

AEROSPACE MATERIAL SPECIFICATION

Lubricant, Semi-Fluid, for Aircraft Gearboxes

1. SCOPE:

1.1 Form:

This specification covers semi-fluid lubricant suitable for use in aircraft gearboxes and transmissions.

1.2 Application:

This product has been used typically for lubricating transmissions in wing slat/flap actuators in certain aircraft, and other mechanisms, but usage is not limited to such applications.

1.3 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.

2. APPLICABLE DOCUMENTS:

The issue of the following documents in effect on the date of the purchase order form 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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 ASTM Publications:

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

ASTM D 942 Oxidation Stability of Lubricating Greases by the Oxygen Bomb Method

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright 2000 Society of Automotive Engineers, Inc.
All rights reserved.

Printed in U.S.A.

QUESTIONS REGARDING THIS DOCUMENT:
TO PLACE A DOCUMENT ORDER:
SAE WEB ADDRESS:

(724) 772-7161
(724) 776-4970
<http://www.sae.org>

FAX: (724) 776-0243
FAX: (724) 776-0790

2.2 ISO Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002, and from Beuth Verlag GmbH, Burggrafenstrasse 6, D-10787 Berlin, Germany.

- | | |
|-----------|--|
| ISO 1817 | Elastomers; Determination of the Resistance to Liquids |
| ISO 10337 | Testing of Mineral Oil Hydrocarbons and Solvents; Determination of Water Content According to Karl Fischer; Indirect Method |
| ISO 14596 | Mineral Oils and Fuels; Determination of Sulfur Content (Total Sulfur); Analysis by Wavelength Dispersive X-Ray Spectrometry (XRS) |

2.3 DIN Publications:

Available from Beuth Verlag GmbH, Burggrafenstrasse 6, D-10787 Berlin, Germany.

- | | |
|-------------|---|
| DIN 50017 | Climates and Their Technical Application; Condensated Water Containing Climates |
| DIN 51363-2 | Testing of Mineral Oils; Determination of Phosphorus Content of Lubrication Oils and Additives; Analysis by X-ray Spectrometry (XRS) |
| DIN 51391-2 | Testing of Lubricants; Determination of the Content of Additive Elements; Analysis by Wavelength Dispersive X-ray Spectrometry (XRS) |
| DIN 51398 | Testing of Lubricants; Procedure for Measurement of Low Temperature Apparent Viscosity by Means of the Brookfield Viscometer (Liquid Bath Method) |
| DIN 51808 | Testing of Lubricants; Determination of Oxidation Stability of Greases; Oxygen Method |

2.4 CEC Publications:

Available from SAE Order Department 782, 400 Commonwealth Drive, Warrendale, PA 15096, USA (outside Europe), and from CEC Secretariat, Madou Plaza, 25th Floor, Place Madou 1, B-1210 Brussels, Belgium (within Europe).

- | | |
|---------------|---|
| CEC-L-07-A-95 | Load Carrying Capacity Test for Transmission Lubricants (FZG Gear Machine) |
| CEC-L-45-A-99 | Viscosity Shear Stability of transmission lubricants (Taper Roller Bearing Rig) |

2.5 Liebherr Publications:

Available from Liebherr Aerospace Lindenberg GmbH, Depm. EB, P.O. Box 1363, D-88153 Lindenberg – Germany.

- | | |
|--------------|----------------|
| PA-697510-01 | Actuator typ A |
| PA 697511-02 | Actuator typ B |

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

This semi-fluid lubricant shall consist of a diester base fluid thickened with a lithium stearate soap and other suitable additives (corrosion protection, EP additives). (See 8.1).

3.2 Properties:

The lubricant shall conform to the requirements shown in Table 1, determined in accordance with test methods as defined in Table 1.

TABLE 1 - Properties

Paragraph	Property	Requirement	Test Method
3.2.1	Appearance	Smooth homogenous uniform appearance, free from lumps, abrasive materials and undesirable fillers and impurities	Visual examination
3.2.2	Viscosity, At 20 °C (68 °F)	1.5 to 2.7 Pa·s (1500 to 2700 centipoise)	4.6.1
3.2.3	Viscosity, Low Temperature, max, at -56 °C (-69 °F)	1000 Pa·s (10,000 poise)	4.6.1
3.2.4	Shear Stability		CEC-L-45-A-99 (The adaptor per App. 1 must be used.)
	Viscosity after 1 hour	1.5 to 2.7 Pa·s (1500 to 2700 centipoise)	4.6.1
	Viscosity after 20 hours	1.2 to 2.7 Pa·s (1200 to 2700 centipoise)	4.6.1
3.2.5	Separation after 168 hours, max	10 mg/cm ²	4.6.2
3.2.6	Water Content, max	1500 mg/kg	ISO 10337
3.2.7	Infrared Spectrum	Identical to qualification sample	-
3.2.8	Additive Concentration as analyzed by elements, ppm: Phosphorus Sulfur Calcium	Qualification sample value ±20%	X-ray-spectrometry: P: DIN 51363-2 S: ISO 14596 Ca: DIN 51391-2
3.2.9	Volume Change at 10 kPa (1.45 psia), max	50%	4.6.3

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	Test Method
3.2.10	Oxidation Stability, 100 hours at 99 °C ± 0.5 (210 °F ± 1) max pressure drop	50 kPa	DIN 51808 or ASTM D 942
3.2.11	Corrosion Protection	No rust	4.6.4
3.2.12	Wear Protection, max wear	12 mg	4.6.5
3.2.13	Elastomer Compatibility Volume change	-2 to + 20%	ISO 1817 and 4.6.6, 120 °C (248 °F) 168 hours
3.2.14	PAT-test (incl. low temperature)	Pass	PA-697510-01 PA 697511-02 Tests per Chapters 4.5/4.7/4.8/4.10 with at least 5 actuators.

3.3 Storage Stability:

The lubricant shall have a minimum shelf life of 24 months in its original and unopened packaging at storage temperatures of between -30 °C and +50 °C (-22 and 122 °F).

3.4 Qualification:

Material furnished under this specification shall be products which are authorized by the qualifying agency for listing on the applicable qualified products list at the time of contract award. (See 4.2.1.1.)

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of the lubricant shall supply all samples for manufacturer's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and perform any confirmatory testing deemed necessary to ensure that the semi-fluid lubricant conforms to the specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for the following requirements are acceptance tests and shall be performed on each batch:

Appearance	(3.2.1)
Viscosity at 20 °C (68 °F)	(3.2.2)
Viscosity, Low Temperature, at -56 °C (69 °F)	(3.2.3)
Shear Stability	(3.2.4)
Separation after 168 hours	(3.2.5)
Water Content	(3.2.6)
IR Spectrum	(3.2.7)
Additive Concentration	(3.2.8)
Volume Change	(3.2.9)

4.2.2 Qualification Tests: All technical requirements are qualification tests and shall be performed prior to or on the initial shipment of lubricant to a purchaser, when a change in ingredients and/or processing requires reapproval as in 4.4.1.1, and when purchaser deems confirmatory testing to be required.

4.2.2.1 Qualification: For qualification, all tests described in Table 1 shall be performed by an approved laboratory authorized by the purchaser, for release of a new semi-fluid lubricant to this specification. The laboratory will provide a recommendation for release to the purchaser who then has authority and may make a final release. In cases of deviation in composition or manufacturing process, written notification is required and such deviations are permissible only after receiving release by the purchaser.

4.3 Sampling and Testing:

4.3.1 For Acceptance Tests: Sufficient lubricant shall be taken at random from each batch to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure.

4.3.1.1 A batch is defined as a quantity of formulated material mixed as one production entity.

4.4 Approval:

4.4.1 Lubricant shall be approved by purchaser before lubricant for production use is supplied, unless such approval be waived by purchaser. Results of tests on the production lubricant shall be essentially the equivalent to those on the approved (qualified) sample.

- 4.4.2 Manufacturer shall use ingredients, manufacturing procedures, processes, and methods of inspection on production product which are essentially the same as those used on the approval sample. If necessary to make any change in ingredients, the place of production, in type of equipment for processing, or in manufacturing procedures, manufacturer shall submit for reapproval a statement of the proposed changes in ingredients and/or processing and, when requested, sample product. Production product made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

- 4.5.1 Standard Tolerances: Unless otherwise specified herein, standard tolerances of Table 2 shall apply.

TABLE 2 - Standard Tolerance

Measurement Units	Tolerance
Temperature	$\pm 1\text{ }^{\circ}\text{C}$ ($\pm 2\text{ }^{\circ}\text{F}$)
Day	± 2 hours
Hour	± 5 minutes
mm (inches)	± 0.20 mm (0.010 inch)

4.6 Test Methods:

- 4.6.1 Viscosity: Viscosity shall be determined at $20\text{ }^{\circ}\text{C}$ ($68\text{ }^{\circ}\text{F}$) and at $-56\text{ }^{\circ}\text{C}$ ($69\text{ }^{\circ}\text{F}$).

Viscosity at $20\text{ }^{\circ}\text{C}$ ($68\text{ }^{\circ}\text{F}$) shall be determined in accordance with DIN 51398, using a Brookfield Viscometer with LVT measuring head, and No. 4 spindle in a cryostat.

Viscosity at $-56\text{ }^{\circ}\text{C}$ ($-69\text{ }^{\circ}\text{F}$) shall be determined using a Brookfield Helipath test rig with HBT measuring head, a cross spindle TE/TF, a liquid bath cryostat suitable for temperatures down to $-56\text{ }^{\circ}\text{C}$ ($69\text{ }^{\circ}\text{F}$), and test glasses in accordance with DIN 51398.

- 4.6.1.1 Procedure: For viscosity at $20\text{ }^{\circ}\text{C}$ ($68\text{ }^{\circ}\text{F}$), fill semi-fluid into test glass up to mark. Stabilize the temperature of the sample in the cryostat for two hours minimum. Read viscosity value after 30 seconds maximum measurement time.

For viscosity at $-56\text{ }^{\circ}\text{C}$ ($-69\text{ }^{\circ}\text{F}$), fill semi-fluid into test glass up to mark. Cool sample down to $-56\text{ }^{\circ}\text{C}$ ($-69\text{ }^{\circ}\text{F}$) and maintain temperature for at least 16 hours. Read viscosity value after two minutes, observing it for 30 seconds and specifying the lowest and highest values during this period.

- 4.6.2 Separation Test: Separation tendency of base oil on uncoated steel shall be determined after 168 hours.

- 4.6.2.1 Test Equipment: Steel strip, ST 1305 or 1405 alloy (SAE 1010) 35 x 150 mm (1.4 x 5.9 inches), glass dish, glass beaker, analytical balance with precision of ± 0.1 mg.
- 4.6.2.2 Procedure: Determine empty weight of glass dish. Degrease metal strip with petroleum fluid having a boiling point of 40 to 60 °C in an ultrasonic bath. Fill beaker with semi-fluid and immerse degreased metal strip in fluid. After several immersions, the surface of the strip should be evenly coated. The coated surface area should measure about 50 cm², equivalent to half the length of metal strip. After a drip-dry period, the semi-fluid should completely cease dripping. The glass dish is positioned under the suspended metal strip. After 168 hours, the glass dish is weighed again. The weight of the drip oil is referenced to the coated surface area and is reported as mg/cm².
- 4.6.3 Volume Change at Low Pressure Conditions:
- 4.6.3.1 Volume change from ambient pressure to that of low-pressure conditions at 10 kPa (1.45 psia or 2.96 inches Hg) at 60 °F shall be determined.
- 4.6.3.2 Test Equipment: 100 ml graduated cylinder, desiccator connected to a vacuum pump equipped with a vacuum controller.
- 4.6.3.3 Procedure: Fill the graduated cylinder with 20 ml of the semi-fluid lubricant. Put the cylinder in the desiccator and reduce the pressure to 10 kPa (1.45 psia). Wait five minutes. Note the volume change as a percentage of original volume.
- 4.6.4 Corrosion Protection: Determine the corrosion protection properties of semi-fluid lubricants as follows:
- 4.6.4.1 Test Equipment: Climate chamber according to DIN 50017, standard test panels D36 Steel (SAE 1010), (available from: Q-Panel Company, 26200 First Street, Cleveland, Ohio, 44145 USA), smooth, glass beaker.
- 4.6.4.2 Procedure: Clean test panels in reagent grade n-hexane, wipe with absorbent cotton, and then wash them in reagent grade petroleum ether having a boiling point of 40 to 60 °C (104 to 140 °F). Fill beaker with semi-fluid and immerse metal panels in the semi-fluid. After several immersions, the surface of the plates should be evenly coated. After a drip-dry period, the semi-fluid should completely cease dripping. Hang the test plates in the climate chamber: Test conditions: 400 hours, 40 °C $\pm$ 3 (104 °F $\pm$ 5), 100% relative humidity (DIN 50017 KK). No rust should be visible on the surface originally coated with semi-fluid lubricant after 400 hours.
- 4.6.5 Wear Protection: Determine wear effects of semi-fluid lubricants on gear teeth at low speed.
- 4.6.5.1 Test Equipment: FZG test rig according to CEC-L-07-A-95 (axle spacing a = 91.5 mm) with low speed drive.

4.6.5.2 Test Conditions:

"C10/0.17/-/10/20-40-40"

Test gears: vehicle "C" – 10 mm tooth width

n (gear) = 30 rpm (pitch line velocity = 0.17 m/s)

T (gear) = 560 Nm (Hertzian stresses = 2000 N/mm²)

4.6.5.3 Procedure: Weigh pinion and gear using precision balance to within ± 1 mg. Install gear set in test transmission. Fill test transmission to level 20 mm above shaft center with test fluid (approximately 1.8 L). Carry out 3 test runs under above conditions: 20 hours / 40 hours / 40 hours. Remove and weigh gear set and pinion at the end of each test period. Total weight loss of pinion and gear, sum of values from both 40-hour tests, shall be equal or less than 12 mg.

4.6.6 Elastomer Compatibility: Semi-fluid lubricants shall be compatible with the following materials: fluoroelastomers (FKM – 70), silicone rubber (SI - 70), acrylonitrile butadiene rubber (NBR – 70).

CAUTION: The referenced materials represent some commonly used aerospace elastomers. The user is cautioned to test any other elastomeric or polymeric material separately.

4.7 Reports:

The supplier of the lubricant shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance requirements, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, batch number, AMS 3057, manufacturer's identification, and quantity.

4.8 Resampling and Retesting:

If any sample used in the above tests fails to meet the specified requirements, disposition of the lubricant may be based on the results of testing three additional samples for each nonconforming sample. Failure of any retest sample to meet the specified requirements shall be cause for rejection of the product represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging:

5.1.1 Individual Containers: The lubricant shall be furnished in standard size containers such as 1 kg and 40 kg, or specified in the purchase order. 40 kg containers with removable sealing cover are preferred. Grease content in each container shall be within $\pm 2\%$ of the stated weight in kg for each size.

5.1.2 Containers of lubricant shall be prepared for shipment in accordance with commercial practice and in accordance with applicable rules and regulations pertaining to handling, packaging, and transportation of the compound to ensure carrier acceptance and safe delivery.