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17 July 1989
SUPERSEDING
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MILITARY SPECIFICATION

GREASE, AUTOMOTIVE AND ARTILLERY

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE.

1.1 Scope. This specification covers one grade of a multi-purpose grease for lubrication of ground vehicles and equipment (see 6.1) and is identified by Military Symbol GAA and NATO Code Number G-403.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Standards. The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

FEDERAL

FED-STD-313	- Material Safety Data Sheets, Preparation and the Submission of.

MILITARY

MIL-STD-105	- Sampling Procedures and Tables for Inspection by Attributes.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: USA Belvoir Research, Development, and Engineering Center, ATTN: STRBE-TSE, Fort Belvoir, VA 22060-5606 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-147 - Palletized Unit Loads.
MIL-STD-290 - Packaging of Petroleum and Related Products.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATIN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

2.1.2 Other Government documents. The following other Government document forms a part of this document to the extent specified herein. Unless otherwise specified, the issue is that cited in the solicitation.

DEPARTMENT OF LABOR (DOL)

OSHA 29CFR1910.1200 - Hazard Communication; Interpretation Regarding Lubricating Oils.

(Guideline CPL 2-2.38 may be obtained from OSHA Publication Office, Room S-4203, 200 Constitution Avenue, NW, Washington, DC 20210.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

D 217 - Cone Penetration of Lubricating Grease.
D 942 - Oxidation Stability of Lubricating Greases by the Oxygen Bomb Method.
D 972 - Evaporation Loss of Lubricating Greases and Oils.
D 1092 - Apparent Viscosity of Lubricating Greases.
D 1403 - Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment.
D 1742 - Oil Separation from Lubricating Grease During Storage.
D 1743 - Corrosion Preventive Properties of Lubricating Greases.
D 1831 - Roll Stability of Lubricating Grease.
D 2265 - Dropping Point of Lubricating Grease Over Wide Temperature Range.
D 2266 - Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method).
D 2596 - Measurement of Extreme Pressure Properties of Lubricating Grease (Four-Ball Method).
D 3527 - Life Performance of Automotive Wheel Bearing Grease.
D 4048 - Detection of Copper Corrosion from Lubricating Grease by the Copper Strip Tarnish Test.
D 4057 - Manual Sampling of Petroleum and Petroleum Products.
D 4289 - Testing Compatibility of Lubricating Greases with Elastomers.
D 4693 - Low-Temperature Torque of Grease-Lubricated Wheel Bearings.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

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(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, (except for related associated detail specifications, specification sheets or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Greases furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.4 and 6.3).

3.1.1 Qualification period. Each grease which satisfies all the requirements of this specification shall be qualified for a period not to exceed five years from the date of its original qualification. When the qualification period has expired, each product must be requalified if the contractor wishes to maintain the formulation as a qualified product and be eligible to bid on prospective procurements. If a product is submitted for requalification and there has been no change in the specification requirements, the qualifying activity may, at its discretion, waive complete retesting and require only partial retesting of the product to determine its continued acceptability.

3.1.2 Formulation changes. Whenever there is a change in the source of the base stock, in the refining treatment or in the additives used in the formulation, requalification will be required. When proposed changes are minor and may not be expected to significantly affect performance, the qualifying activity may, at its discretion, waive complete requalification and may require only partial requalification in order to determine the significance and acceptability of the proposed changes.

3.1.3 Tolerances. The grease supplied under contract shall be identical, within permissible tolerances assigned by the qualifying activity, for the properties listed in 3.3, to the product receiving qualification. The values resulting after the application of the tolerances shall not exceed the maximum nor fall below the minimum limits specified herein (see table I and 3.5).

3.1.4 Material Safety Data Sheets. Material Safety Data Sheets shall be prepared and submitted in accordance with FED-STD-313 and forwarded as specified in 4.4.2 and as instructed by the contracting officer (see 6.5). In addition, a MSDS shall be sent to the procuring activity safety office, and also accompany each exterior shipping carton/container for the Government. The lubricating grease shall have no adverse affect on the health of personnel when used for its intended purpose.

3.2 Materials. The base oil for the grease shall be derived from petroleum fractions, synthetically prepared compounds or a combination of the two types of products. They may be virgin or rerefined (i.e. recycled or reclaimed) stocks or a combination thereof. The grease shall be compounded with a suitable thickening agent and functional additives (oxidation inhibitors, corrosion inhibitors, etc.)

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as necessary to meet the specified requirements. The grease shall contain no dye. The contractor shall certify that no carcinogenic or potentially carcinogenic constituents are present as defined under the Hazard Communication Standard (29CFR1910.1200). Certification to this effect shall be made available to the contracting officer or his designated representative.

3.3 Physical properties. Physical properties of the finished grease shall conform to the requirements specified in table I when tested in accordance with the inspection methods specified in table II and 4.7.

TABLE I. Physical properties.

Characteristics	Limits
Workmanship 1/	PASS
Dropping point, °C, minimum	220
Worked penetration (1/10 mm)	265-295
Corrosiveness (copper strip), maximum 2/	1b
Oxidation stability at 99 °C	
Pressure drop, kPa, maximum	
in 100 hours	34.5
in 400 hours	138.0
Water stability, after 100,000 double strokes, +10.0% water, penetration (1/10 mm), minimum/maximum	-25 to +60
Life performance (four test runs) at 160 °C, hours, minimum	100
Evaporation loss at 99 °C percent, maximum	3.0
Oil separation percent, maximum	5.0
Wear preventive characteristics avg. scar dia. mm, maximum	0.60
Load carrying capacity Load wear index, kgf, minimum	30.0
Low temperature torque N·m, maximum at -54 °C	
breakaway	7.00
running (at 5 min)	5.00
Worked stability, after 100,000 double strokes, penetration (1/10 mm), minimum/maximum	-25 to +60
Salt water corrosion resistance	PASS
Roll stability, penetration (1/10 mm), minimum/maximum	-25 to +60
Elastomer compatibility (CR, NBR-L)	Report
Storage stability, after 180 days at 38 °C	PASS

1/ Workmanship shall be rated by the criteria of 3.5.
2/ The grease shall show no green color in that portion contacting the copper strip. The copper strip shall not tarnish more than a classification of 1b when compared with the ASTM copper strip corrosion standards (ASTM D 4048).

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3.4 Toxicity formulations. The material shall have no adverse effect on the health of the personnel when used for its intended purpose (see 4.4.2 and 6.1). Questions pertinent to this effect shall be referred by the contracting activity to the appropriate departmental medical service who will act as an advisor to the contracting agency (see 6.5).

3.5 Workmanship. The grease shall be homogeneous, smooth in texture, free of entrapped air when examined visually, and shall have no rancid, perfume or alcohol odor.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.4).
b. Quality conformance inspection (see 4.5).
c. Inspection of packaging (see 4.8).

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in 4.3.1.

4.3.1 Test conditions. Test conditions shall be in accordance with 4.6 and the physical values specified in table I apply to the average of determinations made on the sample. Unless otherwise specified in the test method, all tests shall be conducted on unworked grease.

4.4 Qualification inspection. Qualification inspection shall consist of a review of the manufacturer's test report (see 4.4.2) for approval and by testing to determine that the qualification inspection sample (see 4.4.1) complies with all the requirements for the physical properties specified in table I when tested in accordance with the inspection methods specified in table II and 4.7.1 through 4.7.5.1.

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TABLE II. Inspection methods.

Test	ASTM Method
Dropping point	D 2265
Worked penetration	D 217
Corrosiveness (copper strip)	D 4048
Oxidation stability	D 942
Water stability	D 217 1/
Life performance	D 3527
Evaporation	D 972
Oil separation	D 1742
Load carrying capacity	D 2596
Wear preventive characteristic	D 2266
Saltwater corrosion resistance	D 1743 2/
Roll stability	D 1831
Worked stability	D 217
Elastomer compatibility	D 4289
Low temperature torque 3/	Appendix A and D 4693, D 1092

1/ Water stability shall be performed in accordance with 4.7.3.
2/ Saltwater corrosion resistance test shall be performed in accordance with 4.7.2 and rated as specified in 4.7.2.1.
3/ Low temperature torque shall be performed as outlined in test method I (see appendix) or as specified in 4.7.4.

4.4.1 Qualification inspection sample. The qualification inspection test sample shall consist of four 3 kilogram (6.6 pound) cans of grease. The sample shall be forwarded to the US Army Belvoir Research, Development and Engineering Center, ATTN: STRBE-VF, Fort Belvoir, VA 22060-5606. The sample shall be plainly identified by a securely attached durable tag or label marked with the following:

Sample for qualification inspection.
Grease, automotive and artillery (GAA)
Name of manufacturer.
Product code number.
Batch number.
Date of manufacture.
Submitted by (name) (date) for qualification inspection in accordance with MIL-G-10924.

4.4.2 Test results. Two certified copies of the manufacturer's test results, showing that the sample submitted for qualification conforms to the requirements of this specification with the exception of the storage stability test, shall be submitted with the qualification sample. The manufacturer shall provide the location and identity of the plant which produced the qualification inspection sample. The manufacturer shall also submit Material Safety Data Sheets on toxicity of the finished product, base oil, thickener, and for each of the additive components used in the formulation (see 3.1.4).

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4.4.3 Removal of a product from the QPL. The Government reserves the right to re-examine a qualified product whenever deemed necessary to determine that the product continues to meet any or all of the specification requirements. Failure to meet the physical requirements set forth in table I shall be cause for removal from the qualified products list.

4.4.4 Complete requalification inspection. A product once qualified shall be retested at five year intervals for requalification and listing on a new qualified products list.

4.5 Quality conformance inspection. The quality conformance inspection of the grease shall consist of tests of samples from 4.5.2.2 in accordance with table III. Samples shall be labeled completely with the information identifying the purpose of the sample, name of product, specification number, lot and batch number, date of sampling and contract number (see 6.8).

4.5.1 Lot. A lot shall consist of all the grease produced by one manufacturer, at one plant, from the same materials and under essentially the same conditions, provided the operation is continuous and does not exceed a 24 hour period. In the event the process is a batch operation, each batch shall constitute a lot.

4.5.2 Sampling.

4.5.2.1 For examination of filled containers. A random sample of filled containers, fully prepared for delivery, shall be selected from each lot of grease in accordance with MIL-STD-105, inspection level II.

4.5.2.2 For tests. The sample for tests shall consist of two 2.27 kilogram (kg) samples of grease taken at random from filled containers from each lot of grease. For users who obtain grease in large containers, two 2.27 kg samples shall be taken in accordance with ASTM D 4057. The lot shall be unacceptable if either sample fails to comply with any of the tests specified in 4.7.

4.6 Methods of examinations and tests.

4.6.1 Examinations. Each of the filled containers, selected in accordance with 4.5.2.1, shall be examined for defects of the container and closure, for evidence of leakage and for unsatisfactory markings to determine conformance with 5.1. Each sample container shall also be weighed to determine the amount of contents.

4.7 Tests. Tests shall be performed in accordance with table II and 4.7.1 through 4.7.6 to determine conformance with the requirements specified in 3.3.

4.7.1 Workmanship. Remove the lid or top of a can or pail of the test grease. Visually examine the undisturbed sample to determine compliance with 3.5.

4.7.1.1 Failure criteria. Failure of the grease to conform to the PASS requirements of 3.5 shall constitute failure of workmanship.

4.7.2 Salt water corrosion resistance. The test shall be performed using the standard procedure of ASTM D 1743 with the following modifications.

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a. A NaCl solution (1 percent NaCl by weight in distilled water) shall be used in lieu of the specified distilled water.
b. The NaCl solution shall be prepared no more than 24 hours in advance of each test and shall be used for each test.
c. The bearing assembly shall be stored for 24 hours at 52 ±1 °C and 100 percent relative humidity.
d. The inner surface of the test bearing's race shall be cleaned and inspected within 2 hours after the test is terminated.
e. Precision and bias statement. The evaluation of corrosion by the rating system is achieved by means of qualitative ratings (pass or fail). Precision may be judged by the fact that 75 percent of the duplicate results, obtained by 3 different operators with 15 test bearings per sample of grease (3 samples of grease) considering bearings rated pass, were in agreement. Since the results of the test are only intended to give a pass/fail rating, no statement is made about the bias of this method.

4.7.2.1 Failure criteria. Failure of the grease to meet the requirements as defined in ASTM D 1742 under rating shall constitute failure of this test.

4.7.3 Water stability test. Prepare a homogeneous mixture of grease and water by placing nine parts by weight of grease and one part by weight of distilled water in a suitable mixing bowl using an electric kitchen-type mixer (low speed 500 ±10 rpm). Fill a glass syringe with the calculated amount of distilled water and gradually add the water to the grease in the bowl. Mix the contents for 4 ±1 minutes. A spatula may be used to channel the constituents to the mixer. Fill a standard ASTM D 217 grease worker with the mixture and work the sample on a motorized grease worker for 100,000 double strokes (approximately 28 hours). After the test grease containing 10 percent (by weight) distilled water has been subjected to 100,000 double strokes, bring the grease worker and the sample to 25 ±0.5 °C in accordance with the procedure described in ASTM D 217 for prolonged worked penetration. Immediately after the test grease sample reaches 25 ±0.5 °C, rework the sample an additional 60 double strokes. Determine the worked penetration. Compare the worked penetration of the grease-water mixture with the worked penetration (60 double strokes) obtained by the sample under test.

4.7.3.1 Failure criteria. A change in worked penetration of the grease of more than 60 units higher or 25 units lower than the original worked penetration shall constitute failure of the water stability test.

4.7.4 Low temperature torque. The test shall be conducted at -54 ±0.5 °C according to the low temperature torque test method described in the appendix, test method I. The breakaway (maximum) torque shall be determined at the beginning of the operation and the running torque shall be determined after five minutes of operation. Both determinations should be calculated by the averaging of four test runs. If the test apparatus is not available, the test shall be conducted using the ASTM D 1092 test method at -54 °C. The apparent viscosity shall be determined at shear rate, 25 reciprocal seconds. This value is then converted to the breakaway torque (N·m) using the following correlation equation (1). If this alternate method is used, only breakaway torque values can be reported. However, in case of referee disputes, only the results from the low temperature torque test method measured as described in appendix test method I shall be accepted.

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Breakaway torque (N·m) = 2.36 x (apparent viscosity at 25 sec^{-1} x 10^{-4}) + 1.48 (1)

[Standard error: 0.373]

4.7.4.1 Failure criteria. Failure of the grease to meet the requirements of table I in 3.3 shall constitute failure of this test.

4.7.5 Worked stability test. Work a sample of the test grease on a motorized grease worker for 100,000 double strokes (approximately 28 hours) in accordance with the procedure described in ASTM D 217 for prolonged worked penetration. Immediately after the grease has been subjected to 100,000 double strokes, bring the grease worker and the sample to 25 ±0.5 °C in accordance with the procedure described in ASTM D 217 for prolonged worked penetration. Immediately after the test grease sample reaches 25 ±0.5 °C, determine the prolonged worked penetration of the grease.

4.7.5.1 Failure criteria. A change in worked penetration of the grease of more than 60 units higher or 25 units lower than the original worked penetration shall constitute failure of this test.

4.7.6 Storage stability. After being stored for 180 ±5 days at 38 ±3 °C in accordance with appendix, test method II, the test grease shall be examined for conformance to table I.

4.7.6.1 Failure criteria. A change in the performance of the test sample when inspected in accordance with appendix test method II which does not conform to the requirements of table I shall constitute failure of this test.

4.8 Inspection of packaging.

4.8.1 Quality conformance inspection.

4.8.1.1 Unit of product. For the purpose of inspection, a complete pack prepared for shipment shall be considered a unit of product.

4.8.1.2 Inspection lot. The inspection lot shall consist of grease as defined in 4.5.1 packed for shipment.

4.8.1.3 Sampling. Samples for examination of packaging shall be selected at random from each inspection lot in accordance with procedures prescribed in MIL-STD-105.

4.8.1.4 Examination. Samples selected in accordance with 4.8.1.3 shall be examined for conformance to MIL-STD-290. Each non-conforming item shall be classified as a defect.

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TABLE III. Quality conformance tests. 1/

Inspection	Requirement Paragraph	Test Method
Workmanship	3.5	4.7.1
Dropping point	3.3 2/	3/
Worked penetration	3.3	
Corrosiveness (copper strip)	3.3	
Water stability	3.3	4.7.3
Evaporation	3.3	
Oil separation	3.3	
Load carrying capacity	3.3	
Wear preventive characteristics	3.3	
Work stability	3.3	4.7.5
Saltwater corrosion resistance	3.3	4.7.2
Examination of filled containers	4.5.2.1	4.6.1

1/ See 4.5 for additional information on quality conformance testing.
2/ Requirements from 3.3 are listed in table I.
3/ Test methods not identified by specification paragraph number are listed in table II.

5. PACKAGING

5.1 Packing and marking. Unit containers, intermediate containers when required, and exterior/shipping containers shall be in accordance with the level B or level C requirements of MIL-STD-290 as specified (see 6.2). The size and type of unit container shall be as specified (see 6.2). Marking shall be in accordance with MIL-STD-129 and MIL-STD-290.

5.2 Palletization. When specified (see 6.2), the packed grease shall be palletized in accordance with MIL-STD-147.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The grease covered by this specification is intended for the lubrication and surface corrosion protection of all ground vehicles and equipment operated over the temperature range from -54 to +180 °C. This grease may also be used in other applications within this temperature range where a National Lubricating Grease Institute (NLGI) No. 2 consistency grease with oxidation resistant and corrosion prevention properties is desirable. This grease is not intended for use on machinery which comes in contact with food.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.
b. Date of issue of DoDISS applicable and exceptions thereto (see 2.1.1).

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c. Quantity of grease requested, in kilograms.
d. Size and type of container for grease.
e. Level of packing required (see 5.1).
f. When palletization is required (see 5.2).

6.3 Qualification. Awards will be made only for products which are qualified for inclusion on the Qualified Products List at the time set for opening of bids. This qualification should be approved by the qualifying activity for a period not to exceed 5 years from the date of original qualification. If a product is submitted for requalification and there have been no changes in the specification requirement, the qualifying activity may, at its discretion, waive complete retesting or require only partial testing of the product to determine continued acceptability. The activity responsible for the qualified products list is the US Army Belvoir Research, Development and Engineering Center, ATTN: STRBE-VF, Fort Belvoir, VA 22060-5606 and information pertaining to qualification of products may be obtained from the above address.

6.3.1 Qualification information. It is understood that the grease furnished under this specification subsequent to final approval should be of the same composition and should be equal to products upon which approval was originally granted. In the event that the grease furnished under contract is found to deviate from the composition of the approved product, or that the product fails to perform satisfactorily, approval of such products will be subject to immediate withdrawal from the qualified products list.

6.4 International standardization. Certain provisions of this specification (see 1.1) are the subject of international standardization agreements (NATO STANAGs 1135 and 2845). When amendment, revision, or cancellation of this specification is proposed, which will modify the international agreements concerned, the preparing activity will take appropriate action through international standardization channels including departmental standardization office to change the agreement or make other appropriate accommodations.

6.5 Material Safety Data Sheets (MSDS). The contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent government mailing addresses for submission of data are listed in FED-STD-313, appendix B.

6.6 Part or identifying number (PIN). Greases furnished under this specification shall be identified by a PIN number consisting of a "M" prefix and specification number, a single digit "Dash Number" (see table IV), and the revision letter (e.g. M-10924-1-F).

TABLE IV. Dash number designation

Dash number	Container size
1	2.25-oz
2	14.00-oz
3	1.75-lb
4	6.50-lb
5	35.00-lb
6	120.00-lb

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6.7 National stock numbers. The following National Stock numbers have been assigned to the grease covered by this specification:

Tube, 2-1/4 oz. (64 g)	9150-01-197-7688
Cartridge, 14 oz. (400 g)	9150-01-197-7693
Can, 1.75 lb. (800 g)	9150-01-197-7690
Can, 6.50 lb (3 kg)	9150-01-197-7689
Pail, 35 lb. (16 kg)	9150-01-197-7692
Drum, 120 lb. (54 kg)	9150-01-197-7691

6.8 Batch. A batch is defined as that quantity of material which has been manufactured by some unit chemical process and subjected to some physical mixing operation intended to make the final product substantially uniform.

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

6.10 Subject term (key word) listing.

Grease, artillery
Grease, automotive
Grease, ground vehicles
Grease, lubricating
Grease, surface corrosion protection
Grease, temperature range -54 to +180 °C

6.11 AQL certification. This specification is certified to be in compliance with current Army Materiel Command (AMC) policy for the elimination of AQL's/LTPD's (Acceptable Quality Levels/Lot Tolerance Percent Defectives) from military specifications.

(Certified by/date 7/25/89).

Custodians:
Army - ME
Navy - YD
Air Force - 68

Preparing activity:
Army - ME

Project 9150-1035

Review activities:
Army - AR, EA, MI, SM
Navy - SA
DLA - GS

User activities:
Army - AT
Navy - MC, SH

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APPENDIX A

TEST METHOD I

US ARMY LOW TEMPERATURE TORQUE TEST METHOD FOR LUBRICATING GREASES

10. SCOPE

10.1 This appendix details the test method to be used for determining the torque values of lubricating greases using tapered roller bearings when subjected to low temperatures. The method was developed using greases giving torques of less than 80 N·m at -54 °C. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 Specifications. The following specification forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-G-23827 - Grease, Aircraft and Instrument, Gear and Actuator Screw.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATIN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

30. SUMMARY

30.1 A worked sample of the test grease is packed into four test specimen assemblies which simulate the automotive front wheel bearing system. These assemblies are mildly heated and then rotated one revolution. The test assemblies are soaked for 16 hours at -54 °C. At the end of this time, the two test assemblies are rotated consecutively at 1 rpm and both breakaway (starting torque) and torque after 5 minutes of rotation (running torque) are then determined. The two remaining test assemblies are tested after the additional four hours cooling to restore the test temperature.

40. SIGNIFICANCE

40.1 This method was developed to assess the low temperature performance of greases at -54 °C and clearly distinguish between differing grease formulations. The torque data obtained from this test method agree with the low temperature performance of military greases in the field. A correlation was found between the breakaway torque and the apparent viscosity range of 5,000 - 30,000 poises at a shear rate of 25 reciprocal seconds.

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APPENDIX A

50. DEFINITIONS

50.1 Breakaway torque. The maximum torque measured at start of rotation.

50.2 Running torque. The torque value after rotation for a specified period of time (5 minutes).

60. APPARATUS

60.1 Low temperature torque test unit. This test unit consists of an ASTM D 4693 test apparatus which is designed with a cold chamber and two spindle drive systems, torque measuring system, test specimen assembly, and data acquisition and control system. The schematic diagram of US Army low temperature torque test unit is shown in figure 1.

60.1.1 The low temperature test chamber consists of a cascade mechanical refrigeration system, a blower, and a solid state electronic temperature controller. This chamber is designed to maintain the test temperature down to -58 °C. The chamber temperature is monitored with a T type thermocouple.

60.1.2 The spindle drive system consists of a 1/3 hp electric motor, a timing belt and pulley, a gear reducer and a solid stainless steel extension shaft (diameter: 2.2 cm, length: 25.6 cm). The gear reducer provides 84 N·m of maximum output torque and approximately 1 rpm of fixed speed. Two spindle drive systems are mounted externally and connected to the inside of the cold chamber using a solid coupling and extension shaft, respectively. These shafts are supported by two sealed roller bearings which are lubricated with MIL-G-23827 grease. Only the outside supporting bearings are rotated with the extension drive shafts during the test time.

60.1.3 The torque measuring system consists of a strain-gage load cell (capacity: 136 kg), a cylindrical rod (diameter: 1.9 cm length: 22.5 cm), a load button and a DC power supply (capacity 20 V). Two torque measuring systems are mounted on a plate which is situated below and external to the cold chamber. To measure the grease torque, rods are connected to the inside of the cold chamber with the load cell. A spherical load button is attached to the top of the rod to allow for the adjustment of the level of the torque arm. A DC power supply is connected to both load cells and applies 10 volts for the input bridge excitation.

60.1.4 The test specimen assembly is as specified in the ASTM D 4693 test method.

60.1.5 The data acquisition and control system consists of a HP data acquisition and control unit, a HP computer as system controller and the user operation program (LOWTEMP). The HP data acquisition and control unit also contains three plug-in assemblies: relay multiplexer assembly for measuring the torque value, relay multiplexer assembly with thermocouple compensation, and high voltage actuator to control the drive system.

60.2 Laboratory oven, gravity convection, 70 ±3 °C.

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60.3 Grease packer, as described in the ASTM D 3527 test method.

60.4 Spindle holder or test preparation stand.

60.5 Ultrasonic cleaner.

70. CALIBRATION

70.1 Torque calibration. Attach a support disk (diameter: 4 cm), for holding the dead weight, on the top of the rod. Measure output (millivolt) of load cell as a known force (dead weight: 0.5 kg, 1-10 kg) is applied to load cell at the room temperature. Then, the calibration equation shall be determined using the statistic method. The Method of Regression analysis is very suitable to develop the torque calibration equation. The typical calibration curve is shown in figure 2. This calibration needs be done only at the time of initial setup and when occasional checks indicate that it is required.

70.2 Temperature calibration, as described in ASTM D 4693, or equivalent.

70.3 Spring calibration, as described in ASTM D 4693, or equivalent.

80. TEST BEARINGS. Use LM67010-LM67048 and LM11910-LM11949 inboard and outboard bearings, respectively. Timken bearings are suitable. Prior to use in this test, new bearings shall be conditioned by installing any suitable wheel bearing grease in the bearings and running them at room temperature for 48 hours at 1,000 rpm under a normal thrust load of 111 N. ASTM D 3527 test apparatus is suitable for conditioning the bearings.

Note 1. The bearings must be keyed to prevent race rotation on spindle.

90. PROCEDURE

90.1 Clean the test bearings with heptane or equivalent reagent using a ultrasonic cleaner and dry with compressed air.

90.2 Work a grease sample for 60 double strokes using the full scale grease or one-half scale grease worker at room temperature.

90.3 Weigh an inboard and outboard bearing cone to the nearest 0.1g.

90.4 Pack a worked grease sample into the test bearings (inboard: 3.0 ±0.1 g. outboard: 2.0 ±0.1 g) using the following bearing packing procedure: Fill the bearings with the worked test grease using a grease packer utilized in ASTM D 3527 test method. Use care to prevent relative rotation of rollers and bearing components while removing the cones from cups and in all subsequent wiping and handling steps. Strike off excess grease flush using a small spatula. Wipe all grease from cone bore, cone back face, exterior cage surfaces and exposed roller surfaces with a clean lint free cloth or towel and reweigh. Adjust the grease weight in the inboard and outboard cones to 3.0 and 2.0 ±0.1g, by wiping or adding grease to the groove between the cage and cone back face.

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90.5 Clean the bearing cups installed in the hub using heptane and apply a thin film of the test grease to the races.

90.6 Set-up a test specimen assembly according to the following procedure: Without any rotation of the test bearing, the inboard bearing is installed on the spindle. Then, this spindle is mounted on the test preparation stand which was designed for holding it in a vertical position. The hub is gently set on the inboard bearing with the torque arm aligned with the spindle set screw. (i.e., pointing in the same direction). Then, the outboard bearing is placed on the hub. The thrust force (400 N) is applied to the test bearings with a calibrated spring-loading device.

90.7 Prepare four test specimen assemblies using the above test assembly preparation procedure.

90.8 Without disturbing the test assemblies, place them in an oven preheated to 70 ±3 °C for 1 hour.

90.9 Rotate the test specimen assemblies for 1 revolution using the test apparatus at room temperature.

90.10 Install two test specimen assemblies on each drive shaft for the first two tests. Without any handling of the test assemblies, the torque arms should be placed vertically with the drive motors.

90.11 Place the other two test assemblies inside the cold chamber in preparation (cold soak) for the next tests.

90.12 Insert two thermocouples (T type) in the test spindles to monitor the test temperature.

90.13 Start 16 hour cold-soak at -54 ±0.5 °C.

90.14 Following a 16 hour cold-soak, the two torque tests shall be consecutively performed using the LOWTEMP computer application program. The following additional test conditions are applied to the torque test runs:

Test temperature: -54 ±0.5 °C
Test time: 5 minutes
Spindle speed: 1 rpm
Data scanning interval: 20 centiseconds
The torque reading starts when torque value is >0.1 N·m

90.15 Store the test results on a floppy disk and plot them on the formatted papers.

90.16 Cut off the cooling system, and remove the tested specimen assemblies from the drive shafts and place them in the preheated oven until completely dried in order to preclude rust formation.

90.17 For the second series of tests, the two remaining test specimen assemblies shall be set up on the drive shafts identically to the previous tests.

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90.18 Resume the cooling for the next four hours to restore the test temperature.

90.19 After four hours, two additional torque data shall be generated using the above torque measurement procedure.

100. REPORT

100.1 Breakaway torque (N·m).

100.2 Running torque (N·m) at 5 minutes.

Note 2. Both determinations shall be calculated by the average of four test runs.

110. PRECISION

110.1 Repeatability
Breakaway torque: 10%
Running torque at 5 minutes: 7%

Note 3. Duplicate results by the same operator should be considered suspect if they differ from the mean by more than the above amounts at the 95 percent confidence level.

110.2 Reproducibility has not been established.

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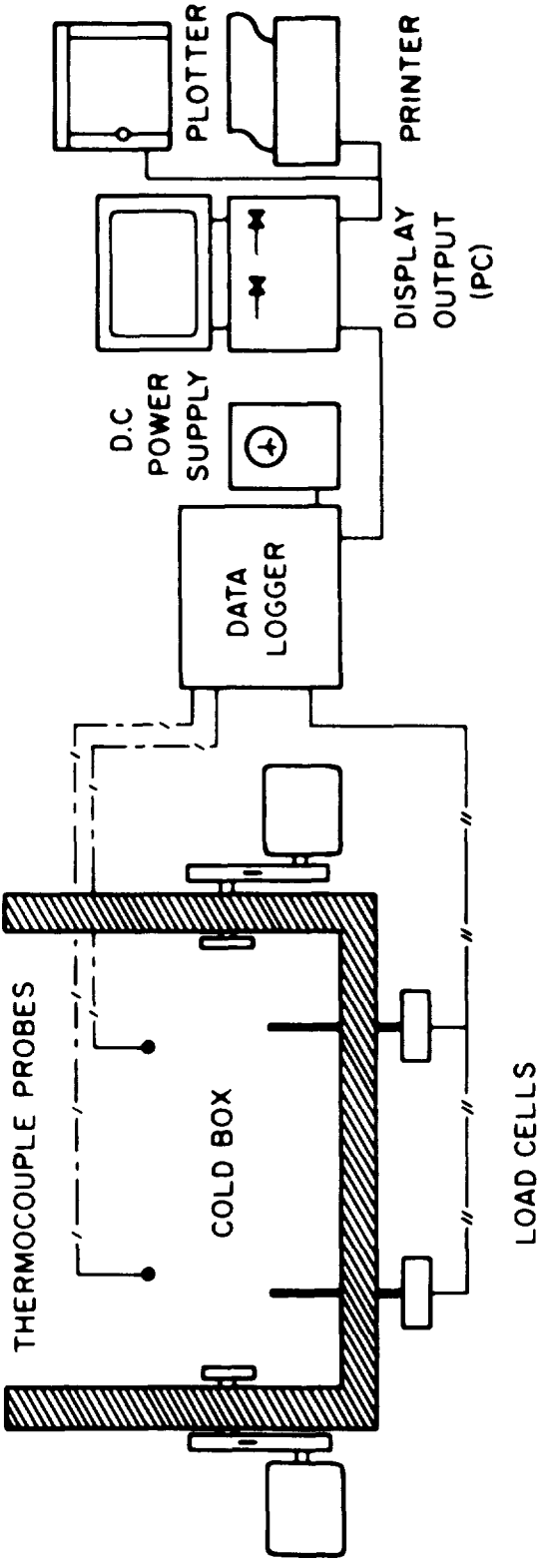

FIGURE 1 Schematic diagram of US Army low temperature torque test unit

X-4819

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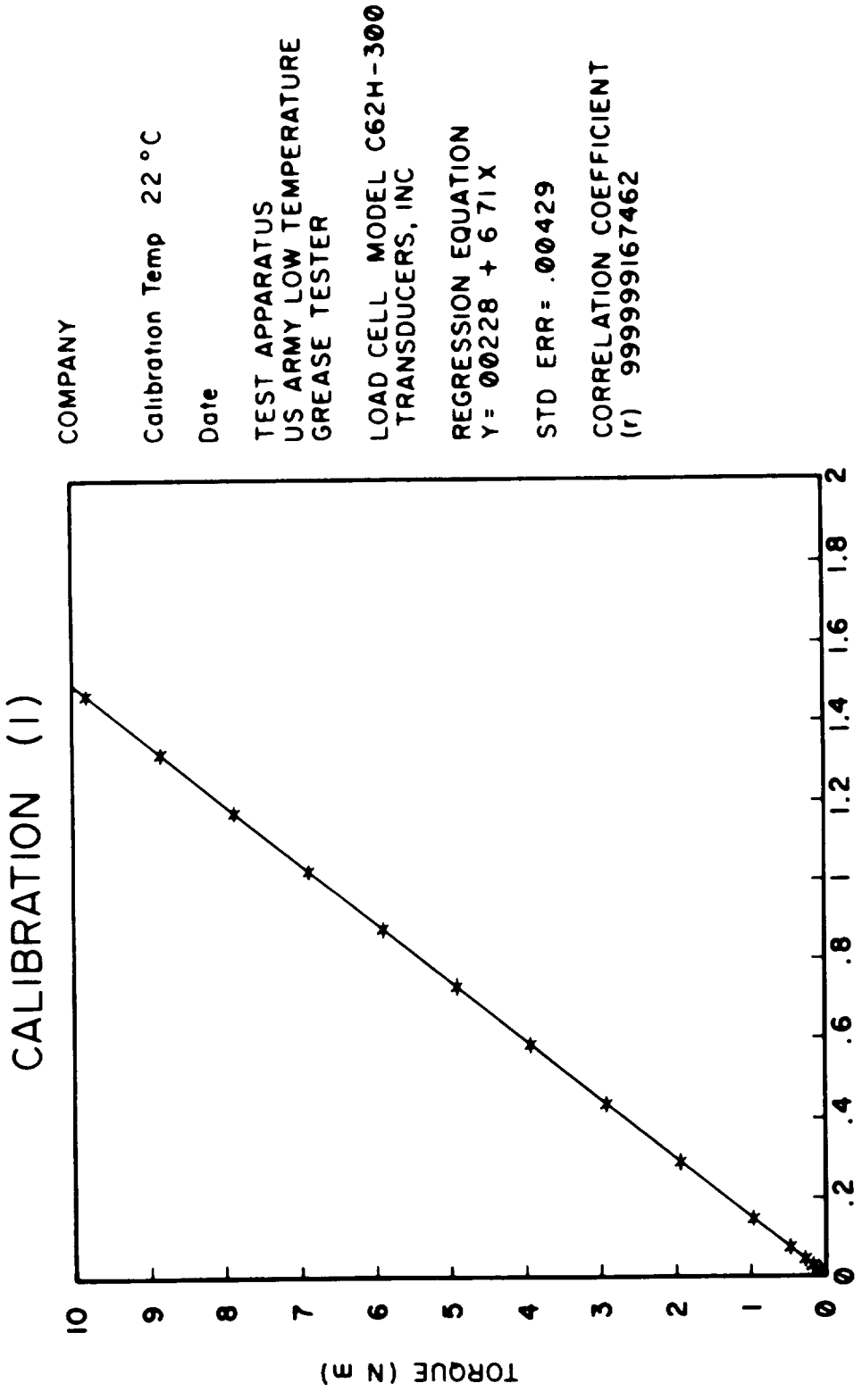

FIGURE 2 Calibration

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APPENDIX B

TEST METHOD II

STORAGE STABILITY OF LUBRICATING GREASES

10. SCOPE

10.1 This appendix details the test method to be used for determining the storage stability of lubricating greases after a specified storage interval. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS.

20.1 Non-Government publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

E 145 - Gravity-Convection and Forced-Ventilation Ovens.

(Application for copies should be addressed to the American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

30 SUMMARY

30.1 A 6.8 kg can of the test grease is unpacked, dated and labeled "Storage Stability Test". The lid or top of the 6.8 kg can or pail is not removed. The undisturbed can or pail of the test grease is placed in a thermostatically controlled, dark, convection oven, meeting the requirements of ASTM E 145, located in an area essentially free from vibration, at 38 ±3 °C for 180 ±5 days. At the end of the specified storage period, the sample of grease is then examined by the inspection methods listed in table I to determine that the physical properties of the storage stability test sample meet the limits set forth.

40 SIGNIFICANCE

40.1 This method was developed to assess the stability of a lubricating grease during storage. It is not intended to predict the stability of a lubricating grease under dynamic service conditions.

50 DEFINITIONS

50.1 Sample size. One 6.8 kg can or pail of grease, sufficient to complete the storage stability testing using the inspection methods indicated in table I and generating duplicate or triplicate sets of data of the test grease is required.

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50.2 Storage stability. The storage stability of the grease is indicated by no changes in the physical performance of the grease beyond the limits indicated in table I.

50.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in 4.3.1.

50.4 Test. Test shall be performed in accordance with table I and 4.7.1 through 4.7.6 to determine conformance with the requirements specified in table I except for oxidation stability at 400 hours, water stability, and low temperature torque.

60. APPARATUS

60.1 Oven, gravity - convection. This test unit shall meet the requirements set forth in ASTM E 145.

70. PROCEDURE

70.1 Label an unopened 6.8 kg can of the test grease with the following:

STORAGE STABILITY TEST

DATE STARTED: TEMPERATURE IN:

DATE OUT: TEMPERATURE OUT:

70.2 Place the can of the test grease in a convection over maintained at 38 ±3 °C for a period of 180 ±5 days. Take care to position the can in center of the oven and raised at least 75 mm from the bottom, to ensure temperature uniformity. The oven should be dark and the temperature thermostatically controlled.

70.3 At the end of the storage interval, withdraw the can of test grease from the oven and determine by inspection methods in table II that the storage stability test sample (see 4.4.1 and 50.1) complies with all the requirements for the physical properties specified in table I and 4.7 through 4.7.5.2 except for oxidation stability at 400 hours, water stability, and low temperature torque.

80. REPORT

80.1 Report the physical values specified in table I, except for oxidation stability at 400 hours, water stability, and low temperature torque.

90. PRECISION

90.1 Precision data have not been developed for this method.

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b ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)* _____

5 PROBLEM AREA

a. Paragraph Number and Wording

b. Recommended Wording

c. Reason/Rationale for Recommendation

6 REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
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