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MILITARY STANDARD

ACOUSTICAL AND VIBRATIONAL STANDARD REFERENCE QUANTITIES

FSC MISC

DEPARTMENT OF THE NAVY

WASHINGTON, D.C. 20362

ACOUSTICAL AND VIBRATIONAL STANDARD REFERENCE QUANTITIES

MIL-STD-1621A(NAVY)

1. This Military Standard is approved for use by the Commands of the Navy for measurement of levels of airborne, liquidborne and structureborne noise.

2. Recommended corrections, additions, or deletions should be addressed to the Naval Ship Engineering Center, Center Building, Prince George's Center, Hyattsville, Maryland 20782.

FOREWORD

The purpose of this standard is to establish uniform reference quantities for measurement of airborne, liquidborne, and structure-borne noise levels as well as a standard graph size and proportions to be used for plotting such measurements.

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1. SCOPE AND APPLICATION

1.1 Scope. This standard covers reference quantities to be used in reporting of all acoustical and vibrational quantities expressed in terms of levels. It also defines acoustical terms and prescribes the plotting format for acoustical measurements.

1.2 Application. This standard applies to new construction and to procurement contracts for installed systems and equipment. It also applies to the reporting of acoustical data generally, except where old construction and procurement contracts for installed systems require otherwise. It does not apply to acoustical ranging to determine vulnerability to acoustical mines.

2. REFERENCED DOCUMENTS

2.1 The issues of the following document in effect on date of invitation for bids form a part of this standard to the extent specified herein.

NONGOVERNMENTAL

AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)
S1.8-1969 - Preferred Reference Quantities for Acoustical Levels.

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

3. DEFINITIONS AND SYMBOLS

3.1 Vibratory motion. Vibratory motion is an oscillation wherein the quantity being observed is descriptive of the motion or position of a mechanical system. Such quantities are acceleration, velocity, and displacement.

3.2 Standard acceleration (g_n). The international standard acceleration of free fall is:

$$g_n = 9.80665 \text{ m/s}^2 = 386.089 \text{ in/s}^2.$$

3.3 Sound pressure (p). Sound pressure is the root mean square sound pressure at a point, unless identified otherwise such as by instantaneous, average (arithmetic mean), or peak.

3.4 Sound power of a source (w). The sound power of a source is the total sound energy per unit time radiated by the source.

3.5 Level (L). The level of a quantity for vibration and acoustics, is the logarithm of the ratio of that quantity to a reference quantity of the same kind. The base of the logarithm, the reference quantity, and the kind of level must be indicated. The unit of level, such as the decibel or neper, serves to identify the base of the logarithm, including any constant of proportionality.

3.6 Reference quantity. The reference quantity for a level is the denominator of the ratio whose logarithm is taken to form the level.

3.7 Sound pressure level (L_p). Sound pressure level, in decibels (dB), is 20 times the logarithm to the base 10 of the ratio of the sound pressure to the reference pressure.

3.8 Sound power level (L_w). Sound power level in dB is 10 times the logarithm to the base 10 of the ratio of the sound power to the reference power.

3.9 Vibratory acceleration level (L_a). Vibratory acceleration level, in dB, is 20 times the logarithm to the base 10 of the ratio of the vibratory acceleration to the reference acceleration.

3.10 Vibratory velocity level (L_v). Vibratory velocity level, in dB, is 20 times the logarithm to the base 10 of the ratio of the vibratory velocity to the reference velocity.

3.11 Vibratory displacement level (L_d). Vibratory displacement level in dB, is 20 times the logarithm to the base 10 of the ratio of the vibratory displacement to the reference displacement.

4. GENERAL REQUIREMENTS

4.1 Objectives. The objectives of this standard are to:

(a) Achieve uniformity in the usage of terminology associated with acoustical and vibrational phenomena. The terminology prescribed is compatible with current engineering nomenclature. Where there are alternatives in the literature, the preferred usage is designated.
(b) Establish standard graph proportions and dimensions for plotting purposes to facilitate comparison of data.
(c) Promote general understanding by the mandatory use of standardized terminology.

4.2 Conventions. Acoustical and vibrational oscillations shall be described in terms of root mean square (sound pressure, acceleration, velocity, or displacement) levels. It is not necessary to include the modifier "root mean square", nor any abbreviation for it; a modifier is needed only if some other meaning is intended. Maximum sound pressure level means the greatest root mean square sound pressure level during a given time. Maximum peak sound pressure level means the level of a peak sound pressure.

5. DETAILED REQUIREMENTS

5.1 Units. Units of the International System (SI) are prescribed for the measurement of acoustical and vibrational quantities. The standardized decimal prefixes may be employed wherever convenient; use of a prefix representing 10 raised to a power that is a multiple of plus or minus 3 is especially recommended.

5.1.1 Sound pressure. The unit of sound pressure is the pascal (Pa). It is equal to the newton per square meter (N/m^2), and equal to 10 dynes per square centimeter (10 dyn/cm^2).

5.1.2 Sound power. The unit of sound power is the watt (W).

5.1.3 Vibratory acceleration. The unit of vibratory acceleration is the meter per second squared (m/s^2). Alternatively, the standard acceleration of free fall (g_n) may be used as a unit of vibratory acceleration.

5.1.4 Vibratory velocity. The unit of vibratory velocity is the meter per second (m/s).

5.1.5 Vibratory displacement. The unit of vibratory displacement is the meter (m).

5.2 Reference quantities. Reference quantities are those specified in ANSI S1.8-1969 for levels.

5.2.1 Liquidborne reference sound pressure. For sound pressure level in a liquid the reference sound pressure (p_o) is 1 micropascal (1 μPa).

5.2.2 Airborne reference sound pressure. For sound pressure level in a gas, the reference sound pressure (p_{og}) is 20 micropascals (20 μPa = 20 $\mu N/m^2$ = 0.0002 microbar).

5.2.3 Reference sound power. For sound power level in any medium, the reference power (w_o) is 1 picowatt (1 pW).

5.2.4 Reference vibratory acceleration. For vibratory acceleration level, the reference acceleration (a_o) is 10 micrometers per second squared (10 $\mu m/s^2 = 10^{-5} m/s^2 = 10^{-3}$ $cm/s^2 = 0.394 \times 10^{-3}$ in/s^2). The reference acceleration is nearly one-millionth of the standard acceleration of free fall (1 μg_n). For brief reporting in accordance with this standard, the reference acceleration may be described as $a_o \triangleq 1\ \mu g_n$.

5.2.5 Reference vibratory velocity. For measurement of vibratory velocity level, the reference velocity (v_o) is 10 nanometers per second (10 nm/s = 10^{-8} m/s = 10^{-6} cm/s = 0.394×10^{-6} in/s).

5.2.6 Reference vibratory displacement. For measurement of vibratory displacement level, the reference displacement is 10 picometers (10 pm = 10^{-11} m = 10^{-9} cm = 0.394×10^{-9} in).

5.3 Documentation standards. Uniformity of documentation is necessary to facilitate mutual understanding and effective comparison and analysis of data from various sources. Units, reference quantities and levels required by this standard are summarized in table I.

Table I - Summary of some levels to be measured, and the respective quantities, units and standard reference quantities.

Quantity	Unit	Standard reference	Level
Liquidborne sound pressure (p)	Pascal (Pa)	p_o = 1 µPa	$L_p = 20 \log (p/p_o)$
Airborne sound pressure (p)	Pascal (Pa)	p_{og} = 20 µPa	$L_p = 20 \log (p/p_{cg})$
Sound power (w)	Watt (W)	P_o = 1 pW	$L_w = 10 \log (w/w_o)$
Vibratory acceleration (a)	Meter per second squared (m/s^2) Standard acceleration (g_n)	a_o = 10 $\mu m/s^2$ $a_o \approx 1 \mu g_n$	$L_a = 20 \log (a/a_o)$
Vibratory velocity (v)	Meter per second (m/s)	v_o = 10 nm/s	$L_v = 20 \log (v/v_o)$
Vibratory displacement (d)	Meter (m)	d_o = 10 pm	$L_d = 20 \log (d/d_o)$

5.3.1 Reference quantity identification. The applicable reference quantity shall be indicated on every table, figure, and graph, and at least once in the text. The reference quantity may be introduced by "re" which indicates that the level is "with reference to." For example, "the sound pressure level is 115 dB, re 1 uPa."

5.3.2 Measurement bands. Levels are to be reported for the bandwidths actually used for measurement. (The bandwidth shall be indicated either in octaves or in hertz (Hz), by use of a modifier of the level; examples are octave-band sound pressure level, third-octave-band acceleration level, 10 Hz band velocity level 6 percent band sound pressure level. Such band levels are to be associated with the respective geometric mid-frequencies of the measurement bands. A mid-frequency may be noted in parentheses following the symbol for the level; for example, $L_p(500)$ means the sound pressure level in the third-octave band centered on 500 Hz.

5.3.3 Plotting format. All plots of data in which a level in decibels is plotted against frequency on a logarithmic scale shall be made on graphs in which a factor of ten in frequency is equal in length to 25 dB (preferred) or 50 dB. Where the bandwidth of analysis is 1/3 octave or larger, one factor of ten in frequency shall be 50 millimeters (mm) (preferred) or 2 inches in length. Figure 1 shows a sample plotting form.

5.3.4 Conversion of levels. Standard reference quantities for acoustical levels have been prescribed herein. Levels based on other reference quantities can be converted to levels based on the prescribed standards by use of table II.

Table II - Conversions to be added to levels originally based on other reference quantities to obtain levels based on present standard reference quantities.

Level	Original reference used	Standard reference	Conversion dB
L_p (Liquidborne)	0.0002 dyn/cm^2	1 µPa	+26
	1 µ bar	1 µPa	+100
	10^{-6} N/m^2	1 µPa	0
L_p (Airborne)	0.0002 dyn/cm^2	20 µPa	0
L_W	10^{-13} W	1 pW	-10
	10^{-12} W	1 pW	0
L_a	10^{-3} cm/s	1 μg_n	0
L_v	10^{-6} cm/s	10^{-8} m/s	0
L_d	10^{-9} cm	10^{-11} m	0

6. NOTES

6.1 THE MARGINS OF THIS STANDARD ARE MARKED "#" TO INDICATE WHERE CHANGES (ADDITIONS, MODIFICATIONS, CORRECTION, DELETIONS) FROM THE PREVIOUS ISSUE HAVE BEEN MADE. THIS WAS DONE AS A CONVENIENCE ONLY AND THE GOVERNMENT ASSUMES NO LIABILITY WHATSOEVER FOR ANY INACCURACIES IN THESE NOTATIONS. BIDDERS AND CONTRACTORS ARE CAUTIONED TO EVALUATE THE REQUIREMENTS OF THIS DOCUMENT BASED ON THE ENTIRE CONTENT IRRESPECTIVE OF THE MARGINAL NOTATIONS AND RELATIONSHIP TO THE LAST PREVIOUS ISSUE.

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APPENDIX

CONVERSION OF VIBRATORY ACCELERATION, VELOCITY AND DISPLACEMENT VALUES

10. SCOPE

10.1 This appendix covers the conversion in dBs of vibratory acceleration, velocity, and displacement values obtained using various sound level meters, accelerometers and integrator systems.

20. MEASUREMENTS

20.1 Measurements of acceleration, velocity and displacement can be and have been made using an accelerometer, a control box (sometimes called an integrator box) and a sound level meter. The control can be switched to give a linear response (acceleration), one stage of integration (velocity), or two stages of integration (displacement). When such instruments are used, in lieu of reference quantities being stated, the dBs corresponding to a particular acceleration, velocity, or displacement are stated.

30. CONVERSION QUANTITIES

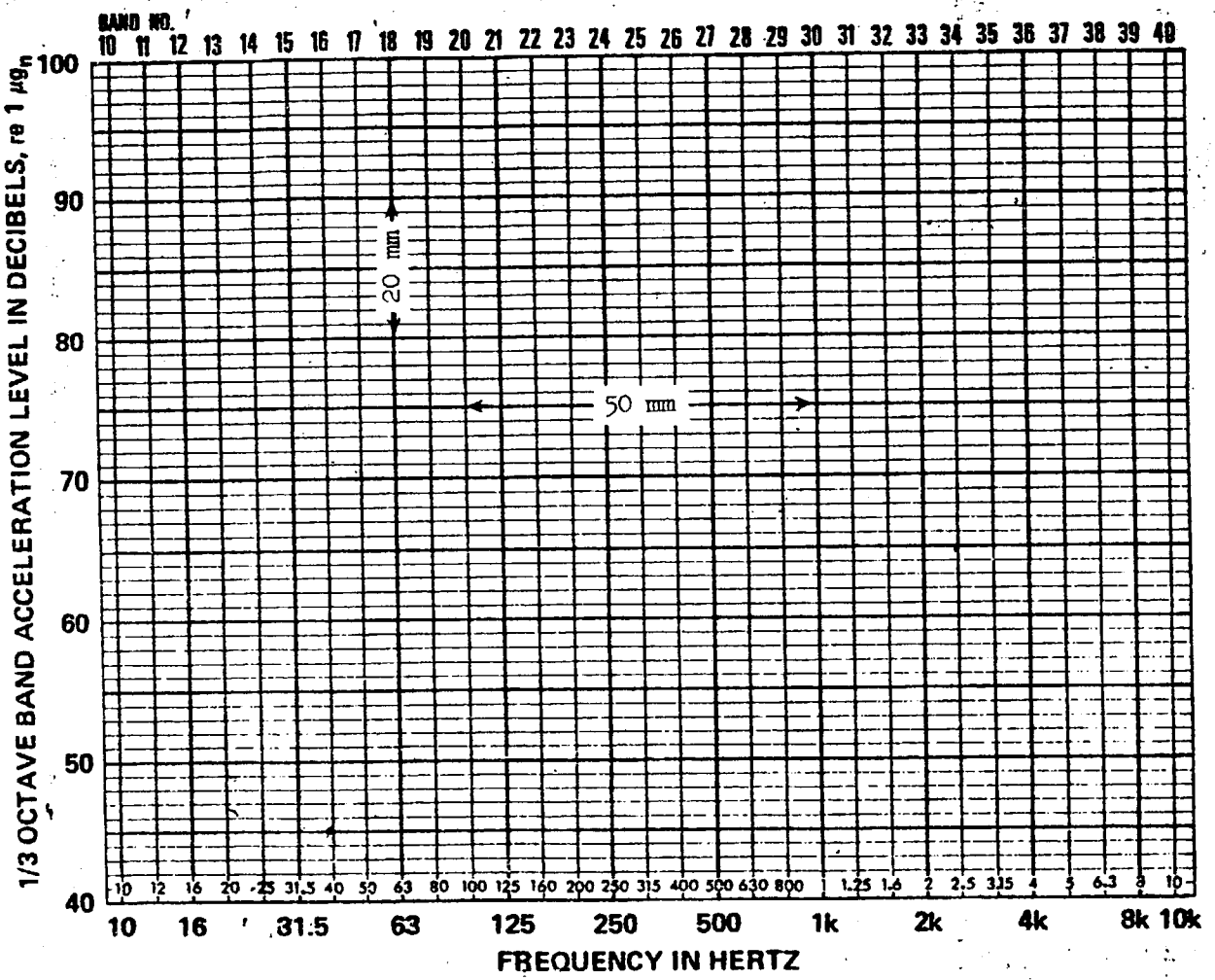
30.1 Conversion quantities in dBs are shown in table III for these systems. These systems are General Radio Corp. systems in common Navy use. (For other systems, the conversion factor will have to be computed if not shown in table I.

Table III - Conversion factors for pickup systems.

Quantity	Corresponding level dB	Pickup system (see note)	Standard reference	Conversion dB
1 in/s^2	40	1/, 4/, 5/	1 μg_n	+ 28
	50	2/		+ 18
	60	3/		+ 8
	70	6/		- 2
1 in/s	80	1/	10^{-8} m/s	+ 48
	90	2/, 4/, 5/		+ 38
	100	3/		+ 28
	110	6/		+ 18
1 in	110	1/	10^{-11} m	+ 78
	120	2/, 4/, 5/		+ 68
	130	3/		+ 58
	140	6/		+ 48

NOTE: Vibration pickup system identification.

Pickup system	Control box	Pickup
1/ 1560 - P11	1560 - P21	1560 - P51
2/ 1560 - P11B	1560 - P21B	1560 - P52
3/ 1560 - P11S1	1560 - P21	759 - P35
4/ 1560 - P11S2	1560 - P21S1	1560 - P53
5/ 1560 - P13	1560 - P23	1560 - P53
6/ 1560 - P14	1560 - P24	1560 - P54



Other typical ordinate notations are Octave band sound pressure level in decibels, re 20 µPa; 1/3 octave band sound pressure level in decibels, re 1 uPa; 1/3 octave band power level, re 1 pW.

Figure 1 - Sample plotting form.

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