METRIC

MIL-STD-1474C
8 March 1991

SUPERSEDING
MIL-STD-1474B(MI)
18 JUNE 1979

MILITARY STANDARD

NOISE LIMITS FOR MILITARY MATERIEL (METRIC)

AMSC A6020

AREA HFAC

DISTRIBUTION STATEMENT A Approved for public release, distribution is unlimited.

FOREWORD

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Commander, U.S. Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5270 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. Three different types of "noise criteria" used to limit noise exposure have evolved:

a. Hearing damage-risk criteria (DRC) are comprehensive statements of the relation between various descriptive parameters of the noise exposure (e.g., sound pressure level, exposure time) and the probability of temporary or permanent hearing loss DRC are statements regarding the probability of hearing loss resulting from noise exposure in specified proportions of the population DRC serve as the data base for developing 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.

b. Hearing conservation criteria are noise exposure limits that, when exceeded, indicate the need for hearing conservation measures. In the Army these criteria, as well as guidelines for conducting comprehensive hearing conservation programs, are contained in DA PAM 40-501, "Hearing Conservation." DA PAM 40-501 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 implementation of educational aspects of these programs; and identifies the roles of command and of all levels of supervision in these programs. Navy criteria and guidelines for conducting hearing conservation programs are found in OPNAVINST 5100.23B "Navy Occupational Safety and Health (NAVOSH) Program Manual",and OPNAVINST 5100.19B "Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat", Air Force criteria are contained in AFR 161-35, "Hazardous Noise Exposure "

c. Materiel design standards provide specific noise limits and other requirements to equipment designers and manufacturers They are intended to cover typical operational conditions. Required noise limits must not be exceeded if the materiel is to be acceptable to the procuring activity. Design standards evolve from considerations of hearing damage-risk, speech intelligibility, aural detection, state-of-the-art of noise reduction, and government legislation.

d. It is important to distinguish among the three types to choose the proper one for application and use in various situations.

This document is based on the provisions of DA PAM 40-501, OPNAVINST 5100.23B, OPNAVINST 5100.19B, and AFR 161-35 for noise exposure criteria and MIL-STD-1472D for communications criteria.

The criteria contained herein are more stringent than Occupational Safety and Health Administration (OSHA) standards and will be used in lieu of OSHA standards (29 CFR 1910.95). Whenever feasible, all new equipment, whether newly designed or purchased, shall emit the lowest possible noise levels.

CONTENTS

PARAGRAPH		PAGE
1.	SCOPE	1
1.1	Scope	1
1.2	Application	1
1.3	Purpose	1
2.	APPLICABLE DOCUMENTS	2
2.1	Government documents	2
2.1.1	Specifications, standards, and handbooks	2
2.1.2	Other Government documents, drawings and publications	2
2.2	Nongovernment publications	3
2.3	Order of precedence	4
3.	DEFINITIONS	5
3.1	Aural nondetectability distance	5
3.1.1	Average hearing	5
3.2	dB(A)	5
3.3	dB(C)	5
3.4	Equivalent continuous sound level	5
3.5	Hearing conservation criteria	6
3.6	Hearing damage-risk criteria	6
3.7	Hearing protectors	6
3.7.1	Attenuating helmets or headsets	6
3.8	Impulse noise	6
3.8.1	Peak pressure level	7
3.8.2	A-duration (pressure wave duration)	7
3.8.3	B-duration (pressure envelope duration)	7
3.9	Materiel design standard	7
3.10	Noise criterion (NC) curves	7
3.11	Speech interference level (SIL-4)	7
3.12	Random incidence corrector	7
3.13	Rated engine speed	7
3.14	Sound pressure level	7
3.15	Steady-state noise	10
3.16	Government Furnished Equipment (GFE)	10
3.17	System	10
3.18	State-of-the-art	10

CONTENTS

PARAGRAPH		PAGE
4.	GENERAL REQUIREMENTS	11
4.1	Subsystems, sets, groups, and units	11
4.1.1	Total system noise	11
4.1.2	Government Furnished Equipment.(GFE)	11
4.1.3	Engineering controls	11
4.2	Posting of noise hazards areas	11
4.3	Manuals	11
4.4	Commercial construction and materials-handling equipment	11
4.5	Pulsating equipment	13
5.	DETAILED REQUIREMENTS	14
5.1	Steady-state noise, personnel occupied areas	14
5.1.1	Noise limits	14
5.1.1.1	Categories	14
5.1.1.2	Maximum	15
5.1.1.3	Acceptance	15
5.1.1.3.1	Compliance	15
5.1.1.3.2	Non-compliance	16
5.1.2	Test requirements	17
5.1.2.1	General	17
5.1.2.1.1	Acceptance criteria	17
5.1.2.1.2	Measurement location	17
5.1.2.1.3	Recording	18
5.1.2.1.4	Noise contours	18
5.1.2.1.5	Equipment openings	18
5.1.2.1.6	Test schedule	18
5.1.2.1.7	Typical duty cycle testing	18
5.1.2.1.8	Sample size	18
5.1.2.2	Operating conditions for system testing	18
5.1.2.3	Operating conditions for mobile equipment testing	19
5.1.2.3.1	Vehicles	19
5.1.2.3.1.1	Vehicle speed and gear	19
5.1.2.3.1.2	Load-carrying equipment	19
5.1.2.3.1.3	Auxiliary equipment	19
5.1.2.3.1.4	Selection criteria	19
5.1.2.3.2	Construction and materials-handling equipment	19

CONTENTS

PARAGRAPH		PAGE
5.1.2.3.3	Watercraft	19
5.1.2.4	Operating conditions for	19
	stationary equipment testing	19
5.1.2.4.1	Speed	19
5.1.2.4.2	Load	20
5.1.2.4.3	Auxiliary equipment	20
5.1.2.5	Test environment, instrumentation, and measurements	20
5.1.2.5.1	Test environment	20
5.1.2.5.1.1	Test site	20
5.1.2.5.1.2	Background noise	20
5.1.2.5.1.3	Surface and grade for vehicle testing	20
5.1.2.5.2	Instrumentation	20
5.1.2.5.2.1	Instrument specifications	20
5.1.2.5.2.2	Calibration	21
5.1.2.5.2.3	Microphones	21
5.1.2.5.3	Measurement	21
5.1.2.5.3.1	Personnel limits and locations during tests	21
5.1.2.5.3.1.1	Operator(s)	21
5.1.2.5.3.1.2	No operator present	21
5.1.2.5.3 1.3	Operator present	22
5.1.2.5.3.1.4	Test personnel	22
5.2	Aural nondetectability	22
5.2.1	Noise limits	22
5.2.1.1	Criteria	22
5.2.1.2	Maximum	26
5.2.2	Test requirements	26
5.2.2.1	Test site	26
5.2.2.2	Equipment operating conditions	26
5.2.2.3	Microphone location	26
5.2.3	Instrumentation	26
5.2.4	Measurements	26
5.3	Community annoyance	33
5.3.1	Noise limits	33
5.3.1.1	Criteria	33
5.3.1.2	Maximum	33
5.3.2	Test requirements	33
5.4	Impulse noise, personnel-occupied areas	34
5 4.1	Noise limits	34

CONTENTS

PARAGRAPH		PAGE
5.4.1.1	Criteria	34
5.4.1.2	Maximum	36
5.4.2	Test requirements	36
5.4.2.1	General	36
5.4.2.1.1	Acceptance criteria	36
5.4.2.1.2	Measurement location	36
5.4.2.1.3	Replications	36
5.4.2.1.4	Recording procedure	37
5.4.2.1.5	Noise contours	37
5.4.2.2	Test environment	37
5.4.2.2.1	Reflecting surfaces	37
5.4.2.2.2	Weather conditions	37
5.4.2.2.3	Background noise	37
5.4.3	Instrumentation	37
5.4.3.1	Instrument specifications	37
5.4.3.1.1	Transducers	37
5.4.3.1.1.1	Transducer applications	38
5.4.3.1.2	Recording systems	39
5.4.3.1.2.1	FM recording	39
5.4.3.1.2.2	Digital recording	39
5.4.3.2	Calibration	39
5.4.3.2.1	General	39
5.4.3.2.2	Calibration method	39
5.4.3.2.3	Electrical calibration	39
5.4.4	Measurement procedure	39
5.4.4.1	Single-impulse systems	39
5.4.4.2	Repetitive systems	39
5.4.4.3	Multicharge systems	40
5.4.4.4	Weapon position	40
5.4.4.5	Transducer locations	40
5.4.4.5.1	Reference transducer	40
5.4.4.5.2	Equal pressure contours	40
5.4.4.6	Transducer orientation	41
5.4.4.6.1	Interior measurements	41
5.4.4.7	Ammunition temperature	41
5.4.4.8	Personnel limits and locations during tests	41
5.4.4.8.1	Operator(s)	41
5.4.4.8.2	Interior noise measurements	41
5.4.4.9	Guidelines	41
5.4.4.9.1	Systems	41
5.4.4.10	Data analysis	42
5.4.4.10.1	Filtering	42
5.4.4.10.2	Weighting networks	42
5.4.4.10 3	Analog to digital converters	42

CONTENTS

PARAGRAPH		PAGE
5.4.4.10.4	FM recordings	42
5.4.4.10.5	Standard conditions	42
5.4.4.10.6	Acoustic energy	42
5.5	Data recording	42
6.	NOTES	46
6.1	Intended use	46
6.2	Issue of DODISS	46
6.3	Applicable Data-Item-Description (DID)	46
6.4	Subject term (key word) listing	46
6 5	Changes from previous issue	46
6.6	Appendix of non-DODISS references	47

FIGURES

1.	Scale for conversion between kPa and dB	8
2.	Example of A-duration; actual pressure-time history of an impulse noise	9
3.	Noise hazard caution sign	12
4.	Level I nondetectability limits for 10-30 meters	27
5.	Level I nondetectability limits for 100-400 meters	28
6.	Level I nondetectability limits for 500-6000 meters	29
7.	Level II nondetectability limits for 10-30 meters	30
8.	Level II nondetectability limits for 100-400 meters	31
9.	Level II nondetectability limits for 500-6000 meters	32
10.	Peak sound pressure levels and B-duration limits for impulse noise	35
11a.	Sample form showing acoustical test data for M561 Cargo Truck	44
11b.	Blank acoustical test data form	45
12.	Sample determination of B-duration	51
13.	Sample determination of B-duration	52
14	Sample determination of B-duration	53
15.	Sample determination of B duration	54
16.	Determination of B-duration	55

CONTENTS

TABLES PAGE

I. Steady-state noise categories.....14
II. Steady-state noise limits (dB(A)) for personnel-occupied areas.....15
III. Level I aural nondetectability limits (dB).....23
IV. Level II aural nondetectability limits (dB).....24
V. Frequency (Hz) and accompanying 1/3 Octave-band ambient noise levels (dB) for both Level I and Level II categories.....25
VI. Sound level limits and test procedures for community annoyance.....33
VII. Impulse noise daily exposure limits.....34

APPENDIX GUIDANCE.....48

10. Details specified by the procuring activity.....48
10.1 Hearing protection..... 48
10.2 Operating conditions for testing.....48
10.3 Aural nondetectability.....49
10.4 Measurement locations when not clearly defined.....49
20. Information to the development test agency.....49
30. Determination of B-duration.....49
30.1 Primary portion.....49
30.2 Secondary fluctuations.....50
30.3 B-duration examples and algorithm.....50

1. SCOPE

1.1 Scope. This standard establishes acoustical noise limits and prescribes testing requirements and measurement techniques for determining conformance to the noise limits specified herein.

1.2 Applicability. This standard applies to the acquisition and product improvement of all designed, or purchased (non-developmental items) ground systems, subsystems, equipment, and facilities that emit acoustic noise. This standard is intended to address noise levels emitted during the full range of typical operational conditions.

1.3 Purpose. This standard provides criteria for designing materiel having noise levels that:

a. Minimize noise induced hearing loss.

b. Achieve acceptable speech communication in a noisy environment.

c. Minimize aural detection by an enemy.

d. Minimize community annoyance.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1473	Standard General Requirements for Color and Marking of Army Materiel

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from Naval Publications and Forms Center, Standardization Documents Order desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are cited in the solicitation.

29 CFR 1910.145	Specification for Accident Prevention, Signs and Tags
40 CFR 204	Noise Emission Standards for Construction Equipment

(Copies of specifications, standards, and other publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the document which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of these documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.1	Acoustical Terminology
ANSI S1.4	Sound Level Meters, Specification for
ANSI S1.10	Calibration of Microphones, Method for the
ANSI S1.11	Octave, Half-Octave, and Third-Octave Filter Sets, Specifications for
ANSI S1.13	Sound Pressure Levels, Method for the Measurement of
ANSI S1.40	Acoustical Calibrators, Specification for

(Requests for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J88	Sound Measurement - Earthmoving Machinery - Exterior
SAE J184	Qualifying a Sound Data Acquisition System
SAE J366	Exterior Sound Level for Heavy Trucks and Buses
SAE J986	Sound Level for Passenger Cars and Light Trucks
SAE J1074	Engine Sound Level Measurement Procedure

(Requests for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

INTERNATIONAL STANDARDS ORGANIZATION

ISO R-226	Normal Equal-Loudness Contours for Pure Tones and Normal Threshold of Hearing Under Free-Field Listening Conditions

(International standards are generally available for reference from libraries. They are also distributed among technical groups and certain Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supercedes the applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

NOTE: Acoustical terms not appearing below are defined in accordance with ANSI S1.1.

3.1 Aural nondetectability distance. The distance at which, for given conditions, the one-third octave-band pressure levels of a noise source at a listener's location are below both the sound level of a quiet environment (see Table V) and average hearing in all one-third octave bands.

3.1.1 Average hearing. The binaural free-field hearing threshold of normal ears for steady-state noise, given in ISO Recommendation R-226.

3.2 dB(A). The unit used to express sound level measured through the A-weighting network of a sound level meter.

3.3 dB(C). The unit used to express sound level measured through the C-weighting network of a sound level meter.

3.4 Equivalent continuous sound level [L_{DoD}]. The time-weighted sound level [dB(A)] that is derived from the actual varying sound level of the source during a given sample time (T). Implicit in this derivation is an exchange between sound level and time of 4 dB per doubling of time. The criterion level is 85 dB(A) for a duration of 8 hours.

$$L_{DoD} = \frac{40}{3} \log_{10} \left[\frac{1}{T} \int_0^T 10^{\frac{3\,L(t)}{40}} dt \right]$$

where

T = total sample time in hours

t = varying time

L(t) = the time varying A-weighted sound pressure level

The L_{DoD} value can be calculated from the following alternate expression when the sound level takes on a sequence of N constant levels, L_i, each lasting for a time period of C_i hours:

$$L_{DoD} = 85 + \frac{40}{3} \log_{10} \left[D \cdot \frac{8}{T} \right]$$

where:

$$D = \sum_{i=1}^{N} \frac{C_i}{T_i}$$

$$T_i = \frac{8}{2^{(L_i - 85)/4}}$$

T = total sample time in hours.

T_i = limiting exposure time at each A-weighted sound pressure level.

L_i = i^{th} A-weighted sound pressure level.

3.5 Hearing conservation criteria. Noise exposure limits that, when exceeded, indicate the need for hearing conservation measures.

3.6 Hearing damage-risk criteria (DRC). Comprehensive statements about the relation between various descriptive parameters of the noise exposure (i.e., sound pressure level, exposure time, etc.) and the probability of temporary or permanent hearing loss.

3.7 Hearing protectors. Devices designed primarily to reduce the noise reaching the auditory system. They may be of any type, i.e., earplugs, noise muffs (circumaural), or attenuating helmets or headsets. For satisfying the requirements of this document they must be on the list approved by the appropriate military Surgeon General.

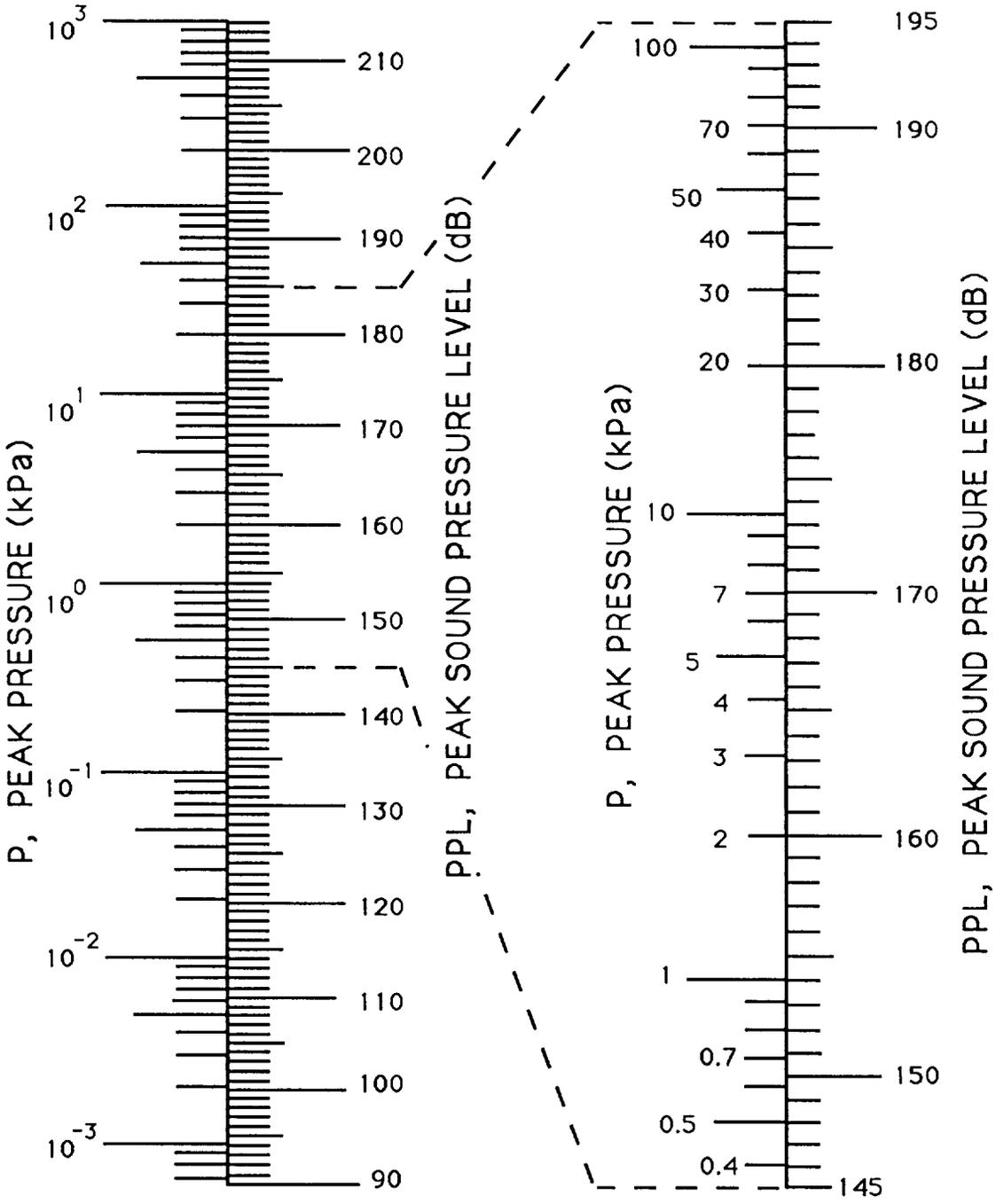
3.7 1 Attenuating helmets or headsets. Hearing protectors that provide the wearer with electronic communications.

3.8 Impulse noise. A short burst of acoustic energy consisting of either a single impulse or a series of impulses. The pressure 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

3.12 Random incidence corrector. A device that reduces the directionality of free field microphones allowing their use in diffuse or random incident sound fields.

3.13 Rated engine speed. If not specified, rated speed shall be 10% less than maximum governed engine speed with no load

3.14 Sound Pressure Level. The sound pressure level, in decibels, of a sound is 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure The reference pressure is 20 μPa, 20 $\mu N/m^2$, 0.0002 μbar, or 0 0002 $dyne/cm^2$



GIVEN P, peak pressure in kPa or psi
THEN
PPL, The peak sound pressure level in dB is given by

$$PPL = 20 \log (P) + 153.98 \text{ dB, P in kPa}$$
$$PPL = 20 \log (P) + 170.75 \text{ dB, P in psi}$$

FIGURE 1. Scale for conversion between kPa and dB.

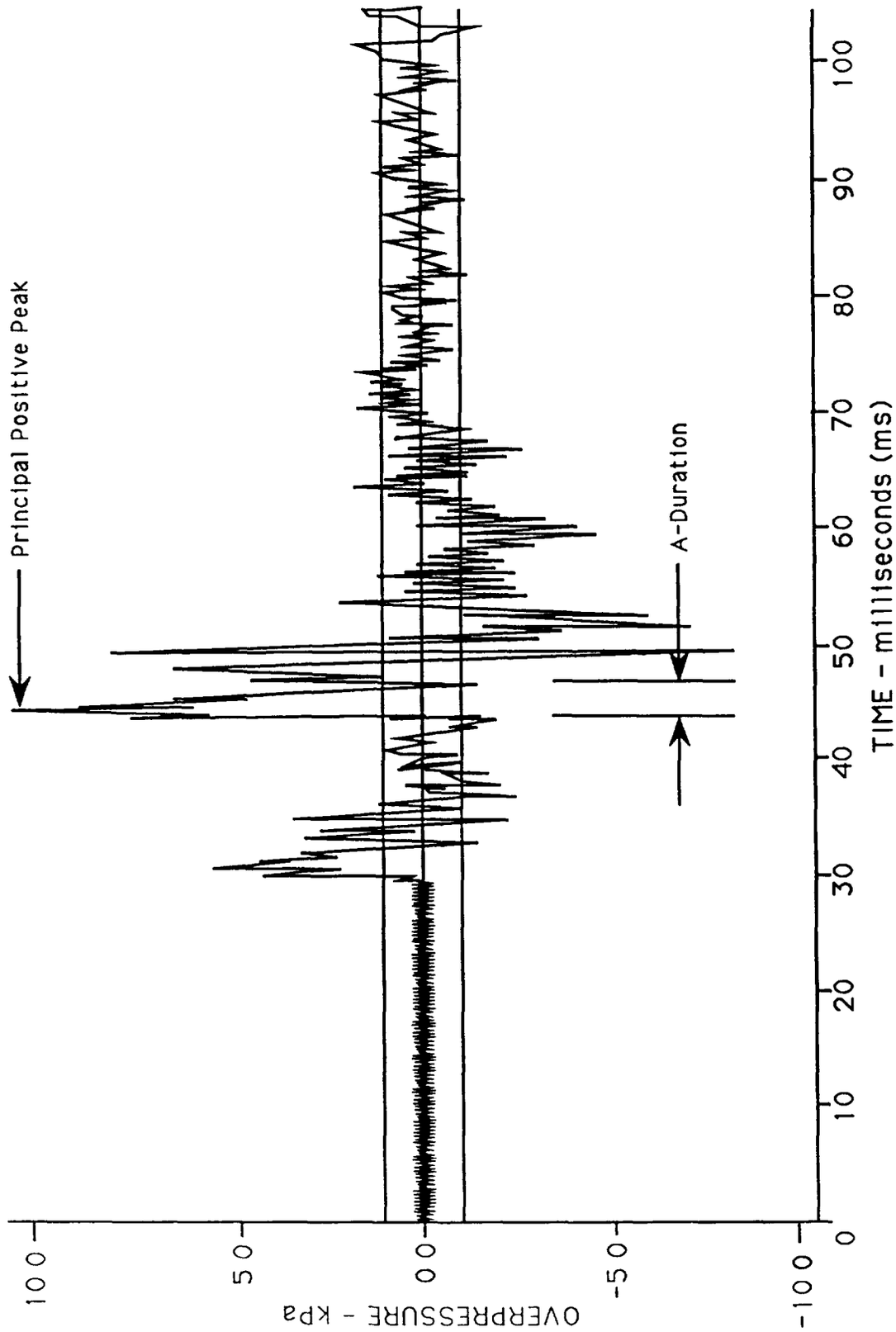


FIGURE 2. Example of A-duration of actual pressure-time history of an impulse noise.

3.15 Steady-state noise. 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.

3.16 Government Furnished Equipment (GFE). Equipment furnished by the Government which is designed into or will otherwise become a part (or subsystem) of the total system being acquired.

3.17 System. A set of elements, items or units which are intended to operate in concert to achieve a common purpose. When GFE is required for system operation (whether or not operation with GFE occurs in all cases of system operation) that GFE is part of the system.

3.18 State-of-the-art. The highest level of scientific and technical knowledge existing at the time of contract award.

4. GENERAL REQUIREMENTS

4.1 Subsystems, sets, groups, and units.

4.1.1 Total system noise. Subsystems, sets, groups, and units including such items as air conditioners, heaters, input/output devices, printers, typewriters, and auxiliary equipment, shall be selected and integrated in such a manner that noise produced by the entire system does not exceed the requirements of this standard. If the total system configuration is unknown, the allowable noise limit for any single item shall be 3 dB below the limit of the applicable system category, as determined by paragraph 5.1.1.1.

4.1.2 Government Furnished Equipment (GFE). The use of GFE shall not eliminate the requirement that the total system conform to this standard.

4.1.3 Engineering controls. Engineering controls shall be the primary means to protect personnel from hazardous noise. Hearing protectors and other measures such as warning signs shall not be solely relied upon unless all noise reduction design approaches have been pursued.

4.2 Posting of noise hazard areas. If steady-state noise levels are 85 dB(A) or greater, regardless of exposure time, at locations specified in 5.1.2.1.2, noise hazard caution signs shall be permanently posted on (or in) the equipment. This provision shall not apply to the exteriors of military combat equipment. Signs should conform to 29 CFR 1910.145, and MIL-STD-1473, as applicable (see Figure 3). They shall be clearly visible and legible to all personnel exposed to the hazard. This posting is required regardless of duty cycle acceptance (see 5.1.2.1.7). Where operating or maintenance conditions seldom exceed 85 dB(A) posting may be unnecessary.

4.3 Manuals. Where steady-state noise is 85 dB(A) or greater, or impulse noise exceeds 140 dB peak pressure level at personnel-occupied areas (e.g., operator, maintenance, observer, and other control positions), operation and maintenance manuals (field and technical manuals, etc.) shall contain appropriate discussion of noise hazards. Discussion shall include the requirement for hearing protection, the type of hearing protection recommended per 3.7, the noise level of the equipment at locations specified in 5.1.2.1.2. and the distance at which the 85 dB(A) or the 140 dB peak pressure level will be met.

4.4 Commercial construction and materials-handling equipment Test requirements and steady-state noise limits are contained herein (see 5 1)

NOTE SIZES SHOULD BE PROPORTIONED IN ACCORDANCE WITH MIL-STD-1473 AND SHOULD BE SUFFICIENTLY LARGE TO ENSURE LEGIBILITY AT REQUIRED READING DISTANCES.

FIGURE 3. Noise hazard caution sign.

4.5 Pulsating equipment. Pulsating equipment (e.g., jack hammers, air tools, impact wrenches) which may be operated for periods of time in excess of one second and where peak level is less than 140 dB(P), shall comply with the steady-state noise provisions herein.

5. DETAILED REQUIREMENTS

5.1 Steady-state noise, personnel-occupied areas.

5.1.1 Noise limits.

5.1.1.1 Categories Table I is provided to guide procurement activity decision in selecting a noise limit category. The corresponding noise limits are shown in Table II.

TABLE I. Steady-state noise categories.

Category* Requirements	System
A	No direct person-to-person voice communication required. Maximum design limit Hearing protection required
B	Electrically-aided communication via attenuating helmet or headset required. Noise levels are hazardous to unprotected ears
C	No frequent direct person-to person voice communication required Occasional shouted communication may be possible at a distance of 0.30 m. Hearing protection required.
D	No frequent person-to-person voice communication required. Occasional shouted communication may be possible at a distance of 0.60 m Levels in excess of Category D require hearing protection.
E	Occasional telephone or radio use or occasional communication at distances up to 1.50 m required (Equivalent to NC-70.)
F	Frequent telephone or radio use or frequent communication at distances up to 1 50 m required (Equivalent to NC-60.)

* Categories A, B, C, and D are based primarily on hearing conservation priorities; the remaining categories are based primarily on communication requirements For fixed-plant facilities, see MIL-STD-1472

TABLE II. Steady-state noise limits (dB(A)) for personnel-occupied areas.

	Limit Category (dB(A))					
	A*	B*	C*	D*	E**	F**
A-weighted Limit	108	100	90	less than 85	75	65
SIL-4 Limit					67	57

* These limits are based on a maximum daily exposure time of 8 hours. In those cases where the mission profile for the equipment being developed or acquired exceeds 8 hours of operation in each 24-hour day, the limits specified in Categories A, B, C, and D shall be reduced to allow for an exposure of longer than 8 hours, as approved by the procuring activity in conjunction with the appropriate military Surgeon General's Office.

** Categories E and F are defined by either the sound level (dB(A) or the speech interference level (SIL-4). If meeting the dB(A) requirement has been documented to be infeasible (see 5.1.1.3.2), then this requirement shall be replaced with the corresponding SIL-4 limit.

5.1.1.2 Maximum.

a. For systems requiring person to person communication, Category E or F shall be selected on the basis of Table I.

b. All other systems shall not exceed Category D.

c. Where the limit of Category D can be documented as being clearly beyond the state-of-the-art, per 5.1.1.3.2, selection of another noise limit shall be made by the procuring activity on the basis of system requirements.

5.1.1.3 Acceptance.

5.1.1.3.1 Compliance. Compliance with the required noise limit shall be documented based upon test requirements of 5.1.2 and the data recording requirements of 5.5.

5.1.1.3.2 Non-compliance. Non-compliance with the required noise limit shall be documented based upon test requirements of 5.1.2 and the data recording requirements of 5.5; additionally, the following shall apply:

a. The required maximum noise limit(s) may be established to be technically infeasible based upon testing and analysis consistent with best engineering practice, which clearly proves that achievement of the required limit(s) is beyond the state-of-the-art for the item/system being procured. Such testing and the resultant analysis shall be conducted and reported by a professionally qualified acoustical consultant or acoustical laboratory. Documentation shall be furnished to the procuring activity for consideration of whether or not increase of the required limit(s) is justified.

b. Documentation shall contain technically defensible data including technically supported design considerations, technically supported design recommendations for noise reduction, and technically supported predictions of the resultant noise levels.

c. Noise reduction feasibility documentation shall also include the following:

(1) Identification of all the noise sources that contribute to the noise level at the locations of interest.

(2) Identification of all noise paths between the noise sources and the locations of interest.

(3) Rank ordering of the source/path combinations in terms of their contribution to the overall level at the locations of interest.

(4) Development of noise control measures for each source/path combination in order of dominance until the required noise levels at the locations of interest are attained.

(5) Clearly stated and technically/fiscally supported trade-off analyses of noise control benefit against other design and performance requirements, consistent with best engineering practice

(6) An experimental procedure known as "window analysis" shall be used in steps (1) through (5). The procedure involves measuring the noise level while eliminating all noise sources and paths except the single one of interest. For example, one type of engine noise source determination could be made by running the engine under load with and without the engine fan being driven.

(7) The window analysis procedure shall be repeated for each of the combinations identified (see (1) to (3) above).

d. Only if the maximum noise limit(s) required has been documented as being clearly beyond the state-of-the-art, may the procuring activity expressly grant written permission to exceed the specified limit(s). Any decision to grant permission to exceed the specified limits shall consider health hazard assessments and the operational impact of the hazards associated with exceeding the limits.

5.1.2 Test requirements.

5.1.2.1 General.

5.1.2.1.1 Acceptance criteria. Noise at locations designated by 5.1.2.1.2 shall meet the specified limit.

5.1.2.1.2 Measurement location. Noise measurements shall be made at:

a. Each operator or crew position.

b. Representative positions where one or more individuals (e.g., passengers) will be located.

c. Occasionally occupied positions (e.g., positions that are likely to be occasionally occupied such as the space in and around a generator set, pump, or arc welder, etc.) during typical operation or maintenance of the item/system.

NOTE: Where the operator, crew, or passenger station(s) is not clearly defined or where unattended use of equipment is intended (e.g., some mobile electric power, pumps, etc.), the noise measurement position(s) shall be designated by the procuring activity.

5.1.2.1.3 Recording. The data recorded and reported shall include the following: A-weighted , C-weighted, and octave-band sound pressure levels, and when appropriate, speech interference levels.

5.1.2.1.4 Noise contours. Where the steady-state noise level of stationary equipment is 85 dB(A) or greater, the distances and directions from the noise source at which the sound level is equal to 85 dB(A) shall be determined. The 85 dB(A) contours shall also be determined for mobile equipment which could, at times, be stationary. The 85 dB(A) contour shall be determined from measurements made at positions around the noise source at angular increments not greater than 45 degrees, and at the noisiest angle. The maximum distance at which 85dB(A) is obtained shall be indicated on the noise hazard sign in 4.3.

5.1.2.1.5 Equipment openings. All windows, vents, and access openings shall be in the normal operation position as defined by the procuring activity. If it is possible to operate with these in either the open or closed positions, both configurations shall be tested.

5.1.2.1.6 Test schedule. During development, sound level measurements shall be made, as a minimum, when the test item is first undergoing testing Measurement of the final system configuration shall be made as early as possible before first article acceptance.

5.1.2.1.7 Typical duty cycle testing. If typical duty cycle testing is specified by the procuring activity, the equivalent continuous sound level (L_{DoD}) shall be determined (see 3.4). Duty cycles shall be as short as practical and the noise exposure of sufficient cycles shall be measured for a minimum duration of 1 hour at rated capacity. When the L_{DoD} does not change over +/-2.0 dB(A) from cycle to cycle, one cycle shall be adequate. The equipment shall be operated at a test site typical of the environment in which the equipment is to be used, as specified by the procuring activity.

5.1.2.1.8 Sample size. Materiel acceptance shall be based on an adequate test sample, the quantity to be determined by the procuring activity.

5.1.2.2 Operating conditions for system testing. Systems shall be operated as required to accomplish their intended missions or functions. All subsystems and auxiliary equipment normally in use shall be operated Heaters and air conditioners shall be operated in accordance with 5 1 2 3.1 3

5.1.2.3 Operating conditions for mobile equipment testing.

5.1.2.3.1 Vehicles.

5.1.2.3.1.1 Vehicle speed and gear. Vehicle noise shall be measured at two-thirds of rated engine speed (not maximum governed speed) or two-thirds of the vehicle speed posted in the vehicle, in the highest gear or in the drive mode if the transmission is automatic, or as specified by the procuring activity (for compliance). The vehicle shall have engine speed or vehicle speed measured by a calibrated tachometer or speedometer, as appropriate. Measurements shall also be made at either 8- or 16-km/h increments. If 16-km/h increments are selected, measurements shall start at 16 rather than 8-km/h.

5.1.2.3.1.2 Load-carrying equipment. All load-carrying equipment shall be operated with two-thirds of maximum payload or as specified by the procuring activity. Vehicles (including tractor/trailer combinations) shall be operated at two-thirds of the off-highway payload. Auxiliary trailed equipment shall not be towed during the test.

5.1.2.3.1.3 Auxiliary equipment. All auxiliary equipment normally in continuous use while the vehicle is in motion shall be operated. (Where both heaters and air conditioners are present, the one producing the higher sound level shall be operated.) Auxiliary equipment normally operated while equipment is stationary shall be tested in accordance with 5.1.2.4. Where heaters and air conditioners may be operated at the same time (such as for humidity control) both shall be operated.

5.1.2.3.1.4 Selection criteria. Where applicable, tests shall be made on new equipment after the officially prescribed break-in time or mileage, and after performance requirements have been met.

5.1.2.3.2 Construction and materials-handling equipment. The procuring activity shall specify a repeatable, steady operating condition that produces about the same noise as a typical duty cycle. The duty cycle will consider speed, load, and test surface.

5.1.2.3.3 Watercraft. Watercraft noise shall be measured under normal cruise/calm water conditions or as specified by the procuring activity.

5.1.2.4 Operating conditions for stationary equipment testing.

5.1.2.4.1 Speed. All equipment shall be operated at maximum-rated continuous duty speed or as specified by the procuring activity.

5.1.2.4.2 Load. All equipment shall be operated at normal maximum-rated load. The exception is that variable-speed equipment, which is normally operated at less than maximum, shall be operated at two-thirds maximum-rated load or as specified by the procuring activity.

5.1.2.4.3 Auxiliary equipment. All auxiliary equipment normally in use shall be operated. Heaters and air conditioners shall be operated in accordance with 5.1.2.3.1.3.

5.1.2.5 Test environment, instrumentation, and measurements. The following applies to measurement of noise for compliance with the limits specified for personnel-occupied areas (see 5.1) and aural nondetectability (see 5.2).

5.1.2.5.1 Test environment.

5.1.2.5.1.1 Test site. Equipment shall be tested in its exact operating location if the location is known and such testing is feasible. When this is not possible, the test site shall be a uniform flat grass surface, free of ice, snow, or vegetation over 0.15 m tall; it shall be free of reflecting surfaces such as buildings, trees, or hillsides within 30 m. An anechoic or hemi-anechoic chamber may be substituted for outdoor measurements

5.1.2.5.1.2 Background noise. When practical, background noise, including wind noise, shall be at least 10 dB below that of the equipment noise being measured. However, background noise shall always be at least 10 dB below the criteria. (Exception: For aural nondetectability measurements (see 5.2), the use of conventional background noise corrections is permitted in accordance with ANSI S1.13.). A windscreen shall be used at wind velocities of 10 km/h or more; measurements shall not be made at velocities of 20 km/h or more.

5.1.2.5.1.3 Surface and grade for vehicle testing. Vehicles shall be driven along a dry, smooth, paved, and level road (<1% grade), free from gravel or other loose material. Vehicles having nonrubber-padded tracks shall be driven on level, compact earth or as specified by the procuring activity. Measurements shall not be made when the road surface is wet, covered with snow or ice, or during precipitation, unless specified by the procuring activity.

5.1.2.5.2 Instrumentation

5 1 2.5.2.1 Instrument specifications. Sound level meters shall conform to requirements for Type 1, as specified by ANSI

S1.4. Band filter sets shall conform to requirements for Type E, Order II, as specified by ANSI S1.11. Other noise recording instrumentation or combinations of instrumentation shall conform to SAE J184 and applicable provisions of ANSI S1.4.

5.1.2.5.2.2 Calibration. Acoustical calibration procedures shall be accomplished in accordance with the sound level meter manufacturer's instructions (see also ANSI S1.10). Calibrators shall conform to ANSI S1.40 Calibration shall address the influence of microphones, cables, amplifiers and recorders. Calibration shall be performed any time instrumentation is changed, before and after each test sequence, but not less than at the start and end of each day.

5.1.2.5.2.3 Microphones. Pressure microphones having an essentially flat response at grazing incidence (90 degrees) should be used, but free field microphones having an essentially flat response at normal incidence (0 degrees) may be used with the addition of a random incidence corrector. The microphone shall ordinarily be placed vertically at the measurement location with the sensitive element up. However, for exterior measurements of stationary test items (at distances greater than three times the major dimension of the test item), a normal incidence microphone without a random incidence corrector may be used if it is pointed at the item.

5.1.2.5.3 Measurement. Data collection shall include on-site, unweighted octave-band, A-, and C-weighted measurements. Slow meter damping shall be used. Tape recording may be used in place of, or in addition to, the above. For those exceptions where the noise level is determined under a typical duty cycle, measurements shall be made with an integrating sound level meter or other recording instruments that measure equivalent continuous sound level as defined in 3.5.

5.1.2.5 3.1 Personnel limits and locations during tests.

5.1.2.5 3.1.1 Operator(s). During testing, the operator(s) shall not occupy that location where the noise is being measured unless required to operate the equipment.

5.1.2 5.3.1.2 No operator present. When no operator is present, the measurement shall be made at the center of the operator's probable head location. For standing locations the microphone shall be 1.60 m above the floor, for sitting locations it shall be 0 80 m above the seat which, if adjustable, shall be positioned at the center of its vertical adjustment range.

5.1.2.5.3.1.3 Operator present. When the operator must be present, the measurement shall be made at ear level, 0.15 m from the right ear. If a wall or other reflective surface is closer than 0.3 m from the operator's right ear, the microphone shall be positioned equidistant from the right ear and that surface.

5.1.2.5.3.1.4 Test personnel. Noise measurements shall be made with the minimum number of people in the area, including test personnel. When noise is being measured in personnel-occupied enclosures, no test personnel or observers shall be present within the enclosure unless required to operate or adjust the test equipment, or to record data.

5.2 Aural nondetectability.

5.2.1 Noise limits.

5.2.1.1 Criteria. Equipment having an aural nondetectability requirement shall not exceed the limits of Tables III or IV, as specified by the procuring activity. These tables provide two categories of limits (Level I and Level II). Selection is based upon the anticipated use of the equipment and the criticality of aural nondetectability, as follows:

a. Level I. Aural nondetectability limits (Table III) assume that the listener is in a quiet rural area (Table V) with the closest heavily used highway and community noise sources further than 4 km away. This limit will provide aural nondetectability under many, but not all, conditions of wind, temperature, terrain and time of day.

b. Level II. Aural nondetectability limits (Table IV) assume that the listener is in the quietest background noise level (Table V) that is likely to be encountered in practice with the closest heavily used highway and community noise sources further than 10 km away. This limit will provide aural nondetectability under most conditions of wind, temperature, terrain and time of day.

TABLE III. Level I Aural Nondetectability Limits (dB).

1/3 Octave Band Frequency (Hz)	Nondetectability Distance (m) 10	20	30	100	200	300	400	500	750	1000	1250	1500	2000	3000	4000	5000	6000
50	53	59	62	61	68	71	74	66	70	73	75	76	79	84	87	90	92
63	50	56	59	59	65	69	71	64	68	71	73	75	78	83	87	91	94
80	49	55	58	60	66	69	72	65	69	72	75	77	81	87	93	97	101
100	46	52	56	59	65	69	72	65	70	73	77	79	84	92	99	104	107
125	41	47	51	58	64	69	72	65	71	76	79	83	89	98	102	105	106
160	39	44	48	55	63	68	72	66	73	79	84	88	93	97	99	101	102
200	42	47	51	52	61	67	72	68	78	82	85	87	89	92	94	96	97
250	44	49	53	50	61	69	76	71	76	79	80	81	83	86	89	91	93
315	46	50	54	50	63	71	75	68	71	73	74	75	77	81	83	86	88
400	43	45	50	51	62	66	68	62	64	66	67	69	71	75	78	81	84
500	42	49	54	54	61	64	66	55	58	60	61	63	65	70	73	77	80
630	37	48	54	55	63	67	68	53	56	58	60	61	64	69	74	78	82
800	31	41	47	54	63	66	68	54	57	59	61	63	66	72	77	82	87
1000	29	37	42	50	59	63	65	54	57	60	62	64	68	74	80	86	91
1250	31	34	39	42	52	57	59	54	57	60	62	65	69	76	83	90	96
1600	31	32	35	36	46	51	54	52	56	59	62	64	69	78	87	95	NA
2000	25	32	32	36	47	52	55	50	54	58	62	65	71	82	92	97	NA
2500	26	36	31	28	39	44	48	46	52	56	60	64	72	86	NA	NA	NA
3150	21	27	34	29	40	46	50	40	47	53	59	64	74	94	NA	NA	NA
4000	21	25	34	25	37	44	49	39	48	56	64	71	86	NA	NA	NA	NA
5000	18	27	25	23	35	43	50	48	60	71	82	93	NA	NA	NA	NA	NA
6300	20	25	30	27	40	50	58	56	73	89	NA	NA	NA	NA	NA	NA	NA
8000	30	35	39	40	54	67	78	79	NA	NA	NA	NA	NA	NA	NA	NA	NA
10000	31	37	42	47	64	81	96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Measurement Distance (m)	2	2	2	10	10	10	10	30	30	30	30	30	30	30	30	30	30

TABLE IV. Level II Aural Nondetectability Limits (dB).

1/3 Octave Band Frequency (Hz)	Nondetectability Distance (m) 10	20	30	100	200	300	400	500	750	1000	1250	1500	2000	3000	4000	5000	6000
50	53	59	62	61	68	71	74	66	70	73	75	76	79	84	87	90	92
63	46	52	56	55	61	65	68	60	64	67	69	71	74	79	83	87	90
80	39	45	49	50	56	60	62	55	59	62	65	67	71	78	83	87	91
100	35	41	44	48	54	58	61	54	58	62	65	68	73	81	87	93	95
125	29	35	38	45	52	56	60	53	59	63	67	71	77	86	90	92	94
160	27	33	37	44	51	56	60	55	62	68	73	77	81	85	88	90	91
200	32	37	41	42	51	57	62	58	67	72	75	76	79	82	84	86	87
250	35	40	44	41	52	60	66	62	67	69	71	72	74	77	80	82	83
315	37	41	46	42	55	63	66	60	63	64	66	67	69	72	75	78	80
400	34	37	41	42	53	57	59	53	55	57	59	60	62	66	69	72	75
500	33	40	45	45	52	55	57	46	49	50	52	54	56	60	64	68	71
630	27	38	44	45	53	57	58	43	46	48	50	51	54	59	64	68	72
800	21	31	37	44	53	56	58	44	47	49	51	53	56	62	67	72	77
1000	19	27	32	40	49	53	55	44	47	50	52	54	58	64	70	76	81
1250	21	24	29	32	42	47	49	44	47	50	52	55	59	66	73	80	86
1600	22	23	26	27	37	42	45	43	47	50	53	55	60	69	78	86	94
2000	16	23	23	27	38	43	46	41	45	49	53	56	62	73	83	94	NA
2500	18	28	23	20	31	36	40	38	44	48	52	56	64	78	92	NA	NA
3150	13	19	26	21	32	38	42	32	39	45	51	56	66	86	NA	NA	NA
4000	14	18	27	18	30	37	42	32	41	49	57	64	79	NA	NA	NA	NA
5000	13	21	20	18	30	38	44	43	55	66	77	87	NA	NA	NA	NA	NA
6300	20	25	30	27	40	50	58	56	73	89	NA	NA	NA	NA	NA	NA	NA
8000	30	35	39	40	54	67	78	79	NA	NA	NA	NA	NA	NA	NA	NA	NA
10000	31	37	42	47	64	81	96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Measurement Distance (m)	2	2	2	10	10	10	10	30	30	30	30	30	30	30	30	30	30

TABLE V. Frequency (Hz) and accompanying 1/3 octave band ambient noise levels (dB) for both Level I and Level II categories.

Frequency (Hz)	Level I - Rural Area Ambient Noise Level (dB)	Level II - Quietest Area Ambient Noise Level (dB)
50	34	29
63	37	29
80	38	28
100	38	26
125	37	24
160	34	23
200	31	21
250	28	19
315	26	18
400	25	16
500	24	15
630	24	14
800	23	13
1000	22	12
1250	21	11
1600	19	10
2000	18	9
2500	16	8
3150	15	7
4000	14	7
5000	12	6
6300	10	6
8000	9	6
10000	8	6

5.2.1.2 Maximum. Equipment noise shall not exceed the specified noise limit for the selected nondetectability distance at the indicated measurement distance The limit shall be satisfied if it is not exceeded in any band at any azimuth around the equipment.

NOTE: The requirements presented in Tables III and IV are shown in graphical form (Figures 4 thru 9). The graphs can be used to plot the measured system/item noise level directly on the figure, thereby determining the frequency that produces detectability, the number of decibels by which the limit is exceeded, and an approximation of the actual nondetectability distance of the materiel.

5.2.2. Test requirements.

5.2.2.1 Test site. The test site shall conform to 5.1.2.5.1.1.

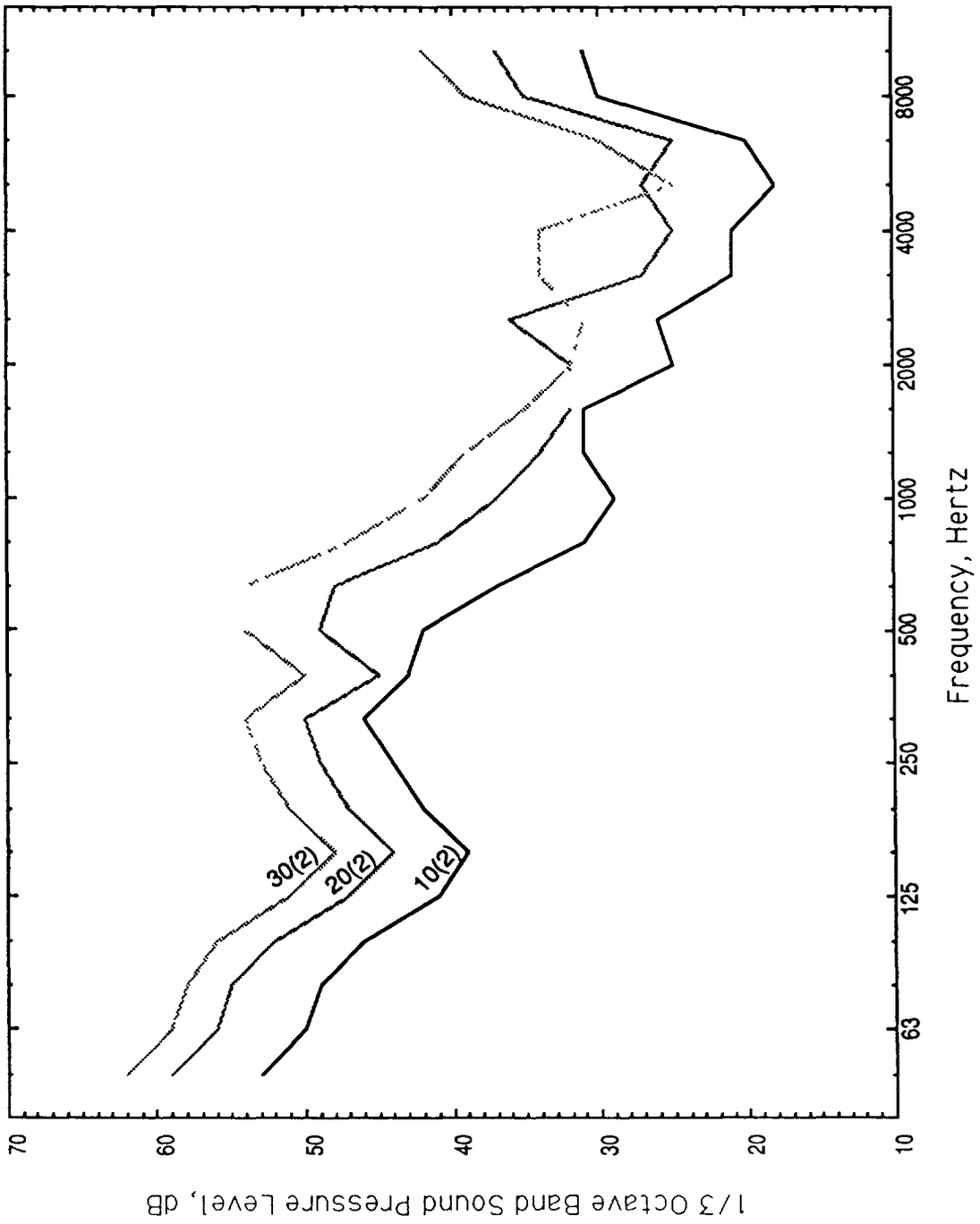
5.2.2.2 Equipment operating conditions. Equipment operating conditions will depend upon the conditions for which nondetectability is required and shall be specified by the procuring activity

5.2.2.3 Microphone location. The microphone shall be positioned 1.2 m above the ground, at the indicated measurement distance.

NOTE. The noise of an item should, whenever possible, be measured at a distance of at least four times the major dimension of the source. Measurements made at this distance follow the inverse square law (6 dB decrease for each doubling of distance) with the resulting measurements being appropriate for predicting nondetectability.

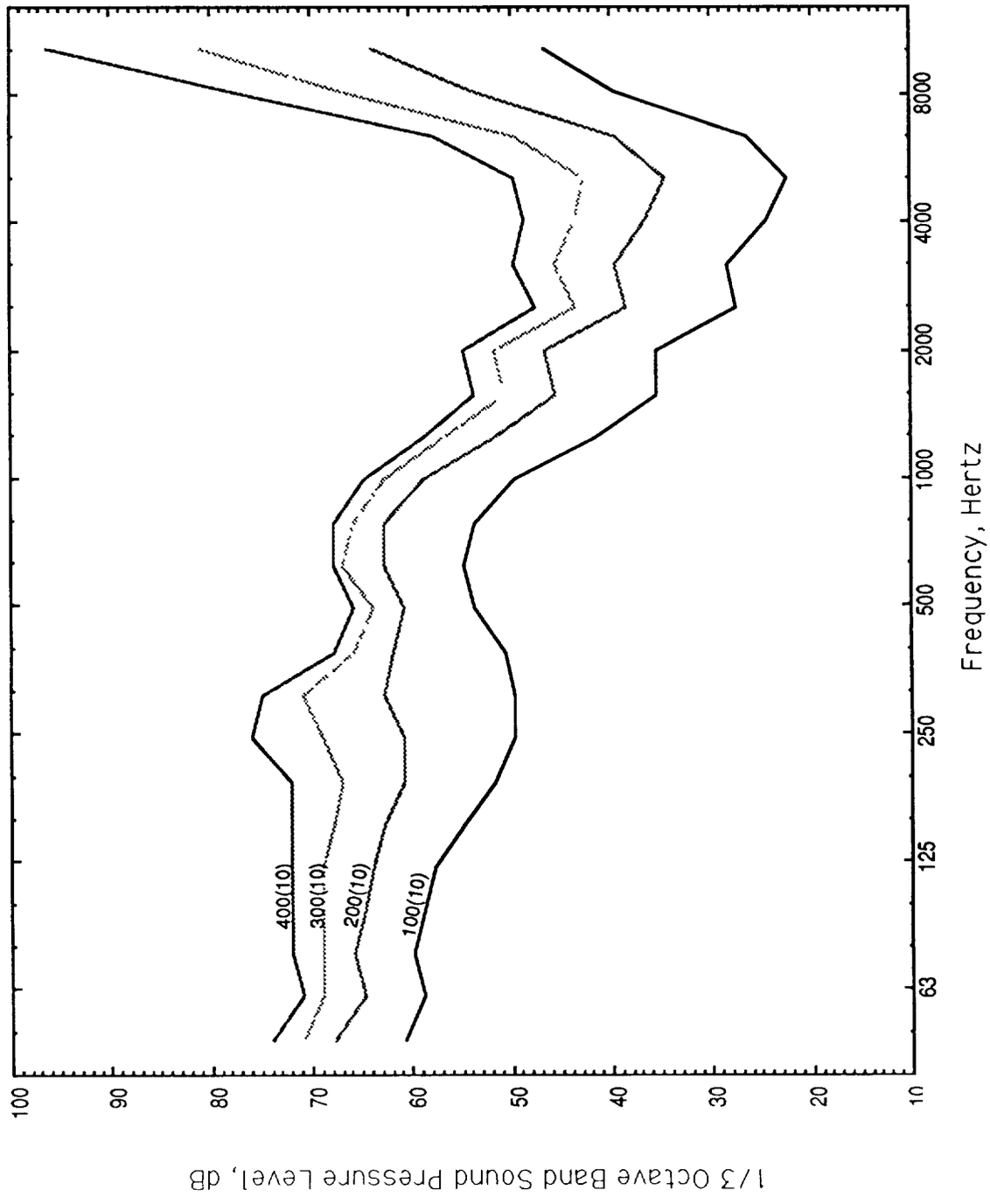
5.2.3 Instrumentation. One-third octave-band filter sets shall conform to the requirements for Type E, Order II, as specified by ANSI S1.11. Other instrumentation shall conform to 5.1.2.5.2, as applicable.

5.2.4 Measurements. Reported measurement values shall be the maximum deflection using the fast exponential-time-averaging characteristics (125-ms time constant) of a sound level meter, or equivalent. Other measurement requirements shall conform to 5.1.4, as applicable



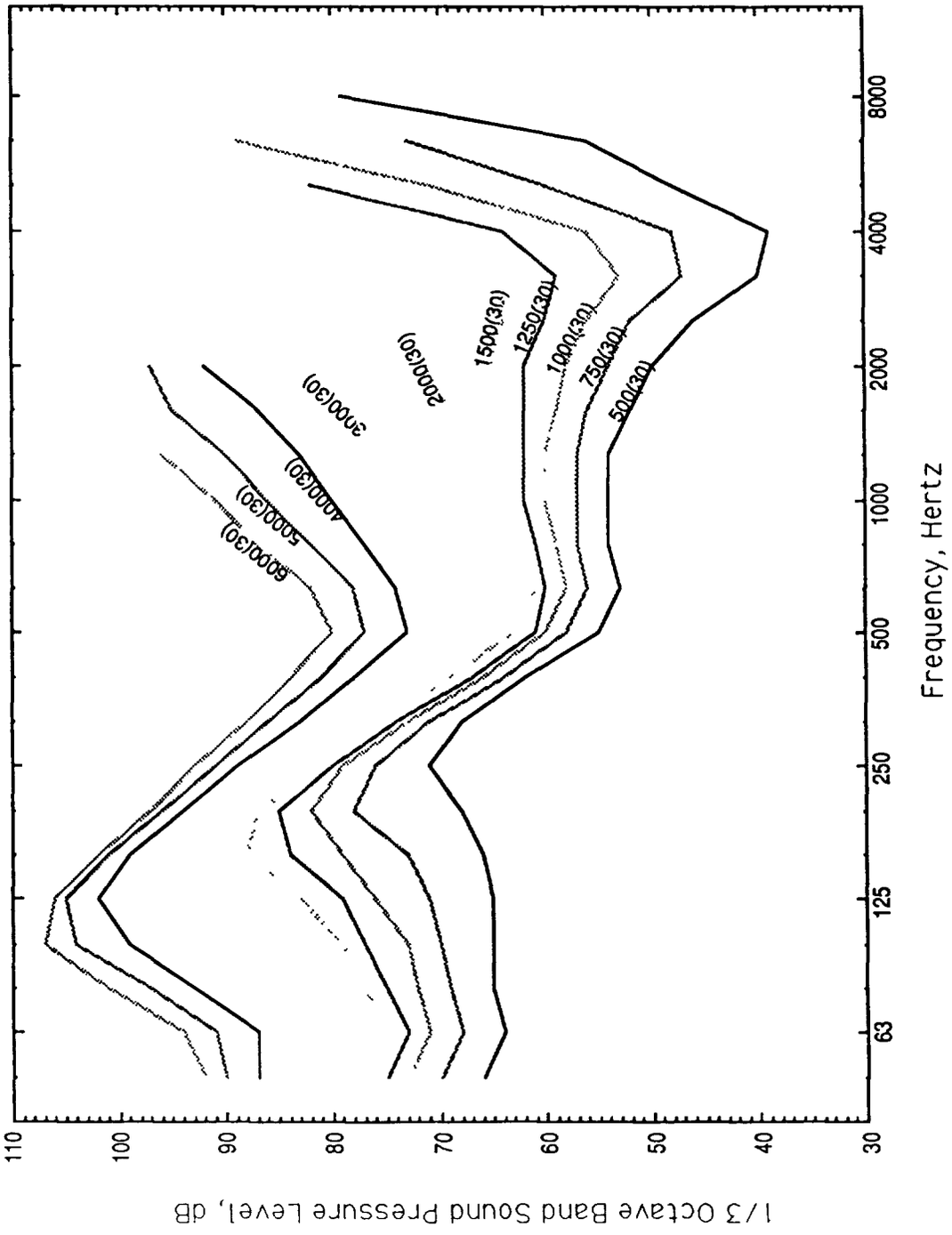
Note: The number in parentheses is the measurement distance in meters.

FIGURE 4. Level I nondetectability limits for 10 - 30 meters.



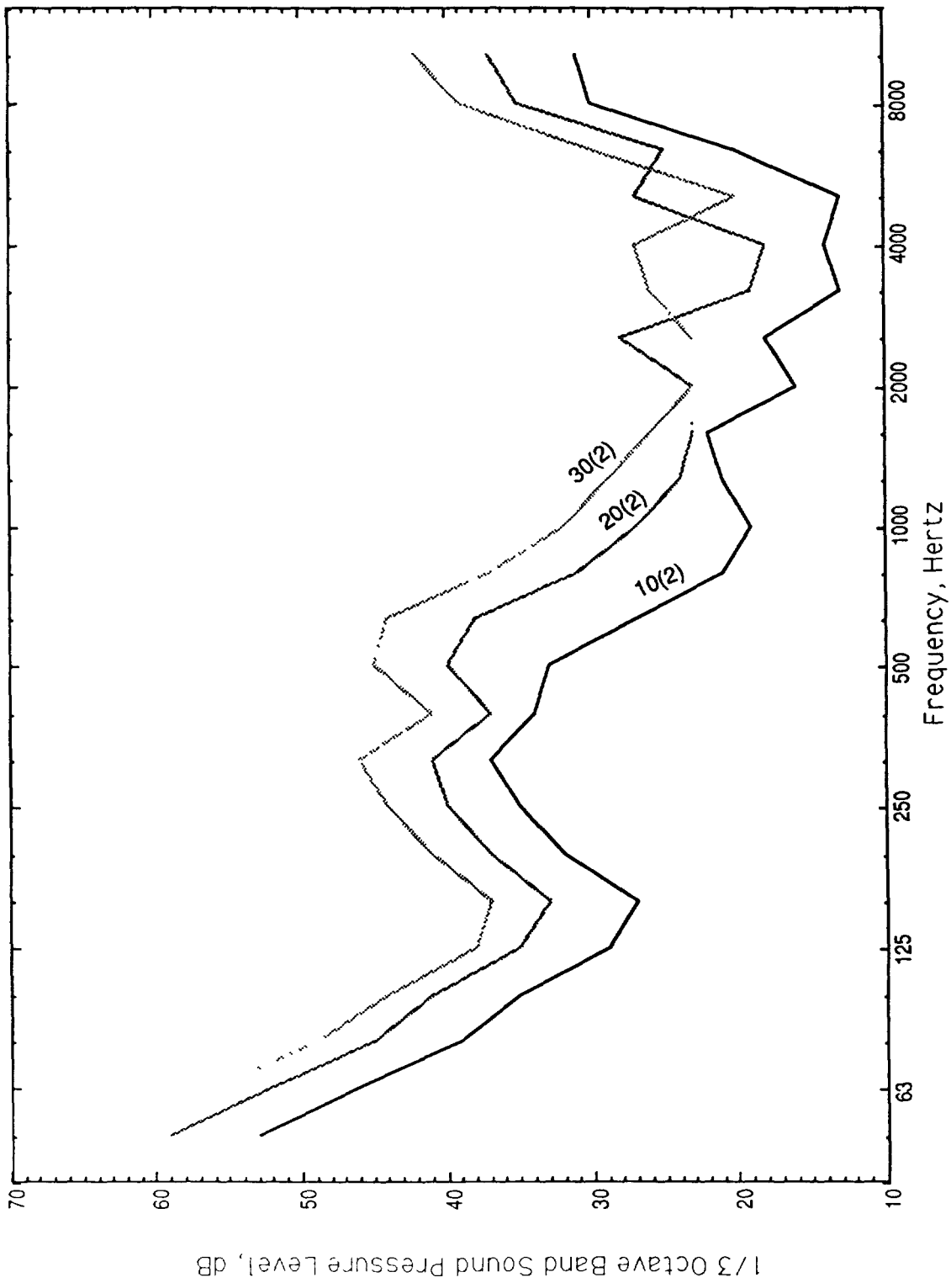
Note: The number in parentheses is the measurement distance in meters.

FIGURE 5. Level I nondetectability limits for 100 - 400 meters.



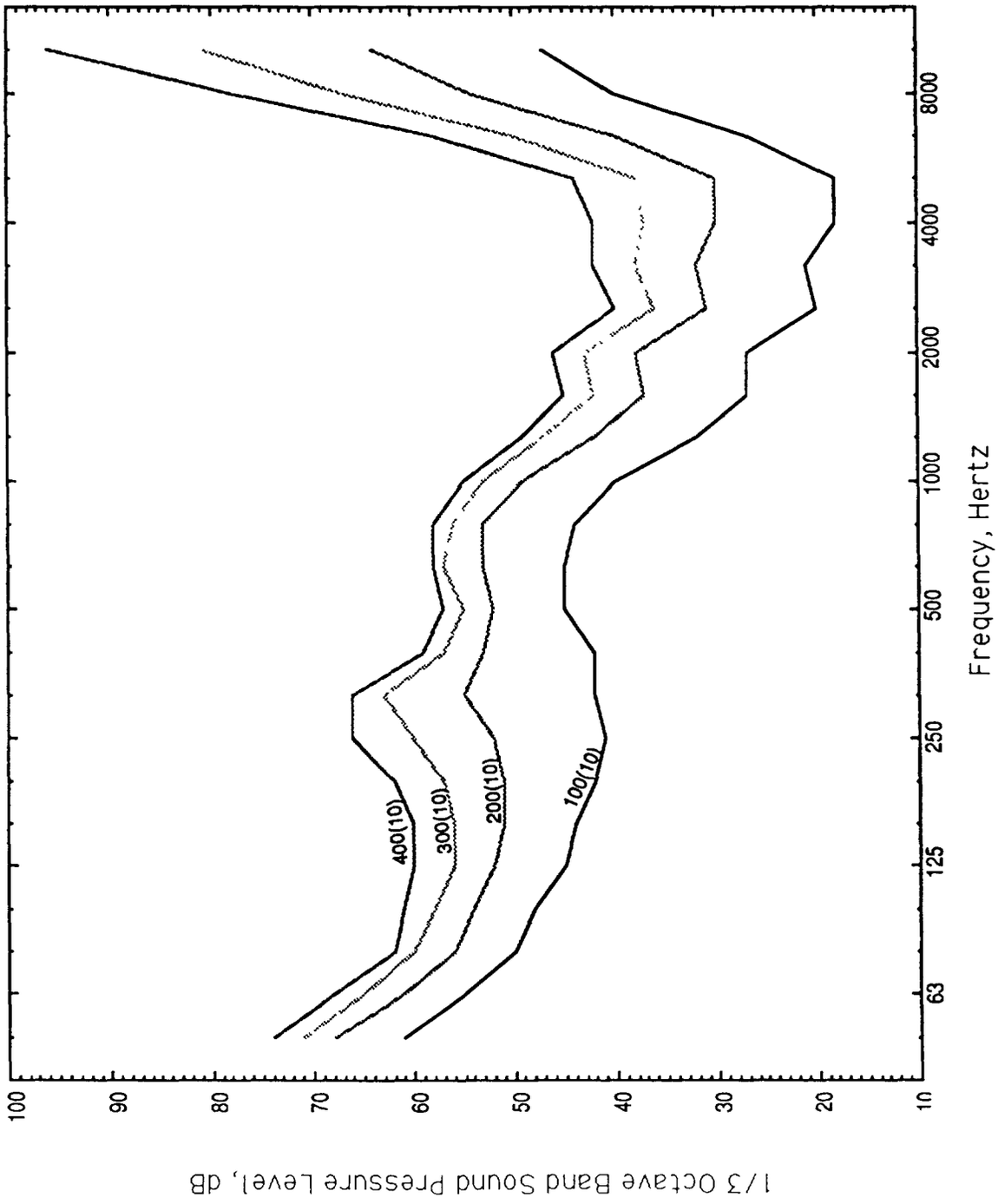
Note: The number in parentheses is the measurement distance in meters.

FIGURE 6. Level I nondetectability limits for 500 - 6000 meters.



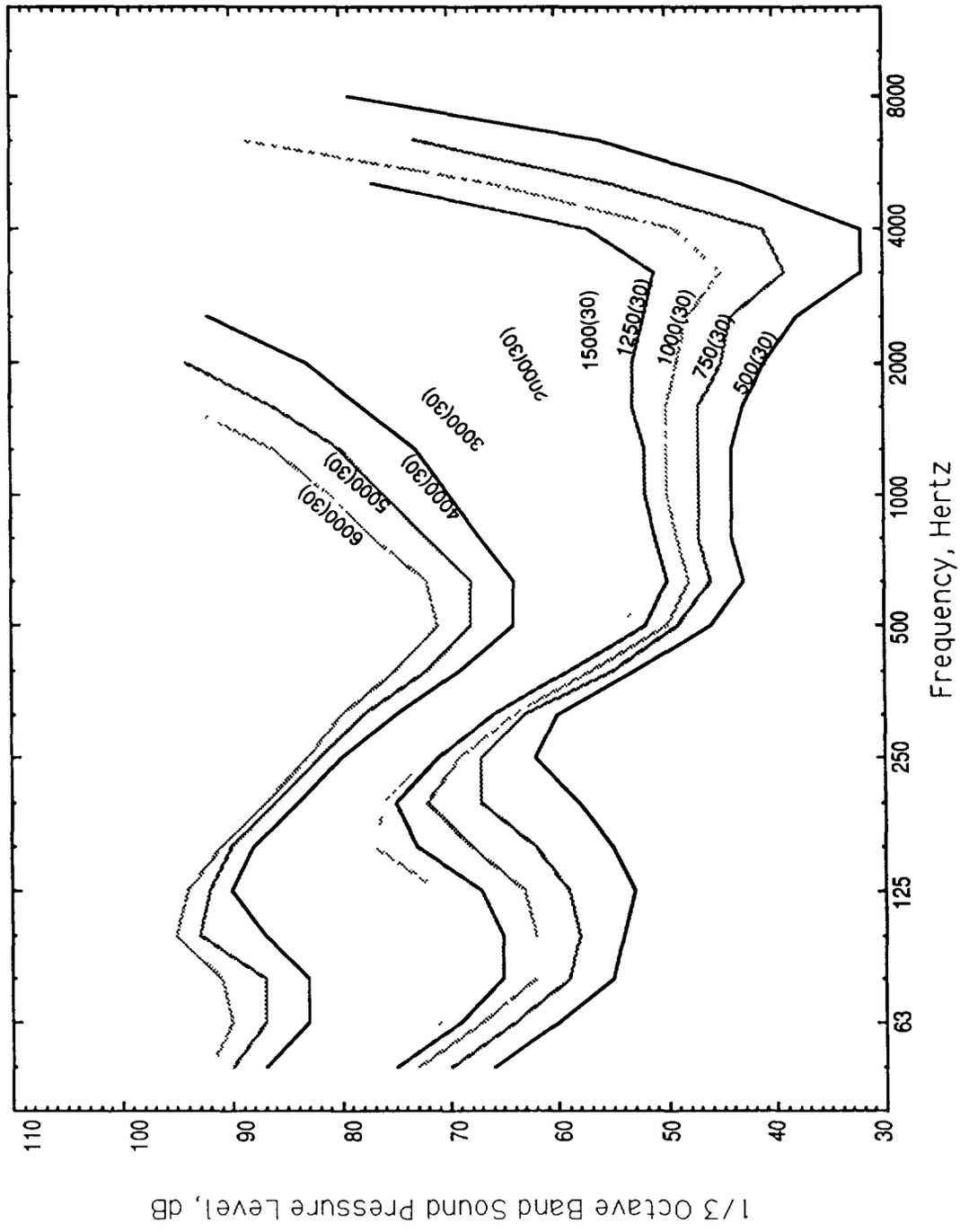
Note: The number in parentheses is the measurement distance in meters.

FIGURE 7. Level II nondetectability limits for 10 - 30 meters.



Note: The number in parentheses is the measurement distance in meters.

FIGURE 8. Level II nondetectability limits for 100 - 400 meters.



Note: The number in parentheses is the measurement distance in meters.

FIGURE 9. Level II nondetectability limits for 500 - 6000 meters.

5.3 Community annoyance.

5.3.1 Noise limits.

5.3.1.1 Criteria. Equipment having a community annoyance noise requirement shall meet the requirements of Table VI (combat vehicles are exempt).

5.3.1.2 Maximum. The sound level limits of Table VI shall not be exceeded.

5.3.2 Test requirements. Tests shall be conducted and noise shall be measured in accordance with the appropriate procedures as specified in Table VI.

TABLE VI. Sound level limits and test procedures for community annoyance.

Type of Equipment	Gross Weight (kg)	Distance from centerline (m)	Sound Level Limit [dB(A)]	Test Procedure
Motor Vehicles[1]	>4,536	15	80	SAE J366
	<4,536	15	80	SAE J986
Construction[1] and Materials-Handling Equipment		15	88	SAE J88
Mobile Generator Sets		7	70	SAE J1074
Portable Air Compressors for Construction Equipment		7	76	40 CFR 204

1/ For equipment wider than 2.75 m, the 15 m distance shall be measured from the side of the vehicle closest to the microphone.

5.4 Impulse noise, personnel-occupied areas.

5.4.1 Noise limits.

5.4.1.1 Criteria. Applicable impulse noise limits are identified by the expected number of daily exposures and the type of hearing protection required. Table VII identifies the required hearing protection for the respective impulse noise limits and expected number of daily exposures; the corresponding peak levels and B-duration values are shown in Figure 10.

TABLE VII. Impulse noise daily exposure limits.

	Max permissible number (N) of exposures/day*		
Impulse Noise Limit	No Protection	Either Plugs or Muffs	Both Plugs and Muffs
W	----------Unlimited Exposure----------		
X	0	2000	40000
Y	0	100	2000
Z	0	5	100

* A single exposure consists of either (a) a single impulse for non-repetitive systems (systems producing not more than one impulse per second, e.g., rocket launchers fired from the shoulder), or (b) a burst for repetitive systems (systems normally producing more than one impulse per second, e.g. automatic weapons (see 5.4.4.2)). The equation for calculating the allowable number of exposures per day is:

$$N_1 = 10^x \text{ where } x = \frac{1}{5}\left[177 - L + 6.64 \log_{10} \frac{200}{T}\right]$$

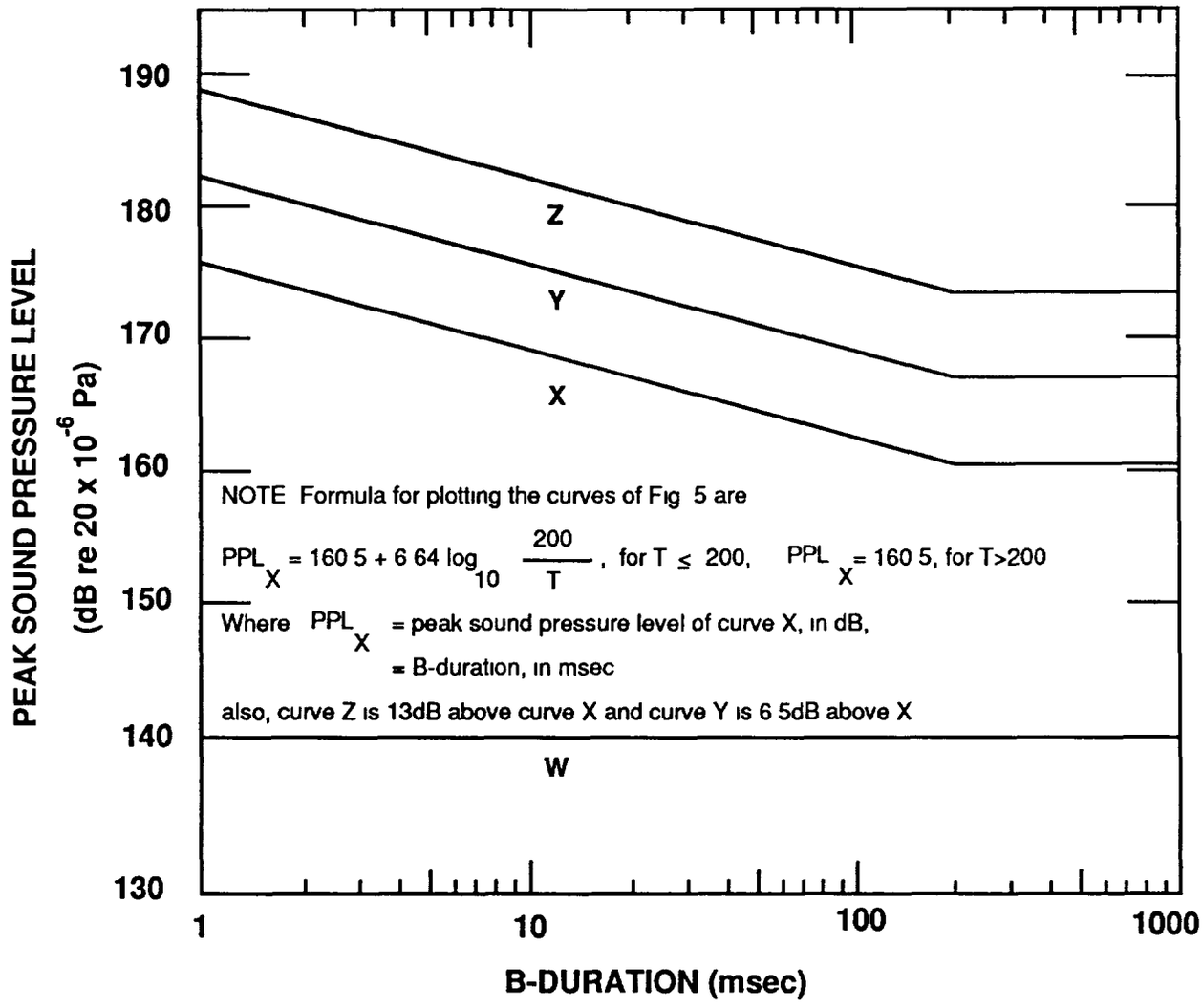
$$N_2 = 20\ N_1$$

Where N_1 = allowable No. impulses/day (single protection)

N_2 = allowable No. impulses/day (double protection)

L = measured peak sound pressure level, in dB

T = measured B-duration in milliseconds



1/ For peak sound pressure levels falling between (but not outside) the labeled curves, the permitted number of exposures per day may be interpolated based on a relationship of 1.5 dB per factor of 2 in the number of rounds.

2/ Use of levels in excess of limit W require mandatory hearing protection.

FIGURE 10. Peak sound pressure levels and B-duration limits for impulse noise (see Table VII to select curve for use).

5 4.1.2 Maximum. The initial requirement is that impulse noise shall not exceed the limits specified for limit W in order to meet the hearing conservation criterion for unprotected ears. Limits X, Y, or Z, for which hearing protection is mandatory, shall be selected only if it can be clearly documented that meeting limit W is beyond the state-of-the-art or that the cost of reducing the noise level to that specified for limit W is prohibitive or that system effectiveness will be seriously degraded by reducing the noise level to that specified for limit W. Limits X, Y, or Z shall be selected only with the approval of the procuring activity subject to reduction of the level to the lowest value consistent with the state-of-the-art and the cost and effectiveness factors noted above. Impulse noise levels above limit W (i.e., anything greater than 140 dB) require the use of hearing protectors for any number of exposures per day.

5.4.2 Test requirements

5.4.2.1 General.

5.4.2.1.1 Acceptance criteria. To be acceptable for use under the impulse noise limit category selected in 5.4.1.1, the measured highest peak pressure level and B-duration shall be below the appropriate impulse-noise requirement as shown in Figure 10.

5.4.2.1.2 Measurement location. Measurements shall be made at each operator or crew position and, if required, at a reference location specified in 5.4.4.5.1. Because reflective surfaces will alter the acoustic exposure, there may be some environments where additional measurements may be appropriate. For example, additional measurements may be made to assess the impulse noise of persons firing weapons from a prone position, a foxhole, a bunker, or an enclosed area. Where the operator or crew station(s) is not clearly defined, the noise measurement position(s) shall be designated by the procuring activity.

5.4.2.1.3 Replications. For those systems having an existing impulse noise data base from at least 10 events, a minimum of three impulses shall be measured for each condition. Where a limited data base exists for a system or where a system design change may influence the impulse noise, a minimum of five impulses shall be measured for each condition. The peak pressure levels and B-durations from these three or five shots shall be sufficient to define the impulse noise characteristics if the range of peak pressure levels does not exceed 3 dB or 5 dB, whichever applies. If this range is exceeded, additional measurements shall be made until the number of measurements equals or exceeds the range in dB

5.4.2.1.4 Recording procedure. The pressure waveform shall be obtained by analog or digital means. It may be displayed directly on a cathode-ray oscilloscope (or equivalent) and photographed, recorded with an FM tape recorder, or stored digitally.

5.4.2.1.5 Noise contours. Where the impulse noise level exceeds 140 dB, the distances and directions from the noise source at which the noise level is equal to 140 dB shall be determined. In addition, the distances and directions from the source at which the noise level is equal to the specified impulse noise limit category (X, Y, or Z) shall be determined if desired. Where the 140-dB contour is too far from the source to make its direct measurement practical, its location may be extrapolated from measurements made at a distance producing a level between 137 and 150 dB and assuming spherical divergence.

5.4.2.2 Test environment.

5.4.2.2.1 Reflecting surfaces. Where practical, measurements shall be made with no reflecting surfaces, including personnel, within 10 m of both the test item and the transducers. For weapons that must be supported, a stand shall be used having minimal reflecting or obstructing surfaces. Particular attention shall be taken to provide an unimpeded reflecting path from the noise source(s) to the ground and back to the transducers.

5.4.2.2.2 Weather conditions. The effect of weather conditions on the performance of all instruments should be considered (e.g., temperature, humidity, and barometric pressure). Instrumentation can be affected by low temperatures and caution should be exercised. Measurements should normally be made at wind speeds below 20 km/h. However, this requirement may be eased when measuring high sound pressure levels.

5.4.2.2.3 Background noise. Background noise, including wind noise, shall be at least 40 dB below the peak pressure level being measured for acceptance (see 5.4.2.1.1) and at least 20 dB below the peak pressure level for noise contours (see 5.4.2.1.5).

5.4.3 Instrumentation.

5.4.3.1 Instrument specifications.

5.4.3.1.1 Transducers. Transducer characteristics and use shall be as follows:

a. Undamped resonance of transducers shall be 100 kHz or greater

b. Transducers not having DC response shall have time constants of 200 ms or greater.

c Transducer non-linearity shall be 3% or less of full scale output.

d. The sensor surface of transducers shall have a diameter not exceeding 6.3 mm. Transducer holders should be of minimum size and should minimize flow interference over the sensor surface.

e. Rise-time capability of transducers shall be shorter than 1/20 of the measured A-duration of the impulse and should not exceed 20 microseconds.

f. Acceleration sensitivity of transducers shall be less than 0.014 kPa/g in the axial direction and less than 0.069 kPa/g in the transverse direction.

g. Transducers shall be chosen to minimize the effects of temperature under the expected test conditions. Output shall be corrected from temperature versus sensitivity curves for the individual transducer.

h. Transducers shall be isolated from any accelerating surfaces to prevent microphonics. Cables should be protected from shock waves by taping them to the stand in a location that minimizes exposure to shock waves. They should be positioned in a direction away from the propagation of the shock wave. All connectors should be isolated from the stand and other grounded objects to prevent multiple ground paths. Long cables should not increase measured rise time.

i. If necessary, transducers should be protected from flash and thermal effects by smoothly covering the sensing surface with a layer of black electrical tape, plus a layer of silver tape, or equivalent, which does not modify the sensitivity or frequency response of the transducer.

5.4.3.1.1.1 Transducer applications.

a. For measurements above 40 kPa (186 dB), pointed or disc-shaped piezoelectric or piezoresistive probes with good aerodynamic characteristics shall be used

b. For measurements below 40 kPa (186 dB), piezoelectric or piezoresistive probes having a blunt cylinder shape may be used.

c. For measurements above 7 kPa (171 dB), condenser microphones shall not be used.

5.4.3.1.2 Recording systems. The complete data acquisition system shall provide a minimum of 35 dB signal-to-noise ratio.

5.4.3.1.2.1 FM recording. The FM tape recorder (if used) shall have a frequency response of DC to 40 kHz or greater, as defined by the Inter Range Instrumentation Group (IRIG) standards. The recorder's reproduce amplifier output filters shall be operated in the linear (optimal transient) phase mode.

5.4.3.1.2.2 Digital recording. Sampling rate shall be a minimum of 160,000 samples/sec. The analog signal shall be filtered, using a Bessel type, with 40 kHz cutoff frequency. The roll-off rate shall be not less than 36 dB/octave.

5.4.3.2 Calibration.

5.4.3.2.1 General. Proper calibration procedures, which include the influence of transducers, cables, amplifiers, recorders, and other instrumentation, shall be accomplished at least daily.

5.4.3.2.2 Calibration method. Transducers shall be calibrated in a manner consistent with their time constant. Acceptable methods are sinusoidal pressure generators, pulse calibrators, dead weight calibrators, or shock tubes.

5.4.3.2.3 Electrical calibration. Electrical calibration of all instrumentation following the transducer is acceptable for field use provided one of the aforementioned calibrations is accomplished on the transducer immediately before and after field use.

5.4.4 Measurement procedure.

5.4.4.1 Single-impulse systems. The pressure history of the impulse noise shall be obtained by producing one impulse at a time.

5.4.4.2 Repetitive systems. The B-duration of a single impulse shall be determined. The number of impulses produced within the first 200 ms 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. This B-duration

shall be used to establish the maximum allowable peak pressure level for the repetitive system.

5.4.4.3 Multicharge systems. For systems with various charges (e.g., separately loaded artillery ammunition), the charge producing the highest peak pressure level shall be measured in addition to those producing lower levels.

5.4.4.4 Weapon position. Weapons shall be tested in all positions and in the system locations from which they are normally fired. Standing position for shoulder-fired and hand-held weapons is defined as being mounted with the barrel or tube centerline 1.60 m above and parallel to the ground.

5.4.4.5 Transducer locations. For shoulder-fired and hand-held weapons, transducers shall be located at the center of each operator or crewmember's probable head location. For other weapons the transducer shall be positioned 1.60 m above the ground surface; for sitting locations it shall be 0.80 m above the seat. When the operator must be present, the measurement shall be made 0.15 m from the ear closest to the noise source (i.e., muzzle or breech, as the case may be) on a line between the operator's ear and the noise source.

5.4.4.5.1 Reference transducer.

a. If required, a transducer shall be placed 2 meters to the side of the major noise source of the weapon (e.g., perpendicular to the muzzle for closed breech systems and perpendicular to the rear for rocket launchers), with the weapon and the sensor 1.60 m above the ground.

b. If required, a reference transducer shall be located on the 135-degree or 225-degree radial (taking the line of fire as 0 degrees). For weapons of bore diameter greater than 20 mm, this transducer shall be located at a distance of 50 bore diameters measured from a point directly under the muzzle with a tube (barrel) elevation of 0 degrees) at a height of 1.60 m. For weapons of smaller bore diameter, the transducer shall be located at the same elevation as the muzzle, at a distance of 1 m.

5.4.4.5.2 Equal pressure contours. Equal pressure contours shall be determined from measurements made at positions around the major noise source of the weapon at angular increments not greater than 45 degrees. The muzzle, muzzle extension, or breech, whichever is the major source, shall be at the grid center. The line of fire shall be in the 0-degree direction. The measurement shall be made as close as possible to the distance that produces the peak pressure level being established. If this distance is too

great, the pressure may be extrapolated from measurements somewhat nearer to the weapon (in the free field) assuming a spherical divergence decay rate (6 dB per doubling of distance).

5.4.4.6 Transducer orientation. Blunt cylinder shaped transducers shall be positioned with the sensing surface facing up if possible. Transducers shall be oriented with reference to the noise source so that the plane passing through the sensing surface includes the noise source. This orientation is defined as grazing incidence (90 degrees). If more than one source is present, such as from a rocket launcher, transducers shall be oriented so that the plane passing through the sensing surface includes the centerline of the tube. This technique will tend to minimize the arrival of shock waves at transducer incidence angles between 0 and 90 degrees, which may cause ringing and overshoot.

5.4.4.6.1 Interior measurements. For interior measurements, such as inside a tank or other reverberant space where the direction of travel of the major shock wave is uncertain (or where major shock waves are expected to arrive from many directions), transducers shall be positioned with the sensing surface facing up, if possible. Transducers shall be oriented at grazing incidence to the center of the major suspected source, e.g., the muzzle or an open hatch.

5.4.4.7 Ammunition temperature. Where the impulse noise emanates from rapid burning of a propellant, measurements should also be taken with the round at the upper and lower operating temperature conditions specified by the system requirements.

5.4.4.8 Personnel limits and locations during tests.

5.4.4.8.1 Operator(s). 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 test item.

5.4.4.8.2 Interior noise measurements. Interior measurements shall be made with the minimum number of people in the area.

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

5.4.4.9.1 Systems. Care should be taken to maintain proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems (A microphone windscreen may be used provided that its effect is less than 1 dB under zero wind velocity conditions for the noise source being measured)

5.4.4.10 Data analysis.

5.4.4.10.1 Filtering. Data shall be analyzed through a low-pass 40 kHz filter of the Bessel type (36 dB/octave roll-off).

5.4.4.10.2 Weighting networks. If used, weighting networks shall meet the requirements of ANSI S1.4.

5.4.4.10.3 Analog-to-digital (A-D) converters. A-D converters shall have a 10-bit word size or greater.

5.4.4.10.4 FM recordings. Analysis of FM tape recordings may be done with appropriate speed-reduction techniques using readout devices having proper frequency response.

5.4.4.10.5 Standard conditions. Data shall be reported without being scaled to standard conditions. However, temperature and pressure conditions shall be reported so that peak pressure, duration, and impulse data may be scaled to standard conditions, if required (101.325 kPa, 288.16 degrees K), using Sach's scaling laws.

5.4.4.10.6 Acoustic energy. If the energy per unit area is to be computed, the specific acoustic impedance of air at the above standard conditions is 417 N s/m^3.

5.5 Data recording. This section lists the data that shall be recorded in addition to noise measurements made in accordance with this standard. As a minimum, the following shall be recorded:

a. Complete list of calibrated instrumentation (e.g. microphone, preamplifier, sound level meter, pistonphone, tape recorder, power supply, oscilloscope, frequency analyzer, etc.) used for measurements, including: nomenclature, model, serial number, manufacturer, date of calibration, and period of calibration.

b. Complete identification of the equipment whose noise is being measured, including nomenclature, 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, such as speed (e.g., 2/3 maximum posted speed), rpm (e.g , rated engine rpm, 2/3 rated engine rpm), nominal muzzle velocity, load, transducer locations and orientation, weapon height and elevation

d. Date, time of day, and location of test.

e. Physical description of the area, including ground surface and reflecting surfaces (if appropriate), a sketch of contributing noise sources, normal personnel operating positions, microphone locations, orientation angles of the microphones with reference to the noise source, and the location of personnel present during the tests. Transducer locations for weapons shall be specified in polar coordinates with the origin being a point below the muzzle with the barrel or tube at 0 degrees elevation.

f. Air temperature, relative humidity, wind direction and speed, barometric pressure, cloud cover, and other atmospheric conditions.

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.).

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

k. Orientation angles of the microphones with reference to the noise source.

l. Frequency response, control settings (including preemphasis, equalization, or other applicable equipment mode), and tape speed of tape recorder, if used.

m. Name, address, and phone number of personnel making the noise measurements, and of personnel such as official witnesses and equipment operator(s).

n. SI units (kPa) may be used with dB, mbar, psi reported where appropriate.

NOTE: See Figures 11a and 11b for a sample test data collection sheet and a blank data collection sheet, respectively.

ACOUSTICAL TEST DATA

TIME 1400	DATE 15 MAY 1990		
TEST ITEM TRUCK CARGO, 1 1/4 TON, 6x6, M561	TEST CONDUCTED BY D R SCRIBNER	TEST ITEM OPERATOR ROBERT RUFF	
REG /MODEL NO 03A 476 70	SERIAL NO 2252 511C	ODOMETER 13,500	HOUR METER
TEST ITEM CONDITION STANDARD CANVAS TOP - DOORS OPEN			
TEMPERATURE 27 4 °C	HUMIDITY 63%	TEST SITE PERRYMAN	SURFACE PAVED
TERRAIN LEVEL			
BAROMETRIC PRESSURE 1012 2 mb	SKY COVER SCATTERED	STATIONARY OPERATION ☐	HIGHWAY DRIVING ☒
DRIVE-BY ☐			
WIND DIRECTION S S W	WIND VELOCITY 8 mp/h	MICROPHONE B&K 4155	SOUND LEVEL METER
OCTAVE ANALYZER B&K 2131			
INTERIOR ☒	EXTERIOR ☐	MICROPHONE LOCATION AS DESCRIBED BELOW	TAPE RECORDER B&K 7006
TAPE NO 1			

GEAR	RPM	APPROX SPEED	dBA	dBB	dBC	ALL PASS	31.5	63	125	250	500	1000	2000	4000	8000	REMARKS
									DRIVER'S EAR POSITION							
1	1900	4 km/h	91	94	95	96		87	89	91	90	86	82	76	69	
2	1900	9 km/h	92	95	96	97		87	89	91	89	86	82	76	69	
3	1900	21 km/h	92	95	97	97		88	89	91	90	87	82	75	69	
4	1900	38 km/h	93	96	99	100		90	91	95	90	88	82	76	70	
									PASSENGER'S EAR POSITION							
1	1900	4 km/h	89	92	94	95		86	88	92	88	84	81	75	68	
2	1900	9 km/h	90	92	94	95		86	87	92	87	85	81	75	68	
3	1900	21 km/h	90	93	95	97		86	88	93	90	86	82	75	68	
4	1900	38 km/h	92	95	97	98		87	90	95	90	87	82	77	69	
			85					106	96	89	83	80	79	79	81	MAXIMUM ALLOWABLE LIMITS
																FOR UNPROTECTED HEARING
																(MIL-STD-1474, CATEGORY 'D')

FIGURE 11a. Sample form showing acoustical test data for M561 Cargo Truck.

ACOUSTICAL TEST DATA				TIME	DATE
TEST ITEM				TEST CONDUCTED BY	TEST ITEM OPERATOR
REG /MODEL NO	SERIAL NO	ODOMETER.	HOUR METER	TEST ITEM CONDITION	
TEMPERATURE	HUMIDITY	TEST SITE		SURFACE	TERRAIN
BAROMETRIC PRESSURE	SKY COVER	STATIONARY OPERATION ☐		HIGHWAY DRIVING ☐	DRIVE-BY ☐
WIND DIRECTION	WIND VELOCITY	MICROPHONE		SOUND LEVEL METER	OCTAVE ANALYZER
INTERIOR ☐	EXTERIOR ☐	MICROPHONE LOCATION		TAPE RECORDER	TAPE NO

GEAR	RPM	APPROX SPEED	dBA	dBB	dBC	ALL PASS	31.5	63	125	250	500	1000	2000	4000	8000	REMARKS

FIGURE 11b. Blank acoustical test data form.

6. NOTES

6.1 Intended use. This standard is intended for use as a noise criteria design standard for military ground materiel, cited contractually in system specifications, and elsewhere, and for use as a basis for that part of noise testing where design characteristics are assessed for purposes of acceptance. It is not intended for use to express binding requirements in conceptual and other early acquisition phases. The standard may be applied to other early acquisition phases. The standard may be applied to traditional, as well as non-developmental item (NDI) acquisitions.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Data Requirements. The following Data Item Descriptions (DIDs) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this standard is applied on a contract, in order to obtain the data, except where DOD FAR Supplement 227.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
5.5	DI-HFAC-80938A	Noise Measurement Report	

The above DIDs were those cleared as of the date of this standard. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DIDs are cited on the DD Form 1423.

6.4 Subject term (key word) listing.

Attenuating helmets or headsets
Aural nondetectability
Average hearing
Background noise
Community annoyance
Decibel
Hearing conservation criteria
Hearing damage risk criteria
Impulse noise
Impulse noise, personnel-occupied areas
Hearing protectors
Noise contours
Noise criterion curves

6.6 Guidance Documents.

AFR 161-35,	Hazardous Noise Exposure
DA PAM 40-501,	Hearing Conservation
29 CFR 1910.95	Occupational Noise Exposure
OPNAVINST 5100.23B,	Navy Occupational Safety and Health (NAVOSH) Program Manual
OPNAVINST 5100.19B,	Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat

APPENDIX

GUIDANCE

10. Details specified by the procuring activity. Applicable details, such as the following, should be specified by the procuring activity in the request for proposal (RFP) and in appropriate follow-up requirements documentation.

10.1 Hearing protection. When it is known that certain types of hearing protection will interfere with the use of helmets or other equipment.

10.2 Operating conditions for testing.

a. Whether typical duty cycle testing is specified for the item (see 5.1.2.1.7).

NOTE: Where the procuring activity has determined that the noise tests at the constant operating conditions stated herein are clearly inappropriate or non-representative, another constant operating condition(s) may be specified by the procuring activity. Where it is not possible to establish any appropriate constant operating condition for the noise test, the equivalent continuous sound level (see 3.4) shall be determined under a typical duty cycle to be specified by the procuring activity.

b. Vehicle engine speed and gear, load and test surface, if different from the standard (see 5.1.2.3.1.1, 5.1.2.3.1.2 and, 5.1.2.5.1.3).

c. Off-road construction and materials-handling equipment speed, load and test surface (see 5.1.2.3.2).

d. Watercraft speed and load, if different from the standard (see 5.1.2.3.3).

e. Stationary equipment speed and load, if different from the standard (see 5.1.2.4.1 and 5.1.2.4.2).

10.3 Aural nondetectability.

a. Limiting band levels, if different from the standard (see 5.2.1.1).

b. Test site conditions other than those specified by the standard, if required (see 5.2.2.1).

c. Equipment operating conditions for test (see 5.2.2.2).

10.4 Measurement locations when not clearly defined.

a. Steady-state noise (see 5.1.2.1.2).

b. Impulse noise (see 5.4.2.1.2).

20. Information to the development test agency. Developing agencies should make appropriate information available to the development test agency, as required, to ensure that test conditions, noise category selection, and evaluation of results are consistent with system requirements, specified hearing protection requirements, if any, and general procuring activity-specified requirements relevant to the provisions of this standard.

30. Determination of B-duration. To establish the B-duration of an impulse noise it is necessary to find the primary portion of the event plus the presence of significant subsequent fluctuations (see 3.8.3).

30.1 Primary portion. The primary portion of an impulse noise is determined as follows:

Let L^+ be the line 20 dB below the positive peak overpressure and parallel to the baseline (see Note).

Let L^- be the reflection of L^+ through the baseline.

Let T_1 be defined by $T_1 = N \times (A - \text{duration})$,

where N is an integer given the initial value of 5, and T_1 can be no greater than 30 ms.

Let T be the time from the first rise above ambient exceeding the line L^+, to the point P at the start of the first subsequent interval of duration greater than or equal to T_1 during which the overpressure lies entirely between L^+ and L^-

If the point P is within time T_1 of the first rise, decrease N by 1 and reapply the criterion. T is defined by the largest N found such that $T>T_1$. (N=1 always works, but this may not be the largest such N.)

NOTE: The baseline is defined by taking 5% of the difference between the positive and negative peak pressure levels. Working back in time from the peak pressure level, average the level over 5 ms intervals until all deviations about the average do not exceed the 5% difference. This average is then used as an estimate of the baseline. The baseline is then used along with the peak pressure level to calculate L^+ and L^-. An acceptable baseline is one in which the 5 ms interval precedes the first excursion exceeding L^+ or L^- by no more than 2 ms.

Now let R = .3 x (T). If $R \leq T_1$, T is the duration of the primary portion. If $R>T_1$, find the point Q at the start of the first interval past P of duration R during which the overpressure lies entirely between L^+ and L^-. The primary portion is then from the start of the interval T to the point Q.

30.2 Secondary fluctuations. Significant subsequent fluctuations are defined as pressure excursions exceeding L^+ or L^- whose total (summed) duration is greater than 10% of the primary portion of the impulse noise.

30.3 B-duration examples and algorithm. Figures 12, 13, 14 and 15 provide sample determinations of B-duration. Figure 16 is a flow diagram for finding B-duration.

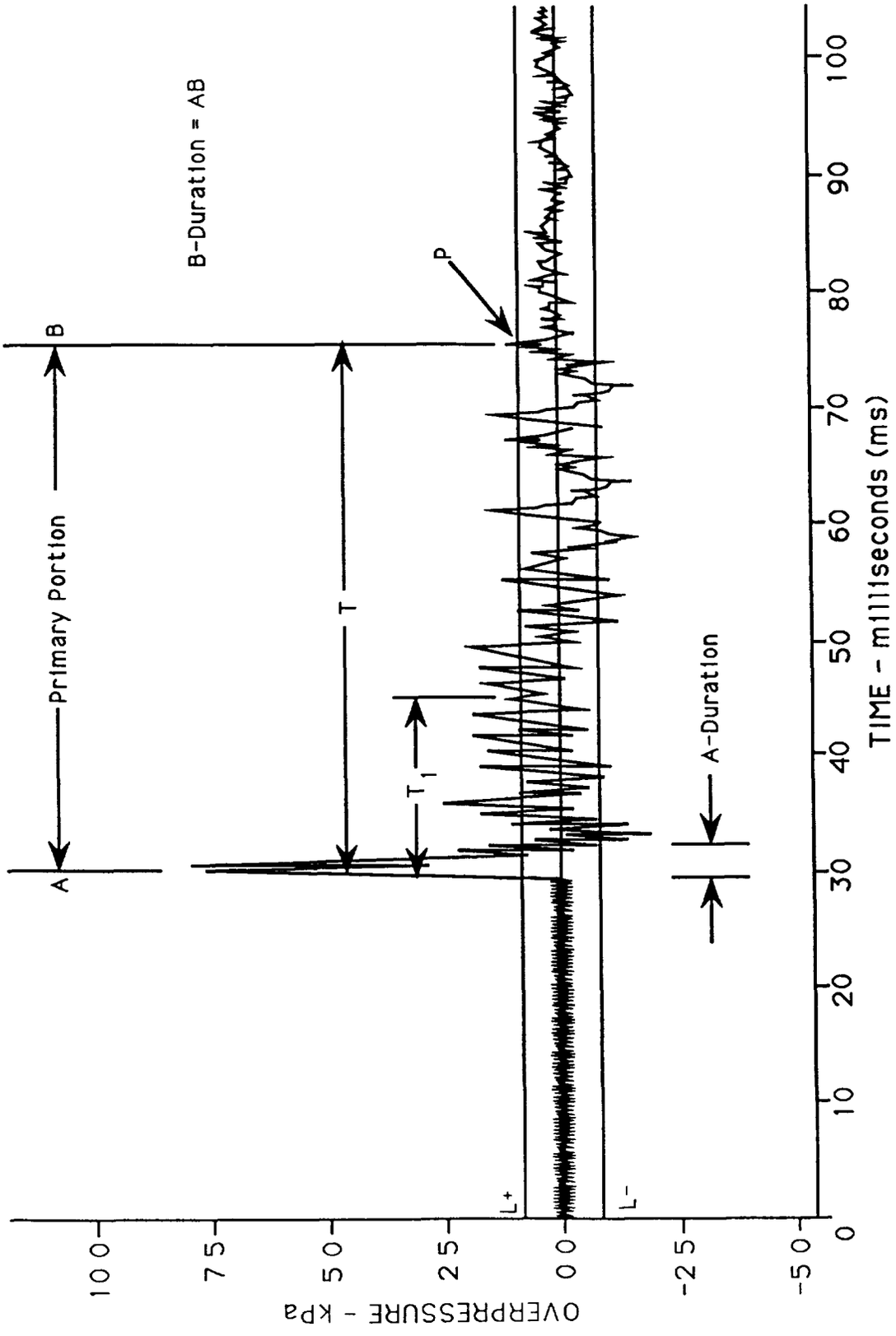


FIGURE 12. Sample determination of B-duration.

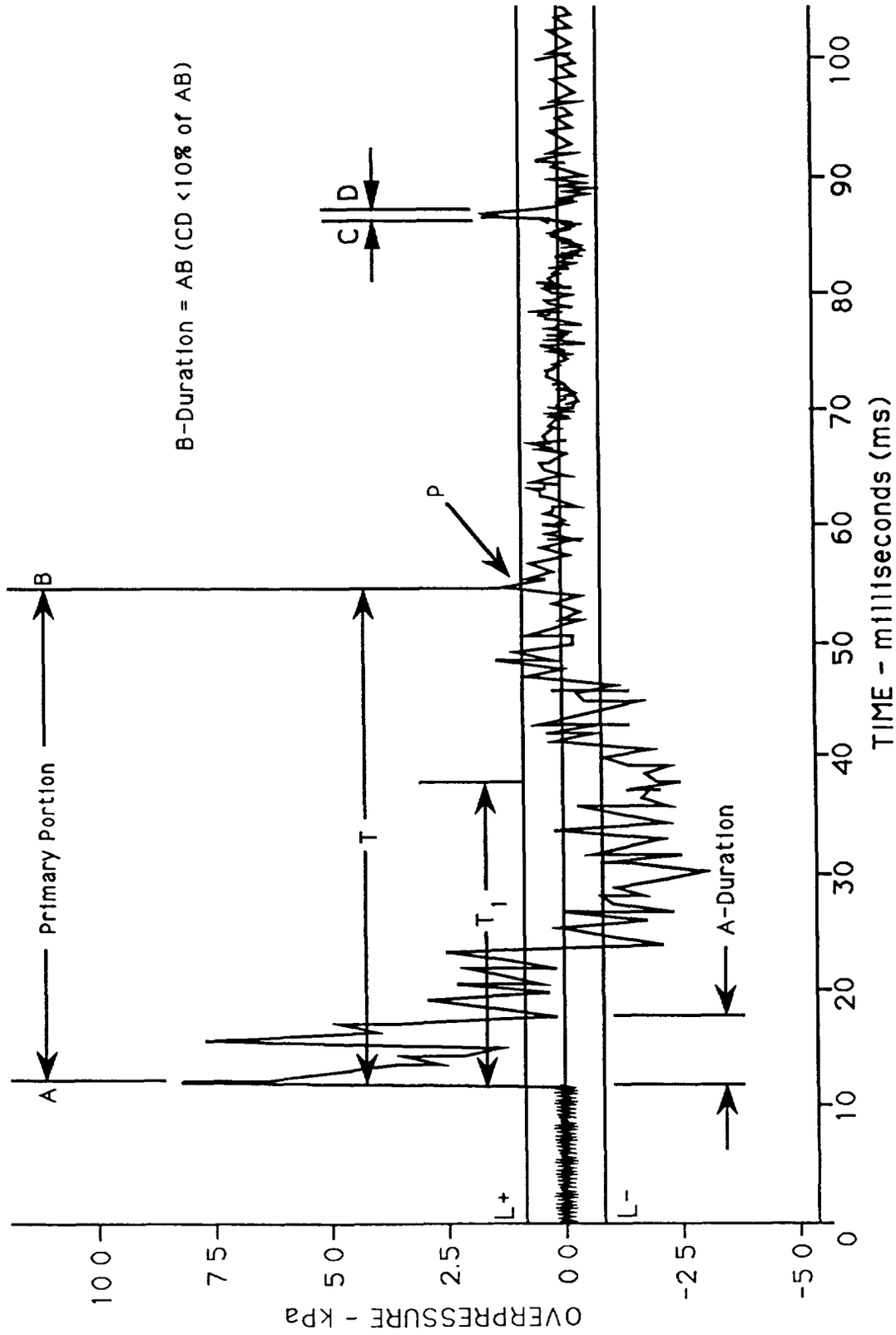


FIGURE 13. Sample Determination of B-duration.

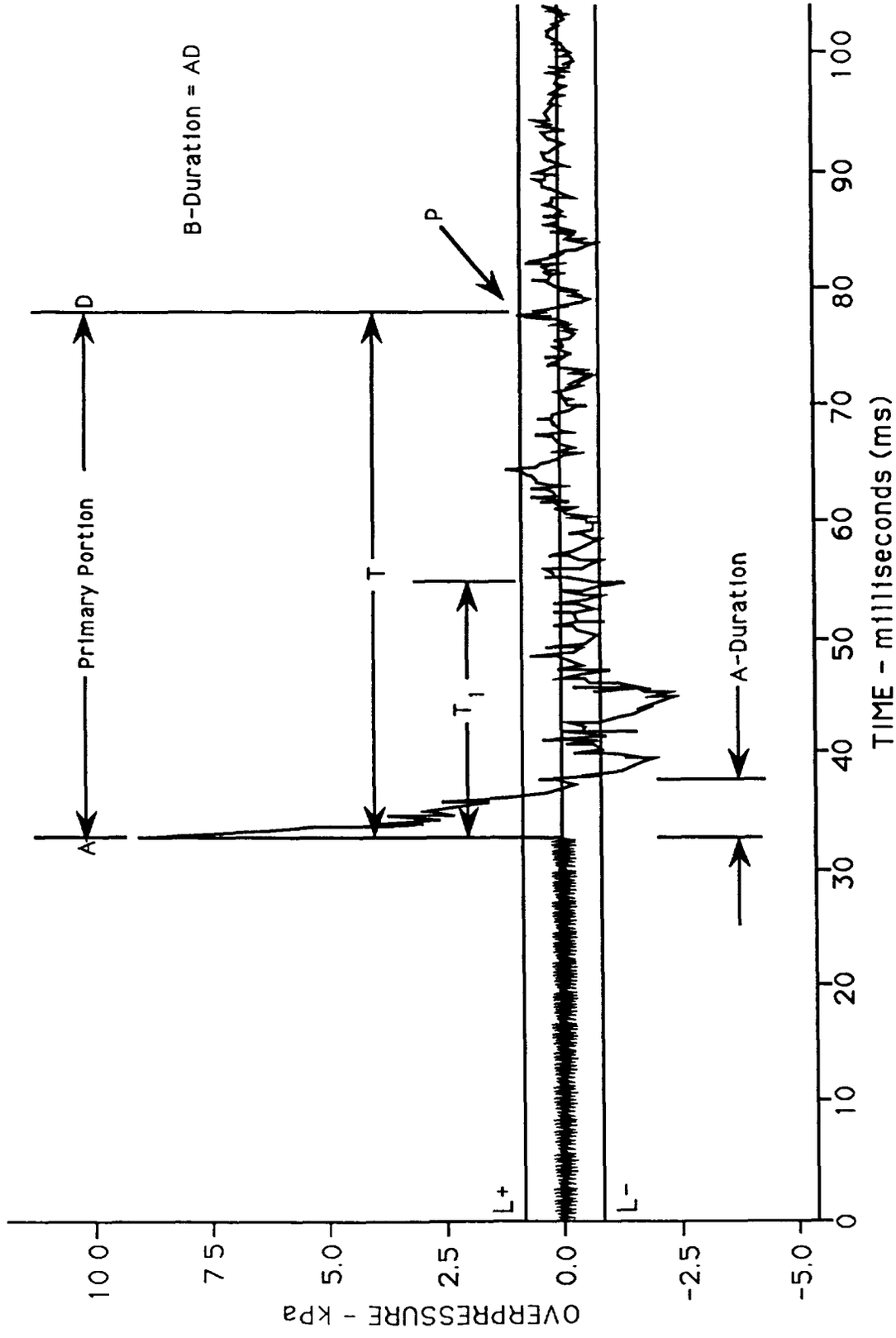


FIGURE 14. Sample determination of B-duration.

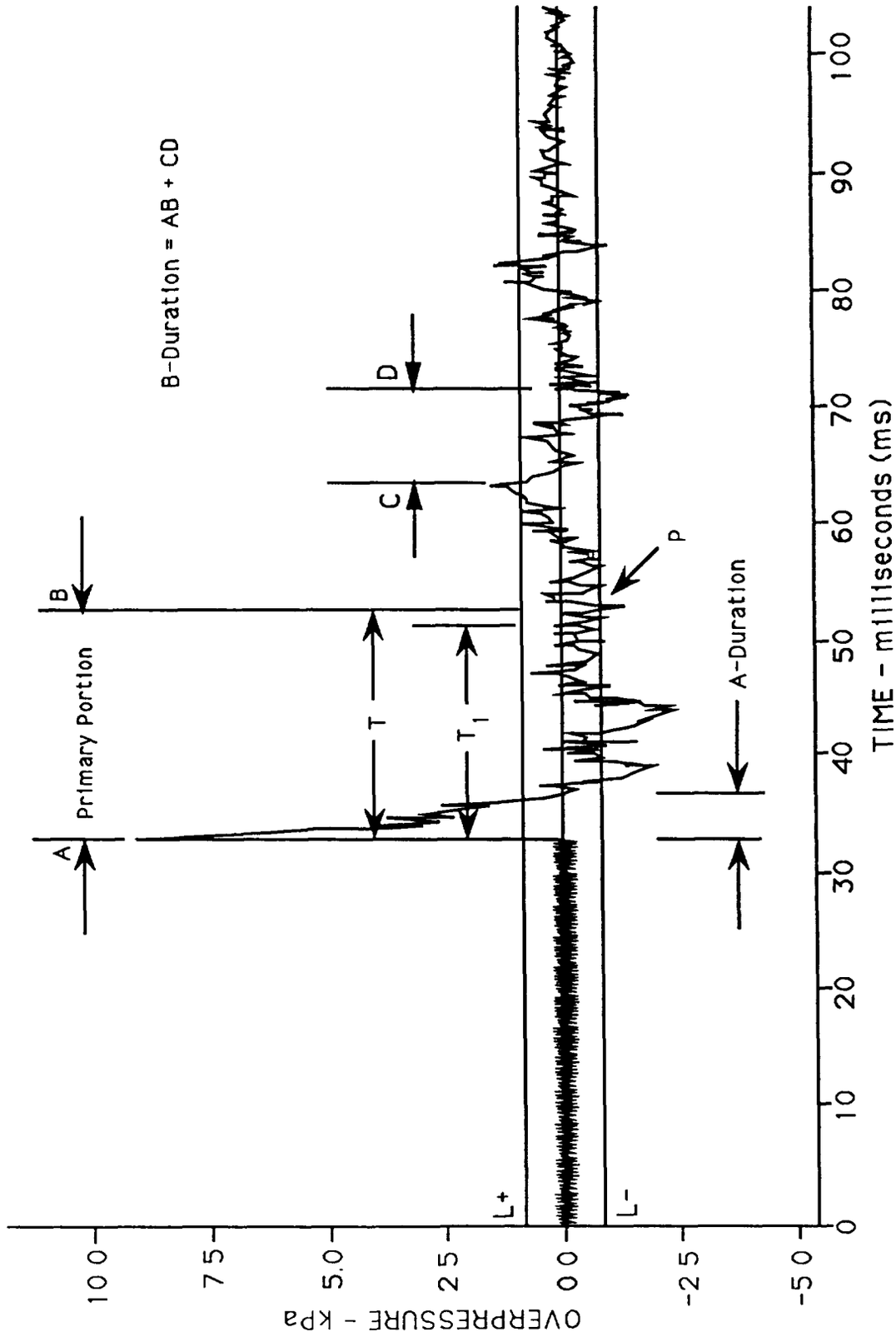


FIGURE 15. Sample determination of B-duration.

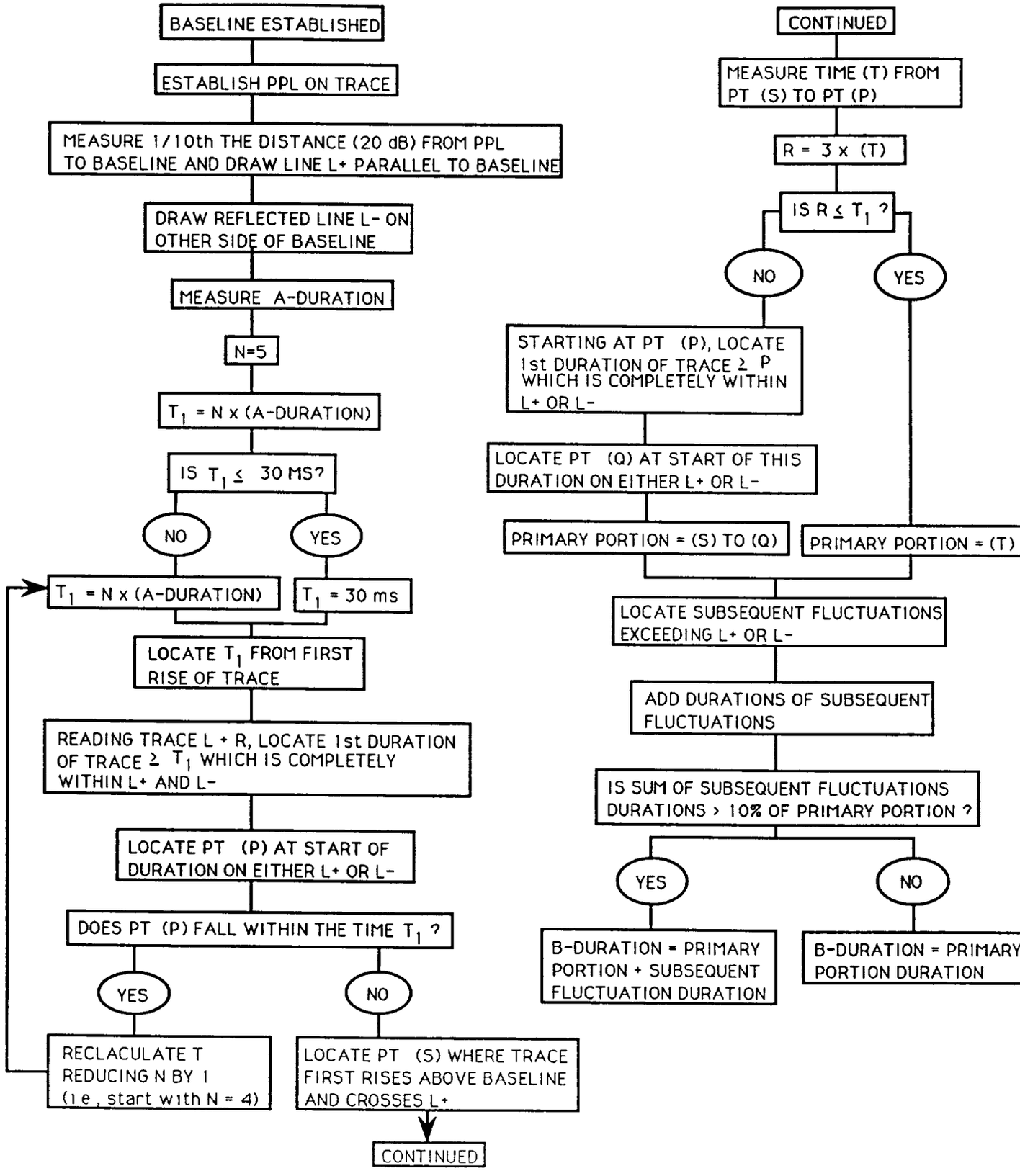


FIGURE 16. Determination of B-duration.

Custodians:
Army - MI
Navy - AS
Air Force - 11

Review Activities:
Army - AM,AT,MD,ME,TE
Navy - OS,TD,YD

Other Government Agencies:
DOT(FAA)
EPA
NASA(MSF)
NIST
DOL(OSHA)

Preparing Activity:
Army - MI

Project No. HFAC 0039

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-STD-1474C	91/03/08

3. DOCUMENT TITLE
NOISE LIMITS FOR MILITARY MATERIEL (METRIC)

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code) (1) Commercial	(2) AUTOVON
U S. Army Missile Command	(205) 876-6980	746-6980
c. ADDRESS (Include Zip Code) Commander, U.S Army Missile Command, ATTN AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5270	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT Defense Quality and Standardization Office 5203 Leesburg Pike Suite 1403 Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	

DD FORM 1426 89 OCT