HEL Standard S-1-63C
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MATERIEL DESIGN STANDARD FOR NOISE LEVELS OF ARMY MATERIEL COMMAND EQUIPMENT

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FOREWORD

Three distinctly different types of "noise criteria" which are used to limit hazardous noise exposure have evolved over the years. It is important to distinguish among the three types in order that the proper type may be chosen for application and use in various situations. The three types of noise criteria are:

a. Hearing damage-risk criteria (DRC)
b. Hearing conservation criteria
c. Materiel design standards.

Hearing damage-risk criteria are comprehensive statements of the relation between various descriptive parameters of noise exposure (i.e., sound pressure level, exposure time, etc.) and the probability of temporary or permanent hearing loss. DRC are formulated and used by acoustical experts and are characterized by their statements about the probability of hearing loss resulting from noise exposure in specified proportions of the population. DRC serve as the data base for the development of hearing conservation criteria and materiel design standards. Examples of current DRC are: "Hazardous Exposure to Intermittent and Steady-State Noise" (1965), and "Proposed Damage-Risk Criterion for Impulse Noise (Gunfire)" (1968), both published by the NAS-NRC Committee on Hearing, Bioacoustics and Biomechanics, Washington, D.C.

Hearing conservation criteria are noise exposure limits which, when exceeded, are indication for the employment of hearing conservation measures. In the Army these criteria, as well as guidelines for conducting comprehensive hearing conservation programs are contained in TB MED 251, "Noise and Conservation of Hearing." TB MED 251 contains information on noise and hearing conservation programs applicable to both military and civilian personnel of the Army; provides guidance for medical officers, occupational physicians, audiologists, and other personnel of the Army Medical Department concerned with implementing these programs; outlines the educational aspects of these programs which must be implemented; and identifies the role of command and all levels of supervision in these programs.

Materiel design standards provide specific noise limits to equipment designers and manufacturers. The noise limits must not be exceeded if the materiel is to be acceptable to the US Army Materiel Command. Design standards evolve from considerations of hearing damage risk, speech intelligibility, aural detection and federal and state legislation, and are intended to cover typical operational conditions.

This document, "HEL STD S-1-63," is the US Army Materiel Command's design standard for noise. It incorporates the provisions of TB MED 251 with respect to noise exposure criteria and MIL-STD-1472 with respect to communications criteria.

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1. INTRODUCTION

1.1 Human Engineering Laboratory (HEL) standards are issued for use by the major subordinate commands of the Army Materiel Command (AMC) and Army Project Management Offices in the area of human factors engineering.

1.2 HEL standards provide guidance to the major subordinate commands of AMC and Army Project Management Offices for the inclusion of human factors engineering requirements in research, development, and procurement of AMC materiel, or in contractual documents.

1.3 HEL standards will serve as the basis for a human factors engineering test and evaluation in accordance with AMC Supplement #1 to AR 602-1, dated 15 July 1969.

1.4 Adherence to the provisions of this standard should result in:

a. Reduced hearing loss among personnel exposed to noise caused by Army materiel;

b. Improved speech communications in the noise environment of Army materiel;

c. When appropriate, decreased possibility of aural detection of Army materiel by the enemy; and

d. Assurance that Army materiel meets applicable state and federal noise limits, and the provisions of TB MED 251 and AR 40-5.

1.5 This document, HEL-S-1-63, is the AMC design standard for noise. The requirements contained herein reflect the official position of the HEL and supersede all other data from this Laboratory pertaining to the subject of this standard.

2. SCOPE

2.1 This standard establishes the acoustical noise levels permitted in and around all equipment designed, developed, or procured by AMC.

2.2 This standard establishes the testing requirements and measurement techniques for determining conformance to the noise limits stated herein.

3. APPLICABLE DOCUMENTS

The documents cited below constitute a part of this standard to the extent specified herein. The latest version of each document shall be used.

REGULATIONS

Army

AR 40-5	Preventive Medicine
AR 385-30	Safety Color Code Markings and Signs
AR 602-1	Man-Materiel Systems, Human Factors Engineering Program
TB MED 251	Noise and Conservation of Hearing

STANDARDS

Military

MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

American National Standards Institute (ANSI)

S1.1	Acoustical Terminology
S1.2	Physical Measurement of Sound, Method for the
S1.4	Sound Level Meters, Specification for
S1.6	Preferred Frequencies and Band Numbers for Acoustical Measurements
S1.8	Preferred Reference Quantities for Acoustic Levels
S1.10	Calibration of Microphones, Method for the
S1.11	Octave, Half-Octave, and Third-Octave Filter Sets, Specifications for
S1.13	Sound Pressure Levels, Method for the Measurement of
Z24.10	Octave-Band Filter Set for the Analysis of Noise and Other Sounds, Specification for an

(Application for price lists and copies should be addressed to American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.)

Society of Automotive Engineers (SAE)

SAE J366	Exterior Sound Level for Heavy Trucks and Buses
SAE J952	Sound Levels for Engine Powered Equipment
SAE J986	Sound Level for Passenger Cars and Light-Trucks

(Application for price lists and copies should be addressed to Society of Automotive Engineers, Inc., 2 Pennsylvania Plaza, New York, New York 10001.)

OTHER

Robinson, D. W. and Whittle, L.S. Acustica 1964, 14, 24-35.

4. DEFINITIONS

Definitions of acoustical terms that do not appear in this section are in accordance with ANSI S1.1.

Aural Non-Detectability Distance is the distance at which, for given conditions, the sound produced by materiel can be heard without electronic aids 50 percent of the time in a quiet environment, by persons with average hearing.

Quiet Environment, for purposes of non-detectability, is an environment in which the octave-band levels at the listener's ears, in the range from 63 to 8000 Hz, are 20 dB.

Average Hearing is that binaural free-field hearing threshold of normal ears for steady-state noise, reported by Robinson and Whittle (see reference).

dBA is the unit used to express sound level measured through the A-weighting network of a sound level meter.

dBC is the unit used to express sound level measured through the C-weighting network of a sound level meter.

Decibel (dB) Reference Level (0 dB) is the level that corresponds to 20 $\mu N/m^2$ or 0.0002 μbar or 0.0002 dynes/cm^2.

Exterior Drive-By Noise is the sound level, in dBA, measured at a specified distance to the side of the line of travel of a vehicle.

Hearing Protectors are devices primarily designed to reduce the noise reaching the auditory system. They may be of any type, i.e., ear plugs, ear muffs, or attenuating helmets or headsets, provided they are approved by The Surgeon General. A current list of approved items can be obtained from The Surgeon General, HQDA (DASG-HE), Washington, D.C. 20314.

Attenuating Helmets or Headsets are hearing protectors which provide the wearer with electronic communications.

Impulse Noise is a short burst of acoustic energy. The pressure-time history of a single impulse includes a rapid rise to a peak pressure, followed by a somewhat slower decay to ambient pressure, both occurring within one second.

Peak Pressure Level is the highest level, in dB, achieved. (Peak pressure is the highest pressure, in PSI, achieved.) Figure 3 shall be used for conversion between PSI and dB.

A-Duration (Pressure Wave Duration) is the time required for the pressure to rise to its initial or principal positive peak and return momentarily to ambient pressure. (See Fig. 2)

B-Duration (Pressure Envelope Duration) is the total time that the envelope of pressure fluctuations (positive and negative) is within 20 dB of the peak pressure level. Included in this time is the duration of that part of any reflection pattern that is within 20 dB of the peak pressure level. (See Fig. 2)

Intermediate Gear means 2nd gear ratio for machines with 3 or 4 gear ratios, 3rd gear ratio for machines with 5 or 6 gear ratios, 4th gear ratio for machines with 7 or 8 gear ratios, etc. (Gear ratio refers to overall gear reductions.)

NC (Noise Criterion) Curves are a widely accepted set of octave band pressure level values used as the basis for indoor noise criteria. They specify the maximum level permitted in each octave band for various types of communication requirements.

NCA (Noise Criterion Alternate) Curves are the same as the NC curves except that the low-frequency limit has been relaxed. These curves are used where economy and system effectiveness dictate a compromise.

Random Incidence Corrector is a device which, when placed on a microphone makes it practically omnidirectional at all frequencies of interest.

Steady-State Noise is a periodic or random variation in atmospheric pressure at audible frequencies which has a duration in excess of one second. It may be continuous or intermittent.

5. GENERAL REQUIREMENTS

5.1 Subsystems

a. Subsystems, such as air conditioners, heaters and auxiliary equipment, shall be designed in such a manner that the noise produced by the entire system does not exceed the requirements of this standard.

b. The fact that a subsystem which contributes to the overall noise may be government-furnished equipment shall not eliminate the requirement that the total system conform to this standard.

5.2 Posting of Noise Hazard Areas. When equipment noise levels are such that hearing protection must be specified as mandatory to meet the provisions of TB MED 251, operation and maintenance manuals shall contain appropriate notations, and caution signs shall be posted on the equipment which are clearly legible to all personnel. Noise-hazard caution signs shall conform to the provisions of AR 385-30 and shall be worded as follows:

CAUTION
NOISE HAZARD
HEARING PROTECTION REQUIRED

5.3 Hearing Protectors. Where required to meet the provisions of TB MED 251, hearing protectors (except those devices requiring individual fitting, under medical supervision--see TB MED 251, Para 8) should be provided as part of the system's equipment. For example, they may be packaged with disposable rocket launchers, or provided in passenger areas of personnel carriers and aircraft, etc.

6. STEADY-STATE NOISE - PERSONNEL-OCCUPIED AREAS

6.1 Noise Limits.

a. Applicable noise limits are identified by the communication requirements at the personnel-occupied areas. Criteria for selecting the appropriate noise limits are listed in 6.1 -d, and the corresponding noise limits are shown in Tables 1 and 2 for Preferred and Commercial Frequencies, respectively. The use of Table 1 is mandatory for procurement of new AMC materiel; Table 2 shall be used to compare noise levels of older materiel with this standard.

b. The limits for Categories A, B, C, and D are based primarily on hearing conservation priorities, while the remaining categories are based primarily on communication requirements.

c. Every effort shall be made to reduce system noise to or below the limits specified in Category D. (Category D meets the unprotected exposure criteria of TB MED 251 for eight hours.) Where the limits specified for Category D can be documented as being clearly beyond the state of the art, the following rules shall apply:

1. For systems where electronically-aided communication is required and the use of attenuating helmets or headsets is a system requirement (e.g., certain track-laying vehicles or aircraft) Category B may be substituted.

2. For systems where no frequent direct person-to-person voice communication is required, but intermittent shouted communication is required, Category C may be substituted.

3. Category A shall be selected only if there is no requirement for direct person-to-person voice communication and analysis of the feasibility of attenuating the noise, conducted by a qualified acoustical laboratory or consultant demonstrates that:

(a) The cost of reducing the noise level to or below that specified for Category C is prohibitive; or

(b) System effectiveness will be seriously degraded by reducing the noise level to or below that specified for Category C.

d. Steady-State Noise Category Selection Criteria:

Note: Materiel producing noise levels above 85 dBA in personnel occupied areas shall have a caution sign attached to the item per Section 5.2. (See also TB MED 251.)

Category	Criteria for Selection
A	No direct person-to-person voice communication required. Maximum design limit for AMC equipment. Hearing protection required at all times.
B	Electronically-aided communication required via attenuating helmet or headset.
C	No frequent direct person-to-person voice communication required. Intermittent shouted communication may be possible at a distance of one foot. Commonly achievable.
D	No frequent direct person-to-person voice communication required. Intermittent shouted communication may be possible at a distance of 2 feet. Desirable but rarely achievable. Meets unprotected exposure criteria of TB MED 251 for 8 hours.
E	Aircraft: frequent direct person-to-person voice communication required. (Equivalent to NCA 70.)
F	Intermittent electronically-aided voice communication required via non-attenuating headset or loudspeaker; infrequent direct person-to-person voice communication required; no telephone use required. (Equivalent to NC-70.)
G	Frequent electronically-aided voice communication required via non-attenuating headset or loudspeaker; frequent direct person-to-person voice communication required; infrequent telephone use required. (Equivalent to NC-60.)
H	Frequent telephone use required. (Equivalent to NC-50.)

Table 1

Steady State Noise Limits for Categories of Personnel Occupied Areas

(Preferred Frequencies [ANSI S1.11])

Octave Band Limits (Hz)	Center Frequency (Hz)	Band Pressure Level (dB)							
		A*	B*	C*	D	E	F	G	H
44 - 88	63	130	121	111	106	96	83	77	71
88 - 177	125	119	111	101	96	87	79	72	64
177 - 354	250	110	103	94	89	80	75	67	58
354 - 707	500	106	102	88	83	75	72	63	54
707 - 1414	1000	105	100	85	80	72	71	61	51
1414 - 2828	2000	112	100	84	79	70	70	59	49
2828 - 5657	4000	110	100	84	79	69	69	58	48
5657 - 11314	8000	110	100	86	81	68	68	57	47

*Note: Noise hazard caution signs shall be posted in or on equipment when limit A, B, or C is selected (see Section 5.2).

Table 2

Steady State Noise Limits for Categories of Personnel Occupied Areas

(Commercial Frequencies [ANSI Z24.10])

Octave Band Limits (Hz)	Center Frequency (Hz)	Band Pressure Level (dB)							
		A*	B*	C*	D	E	F	G	H
37.5 - 75	53	133	124	114	109	100	85	79	73
75 - 150	106	121	113	103	98	89	80	73	66
150 - 300	212	111	104	95	90	82	76	68	60
300 - 600	425	107	102	89	84	76	73	64	55
600 - 1200	850	105	100	85	80	73	71	62	52
1200 - 2400	1700	112	100	84	79	70	70	60	50
2400 - 4800	3400	110	100	84	79	69	69	58	48
4800 - 9600	6800	110	100	85	80	68	68	57	47

*Note: Noise hazard caution signs shall be posted in or on equipment when limit A, B, or C is selected (see Section 5.2).

6.2 Test Requirements.

6.2.1 General

a. To be acceptable for use under the selected noise-limit category, the equipment noise shall not exceed the octave band limits given in Section 6.1 in any octave band.

b. Noise measurements shall be made at:

(1) each operator position;

(2) at representative positions where a group of personnel (e.g., passengers) will be located.

Note: Where the operator station is not clearly defined the noise measurement position shall be designated by the procuring command. Likewise, the procuring command shall designate representative noise measurement locations where a group of personnel (e.g., passengers) will be located.

c. The data recorded and reported shall include octave band pressure levels, dBA, and dBC.

d. All windows, vents, and access openings shall be closed, except those normally opened for proper operation of the equipment.

6.2.2 Mobile Equipment.

a. General.

(1) All load-carrying equipment shall be operated with two-thirds of maximum payload.

(2) All auxiliary systems normally in continuous use while the equipment is in motion shall be operated.

(3) Auxiliary systems normally operated while equipment is stationary shall be tested in accordance with 6.2.3.

b. Vehicles.

(1) Vehicles shall be driven along a paved level ($\pm$ 1 percent grade) road, except for those vehicles having non-rubber padded tracks which shall be driven on a level, unpaved surface.

(2) Vehicle noise shall be measured at two-thirds of maximum rated or governed engine speed. Vehicles shall be operated in each gear, where possible, and each dBA level shall be recorded. An octave band analysis shall then be performed under that condition producing the highest dBA level.

c. Off-Road Construction and Materiel -Handling Equipment noise shall be measured at full governor control setting, in an intermediate gear, under a typical load condition. The load and test surface shall be specified by the procuring command, but in no case shall the load be less than two-thirds of maximum rated load.

d. Watercraft noise shall be measured under normal cruise conditions.

e. Aircraft

(1) Fixed wing aircraft noise shall be measured under normal cruise conditions.

(2) Rotary wing aircraft noise shall be measured at normal climb, normal cruise, normal descent, and normal hover, and the dBA level measured under each condition shall be recorded. An octave-band analysis shall be performed under that condition producing the highest dBA level. Normal hover shall be accomplished at an altitude of less than 3 meters (10 ft) above a level grass-covered surface.

6.2.3 Stationary Equipment.

a. All equipment shall be operated at maximum rated continuous duty speed.

b. All equipment shall be operated with two-thirds of maximum rated load. Exception: For those items of equipment where this load is inappropriate (e.g., due to stall) the procuring command shall specify the load condition to be used.

c. All auxiliary systems normally in continuous use shall be operated.

7. AURAL NON-DETECTABILITY

7.1 Noise Limits. Table 3 shows noise limits which shall not be exceeded by those items of equipment (excluding aircraft) which have an aural non-detectability requirement. These limits are for non-detectability under commonly found favorable sound propagation conditions. The actual detection distance for specific conditions of terrain, wind, background noise, etc., may occasionally be greater but more often will be smaller. The octave band pressure levels at the "measurement distances" must not be exceeded in any band if non-detectability is to be achieved at the corresponding "nominal non-detectability distances."

Table 3

Aural Non-Detectability Steady-State Noise Limits

Measurement Distance (m)	Center Frequency (Hz) 63	125	250	500	1K	2K	4K	8K	Nominal Non-Detectability Distance (m)
1-1/4	48	34	32	32	32	32	32	32	5
2	59	45	43	43	43	44	44	45	30
6	60	46	44	45	45	46	47	48	100
10	62	48	46	46	47	48	51	54	200
10	66	52	50	50	51	53	57	61	300
15	65	51	49	49	50	53	59	64	400
20	64	50	48	49	50	53	60	67	500
25	66	52	50	51	53	58	68	79	750
25	68	54	52	54	57	63	77	85	1000
25	70	56	54	56	60	67	85	85	1250
25	72	58	56	59	63	72	85	85	1500
25	74	60	58	62	68	80	85	85	2000
25	80	66	64	72	84	85	85	85	4000

7.2 Test Requirements.

a. Equipment noise which does not exceed the octave band pressure level limits of Table 3 on any azimuth at each "measurement distance" for the respective "nominal non-detectability distance" will be deemed to meet the requirements of this standard. Listener tests are not required.

b. Tests shall be conducted on a uniform, flat, grass surface, free of tall vegetation or snow.

c. Equipment operating conditions will depend upon the conditions for which non-detectability is required, and shall be specified by the procuring command.

d. The microphone shall be positioned 4 ft (1.2 m) aboveground at the appropriate measurement distance.

NOTE: Great care must be taken when measuring the noise of a large item at close distances. Wherever possible the measurement distance should be more than three times the major dimension of the item. Measurements made at a distance which is less than three times the major dimension of the noise source may be in the near field, in which case the inverse square law does not hold and the resulting noise measurements may be inappropriate for predicting non-detectability.

8. MEASUREMENT AND INSTRUMENTATION PROCEDURES FOR STEADY-STATE NOISE. The following procedures shall be used to measure noise for compliance with the limits specified for personnel-occupied areas (Section 6) and aural non-detectability (Section 7). In addition, the data reporting requirements of Section 12 shall be followed.

8.1 Personnel Limits and Locations During Tests

a. During testing the operator (s) shall not occupy that location where the noise is being measured unless required to operate the equipment.

(1) When no operator is present the measurement shall be made at the center of his probable head location. For standing locations the microphone shall be positioned 165 cm (65 in) above the floor; for sitting locations it shall be 80 cm (31.5 in) above the seat. The location of the microphone shall be documented (see 12e).

(2) When the operator must be present the measurement shall be made 15 cm (≈6 in) horizontally to the right of his right ear. If a wall or other reflective surface is closer than 30 cm from his right ear, the microphone shall be positioned equidistant from his right ear and that surface. The microphone location shall be documented (12e).

b. Interior noise measurements shall be made with the minimum number of people required in the area, including test personnel; in no case shall more than three people be present.

c. Exterior measurements shall be made with the measuring technician standing about 90 degrees off of a line extending through the noise source and the microphone. Bystanders will be positioned behind the technician on a line through the technician and microphone.

8.2 Test Environment

a. The background noise level, including wind noise, shall be at least 10 dB below that of the equipment noise in each octave band. (Exception: For aural non-detectability measurements (Section 7) the use of conventional background noise corrections is permitted. See ANSI S1.13.

b. The test site shall be an open area of uniform grade and free of reflecting surfaces such as buildings, trees, or hillsides within 30 meters.

8.3 Microphone Orientation

a. For interior measurements the microphone shall be placed at the measurement location vertically with the sensitive element up. Microphones having an essentially flat response (± 2 dB from 40-12000 Hz) at grazing incidence (90°) should be used. Microphones having a flat response at normal incidence (0°) shall require the use of a random incidence corrector.

b. For exterior measurements the microphone shall be oriented, relative to the noise source, in a manner which produces the most uniform frequency response based on the instrument manufacturer's instructions.

8.4 Calibration. Proper acoustical calibration procedures shall be accomplished, to include the influence of cables, etc., before and after each test sequence. Internal electronic calibration means are acceptable for field use, provided that the acoustical calibration is accomplished immediately before and after field use. (See also ANSI S1.10.)

8.5 Instrumentation Procedures

8.5.1 Instrument Specifications.

a. All test instrumentation and procedures shall meet the appropriate specifications listed in Section 3.

b. The Sound Level Meter used shall be type 2 (or better) based on ANSI S1.4. Octave Band Filter Sets shall meet the requirements of type E, class II, based on ANSI S1.11.

8.5.2 Instrument Settings

a. The octave band analysis shall be made using the "linear" or "flat" weighting network. The C-weighting network shall be used only if no linear setting is available on the particular instrument being used.

b. Slow meter damping shall be used.

8.5.3 Guidelines. The following guidelines should be observed, in addition to those specified in the instrument manufacturer's manual:

a. Batteries should be checked and replaced and recharged, if necessary, prior to both calibration and measurement.

b. Instruments should be warmed up prior to calibration and measurements in accordance with the manufacturer's instructions.

c. The technician should listen to the output of the instrument through a headset, prior to and while measuring noise, to aurally discern instrument abnormalities and overload or excess electronic noise conditions.

d. Great care must be taken not to overload the input amplifier when using sound level meters having a two-stage attenuator (i.e., one attenuator before (input), and another attenuator after (output) the filter network.) Once the attenuators have been adjusted to measure the overall level, adjust only the output attenuator to measure the band pressure level or the weighted SPL.

e. A gooseneck or extension cable should be used for greater convenience and improved microphone to sound level meter separation.

f. The measurement should include both an on-site octave band analysis and a one minute tape recording, if possible. The tape recording can be used for further analysis in the laboratory and/or comparison to the on-site measurement data.

g. At the conclusion of an octave band analysis, the data should be examined to verify the following simple checks on measurement accuracy:

(1) No octave band level can be greater than the overall SPL;

(2) The sum of the octave band levels, computed by the appropriate method, will approximately equal the measured overall SPL;

(3) Adjacent octave bands should normally not have levels differing by more than about 20 dB.

(4) The levels in several adjacent octave bands normally should not be identical. If they are, this might indicate measurement of the electronic "floor" of the instrumentation.

9. EXTERIOR DRIVE-BY NOISE

Table 4 shows noise limits which shall not be exceeded by those items of equipment which have an exterior drive-by noise requirement. These limits shall not be exceeded at a point 50 ft (15.2 m) from the center of the line of travel. Exterior drive-by noise shall be measured in accordance with the appropriate SAE test procedure cited in Table 4. A tolerance of +2 dB is permitted to allow for variations in test conditions.

Table 4

Sound Level Limits and Test Procedures for Exterior Drive-By Noise

Type of Equipment	Gross Weight (lbs)	Sound Level Limit (dBA)	Test Procedure
Motor Vehicles	>6000	86	SAE J366
	≤6000	84	SAE J986
Construction and Materiel-Handling Equipment	-	88	SAE J952

10. IMPULSE NOISE

10.1 Impulse-Noise Limits. The fundamental unprotected exposure criterion for impulse noise is 140 dB as stated in TB MED 251. To select the appropriate design limit for impulses greater than 140 dB, for which hearing protection is mandatory, enter Table 5 with the expected number of daily exposures and the type of hearing protection to be used, and then select the indicated curve in Figure 1. Figure 1 shows the permissible peak pressure level and B-duration which shall not be exceeded by the system. A single exposure consists of either:

a. A single impulse (no more than one impulse per second) for non-repetitive systems (e.g., semi-automatic weapons); or

b. A burst in the case of systems normally producing more than one impulse per second (e.g., automatic weapons.)

Table 5

Impulse-Noise Limit Selection Criteria

Expected Number of Exposures per Day	Type of Hearing Protector		
	None	Either Plugs or Muffs	Both Plugs and Muffs
1000	W	X	Y
100	W	Y	Z
5	W	Z	*

* Higher levels than Curve Z not permitted due to possibility of other non-auditory physiological injury.

10.2 Test Requirements.

10.2.1 General

a. To be acceptable for use under the impulse-noise limit category selected in 10.1, peak pressure level and B-duration of a single exposure shall be below the appropriate impulse-noise requirement as shown in Figure 1.

b. Impulse-noise measurements shall be made at each operator or crew position.

NOTE: Where the operator or crew station(s) is not clearly defined, the noise measurement position(s) shall be designated by the procuring command.

c. The average of at least three peak pressure levels and three B-duration measurements shall be reported. The average of three measurements will be sufficient if the range of peak pressure levels does not exceed 3 dB. If the range of peak pressure levels exceeds 3 dB, additional measurements shall be made until the number of measurements equals or exceeds the range in dB.

d. For weapons with various charges (e.g., separately-loaded artillery ammunition), that charge producing the highest peak pressure level shall be reported.

e. For noise measurement purposes, shoulder fired and handheld weapons shall be mounted with the barrel or tube at least 165 cm (65 inches) above and parallel to the ground. All other weapons shall be operated in the physical position and in the system location from which they are normally fired.

10.2.2 Non-Repetitive Systems. Pressure vs. time histories shall be made of the impulse noise by producing one impulse at a time.

10.2.3 Repetitive Systems. The B-duration of a single impulse (e.g., round) shall be determined. The number of impulses produced within the first 200 milliseconds shall also be determined. This number of impulses shall be multiplied by the average B-duration of single impulses to determine an effective B-duration, which shall be used to establish the maximum allowable peak pressure level for the repetitive system.

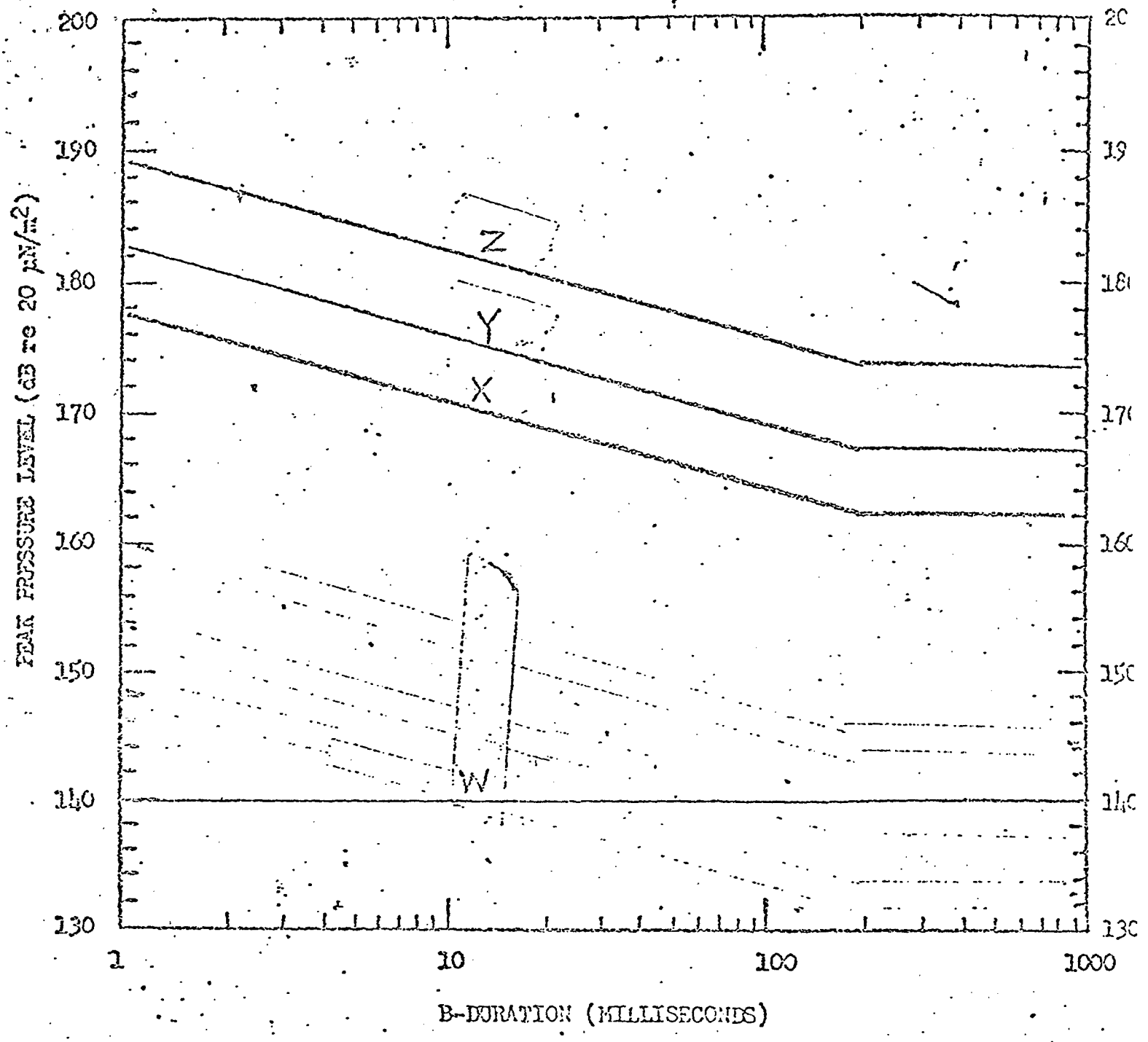

Figure 1. Peak pressure level and B-duration limits for impulse noise. (See Table 5 to select curve for use. Note: Use of curves X, Y and Z requires mandatory hearing protection per TB Med 251.)

11. MEASUREMENT AND INSTRUMENTATION PROCEDURES FOR IMPULSE NOISE

11.1 Personnel Limits and Locations During Tests

a. During testing the operator and/or crew shall not occupy the location(s) where the noise is being measured unless essential to the operation of the equipment.

(1) When no operator is present the measurement shall be made at the center of his probable head location 165 cm (65 in) above the ground. The location of the microphone shall be documented.

(2) When the operator must be present the measurement shall be made 15 cm (≈6 in) from the ear closest to the noise source (i.e., muzzle or breech as the case may be) on a line between his ear and the noise source. The microphone location shall be documented.

b. Interior measurements shall be made with the minimum number of people in the area, not to exceed three.

11.2 Test Environment

a. Noise measurements shall be made with no reflecting surfaces, including personnel, within 10 m, other than those normally present. The measuring technician and all instrumentation should also be further than this distance from the noise source.

b. Background noise level shall be at least 25 dB below the peak pressure level being measured.

11.3 Microphone Orientation. The transducer shall be positioned with the sensing surface up, and shall be oriented with reference to the noise source so that the pressure wave strikes the sensing surface at grazing incidence (90°).

11.4 Calibration. Proper calibration procedures shall be accomplished, to include the influence of cables, etc., before and after each test sequence. Electrical calibration means are acceptable for field use, provided that a pistonphone, acoustical calibrator, shock tube, drop test, or static pressure calibration is accomplished immediately before and after field use.

11.5 Instrumentation Procedures.

11.5.1 Pressure versus Time History of the impulse shall be measured by either of the following methods:

a. Directly photographing the trace obtained on a cathode-ray oscilloscope connected to a transducer system; or

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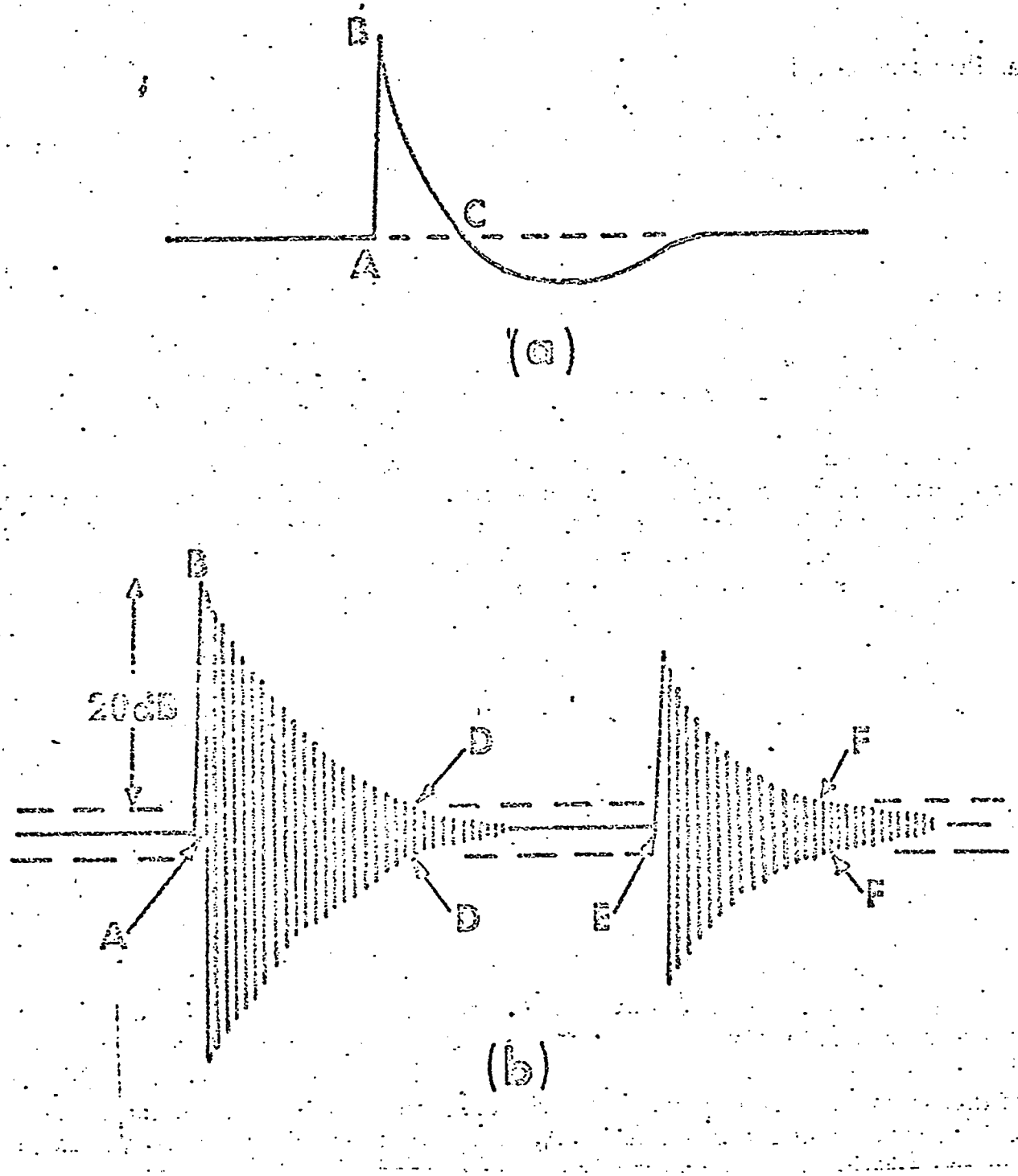

Figure 2. Idealized Pressure-Time History of an Impulse Noise.

Peak Pressure Level: pressure difference AB
A-duration (pressure wave duration): time difference AC
B-duration (pressure envelope duration): time difference AD(+EF when a reflection is present).

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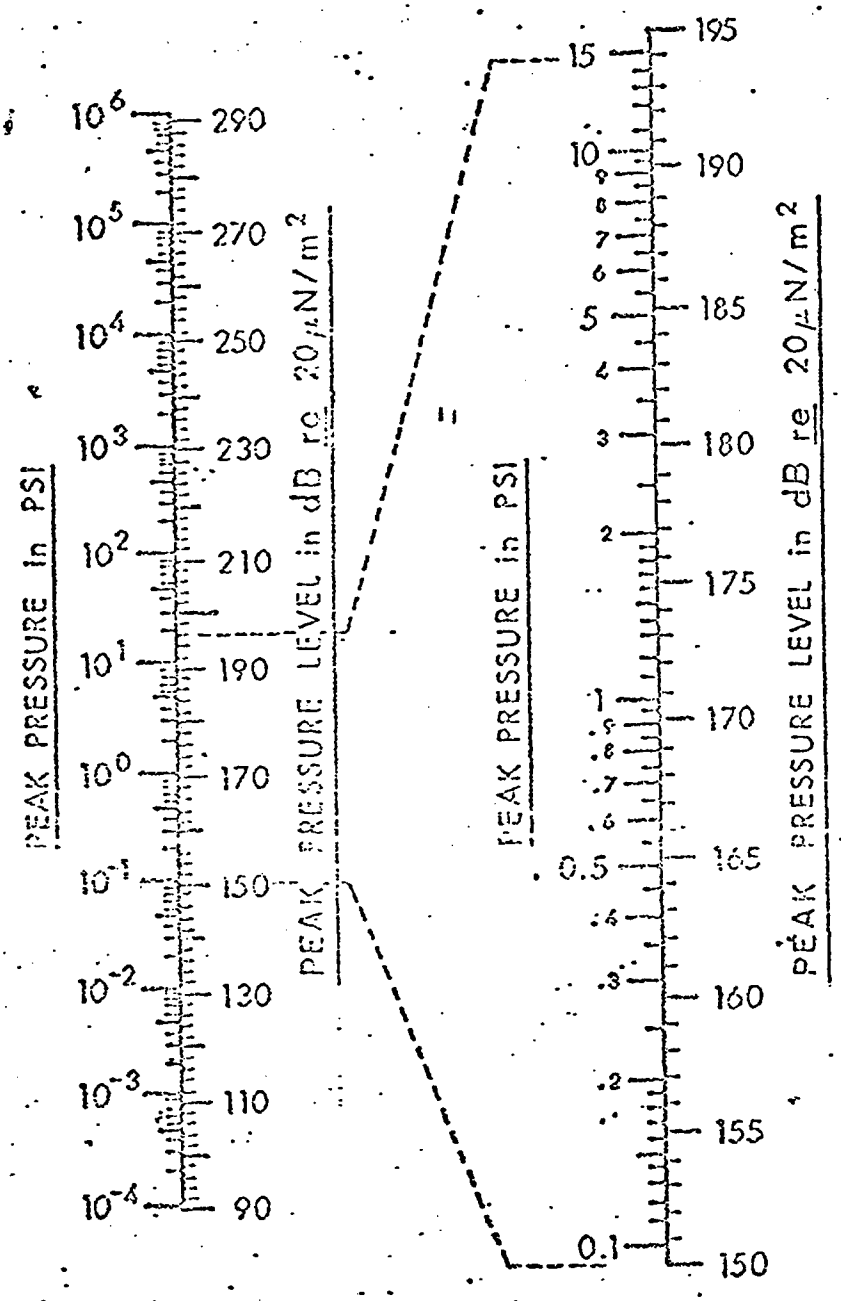

Figure 3. Nomogram for Conversion Between PSI and dB.

"12. DATA REPORTING REQUIREMENTS. This section lists the data which shall be reported in addition to noise measurements made in accordance with this standard. As a minimum the following shall be reported:

a. Complete list of instrumentation used for the measurements, including name, type, serial number and manufacturer.

b. Complete identification of the equipment whose noise is being measured including name, type, serial number, mileage, if appropriate, and any modifications to the equipment.

c. Complete description of the operational conditions under which the test was conducted including speed, RPM, load, etc.

d. Date and location of test.

e. A physical description of the area, including ground surface and reflecting surfaces, if appropriate, a sketch of all noise sources, normal personnel operating positions and microphone locations and the location of persons physically present during the tests.

f. Air temperature, relative humidity, and wind speed.

g. Background noise level, using the same bandwidth employed for the measurements of the noise source.

h. Method and time of calibration.

i. Bandwidth of frequency analyzer (octave, one-third octave, etc.) and whether C-weighted or flat.

j. Time response of the measuring system (i.e., "slow" or "fast" response, or alternate appropriate description).

k. Locations and orientation angles of the microphones with reference to the noise source.

l. Frequency response and tape speed of tape recorder, if used.

m. Name and address of personnel making the noise measurements.