Report 2396

GREASE VERSUS OIL LUBRICATION OF WHEEL BEARINGS IN ARMY EQUIPMENT

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The US Army has the largest fleet of ground equipment in the United States. The number of vehicles is in the hundreds of thousands, and there are many types ranging from cars, trucks, and buses to a variety of tracked, wheeled, and mechanical/construction equipment and trailers. The mobility doctrine has led DoD to install wheels on many types of equipment so that all support activities, in addition to combat operations, can be performed locally in the field.

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These cars, trucks, buses, etc., are procured both commercially (off-the-shelf adoption for Army use) and through development programs in which contractors design and build equipment such as combat and tactical vehicles for Army use according to specifications developed by the Army.

Wheel bearings are present in all of these vehicles, and the US Army has used grease lubrication of wheel bearings for many years. However, in some instances oil has been used for lubrication of these bearings. This is common practice for commercial axles, and this approach is continuing to be used more frequently by contractors and developing agencies as well. The M1 Abrams tank, the M2 family (infantry and cavalry fighting vehicles and the Multiple Launch Rocket System), and the M915A1 trucks are recently fielded vehicles developed for the US Army, and all of these vehicles use oil in the wheel bearings. The USMC LVPT-7 amphibious landing craft also uses oil. The M48 and M60 tanks, the M113 family of armored personnel carriers, the M109 and M110 self-propelled howitzers, and M88 and M578 recovery vehicles are all tracked vehicles which were developed using oil to lubricate the wheel bearing and which were subsequently changed over to grease because of problems with leakage, contamination, and failures.

The US Army fleet of ground equipment has a unique mission, quite unlike that in the commercial sector. This mission includes readiness and mobility in any geographical location, from the arctic to the desert. These unique military requirements coupled with the need to provide cost-effective lubricants dictates the use of lubricants which will meet these military operational requirements.

The lubrication of wheel bearings on all mobility equipment is one example. The US Army is adopting grease for several reasons: (1) minimal lubricant loss of leakage; (2) elimination of seasonal oil change in the bearings, including a change of oils when deployed into cold regions; (3) grease requires minimal maintenance; (4) grease is more tolerant to water than is oil; (5) greases have better corrosion/rust protection additives; (6) grease will form a barrier against penetration of dust or moisture; (7) grease will form a full lubricant packing in the bearings; and (8) immediate attention is required when oil leaks occur (for combat vehicles this is frequently not feasible).

The advantages of oil as opposed to grease are higher operating temperatures and better heat transfer properties. The current technology in grease manufacture, however, extends the upper temperature limits of grease up to and beyond that of some oils. Thus, grease is the lubricant of choice for the lubrication of wheel bearings in Army equipment.

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IN ARMY EQUIPMENT

I. INTRODUCTION

The US Army has a ground vehicle fleet which contains hundreds of thousands of vehicles which include many different types such as cars, trucks, buses, armored (tracked) vehicles, off-road equipment, materials-handling equipment, and trailers. This equipment can generally be classified as follows:

Vehicle Type	Procurement Category
Administrative Vehicles	Commercial
Tactical Vehicles	Military/Commercial
Tanks	Military
Armored Personnel Carriers	Military
Self-Propelled Artillery	Military
Missile Launchers	Military
Fighting Vehicles	Military
Recovery Vehicles	Military
Materials-Handling Equipment	Commercial
Combat Engineering Equipment	Commercial/Military
Trailers (all types)	Commercial/Military
Soldier Support Equipment (e.g., water purification, etc.)	Military

The types listed are designed for different end use applications such as construction work, highway and off-highway use, warehouse operation, combat and combat support, etc. Within Department of Defense there are other types of ground equipment such as the US Marine Corps (USMC) LVPT-7 amphibious landing craft. This vehicle is both a watercraft and a tracked land vehicle (Figure 1) and must function in both environments. Although this range of vehicle types is diverse, with each having different missions, all vehicles and equipment have road wheels with tapered roller wheel bearings which vary in size from approximately 1½ inches to over a foot in diameter.

The mission of the US Army is the defense of the US by the use or maintenance of a viable force. This force must be ready and mobile at any given time for duty in any geographical location ranging from the desert to the tropics and the arctic. The mission of the Materials, Fuels, and Lubricants Laboratory within the Belvoir Research and Development Center is to perform the research and development necessary to develop products which meet the performance requirements of Army materiel; that is, operational readiness and combat effectiveness in any geographical location.

The requirements imposed upon Army materiel are different from those in the commercial/industrial sector, even in those instances where a commercially available vehicle is used by the Army. Furthermore, logistic support required by the Army is an important cost factor, but in critical situations the lower the degree of complexity of support required by the Army, the better the chances of success. This policy dictates that Military Standard products (such as greases) be used and that the number of these products be minimized. The Army has worked and continues to work toward the goal of a single multipurpose grease for all applications in the millions of grease lubrication points in Army equipment. While this goal has not been achieved as yet, many steps are being taken to move in this direction.

II. OBJECTIVE

The objective of this report is to explore the issue of lubrication for wheel bearing applications in Army equipment. The two basic modes of lubrication are grease or oil. Each will be discussed with respect to the Army mission, cost, and logistics factors so that a rational solution to this problem can be obtained.

Figure 1. US Marine Corps LVPT-7 amphibious landing craft.

III. DISCUSSION

1. Requirements. The development of lubricants for Army materiel is directed toward meeting the unique requirements of the Army. These requirements are similar in some respects to those of the commercial sector and are listed in generalized form as follows:

Cost: Minimum possible.

Logistics: Readily available; widely used.

Readiness: Equipment must be ready to roll.

Mobility: Equipment must function over time.

Performance: Performance at temperature extremes (over time).

a. Cost. Any item purchased by the Government must be purchased at a price as low as possible so that efficient use of resources and fair competition within the commercial marketplace are achieved. New products or developments within the Army are judged with respect to their cost or cost savings prior to their entry into the Military supply system.

b. Logistics. The total amount of support required to maintain available force is a strong influence on the ability of that force to be effective. The previously discussed approach of multipurpose lubricants will significantly reduce logistic problems where supplies are needed by the troops since one all-purpose grease will have multiple-use applications.

c. Readiness. The operational readiness of the fleet must be maximized in that "immediate" response time is, in itself, a deterrent and the more ready the force, the better the deterrent for automotive grease. This simply means that the wheels must be ready to roll even in equipment which does not see a great deal of activity (i.e., prepositioned storage). This has been a problem in equipment stationed near the ocean, where wheel bearings can become severely corroded and fail (Figure 2). Corrosion can even appear in vehicles in the desert where washing is performed regularly to remove sand and other abrasive debris.

d. Mobility. If readiness is achieved, mobility must follow, as the troops must be able to function over a period of time. Lubricants must then be in good initial condition and be able to sustain performance for these periods (the lubrication intervals).

Figure 2. Severely corroded wheel bearing.

e. Performance. The mobility doctrine (i.e., combat effectiveness) says that the Army must be capable of performing its mission in any geographical location; hence the lubricants must be capable of performing at temperatures from as low as -65° F to as high as 300° F (-56° C to 148.9° C). The grease or oil must then be able to provide corrosion protection and lubrication over these temperature ranges, initially (i.e., for equipment at rest), during use, and for as long as possible with the lowest number of products at the least possible cost.

2. Procurement. The US Army does not manufacture any of its vehicles and must, therefore, depend upon Industry for meeting its needs. The Military unique requirements for tanks, trucks, self-propelled howitzers, etc., do overlap to some degree with parts which are available for Industry. This equipment is off-the-shelf commercial procurement (e.g., administrative vehicles); some is fully developed for the Army (e.g., tanks), while there are intermediate systems as well. All of these procurements use the maximum amount of commercially available parts because of the high development costs. Wheel bearings and axles on vehicles are, in general, commercially available or very near in design to being off-the-shelf items. When the Army imposes requirements on purchases, a price must be paid for the extra developmental work involved. Thus wheel bearing lubrication, in general, is dictated initially by Industry and is sometimes modified by the Army developer at a later date. This is because the use to which the equipment will be operated within the Army is different from that of the commercial sector, even though the axles or wheel bearings may be exactly the same as in commercial trucks or cars. This can be a problem for the Army because initial cost savings (by strictly commercial items) can lead to field problems originating from the Army's more severe operational use.

IV. GREASE VERSUS OIL

1. Advantages of Grease Over Oil. Advantages of grease over oil lubrication of road wheels in Army equipment are briefly summarized as follows:

a. Leakage. Lubricant loss in wheel bearings will lead to bearing failures. Grease will not leak out of the hub cavity when seals leak (or fail) or when sight glasses on the hubs are ruptured. Grease lubrication will therefore eliminate all failures due to lubricant loss.

b. Seasonal Lubricant Changes. Figure 3 shows the operating temperatures of various lubricants. The grease, MIL-G-10924 (GAA), has a wide temperature range and need not be changed for seasonal weather conditions. In addition, cross contamination of the oil lubricants after seasonal oil changes can adversely affect the resulting lubricant's flow properties and lead to lubricant starvation in some instances (i.e., temperatures below the pour point of the oil).

c. Maintenance. Grease does not require continual, daily checks to maintain the proper lubricant level or to determine if water contamination has occurred.

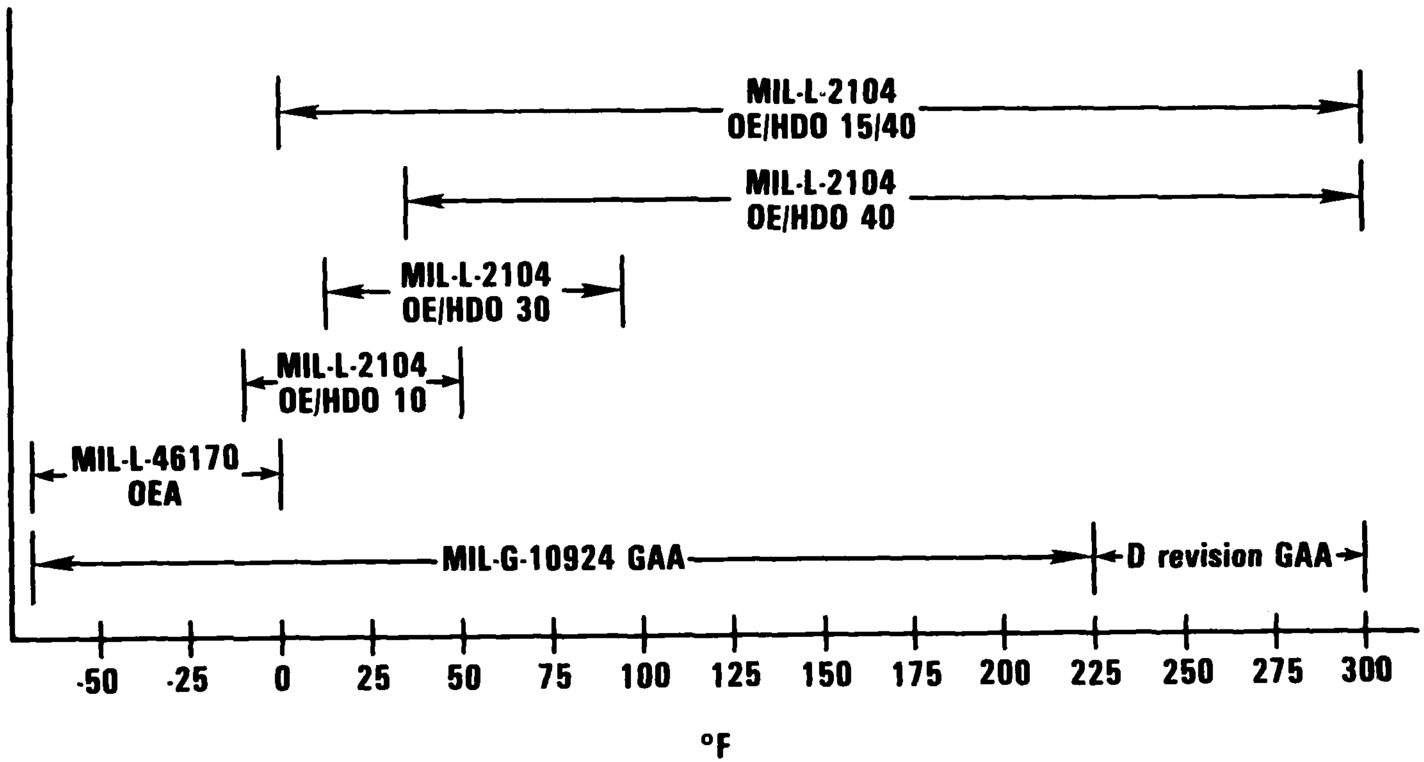

Figure 3. Operational temperature ranges for various lubricants.

d. Tolerance to Water. Grease is more resistant to water contamination than is oil. The MIL-G-10924D specification includes a consistency retention test performed on 90-percent grease/water mixture. Engine oils will emulsify with water and reduce the effective lubrication significantly. Also, water admixed with oil can induce the growth and proliferation of microbiological organisms.

e. Corrosion Protection. Grease has superior corrosion/rust protection compared to oil and is not easily displaced by water (leaving metal parts unprotected).

f. Contaminant Barrier. Grease as a semisolid forms a more effective shield or barrier to contamination than does oil and a hub immersed in mud or water is more likely to prevent the influx of these contaminants than is oil.

g. Lubricant Film. Grease produces a thicker lubricant film than do engines oils such as MIL-L-46167 (Arctic Engine Oil, a SAE Grade 5W-20) which is used in cold climates.

h. Military Worth. The wide temperature range for operability and readiness, the reduction of down time for seasonal oil changes, and the elimination of leaks which require immediate attention all favor grease for the lubrication of Military wheel bearings.

i. EP/Antiwear. Antiwear, extreme pressure additives are used in the formulation of wheel bearing greases but not in engine oils. Thus, wear protection and long operating lifetimes are not expected for oil-lubricated bearings.

2. Advantages of Oil Over Grease. The advantages of oil over grease lubrication of wheel bearings are:

a. Heat Flow. Oil, being a liquid, is capable of conducting heat away from bearings more efficiently than does grease and reaches points in the system where grease may not reach.

b. Operating Temperature. The operating temperature for oils was higher than were those for greases (Figure 3).

3. Summary. For Military applications, grease is the desired form of lubrication of wheel bearings. There are, however, several problems associated with this approach.

a. Heat Flow and Temperature Limit. The use of a grease with a higher upper temperature limit than that shown in Figure 3 for MIL-G-10924 (GAA) would significantly improve these factors by extending operating range beyond that encountered in the bearings, even on an intermittent basis. This can be accomplished by modifying the MIL-G-10924D specification to increase the minimum dropping point limit to 350° F (176.7° C) which would extend the operating temperature range out to 300° F (148.9° C) for the grease. This would also reduce significantly any problems associated with hotter running bearings by improving the grease life at higher temperatures relative to the previous GAA grease.

b. Operational Problems With Oil Lubrication. The Army equipment in the following list are all tracked vehicles which were developed with oil-lubricated wheel bearings and subsequently were changed to grease because of the operational problems with oil lubrication including failures:

Designation	Type
M48	Tank
M60	Tank
M110	Self-Propelled Howitzer
M113	Armored Personnel Carrier
M109	Self-Propelled Howitzer

One potential problem with conversion from oil to grease is overlubrication. The bearings are not removed but are greased in the hub through a grease nipple (placed in the oil drain hole). Greasing the wheel bearings in this way will fill the hub completely with grease. Although not reported, this condition will cause the bearings to run hotter than usual but a higher dropping point grease will eliminate this potential problem.

c. The Army is currently procuring tracked vehicles which are configured with oil-lubricated wheel bearings. For instance, the M1 Abrams tank; the M2 and M3 infantry and cavalry fighting vehicles; the Multiple Launch Rocket System; and the M915 series of trucks are a few of the recently fielded vehicles which appear to be headed for eventual conversion to grease lubrication. A project is being pursued at the Belvoir Research and Development Center which will ultimately enable contractors and Army developers to rapidly obtain information concerning lubricant usage so that Army needs can be designed into future systems. This computer-aided design system is a data base approach to handling the many lubrication points associated with Army equipment, as well as other types of information such as replacement lubricants. In this way, the entire operating lubrication activity of the Army can be maintained effectively and a great deal more consistency is anticipated. For example, the high cost of developing an oil-lubricated system, the failures which occur, and the conversion to grease could all be replaced by initial development of a grease system.

d. In the rear axles of 5-ton and 2½-ton trucks, gear oil from the differential is free to pass through the axle and enter the hub. If the hubs are removed (Figure 4) this gear oil will drain out of the axle onto the floor. The gear oil then penetrates the bearing seals and washes away the grease from the bearings, resulting in pseudo-oil-lubricated rear axles. Proper sealing of the axles would eliminate this problem, which is interfering with attempts to extend lubrication intervals for these vehicles. Again, seal failures which cause external leakage can lead to bearing failures, particularly after the grease has been washed away. This problem appears to be general for all tactical vehicles in these classes and, possibly, others. The effect of gear oil contamination on the grease during this process is unknown, but the additive packages are not compatible and the previously discussed corrosion problem may be an area where problems can occur. The effect of the grease on the gear oil also is not certain, but the acidic thickeners in grease are expected to cause problems. Thus, the ideal situation in these vehicles will be to separate the two incompatible lubricants, and the means for accomplishing this is currently under study.

e. One goal of the grease program is to extend the lubrication intervals for equipment so that fewer maintenance hours are required (as well as less materials). In order for this to be accomplished, a program for developing greases with advanced properties is required. This advanced grease must be able to perform for a longer time than the current GAA and, hence, will need to be evaluated for its lubrication properties over this period of time (2 years). The most important property for this program is antiwear so that failures because of lubricant do not begin to appear at greater rates than those observed currently (with the shorter intervals).

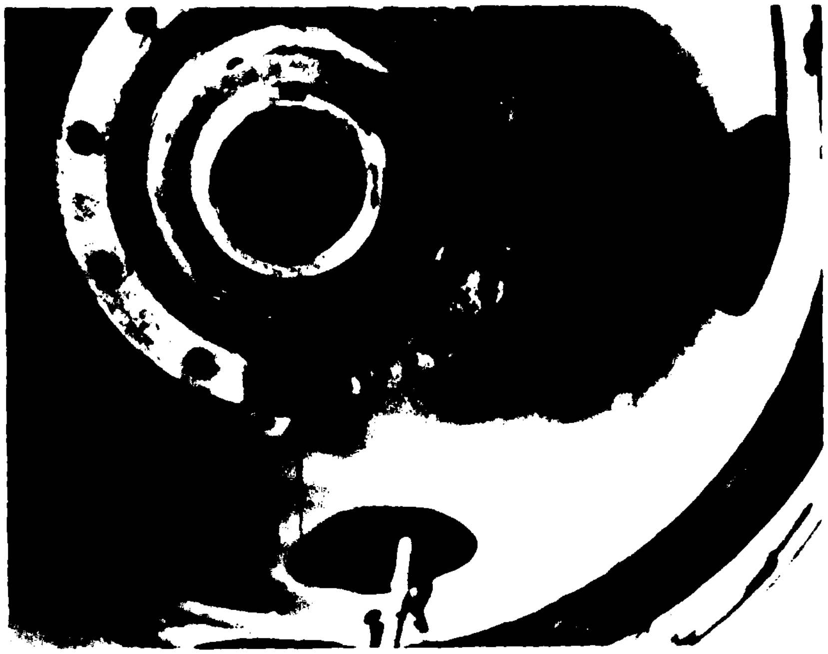

Figure 4. Gear oil draining from a truck rear axle.

V. CONCLUSIONS

The lubrication of wheel bearings of US Army vehicles is currently by both oil and grease. Many important oil systems have been converted from oil to grease, the most recent being the M109 self-propelled howitzers. The tracked vehicles (and one tactical truck) recently fielded by the Army are oil-lubricated systems, and it is anticipated that conversion to grease will be forthcoming. Grease is the lubricant of choice for those reasons given. The single disadvantage of grease lubrication can be significantly reduced by the use of a 350° F (176.7° C) (min) dropping-point grease, and a grease with this dropping point will be supplied under the recently issued MIL-G-10924D specification. Further advances in wheel bearing lubrication under current Army programs involve extending lubrication intervals by using high-performance greases for longer life. The field problem with tactical vehicles (seal failure or non-sealing) will need to be eliminated or lubrication interval extension cannot be achieved for tactical vehicles. The lubrication requirements for future systems development programs for Army equipment will be facilitated by a computer-aided design tool being developed at the Belvoir Research and Development Center using a data base approach so that consistency in policies can be maintained at the design level by both the Army and the contractor.

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