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14. ABSTRACT
This TOP establishes the testing that will be performed to support certification by a cognitive agency and Health Usage Monitoring System (HUMS). Any system that is intended to be permanently installed on an aircraft and that will be used to perform maintenance actions, vibration tests and checks, and monitoring aircraft systems operation limitations required by the technical manual will be tested IAW this TOP.

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

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HEALTH USAGE MONITORING SYSTEM TESTING

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1. SCOPE.

1.1 This Test Operations Procedure (TOP) establishes the testing that will be performed to support certification by a cognitive agency using a Health Usage Monitoring System (HUMS). Any system that is intended to be permanently installed on an aircraft and will be used to perform maintenance actions, vibration tests and checks, and monitoring aircraft systems operation limitations required by the technical manual will be tested in accordance with (IAW) this TOP. These functions include main and tail rotor smoothing, performing scheduled and/or special component vibration tests or checks, and monitoring aircraft system performance and usage.

1.2 Purpose.

The purpose of this TOP is to ensure that proposed HUMS accurately measures aircraft and component vibrations and that diagnostic corrective actions produce results that are at least as good as the current Army standard vibration measuring and diagnostic equipment.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Testing may be conducted at any facility that supports helicopter flight and maintenance operations.

2.2 Instrumentation.

An Army standard aviation vibration analyzer or an approved comparable system designated by the Army or the aircraft manufacturer will be installed to collect comparison data.

3. REQUIRED TEST CONDITIONS.

The HUMS should be operational, including all on-aircraft displays and crew interface controls. Aircraft compatibility checks and tests, system calibration steps, and functional checkouts (required by the installation documents and the airworthiness release) must be completed prior to this test. Computer-based ground stations must be operational and made available to the testers. All required interface cables or data transfer devices must be available at the test site. If possible, the comparison data collection system should be configured to collect data simultaneously with the system under test. If simultaneous data collection is not possible, back-to-back data collection is permissible.

4. TEST PROCEDURES.

4.1 Main-Rotor Smoothing.

The complete main rotor smoothing process will be performed. Standard rotor smoothing flight profiles required by the appropriate aircraft technical manual, the Maintenance Test Flight manual, and the HUMS operating procedures manual will be flown. The baseline vibration environment of the aircraft will be measured. Based on this vibration environment, standard rotor system adjustments will be applied that will create a vibration environment that is above established goals and typical of the vibration levels found following replacement of major rotor system components or scheduled maintenance inspections and servicing. Using known rotor adjustment sensitivities, the predicted above-goal condition should not exceed limits set forth by the cognitive airworthiness agency. If no limits have been set, maximum predicted vibration levels should not exceed ten times the rotor-smoothing vibration goals. After the adjustments have been applied, the vibrations will be measured and the HUMS will be used to calculate a set of corrections that should reduce vibration levels to acceptable levels and the rotor smoothing goals. After each set of corrections the vibration levels will be measured; if necessary, additional sets of HUMS-generated corrections will be applied until rotor smoothing goals have been obtained. The test director will evaluate the data after each set of corrections and will determine if additional sets of HUMS-generated corrections will be applied.

4.2 Tail Rotor Balancing.

The baseline vibration levels of the tail rotor will be measured. Based on this vibration level, standard adjustments will be applied that will create a vibration environment that is above established limits and typical of the vibration levels found following replacement of major system components or scheduled maintenance inspections and servicing. Using known adjustment sensitivities, the predicted vibration level should not exceed limits set forth by the cognitive airworthiness agency. If no limits have been set, maximum predicted vibration levels should not exceed five times the tail rotor balancing vibration limits. After the adjustments have been applied, tail rotor vibrations will be measured and the HUMS will be used to calculate a set of corrections that should reduce vibration levels to acceptable levels and the balancing limits. After each set of corrections, the vibration levels will be measured, if necessary; additional sets of HUMS-generated corrections will be applied until tail rotor balancing limits have been obtained. The test director will evaluate the data after each set of corrections and will determine if additional sets of HUMS-generated corrections will be applied.

4.3 Scheduled Maintenance Vibration Tests and Checks.

The aircraft will be configured and operated in accordance with the aircraft technical manual or the HUMS operating procedures manual for the test being performed. If the check requires only a vibration measurement, the check can be performed in conjunction with other testing. If the test requires a measurement and a diagnostic corrective action, a separate test will be performed. For those tests that require a corrective action, a baseline vibration measurement will be performed. Based on this vibration level, standard adjustments will be applied that will create a

vibration level that is above established limits and typical of the vibration levels found following replacement of components or scheduled maintenance inspections and servicing. Using known adjustment sensitivities, the predicted vibration level should not exceed limits set forth by the cognitive airworthiness agency or the technical manual. If no limits have been set, maximum predicted vibration levels should not exceed four times the vibration limit for that test. After the adjustments have been applied, the resulting vibrations will be measured and the HUMS will be used to calculate a set of corrections that should reduce vibration levels to acceptable levels and the established limits. After each set of corrections, the vibration levels will be measured; if necessary, additional sets of HUMS-generated corrections will be applied until vibration limits have been obtained. The test director will evaluate the data after each set of corrections and will determine if additional sets of HUMS-generated corrections will be applied.

4.4 Usage Monitoring.

Usage monitoring data will be collected in conjunction with other testing. If a specific flight condition is required, a flight data card will be prepared that describes that condition and it will be performed as a separate event.

5. DATA REQUIRED.

Three sets of data will be recorded by the system under test and the comparison data collection system for each test condition, test state, and event. All adjustments and corrections applied to the aircraft must be recorded. The exact type of adjustment, the magnitude, and the direction must be recorded. The date, time, flight number, test, and event must be recorded so resulting vibrations can be correlated to the adjustments applied. At least one archival copy of all data will be created and stored on a separate computer to prevent data loss in the event the HUMS or comparison system computer fails.

6. PRESENTATION OF DATA.

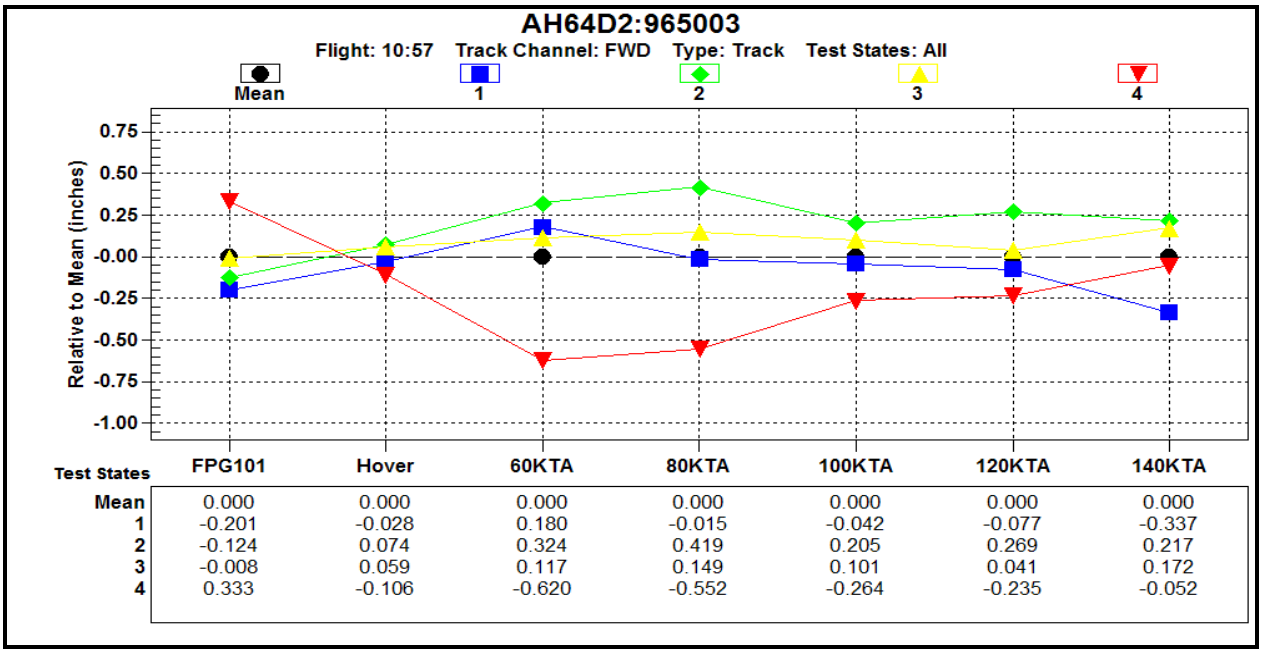
The HUMS and the comparison system displays and presentations will be used. No off-system display, presentation, or data reduction is required.

6.1 Main Rotor Blade Track.

a. Main rotor track display shall include the helicopter identification and the flight in which the data was collected. Each individual blade of the rotor system shall be identified and the measured distance from center that each blade is at each test state must be displayed. A sample data set is shown in Figure 1.

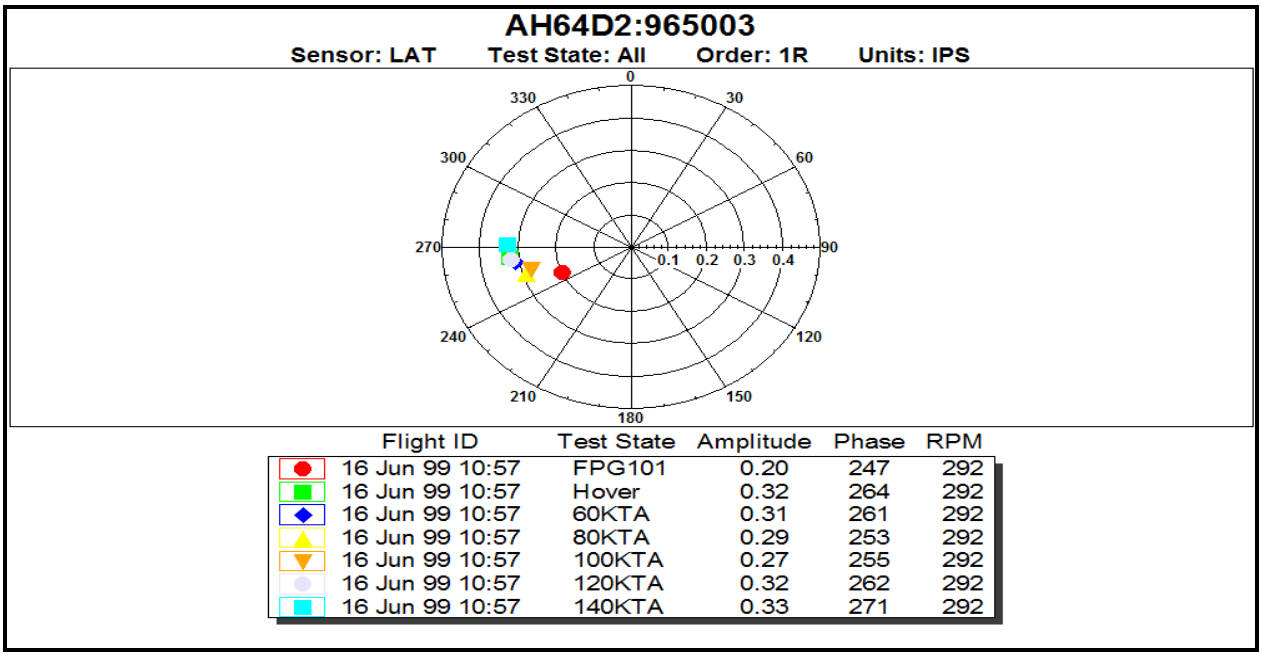
b. The main rotor vibration plot shall include the helicopter identification, the flight in which the data was collected, and the sensor that was used to collect the data. The data display

shall include the amplitude and phase angle of the vibration at each test state. A sample data plot is provided in Figure 2.



Test States	FPG101	Hover	60KTA	80KTA	100KTA	120KTA	140KTA
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	-0.201	-0.028	0.180	-0.015	-0.042	-0.077	-0.337
2	-0.124	0.074	0.324	0.419	0.205	0.269	0.217
3	-0.008	0.059	0.117	0.149	0.101	0.041	0.172
4	0.333	-0.106	-0.620	-0.552	-0.264	-0.235	-0.052

Figure 1. Main rotor blade track sample data.



Flight ID	Test State	Amplitude	Phase	RPM
16 Jun 99 10:57	FPG101	0.20	247	292
16 Jun 99 10:57	Hover	0.32	264	292
16 Jun 99 10:57	60KTA	0.31	261	292
16 Jun 99 10:57	80KTA	0.29	253	292
16 Jun 99 10:57	100KTA	0.27	255	292
16 Jun 99 10:57	120KTA	0.32	262	292
16 Jun 99 10:57	140KTA	0.33	271	292

Figure 2. Main rotor vibration polar plot.

6.2 Spectrum Displays.

Spectrum displays shall be available for each sensor or monitored component. The display shall include the helicopter identification, the flight or date and time of the data collection event, and the sensor used to collect the data or the monitored component. The amplitude of the vibration in relation to the frequency at which it occurred must be displayed. A sample spectrum display is provided as Figure 3.

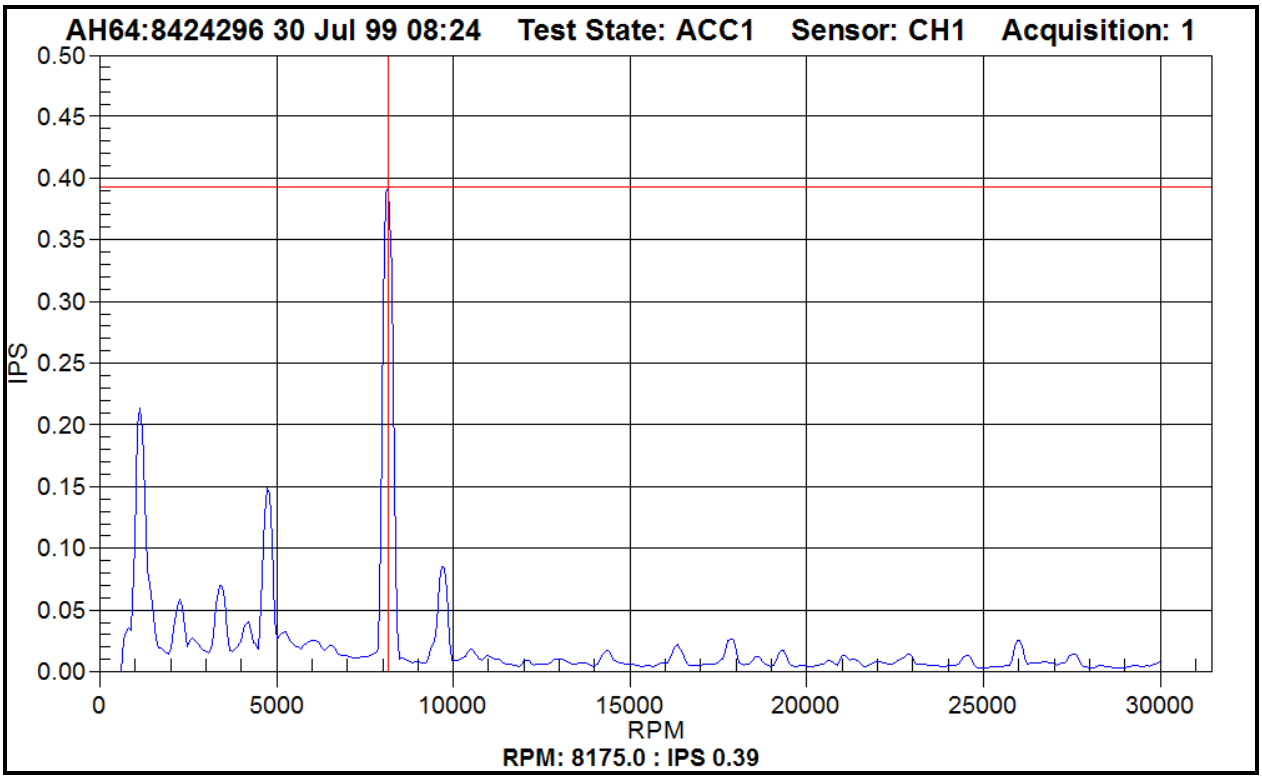


Figure 3. Spectrum display sample.

APPENDIX A. ABBREVIATIONS

HUMS	Health Usage Monitoring System
IAW	in accordance with
MIL-STD	military standard
TOP	Test Operations Procedure

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APPENDIX B. REFERENCES.

For information only (related publications).

Military Standard (MIL-STD)-882D, Standard Practice for System Safety, 10 February 2000.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Flight Test Directorate (TEDT-AC-FT), US Army Redstone Test Center, Building 30137, Peters Street, Cairns Army Airfield, Fort Rucker, AL 36362-5276. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.