

NASA TESTING
FORT HOOD, TEXAS



REPORT OF PRODUCT TESTING
M - 113 COOLING FAN ANGLE DRIVE
FORT HOOD, TEXAS

Scope of this report

This report details testing performed at Fort Hood , Texas during May and June 1983 on the cooling fan assembly of the M -113 Armored Personnel Carrier and related series vehicles.

Situation

The cooling fan assembly in these vehicles experiences higher failure rates than would seem normal for such a mechanical assembly. This led to a disproportionate recurrence of **NOT MISSION CAPABLE** (NMC) ratings from failure.

Test Objective

The objective of the test is basically two - fold. First to determine if the currently used lubricant was sufficient for this application, and secondly, to determine the feasibility of a lubricant which provided a wide S.A.E. range coupled with a bonded dry - film lubricant.

Test Methodology

The fans were driven by a seven and one - half (7 1/2) electric motor on each fan assembly, through a pulley and belt arrangement. The motors provided 1760 r.p.m. fixed speed.

In **Phase 1**, ratios were set to produce fan r.p.m.'s of 3461; and in phase 2 ratios were set to produce fan r.p.m.'s of 4861.

Phase 1 of test to last @ 50 hours with **Phase 2** of testing to last an additional 50 hours , for a total of 100 hours running time.

This is an acceptable procedure and was patterned after the Federal Aviation Administration test procedures for lubrication certification and type acceptance.

Unit #1 was a *salvage* M - 113 A 2 cooling fan repaired and assembled by L.V. Cammack and inspected and certified as being in compliance with the specifications and tolerances of TM 9 - 2520 - 238 -34. C2. by Charles

Taylor and Jack Peebles. It was lubricated with BOP Formula 844.

Unit #2 was a new issue unit from D.I.O., inspected and certified by; Jack Peebles. This unit was lubricated with MIL -L-21260, Grade 2, SAE 30 drawn from stock.

Variances

During assembly of Unit # 1, it was discovered that the gear housing around needle bearing 20 was scarred. This was filed and emory clothed, cleaned and blown dried. Both Input / Output gears were shimmed to minimize backlash.

Test Run 1 - 6

First run lasted 8 minutes and 30 seconds at which time both fuses blew. During this time both units seemed to function normally. Unit # 1 had a pronounced vibration which could be felt in the dust cover and had a low frequency noise of an undetermined nature.

Test Run # 7

Units are displaying great differences. Test carried through 34:04:27 for this run differences noted as follows:

- **09:57:32** fuses failed Unit #1 bearing slightly warm Housing slightly warm. Unit # 2 housing very warm, input shaft was slightly hot. A grinding noise could be detected in Unit # 2 with a stethoscope, coast down time 7 seconds shorter than Unit # 1.
- **28:12:00** Unit # 2 had a loud whine that lasted about a minute then disappeared. It sounded like some sort of metal to metal contact was taking place. Unit # 1 still had a slight whine.
- **30:30:00** Both units stopped for inspection. a new noise could be heard in Unit # 2 coast down time @ 10 seconds shorter than Unit #1. Unit # 2 housing was warm with input shaft being hot. Unit # 1 remained slightly warm to warm on all surfaces.
- **32:37:43** A new loud grinding noise was heard from Unit #2 for about 15 seconds. Stethoscopic inspection determined this noise to be coming from the gears.
- **34:04:27** A loud grinding noise developed in Unit #2 both units stopped for inspection. Coast down time for Unit # 2 @ 15 seconds shorter than Unit #1. Unit #1 had no surface temperature greater than slightly warm. Unit #2 Upper housing very warm, Lower housing slightly hot. Shaft and inner bearing very hot. TESTING OF UNIT # 2 WAS THEREFORE TERMINATED. Unit # 1 was operating in a normal manner.

Test Run 8 - 10

Unit # 1 was run for 12:48:20 with no remarkable notations. None of the surfaces were greater than warm. No unusual noises heard.

It was decided both units should be run at a higher r.p.m.'s in order to push at least one of the units to some degree of self destruction.

Unit #1 was run at 4861 rpm for 14:43:15 to see if it could be knocked out of service as well. During the run there were no remarkable notations. Unit only ran slightly warm to warm.

Both units were run side by side. Unit #1 performed normally and ran no greater temperatures than warm. Unit #2 initially performed normally, due to it's ability to have cooled down. However soon began making a noticeable grinding noise during the end of the run. Temperatures for the housing were warm and very warm with the shaft being very hot.

Test Run 14

Test was terminated at this point. Total time for both units at elevated rpm's **22:56:22**. It was determined in the interest of safety the tests be terminated. **Unit #2 housing surfaces were very hot with shaft being very hot**. There was also a grinding noise in frequency noted during the run which was the determining factor to terminate the tests. **Unit #1 performed normally with surface temperatures only running slightly warm**.

Post Test Inspection

All components of Unit #1 were found to be serviceable with no indication of wear nor deterioration. Oil Unit #1 was clean and manifested no signs of deterioration.

In the inspection of Unit #2 the first feature to be noticed was the scoring of the inner diameter of the fan tower. It was this scoring that lead to the cessation of the testing. Disassembly showed greater bearing failure that had been suspected. Oil from Unit #2 appeared to have sustained some degree of burning. All internal parts were sent to **N.A.S.A.** labs for detailed inspection.

Testing at **NASA proved the coating to be 1 micron thick and bonded to the metal surfaces**. The tests were performed with NASA's electron Microscope and proved the dry-film lubricant had rebonded only to the bare metal surfaces and not to itself. **NASA photos are included in this summary**.

Recommendation

It is recommended that the Angle Drive Fan Assemblies of the M-113 and related series vehicles be treated with BOP Formula and that they only be run with this lubricant installed.

Temperature Scale Explanation

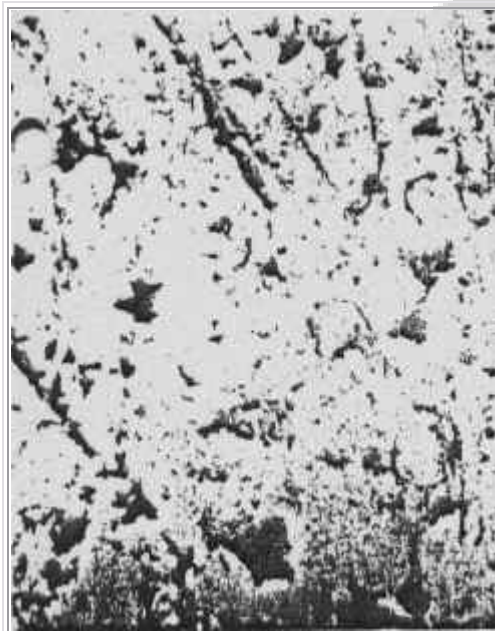
Slightly Warm - a slight temperature elevation can be noted but is minor
Warm - temperature elevation is very apparent but does not cause discomfort if held
Very Warm - causes discomfort if held but does not cause pain
Slightly Hot - causes discomfort and pain if held to skin discoloration
Hot - pain if held, prolonged contact results in minor skin discoloration
Very Hot - causes pain and skin discoloration if touched
Extremely Hot - causes pain and blistering if touched

Duration of Tests Run

Run #	Total Hours Run	
	UNIT # 1	UNIT # 2
1-3	00:30:51	00:30:51
4-6	03:44:25	03:44:25
7-9	65:20:27	37:48:52
10-12	75:55:27	54:33:07
13-14	82:17:34	61:15:14

Run # 1 thru Run # 8 were made with input RPM of 3641

Run # 9 thru Run # 14 were made with input RPM of 4861



Inner Race from Treated Bearing (fig 3)

The surface coated with BOP and although the coverage is not complete, the picture shows conclusive evidence of the protection afforded the surface and that the bonding has withstood a considerable amount of extreme friction.

For all practical purposes, this surface can be considered "brand new". It becomes more dramatic when compared with the untreated surface below, and it is remembered that both surfaces were sustaining identical amounts of use.

This race is apparently capable of sustained operation and would still be serviceable.



Race from Untreated Unit (fig4)

This photo shows the results of the ball in Fig. 2 skidding across the surface.

This is the classic example of galling of a race by a ball due to inadequate lubrication. Close examination shows that the metal is being "peeled" as well as scored. Pitting is also occurring.

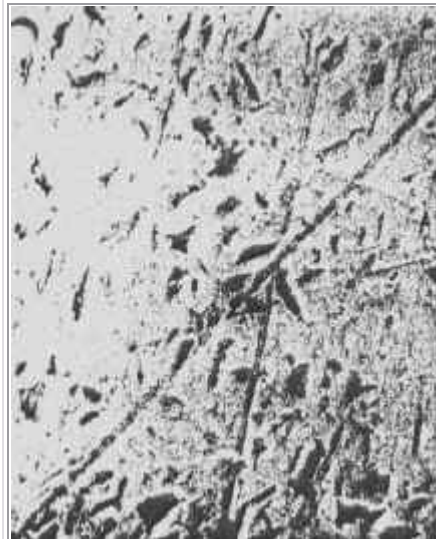
It was this wear which allowed the impeller to develop the horizontal movement which resulted in the scoring of the inner diameter of the fan tower.



Ball Bearing from Treated Unit (fig. 1)

This surface shows signs of almost total coating with BOP and **virtually no wear or deterioration.** There is no indication of skid, smearing, brineeling, nor spalling.

This ball surface is only slightly different from a new ball.



Ball Bearing for Untreated Unit (fig 2)

This ball surface shows considerable wear. There is evidence of primary brineeling, skidding and spalling.

In spite of the fact that the ball wears the least (in comparison with the race) this ball does show that it is wearing.

Wear of this nature is generally the result of inadequate lubrication. It is discussed in more detail in the evaluation of this report.



Gear in Treated Unit (fig. 5)

This gear is virtually without wear. Were it not for the coating of film it could be brand new.

The marks left by milling prove conclusively that the bonding agent does not rebond to itself. The one (1) micron thick coating has not filled the holes left by the milling process, but the coverage almost total. This dry - film lubricant was responsible for the extraordinary temperature dropping the treated unit.

The fluid lubricant has filled it's job in this unit and the dry film of BOP has reduced friction and wear



Gear in Untreated Unit (fig 6)

The gear surface sustained considerable wear and deterioration. Galling has occurred and brineeling also.

The flaking of metal can be seen and in the lower left hand corner, and actual flake can be seen.

The temperature has been exceedingly high, as evidenced by the bubbling effect.

Wear of this nature is almost always a result of inadequate lubrication. It can result in a syndrome wherein the surface is worn, then that wear defeats the formation of the oil wedge which creates higher heating which defeats the oil wedge, etc., etc.,

Photos 2000X - NASA Pasadena, Texas

