SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS1551A

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Superseding AMS1551

Cleaner, Turbine Engine Gas Path Aqueous Type

RATIONALE

This specification was revised to meet current verbiage required by SAE standards with no technical changes.

1. SCOPE

1.1 Form

This specification covers petroleum distillate-free cleaner in the form of an aqueous-base liquid concentrate or a ready-to-use liquid.

1.2 Application

This cleaner has been used typically for cleaning installed turbine engines by spraying diluted cleaner or ready-to-use cleaner into the intake during either a starter crank operation or on-line engine cleaning in accordance with the engine manufacturer's procedure, but usage is not limited to such applications.

1.3 Classification

Cleaner conforming to this specification is classified as follows:

Class 1: Liquid concentrate
Class 2: Ready-to-use liquid

1.3.1 Class 1 shall be supplied unless Class 2 is ordered.

1.4 Dilution Water Requirements

Water used for dilution of the concentrate or during engine wash operations shall meet the requirements specified by the engine manufacturer.

1.5 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2416	Plating, Nickel-Cadmium, Diffused
AMS2470	Anodic Treatment of Aluminum Alloys, Chromic Acid Process
AMS2475	Protective Treatments, Magnesium Alloys
AMS4025	Aluminum Alloy, Sheet and Plate, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-0), Annealed
AMS4037	Aluminum Alloy, Sheet and Plate, 4.4Cu - 1.5Mg - 0.60Mn (2024; -T3 Flat Sheet, -T351 Plate), Solution Heat Treated
AMS4041	Aluminum Alloy, Alclad Sheet and Plate, 4.4Cu - 1.5Mg - 0.60Mn, Alclad 2024 and 1-1/2% Alclad 2024, -T3 Flat Sheet; 1-1/2% Alclad 2024-T351 Plate
AMS4045	Aluminum Alloy Sheet and Plate, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr, 7075: (-T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
AMS4049	Aluminum Alloy, Sheet and Plate, Alclad, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (Alclad 7075; -T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
AMS4376	Plate, Magnesium Alloy, 3.0Al - 1.0Zn - 0.20Mn (AZ31B-H26), Cold Rolled and Partially Annealed
AMS4911	Titanium Alloy, Sheet, Strip, and Plate, 6Al - 4V, Annealed
AMS4916	Titanium Alloy Sheet, Strip, and Plate, 8Al - 1Mo - 1V, Duplex Annealed
AMS5040	Steel, Sheet and Strip, 0.15 Carbon, Maximum, Deep Forming Grade
AMS5045	Steel, Sheet and Strip, 0.25 Carbon, Maximum, Hard Temper
AMS5046	Carbon Steel, Sheet, Strip, and Plate, (SAE 1020 and 1025), Annealed
AMS5504	Steel, Corrosion and Heat-Resistant, Sheet, Strip, and Plate, 12.5Cr (SAE 51410), Annealed
AMS5510	Steel, Corrosion and Heat-Resistant, Sheet, Strip and Plate, 18Cr - 10.5Ni - 0.40Ti (SAE 30321), Solution Heat Treated
AMS5536	Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate, 47.5Ni - 22Cr - 1.5Co - 9.0Mo - 0.60W - 18.5Fe, Solution Heat Treated
AMS5544	Nickel Alloy, Corrosion and Heat Resistant, Sheet, Strip, and Plate, 57Ni - 19.5Cr -13.5Co - 4.2Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode or Vacuum Induction Melted, Annealed
AMS5608	Cobalt Alloy, Corrosion and Heat Resistant, Sheet, Strip, and Plate, 40Co - 22Cr - 22Ni - 14.5W - 0.07La, Solution Heat Treated
AMS7267	Rings, Sealing, Silicone (VSI) Rubber, Heat-Resistant, Low Compression Set, 70 - 80
AMS7271	Rings, Sealing, Butadiene-Acrylonitrile (NBR) Rubber, Fuel and Low Temperature Resistant, 60 - 70
AMS7273	Rings, Sealing, Fluorosilicone (FVMQ) Rubber, High Temperature Fuel and Oil Resistant, 70 - 80
AMS7276	Rings, Sealing, Fluorocarbon (FKM) Rubber, High-Temperature-Fluid Resistant, Low Compression Set, 70 to 80
ARP1755	Effect of Cleaning Agents on Aircraft Engine Materials, Stock Loss Test Method

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 93	Flash Point by Pensky-Martens Closed Tester
ASTM D 445	Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
ASTM D 1141	Substitute Ocean Water
ASTM D 1193	Reagent Water
ASTM D 1568	Sampling and Chemical Analysis of Alkylbenzene Sulfonates
ASTM D 2240	Rubber Property - Durometer Hardness
ASTM D 2667	Biodegradability of Alkylbenzene Sulfonates
ASTM D 4191	Sodium in Water by Atomic Absorption Spectrophotometry
ASTM D 4192	Potassium in Water by Atomic Absorption Spectrophotometry
ASTM E 70	pH of Aqueous Solutions with the Glass Electrode
ASTM E 442	Chlorine, Bromine, or Iodine in Organic Compounds by Oxygen Flask Combustion
ASTM F 483	Total Immersion Corrosion Test for Aircraft Maintenance Chemicals
ASTM F 484	Stress Crazing of Acrylic Plastics in Contact with Liquid or Semi-Liquid Compounds
ASTM F 502	Effects of Cleaning and Chemical Maintenance Materials on Painted Aircraft Surfaces
ASTM F 519	Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals
ASTM F 945	Stress-Corrosion of Titanium Alloys by Aircraft Engine Cleaning Materials
ASTM F 1104	Preparing Aircraft Cleaning Compounds, Liquid Type, Water Base, for Storage Stability Testing
ASTM F 1110	Sandwich Corrosion Test

2.3 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-P-25690	Plastic Sheets and Parts, Modified Acrylic Base, Crack Propagation Resistant
MIL-C-81751	Coating, Metallic Ceramic

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall be optional with the manufacturer but should contain water, biodegradable surfactants, and other additives as required to produce a homogeneous product meeting the requirements of 3.1.1 and 3.2. The compound shall contain no known or suspected human carcinogens, heavy metals, hydrocarbon solvents, phenol, or cresol.

3.1.1 Element Content

Cleaner shall not exceed the concentrations shown in Table 1, determined in accordance with specified test methods.

TABLE 1 - COMPOSITION

Element	Concentration ppm by Weight Class 1	Concentration ppm by Weight Class 2	Test Method
Sulfur	500	100	IPC-AES
Chlorine	100	20	ASTM E 442
Sodium	50	10	ASTM D 4191 (AAS)
Potassium	50	10	ASTM D 4192 (AAS)
Phosphorus	50	10	ICP-AES
Other Metals, max	10	2	ICP-AES

3.1.1.1 Class 1 cleaner shall be diluted to 10% by weight in ASTM D 1193, Type III, water for inductively coupled plasma-atomic emission spectroscopy (ICP-AES) and atomic absorption spectroscopy (AAS). Class 1 cleaner results are to be calculated and reported in terms of the undiluted cleaner. For Class 2 cleaner, no dilution shall be used.

3.2 Properties

Cleaner shall conform to the following requirements; tests shall be performed in accordance with specified test methods on cleaner as supplied except as otherwise specified herein:

3.2.1 Cleaner As Supplied

3.2.1.1 Ash Content

Shall not exceed 0.05% by weight for Class 1 and shall not exceed 0.01% by weight for Class 2, determined in accordance with 3.2.1.1.1.

3.2.1.1.1 Using a balance accurate to 0.1 mg, weigh approximately 10 grams cleaner into a tared porcelain crucible. Heat crucible for 24 hours ± 0.5 at 105 °C ± 5 (221 °F ± 9) plus an additional 24 hours ± 0.5 at 464 °F ± 9 (240 °C ± 5). Heat crucible in a Bunsen-type gas flame, ignite the contents, and heat for 10 minutes ± 0.1. Heat crucible in a muffle furnace for 2 hours ± 0.1 at 1904 °F ± 54 (1040 °C ± 30), cool in a desiccator, and weigh residue. Ash content is the residue expressed as a percentage of the initial sample weight.

3.2.1.2 Biodegradability

Vendor shall supply evidence that surfactants used in the compound shall be at least 90% biodegradable, determined in accordance with ASTM D 2667 or other method appropriate to surfactant type.

3.2.1.3 Flash Point

Shall be not lower than 203 °F (95 °C), determined in accordance with ASTM D 93.

3.2.1.4 Viscosity

Shall be not more than 25 centistokes (26 centipoise) at 81 °F ± 2 (27 °C ± 1), determined in accordance with ASTM D 445.

3.2.1.5 Low-Temperature Stability

The cleaner shall not separate on warming to room temperature from -15 °F (-26 °C). A 50 mL sample shall be refrigerated at -15 °F ± 2 (-26 °C ± 1) for 24 hours ± 0.5, removed from the refrigerator, exposed to room temperature for 8 hours ± 0.25, and, without agitation, examined for homogeneity.

3.2.1.6 Accelerated Storage Stability

The cleaner shall show no marked change in appearance, shall not separate, and shall not cause any visual corrosion of AMS5046 steel strip, when tested as in 3.2.1.6.1.

3.2.1.6.1 Polish a AMS5046 steel strip, nominally 0.04 x 0.5 x 6 inches (1.0 x 13 x 152 mm), using 280 grit silicon carbide paper. Clean the specimen using absorbent paper tissue and wiping with a suitable solvent and then with isopropanol. Dry the specimen at ambient temperature, place it in a clean glass pressure bottle, add enough cleaner to cover half of the strip, cap the bottle, roll it on its side to coat the strip, and immerse the bottle in a water or oil bath. Program the temperature of the bath for 120 °F ± 4 (49 °C ± 2) for 8 hours ± 0.25 and no heat input for 16 hours ± 0.5. After five 24-hour cycles, and without agitation, examine the cleaner and the steel strip.

3.2.1.7 Storage Stability

Cleaner shall exhibit no visual evidence of deterioration and shall conform to all other technical requirements, after storage in accordance with ASTM F 1104 for one year.

3.2.1.8 Hard Water Stability

Cleaner, when mixed with synthetic hard water, shall not show any evidence of separation after standing undisturbed for 16 hours ± 0.5 at 77 °F ± 2 (25 °C ± 1). Synthetic hard water shall be prepared by dissolving 0.20 gram ± 0.005 calcium acetate monohydrate and 0.14 gram ± 0.005 magnesium sulfate heptahydrate in 1 liter of ASTM D 1193, Type III, water. Test solution shall be prepared by pouring 10 mL cleaner into a 50 mL graduated cylinder, adding 40 mL of synthetic hard water, and shaking for 15 seconds ± 1; after standing undisturbed for 16 hours ± 0.5, the solution shall be examined for separation.

3.2.1.9 Insoluble Matter

Shall be no more than 0.001% by weight for Class 1 and no more than 0.001% by weight for Class 2, determined in accordance with 3.2.1.9.1.

3.2.1.9.1 Undiluted cleaning compound, after having been stored undisturbed for at least one week, shall be thoroughly agitated and two 100 gram samples withdrawn and weighed to the nearest gram. The insoluble matter shall be collected with the aid of a vacuum filtering apparatus capable of producing 200 to 250 mm of vacuum (water tap filter pump), a 250 mL filtering flask, a 4.25 cm Buchner funnel, and three pieces of filter paper (Whatman No. 1 or equivalent). Two filter papers for each determination shall be dried at 140 °F ± 4 (60 °C ± 2) for 30 minutes, cooled in a desiccator, and weighed to the nearest milligram. The filter papers shall be stacked in the Buchner funnel with the unweighed filter paper on the bottom, the vacuum started, and the test sample filtered. The sides of the sample container shall be rinsed with 25 mL of the filtrate and the rinse mixture transferred to the funnel. The sides of the funnel shall be rinsed with an additional 25 mL of the filtrate and the liquid filtered. The vacuum shall be maintained for an additional 5 minutes. The top and middle filter papers shall be dried for 10 minutes at 221 °F ± 4 (105 °C ± 2), cooled in a desiccator, and weighed to the nearest milligram. The percent insolubles shall be calculated using Equation 1.

$$\text{Percent insolubles} = \frac{A_2 - \left(\frac{B_2}{B_1}\right)A_1}{\text{Weight of Sample}} \times 100 \qquad \text{(Eq. 1)}$$

where:

A_1 = initial weight of top filter paper

B_1 = initial weight of middle filter paper

A_2 = final weight of top filter paper

B_2 = final weight of middle filter paper

3.2.1.10 Effect on Acrylics

There shall be no crazing or staining of MIL-P-25690 stretched acrylic plastic, determined in accordance with ASTM F 484.

3.2.1.11 Hot Corrosion

Cleaner shall neither produce visual corrosion nor localized microscopic corrosion where the depth of attack is greater than 0.0003 inch (0.0075 mm), determined in accordance with 3.2.1.11.1 on the alloys shown in Table 2.

TABLE 2 - HOT CORROSION PARAMETERS

Panel Material	Bake Temperature °F	Bake Temperature °C
AMS4025 Aluminum Alloy	399	204
AMS4037 Aluminum Alloy	399	204
AMS4911 or MAM 4911 Titanium Alloy	900	482
AMS4916 Titanium Alloy	900	482
AMS5040 Carbon Steel, nickel-cadmium plated as in AMS2416	849	454
AMS5040 Carbon Steel, coated with MIL-C-81751, Type I, Class 4	750	399
AMS5504 Stainless Steel	1051	566
AMS5510 Stainless Steel	1600	871
AMS5536 Nickel Alloy	1600	871
AMS5544 Nickel Alloy	1600	871
AMS5608 Cobalt Alloy	1600	871

3.2.1.11.1 Degrease two 1 x 0.5 x 0.05 inch (25 x 13 x 1.3 mm) panels of each alloy using absorbent paper tissue and wiping with a suitable solvent and then with isopropanol. After drying at ambient temperature for 60 minutes ± 5, immerse one panel of each type in cleaning compound for 15 seconds, and air dry. Bake both panels of each type for 8 hours ± 0.1 at the indicated temperature ±9 °F (±5 °C). Cross-section, mount, and metallographically examine both the treated and control panels of each type at 250X magnification. Oxidation of the control can be deducted from test specimen corrosion.

3.2.1.12 Titanium Stress Corrosion

Cleaner shall produce no microscopic cracking of either AMS4911 or AMS4916 titanium alloy, determined in accordance with ASTM F 945, Method A.

3.2.2 Cleaner, Concentrated and Diluted

Class 1 cleaner, supplied as a concentrated liquid, and diluted to 20% by volume with ASTM D 1193, Type III, water and Class 2 cleaner, as supplied, shall meet the following requirements:

3.2.2.1 Total Immersion Corrosion

Cleaner shall neither show evidence of corrosion nor cause a weight change of any test panel greater than that shown in Table 3, determined in accordance with ASTM F 483 after 168 hours.

TABLE 3 - TOTAL IMMERSION CORROSION PARAMETERS

Panel Material	Weight Change mg/cm^2 per 24 hours, max
AMS4037 Aluminum Alloy, anodized as in AMS2470	0.3
AMS4041 Aluminum Alloy (optional)	0.3
AMS4049 Aluminum Alloy	0.3
AMS4376 Magnesium Alloy, dichromate treated as in AMS2475	0.2
AMS4911 Titanium Alloy	0.1
AMS5045 Carbon Steel	0.8

3.2.2.2 Sandwich Corrosion

Cleaner shall produce a rating not worse than 1, determined in accordance with ASTM F 1110.

3.2.2.3 Hydrogen Embrittlement

Cleaner shall be non-embrittling, determined in accordance with ASTM F 519, Type 1a, 1c, or 2a.

3.2.2.4 Effect on Painted Surfaces

Cleaner shall neither decrease the hardness of the paint film by more than two pencil hardness levels nor shall it produce any streaking, discoloration, or blistering of the paint film, determined in accordance with ASTM F 502.

3.2.3 Cleaner at Use Dilution

Class 1 cleaner diluted to 20% by volume with ASTM D 1193, Type III, water and Class 2 cleaner as supplied, shall meet the following requirements:

3.2.3.1 pH

Shall be 7.5 to 9.5, determined in accordance with ASTM E 70.

3.2.3.2 Effect on Silicone Elastomers

The cleaning compound shall not change the durometer hardness of elastomers by more than the amount shown in Table 4 after testing as specified in 3.2.3.2.2.

TABLE 4 - ALLOWABLE DUROMETER CHANGES IN SILICONE ELASTOMERS

Elastomer[(1)]	Change in Hardness, pts
Elastomer No. 1 (Dow Corning Silastic J)	±5
Elastomer No. 2 (Dow Corning 93-118)	±7
Elastomer No. 3 (General Electric RTV 159)	±5

Note: [(1)] Elastomers shall be as specified or equivalent molecular structure

3.2.3.2.1 Preparation of Test Specimens

Dow Corning elastomers Silastic J and 93-118 and General Electric elastomer RTV 159 or equivalent shall be mixed as specified by the manufacturer and pressed in a 1/8 inch (3.2 mm) thick sheet mold until cured. Silastic J and RTV 159 shall be cured at room temperature for one week, while 93-118 sealant shall be cured at 302 °F (150 °C) for 135 minutes. Two 1.0 x 2.0 inch (25 x 50 mm) specimens shall be cut from each cured sheet.

3.2.3.2.2 Test Procedure

Class 1 cleaning compounds shall be diluted to 20% by volume with ASTM D 1193, Type III, water for testing; Class 2 cleaning compound shall be tested as received. Immerse two specimens of each elastomer in the cleaning solution at 151 °F ± 2 (66 °C ± 1) for 30 minutes. Remove specimens from the solution, rinse with tap water, dry with paper towel, and test within 30 minutes for Shore A hardness in accordance with ASTM D 2240.

3.2.3.3 Effect on Epoxy Adhesives

The cleaning compound shall not decrease the pencil hardness of adhesive films by more than the amount shown in Table 5 when tested as specified in 3.2.3.3.2.

TABLE 5 - ALLOWABLE HARDNESS CHANGES IN ADHESIVE FILMS

Adhesive[1]	Decrease in Pencil Hardness Values, max
Adhesive No. 1 (3M Company AF 163)	3
Adhesive No. 2 (Dexter-Hysol EA 9689)	1

NOTE: [1]Adhesives as specified, or equivalent molecular structure

3.2.3.3.1 Preparation of Test Specimens

Using unprimed, 0.020 inch (0.51 mm) thick aluminum sheet, prepare 2 inch (51 mm) square panels coated with 0.005 to 0.010 inch (0.13 to 0.25 mm) of 3M Company AF163 adhesive, or equivalent, cured for 1 hour at 250 °F ± 2 (121 °C ± 1) at 40 psi (276 kPa). Panels coated with 0.005 to 0.010 inch (0.13 to 0.25 mm) of Dexter-Hysol EA 9649 adhesive, or equivalent, shall be cured for one hour at 351 °F ± 2 (177 °C ± 1) at 55 psi (379 kPa). Panels shall be cured in a press using a sheet of polyvinyl fluoride to ensure release of the adhesive coated panel from the top plate.

3.2.3.3.2 Test Procedure

Class 1 cleaning compounds shall be diluted to 20% by volume with ASTM D 1193, Type III, water for testing; Class 2 cleaning compound shall be tested as received. Immerse a 2-inch (51-mm) square test specimen in the cleaning solution at 151 °F ± 2 (66 °C ± 1) for 30 minutes. Remove specimens from the solution, rinse with tap water, dry with paper towel, and test for pencil hardness in accordance with ASTM F 502 after 24 hours at room temperature.

3.2.3.4 Effect on O-Ring Materials

The cleaning compound shall not change the durometer hardness of the elastomers by more than the amount shown in Table 6 after testing as specified in 3.2.3.4.1.

TABLE 6 - ALLOWABLE DUROMETER CHANGES IN O-RING MATERIALS

O-Ring Material	Change in Hardness, pts
AMS7267 Silicone Rubber	-10 to +5
AMS7271 Butadiene-Acrylonitrile Rubber	0 to +15
AMS7273 Fluorosilicone Rubber	-10 to 0
AMS7276 Fluorocarbon Rubber	-5 to +15