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00 USARTL-TR-79-3 6 65 ORIVESHAFT ALIGNMENT INDICATOR AB Frank A. Bill, Robert B. Bossler, Jr. KAMAN AEROSPACE CORPORATION Old Windsor Road FILE COPY Bloomfield, Conn. 06002 January 1979 200 Final Report for Period November 1975 - May 1978 Approved for public release; distribution unlimited. DC 70770 20 1979 55UU **Prepared** for D APPLIED TECHNOLOGY LABORATORY U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM) Fort Eustis, Va. 23604 79 03 19

APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

The program reported herein is part of a continuing effort of the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), to conduct investigations directed toward improving inspection and maintenance procedures on Army helicopters. The objective of this program was to facilitate engine transmission alignment by providing an improved static alignment procedure and dynamic alignment capabilities which permit in-flight measurement. The results presented in this report demonstrate that there is an alignment problem with the UH-1/AH-1 fleet. Of 31 UH-1/AH-1 helicopters checked, 61 percent exceeded specified limits. These helicopters had been previously aligned with the current technique. The next step in the development of the improved alignment procedure would be to militarize the DSAI; however, no work is planned by this laboratory.

The technical monitor for this contract was Mr. Meyer B. Salomonsky, Aeronautical Systems Division.

DISCLAIMERS

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

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20. ABSTRACT

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system cost. The second-generation concept was investigated under Contract DAAJ02-77-C-0006. The investigation included design and manufacture of a prototype alignment-measuring tool, ground and flight tests, and a survey of the existing driveshaft alignments of Army helicopters. The survey included eight UH-1 at Bradley Field, Connecticut, ten UH-1 at Felker Field, Fort Eustis, Virginia, and ten UH-1 at Simmons Field, Fort Bragg, North Carolina. Subsequently, three AH-1 were measured at Felker Field, and finally a UH-1 with sling load was measured at Kaman. The significant measurements were static alignment, hover at a 5-foot skid height, and low-speed high-power climb (70 knots forward speed, 1000 ft/minute climb). Statistical analysis of the test data indicates that 99.73 parcent (\pm 3 σ) of the Army UH-1 fleet has a driveshaft mis-alignment of 4.96° or less during the highest steady state condi-tion (low-speed high-power climb). This steady state misalignment can be reduced to less than 1.5° by specifying appropriate and attainable alignment limits for hover at a 5-foot skid height. Further, alignment checks can be more easily performed with the tool and procedure described herein than with the standard procedure of TM55-1520-210-20. It is recommended that an evaluation quantity of driveshaft alignment tools be procured as a first step toward improving the driveshaft alignment of Army UH-1/AH-1 helicopters.

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PREFACE

The Applied Technology Laboratory of the U.S. Army Research and Technology Laboratories (AVRADCOM) supervises research programs aimed at improving the maintainability of current and future Army helicopters. The alignment of driveshafts in helicopters has been identified as a maintenance problem area. In particular, the alignment procedure for the main driveshaft of the UH-1 has been found to be very difficult and time con-Accordingly, a driveshaft alignment indicator was suming. investigated under Contract DAAJ02-76-C-0010. Technical direction was provided by Mr. R. Prather, Aerospace Engineer at the Applied Technology Laboratory. The final report was not published and remaining funds were deobligated because a secondgeneration concept was evolved which indicated improved accuracy and greatly reduced system cost. The second-generation concept was investigated under Contract DAAJ02-77-C-0006. Technical direction was provided by Mr. M. B. Salomonsky, Aerospace Engineer, Applied Technology Laboratory. This report covers work performed under both contracts, including design and manufacture of a prototype Army maintenance tool suitable for use on the UH-1/AH-1, ground and flight tests, and a field survey to measure actual driveshaft alignment in Army helicopters. The work was accomplished during the periods from 12 November 1975 to 7 June 1976 and from 23 December 1976 to 19 June 1978. The work was conducted at Kaman Aerospace Corporation, Bloomfield, Connecticut under the technical supervision of Mr. Frank A. Bill and Mr. Paul J. Meiselman of the Mechanical Test Group. Overall cognizance of the program was maintained by Mr. Robert B. Bossler, Jr., Chief of Mechanical Systems Research.

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INTRODUCTION

Measuring alignment in flight (dynamically) is estimated to be 10 times as valuable as measuring alignment statically. If the dynamic misalignments can be readily measured during various flight regimes, alignment can be ground-adjusted to provide the best operational compromise. Otherwise, static alignment must be based on estimated dynamic behavior. Accurate dynamic measurement would allow precise offsets for each individual helicopter, and different offsets when the same driveshaft is used for different aircraft (UH-1 vs. AH-1).

The specific problem of alignment of the main driveshaft of the UH-1 helicopter was rated in USAAMRDL TR 72-11B¹. The driveshaft alignment problem on the UH-1 was rated as high for the safety factor and medium for the factors of maintenance workload and helicopter availability.

The current UH-1 driveshaft alignment procedure is given in TM55-1520-210-20². That procedure is reproduced in Appendix A. Main driveshaft alignment is checked statically using a set of special mechanical tools. Prior to the check, four jacks and a depth micrometer are used to position and hold the softmounted transmission parallel to its supporting structure. The lift link must also be unloaded by these jacks.

With the driveshaft removed, an extendable plug gage assembly is attached to the engine output. The plug serves to extend the rotational centerline of the engine output to a target plate mounted on the transmission input. An eccentrically located hole in the target plate will accept the plug gage if the vertical and lateral position of the transmission is correct. Nonparallelism of the rotational centerlines of the engine output and the transmission input is checked next, by attaching a dial indicator to the extendable plug gage assembly and trammelling the surface of the target plate which is perpendicular to the transmission input quill. It is required that the transmission be statically rotated CCW when viewed from above and offset to the right and lowered with respect to the engine centerline.

- Clark, M. W., Krauss, W. K., Ciccotti, J. M., IDENTIFICA-TION AND ANALYSIS OF ARMY HELICOPTER RELIABILITY AND MAIN-TAINABILITY PROBLEMS AND DEFICIENCIES, VOLUME II, American Power Jet Company: USAAMRDL Technical Report 72-11B, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, April 1972, AD 901457L.
- Technical Manual, TM55-1520-210-20, ORGANIZATION MAIN-TENANCE MANUAL, ARMY MODEL UH-1D/H HELICOPTERS, Department of the Army, Washington, D.C., 10 September 1971.

Main driveshaft alignment is altered by selectively shimming between one or more of the engine tubular mounts and the engine deck, thereby shifting the position of the engine.

The existing alignment tool provides three different types of indications of misalignments. A plug will not enter a hole, the plane of maximum misalignment is related to clock positions, and the angle of misalignment is related to the differences between min and max dial indicator readings. The mechanic is left to his own devices to determine the interaction of these three signals of the misalignment. Not surprisingly, he usually shims the engine by the long process of trial and error.

The problem of driveshaft alignment in helicopters was found to be significant by Kaman investigators as reported in USAAMRDL TR 75-7³. A general case solution for future design was outlined. Independent of the alignment problem investigations, the U.S. Army Aviation Systems Command (AVSCOM), identified the UH-1 driveshaft as a candidate for improvement, in order to reduce maintenance and to provide a longer service life. A driveshaft using KAflex couplings (a Kaman product) was selected for evaluation as a candidate replacement. The alignment of both the KAflex driveshaft and the standard Bell driveshaft were precisely measured during both ground and flight test of the baseline (Bell) driveshaft and the test (KAflex) driveshaft.

An opportunity thus existed for a real-world proof-of-concept test of a driveshaft alignment indicator. Equipment and procedures at hand included the bailed UH-1 and a driveshaft alignment measurement system, already tested and operational, to be used as a baseline monitoring system. The existing measurement system included telemetry of data to ground by pilot command, followed by computer printout of the driveshaft alignment. Driveshaft alignment had already been measured precisely throughout the UH-1 flight envelope.

This report describes work done to evaluate an in-flight driveshaft indicator that is suitable for use on both UH-1 and AH-1 aircraft, a survey to determine the driveshaft alignment now existing on Army helicopters, and an improved driveshaft alignment procedure including a simplified shimming technique.

 Cook, T. N., Starses, F. E., Haire, G. W., ARMY AIRCRAFT SUBSYSTEM AND COMPONENT INSTALLATION DESIGN INVESTIGATION, Kaman Aerospace Corporation: USAAMRDL Technical Report 75-7, Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, February 1975, AD A007245.

DRIVESHAFT ALIGNMENT INDICATOR DESIGN DESCRIPTION

The driveshaft alignment indicator is described in this section. Two separate interchangeable strut assemblies are used. One strut assembly is mounted in the vertical plane, directly above the driveshaft, and measures the vertical angle. The second strut assembly is mounted in the horizontal plane and measures the horizontal angle. Additional components include an A-frame, which is attached to the engine particle separator, and a transmission mount plate. These structures provide mounts for the strut assemblies. Modified inlet baffles are required to accommodate the strut assemblies. The signals from the strut assemblies are transmitted by cables to a power supply/demodulator box. The signals are converted to digital angle displays and read on a meter box.

The strut assemblies are shown in use schematically in Figure 1. The entire system is illustrated in Figure 2. The A-frame mount for the particle separator, the power supply/demodulator, and the digital readout box are shown in Figures 3, 4, and 5, respectively. The strut assemblies with associated hardware are shown in Figure 6 installed in a UH-1H helicopter, and in Figure 7 in an AH-1 helicopter.

Each strut assembly consists of a telescoping shaft to which is mounted at Multi-Vit sensor. The Multi-Vit sensor is a noncontacting electronic micrometer which is extremely accurate.* The shaft is freely extensible or compressible to accommodate change of length. The strut engages selfaligning bearings at each end. The bearings are mounted in a target plate whose location is sensed by the Multi-Vit. The target plate also contains an alignment hole which receives an aligning pin attached to the strut assemblies. The alignment pin/hole arrangement keeps the Multi-Vit aimed at the target plate.

The strut assemblies form a trapezoid with the driveshaft, as can be seen in Figure 1. A coupling angle change causes a slightly amplified angle change between the strut assembly and the target plate. The angle between the strut assembly and the target plate is measured by the Multi-Vit in terms of distance from the Multi-Vit to the target plate. The distance measurement is converted to an angle, corrected for the aforementioned amplification, and displayed in degrees (x.xx) on the panel meter on the digital readout box. There is no mixing of the signals from the two strut assemblies. The angle measurements are completely independent.

* Product of Kaman Sciences Corporation, 1500 Garden of the Gods Road, Colorado Springs, Colorado, 80907.



Figure 1. Strut Installation - Schematic.











Figure 5. Digital Readout Box.





The angle measurements reproduce the arrangement used for vertical angle measurements in the first contract. The original vertical angle measurement was found to be very precise. It was shown to be not affected by changes in the horizontal angle or by relative rotation of the engine with respect to the transmission. It was not affected by the radial distance from the driveshaft to the link assembly.

Driveshaft change of length was found to be very slight and of no practical significance. It need not be measured. Also, the difference in length between the standard driveshaft (8.68 inches) and the KAflex driveshaft (7.56 inches) did not have a significant effect on measured misalignment angles. Plots of the angle measurements made with each shaft can be superimposed with no discernible difference.

The strut assemblies are interchangeable. This has the advantage of allowing both angles to be measured, although only one at a time, in the event that one system malfunctions. Also, the use of two identical strut assemblies will reduce the cost of procurement and in-service cost.

The strut assemblies can be reversed to read the alignment angles of the engine-end coupling. A switch on the digital readout box is used to select the appropriate correction circuits for the transmission-end coupling or the engine-end coupling. Measurement of the misalignment of the engine-end coupling is not felt to be as important as the measurement of transmission-end coupling misalignment. Transmission-end coupling misalignment is larger than engine-end coupling misalignment because the transmission is isolation-mounted while the engine is not. As a result, the transmission rotates about the rotor axis in response to a torque change, causing the larger horizontal angle to occur at the transmission-end coupling. Also, when the transmission rocks about a transverse axis in response to fore-and-aft cyclic pitch, the larger vertical angle occurs at the transmission-end coupling. Historically, the transmission-end coupling has shown more wear than the engine-end coupling, which also indicates larger misalignment. However, the option of actually measuring engine-end coupling misalignment could be useful in a troubleshooting situation.

The driveshaft alignment indicator will fit both the UH-1 and the AH-1 helicopters. It has been observed that the AH-1 mission causes more large-misalignment events than the UH-1 mission. Thus, dynamic alignment measurement is important to the AH-1. The driveshafts are the same, as are the input quill geometry and the particle separator geometry. The intake baffles and the control systems are different. The digital readout box contains adjustments for zero and slope. Zero misalignment can be set physically with a ceramic spacer between the Multi-Vit and the target plate. Then the zero-set adjustment on the digital readout box is turned until the digital panel meter reads 0.00 degrees. A similar adjustment for slope changes the reported angle versus the apparent angle. However, the actual driveshaft angle has to be measured, such as with a dial indicator, to verify the proper slope. Slope change is needed to accommodate the difference between the angle seen by the strut assembly and the angle experienced by the driveshaft coupling.

Important design characteristics are listed below:

- 1. Usable on UH-1 and AH-1 helicopters.
- Usable with the standard gear coupling or the KAflex coupling.
- 3. Interchangeable strut assemblies.
- 4. Reversible strut assemblies.
- 5. Usable without driveshaft removal.

PROTOTYPE VERIFICATION

Verification of the ability of the driveshaft alignment indicator (DSAI) to measure driveshaft alignment is reported in this section. This verification was accomplished by comparing the alignment readings of the prototype DSAI with a baseline monitoring system. The baseline monitoring system was developed for flight testing of a UH-1 driveshaft using KAflex couplings. The alignment of both the standard Bell driveshaft and the KAflex driveshaft were precisely measured during both ground and flight test. The measurement system included telemetry of data to ground by pilot command, followed by computer printout of the driveshaft alignment. Driveshaft alignment was measured throughout the UH-1 envelope. The driveshaft was aligned per TM55-1520-210-20 as described in Appendix A.

The principle of operation of the baseline monitoring system is illustrated in Figure 8. Three Multi-Vits are mounted on the transmission at 120° intervals on a circle of 10.2 inches diameter. A steel disc is attached to the center shaft of the standard driveshaft assembly. At zero misalignment, the Multi-Vits are equally distant from the disc. The vertical, horizontal, and resultant total alignment angle of the transmissionend coupling, as well as change of length, can be calculated by geometric relationships. The angles calculated from Multi-Vit signals were checked statically by finding the distance from the Multi-Vits to the disc with a telescoping gage and measuring the telescoping gage with a micrometer. The angles were independently calculated using the micrometer measurements. They confirmed the angles calculated using the Multi-Vit sensors, thus providing angle measurements based on certified standards and traceable to the National Bureau of Standards.

Verification of the DSAI began with static testing. The driveshaft was aligned per Bell Helicopter Textron Service Bulletin No. 205-76-9⁴ as described in Appendix B. The transmissionend coupling angle was measured simultaneously by using the telescoping gage with micrometer technique, by the baseline Multi-Vit system, and by the DSAI. All three systems concurred. The helicopter was then loaded to 8600 lbs gross weight and suspended by an overhead hoist attached to the rotor hub. Alignment angle measurements were taken using all three systems, while the helicopter was suspended, at 8600 lbs gross weight, aft C.G. (Station 138). The process was repeated for forward C.G. (Station 133).

 ENGINE TO TRANSMISSION DRIVESHAFT ALIGNMENT Service Bulletin No. 205-76-9, Bell Helicopter Textron, Forth Worth, Texas, 9 September 1976.





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The DSAI was then flight tested. The DSAI features a hold switch that takes an average reading over a 2-second interval. The pilot held conditions for a data point for several seconds and then depressed a telemetry switch. The angle measurements of both the DSAI and the baseline monitoring system were simultaneously telemetered to ground and recorded on a computer printout. Measurements were taken throughout the UH-1 flight envelope for two conditions, 8600 lbs gross weight with max aft C.G. and 8600 lbs gross weight with max forward C.G. The results are given in Figures 9 through 16. Also included in Figures 9 through 12 are the alignments measured by the baseline monitoring system for alignment per TM55-1520-210-20 with 8600 lbs gross weight, max forward C.G. A positive vertical angle exists when the transmission-end coupling is above the engine-end coupling. A positive horizontal angle exists when the transmission-end coupling is to the right of the engineend coupling. Positive vertical angle measurements at max aft C.G. show the DSAI measurements to be consistently smaller than the baseline monitoring system. The discrepancy was cause for concern. However, the consistent low readings had not occurred previously. Also, they did not occur during the testing required to develop shim curves, as reported in the next section. The shim curve tests are reported in Table 1 and illustrated in Figures 18 through 23. Subsequently it was learned that the DSAI develops a drift of 0.2 degree per hour, after the power has been on for an hour, thus explaining the variations in accuracy. Consequently, all testing was done with as short a power-on period as possible. In any event, the trend indicates that the field survey measurements would tend to minimize misalignment, not exaggerate misalignment. Repeating the flight test was judged not worth the cost.



Figure 9. Ground and Hover Alignments, Forward C.G. (Station 133), 8600 Lbs G.W.
















Figure 7. Strut Assemblies Installed in an AH-1 Helicopter.

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DRIVESHAFT ALIGNMENT PROCEDURE INVESTIGATION

An objective of this program was to develop an improved procedure for making a desired change in driveshaft alignment. This section reports how the improved procedure was developed. The improved procedure is given in detail in Appendix C.

Driveshaft alignment in the UH-1 and AH-1 helicopter is adjusted by changing the thickness of shims located between the engine mount support legs and the deck to which the legs are attached. Shim locations and identifying letters are shown in Figure 17. Initial data required for this task was obtained by changing the shim thickness under each of the six engine mount legs and measuring the resulting driveshaft alignment. The shim thicknesses and alignment data are given in Table 1. The alignment was measured by both the DSAI and the baseline monitoring sys-The data are plotted in Figures 18 through 23 to illustem. trate the effect on driveshaft alignment of shim thickness change. The data were used to calculate rate of change of angle as a function of shim change. This information was used to prepare Figure 24, Driveshaft Alignment Chart With Shimming Instructions.

Thus, the DSAI alignment technique for measuring and correcting driveshaft alignment has been resolved to the following procedure:

- 1. Install the DSAI and measure the forward coupling horizontal and vertical angles while the aircraft is being flown at a 5-foot hover.
- 2. Plot the measured angles on the forward coupling alignment chart shown in Figure 24.
- 3. Use the shim schedule of Figure 24 to determine the shim location and thickness change needed to bring the driveshaft horizontal and vertical angles within the elliptical envelope of the forward coupling alignment chart for alignment per TM55-1520-210-20.
- 4. Install the shims and recheck the alignment at a 5foot hover by use of the DSAI.

The DSAI alignment technique was tested as reported in Figures 25 and 26. Figure 25 presents driveshaft vertical angle in degrees versus descents and climbs in feet per minute. Figure 26 presents the horizontal angle versus descents and climbs. Data are presented for a gross weight of 8600 pounds with both a forward and an aft C.G. location. In addition, the driveshaft angles are shown for a predicted and observed alignment change. Comparison of the predicted and observed alignment change indicates that the technique is satisfactory. take baffles and the control systems are different.





	SHIM	LOCAT	INCI	AND		VER	DEGREES	HORI: ANGLE,	ZONTAL DEGREES
A	В	С	D	E	F	DSAI	BSLN	DSAI	BSLN
0.300	.063	.250	.157	.062	.181	-1.12	-1.11	+0.69	+0.76
0						-1.39	-1.11	+0.67	+0.81
	.300					+1.75	+1.46	-3.58	-3.00
	0					-2.18	-1.73	+1.73	+1.96
**	.063					-1.39	-1.10	+0.67	+0.80
		.125				-1.03	-0.81	-0.50	-0.41
		0				-0.54	-0.60	-1.47	-1.42
		.250	.300			-1.59	-1.25	+1.58	+1.59
			0			-0.32	-0.20	-1.75	-1.41
			.157	.300		-0.76	-0.78	-1.42	-1.21
				0		-1.06	-0.92	+0.98	+1.02

TABLE 1. SHIM THICKNESS AND FORWARD COUPLING ALIGNMENT

DSAI: Driveshaft Alignment Indicator Baseline Monitoring System BSLN:

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062

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. 300

.150

.181

0

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-3.33

-0.74

+1.83

-1.11

-2.65

-0.66

+1.49

-0.89

+0.69

+0.68

+0.62

+0.34

+0.87

+0.77

+0.76

+0.45









Horizontal Angle, Degrees

то	move	1/2	degree	to the left, remove .075" from Leg "A".
То	move	1/2	degree	to the right, add .075" to Leg "A".
То	move	1/2	degree	to the left, add .063" to Leg "E".
То	move	1/2	degree	to the right, remove .063" from Leg "E".
То	move	1/2	degree	up, remove .029" from Leg "F".
То	move	1/2	degree	down, add .029" to Leg "F".
То	move	1/2	degree	up and 1/2 degree right, add .038" to Leg "B".
то	move	1/2	degree	down and 1/2 degree left, remove .038" from Leg "B".
То	move	1/2	degree	left and 1/4 degree up, add .058" to Leg "C".
То	move	1/2	degree	right and 1/4 degree down, remove .058" from Leg "C".
То	move	1/2	degree	left and 1/4 degree down, remove .045" from Leg "D".
TO	move	1/2	degree	right and 1/4 degree up, add .045" to Leg "D".



Figure 24. Driveshaft Alignment Chart with Shimming Instructions.









FIELD SURVEY

The results of a survey of the driveshaft alignments of Army helicopters is reported in this section. The survey included eight UH-1 at Bradley Field, Connecticut, ten UH-1 at Felker Field, Virginia, ten UH-1 at Simmons Field, North Carolina, three AH-1 at Felker Field, Virginia and a UH-1 with sling load at Kaman. The significant measurements were static alignment, hover at a 5-foot skid height, and low-speed high-power climb (70 knots forward speed, 1000 ft/minute climb). The static measurement indicates whether the alignment is approximately correct, i.e., safe enough for takeoff. The 5-foot skid height was selected as a safe altitude at which to measure dynamic driveshaft alignment. The low-speed high-power climb is the highest steady state misalignment encountered in the flight envelope. Driveshaft alignment using the DSAI should be based on measurements made during 5-foot skid height hover. Data taken during the field survey at 5-foot skid height were plotted and compared on the forward coupling alignment chart, Figure 27.

Field Survey at Bradley Field

Using Figure 27 to plot recorded data, field testing of the DSAI began at the Army National Guard Facility, Bradley Field, Windsor Locks, Connecticut. Six aircraft equipped with selfpurging particle separators and two normally equipped with the non-self-purging particle separators were flown for evaluation. Each aircraft configured with the DSAI was flown, at least through the hover points, by two different pilots. The data for a 5-foot hover on each of the eight helicopters at Bradley Field is presented in Figure 28. Only eight data points are shown because all points were essentially the same for each aircraft even though two different pilots flew each aircraft. No attempt was made to realign any of the National Guard helicopters flown. An attempt was made to check the driveshaft alignment of one UH-1 using the standard alignment procedure per TM55-1520-210-20. The attempt was stopped after two days because of the press of the flight schedule at Bradley Field.

Field Survey at Felker Field

Ten UH-1 helicopters equipped with the DSAI were flown at Felker Field, Fort Eustis, Virginia. The recorded results for 5-foot skid height hover are presented in Figure 29. One of the aircraft flown that showed a high vertical reading on the DSAI was checked for alignment using the standard alignment tool and found to be outside of limits. This aircraft had approximately 964 hours since the last known alignment. An



Figure 27. Forward Coupling Alignment Chart.



Gross Weight: <u>Range from 7231 lbs to 7726 lbs</u>. Center of Gravity: <u>Range from 137.0 inches to 141.7 inches</u>. Plotted data from 5-foot hover.

Figure 28. Eight UH-1 Helicopters Flown at Bradley Field.

alignment change was made using the shim curve data developed at Kaman. This was followed by a standard alignment check for verification and the aircraft was reflown for evaluation.

Both alignment tools showed that the aircraft was aligned within tolerance after the shim change. Figure 30 presents the data recorded at a 5-foot skid height hover both before and after the alignment change. Two other aircraft that were flown with the DSAI and found within limits were checked using the standard alignment tool and procedures and showed good agreement between both alignment tools.

Field Survey at Simmons Field

Further field evaluation was conducted at Simmons Field, Fort Bragg, North Carolina, using 10 additional UH-1 aircraft. Figure 31 presents the data for a 5-foot skid height hover. The average airframe time for aircraft flown was 4416 hours at Felker Field and 706 hours at Simmons Field, indicating that the data represent a wide cross section of UH-1 aircraft. No attempt was made to alter the alignment of any of the aircraft at Simmons Field.

Field Survey of AH-1 Aircraft at Felker Field

Field evaluation of the DSAI on AH-1 aircraft was conducted at Felker Field, Fort Eustis, Virginia.

Three AH-1 aircraft were configured with the DSAI and flown through the same envelope previously used for UH-1 aircraft. Each of the three AH-1's flew the hover conditions twice, once at the start of the flight and then again at the end of the flight, giving effectively two sets of hover data for each aircraft. Additionally, one AH-1 configured with TOW launchers was flown through three autorotative points at 61, 70, and 99 knots, giving data at minimum rate of descent, maximum glide angle, and the 70-knot point which was common to all previous measurements. A fourth AH-1 was configured with the DSAI but flight testing was cancelled due to bad weather conditions. A fifth and the last AH-1 available at Felker Field was down for maintenance and not expected to be in an up status for some time.

Figure 32 presents a summary of the hover data from the three AH-1 aircraft flown at Felker Field.

UH-1 Evaluation With Sling Load at Kaman

The alignment during flight with an external sling load on UH-1



Gross Weight: Range from 6989 lbs to 7413 lbs. Center of Gravity: Range from 139.8 inches to 144.6 inches. Plotted data from 5-foot hover.

Figure 29. Ten UH-1 Helicopters Flown at Felker Field.





Figure 30. UH-1 Flown Before and After Alignment Change -Felker Field.



Horizontal Angle, Degrees

Gross Weight: Range from 7265 lbs to 7638 lbs. Center of Gravity: Range from 137.01 inches to 139.5 inches. Plotted data from 5-foot hover.

Figure 31. Ten UH-1 Helicopters Flown at Simmons Field.



Horizontal Angle, Degrees

Gross Weight: <u>Range from 7007 lbs to 8793 lbs</u>. Center of Gravity: <u>Range from 197.2 inches to 199.5 inches</u>. Plotted data from 5-foot hover.

Figure 32. Three AH-1 Helicopters Flown at Felker Field.

aircraft was thought to be possibly critical to shaft alignment. A contract modification was negotiated to evaluate the DSAI on a UH-1 aircraft configured with a sling load. Figure 33 shows the UH-1 aircraft at Kaman, in normal TM55-1520-210-20 alignment, configured with an external cargo hook and in flight with a 2000-pound sling load. The steady state alignments recorded with the DSAI are given in Table 2. TABLE 2. SLING-LOAD TEST DATA

	WITHOU7 7413 C.G.	r SLING LON 1bs GW Sta. 136	AD	WITH 941 C.G	SLING LOAN 3 lbs GW . Sta. 136	0
SLING LOAD TEST CONDITIONS	VERT. ANGLE (Degrees)	HORIZ. ANGLE (Degrees)	TORQUE METER (Psi)	VERT. ANGLE (Degrees)	HORIZ. ANGLE (Degrees)	TORQUE METER (Psi)
Hover at 20 Feet	+1.09	23	32	+1.58	75	42
70-Knot Level Flight	+1.06	05	20	+1.39	41	30
70-Knot Right Turn	+1.04	05	20	+1.37	46	30
70-Knot Left Turn	+1.03	04	20	+1.31	11	27
1000 Feet/Minute Climbs at 70 Kn	+1.29	46	30	+1.84	92	50
1000 Feet/Minute Descent at 70 Kn	+ .83	+.52	6	+ .94	+.48	2
Climb & Departure from Hover	+1.59	07	29	+2.23	76	47
Approach to a Hover	+ .59	+.28	17	+1.63	22	41
Right Hovering Turn	+1.08	0	29	+1.63	68	42
Left Hovering Turn	+1.08	11	29	+1.73	72	45

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Figure 33. Army UH-1H with a 2000-Pound Sling Load.

FIELD SURVEY OBSERVATIONS

Observations were made during the field survey concerning the engine mount shim approach to driveshaft alignment. The shims are subject to having the material around the bolt holes torn or worn away, thus allowing the shims to be squeezed out from underneath the engine mounts. Loss of shims changes driveshaft alignment and leaves the engine mount loose. Loose shims found in the engine compartment are measured with a micrometer and If shims are not found, the engine mount is simply replaced. retightened. No alignment check is performed. Loose and missing shims were found in several aircraft during field evaluation, including aircraft other than those surveyed. Engine mount fittings are attached to structure by bolts which engage nut plates under the deck. The nut plates wear out with time. Loose bolts were observed in some engine compartments due to worn-out nut plates.

One aircraft which was not used for this evaluation had shims in excess of that allowable at location D, (see Figure 17). Tripod inboard leg fittings with P/N 205-060-139-1 should not exceed 0.250 inch shim thickness. All other fittings (P/N 205-060-135-1) must not exceed 0.300 inch thickness. In this case the shim stack was over 3/4 inch. When the crew chief was questioned, the answer was "The aircraft was received this way and has had no driveshaft problems." The second question was about the maximum limit of shim thickness which was ob-"We haven't had any problem viously exceeded. The answer: except for shims getting loose under the leg. We check it before and after every flight. Besides, it's too much trouble to go through the alignment check." Unfortunately this aircraft was not flown with the DSAI as it was always scheduled for missions.

The engine is suspended at three points by the engine mount, (See Figure 34). The bipod support, on the right-hand side, and tripod support, on the left-hand side, both have pillow blocks with hinged bearing caps. These caps retain bearings (7) mounted on the two trunnions (6). Some engine installations were found to have excessive wear in the pillowblocks (2) and bearing caps (8). Some installations had shims around the bearings (7) to compensate for wear. Excess bearing slop was first detected during the field survey when static alignment was different before and after a flight, indicating that the engine had shifted. Bearing slop can have the same effect on alignment as a shim change, depending on the direction of mount forces. The effect on dynamic alignment would only be seen under dynamic conditions.





In order to test the usability of the DSAI, alignment on some helicopters was measured entirely by Army personnel who were instructed by other Army personnel. All users said they preferred the DSAI to the present alignment procedure. It was found that dynamic alignment can be measured at the rate of two helicopters per day without extraordinary effort. The DSAI requires the removal of the particle separator for installation of the modified baffle. The particle separator is removed every 25 hours to allow the engine to be flushed, so removal and reinstallation are familiar processes and not a problem.

Users were also receptive to the idea of using turnbuckles in the engine mount legs. Turnbuckles would eliminate shims with their attendant problems, reduce the support inventory, and allow very simple, very precise driveshaft alignment without dismantling the engine mount. This approach was very successful on the Kaman UH-2 helicopter. Study of the shim curves, Figures 18 through 23, indicates that possibly only legs E and F on Figure 17 would require turnbuckles.

Concerning present practice, the alignment procedure specified in TM55-1520-210-20 is difficult and time consuming. Alignment checks required two men for three days. Of the 31 alignments measured with the DSAI, 19 exceeded the limits of the alignment specified in the -20 manual. However, the alignment specified in the -20 manual does not result in the lowest alignment at high power where damage is most likely to occur. The alignment resulting from Bell Helicopter Company Service Bulletin No. 205-76-9 (Appendix B) was evaluated. The changes specified in the bulletin would reduce misalignment at high power somewhat, but further misalignment reduction at high power can be achieved.

The field survey experience indicates that the DSAI can be improved. All threads in the A-frame should incorporate inserts to increase thread life. All A-frame and dogleg attaching bolts should be the same size. All electronic adjusting devices should have a locking provision. The cables from the multi-vits have swaged end fittings at the lead-ins to the demodulator box. One end fitting failed, indicating that the swaged end fitting is too weak for the helicopter vibratory environment. The digital meter box would be improved if it could be reduced in size, perhaps by moving parts to the demodulator box.

The voltage polarity on one UH-1 helicopter was found to be reversed, i.e., standard positive had been hooked up to negative and, of course, standard negative was positive. This damaged demodulator box components. All subsequent testing included a test for polarity before attaching the DSAI 28 V power cable.

The DSAI has a provision to inspect and correct the zero-degree measurement by inserting a ceramic spacer between the multivit and the target plate, rotating the strut assembly until both the multi-vit and the target plate are in contact with the ceramic spacer, and adjusting a screw until the digital panel meter reads 0.00 degrees. Techniques should be developed that would allow inspection and correction of alignment readings at other angle measurements, such as ± 2 degrees. The present design has a drift with time, possibly due to temperature increase. Measured drift during bench checks was 0.2 degree per hour of use. A possible solution might be better cooling provision.

Table 3 of this report presents a summary of the conditions flown and measurements made during field evaluation at Bradley Field, Felker Field, and Simmons Field together with the aircraft serial number, weight and balance, total airframe hours, and the time since the last known alignment. Transient alignments were observed but not recorded. They are dependent on pilot technique to a large degree. The scatter in observed alignment plus the effects of pilot technique indicate that forward couplings encounter severe misalignments, especially during transition from hover to low-speed high-power climb and during low-speed high-power climb.

TABLE 3. FIELD SURVEY DATA

UH-1H AIRCRAFT 63-12975 <u>cond.</u> (VERT. ANGLE Degrees	HORIZ. ANGLE)(Degrees)	TORQUE Meter (Psi)	GROSS WEIGHT (Lbs)	C.G. STATION (Inches)	TOTAL AIRFRAME TIME (Hours)	TIME SINCE LAST ALIGNMENT (Hours)
2' Hov.	+1.40	+.01	29	7524	137	3708	180
5' Hov.	+1.64	+.15	31				
10' Hov.	+1.63	+.19	33				
15' Hov.	+2.27	+.20	32				
5' Hov.	+1.79	+.17	30				
5' Hov.	+1.74	+.12	30				
2' Hov.	+1.37	+.09	29				
5' Hov.	+1.16	+.08	29				
10' Hov.	+1.72	+.08	29				
15' Hov.	+2.38	+.04	28				
5' Hov.	+1.41	+.13	28				
5' HOV.	+1.47	+.10	30				
Static	+ .55	+.98					
66-16510							
- Static	15	+.68		7508	140.7	4414	271
2' Hov.	+1.25	34	30				
- 5' Hov.	+1.18	44	32				
10' Hov.	+1.37	50	34.5				
70 Kn	+1.01	28	21				
70 Kn							
- 1000'/min.	+1.60	78	34				
70 Kn							
1000'/min.	+ .63	+.22	9.5				
70 Kn			•				
AUTO	+ .38	+.69	20 5				
5' HOV.	+1.02	40	30.5				
70-16515							
- Static	-65	+.60		7434	138.8	1125.3	1125.3
2' Hov.	+.49	72	27				
- 5' Hov.	+.56	76	29				
10' Hov.	+.50	79	30.5				
70 Kn	+.35	40	20				
70 Kn							
-1000'/Min.	+.57	79	31				
/0 Kn	~	0.5	•				
1000./Min.	04	05	9				
JU Kn	- 50	+ 47	0				
AULO	50	- 72	27				
5° nov.	+.31	12	21				
-Data used in s	tatisti	ical ana	lysis				

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UH-1H AIRCRAFT	VERT.	HORIZ.	TORQUE	GROSS WEIGHT	C.G. STATION	TOTAL AIRFRAME TIME	TIME SINCE LAST ALIGNMENT
72-21487 COND. (I	egrees)(Degrees)	(Psi)	(Lbs)	(Inches)	(Hours)	(Hours)
- Static	+ .56	+2.34		7231	139.9	827.1	827.1
2' Hov.	+1.84	+1.39	26				
- 5' Hov.	+2.09	+1.38	27				
10' Hov.	+2.23	+1.36	30				
70 Kn	+1.81	+1.58	17				
70 Kn							
- 1000'/Min.	+2.45	+1.15	30				
70 Kn							
1000'/Min.	+1.60	+1.86	8				
70 Kn							
Auto	+1.33	+2.32	0				
5' Hov.	+1.85	+1.29	27				
Static	+ .71	+2.05					
60-15222							
- Static	-1 03	+ 33		7557	138 7	4083 6	174 1
2' Hoy	+ 16	- 99	29	1551	130.7	1005.0	1/1.1
- 5' Hov.	+ .48	-1.05	30				
10' Hov.	+1.32	-1.07	30				
70 Kn	+ .72	92	20				
70 Kn							
- 1000'/Min.	+1.24	-1.25	32				
70 Kn							
1000'/Min.	+ .45	46	9				
70 Kn							
Auto	+ .04	0	0				
5' Hov.	+ .75	-1.09	30				
Static	60	+ .08					
70-16516				7700	127 6	1124 7	1124 7
- Static	+ .25	+2.20		//26	137.6	1134.7	1134./
2. HOV.	+1.39	+ ./1	28				
- 5' HOV.	+1.//	+ . /4	30				
10 HOV.	+2.10	+ .01	10				
70 Kn 70 Kn	+ .94	+1.10	10				
- 1000'/Min	+2 07	+ 25	22				
70 Kn	12.07	1 .25	55				
1000'/Min.	+1.44	+ .76	20				
70 Kn							
Auto	+ .78	+1.72	0				
5' Hov.	+1.49	+ .57	29				
Static	+ .30	+2.04					

- Data used in statistical analysis

UH-1H AIRCRAFT	VERT.	HORIZ.	TORQUE	GROSS WEIGHT	C.G. STATION	TOTAL AIRFRAME TIME	TIME SINCE LAST ALIGNMENT
69-15127 COND. (Degrees)(Degrees)	(Psi)	(Lbs)	(Inches)	(Hours)	(Hours)
- Static	+1.00	+1.58		7257	139.2	2385.3	2385.3
2' Hov	. +2.25	+ .70	28			200010	2303.3
- 5' Hov	. +2.33	+ .65	29				
10' Hov	. +2.50	+ .54	32				
70 Kn	+2.24	+ .67	21				
- 1000'/Min	. +2.62	+ .28	34				
70 Kn							
1000'/Min	. +1.84	+1.11	9				
70 Kn							
Auto	+1.54	+1.53	0				
5' Hov	. +2.41	+ .61					
Static	+1.02	+1.63					
64-13768							
- Static	+ .50	+2.33		7392	141.7	3949.	699
2' Hov	. +2.04	+1.09	26				
- 5' Hov	. +2.19	+1.04	27				
10' Hov	. +2.54	+ .86	30				
70 Kn	+2.33	+1.04	20				
70 Kn							
- 1000'/Min	. +2.80	+ .62	31				
70 Kn							
1000'/Min.	. +1.83	+1.51	9				
70 Kn							
Auto	+1.62	+2.10	0				
5' Hov	. +2.50	+ .90	27				
Static	+ .68	+2.44					
CA 10007							
64-13897 Chatia	.1			7005	141 0	4105 1	164 1
- Static	+1.23	+1.0/		7005	141.8	4125.1	164.1
2º HOV	. +2.61	11	20				
- 5' HOV	. +2.03	10	27.5	,			
10 HOV	. +3.11	30	29				
70 Kn	+2.78	05	28				
10001 /Min	12 20	- 20	20				
- 1000 /MIII	. +3.20	39	30				
1000! /Min	+2 57	+ 24	14				
70 min	. +2.37	+ .24	14				
Auto	+2 11	+1 07	0				
5' How	+2.11	- 25	29				
Statio	+1.20	+ 01	20				
Julic	11.20						
- Data used in	statist	ical a	nalvsis	3			

UH-1H AIRCRAFT	VERT.	HORIZ.	TORQUE	GROSS	C.G.	TOTAL AIRFRAME TIME	TIME SINCE LAST
66-1140 COND. (D	egrees)(Degrees)	(Psi)	(Lbs)	(Inches)	(Hours)	(Hours)
- Static	45	+1.20		7051	142.6	4070.2	1245.9
2' HOV.	+1 44	+ 03	26	1031	112.0	10/0.2	1245.5
- 5' HOV.	+1.48	08	28				
10' Hov.	+1.52	14	30				
70 Kn	+1.16	+ .13	20				
70 Kn							
- 1000'/Min.	+1.55	20	28				
70 Kn							
1000'/Min.	+ .86	+ .61	8				
70 Kn							
Auto	+ .53	+1.22	0				
5' Hov.	+1.44	0	26				
Static	35	+1.17					
66-16305							
- Static	+ .82	+1.78		7073	140.5	4347.1	882.2
2' Hov.	+2.31	+ .53	28				
- 5' Hov.	+2.57	+ .48	30				
10' Hov.	+2.98	+ .41	31				
70 Kn	+2.54	+ .74	21				
70 Kn							
- 1000'/Min.	+2.85	+ .33	30				
70 Kn			1.0				
1000'/Min.	+2.25	+1.11	12				
70 Kn	.1 02	+1 62	•				
Auto	+1.92	+1.03	20				
5' HOV.	+ 77	+1 60	20				
Static	+ .//	+1.00	_				
68-15239							
- Static	- 45	+1 11		7152	144.6	4304.1	1002.8
2' Hov.	+1.27	+ .04	25	1152	144.0	4504.1	1002.0
- 5' HOV.	+1.60	+ .05	29				
10' Hov.	+1.87	+ .02	27				
70 Kn	+1.42	+ .20	17				
70 Kn			_				
- 1000'/Min.	+1.82	24	28				
70 Kn							
1000'/Min.	+1.01	+ .53	10				
70 Kn							
Auto	+.72	+1.10	0				
5' Hov.	+1.37	07	25				
Static	42	+1.06					
- Data used in	statist	tical a	nalysi	s			

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UH-1H AIRCRAFT 69-15455 COND. (D	VERT. ANGLE egrees)(HORIZ. ANGLE Degrees	TORQUE METER) (Psi)	GROSS WEIGHT (Lbs)	C.G. STATION	TOTAL AIRFRAME TIME (Hours)	TIME SINCE LAST ALIGNMENT (Hours)
B	EFORE	ALTGNME	NT	3	1-11011007		
- Static	+ .77	+1.09		7180	139.3	2620.1	964
2' Hov.	+2.78	04	27				
- 5' Hov.	+3.16	12	30				
10' Hov.	+3.41	19	31				
70 Kn	+3.03	+ .03	19				
70 Kn							
- 1000'/Min.	+3.40	34	29				
70 Kn							
1000'/Min.	+2.62	+ .32	10				
70 Kn							
Auto	+2.37	+1.05	0				
5' Hov.	+3.21	29	29				•
Static	+ .95	+ .92					
69-15455 <u>A</u>	FTER RI	EALIGNM	ENT				
- Static	16	+ .70		7180	139.3		0
2' Hov.	+2.52	31	27	1200	10000		•
- 5' Hov.	+2.27	38	29				
10' Hov.	+2.63	46	30				
70 Kn	+2.37	12	18				
70 Kn							
- 1000'/Min.	+2.56	56	28				
70 Kn							
1000'/Min.	+2.10	+ .24	9				
70 Kn							
Auto	+1.52	+ .68	0				
5' Hov.	+2.77	34	28				
Static	0	+ .87					
69-16270							
- Static	+ .62	+2.20		6989	141.75	4698.9	763.5
2' Hov.	+2.47	+1.19	26				
- 5' Hov.	+2.74	+1.10	28				
10' Hov.	+2.98	+1.09	30				
70 Kn	+2.91	+1.22	20				
70 Kn							
- 1000'/Min.	+3.21	+ .84	31				
70 Kn							
1000'/Min.	+2.63	+1.68	8				
70 Kn							
Auto	+2.27	+2.21	0				
5' Hov.	+2.80	+1.03	28				
Static	+ .47	+2.18					
- Data used in	statist	ical a	nalvsi	s			

UH-1H AIRCRAFT 66-17037 <u>Cond.</u> ()	VERT. ANGLE Degrees)(D	HORIZ. ANGLE egrees)	TORQUE Meter (Psi)	GROSS WEIGHT (Lbs)	C.G. STATION (Inches)	TOTAL AIRFRAME TIME (Hours)	TIME SINCE LAST ALIGNMENT (Hours)
- Static	69 +	1.20		7413	139.64	3587.6	519.8
2' Hov.	+ .71 -	. 12	30				
- 5' Hov.	. +1.09 -	.23	33				
10' Hov.	+1.23 -	. 29	33				
70 Kn	+ .91 -	.06	21				
70 Kn							
- 1000'/Min.	. +1.31 -	40	32				
70 Kn							
1000'/Min.	. + .50 +	49	9				
70 Kn	실망을 보는 것이?						
Auto	+ .33 +	-1.04	0				
5' Hov.	. + .81 -	.22	28				
Static	58 +	-1.15					
66-1043							
Static	+ .72 +	.68		7166	139.9	7071.3	2222.7
2' Hov.	+2.54 -	.50	30				
5' Hov.	+2.72 -	. 54	31				
10' Hov.	+2.81 -	.60	33				
2' Hov.	+2.56 -	.50	30				
5' Hov.	+2.73 -	.56	31				
10' Hov.	2.81 -	.59	33				
Static	+ .90 +	.59					
70-15851							
2' Hov.	+1.21 +	. 14	26	7156	139.8	3212	0
5' Hov.	+2.12 +	.13	27				
10' Hov.	+2.61 +	.06	27				
70 Kn	+1.46 +	. 32	27				
70 Kn							
- 1000'/Min.	+1.76 -	. 05	28				
70 Kn							
1000'/Min.	+1.00 +	.67	10				
70 Kn							
Auto	+ .93 +	1.14	0				
- 5' Hov.	+1.53 +	.13	27				
- Static	0 +	1.14					

- Data used in statistical analysis

UH-1H AIRCRAFT 73-21775	VERT. ANGLE	HORIZ. ANGLE	TORQUE METER	GROSS WEIGHT	C.G. STATION	TOTAL AIRFRAME TIME	TIME SINCE LAST ALIGNMENT
COND. (Degrees)	(Degrees)	(Psi)	(Lbs)	(Inches)	(Hours)	(Hours)
- Static	+ .52	+ .99		7452	137.5	563	563
2' Hov.	+1.40	29	27				
- 5' Hov.	. +1.50	31	29				
10' Hov.	. +1.58	33	30				
70 Kn	+1.49	22	20				
70 Kn							
- 1000'/Min.	+2.03	62	32.5				
70 Kn							
1000'/Min.	+1.08	+ .31	9				
Auto	+ .99	+ .79	0				
5' Hov.	+ .58	+ .96	29				
Static	+ .58	+ .96					
73-21774							
- Statio	- 07	+2 06		7570	127 00	500 E	500 F
- Static	9/	+1.46	20	1510	137.99	582.5	582.5
Z HOV.	12	+1 22	30				
- 5 HOV.	+ .13	+1.33	34 5				
10 HOV.	+ 12	+1.29	34.3				
70 KH	+ .12	T1.04	21				
- 10001 /Min	+ = C		24				
- 1000 /MIN.	· · · · · · · · · · · · · · · · · · ·	+ .00	34				
10001 /Min	- 20	12 27	7				
70 Vn	20	+2.37	'				
Auto Ki	- 52	12 03	0				
AULO	55	+1 34	22				
Static	- 70	+1.34	33				
Statit	70	+3.02					
69-15688							
- Static	79	+1.34		7361	138.74	662.8	662.8
2' Hov.	+ .34	+ .21	28				
- 5' Hov.	+ .36	+ .06	30				
10' Hov.	+ .43	04	32				
70 Kn	+ .21	+ .34	20				
70 Kn							
- 1000'/Min.	+ .64	08	32				
70 Kn							
1000'/Min.	08	+ .69	12				
70 Kn							
Auto	43	+1.33	0				
5' Hov.	+ .30	+ .11	30				
Static	74	+1.35					
- Data used in	statist	tical an	nalysis				

63

		and the second sec
TOAD	2	(continued)
TADLE		(CONLINGED)

		INDUD	5 (001	.c=mucu		TOTAL.	TIME
UH-IH	VERT.	HORIZ.	TOROUE	GROSS	C.G.	AIRFRAME	SINCE LAST
AIRCRAFT	ANGLE	ANGLE	METER	WEIGHT	STATION	TIME	ALIGNMENT
71-20251 COND. (D	egrees)(Degrees)	(Psi)	(Lbs)	(Inches)	(Hours)	(Hours)
- Static	+ .71	+1.11		7294	138 07	1014	*
2' How	+1 75	- 23	26	1234	130.07	1014	
- 5' How	+1 06	- 34	20				
- 5 HOV.	+1.90		20				
IU HOV.	+2.03	40	30				
70 KH	+1./6	08	19				
70 Kh							
-1000'/Min.	+2.36	57	30				
70 Kn							
1000'/Min.	+1.46	+ .45	8				
70 Kn							
Auto	+1.36	+ .92	0				
5' Hov.	+1.83	19	26				
Static	+ .79	+ .98					
Deacte							
69-15248							
- Static	33	+1.54		7599	137.01	784	370
2' Hov.	+1.24	+ .18	27				
5' Hov.	+1.45	+ .18	30				
10' Hov.	+1.47	+ .01	31				
70 Kn	+ .76	+ .39	17				
70 Kn							
- 1000'/Min	+1 26	- 01	30				
- 1000 /MIII.	+1.20	01	50				
			•				
1000 /MIN.	+ .50	T .02	9				
70 Kh							
Auto	+ .13	+1.37	0				
- 5' Hov.	+1.18	+ .18	30				
Static	15	+1.44					
67-17238							
- Static	+ 12	+1 00		7449	130 5	3944 7	346 2
- Static	+1 22	+1.09	27	/440	139.5	3344.7	540.2
2 HOV.	+1.32	+ .02	21				
- 5' Hov.	+1.75	02	30				
10. Hov.	+1.80	08	32				
70 Kn	+1.47	+ .10	19				
70 Kn							
- 1000'/Min.	+2.40	55	36				
70 Kn							
1000'/Min.	+1.18	+ .53	8				
70 Kn							
Auto	+1.07	+1.12	0				
5' HOY	+1.29	+ .14	30				
Static	+ 04	+1.07					
Static	* • • • •						
- Data used in	statio	tical	analve	is			
- Data used In	statis	ocical	anarys	To Deter		In Ter D	ack of a

* Time of last alignment unknown. Entry made in Log Book of a center deck repair a few months prior to this flight, however, no airframe hours noted.

UH-1H AIRCRAFT 70-16413 COND. (1	VERT. HO ANGLE AN Degrees)(Deg	RIZ. GLE rees)	TORQUE Meter (Psi)	GROSS WEIGHT (Lbs)	C.G. STATION (Inches)	TOTAL AIRFRAME TIME (Hours)	TIME SINCE LAST ALIGNMENT (Hours)
- Static	27 +	.94		7520	137.01	1417.5	47.5
2' Hoy.	+ .32 -	25	29				
- 5' Hov.	+ .38 -	29	30				
10' Hov.	+ .44 -	.36	32.5				
70 Kn	+ .06 + .	.03	19				
70 Kn							
- 1000'/Min.	+ .83	. 31	31				
70 Kn							
1000'/Min.	12 + .	.12	9.5				
70 Kn							
Auto	45 + .	. 89	0				
5' Hov.	30	.35	30				
Static	27 +1.	.30					
69-15866							
- Static	-1.06 + .	.88		7638	137.76	897	897
2' Hov.	25	25	27				
- 5' Hov.	03	47	29				
10' Hov.	00	.61	32				
70 Kn		20	18				
70 Kn							
- 1000'/Min.	+ .33	69	31				
70 Kn							
1000'/Min.	50 + .	.32	6				
70 Kn							
Auto	63 + .	.80	0				
5' Hov.	+ .10	. 48	29				
Static	-1.23 + .	85					
69-15054							
- Static	17 +1.	28		7483	137.94	3047.1	*
2' Hov.	+1.06 + .	07	27				
- 5' Hov.	+1.32	03	30				
10' Hov.	+1.51	0	34				
70 Kn	+1.16 + .	10	18				
70 Kn							
- 1000'/Min.	+1.85	07	35				
70 Kn							
1000'/Min.	+ .87 + .	26	10				
70 Kn							
Auto	+ .68 + .	.92	0				
5' Hov.	+1.32	0	29				
Static	+ .06 +1.	.13					
- Data used in	etatistic	ala	nalvei	s.			

 Data used in statistical analysis.
* Time of last alignment unknown. Crew chief stated alignment work done approximately one year ago, but no entry could be found in log book.

UH-1H AIRCRAFT 302 <u>COND.</u> (D	VERT. ANGLE egrees)(HORIZ. ANGLE Degrees)	TORQUE METER (Psi)	GROSS WEIGHT (Lbs)	C.G. STATION (Inches)	TOTAL AIRFRAME TIME (Hours)	TIME SINCE LASI ALIGNMENT (HOURS)
Static	+ .55	+1.60		7265	138.6	1632	*
2' Hov.	+1.28	+ .46	24				
5' Hov.	+1.28	+ .45	28				
10' Hov.	+1.55	+ .45	30				
5' Hov.	+1.21	+ .38	31				
Static	+ .56	+1.42					
PROD							
AH-1S							
AIRCRAFT							
76-22572							
Static	94	+1.17		8459	197.2	97.3	97.3
2' Hov.	55	+ .09	64%				
5' Hov.	41	+ .10	68%				
10' Hov.	25	05	72%				
70 Kn	11	+ .50	448				
70 Kn							
- 1000'/Min.	+ .21	+ .20	62%				
70 Kn							
1000'/Min	15	+ .81	26%				
61 Kn							
Auto	05	+1.32	0				
70 Kn							
Auto	16	+1.23	0				
99 Kn							
Auto	34	+1.30	0				
2' Hov.	26	+ .10	62%				
5' Hov.	25	+ .05	65%				
10' Hov.	11	+ .04	70%				
Static	83	+1.14					

- Data used in statistical analysis

* Time of last alignment unknown. Aircraft has a history of overhaul several times, including crash damage, but no airframe time is noted.

AH-1S	VERT.	HORIZ.	TORQUE	GROSS	C.G.	TOTAL AIRFRAME	TIME SINCE LAST
	ANGLE	ANGLE	METER	WEIGHT	STATION	TIME	ALIGNMENT
70-16082 COND. (E	egrees)(Degrees)	(Psi)	(Lbs)	(Inches)	(Hours)	(Hours)
Static	41	+1.17		8793	199.5	552.0	253.7
2' Hov.	+ .39	03	35				
5' Hov.	+ .43	10	38				
10' Hov.	+ .50	17	39.5	;			
70 Kn	+ .78	+ .39	21				
70 Kn							
1000'/Min.	+1.37	93	45				
70 Kn							
1000'/Min.	+ .62	+ .79	6				
70 Kn							
Auto	+ .59	+ .96	0				
2' Hov.	+ .55	08	36				
5' Hov.	+ .55	16	38				
10' Hov.	+ .67	14	39.5				
Static	38	+ .85					
AH-1G							
67-15823							
2' Hoy	+2 70	+1 43	26 5	7007	198 4	2083 9	*
5' Hov.	+2 98	+1 36	28	, ,007	190.4	2005.5	
10' Hov.	+3 03	+1 33	29 5				
70 Kp	+3 03	+1 97	15				
70 Kn	13.05	11.57	13				
1000'/Min	+3 10	+1 58	29				
70 Kp	13.10	11.50	25				
1000'/Min	+2 85	+2 26	6				
70 Kn	12.05	12.20	v				
Auto	+2 75	+2.45	0				
2' HOV	+2 66	+1 37	25 5				
5' Hov	+2.93	+1.33	28				
10' HOV.	+2 92	+1.34	29				
Static	+2 20	+2 30					
Static		.2.50					

* Time of last alignment unknown. Log book states that an engine deck overhaul and modification were done on 25 March 1976, but no airframe time is noted. However, a repair conducted prior to overhaul and modification is noted at 1839.4 airframe hours and a subsequent repair is noted at 2015 airframe hours, placing last alignment somewhere in between.

STATISTICAL ANALYSIS OF FIELD SURVEY DATA

Statistical analysis of UH-1 forward coupling alignment was performed using normal distribution and based on a significant sample size (25 sets of data). The data were analyzed for mean value $(\bar{\mathbf{x}})$, standard deviation (σ) , mean ± 3 standard deviations $(\bar{\mathbf{x}} \pm 3\sigma)$, and coefficient of variation ($cv = \sigma/\bar{\mathbf{x}}$). The values given by $\bar{\mathbf{x}} \pm 3\sigma$ include 99.73 percent of a normally distributed population. The alignments analyzed were for static, hover with 5-foot skid height, and low-speed high-power climb. The data and the results of the analysis are given in Table 4. The mean values for the three alignment cases are given in Figure 35. Also shown in Figure 35 is the maximum misalignment predicted by the analysis, $\bar{\mathbf{x}} \pm 3\sigma$, for low-speed high-power climb. The maximum misalignment predicted is 4.96 degrees.

The data were examined to evaluate the change in alignment that occurs when the UH-1 transitions from the static case to the 5foot hover case and to low-speed high-power climb. The change in alignment angles and the analysis results are presented in Table 5.

These data were used to predict the improved alignment that would result with driveshaft alignment specified at the 5-foot hover condition, shown in Figure 36. Suggested alignments are: vertical angle -.35 degree \pm .50 degree and horizontal angle +.25 degree \pm .25 degree. At low-speed high-power climb, the resulting nominal alignment would be: vertical angle + .01 degree \pm .5 degree, horizontal angle +.01 degree + .25 degree.

The maximum misalignment predicted uses $\overline{x} + 3\sigma$ for the vertical angle and $\overline{x} - 3\sigma$ for the horizontal angle. The one-way use of the 3σ values is based on the observation that in no case did the vertical angle decrease or the horizontal angle increase as the helicopter transitioned from the 5-foot hover case to low-speed high-power climb. The envelope of alignment at lowspeed high-power climb is thus: vertical angle = +.01 ± .5, +.55 or -0 = +1.06 to -.49, horizontal angle = +.01 ± .25, +0 or -.41 - +.26 to -.65. The maximum possible misalignment for the high power condition would be slightly over 1 degree.

The static alignment would be the result of change in power to zero. The nominal static alignment would be: vertical angle -1.88 degrees, horizontal angle +1.46 degrees. The resultant static misalignment angle would be 2.38 degrees. The angle appears high. However, the power is zero and no damage can occur. TABLE 4. ANGLES AND ANALYSIS FOR THREE CONDITIONS

	STAT	IC	5-F00T	HOVER	70 KN PWD.	1000 FT/MIN
NO.	VERT. ANGLE (Degrees)	HORIZ. ANGLE (Degrees)	VERT. ANGLE (Degrees)	HORIZ.ANGLE	VERT. ANGLE (Degrees)	HORIZ ANGLE
66-16510	15	.68	1.18	44	1.60	78
70-16515	65	.60	.56	76	.57	79
72-21487	+ .56	2.34	2.09	+1.38	2.45	+1.15
68-15223	-1.03	.33	.48	-1.05	1.24	-1.25
70-16516	+ .25	2.20	1.77	+ .74	2.07	+ .25
69-15127	1.00	1.58	2.33	+ .65	2.62	4 .28
64-13768	+ .50	2.33	2.19	+1.04	2.80	+ .62
64-13897	+1.23	1.07	2.63	10	3.20	39
66-1140	45	1.20	1.48	08	1.55	20
66-16305	+ .82	1.78	2.57	+ .48	2.85	+ .33
68-15239	45	1.11	1.60	+ .05	1.82	24
69-15455	11. +	1.09	3.16	12	3.40	34
69-15455	16	.70	2.27	38	2.56	56
66-16270	+ .62	2.20	2.74	1.10	3.21	+ .84
66-17037	69	1.20	1.09	23	1.31	40
70-15851	•	1.14	1.53	+ .13	1.76	05
73-21775	+ .52	66.	1.50	31	2.03	62
73-21774	97	3.06	.13	+1.33	.56	+ .88
69-15688	79	1.34	.36	90. +	.64	08
71-20251	11. +	1.11	1.96	34	2.36	57
69-15248	33	1.54	1.18	+ .18	1.26	01
67-17238	+ .13	1.09	1.75	02	2.40	55
70-16413	27	.94	.38	29	. 83	31
69-15866	-1.06	. 88	03	47	. 33	69
69-15054	17	1.28	1.32	03	1.85	07
IX	0024	1.3945	1.5288	.1008	1.8908	142
0 5	.4538	.4166	.76082	. 39944	.80527	.34018
D	.6737	.6455	.87225	.63201	75793.	. 58325
3 0	2.0210	1.9364	2.61675	1.89604	2.69211	1.74976
x + 3 d	2.0186	3.3310	4.14555	1.9968	4.58291	1.60776
x - 30	-2.0234	5419	1.08795	-1.79524	80131	-1.89176
CV= 0/X	-280.69	.1938	.80174	.3520	1.11988	.36277

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Horizontal Angle, Degrees



				5 FT HOVER	TO 70 KN FWD	
	STATIC TO 5-FT HOVER			1000 FT/MIN CLIMB		
TAIL NO.	VERT. ANGLE HORIZ.ANGLE			VERT. ANGLE HORIZ, AN		
	(Degrees)	(Degrees)		(Degrees)	(Degrees)	
66-16510	1.33	1.12		.42	.34	
70-16515	1.21	1.36		.01	.03	
72-21487	1.53	.95		.36	.23	
68-15223	1.51	1.38		.76	.20	
70-16516	1.52	1.46		.30	.49	
69-15127	1.33	.93		.29	.37	
64-13768	1.69	1.29		.61	.42	
64-13897	1.40	1.17		.57	.29	
66-1140	1.93	1.28		.07	.12	
66-16305	1.75	1.30		.28	.15	
68-15239	2.05	1.06		.22	.29	
69-15455	2.43	1.08		.29	.18	
69-15455	2.39	1.21		.24	.22	
66-16270	2.12	1.10		.47	.26	
66-17037	1.78	.97	1	.22	• .17	
70-15851	1.53	1.01		.23	.18	
73-21775	.98	.68		.53	.31	
73-21774	1.10	1.73		.43	.45	
69-15688	1.15	1.28		.28	.14	
71-20251	1.25	1.45		.40	.23	
69-15248	1.51	1.36		.08	.19	
67-17238	1.62	1.11		.65	.53	
70-16413	.65	1.23		.45	.02	
69-15866	1.03	1.35		.36	.22	
69-15054	1.49	1.31		.53	.04	
x	1.5312	1.2068		.362	.2428	
σ²	.1837	.0464		.0342	.0184	
σ	.4286	.2155		.1849	.1358	
3σ	1.2858	.6464		.5547	.4073	
_						
x + 3σ	2.8170	1.8532		.9167	.6501	
x - 3σ	.2454	.5604		1927	1645	
$cv = \sigma/\bar{x}$.27992	.1785		.5107	.5591	

TABLE 5. CHANGE IN ANGLES AND ANALYSIS



Horizontal Angle, Degrees

Figure 36.

 Improved Alignment Possible for Three Conditions and Maximum Expected Misalignment.

CONCLUSIONS

1. Dynamic drive shaft alignment measurement is more efficient, more accurate and more realistic than static shaft alignment measurement.

2. More UH-1 and AH-1 drive shaft alignments were found out of specific alignment (19) than within specified alignment (12).

3. UH-1 and AH-1 drive shaft alignment checks required 48 manhours (two men for three days) when performed in accordance with TM 55-1520-210-20 (static alignment checks only).

4. UH-1 static and dynamic drive shaft alignment checks required 2 to 6 man-hours when performed with the drive shaft alignment indicator using the procedure of Appendix C.

5. Alignment change can be expedited through use of the data reported herein on shim change vs alignment change.

6. Textron Bulletin No. 205-76-9 is an improvement over TM 55-1520-210-20 alignment. Further improvement is possible.

7. Maximum operating misalignment of UH-1 drive shafts can be reduced from 4.96 degrees to 1.24 degrees for the worst high-power steady-state case measured, which was low-speed high-power climb.

RECOMMENDATIONS

1. Procure an evaluation quantity of drive shaft alignment indicator tools and undertake a program to reduce the highpower misalignment of UH-1 and AH-1 drive shafts.

2. Specify drive shaft alignment based on acceptable static alignment followed by measurement at 5-foot skid height hover.

3. Investigate the cost and benefits of replacing the present UH-1 engine-mount shim arrangement with a turnbuckle in each of two engine mount legs. The program should include design and analysis, followed by manufacture and test of several ship sets.

APPENDIX A

DRIVESHAFT ALIGNMENT PER TM55-1520-210-20

This appendix describes driveshaft alignment per Department of the Army Technical Manual TM55-1520-210-20, Organizational Maintenance Manual, Army Model UH-1D/H Helicopters, PP. 7-23-7-25 (Reference 2). The procedure was developed as part of the evaluation of the driveshaft alignment indicator tool.

Main driveshaft alignment is currently checked statically using a set of special mechanical tools. Prior to the check, four jacks and a depth micrometer are used to position and hold the soft-mounted transmission parallel to its supporting structure.

With the driveshaft removed, an extendable plug gage assembly is attached to the engine output. The plug gage serves to extend the rotational centerline of the engine output to a target plate mounted on the transmission input. An eccentrically located hole in the target plate will accept the plug gage if the vertical and lateral position of the transmission is correct. Nonparallelism of the rotational centerlines of the engine output and the transmission input is checked next, by attaching a dial indicator to the extendable plug gage assembly and trammelling the surface of the target plate which is perpendicular to the transmission input quill.

Main driveshaft alignment is altered by selectively shimming between one or more of the engine tubular mounts and the engine deck, thereby shifting the position of the engine.

ALIGNMENT PROCEDURE

	ALIGNMENT PROCEDURE
	<pre>1- Open engine cowling and transmission fairing. (Figure Al)</pre>
ro	2- Remove engine intake filters. (Figure A2)
CESS	3- Remove upper panel of induction baffle. (Figure A3)
AC(SH/	4- Remove upper half of particle separator. (Figure A4)
	5- Remove short shaft.
A	6- Remove pylon soundproofing.
ISS TO	7- Remove lower access panels on both sides of pylon. (Figure Al)
ACCE	 8- Remove upper access panels on both sides of pylon. (Figure Al)
	9- Mount maintenance hoist on helicopter. (Figure A5)
	10- Attach hoisting clevis to top of mast nut.
NOIS:	11- Remove nut and washer from lift link lower bolt. (Figure A6)
LEVE	12- Hoist transmission to unload lift link bolt.
RAN	13- Install A4 leveling jacks. (Figure A6)
H	14- Adjust jacks so that transmission is parallel to supporting structure.

ALIGNMENT PROCEDURE

	ALIGNMENT PROCEDURE
DLING	15- Adjust position of eccentric hole in target plate. (Figure A7)
LL TOC AND LIBRAT	16- Secure target plate to transmission curvic coupling. (Figure A7)
INSTAJ	17- Secure gage pin assembly to engine curvic coupling. (Figure A7)
	18- Push plunger of gage pin assembly forward toward target plate, (Figure A7)
	19- Largest diameter of plunger should enter target hole. If not, note amount and location of interference.
IMENT	20- Mount dial indicator on plunger so that tip contacts target plate. (Figure A7)
SCK ALIGN	21- Rotate dial indicator at least one turn and stop at point of greatest reading. This should occur between 8 and 10 o'clock positions on target plate. "Zero" the indicator.
CHI	22- Rotate "zeroed" indicator another turn and check total indicator reading. Should not exceed .016 inch.
	NOTE
	Assume misalignment is incorrect and engine must be shimmed.
ω	23- Loosen screws around intake bellmouth in forward firewall and around attachment ring in rear fire- wall. (Figures A8 and A9)
SHIM	24- Consult Figure A7 to determine where shim stack must be altered. Make shim change.

ALIGNMENT PROCEDURE

	ALIGNMENT PROCEDURE
TN	25- Push plunger of gage pin assembly forward toward target plate. Largest diameter of plunger should enter target hole.
ALIGNME	26- Rotate dial indicator at least one turn and stop at point of greatest reading. This should occur between 8 and 10 o'clock positions. "Zero" the indicator.
ECHECK	27- Rotate "zeroed" indicator another turn and check T.I.R. Should not exceed .016 inch.
H	Assume alignment is correct at this point.
RE- MOVE TOOL- ING	28- Remove alignment tool set, leveling jacks, and maintenance hoist.
	29- Retighten screws in firewalls.
	30- Install nut, washer, and cotter pin on lower bolt of lift link.
RAFT	31- Install short shaft.
IRCI	32- Install upper half of particle separator.
KE A	33- Install upper panel of induction baffle.
ECUF	34- Install engine intake filters.
SI	35- Close engine cowling and transmission fairing.

ALIGNMENT PROCEDURE

	ALIGNMENT PROCEDURE
Exer	36- Close upper access panels on both sides of pylon.
AFT	37- Close lower access panels on both sides of pylon.
SECUI	38- Install soundproofing.
1	END









66 Induction Baffle, Upper Panel 9 Location in Helicopter Figure A3. Induction Baffle Installation. 80





Figure A5. Maintenance Hoist.



Figure A6. Leveling Main Transmission.







APPENDIX B

BELL HELICOPTER COMPANY SERVICE BULLETIN NO. 205-75-9

This service bulletin changes the static driveshaft alignment. One purpose of this program was to evaluate the effect of the changes made by this service bulletin. The procedure described in Appendix A is retained.

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	SERVICE BULLETIN NO. 205-76-9	
	DATE 0-9-76	
REV.	TOTACE OF A DET A COMPANY PAGE NO. 1 of 3	
SERVICE APPROVAL	ENGINEERING APPROVAL	•
SUBJECT:	ENGINE TO TRANSFILSSION DRIVE SHAFT ALIGNMENT.	
REASON:	To provide improved gear patterns.	
HELICOPTERS AFFECTED:	205A-1 Helicopters S/N 30001 thru 30232 205A-1 Helicopters S/N 30233 and subsequent will have these changes accomplished prior to delivery.	
WEIGHT CHANGE:	Not applicable.	
ACCOMPLISHMENT:	(A) Helicopters actively engaged in transp- ortation of external cargo - no later than the next thirty (30) hours of opera- tion or within ten (10) days after receipt of this bulletin, whichever occurs first.	
	(B) Helicopters in standard passenger con- figuration and not engaged in transporta- tion of external cargo - at next conven- ient scheduled maintenance period or engine change but no later than the next scheduled airframe overhaul inspection.	
DESCRIPTION:		
1. Remove the main d appropriate Maint	rive shaft assembly in accordance with the chance Manual.	
 Align the engine the appropriate M plate settings an 	to transmission drive shaft in accordance with aintenance Manual using the following target d tolerances:	
	NOTE	
For e disco	ase of leveling transmission, mnect 5th mount assembly.	
A. Index the targ	et plate inner scale to 8.0 (instead of 3.5).	
B. Index the targ	et plate outer scale to 35.6 (instead of 1.75).	

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> C. When checking angularity zero dial indicator at 2.5 inch radius at 12 o'clock position. Read + .030± .004 at 6 o'clock. Re-zero indicator at the 3 o'clock position. Read + .006 ± at .004 at 9 o'clock.

NOTE

Plus indicator reading means that flange on transmission is closer to flange of the engine.

3. If the total laminated shim thickness (P/N 205-060-137-1 or 205-060-138-1) under any engine support fittings exceeds .188 inches, fabricate a plate of 2024-T4 aluminum alloy .100 inch thick, same outside dimensions as shim stock. Structurally bond the plate to the engine service deck with EC934. Total thickness of shims and plate under any engine mount fitting must not exceed .283 inches.

NOTE

Check engine deck fitting screws and bolts for proper length and thread engagement.

- Reinstall the drive shaft assembly in accordance with the appropriate maintenance manual.
- Check drive shaft alignment whenever one or more of the following conditions exists.
 - A. Excessive wear of the coupling spline.
 - B. Indications of excessive heating.
 - C. Replacement of the transmission isolation mounts.
 - D. Hard landings.
 - E. Replacement of the main transmission.
 - F. Replacement of the engine or engine mounts.
 - G. Major repair or replacement of components is required in center fuselages tail boom or pylon support structure.
 - H. Drive shaft misalignment is suspected for any reason.

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6. Parts Required

Part Number	Nomenclature	Quantity	
205-060-137-1	Shim	2	
205-060-138-1	Shim	1	

The material necessary to meet the requirements of this Service Bulletin must be procured from your usual Bell Helicopter Textron Spare parts source. Orders must include the ship-to address.

 Information contained in this Service Bulletin will be incorporated into the next revision of the 205A-1 Maintenance Manual.

APPENDIX C

PROCEDURE FOR USING THE DRIVESHAFT ALIGNMENT INDICATOR

This procedure was developed as part of the evaluation of the driveshaft alignment indicator tool. Also, it is intended to be preliminary to an Aviation Unit Maintenance (AVUM) procedure.

Description of Driveshaft Alignment Indicator

The driveshaft alignment indicator installation is shown in Figures 2 and Cl. Freely moving compressible struts are mounted to slightly amplify the misalignment angles imposed on the driveshaft couplings. The struts are mounted to structure by spherical self-aligning bearings. The bearings are located in target plates mounted on the transmission adapter plate and in target plates mounted on an A-frame attached to the engine particle separator. The struts are allowed to extend and compress freely to accommodate axial motions. The measuring devices are multi-vit noncontact electronic micrometers. The multi-vits are used to measure angular misalignment of the struts with respect to the transmission, and therefore the driveshaft. Measurement of angular misalignment of the engine-end coupling requires reversing the driveshaft indicator tool. The same mounting provisions accept the tool in either direction.

The alignment procedure is described and illustrated in preliminary AVUM form on the following pages. Photographs of components and of steps in the installation process are shown in Figures C9 through C23. The installation steps can be reversed for tool removal.

Note: Static and dynamic misalignment criteria are based on TM55-1520-210-20. Criteria based on this study would change Step 16 and Figure C6. On Figure C6, the safe envelope for hover at 5-foot skid height would be: vertical angle -1 degree to -3 degrees, horizontal angle 0.5 degree to 1.5 degrees. The acceptable alignment envelope on Figure C6 for hover at 5-foot skid height would be: vertical angle +.15 degree to -.65 degree, horizontal angle +.5 degree to 0 degree.

820.0240	ALIGNMENT PROCEDURE
1-	Open engine cowling and transmission fairing, Figure C2.
2-	Remove engine intake filters, Figure C3.
3-	Remove upper vertical panel of induction baffle, Figure C5.
4-	Remove upper and lower halves of particle separator, Figure C4.
5-	Remove lower vertical panel of induction baffle, Figure C5.
6-	Install modified lower baffle assembly and lower half of particle separator.
7-	Install transmission adapter on the transmission housing leaving an even amount of washers under each of the three mounting studs, Figure Cl.
8-	Install A-frame assembly on front of upper half of particle separator and reinstall on engine, Figure Cl.
9-	Place modified upper baffle assembly in position.
10-	Insert horizontal angle strut assembly in position between the A-frame and the trans- mission adapter, Figure Cl.
11-	Insert vertical angle strut assembly in position between the A-frame and transmission adapter and secure modified upper baffle assembly, Figure Cl.
12-	Connect two electrical signal cables to the strut assemblies.
13-	Secure demodulator power supply in aft cabin and connect electrical signal cable. Place indicator at observer's station and connect electrical sig- nal cable.
14-	Check the polarity of the aircraft wiring system and connect the power cable to the helicopter 28 VDC receptacle.

ALIGNMENT PROCEDURE

- 15- Switch power on, set selector switch to TRANS. Check for meter indication. If not OK, check for power available at receptacle. Check power cable.
- 16- Check static alignment for safe hover at 5-foot skid height: vertical angle +1 degree to -1 degree, horizontal angle +2.5 degrees to +.5 degree. Turn power off. If static alignment is not within limits, perform Steps 25 and 26, repeat Step 16.
- 17- Install engine intake filters.
- 18- Close engine cowling and transmission fairing.
- 19- With observer at his station, bring helicopter to 5-foot skid height hover.
- 20- Switch power on, check that selector switch is set to TRANS. Observe and record two meter readings.
- 21- Land helicopter and shut down engine.
- 22- Compare two readings with published requirements.
- 23- Plot the values for V and H on Figure C6. If the point falls anywhere within target area, alignment is acceptable per TM55-1520-210-20.

NOTE

Assume alignment is incorrect and engine must be shimmed.

24- Open engine cowling and transmission fairing.

- 25- Loosen screws around intake bellmouth in forward firewall and around attachment ring in aft firewall, Figures C7 and C8.
- 26- Consult Figure C6 to determine amount and location of shim change required. Make shim change. After shim change tighten screws around intake bellmouth and in aft firewall.
- 27- Close engine cowling and transmission fairing.

ALIGNMENT PROCEDURE

- 28- With observer at his station, bring helicopter to 5-foot skid height hover.
- 29- Switch power on. Observe and record two meter readings.
- 30- Land helicopter and shut down engine.
- 31- Plot values for V and H on Figure C6. NOTE

Assume alignment is correct at this point.

- 32- Open engine cowling and transmission fairing.
- 33- Remove engine intake filters.
- 34- Remove modified upper panel of induction baffle and remove link assemblies and electric cables.
- 35- Remove particle separator and A-frame and transmission adapter.
- 36- Install original upper and lower panels of induction baffle.
- 37- Install particle separator.
- 38- Install engine intake filters.

39- Close engine cowling and transmission fairing.



Figure Cl. Driveshaft Alignment Indicator Installation.







Figure C2. Fairing, Cowling, and Access Panels.



Figure C3. Engine Air Intake Filters.





Figure C5. Induction Baffle Installation.



UH-1 Forward Coupling Alignment for Hover at 5-Foot Skid Height per TM55-1520-210-20



То	move	1/2	degree	to the left, remove .075" from Leg "A".
То	move	1/2	degree	to the right, add .075" to Leg "A".
То	move	1/2	degree	to the left, add .063" to Leg "E".
То	move	1/2	degree	to the right, remove .063" from Leg "E".
То	move	1/2	degree	up, remove .029" from Leg "F".
то	move	1/2	degree	down, add .029" to Leg "F".
то	move	1/2	degree	up and 1/2 degree right, add .038" to Leg "B".
то	move	1/2	degree	down and 1/2 degree left, remove .038" from Leg "B".
То	move	1/2	degree	left and 1/4 degree up, add .058" to Leg "C".
То	move	1/2	degree	right and 1/4 degree down, remove .058" from Leg "C".
То	move	1/2	degree	left and 1/4 degree down, remove .045" from Leg "D".
To	move	1/2	degree	right and 1/4 degree up, add .045" to Leg "D".



Figure C6. Driveshaft Alignment Chart with Shimming Instructions.
















Figure C14. Power Supply/Demodulator Box.





















Figure C23. Upper Half of Modified Baffle Installed, Vertical Strut Assembly Installed.

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