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This TOP describes procedures for measuring external acoustical noise of Army helicopters. It covers test procedures for the measurements of steady-state and impulse noise.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-106
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EXTERNAL ACOUSTICAL NOISE MEASUREMENTS FOR AVIATION SYSTEMS

1. SCOPE

This TOP describes procedures for measuring external acoustical noise of Army helicopters. It covers test procedures for the measurements of steady-state and impulse noise. These measurements may be made to determine compliance with applicable specifications (e.g., Military-Standard (MIL-STD)-1474C[1**]), evaluate the need for hearing protection, provide data for a hearing damage risk assessment, determine the impact of acoustical noise on speech intelligibility, or for measuring the 85 dB(A) contour around the aircraft. For acoustical noise measurements during maintenance operations (e.g., in the vicinity of a ground power unit), for measuring aural nondetectability, for measuring external acoustical noise fly-by signature, or

*This TOP supersedes TOP 7-3-526, 10 June 1971.
**Footnote numbers/letters match those in Appendix D, References.
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for measuring acoustical noise for military vehicles other than helicopters and for general equipment, see TOP 1-2-608[2]. For measuring helicopter internal steady-state acoustical noise, see TOP 7-3-530[3]. Requirements for impulse noise measurements for personnel-occupied areas are specified in MIL-STD-1474.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

a. Portions of the test requiring ground measurements require a suitable helicopter operating environment that is free of other noise sources and sound-reflecting surfaces. Portions of the test requiring flight (hover) measurements in addition require an operating environment which permits safe performance of aircraft hover operations.

b. The testing area shall consist of a smooth, straight, paved surface which is level (<1% grade) and free of all loose gravel or other foreign matter. The surface must be free of all sound reflecting surfaces (such as buildings, trees, hillsides, or signboards) for 30m (100 ft) on all sides of the aircraft. Measurements are not made when either the paved surface or the measurement surface is wet, covered with snow or ice, or during precipitation, unless requested by the test sponsor.

2.2 Instrumentation.

Devices for Measuring:	Permissible Error of Measuring Device:
Steady-state noise (see 2.2b)	±0.5 dB* from 20.0 Hertz (Hz) to 20 kiloHertz (kHz)
Impulse-noise (see 2.2.c)	Peak pressure level to ±1 dB, A-duration, B-duration to ±10%
Sound-level	Calibration signals to ±0.3 dB
Meteorological conditions:	
Wind speed	0 to 9 meters/second (m/s), ±0.8 m/s (0 to 20 miles per hour (mph), ±1 3/4 mph)

*All decibel (dB) values in this TOP are referenced to 20 microPascals sound pressure level (20 μPa SPL).

Wind direction	±3°
Ambient temperature	-10 degrees Celsius (°C) to +50°C, ±1°C (14 degrees Fahrenheit (°F) to 122°F, ±2°F)
Relative humidity (RH)	5% to 100% RH, ±3%

a. Steady-state noise measuring system.

(1) Microphones should meet the requirements of American National Standards Institute S1.4[a] and should be of the random incidence type with a flat frequency response from 20 Hz to 20 kHz. A microphone windscreen should always be used to shield against wind effects.

(2) Sound-level meters shall conform to the requirements for Type 1 as specified by ANSI S1.4.

(3) Octave band filter sets shall conform to the requirements for Type E, Order II, as specified by ANSI S1.11[b].

(4) A calibrator capable of producing a tone at a known frequency and known sound level (±0.3 dB) shall be used.

(5) Tape recorders shall meet the requirements of ANSI S6.1[c].

(6) A spectrum analyzer capable of displaying the signal received from either a microphone or tape recorder shall be used. The spectrum analyzer shall be capable of showing octave band levels for all octave band center frequencies from 20 Hz to 20 kHz, and A-weighting level in accordance with ANSI S1.4.

b. Impulse-noise measuring system.

(1) Microphones/transducers having a flat dynamic response of ±2 dB over the frequency range of 20 Hz to 40 kHz are required. Microphones having the appropriate dynamic range and rise-time characteristics should be used for measurements up to 171 dB. Transducers (blast gauges) should be used for measurements above 171 dB. Microphones and transducers should have suitable conditioning electronics.

(2) A frequency modulated (FM) magnetic tape recorder having a frequency response up to 40 kHz (±0.5 dB) or greater is required.

(3) A digital oscilloscope or other suitable equipment to digitize peak intensity and duration of impulse noise is required. Sampling rate, signal filtering, and roll-off rate shall be in accordance with MIL-STD-1474C, para 5.4.3.1.2.2.

3. REQUIRED TEST CONDITIONS

3.1 Safety. During testing, only data collectors and the minimum flight crew required for safe operation of the aircraft shall be in the test area. All aircrew and test personnel should wear, at a minimum, sound attenuating helmets as required by Army Regulation (AR) 95-1[5], or other equipment as required to comply with requirements of DA Pam 40-501[6]. All other personnel shall wear eye, face, and hearing protection as required by DoD instruction 6055.12[4] and OSHA 29 CFR 1910.133.

3.2 Facilities.

a. Facilities shall meet the requirements specified in paragraph 2.1.

b. Scaled drawings shall be made showing the location and orientation of the aircraft and microphone or transducers within the test area for the various test conditions required.

c. The test will be conducted with the aircraft configured and operated as expected during normal field operations. Measurements will be made while the aircraft is at maximum allowable gross weight and at a normal (±5%) rated rotor speed (either percent RPM or rotor speed).

3.3 Instrumentation/Preparation.

a. Select appropriate instrumentation from that listed in paragraph 2.2.

b. Assemble the noise measuring system prior to data collection to assure that all components are in working order with a valid calibration certificate. Perform a system checkout by using the acoustical calibrator to present a sound of known frequency and sound pressure level. Assure that system output matches the signal source.

c. Prepare an acoustical noise data form similar to the sample data sheet presented in Appendix A. Record the date, time and place of test trials, aircraft type and serial number, gross weight and any unusual features of the aircraft configuration, and specific test conditions.

3.4 Environment.

a. Do not take measurements when ambient wind velocities exceed 5.4 m/s (12 mph) or during active precipitation. Shield microphones against wind effects at all times. Data shall be corrected for the wind screen effects using the appropriate wind screen freefield correction curves.

b. Changes in weather conditions (e.g., temperature, humidity, barometric pressure) can affect the performance of instrumentation and should be considered. Significant weather variations may require the re-calibration

of sound measuring devices. Consult the manufacturer's performance specifications for guidance.

4. TEST PROCEDURES.

4.1 Steady-state noise measurements. For test purposes, steady-state noise is defined as a periodic or random variation in atmospheric pressure at audible frequencies. It may be continuous, intermittent, or fluctuating, with the sound pressure level varying over a wide range, provided such variations have a duration exceeding 1 second.

4.1.1 Methods.

a. Install noise measurement instrumentation (using microphone windscreens) 1.6m (5.3 ft) above the ground and 60m (200 ft) from the aircraft or at an alternate distance as determined by the specific test objective, IEP or TDP, or the test sponsor. At a minimum, take measurements from the front, rear, right side, and left side of the aircraft.

b. Record pressure altitude, temperature and relative humidity on the data collection sheet (Appendix A).

c. Record calibration tone of known frequency and dB level for at least 30 seconds at the beginning and end of each recording tape or as recommended by the equipment manufacturer.

d. Tape record all data. The recording time of each noise data sample shall be sufficient to produce at least 30 continuous seconds of data to be analyzed.

e. If an 85 dB(A) noise contour curve around the exterior of the aircraft is required, place microphones 1.6m (5.3 ft) above the ground at angular increments of not greater than 45 degrees, using at least 2 microphones per line. Locate one microphone at a higher than 85 dB(A) location and one microphone at a lower than 85 dB(A) location. Determine the distances and directions from the aircraft at which the noise level is equal to 85 dB(A). Take as many readings as necessary to accurately plot an 85 dB(A) contour curve around the exterior of the aircraft similar to that contained in Appendix B.

f. At a minimum, collect data with the aircraft on the ground and at a hover according to the following conditions.

(1) Ground Tests.

(a) Auxiliary power unit (APU) only running (if so equipped).

(b) APU running (if so equipped) with engines and rotors at ground idle.

(c) Engines and rotors at 100% revolutions per minute (RPM).

(d) Orientation of noise measurement instrumentation, at a minimum, corresponding to those specified in paragraph 4.1.1 a.

(2) Hovering Flight Tests.

(a) Measurements will be taken with the aircraft hovering in ground effect. The helicopter will hover at five feet (skid height) as indicated by the radar altimeter (or other appropriate means).

(b) Orientation of noise measurement instrumentation, at a minimum, corresponding to those specified in paragraph 4.1.1 a.

4.1.2 Data Required. For ground tests and hovering flight tests, the following data snall be recorded.

a. Test site characteristics (surface, terrain, etc.) specified in para 2.1.

b. Meteorological data (temperature, humidity, barometric pressure, wind direction and velocity).

c. Microphone locations.

d. Sound level in dB(A), dB(C) and for each octave band.

e. For noise contours, distances and directions from aircraft at which 85 dB(A) is measured/calculated.

f. Test identification data such as aircraft type, relevant aircraft configurations, type of test (ground, hover), data collector and test director, test participants (pilots), and other relevant test information.

g. List of all instrumentation used.

4.2 Impulse Noise Measurements. For test purposes, impulse noise is defined as a short burst of acoustical energy consisting of either a single impulse or a series of impulses. The pressure time history of a single impulse includes a rapid rise to a peak pressure, followed by a somewhat slower decay of the pressure envelope to ambient pressure, both occurring within 1 second. A series of impulses may last longer than 1 second.

4.2.1 Methods.

a. Determine measurement locations relative to the noise source (weapon) in accordance with the requirements of the test plan. Make a sketch showing the location and orientation of the test item and each microphone/transducer location with respect to the test site.

b. When expected pressure levels are in excess of 171 dB, use suitable pressure transducers (e.g., blast gauges). When expected pressure levels are below 171 dB, use fast response microphones. Record impulse noise with an FM tape recorder having a flat (±0.5 dB) frequency response up to at least 40 kHz. (If speed reduction techniques and direct readout devices are used in the analysis of the recorded noise data, the frequency response characteristics of the devices must be at least proportionally equivalent to the characteristics of the recording device.)

c. Ensure that all instrumentation used has a valid calibration certification. Make an instrumentation calibration check at the test site prior to, during, and immediately following the test using a sound of known frequency and sound pressure level using the microphone and recording system installed.

d. Record peak pressure level in dB, A-duration, and B-duration in suitable time units for each microphone location and each replication of the measurement (weapon firing). Record impulse noise data for at least three separate replications at each measuring position. Use the arithmetic means for the peak pressure levels, A-durations, and B-durations from the measurement replications (if consistent) to define the impulse noise when the range of peak pressure levels does not exceed 3 dB. If the range of peak pressure levels exceeds 3 dB, conduct additional replications until the number of measurements equals or exceeds the range in dB.

e. When possible, take data analysis equipment to the test site to determine whether the peaks of the recorded impulse noises are within the 3 dB range. If data analysis equipment cannot be taken to the test site, fire additional rounds to provide greater assurance of adequate test data.

f. Conduct all weapon firing tests on an appropriate firing range. Unless otherwise stipulated in the test plan, record noise measurements with weapons positioned at realistic locations comparable to those employed in combat or training exercises. Elapsed time between rounds firing should be sufficient to allow the pulse envelope to decay to ambient levels before the next round is fired.

g. If a 140 dB noise contour curve is required, place a transducer 1.6m (5.3 ft) above the ground plane as close to the test item as is considered safe (in accordance with associated guidance documents) and on each 45° radial line centered at the test item. If the weapon system (test item) can be considered symmetrical, measurements may be made on one side only. Place a second series of transducers twice the distance from the noise source as the first set, a third series of transducers twice the distance of the second, and a fourth series of transducers twice the distance of the third. From this configuration, a 140 dB noise contour curve around the test item can be predicted by interpolation.

4.2.2 Data Required.

a. Test identification data such as weapon system, aircraft type and configuration, data collector and test director, test item operators, and other relevant test information.

b. For weapon systems, type of ammunition, when applicable.

c. Meteorological data (temperature, humidity, barometric pressure, wind direction and velocity).

d. Microphone locations.

e. Peak pressure level, A-duration, and B-duration measurements of impulse noise for each microphone location.

f. For noise contours, record distances and directions from test item at which 140 dB peak is measured.

g. List of all instrumentation used.

5. DATA REDUCTION AND PRESENTATION

5.1 Steady-State Noise.

a. Tabulate direct measurement data on an appropriate data sheet which specifies all relevant test conditions.

b. When data are recorded on magnetic tape, analyze the data in the laboratory for each requirement specified by the test sponsor. If a requirement is not specified, analyze the data for dB(A), dB(C), and octave band sound levels.

c. Present data for 85 dB(A) contour curves as shown in Appendix B.

d. When required, compute the equivalent continuous noise level (L_{DoD}) as described in MIL-STD-1474C.

5.2 Impulse Noise.

a. Analyze copies of the oscilloscopic traces, digital signal, or the magnetic tape record to determine peak pressure level, A-duration, and B-duration as specified in MIL-STD-1474C. Present in tabular form as shown in Appendix C.

b. For systems that produce repetitive impulses, determine the number of impulses produced within the first 200 milliseconds. Multiply number of impulses by the average B-duration of single impulses to determine an effective B-duration, which is used to establish the maximum allowable peak-pressure level for the repetitive system.

c. Tabulate the data to determine safety conditions for personnel. When making comparison noise tests between two types of weapons or ammunition, or to determine whether a simulator is loud enough to represent the actual system, only peak pressure levels are required and are reported by round number (as shown in Appendix C).

d. Present data taken for 140 dB contour curves as shown in Appendix B.

Recommended chanages of this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TC-D, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: U.S. Army Aviation Technical Test Center, ATTN: STEAP-MP-P, Fort Rucker, AL 36362-5276. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A. DATA COLLECTION WORKSHEET

Test Name_____ Date_____

TECOM Proj. No._____

Aircraft Type:_____ Serial No._____

Location_____

Takeoff Gross Weight_____

Pressure Altitude_____Temp_____Humidity_____

A/C Configuration Notes_____

_____

Calibrator Type/Model:_____

Microphone(s) Type/Model:_____

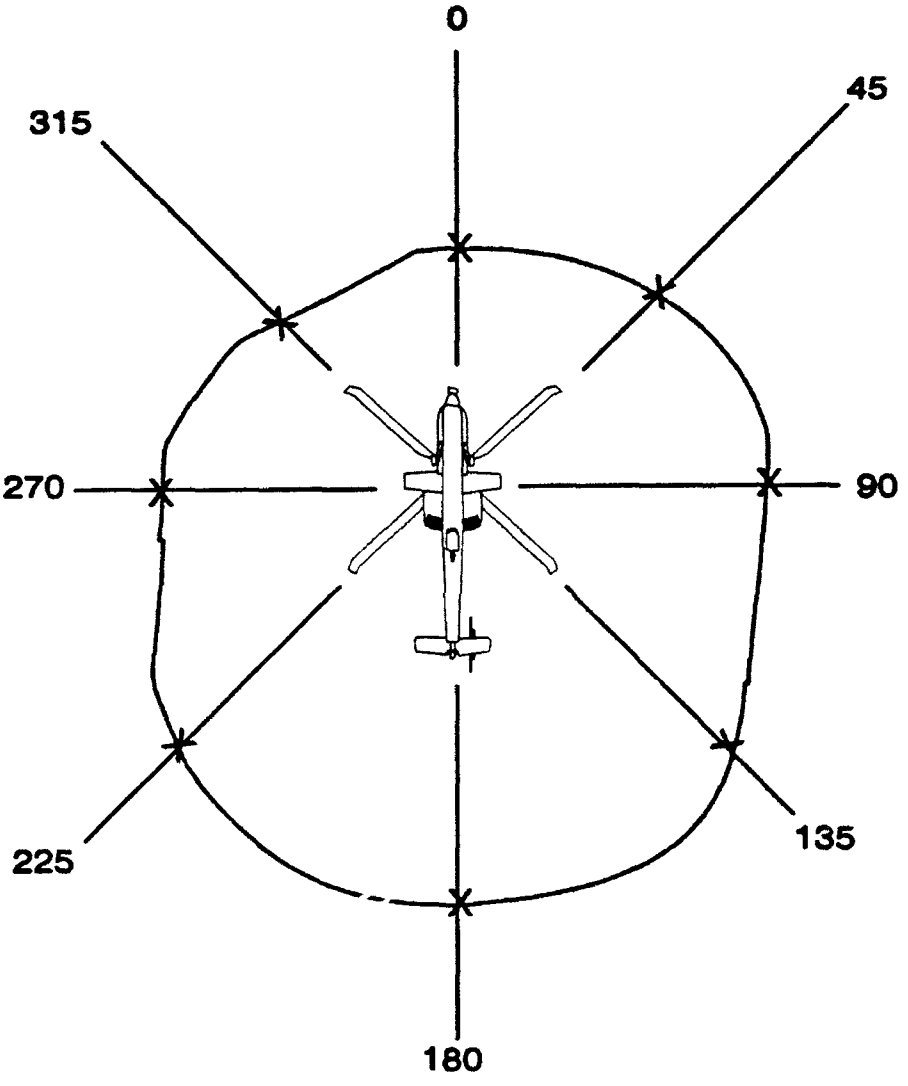
Serial No(s):_____

Microphone Locations:_____

Tape Recorder/Model:_____ Serial No._____

Tape ID	Test Condition	Start ID	Attenuator Setting

APPENDIX B. SAMPLE 85 dB(A) NOISE CONTOUR CURVE



Numerals Represent Angular Increments
X Represents Distance Measurements

APPENDIX C. SAMPLE PRESENTATION OF IMPULSE NOISE LEVELS

Comparison Impulse-Noise Levels

Weapon System 1				Weapon System 2			
Round	Peak SPL (dB)	"A" Duration (ms)	"B" Duration (ms)	Round	Peak SPL (dB)	"A" Duration (ms)	"B" Duration (ms)
1	152	0.7	111	1	146	1.0	141
2	153	0.8	106	2	145	1.2	137
3	151	0.9	101	3	146	0.9	135
4	152	0.7	107	4	145	1.1	131

APPENDIX D. REFERENCES

NOTE: Each agreeing nation reserves the right not to use the referenced documentation until formal acceptance of the documentation by its country.

1. MIL-STD-1474C, Noise Limits for Military Materiel, 8 March 1991.

2. TECOM TOP 1-2-608, Sound Level Measurements, 17 July 1981.

3. TECOM TOP 7-3-530, Steady State Acoustical Noise Measurements in Aviation Systems, 28 February 1992.

4. DoDI 6055.12, Department of Defense Hearing Conservation Program.

5. AR 95-1, Flight Regulations, 30 May 1990.

6. DA Pam 40-501, Hearing Conservation, 27 August 1991.

REFERENCES FOR INFORMATION ONLY

a. ANSI S1.4 - 1983, Specification for Sound Level Meters, 17 February 1983.

b. ANSI S1.11 - 1986, Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters, 16 July 1986.

c. ANSI S6.1 - 1973, Qualifying a Sound Data Acquisition System, 18 October 1973.

d. AR 95-3 Army Aviation: General Provisions, Training, Standardization, and Resource Management, 27 September 1990.