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AEROSPACE STANDARD

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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. They may be suitable for use in a vacuum at temperatures ranging from -365 °F to +1400 °F (-200 °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 user 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.

TABLE 1 - Types of Dry Film Lubricant

	Temperature Limits Min	Temperature Limits Max	Usage	Primary Lubricant	Binder	Max Cure Temp.	Thermal Stability ±15 °F (±8 °C)	Stress Corrosion Resistance
Type I	-65 °F (-54 °C)	+450 °F (232 °C)	General Purpose: Titanium, Aluminum, Low/High Alloy Steels	MoS_2	Epoxy/ Phenolics	400 °F (204 °C)	450 °F (232 °C)	Pass
Type II	-65 °F (-54 °C)	+450 °F (+232 °C)	General Purpose: Titanium, Aluminum, Low/High Alloy Steels	MoS_2	Epoxy	Air Dry	450 °F (232 °C)	Pass
Type III	-65 °F (-54 °C)	+750 °F (+399 °C)	Corrosion Resistant Steels - Heat Corrosion Resistant Steels, Titanium Alloys	MoS_2	Polyamide-imide	600 °F (316 °C)	750 °F (399 °C)	Pass
Type IV	-65 °F (-54 °C)	+1400 °F (+760 °C)	Corrosion Resistant Steels - Heat Corrosion Resistant Steels, Waspalloy	Graphite	Phosphate	750 °F (400 °C)	1400 °F (760 °C)	Pass
Type V	-65 °F (-54 °C)	+850 °F (+454 °C)	Corrosion Resistant Steels - Heat Corrosion Resistant Steels	MoS_2	Silicone	Air Dry 24 h	850 °F (454 °C)	Pass
Type VI	-365 °F (-220 °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_2	Phosphate, Silicone or Silicate	500 °F (260 °C)	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.

2.1 SAE Publications:

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

AMS 2825 Material Safety Data Sheets
AMS 5731 Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant Steel
AMS 5734 Steel Bars, Forgings, and Tubing, Corrosion and Heat Resistant Steel
AS7466 Bolts and Screws, Nickel Alloy, Corrosion and Heat Resistant Forged Head, Roll Threaded, Fatigue Rated
AS7467 Bolts and Screws, Nickel Alloy, Corrosion and Heat Resistant Forged Head, Roll Threaded, Stress-Rupture Rated

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 117	Test Method for Salt Spray (Fog) Testing
ASTM E 595	Test Method for Total Mass Loss and Collected Volatile Condensible 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

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 O-148
MIL-A-8243	Anti-Icing and Deicing-Defrosting Fluids
MIL-L-23699	Lubricating Oil, Synthetic Base
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, Nato Code Number H-537
MIL-STD-1312-9	Fastener Test Method 9, Stress Corrosion
MIL-STD-2073-1	DOD Material Procedures for Development and Application of Packaging Requirements
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, halogens, or halogenated compounds 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.

3.2 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 3.13, the lubricant shall be completely cured and bonded to panels 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.

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.

3.6 Stress Corrosion Resistance:

The lubricant film shall not, when tested in accordance with 4.2.3, induce embrittlement or corrosion in specimens while under load after 500 h alternate immersion.

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 (b) Dry grit blast with 120-400 mesh aluminum oxide at a blasting pressure of 40 psi ± 10 psi (2.758 $(10)^5$ Pa ± 6.894 $(10)^4$ Pa)
Precipitation Hardened and 300 Series Stainless Steel	(a) Degrease with approved alkaline cleaner (b) Dry grit blast with 120-400 mesh aluminum oxide at a blasting pressure of 40 psi ± 10 psi (2.758 $(10)^5$ Pa ± 6.894 $(10)^4$ Pa) (c) Passivate, QQ-P-35
Super Alloys, High Nickel Base Alloys and Other Corrosion Resistant Steels	(a) Degrease with approved alkaline cleaner (b) Dry grit blast with 120-400 mesh aluminum oxide at a blasting pressure of 40 psi ± 10 psi (2.758 $(10)^5$ Pa ± 6.894 $(10)^4$ Pa) (c) Passivate, QQ-P-35
Aluminum Alloys	(a) Degrease with approved alkaline cleaner (b) Dry grit blast with 120-240 mesh aluminum oxide to an optimum surface roughness of about 32 Rd (c) Chromate per MIL-C-5541
Titanium Alloys	(a) Degrease with approved alkaline cleaner (b) Dry grit blast with 120-240 mesh aluminum oxide

3.7 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 4.2.4.

3.8 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 4.2.5.

3.9 Shock Sensitivity to Liquid Oxygen:

The lubricant film, shall show no adverse reaction to liquid oxygen when tested in accordance with 4.2.6.

NOTE: This requirement pertains to Type VI lubricants only.

3.10 Film Appearance:

The lubricant film shall appear free from cracks, scratches, blisters, foreign matter or other surface imperfections when examined in accordance with 4.2.7.

3.11 Corrosion Resistance:

Type I and II lubricants shall show no signs of substrate corrosion greater than 1/16 in in diameter when tested in 4.2.8, exposure times shall be 100 h for Type I and 72 h for type II.

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

3.12 Coefficient of Friction:

The lubricant film shall have a coefficient of friction between 0.07 to 0.13 when tested in accordance with 4.2.9.

3.13 Wear Requirements:

3.13.1 Type I Lubricants:

3.13.1.1 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.

3.13.1.2 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).

3.13.2 Type II Lubricants:

3.13.2.1 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.

3.13.2.2 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).

3.13.3 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.

3.13.4 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.