METRIC

MIL-STD-871D USAF
20 JUN 2019

SUPERSEDING
MIL-STD-871C
30 JUN 2015

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

ELECTRO-CHEMICAL STRIPPING OF INORGANIC FINISHES

This specification is approved for use by all Departments and Agencies of the Department of Defense.

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

AMSC: N/A

AREA: MFFP

FORWARD

1. This detail standard is approved for use by the AF70 Hill AF Base, OO-ALC/EN Engineering Office, Department of the Air Force, and is available for use by all Departments and Agencies of the Department of Defense.

2. This standard provides guidance on the processes for stripping inorganic finishes from military components.

3. Comments, suggestions, or questions on this document should be addressed to OO-ALC/EN, Bldg. 849, Hill AFB, UT 84056 or email to: OOALC.EN.Workflow@us.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database https://assist.dla.mil.

SUMMARY OF CHANGE ONE MODIFICATIONS

PAGE / PARAGRAPH	MODIFICATIONS
Page I – Title	Changed
Page ii – Forward	Changed
Page iii – Summary of changes	Changed
Page iv – v Table of contents	Changed
2.2.1 – 2.2.2	Changed
2.3	Changed
4.1	Changed
4.1.1. – 4.1.2	Changed
4.1.3.3 – 4.1.3.4	Changed
4.1.3.5	Added
4.2 – 4.5	Deleted (Moved to 5)
5.2 – 5.5	Changed
5.5.1 – 5.5.7	Changed
5.3.8 – 5.3.9	Added
TABLE I – III	Changed
5.6	Changed
5.6.2 – 5.6.15	Changed
5.6.6 – 5.6.7	Changed
5.7 – 5.7.6	Changed
5.8 – 5.9	Changed
Concluding Material	Changed

CONTENTS

1. SCOPE

1.1 Scope. This standard covers the process and materials required for the stripping of inorganic finishes. Subsequent heat treating techniques needed to ensure hydrogen embrittlement relief of the steel substrate are also described.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 and 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, and 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, handbooks, and commercial item descriptions (CID). 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 cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS AND STANDARDS

MIL-DTL-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-PRF-29602	Performance Specification Cleaning Compounds, Parts Washer and Spray Cabinet
MIL-PRF-87937	Performance Specification Cleaning Compound, Aerospace Equipment

(Copies of these documents are available online at https://assist.dla.mil.)

COMMERCIAL ITEM DESCRIPTIONS

A-A-55820	Orthophosphoric (Phosphoric) Acid, Technical
A-A-55827	Chromium Trioxide, Technical
A-A-55828	Sulfuric Acid, Technical
A-A-55829	Acetic Acid, Glacial, Technical
A-A-59105	Nitric Acid, Technical
A-A-59260	Sodium Hydroxide
A-A-59282	Chemicals, Analytical
A-A-59476	Ammonium Nitrite, Anhydrous, Technical
A-A-59563	Sodium, Carbonate, Anhydrous, Technical

(Copies of these documents are available online at https://assist.dla.mil.)

2.2.2 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 of these documents are those cited in the solicitation or contract.

Air Force	Drawing	200310641
Air Force	Drawing	201027456

(Copies of these drawings are available online at https://jedmics.af.mil/webjedmics/index.jsp or mail to OO-ALC/EN, Bldg. 849, Hill AFB, UT 84056, or email to: OOALC.EN.Workflow@us.af.mil.)

Air Force Technical Order	1-1-691

(A copy of this document is available online at https://www.my.af.mil/etims/ETIMS/index.jsp or mail to OO-ALC/EN, Bldg. 849, Hill AFB, UT 84056, or email to: OOALC.EN.Workflow@us.af.mil.)

CODE OF FEDERAL REGULATIONS (CFR)

Title 29 CFR 1910 § Z	Occupational Safety and Health Administration (OSHA) – Toxic and Hazardous Substances

(A copy of this document is available online at https://www.osha.gov/laws-regs/regulations/standardnumber/1910.)

2.3 Non-Government standards and publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E1146	Muriatic Acid (Technical Grade Hydrochloric Acid)
ASTM D1732	Standard Practices for Preparation of Magnesium Alloy Surfaces for Painting
ASTM F519	Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

(Copies of these documents are available at https://www.astm.org.)

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS2750	Pyrometry
SAE AMS-M-3171	Magnesium Alloy, Processes for Pre-treatment and Prevention of Corrosion on
SAE AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts

(Copies of these documents are available online at https://www.sae.org.)

AMERICAN CHEMICAL SOCIETY (ACS)

Reagent Chemicals Replacement of Federal Specification O-G-491D

(A copy of this document is available online at https://pubs.acs.org/ or at Reagent Chemicals.

2.4 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 High Strength Steel. For the purpose of this standard, high strength steel is defined as steel heat treated to 1240 mega pascals (MPa) (180,000 pound – force per square inch {PSI}) and above.

4. GENERAL REQUIREMENTS

4.1 Materials and equipment.

4.1.1 Materials. The use of recycled, reclaimed, environmentally preferable, or bio-based materials shall be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous lifecycle costs.

4.1.2 Toxic chemicals, hazardous substances, and ozone-depleting chemicals. The use of toxic chemicals, hazardous substances, or ozone-depleting chemicals shall be avoided, if feasible.

CAUTION: Some materials listed in this document are classified as hazardous and toxic substances. Personnel exposure to such materials shall be within the limits specified in OSHA Standard Title 29 CFR 1910-1000 Subpart Z.

4.1.3 Equipment.

4.1.3.1 Tanks shall be resistant to the operating temperatures and the chemical environment.

4.1.3.2 Stripping tanks to be operated at temperatures other than room temperature shall be equipped with automatic temperature indicating and regulating devices.

4.1.3.3 Either generated or rectified direct current (DC) shall be used. An ammeter shall be placed in series with the tank anode. The ammeter shall have sufficient shunts and switches to provide a full-scale reading equal to the maximum capacity of the power source, and an accuracy of ± 10% of the current being measured.

4.1.3.4 If embrittling strip processes are used and high strength steels are processed, an oven capable of baking parts at 190° ± 14°C (375° ± 25°F) shall be located near the stripping line. The size of the oven shall be adequate to enclose the parts to be stripped.

4.1.3.5 The oven shall be equipped with temperature indicating, recording, and regulating devices. The oven's pyrometry shall be tested and calibrated IAW SAE AMS2750 test methods.

5. DETAILED REQUIREMENTS

5.1 Immersion of Parts. Parts shall be immersed in the process solutions in a manner to prevent localized effects such as interface attack or corrosion.

5.2 Immersion Processes. Immersion processes are preferred for stripping parts with recessed areas, intricate shapes, or hollow areas.

5.3 Procedure.

5.3.1 Step No 1: Degrease parts as necessary. Degreasing shall be accomplished with water-based cleaners, provided they are IAW either MIL-PRF-29602 or MIL-PRF-87937.

5.3.2 Step No 2: Mask off or remove dissimilar metals as necessary. Sections or areas of a part that are not to be stripped shall be masked off. Plug and masking materials that do not contaminate the stripping solution shall be used. Masking shall be performed at the most convenient step prior to stripping.

5.3.3 Step No 3: When an embrittling strip solution is used and the parts are high strength steel, the parts (except those that are carburized) shall be baked for stress relief for four (4) hours minimum at 190° ± 14° C (375° ± 25°F) prior to stripping. Parts that are carburized shall be baked for four (4) hours minimum at 135 ± 14 °C (275 ± 25 °F) prior to stripping. For parts fabricated from music wire, 52100, 440C, or other alloys tempered at or below 375° F (191° C) seek engineering disposition for bake times and temperatures, AMS2759/9 may be consulted for additional information. This bake is not required for solutions 1, 3, 5, 6, 11, and 14, which are not embrittling.

5.3.4 Step No. 4: Mask and rack parts as necessary. When current flow is required, sufficient contact area and pressure shall be provided to carry the current without local overheating. Racking shall be performed at the most convenient step prior to stripping.

5.3.5 Step No. 5: Strip the inorganic coating in the appropriate solutions from Table I or II. Strip parts in the shortest time necessary to remove coating. Refer to Table III and paragraph 5.4 for information on solution makeup, control limits, and process notes.

5.3.6 Step No. 6: Rinse part immediately and thoroughly in clean water. Many of the stripping solutions described here can cause corrosion or discoloration if they are not fully rinsed off and left to dry on the metal surface.

NOTE: (Optional) After step 6, corrosion may be removed IAW Technical Order (TO) 1-1-691.

5.3.7 Step No. 7: For the final rinse of parts, it is recommended to use clean hot water to facilitate drying, then followed by clean dry pressurized air. Corrosion preventive compounds may be added to the rinse tanks to preclude rust formation after protective coatings removal. Additive concentration shall be below (four) 4%. If high strength steels are processed, the corrosion preventive compounds shall be tested IAW ASTM F519 at operating conditions and shall not cause hydrogen embrittlement.

5.3.8 Step No. 8: High strength steels (excluding carburized parts) shall be baked within four (4) hours of stripping for four (4) hours minimum at 190° ± 14°C (375° ± 25°F). High strength steels that are carburized shall be baked within four (4) hours of stripping for four (4) hours minimum at 135 ± 14 °C (275 ± 25 °F). For parts fabricated from music wire, 52100, 440C, or other alloys tempered at or below 375 °F (191° C) seek engineering disposition for bake times and temperatures, AMS2759/9 may be consulted for additional information. Other process operations may be performed on the part, provided they are accomplished within the four (4) hour time limit. No plating or other embrittling process shall be performed prior to baking. Steel parts stripped in solutions 1, 3, 5, 6, 11, and 14, do not require baking.

NOTE: After chemically stripping aluminum from steel heat treated to 1240 MPa (180,000 psi) and above, parts shall be baked IAW Step No. 8.

5.3.9 Step No. 9: Inspect the component to ensure complete removal of the coating and verify that it has not been damaged by the stripping process. After stripping, the part shall have a smooth finish, free from pits, nodules, and any other indications of harmful defects as a result of the stripping process. The stripping solutions described here should not etch the underlying metal surface if used properly. If any unexpected etching of the base metal occurs, stop using the strip solution immediately and determine the cause of the problem.

TABLE I
Stripping of metal coatings

Base Metal / Coating	Low Alloy Steel	Corrosion Resistant Steel	Aluminum Alloys	Copper Alloys
Brass Or Bronze	1 or 14	1, 2, 14	2 or 14 [1]	N/A
Cadmium or Titanium Cadmium	1 or 3	1, 2, 3	2	3 or 4
Chromium	5 or 6	5 or 6	7 or 15	4
Copper	1 or 14	1, 2, 14	2 or 14 [1]	N/A
Lead or Lead Solder	6, 8 [2], 14	2, 6, 8, 14	2 or 14 [1]	8 or 14
Gold	1	1	7	1
Nickel or Electroless Nickel	7 [2], 14	2, 7, 14	2, 14 [1]	7 [1] or 14
Silver	1	1 or 2	2	1 [1] or 9
Tin	1, 4 [1] [2], 6, 14	1, 2, 4 [1], 6, 14	2 or 14 [1]	4 or 14
Zinc	1 or 4 [1] [2]	1, 2, 4	2	4
Zinc Nickel	3	3	N/A	3
Aluminum	6 [3]	6 [3]	6 [1] [3]	N/A

[1] CAUTION: This solution attacks the base metal.

[2] CAUTION: This solution shall not be used for high strength steels.

[3] NOTE: Any suitable alkaline solution with pH above 10 may be used.

TABLE II
Stripping of conversion coatings.

BASE METAL	COATING	STRIPPING SOLUTION
Ferrous	Black Oxide	4 1
Ferrous	Manganese Phosphate	10 or 11
Ferrous	Zinc Phosphate	10 or 11
Ferrous	Ferrous Phosphate	10 or 11
Ferrous	Dry Film Lubricants	10
Magnesium	ASTM D1732	10
Magnesium	SAE AMSM3171	10
Aluminum	Dry Film Lubricants	10
Aluminum	MIL-DTL-5541	12
Aluminum	Anodized Coatings	12 or 13
Zinc	Conversion Coatings	12
Cadmium	Conversion Coatings	12

1 CAUTION: This solution attacks bare metal.

TABLE III
Process solutions.

Stripping Solution	Section	Processing Solution	Immersion	Electrolytic
1	5.4.1	Cyanide – Caustic		X
2	5.4.2	Nitric Acid	X	
3	5.4.3	Ammonium Nitrate	X	
4	5.4.4	Hydrochloric Acid	X	
5	5.4.5	Hydroxide – Carbonate		X
6 [1] [2]	5.4.6	Sodium Hydroxide		X
7	5.4.7	Sulfuric Acid		X
8	5.4.8	Acetic Acid-Hydrogen Peroxide	X	
9	5.4.9	Sulfuric – Nitric Acid	X	
10	5.4.10	Chromic Acid	X	
11	5.4.11	Caustic – Cyanide	X	
12	5.4.12	Chromic – Phosphoric Acid	X	
13	5.4.13	Chromic – Sulfuric Acid	X	
14	5.4.14	Multi–deposit Strip	X	
15	5.4.15	Chrome Strip from Aluminum		X

[1] CAUTION: When using solution six (6) or any alkaline solution, immersion only shall be used to strip aluminum.

[2] CAUTION: Solution six (6) shall not be used to strip both aluminum from steel and chrome from steel in the same processing tank.

5.4 Stripping Solutions. The stripping solutions in Table III are referenced in the Tables I and II. Refer to the listed sections for information on solution make-up, control limits, and process notes. Proprietary formulations are available for several strip processes. One example is a non-cyanide formulation to replace the cyanide based Multi-Deposit Strip, Solution 14. Proprietary formulations may be used provided the necessary precautions are taken to avoid substrate attack and hydrogen embrittlement. If a proprietary formulation is used, testing IAW ASTM F519 shall be accomplished to determine whether an embrittlement relief bake is required in accordance with paragraph 5.3.8. Some flame spray applied nickel based coatings may also be stripped with a nickel strip solution. Removal of tungsten carbide coatings from steel is described in Air Force drawing 200310641. Removal of Zinc Nickel coatings can be performed with Solution 3; this process is described in Air Force drawing 201027456. Dust or smut remaining on the components at the completion of coating removal may be removed with plastic media blast, soft bristle brush, soft backed abrasive pad such as ScotchBrite® , or pressurized air. Ensure that the techniques used do not damage, or in any way adversely affect the component.

5.4.1 Solution 1: Cyanide – Caustic

	Initial Makeup	Control
Sodium Cyanide	90 g/L (12 oz/gal)	82 – 98 g/L (11 – 13 oz/gal)
Sodium Hydroxide	15 g/L (2 oz/gal)	8 – 22 g/L (1 – 3 oz/gal)
Temperature	Room to 71°C (Room to 160°F)	
Procedure	Make parts anodic at 2 volts maximum	

5.4.2 Solution 2: Nitric Acid

	Initial Makeup	Control
Nitric Acid	Concentrated (35° – 42° Baumė)	Use until ineffective or maximum dissolved metal
Dissolved Metal		30 g/L max (4 oz/gal max)
Temperature	Room	
Procedure	Immersion	

5.4.3 Solution 3: Ammonium Nitrate

	Initial Makeup	Control
Ammonium Nitrate	105 – 160 g/L (14 – 21 oz/gal)	None, use until ineffective Monitor for adverse effects
Dissolved Metal		None, use until ineffective Monitor for adverse effects
Temperature	Room	
Procedure	Immersion, not to exceed 60 minutes	Monitor steel surfaces for etching or excessive corrosion

NOTE: Commercially available alternatives to Ammonium Nitrate IAW A-A-59476 may be used. Alternates shall be technical grade or purified, and may be in powder or granular form or aqueous solution.

5.4.4 Solution 4: Hydrochloric Acid

	Initial Makeup	Control
Hydrochloric Acid	255 g/L (34 oz/gal)	210 – 260 g/L (28 – 34 oz/gal)
Antimony Trioxide	15 g/L (2 oz/gal)	8 – 22 g/L (1 – 3 oz/gal)
Dissolved Metal		30 g/L max (4 oz/gal max)
Temperature	Room	
Procedure	Immersion	

5.4.5 Solution 5: Hydroxide – Carbonate

	Initial Makeup	Control
Sodium Hydroxide	52 g/L (7 oz/gal)	45 – 60 g/L (6 – 8 oz/gal)
Sodium Carbonate	68 g/L (9 oz/gal)	60 – 75 g/L (8 – 10 oz/gal)
Temperature	Room	
Procedure	Make part anodic at 4 – 6 volts	

5.4.6 Solution 6: Sodium Hydroxide

	Initial Makeup	Control
Sodium Hydroxide	75 g/L (10 oz/gal)	None, use until ineffective, monitor for adverse effects
Temperature	Room	
Procedure	Make part anodic at 5 – 7 volts	

5.4.7 Solution 7: Sulfuric Acid

	Initial Makeup	Control
Sulfuric Acid	1125 g/L (150 oz/gal)	1100 – 1150 g/L (147 –154 oz/gal)
Glycerin	30 g/L (4 oz/gal)	22 – 38 g/L (3 – 5 oz/gal)
Dissolved Metal		30 g/L max (4 oz/gal max)
Temperature	Room	
Procedure	Make part anodic at 2 volts	

5.4.8 Solution 8: Acetic Acid – Hydrogen Peroxide

	Initial Makeup	Control
Acetic Acid	2 parts by volume	Make no Additions
Hydrogen Peroxide 30%	1 part by volume	Use to Depletion
Temperature	Room	
Procedure	Immersion	

5.4.9 Solution 9: Sulfuric Acid – Nitric Acid

	Initial Makeup	Control
Sulfuric Acid	64 – 68° Baumė	19 parts by volume
Nitric Acid	38 – 42° Baumė	1 part by volume
Temperature	Room	
Procedure	Immersion	

5.4.10 Solution 10: Chromic Acid

	Initial Makeup	Control
Chromic Acid	190 g/L (25 oz/gal)	175 – 210 g/L (23 – 28 oz/gal)
Dissolved Metal		30 g/L max (4 oz/gal max)
Temperature	Room	
Procedure	Immersion	

5.4.11 Solution 11: Caustic – Cyanide

	Initial Makeup	Control
Sodium Hydroxide	180 g/L (24 oz/gal)	175 – 200 g/L (23 – 27 oz/gal)
Sodium Cyanide	90g/L (12 oz/gal)	75 – 105 g/L max (10 – 14 oz/gal max)
Temperature	Room	
Procedure	Immersion	

5.4.12 Solution 12: Chromic – Phosphoric Acid

	Initial Makeup	Control
Chromic Acid	22 g/L (3 oz/gal)	15 – 30 g/L (2 – 4 oz/ gal)
Phosphoric Acid	45 g/L (6 oz/gal)	39 – 60 g/L (5 – 8 oz/gal)
Dissolved Metal		30 g/L max (4 oz/gal max)
Temperature	82° C to boiling (180° F to boiling)	
Procedure	Immersion	

5.4.13 Solution 13: Chromic – Sulfuric Acid

	Initial Makeup	Control
Chromic Acid	22 g/L (3 oz/gal)	15 – 30 g/L (2 – 4 oz/ gal)
Sulfuric Acid	45 g/L (6 oz/gal)	30 – 60 g/L (4 – 8 oz/gal)
Dissolved Metal		15 g/L max (2 oz/gal max)
Temperature	68° – 77° C (154° – 171° F)	
Procedure	Immersion	

5.4.14 Solution 14: Multi-deposit Strip

	Initial Makeup	Control
Meta Nitro Benzene Sulfonate	60 g/L (8 oz/gal)	45 – 75 g/L (6 – 10 oz/gal)
Sodium Hydroxide	15 g/L (2 oz/gal)	pH: 11 – 12
Sodium Cyanide	90 g/L (12 oz/gal)	75 – 105 g/L (10 – 14 oz/gal)
Temperature	49° – 55° C (120° – 130° F)	
Procedure	Immersion	

5.4.15 Solution 15: Chrome Strip from Aluminum

	Initial Makeup	Control
Sulfuric Acid	175 g/L (23 oz/gal)	150 – 200 g/L (20 – 27 oz/gal)
Dissolved Metal		30 g/L max (4 oz/gal max)
Temperature	Room	
Procedure	Make anodic at 4 – 6 volts	

5.5 Solution Makeup: Unless otherwise specified, the following procedure shall be used in making up solutions:

5.5.1 Fill tank approximately 1/3 to 1/2 full with water.

5.5.2 Add solid chemicals slowly and stir until dissolved.

5.5.2.1 Add basic chemicals such as sodium hydroxide (NaOH) slowly with mixing and allow solution to cool to normal temperature. This procedure shall be used with either solid sodium hydroxide or liquid sodium hydroxide.

5.5.3 Add liquid acids slowly with mixing and allow solution to cool to normal temperature.

5.5.4 Add other liquid chemicals.

5.5.5 Fill tank to operating level with water and mix thoroughly.

5.5.6 Bring solution to operating temperature.

5.6 Analysis. A laboratory analysis of stripping solutions shall be performed as often as deemed necessary to ensure that such solutions comply with this standard.

5.7 Rejection of parts. Parts that have been damaged by stripping shall be rejected, the stripping process halted, and investigation performed to determine cause. Examples of damage include: burning, warping, cracking, pitting, etching, or distortion.

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 provides guidance on the processes for electro/chemical stripping of inorganic coatings from metallic substrates. It is an Air Force unique repair/manufacturing standard.

6.2 Subject term (key word) listing.
Hazardous
Process

6.3 Changes from previous issue. Marginal notation are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes. A change summary page identifies where changes were made.

CONCLUDING MATERIAL

Custodians:
Air Force – 70

Preparing Activity
Air Force – 70

Project MFFP-2019-010

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.