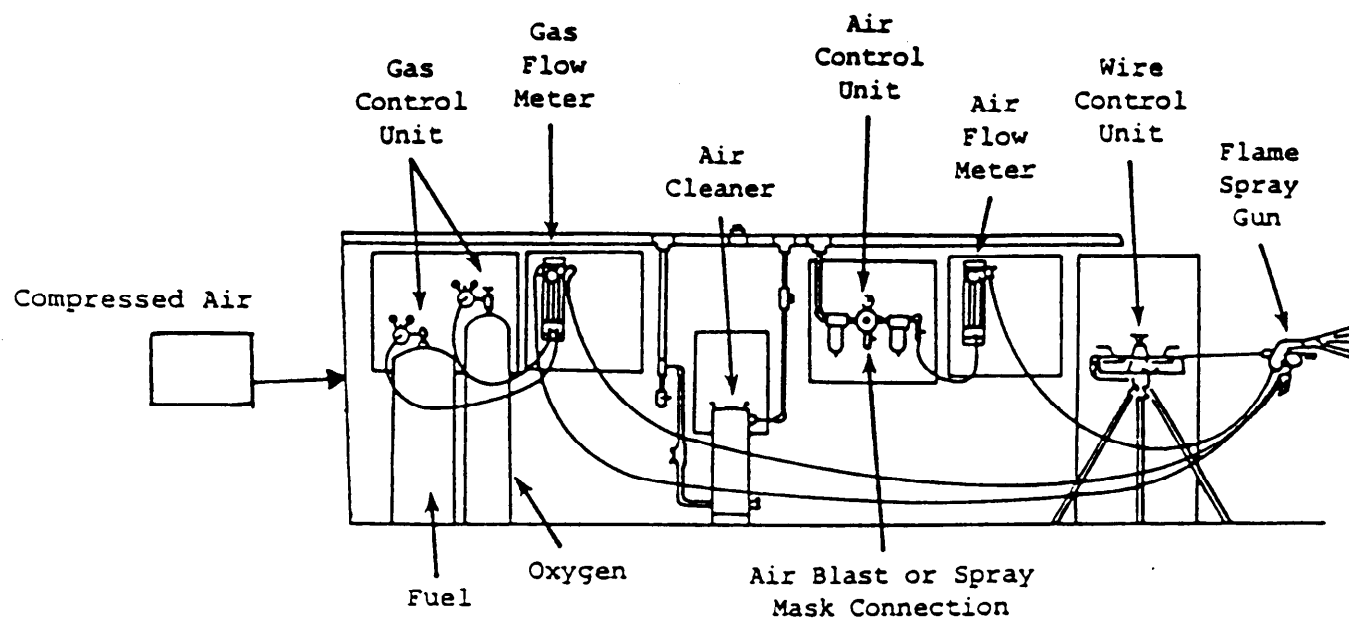


FIGURE 1. Typical metal spray system.

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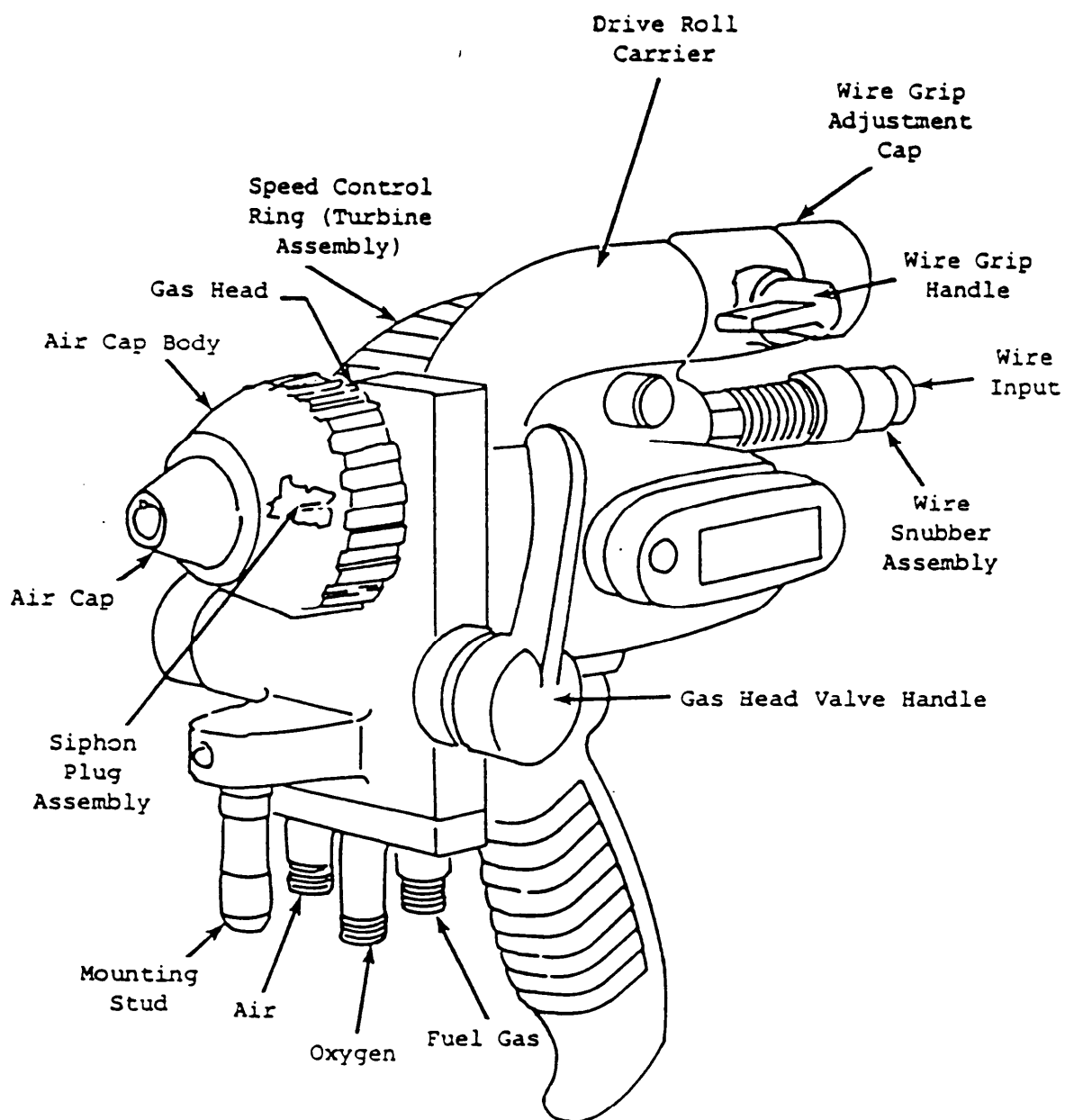


FIGURE 2. Typical wire spray gun.

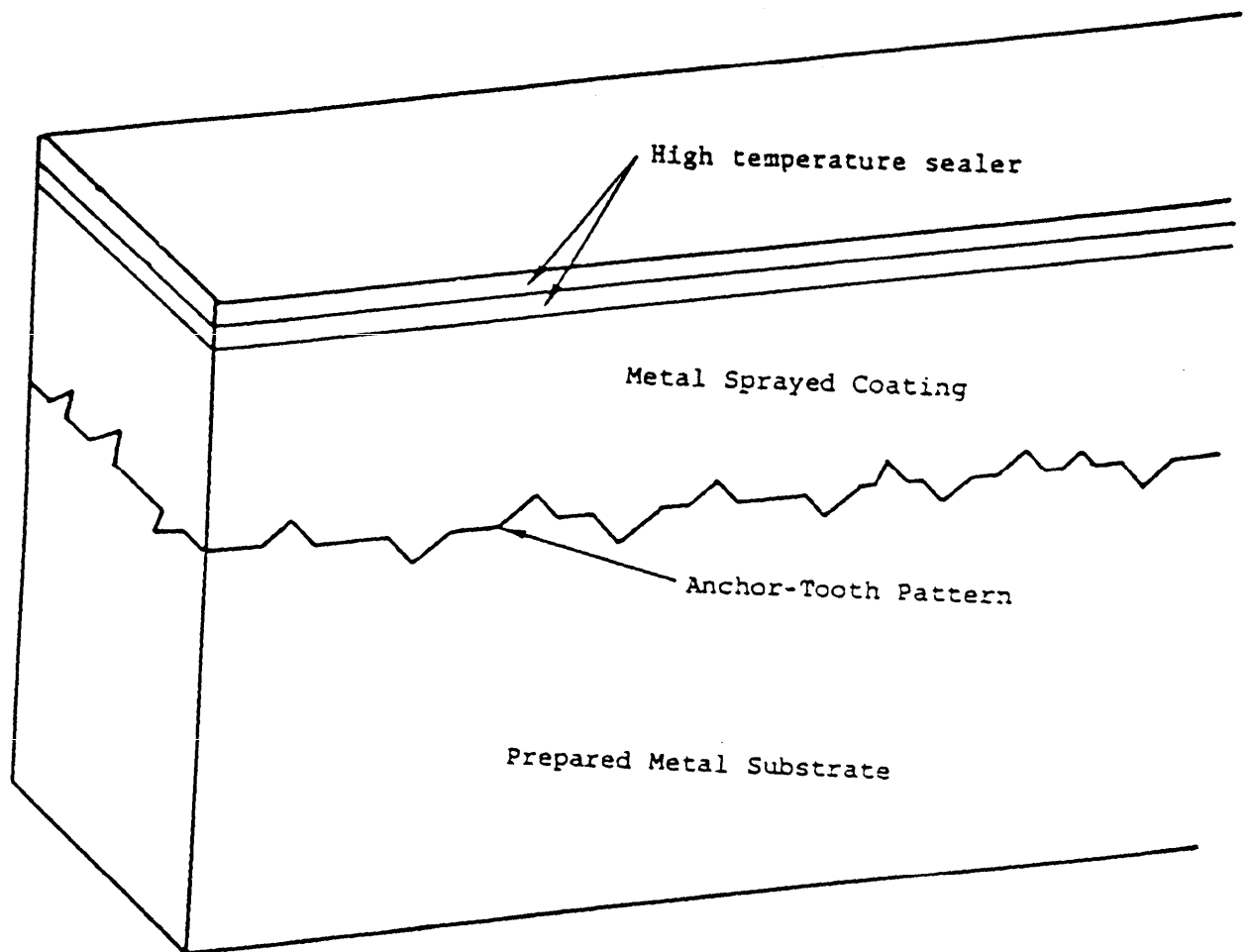


FIGURE 3. Type I system with heat-resisting, high temperature sealer (silicone aluminum sealer).

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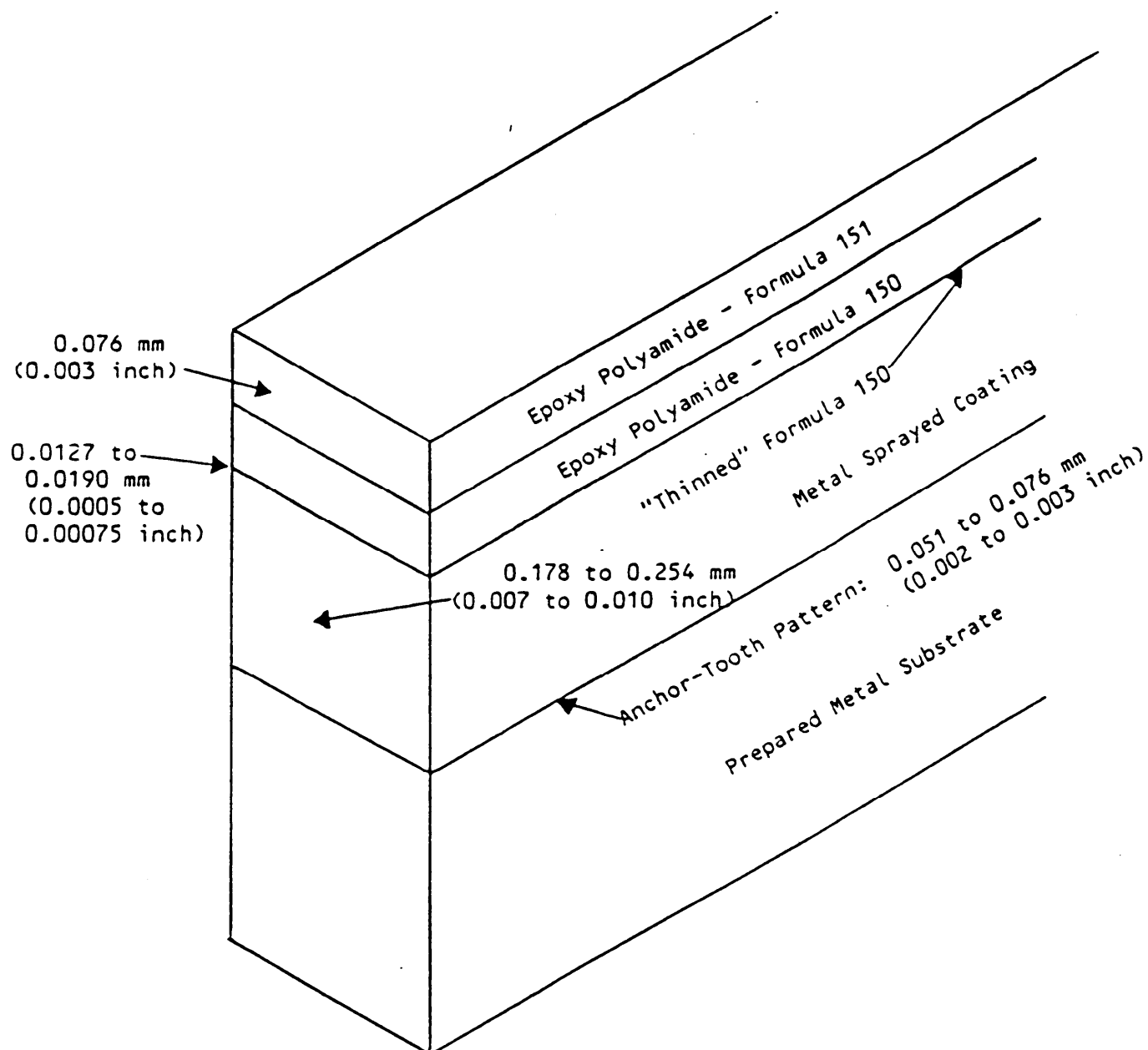
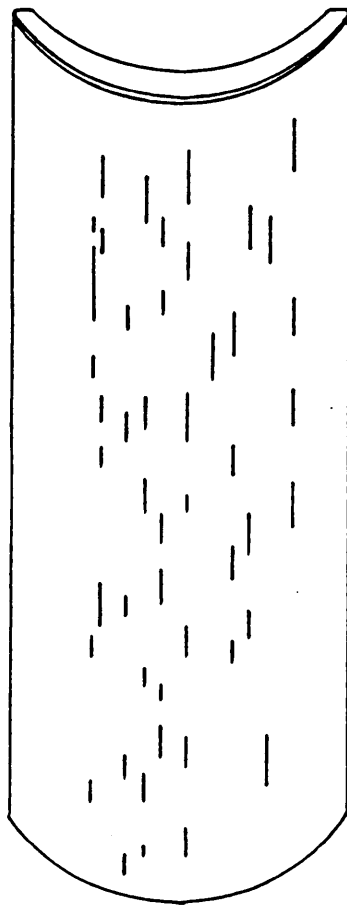


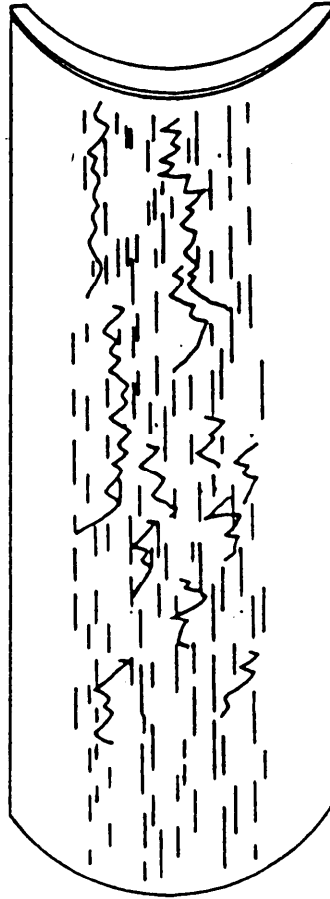
FIGURE 4. Type II system with low temperature sealer  
(epoxy polyamide and cosmetic topcoat).

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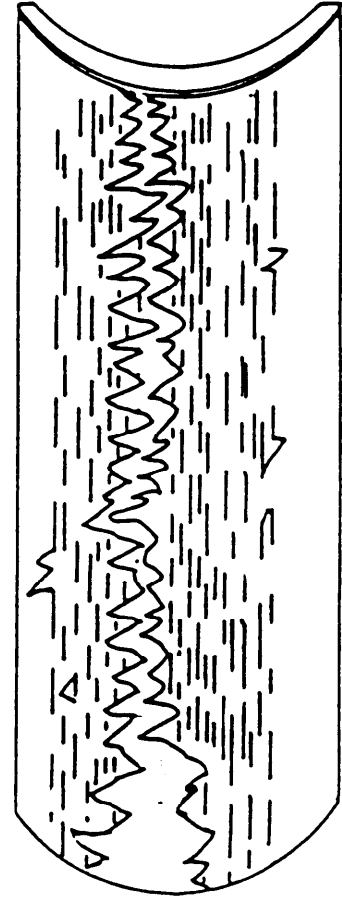
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IDEAL  
Smooth Surface



MARGINAL  
Cracks



REJECT  
Disbonding  
Delamination

FIGURE 5. Coupon bend test accept or reject examples.

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1. Job control number \_\_\_\_\_ 2. Date \_\_\_\_\_

3. Ship system \_\_\_\_\_ 4. System component \_\_\_\_\_

5. Area to be sprayed \_\_\_\_\_

6. Masking information (area not to be sprayed) \_\_\_\_\_

7. Base material (type) \_\_\_\_\_

8. Preparation methods:

Cleaning: Degrease solvent: \_\_\_\_\_  
Oven bake temp \_\_\_\_\_; time \_\_\_\_\_

Rough blasting: Grit type and size: \_\_\_\_\_

Anchor-tooth blasting: Grit type, size, and profile: \_\_\_\_\_

Masking information \_\_\_\_\_

9. Thermal sprayed coating (type and thickness) \_\_\_\_\_

10. Seal coat (types and thicknesses) \_\_\_\_\_

11. Top coat (type) \_\_\_\_\_

Inspection procedures and results:

Visual examination (inspector initial) \_\_\_\_\_

Thickness measurement (inspector initial) \_\_\_\_\_

Knife peel test (inspector initial) \_\_\_\_\_

Item accepted? (Yes/No) \_\_\_\_\_

Sprayer's identification:

Name/number \_\_\_\_\_

Inspector's identification:

Name/number \_\_\_\_\_

FIGURE 6. Sample metal spray report.

# STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

## INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

### I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER  
MIL-STD-2138A(SH)

2. DOCUMENT DATE (YYMMDD)  
1992 May 13

### 3. DOCUMENT TITLE

METAL SPRAYED COATINGS FOR CORROSION PROTECTION ABOARD NAVAL SHIPS (METRIC)

### 4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

### 5. REASON FOR RECOMMENDATION

### 6. SUBMITTER

a. NAME (Last, First, Middle Initial)

b. ORGANIZATION

c. ADDRESS (Include Zip Code)

d. TELEPHONE (Include Area Code)

7. DATE SUBMITTED  
(YYMMDD)

(1) Commercial  
(2) AUTOVON  
(if applicable)

### 8. PREPARING ACTIVITY

a. NAME Technical Point of Contact (TPOC):

Mr. Meikle (SEA 5141)

b. TELEPHONE (Include Area Code)

(1) Commercial

(2) AUTOVON

PLEASE ADDRESS ALL CORRESPONDENCE AS FOLLOWS:

TPOC: 703-602-0214

332-0214

c. ADDRESS (Include Zip Code)

Commander, Naval Sea Systems Command  
Department of the Navy (SEA 5523)  
Washington, DC 20362-5101

IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:

Defense Quality and Standardization Office  
5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466  
Telephone (703) 756-2340 AUTOVON 289-2340