

Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting
Procurement Specification

1. SCOPE:

This SAE Aerospace specification establishes the requirements for heat cured solid film lubricants for aerospace fastener/threaded applications only. For other general or high temperature applications, see AS1701.

1.1 Application:

For aerospace fastener applications where temperatures may range from -68 to 204 °C (-90 to 400 °F).

1.2 Type:

This specification establishes the following types:

Type I: A cure temperature of 150 ± 15 °C (302 ± 27 °F) and endurance life of 250 min. Replaces MIL-L-46010, Type I.

Type II: A cure temperature of 204 ± 15 °C (400 ± 27 °F) and endurance life of 450 min. Replaces MIL-L-46010, Type II.

1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve use of hazardous materials, this specification does not address the hazards which may be involved in such use. The product manufacturer shall prepare materials safety data sheets (MSDS) in accordance with AMS 2825 and abide by MSDS requirements to ensure familiarity with the safe and proper handling of hazardous materials used and take necessary precautionary measures to ensure the health and safety of all personnel involved.

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FAX: (724) 776-0790

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SAE AS5272

2. REFERENCES:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2825 Material Safety Data Sheets
AS1701 Lubricants, Solid Dry Film

2.2 AIA Publication:

Available from AIA of America, Inc, 1250 Eye Street NW, Washington, DC 20005.

NAS850 General Packaging Standard
NAS854 Hazardous Material Packaging and Safety Data Sheet Preparation

2.3 US Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

TT-N-95 Naphtha, Aliphatic
QQ-A-250/5 Aluminum Alloy, Alclad 2024, Plate and Sheet
MIL-C-372 Cleaning Compound, Solvent for Bore of Small Arms and Automatic Weapons
FED-STD-791 Lubricants, Liquid Fuels, and Related Products, Methods of Testing
VV-D-1078 Damping Fluid, Silicone Base (Dimethyl Polysiloxane)
MIL-A-8243 Anti-icing and Deicing-Defrosting Fluid
MIL-A-8625 Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-L-14107 Lubricating Oil, Weapons, Low Temperature
DOD-P-16232 Phosphate Coatings, Heavy, Manganese or Zinc Base (for Ferrous Metals)
MIL-L-23699 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-156

MIL-L-46000 Lubricant, Semi-Fluid, (Automatic Weapon)
MIL-L-46010 Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting
MIL-H-46170 Hydraulic Fluid, Rust Inhibited, Fire Resistant, Synthetic Hydrocarbon Base
MIL-PRF-63460 Lubricant, Cleaner and Preservative for Weapons and Weapon Systems
MIL-T-83133 Turbine Fuel, Aviation, Kerosene Types
DOD-L-85336 Lubricant, All Weather (Automatic Weapons)

SAE AS5272

2.4 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 108	Steel Bars, Carbon, Cold-Finish, Standard Quality
ASTM A 167	Stainless and Heat-Resisting Chromium-Nickel-Steel Plate, Sheet and Strip
ASTM B 117	Salt Spray (Fog) Test
ASTM B 244	Measurement of Thickness of Anodic Coatings on Aluminum and Other Non-Conductive Coatings on Non-Magnetic Base Metals with Eddy Current Instruments
ASTM B 499	Measurements of Coatings Thicknesses by the Magnetic Method: Non-Magnetic Coatings on Magnetic Base Metals
ASTM D 56	Test Method for Flash Point by Tag Closed Tester
ASTM D 1141	Substitute Ocean Water
ASTM D 1186	Nondestructive Measurement of Dry Film Thickness of Nonmetallic Coatings Applied to a Ferrous Metal Base
ASTM D 1193	Reagent Water
ASTM D 1400	Nondestructive Measurement of Dry Film Thickness of Non-Conductive Coatings Applied to a Non-Ferrous Metal Base
ASTM D 2510	Adhesion of Solid Film Lubricants
ASTM D 2511	Thermal Shock Sensitivity of Solid Film Lubricants
ASTM D 2625	Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Method)
ASTM D 2649	Corrosion Characteristics of Solid Film Lubricants
ASTM F 22	Standard Test Method for Hydrophobic Surface Films by the Water-Break Test

3. REQUIREMENTS:

3.1 Materials:

Component materials used in the manufacturing of this lubricant shall consist essentially of finely powdered lubricating solids dispersed in a suitable liquid binder. The lubricant shall contain no graphite, powdered metal, or ozone depleting substances. Recycled materials may be used provided the lubricant meets the requirements of the specification. The lubricant shall be suitable for application by brushing, dipping, or spraying. The applied film for Type I shall be capable of being cured within 60 minutes at $150 \pm 15^\circ\text{C}$ ($302 \pm 27^\circ\text{F}$). The applied film for Type II shall be capable of being cured within 60 minutes at $204 \pm 15^\circ\text{C}$ ($400 \pm 27^\circ\text{F}$).

3.2 Film Appearance and Thickness:

The bonded solid film lubricant, when examined as specified in 4.4.1, shall appear uniform in color and shall be smooth, free from any cracks, scratches, pinholes, blisters, bubbles, runs, sags, foreign matter, grit, rough particles, or separation of ingredients. The thickness of the cured film for Types I and II shall be between 0.008 mm (.0003) and 0.013 mm (.0005) with no single reading less than 0.005 mm (.0002) or greater than 0.018 mm (.0007).

SAE AS5272

3.3 Performance Characteristics:

3.3.1 Film Adhesion: The bonded solid film lubricant, when tested as specified in Table 1, shall not be lifted to expose any bare metal surface. A uniform deposit of powdery material clinging to the tape is acceptable.

TABLE 1 - Quality Performance Inspection Tests

Characteristic	Test Method Government	Test Method ASTM	Requirement Paragraph
Film Thickness ¹			3.2
Aluminum		D 1400 or B 244	
Steel		D 1186 or B 499	
Film Adhesion		D 2510 Procedure A	3.3.1
Resistant to Fluids ^{2, 7}		D 2510 Procedure C	3.3.2
Thermal Stability ^{3, 7}		D 2511	3.3.3
Endurance Wear Life ^{4, 7}		D 2625 Procedure A	3.3.4
Load Carrying Capacity ^{4, 7}		D 2625 Procedure B	3.3.5
Aluminum Corrosion ⁵		D 2649	3.3.6
Sulfurous Acid/Salt Fog ⁶	FED-STD-791		3.3.7
Salt Spray (Fog) ⁵		B 117	3.3.8
Solid Content (See 4.4.2)	---	---	3.3.9
Storage Stability	FED-STD-791		3.3.10

¹ Film thickness is determined after panels are air dried then baked for 120 ± 5 min at 150 ± 15 °C (302 ± 27 °F) for aluminum or 60 ± 5 min at 204 ± 15 °C (400 ± 27 °F) for steel.

² Test fluids shall be in accordance with Table 2.

³ Any condensation shall be removed with clean, dry compressed air. The dried panel shall then be subjected to the film adhesion test.

⁴ The surface of test pins and vee-blocks shall be pretreated with phosphate in accordance with DOD-P-16232, Type Z or Type M, Class 3 with a weight to DOD-P-16232, Type Z or Type M, Class 3 with a weight of 11 to 22 g/m² after grit blasting, 180 to 220 grit aluminum oxide, 50 to 60 RMS.

⁵ All lubricant film thicknesses must conform to 3.3 when prepared in accordance with 4.3.2 before placing in salt fog cabinet in accordance with ASTM B 117.

⁶ The panels shall be subjected to four cycles. Each cycle consisting of 2 h spray time and 24 h drying time before inspection.

⁷ When performing ASTM D 2510, ASTM D 2625, or FED-STD-791 test methods, use naphtha, aliphatic conforming to TT-N-95 followed by acetone or any environmentally safe cleaner that sufficiently cleans surfaces to pass ASTM F 22, instead of MIL-T-27602, trichloroethylene, MIL-C-81302, trichlorotrifluoroethane, or MIL-T-81533, 1,1,1-trichloroethane.

3.3.2 Resistance to Fluids: The bonded solid film lubricant, when tested as specified in Table 1, after immersion in each of the fluids as specified in Table 2, shall not be lifted by the tape to expose any bare metal surface; nor shall the solid film lubricant soften, lift, blister, crack, or peel. A uniform deposit of powdery material clinging to the tape is acceptable.

SAE AS5272

TABLE 2 - Test Fluids

Test Fluid	Specification
Anti-Icing Fluid	MIL-A-8243
Cleaning Compound, Solvent for Bore of Small Arms and Automatic Weapons	MIL-C-372
Reagent Water	ASTM D 1193, Type III
Substitute Ocean Water	ASTM D 1141, Vol. 31
Hydraulic Fluid, Rust Inhibited, Fire Resistant, Synthetic Hydrocarbon Base	MIL-H-46170
Turbine Fuel, Aviation, Kerosene Types	MIL-T-83133, JP-8
Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	MIL-L-23699
Damping Fluid, Silicone Base (dimethyl polysiloxane)	VV-D-1078
Lubricating Oil, Weapons, Low Temperature	MIL-L-14107
Lubricant, Semi-Fluid (Automatic Weapons)	MIL-L-46000
Lubricant, Cleaner and Preservative for Weapons and Weapon Systems	MIL-PRF-63460
Lubricant, All Weather (Automatic Weapons)	DOD-L-85336

- 3.3.3 Thermal Stability: The thermal stability of the bonded solid film lubricant shall be such that, when tested as specified in 4.4, the film shall not flake, crack, or lift and shall conform to the requirements for film adhesion, (see 3.3.1).
- 3.3.4 Endurance Wear Life: When tested in four trials in accordance with Table 1, the bonded solid film lubricant shall have an average endurance life at 1000 pounds load (lbf) as follows:
- Type I: 250 minutes with no single test less than 210 minutes
Type II: 450 minutes with no single test less than 390 minutes
- 3.3.5 Load Carrying Capacity: When tested in two trials in accordance with Table 1, the bonded solid film lubricant shall have the following capacity:
- Type I: 2500 lbf (11,120 N) with no single test less than 2250 lbf (10,000 N).
Type II: 2000 lbf (8,900 N) with no single test less than 1750 lbf (7,780 N).
- 3.3.6 Aluminum Corrosion Resistance (Type I): When subjected to heat and high humidity conditions as specified in 4.4, the bonded solid film lubricant on anodized aluminum panels as specified in 4.3.2.1 shall not show or cause discoloration, pitting, formation of white deposits, or other evidence of corrosion.

SAE AS5272

- 3.3.7 Sulfurous Acid-Salt Spray (Type I): When applied to steel panels as specified in 4.3.2.2 and exposed to sulfurous acid-salt spray in accordance with Table 1, there shall be no resultant pitting, visible corrosion, or staining.
- 3.3.8 Salt-Spray (Fog) Test (Type II): The lubricant, after being applied to steel panels as specified in 4.3.2.2 shall show no more than three rust spots per panel, none greater than 1.0 mm (.039) in diameter after 100 h exposure to a 5% salt spray solution in a salt fog cabinet in accordance with ASTM B 117.
- 3.3.9 Solids Content: The lubricant shall contain not less than 40% by weight of solid material when tested as specified in 4.4.2.
- 3.3.10 Storage Stability: Qualification requirement only, the fluid lubricant, after a minimum storage period as specified in 4.4.3, shall conform to the requirements for endurance life, (see 3.3.4), and the sulfurous acid-salt spray, (see 3.3.7) for Type I or the salt -spray (fog) test (see 3.3.8) for Type II when tested as specified in 4.4.

3.4 Toxicity:

The lubricant shall have no adverse effects on human health when it is used as intended. Questions on toxicology shall be referred by the procuring activity to the appropriate departmental medical service after consulting the qualifying activity. A material safety data sheet shall be submitted as specified in 1.3.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer is responsible for all the performance of all inspecting requirements as specified herein. Except as otherwise specified in the contract or purchase order, and unless disapproved by the procuring activity, the manufacturer's own or any other facilities suitable for the performance of the inspection requirements specified herein, may be used. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

- 4.1.1 Responsibility for Compliance: All items shall meet all requirements of Sections 3 and 5. The inspection set forth in this specification shall become part of the manufacturer's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the manufacturer of the responsibility of assuring that all products or supplies submitted to the procuring activity for acceptance comply with all requirements of the contract or purchase order. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the procuring activity to acceptance of defective material.

SAE AS5272

4.2 Quality Conformance Inspection:

The quality conformance inspection shall consist of inspection of samples for tests (see 4.2.2) for all of the tests specified in Table 1, except for thermal stability (see 3.3.3), aluminum corrosion resistance (see 3.3.6), and storage stability (see 3.3.10), and inspection of samples of filled containers (see 4.2.3) for compliance to Section 5. Samples shall be labeled completely with information identifying the purpose of the sample, name of the product, specification number, lot and batch number, date of sampling, and contract or purchase number.

- 4.2.1 Lot or Batch: All lubricant manufactured as one batch shall be considered a lot and shall be numbered as such for purpose of inspection. A batch is defined as the end product of all the raw materials mixed or blended in a single operation.
- 4.2.2 Samples for Tests: The sample for test shall consist of four separate quarts of lubricant selected at random from each lot of lubricant. The lot shall be unacceptable if a sample fails to meet any of the test requirements specified.
- 4.2.3 Sample for Examination of Filled Containers: A random sample of filled containers shall be selected from each lot of lubricant in accordance with Table 3. Acceptance quality shall be based on zero defectives.

TABLE 3

Lot or Batch Size		Sample Size
1		1
2 to	8	2
9 to	15	3
16 to	25	5
26 to	50	8
51 to	90	13
91 to	150	20
151 to	280	32
281 to	500	50
501 to	1200	80

SAE AS5272

4.3 Inspection Conditions:

4.3.1 Atmospheric Conditions: Unless otherwise specified, all examinations and tests shall be performed at a temperature of 25 ± 3 °C (77 ± 5 °F) and at a relative humidity between 30 and 70%.

4.3.2 Preparation of Test Panels:

4.3.2.1 Preparation of and application to test Panels for Type I Solid Film Lubricant (Aluminum and CRES): The panels shall be made from aluminum alloy conforming to QQ-A-250/5, anodized to conform to MIL-A-8625, Type II sulfuric acid anodize, and measuring approximately 0.05 cm (.020) by 7.6 cm (3.00) by 15.2 cm (6.00); and corrosion resistant steel conforming to ASTM A 167, and measuring approximately 0.09 cm (.035) by 7.6 cm (3.00) by 15.2 cm (6.00). The panels shall be pre-cleaned with aliphatic naphtha conforming to TT-N-95 or any environmentally safe cleaner that sufficiently cleans surfaces to pass ASTM F 22. This cleaner shall not cause damage; i.e., hydrogen embrittlement, etc. to the surface being cleaned. The corrosion resistant steel panels shall have both faces and all edges grit-blasted with 180 to 220 grit aluminum oxide. Application of the lubricant shall be performed in a well ventilated area or hood where no fumes or ignition sources are present. Only one side of each panel shall be fully coated, except for two of the anodized aluminum panels which shall have the lubricant applied to a 2.54 cm (1.00) wide strip to enable measurement of the film thickness. A spray application technique shall be used to coat the panel for the tests specified herein. The solid film lubricant thickness, after cure, shall be 0.005 (.0002) to 0.013 mm (.0005). Three coats shall be the maximum number required to obtain the desired film thickness. Air drying at 25 ± 3 °C (77 ± 5 °F) for 10 min between coats is allowed. After the final coat has been applied, the coated specimens shall be allowed to air dry for 30 min, a flash cure at 65 to 79 °C (149 to 174 °F) for 10 to 30 min until dry to the touch is also permitted. The coated specimens shall then be placed in an air circulating oven at 150 ± 15 °C (302 ± 27 °F) for 1 h. The coated specimens shall be removed from the oven and allowed to cool to room temperature. At least two test panels specimens shall be used in each test method. A total of 30 aluminum panels and two corrosion resistant steel panels are required for testing in accordance with performance requirements of this specification.

SAE AS5272

4.3.2.2 Preparation of and application to test Panels for Solid Film Lubricant (Steel): The panels shall be made from steel panels approximately 0.32 cm (.126) by 7.6 cm (3.00) by 15.2 cm (6.00) conforming to ASTM A 108. The panels shall be pre-cleaned with aliphatic naphtha conforming to TT-N-95 or any environmentally safe cleaner that sufficiently cleans surfaces to pass ASTM F 22. This cleaner shall not cause damage; i.e., hydrogen embrittlement, etc. to the surface being cleaned. The steel panels shall have both faces and all edges grit-blasted with 180 to 220 grit aluminum oxide. Phosphate the panels, weight should be 11 to 22 g/m², in accordance with DOD-P-16232, using ASTM B 499 or ASTM D 1186 to measure the thickness of the phosphated panels. The steel panels shall be dipped or sprayed to the same thickness as specified for the aluminum panels, see 4.3.2.1. After air drying 30 min, a flash cure at 65 to 79 °C (149 to 174 °F) for 10 to 30 min until dry to the touch is also permitted, bake the panels in an air circulating oven at 150 ± 15 °C (302 ± 27 °F), Type I, or 204 ± 15 °C (400 ± 27 °F), Type II for 1 h. The coated specimens shall be removed from the oven and allowed to cool to room temperature. At least two test panels specimens shall be used in each test method. A total of two steel panels, two steel disks and six sets of pins and vee-block blocks are required for testing in accordance with performance requirements of this specification.

4.4 Methods of Inspection:

Methods of inspection shall be in accordance with Table 1 and 4.4.1 through 4.4.3.

- 4.4.1 Film Thickness and Appearance: The bonded solid film lubricant specimens shall be examined visually and microscopically at magnification of 12X for uniformity in color, smoothness and evidence of cracks, scratches, pinholes, blisters, bubbles, runs, sags, foreign matter, grit, rough particles, and separation of ingredients.
- 4.4.2 Solids Content: Stir the lubricant thoroughly, weigh 5.0 ± 0.5 grams into a disposable weighing dish, (Fisher Scientific catalog number 08 to 732, or equivalent). Place the dish and contents into a forced draft oven maintained at a temperature of 49 ± 3 °C (120 ± 5 °F) for 18 ± 1 h. Remove from oven and place in desiccator. Raise temperature of oven to 204 ± 3 °C (400 ± 5 °F) and replace dish with residue into 204 ± 3 °C (400 ± 5 °F) oven for 1 additional hour. Remove dish and contents and cool in a desiccator. When cool, weigh dish and contents. Calculate percent by weight of solids in fluid lubricant as shown in Equation 1:

$$\text{Percent total solids} = \frac{\text{Weight of solid materials (grams)}}{\text{Weight of sample (grams)}} \times 100 \quad (\text{Eq. 1})$$

- 4.4.3 Storage Stability: Set aside a one-quart qualification sample in a storage area maintained at 25 ± 3 °C (77 ± 5 °F) for a period of one year ± 7 days. At the end of the storage period, determine the endurance life, see 3.3.4, of the cured lubricant film, the sulfurous acid-salt spray, see 3.3.7 for Type I, and the salt-spray (fog) test, see 3.3.8 for Type II.