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

Provides a method of evaluating shock and vibration characteristics of vehicles during operation over selected test courses. Describes procedures for measuring structural response and response of components, equipment, cargo, and personnel positions. Describes instrumentation and courses, and provides guidelines for determining points at which three standardized levels of human exposure are reached. Applicable to wheeled and tracked vehicles.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-101
*Test Operations Procedure 2-2-808
AD No. A106358

FIELD SHOCK AND VIBRATION TESTS OF VEHICLES

1. SCOPE. This TOP describes a procedure for determining the shock and vibration characteristics of both wheeled and tracked military vehicles, including consideration of components, on-board equipment, cargo, and personnel, during operation over selected test courses. It also provides guidelines for determining points at which three standardized levels of human exposure are reached.

Shock and vibration tests of vehicles are conducted only when there is a need to obtain data which can be used to produce vibration schedules for vibrators. (Ordinarily this is necessary when the vibration schedules for installed equipment in MIL-STD-810C (1*) are not believed to be representative of the vehicle under test, and there are specific sensitive subsystems (including ammunition) which must undergo vibration tests.) The vibrators in turn are used to determine if equipment installed in the vehicle will be able to withstand many miles of vehicle vibration.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Automotive test courses	Selected from those listed in TOP 1-1-011 (2*) to suit test requirements--equivalent courses may be used.
Load-vibration test course	As described in TOP 1-1-011.

*This TOP supersedes TOP 2-2-808, 26 September 1979.

(1*) Footnote numbers correspond to reference numbers in Appendix A.

Instrument van or On-board data-transmission system	As described in TOP 2-1-005 (3*). Similar to Aberdeen Proving Ground's Automatic Data Acquisition and Processing Techniques (ADAPT) (4*).

2.2 Instrumentation.

Transducers	Accelerometers, free or rate gyros, displacement or strain gages as needed for shock and vibration levels expected.

3. REQUIRED TEST CONDITIONS.

3.1 Test Vehicles.

a. Inspect, service, and insure that preliminary operation of new vehicles has been accomplished in accordance with TOP 2-2-505 (5*).

b. Load the vehicle with its rated payload or combat weight.

c. Establish maximum and minimum test speeds for the vehicle in accordance with TOP 2-2-602 (6*).

3.2 Instrumentation.

a. Mount appropriate transducers at various representative locations selected to provide a comprehensive determination of the shock and vibration regimes in the test system during field operation. The number of spring mass systems (degrees of freedom) of interest usually dictates the number of transducers used and their locations. Measure both input and response between each major spring mass system. For instance, install accelerometers on the unsprung parts of the vehicle as well as on the sprung mass, utilizing the more rigid members of the system. For wheeled vehicles, install accelerometers on axles, in the cab, and on the cargo bed. For tracked vehicles, install them on road-wheel arms and on the basic hull structure, fore and aft, and in the driver and personnel compartments. Figure 1 shows two typical accelerometer installations.

b. Install accelerometers to measure vibration frequency and acceleration in three directions (longitudinal, transverse, and vertical) at a zero reference point located at the seat surface, directly below the operator's buttocks and midway between the ischia, to permit analysis of the whole-body vibration transmitted to the driver. Mount transducers on a semirigid disc as shown in Figure 3, SAE J1013, (7*) and interpose them between the seat cushion and the driver. If necessary, make similar measurements at other passenger or crew positions. (See ISO Standard 2631.) (8*) If all crew positions are not occupied during the test, secure a dummy load of 200 pounds on each empty seat in a manner that prevents shifting during test trials.

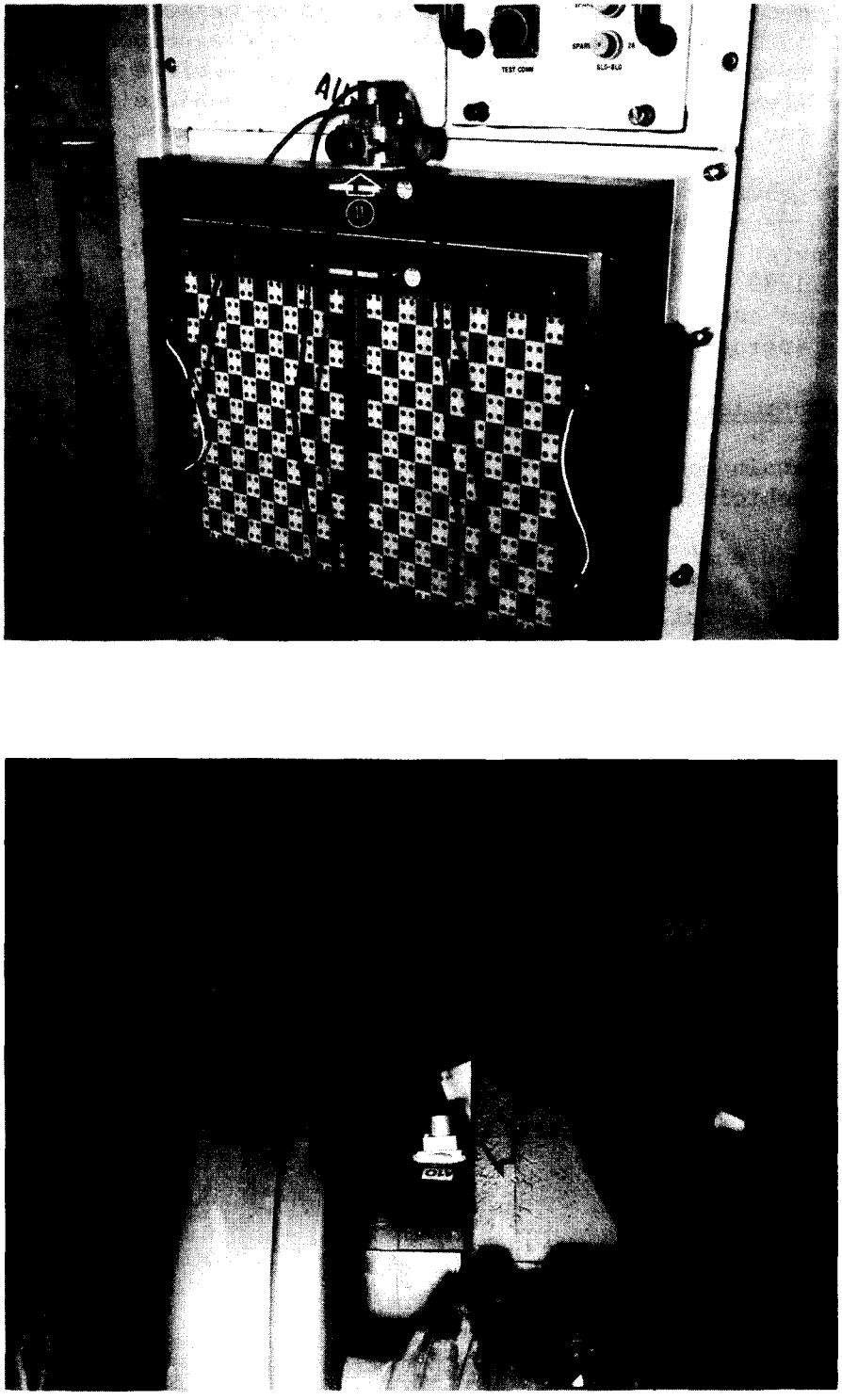

Figure 1. Transducers Mounted for Field Vibration Test on Top of Patchboard in Land Combat Support System (LCSS) (Upper Photograph) and on Axle Housing of the XM860 Semitrailer.

c. If one of the purposes of the test is to measure the vibration response of particular on-board equipment or vehicle components, install appropriate transducers on these items and on the vehicle structures that support the items. Vibration measurements on the vehicle structure are needed to describe the input vibration to the specific equipment or component.

d. For ease of instantaneous determination and reporting of absorbed power, use a meter that will read out in absorbed power. The analog circuits for such a meter are pictured on pages C-222 and C-224, Vol. II, Technical Report No. 11789 (LL 143). (9*) The required acceleration data for computing absorbed power can be recorded in the same manner as discussed for other transducers (paragraph 5), and then processed to provide absorbed-power levels.

3.3 Test Controls.

a. Maintain correct levels of lubricants, hydraulic fluid, coolant, etc., in the test vehicle throughout the test.

b. Insure that all transducers and data-recording equipment are in a current state of calibration, provide acceptable resolution, and have a flat response over the full frequency spectrum of interest.

c. Maintain the severity level of each test course as consistently as possible throughout the test using the procedures described in TOP 1-1-010. (10*)

d. Observe all safety SOPs throughout test operations.

e. Maintain constant course speeds when recording vibration data.

4. TEST PROCEDURES.

a. Connect the transducers to the on-board signal-conditioning and transmitting equipment for transmission of the data to a remote data-handling station such as with APG's ADAPT system. If an on-board system is not available, connect the transducers to recording equipment using cables suspended between the test vehicle and an instrument van, which is operated on a smooth road paralleling the test courses. (See Figure 2.)

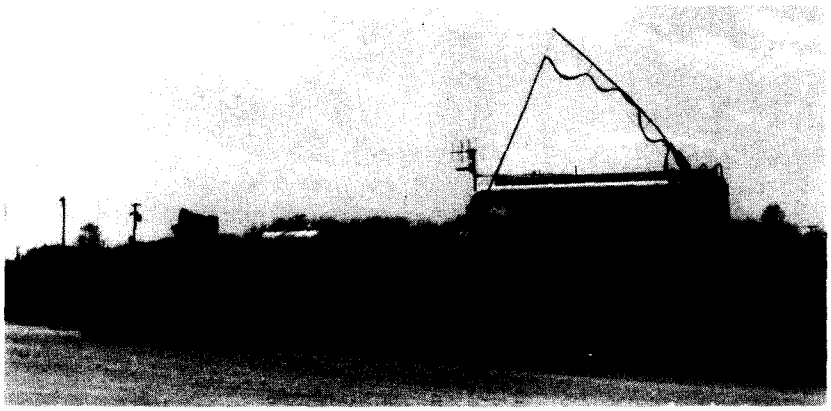

Figure 2. Typical Road Vibration Setup Using Landlines to an Instrument Van.

b. Operate the test vehicle over the test courses listed below, unless otherwise specified, first at minimum speed and then at increased-speed increments until driver discomfort or shock and vibration intensity prevents safe continuation of the test runs (step c below). Record transducer output signals on magnetic tape for each speed increment.

Recommended Test Courses*

Perryman Paved Road
Munson 6-Inch Washboard
Munson Belgian Block
Munson 2-Inch Washboard
Munson 3-Inch Spaced Bump
Munson Radial Washboard
Perryman Cross-Country No. 1
Perryman Cross-Country No. 3

*Courses are those used at Aberdeen Proving Ground, and described in TOP 1-1-011. Equivalent courses may be used.

c. For the health and safety of drivers, terminate test operations or change drivers (unless directed otherwise) when the longitudinal (relative to the driver) or transverse acceleration exceeds the "exposure limit" recommended by ISO Standard 2631. (To establish "exposure limit," multiply acceleration values in Figures 3 and 4 by 2.) Test operations may also be terminated when the driver feels that he cannot control the vehicle, or it is unsafe to continue.

NOTE: ISO Standard 2631 establishes three levels of vibration exposure to define the human response in order of increasing severity:

Reduced-comfort boundary--the vibration frequency, acceleration, and exposure time at which one experiences reduced comfort.

Fatigue-decreased proficiency boundary--the vibration frequency, acceleration, and exposure time at which there is a significant risk of impaired working efficiency.

Exposure limit--the vibration frequency, acceleration, and exposure time at which there is a significant risk to health or safety.

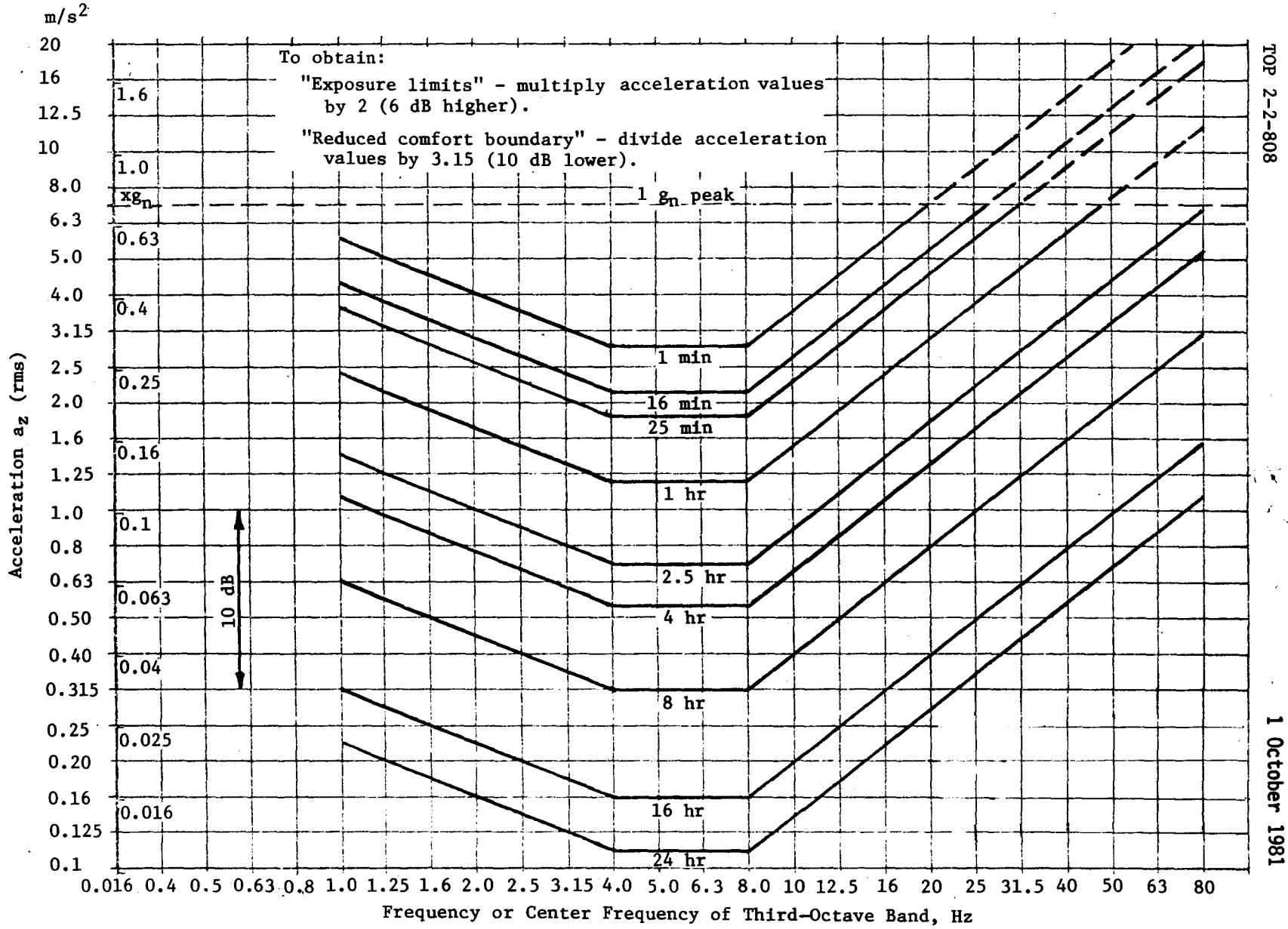

Figure 3. Longitudinal (a_z) Acceleration Limits for Man as a Function of Frequency and Exposure Time. Values above show the "Fatigue-Decreased Proficiency Boundary" (From ISO Standard 2631-1974). (Note: Longitudinal acceleration for a standing or sitting man is measured vertically.)

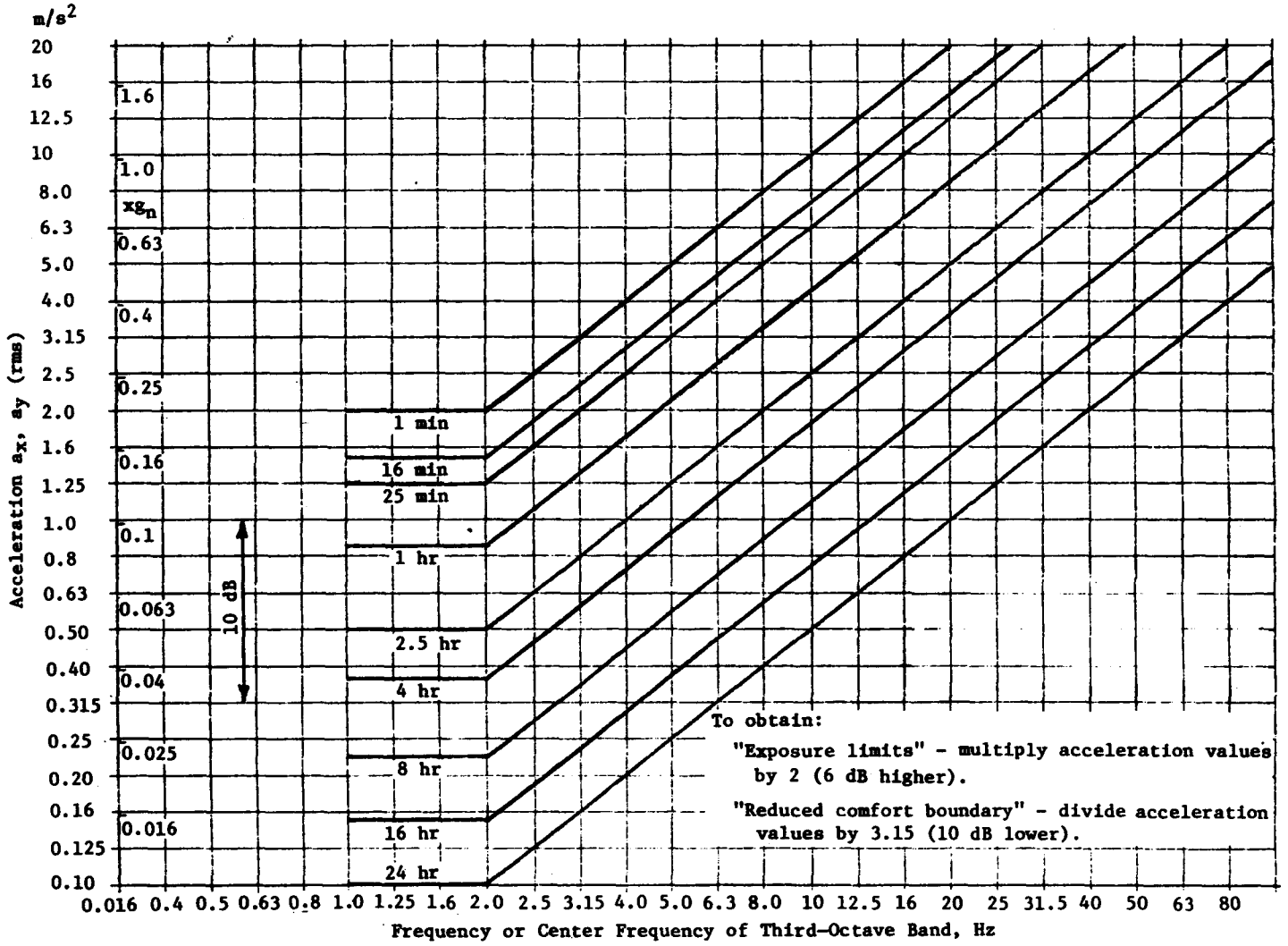

Figure 4. Transverse (a_x, a_y) Acceleration Limits for Man as a Function of Frequency and Exposure Time. Values above show the "Fatigue-Decreased Proficiency Boundary" (from ISO Standard 2631-1974).

5. DATA REQUIRED.

a. Test date.

b. Vehicle identification, serial number, and date of manufacture.

c. Courses traversed.

d. Test course description.

e. Speeds over each course.

f. Starting and completion times.

g. Transducer and recording system identification and description.

h. Photographs and narrative descriptions of transducer locations for structural, cargo, or personnel-position measurements.

i. Tape record of shock and vibration data.

j. Magnetic tape number.

k. Detailed description of the vehicle load to include, but not be limited to:

(1) Weight.

(2) Composition.

(3) Distribution.

(4) Method(s) of security.

l. Damage or impaired operation of vehicle components as a result of traveling over the test courses.

6. PRESENTATION OF DATA.

a. Using appropriate data-processing equipment, reduce the recorded test data in a format(s) to provide the proper information to meet the objectives of the test. Such formats may include, but not be limited to, amplitude distribution, power spectral density, coherence, transmissibility, mechanical impedance, and shock response spectrum for shock data. These and other techniques are described in TOP 1-1-050. (11*)

b. Take analyzed data, collected from personnel positions and from the vibration limits in paragraph 5.8.4, MIL-STD-1472B (12*) (which are the same as those of Figures 3 and 4 of this TOP), and tabulate speeds and exposure times at which the three key exposure levels (i.e., reduced-comfort boundary, fatigue-decreased proficiency boundary, and exposure limits (See note after step 4c.)) are reached.

c. Determine for each test condition the average absorbed power at each personnel station where accelerometers are located. (This is information required by the Army Mobility Model.)

(1) The test conditions should include courses with roughness from 0.5 rms in. to 3 rms in. in 0.5-rms-in. increments. Courses with roughness greater than 3 rms in. should also be included in test conditions where practical. The intent of such courses is to represent natural terrain or to be of a profile that simulates natural terrain.

(2) The vehicle's velocity should be presented for each roughness condition when the absorbed power is 6 watts. Other absorbed-power values may be reported, but are not necessary for the model's input.

Recommended changes to this publication should be forwarded to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, MD 21005. Technical information may be obtained from the preparing activity: Commander, US Army Aberdeen Proving Ground, ATTN: STEAP-MT-M, Aberdeen Proving Ground, MD 21005. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A
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