SAE INTERNATIONAL

AEROSPACE STANDARD

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Superseding AS1701C

(R) Lubricant, Solid Film

RATIONALE

Delete AS7108, clarify thickness requirements for coating of threads, clarify tape test requirements, update references, and general revision.

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 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 to +1400 °F (-221 to 760 °C).

1.2 Product Classification

In this document is defined the various classes of solid 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 product vendor shall prepare materials safety data sheets (MSDS) in accordance with ANSI Z400.1 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 - CLASSES OF SOLID FILM LUBRICANTS

Class	Temperature Limits Min	Temperature Limits Max	Usage	Primary Lubricant	Binder	Cure	Thermal Stability ±15 °F (±8 °C)	Corrosion Resistance
Class I	-65 °F (-54 °C)	+450 °F (+232 °C)	General Purpose: Titanium, Aluminum, Low/High Alloy Steels	MoS_2	Organic	Heat Cure	450 °F (232 °C)	Pass
Class II	-65 °F (-54 °C)	+450 °F (+232 °C)	General Purpose: Titanium, Aluminum, Low/High Alloy Steels	MoS_2	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_2	Organic	Heat Cure	750 °F (399 °C)	Pass
Class IV	-65 °F (-54 °C)	+1400 °F (+760 °C)	Corrosion Resistant Steels, Heat-Corrosion Resistant Steels Waspalloy	Inorganic Pigments	Inorganic	Heat Cure	1400 °F (760 °C)	Pass
Class V	-65 °F (-54 °C)	+850 °F (+454 °C)	Corrosion Resistant Steels, Heat-Corrosion Resistant Steels	MoS_2	Inorganic	Air Dry or Heat Cure	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 UDM11	MoS_2	Inorganic	Heat Cure	850 °F (454 °C)	Pass

2. APPLICABLE DOCUMENTS

The following publications form a part of this document 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 document and 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.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1-724-776-4970 (outside USA), www.sae.org.

AMS1424 Deicing/Anti-Icing Fluid, Aircraft, SAE Type I

AMS2488 Anodic Treatment - Titanium and Titanium Alloys - Solution pH 13 or Higher

AMS2700 Passivation of Corrosion Resistant Steels

2.2 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI Z400.1/Z129.1 Hazardous Workplace Chemicals - Hazard Evaluation And Safety Data Sheet And Precautionary Labeling Preparation

2.3 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 B117 Test Method for Salt Spray (Fog) Testing

ASTM E595 Test Method for Total Mass Loss and Collected Volatile Condensable Materials From Outgassing in a Vacuum Environment

ASTM D1141 Substitute Ocean Water

ASTM D1193 Reagent Water

ASTM D2510 Test Method for Adhesion of Solid Film Lubricants

ASTM D2512 Compatibility of Materials With Liquid Oxygen (Impact Sensitivity Threshold and Pass-Fail Techniques), Test Method for

ASTM D2625 Test Method for Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vee Method)

ASTM D2714 Test Method for Calibration and Operation of the Falex Block-On-Ring Friction and Wear Testing Machine

ASTM D3359 Test Method for Measuring Adhesion by Tape Test

ASTM D7901 Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applies to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

2.4 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, http://quicksearch.dla.mil/.

MIL-DTL-16232 Phosphate Coatings, Heavy, Manganese or Zinc Base (For Ferrous Metals)

MIL-DTL-5541 Chemical Conversion Coatings on Aluminum and Aluminum Alloys

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST

MIL-PRF-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, Nato Code Number 0-148

MIL-A-8625 Anodic Coatings for Aluminum and Aluminum Alloys

MIL-PRF-23699 Lubricating Oil, Aircraft Turbine Engine, Nato Code Number 0-156

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, Nato Code Number H-537

O-M-232 Methanol (Methyl Alcohol)

VV-D-1078 Damping Fluid, Silicone Base (Dimethyl Polysiloxane)

3. TECHNICAL REQUIREMENTS

3.1 General

The solid dry film lubricants shall not contain silver or its compounds, lead or halogenated solvents as part of their formulations. Class IV lubricants shall not contain molybdenum disulfide or other sulfur bearing compounds. 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 in which they are used.

3.1.1 Physical Properties

The application of the solid film lubricants to the product or component, 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 the manufacturer's technical data sheet.

3.2 Lubricant Composition

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

3.3 Bonding Capability

The solid 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 on external surfaces requiring coating shall be 0.0002 to 0.0005 inch thick (0.0051 to 0.0127 mm thick) when determined in accordance with 4.2.1. Unless otherwise specified, internal surfaces requiring coating shall show complete coverage with no restrictions on thickness when determined visually with no magnification. Surfaces defined as coating optional, external or internal shall not be inspected for coverage or thickness.

3.4.1 Internally Threaded Components

Unless otherwise specified on the part drawing or product specification, for internally threaded fasteners (e.g., nuts, inserts), the cured film for all types shall show complete coverage in the threaded area with no requirement for thickness verification other than visual. The coated internal threads shall permit a minimum free rotation of three-quarters turn on a corresponding mating bolt.

3.4.2 Externally Threaded Components

Unless otherwise specified on the part drawing or product specification, for externally threaded fasteners (e.g., bolts, studs), the cured film for all types shall show complete coverage with no requirement for thickness verification other than visual in the threaded area. The coated external threads shall permit a minimum free rotation of three-quarters turn on a corresponding mating nut or ring gage (GO).

3.5 Film Adhesion

The bonded solid film lubricant, when tested in accordance with 4.2.2, shall not be lifted to expose any bare metal surface. For threaded fasteners, the coating shall be continuously bonded to the fastener and shall not display loss of adhesion or separation from the fastener when examined at a magnification of 4X.

3.5.1 Fluid Resistance

The lubricant film shall not flake, crack, peel, or be removed when tested according to 4.2.2.3.

TABLE 2 - SURFACE TREATMENT PRIOR TO COATING

Material	Surface Treatment Prior to Coating Application
Carbon and Low Alloy Steels	(a) Degrease with alkaline cleaner, solvent cleaner, or vapor degrease (b) Unplated parts only: Dry grit blast with 120-400 mesh aluminum oxide. (c) Phosphate per MIL-DTL-16232 type M or Z Class 3.
Precipitation Hardened, 300 Series and 400 Series Stainless Steel, Other Corrosion Resistant Steels, Nickel Base Alloys, and Super Alloys	(a) Degrease with alkaline cleaner, solvent cleaner or vapor degrease (b) Unplated parts only: Dry grit blast with 120-400 mesh aluminum oxide. (c) Passivate, AMS2700.
Aluminum Alloys	(a) Degrease with alkaline cleaner, solvent cleaner, or vapor degrease (b) Unplated parts only: Dry grit blast with 120-400 mesh aluminum oxide, or equivalent to an optimum surface roughness of about 32 RHR. (c) Chromate per MIL-DTL-5541 or anodize per MIL-A-8625.
Titanium Alloys	(a) Degrease with alkaline cleaner (b) Unplated parts only: Dry grit blast with 120-240 mesh aluminum oxide, or equivalent, or alkaline anodize per AMS2488.

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.

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.

NOTE: This requirement pertains to Class VI lubricants only.

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 lubricant films 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 hours for Class I and 72 hours 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 of 0.03 to 0.13 when tested in accordance with 4.2.8 and the test shall be performed in an oscillatory mode if static coefficient is to be determined.

3.12 Wear Requirements

3.12.1 Class I Lubricants

3.12.1.1 Endurance Life

The lubricant film shall have an average Falex endurance life of 450 minutes at 1000 pound-force (4450 N) load, 750 pound-force (3336 N) load on the direct reading gauge. No single test shall be less than 390 minutes when tested in accordance to 4.2.9.

3.12.1.2 Load Carrying Capacity

The lubricant film shall have an average Falex load carrying capacity of not less than 2500 pound-force (11120 N) gauge. No single test shall be less than 2250 pound-force (10010 N) when tested in accordance with 4.2.9.

3.12.2 Class II Lubricants

3.12.2.1 Endurance Life

The lubricant film shall have an average Falex endurance life of 90 minutes at 1000 pound-force (4450 N) load. No single test shall be less than 75 minutes when tested in accordance with 4.2.9.

3.12.2.2 Load Carrying Capacity

The lubricant film shall have an average Falex load carrying capacity of not less than 2500 pound-force (11120 N) gauge. No single test shall be less than 2000 pound-force (8896 N) when tested in accordance to 4.2.9.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Qualification Tests/Inspection

The product manufacturer is responsible for the qualification tests and inspection requirements as specified in 4.1.1 and 4.1.2. The coating vendor is responsible for the inspection requirements as specified in 4.1.3.

4.1.1 Qualification Tests

Solid film lubricant products that are supplied in compliance with this document shall be products that have passed all the requirements specified in Section 3 as applicable to each class.

4.1.2 Acceptance Tests for Product

Each batch/lot of solid dry film lubricant product shall pass the tests (as applicable to the product class) for coating thickness (3.4), film adhesion (3.5), film appearance (3.9), and wear life requirements (3.12).

4.1.3 Acceptance Tests for Processed/Coated Parts

Each lot of processed/coated parts shall pass the tests for coating thickness (3.4), film adhesion (3.5), and film appearance (3.9).

4.2 Classification of Tests

4.2.1 Coating Thickness Measurement

Coating thickness shall be determined in accordance with ASTM D7901.

4.2.2 Film Adhesion

Film adhesion shall be determined in accordance with ASTM D3359 Test Method B.

4.2.2.1 Threaded Fasteners

Apply a length of 1 inch wide tape per 4.2.2.2 to the shank of an externally threaded fastener or the bearing surface of an internally threaded fastener. Remove the tape with a quick motion and examine tape and part for lifting of the coating from the shank or bearing surface. A uniform deposit of powdery material may cling to the tape, but the lifting of any flakes or particles of the lubricant, which exposes a base metal surface on the part shall be cause for rejection

4.2.2.2 Tape

Tape for film adhesion test shall be 3M Company No. 250 tape (or equivalent; i.e., 1 inch wide, paper backed, pressure sensitive masking tape, with an adhesive strength greater than or equal to 25 ounce/inch when tested in accordance with ASTM D3330/D3330M procedure A). The tape shall be no older than 6 months from the date of manufacturing if stored in an uncontrolled environment. The tape shall be no older than 1 year from the date of manufacture if maintained indoors in a controlled environment of 40 to 90 °F and 10 to 70% relative humidity.

4.2.2.3 Fluid Resistance

Test the coated panels in accordance with ASTM D2510 procedure C, in the liquids specified below:

a. ASTM D1141 Vol. 31

b. AMS1424

c. VV-D-1078

d. MIL-PRF-83282

e. MIL-PRF-23699

f. MIL-PRF-7808

g. MIL-DTL-5624

h. Methanol (O-M-232) 44 parts by volume and Reagent water (D1193) 56 parts by volume