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400 Commonwealth Drive, Warrendale, PA 15096-0001

## AEROSPACE STANDARD

**SAE** AS1701

REV.  
A

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Submitted for recognition as an American National Standard

### LUBRICANT, SOLID DRY FILM

#### 1. SCOPE:

This document covers the performance requirements for solid dry film lubricants, air dried, or heat cured for use in aerospace applications. These lubricants are intended to prevent galling, and may be capable of remaining effective for extended periods of time after exposure to extreme environmental conditions.

##### 1.1 Field of Application:

The solid dry film lubricants covered by this document are intended for aerospace applications exposed to extreme environments. Some may be suitable for use in a vacuum at temperatures ranging from -365 °F to +1400 °F (-221 °C to 760 °C).

##### 1.2 Product Classification:

In this document is defined the various types of dry film lubricants, their temperature limitations, and compatibility usage (see Table 1).

##### 1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this document may involve the use of hazardous materials, this document does not address the hazards which may be involved in such use. The vendor 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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TABLE 1 - Types of Dry Film Lubricant

	Temperature Limits Min	Temperature Limits Max	Usage/Mil Spec	Primary Lubricant	Binder	Max Cure Temp	Thermal Stability ±15 °F (±8 °C)	Stress Corrosion Resistance
Class I	-65 °F (-54 °C)	+450 °F (+232 °C)	General Purpose: Titanium, Aluminum, Low/High Alloy Steels MIL-L-46010 Type I Solvent Base Type II Solvent Base Type III Water Base, Low VOC, No Lead	MoS <sub>2</sub>	Organic	400 °F (204 °C)	450 °F (232 °C)	Pass
Class II	-65 °F (-54 °C)	+450 °F (+232 °C)	General Purpose: Titanium, Aluminum, Low/High Alloy Steels MIL-L-46147 Type I Solvent Base Type II Low VOC	MoS <sub>2</sub>	Organic	Air Dry	450 °F (232 °C)	Pass
Class III	-65 °F (-54 °C)	+750 °F (+399 °C)	Corrosion Resistant Steels, Heat-Corrosion Resistant Steels, Titanium Alloys	MoS <sub>2</sub>	Organic or Inorganic	600 °F (316 °C)	750 °F (399 °C)	Pass
Class IV	-65 °F (-54 °C)	+1400 °F (+760 °C)	Corrosion Resistant Steels, Heat-Corrosion Resistant Steels, Waspalloy	Graphite	Inorganic	950 °F (510 °C)	1400 °F (760 °C)	Pass
Class V	-65 °F (-54 °C)	+850 °F (+454 °C)	Corrosion Resistant Steels, Heat-Corrosion Resistant Steels	MoS <sub>2</sub>	Inorganic	Heat Cure or Air Dry	850 °F (454 °C)	Pass
Class VI	-365 °F (-221 °C)	+850 °F (+454 °C)	Corrosion Resistant Steels, Heat-Corrosion Resistant Steels, Nickel- Based Alloys, Titanium Alloys for use with Fuels Oxidizers such as Hydrazine, LOX, Nitrogen Tetroxide UDMH	MoS <sub>2</sub>	Inorganic	500 °F (260 °C)	850 °F (454 °C)	Pass

## 2. APPLICABLE DOCUMENTS:

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. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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### 2.1 SAE Publications:

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

AMS 2488 Titanium Anodize  
AMS 2825 Material Safety Data Sheets

AS7108 National Aerospace and Defense Contractors Accreditation Program Requirements for Chemical Processing

### 2.2 ASTM Publications:

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

ASTM B 117 Test Method for Salt Spray (Fog) Testing  
ASTM E 595 Test Method for Total Mass Loss and Collected Volatile Condensable Materials From Outgassing in a Vacuum Environment  
ASTM D 1141 Substitute Ocean Water  
ASTM D 1186 Test Method for Non-Destructive Measurement of Dry Film Thickness of Non-Magnetic Coatings Applied to a Ferrous Base  
ASTM D 1193 Reagent Water  
ASTM D 1400 Test Method for Non-Destructive Measurement of Dry Film Thickness of Non-Conductive Coatings Applied to a Non-Ferrous Metal Base  
ASTM D 2510 Test Method for Adhesion of Solid Film Lubricants  
ASTM D 2512 Compatibility of Materials With Liquid Oxygen (Impact Sensitivity Threshold and Pass-Fail Techniques); Test Method for  
ASTM D 2625 Test Method for Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vee Method)  
ASTM D 2714 Test Method for Calibration and Operation of the Falex Block-On-Ring Friction and Wear Testing Machine  
ASTM D 3359 Test Method for Measuring Adhesion by Tape Test  
ASTM D 3951 Commercial Packaging

### 2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

DOD-P-16232 Phosphate Coatings, Heavy, Manganese or Zinc Base (For Ferrous Metals)  
MIL-B-131 Barrier Materials, Water Vaporproof, Greaseproof, Flexible, Heat-Sealable  
MIL-C-5541 Chemical Conversion Coatings on Aluminum and Aluminum Alloys  
MIL-H-5606 Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance  
MIL-T-5624 Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST  
MIL-L-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, Nato Code Number 0-148  
MIL-A-8243 Anti-Icing and Deicing-Defrosting Fluids  
MIL-A-8625 Anodic Coatings for Aluminum and Aluminum Alloys  
MIL-L-23699 Lubricating Oil, Synthetic Base

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### 2.3 (Continued):

MIL-L-46010	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting
MIL-L-46147	Lubricant, Solid Film, Air Cured, Corrosion Inhibiting
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, Nato Code Number H-537

O-M-232--	Methanol (Methyl Alcohol)
QQ-P-35--	Passivation Treatments for Corrosion-Resistant Steel
VV-D-1078	Damping Fluid, Silicone Base (Dimethyl Polysiloxane)

### 3. TECHNICAL REQUIREMENTS:

#### 3.1 General:

The lubricants shall not contain silver or its compounds; lead or halogenated solvents as part of their formulations. The lubricants shall consist essentially of lubricating solids, dispersed in a suitable binder and be capable of being applied by either brushing, spraying, or dipping. The user should know which lubricants cause detrimental effects for the applications used on.

3.1.1 Physical Properties: The application of the lubricants to the product, including curing, shall have no adverse effect on the physical or mechanical properties of the product.

3.1.2 Process Application: Process application shall be in accordance with the requirements of AS7108.

#### 3.2 Lubricant Composition:

The composition of the dry film lubricant shall be such to produce cured film coatings capable of meeting the requirements of this document.

#### 3.3 Bonding Capability:

The solid dry film lubricants shall be capable of being applied as a coating to specified surface(s), completely cured, and ready for use. For testing requirements in 3.4 through 3.12, the lubricant shall be completely cured and bonded to panels, specimens, or actual parts.

3.3.1 Surface Treatment of Parts: To obtain maximum adhesion and to minimize the possibility of surface contamination, surfaces of parts shall be treated per Table 2 prior to the coating application unless otherwise specified in the purchase order or applicable drawing.

#### 3.4 Coating Thickness:

Unless otherwise specified, the coating thickness will be 0.0002 to 0.0005 in thick (0.0051 to 0.0127 mm thick) when determined in accordance with 4.2.1.

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## 3.5 Film Adhesion:

The solid film lubricants when tested in accordance with 4.2.2 shall not be lifted from the test panel or part such that the substrate is exposed. The coatings may have a uniform deposit of powdery material clinging to the tape.

3.5.1 Fluid Resistance: The lubricant film shall not flake, crack, peel, or be removed when tested according to 4.2.2.1.

TABLE 2 - Surface Treatment Prior to Coating

Material	Surface Treatment Prior to Coating Application
Carbon, Low Alloy and Magnetic Steels and 400 Series Stainless Steels	(a) Degrease with approved alkaline cleaner or vapor degrease (b) Unplated parts only: Dry grit blast with 120-400 mesh aluminum oxide at a blasting pressure of 40 psi $\pm$ 10 psi (2.758 (10) <sup>5</sup> Pa $\pm$ 6.894 (10) <sup>4</sup> Pa).
Precipitation Hardened and 300 Series Stainless Steel	(a) Degrease with approved alkaline cleaner or vapor degrease (b) Unplated parts only: Dry grit blast with 120-400 mesh aluminum oxide at a blasting pressure of 40 psi $\pm$ 10 psi (2.758 (10) <sup>5</sup> Pa $\pm$ 6.894 (10) <sup>4</sup> Pa). (c) Passivate, QQ-P-35
Super Alloys, High Nickel Base Alloys and Other Corrosion Resistant Steels	(a) Degrease with approved alkaline cleaner or vapor degrease (b) Unplated parts only: Dry grit blast with 120-400 mesh aluminum oxide at a blasting pressure of 40 psi $\pm$ 10 psi (2.758 (10) <sup>5</sup> Pa $\pm$ 6.894 (10) <sup>4</sup> Pa). (c) Passivate, QQ-P-35
Aluminum Alloys	(a) Degrease with approved alkaline cleaner or vapor degrease (b) Unplated parts only: Dry grit blast with 120-240 mesh aluminum oxide to an optimum surface roughness of about 32 Rd (c) Chromate per MIL-C-5541 or anodize per MIL-A-8625
Titanium Alloys	(a) Degrease with approved alkaline cleaner (b) Unplated parts only: Dry grit blast with 120-240 mesh aluminum oxide or alkaline anodize per AMS 2488

## 3.6 Thermal Stability:

The lubricant film shall not flake, crack, or peel and shall meet the requirements of 3.5 and 3.10 when tested in accordance with 4.2.3.

**SAE AS1701 Revision A****3.7 Vacuum Stability:**

The lubricant film shall show a total mass loss of less than or equal to 1.0% and collected volatile condensable material measurement less than or equal to 0.1%, when tested in accordance with 4.2.4.

**3.8 Shock Sensitivity to Liquid Oxygen:**

The lubricant film, shall show no adverse reaction to liquid oxygen when tested in accordance with 4.2.5.

NOTE: This requirement pertains to Class VI lubricants only.

**3.9 Film Appearance:**

The lubricant film shall appear free from cracks, scratches, blisters, foreign matter or other surface imperfections when examined in accordance with 4.2.6.

**3.10 Corrosion Resistance:**

Class I and II lubricants shall show no signs of substrate corrosion greater than 1/16 inch in diameter when tested in 4.2.7, exposure times shall be 100 h for Class I and 72 h for Class II.

NOTE: All other classes are designed for corrosion resistant alloys and materials.

**3.11 Coefficient of Friction:**

The lubricant film shall have a static coefficient of friction between 0.07 to 0.13 when tested in accordance with 4.2.8.

**3.12 Wear Requirements:****3.12.1 Class I Lubricants:**

**3.12.1.1 Endurance Life:** The lubricant shall have an average Falex endurance life of 450 min at 1000 lbf (4450 N) load, 750 lbf (3336 N) load on the direct reading gauge. No single test shall be less than 390 min.

**3.12.1.2 Load Carrying Capacity:** The lubricant shall have an average Falex load carrying capacity of not less than 2500 lbf (11 120 N) gauge. No single test shall be less than 2250 lbf (10 010 N).

**3.12.2 Class II Lubricants:**

**3.12.2.1 Endurance Life:** The lubricant shall have an average Falex endurance life of 60 min at 1000 lbf (4450 N) load. No single test shall be less than 56 min.

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3.12.2.2 Load Carrying Capacity: The lubricant shall have an average Falex load carrying capacity of not less than 2500 lbf (11 120 N) gauge. No single test shall be less than 2000 lbf (8896 N).

3.12.3 Test Specimen Preparation: Lubricants shall be applied to phosphated steel specimens in accordance with DOD-P-16232 Type M Class 3. The cured lubricant shall have a film thickness of 0.0002 to 0.0005 in thick (0.0051 to 0.0127 mm thick) when determined in accordance with 4.2.1.2.

3.12.4 Test Method: Testing shall be in accordance with ASTM D 2625.

**4. QUALITY ASSURANCE PROVISIONS:****4.1 Responsibility for Inspection:**

Unless otherwise specified in the contract or purchase order, the vendor is responsible for the performance of all test and inspection requirements as specified herein. Except as otherwise specified, the vendor may use his/her own or any commercial laboratory acceptable to the purchaser. The purchaser has the right to perform any inspection set forth in the document whenever it is deemed necessary to assure that the item conforms to prescribed requirements.

**4.2 Classification of Tests:****4.2.1 Coating Thickness Measurement:**

4.2.1.1 Nonferrous Material: Coating thickness shall be determined in accordance with ASTM D 1400.

4.2.1.2 Ferrous material: Coating thickness shall be determined in accordance with ASTM D 1186.

4.2.2 Film Adhesion: Film adhesion shall be determined in accordance with ASTM D 3359 Test Method B.

4.2.2.1 Fluid Resistance: Test the coated parts in accordance with ASTM D 2510 procedure C, in the liquids specified below:

- a. ASTM D 1141 Vol. 31
- b. MIL-A-8243
- c. VV-D-1078
- d. MIL-H-83282
- e. MIL-H-5606
- f. MIL-L-23699
- g. MIL-L-7808
- h. MIL-T-5624
- i. Methanol (O-M-232) 44 parts by volume and Reagent water (D1193) 56 parts by volume

The lubricant shall not demonstrate softening, blistering, discoloration, undercutting, or loss of adhesion.