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MILITARY STANDARD

AIRBORNE AND STRUCTUREBORNE NOISE MEASUREMENTS AND ACCEPTANCE CRITERIA of SHIPBOARD EQUIPMENT

DEPARTMENT OF THE NAVY

BUREAU OF SHIPS

WASHINGTON, D C., 20360

Airborne and Structureborne Noise
Measurements and Acceptance Criteria of
Shipboard Equipment
MIL-STD-740B(SHIPS)

1. This military standard has been approved by the Bureau of Ships and is mandatory for use by activities under the cognizance of the Bureau of Ships, effective 13 January 1965

2. Recommended corrections, additions, or deletions should be addressed to the Chief, Bureau of Ships, Department of the Navy, Washington, D. C. 20360

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FIGURES

1. SCOPE and APPROACH

1.1 Scope. - This standard covers acceptable instrumentation and procedures for the measurement of and acceptance criteria for, airborne and structureborne noise of Naval shipboard equipment.

1.2 Application - This standard is intended to supplement equipment, shipbuilding and purchase specifications, and similar documents, applicable to all Naval shipboard equipment required to be quieter than equipment produced by normal production practices, except that structureborne noise requirements for main propulsion turbines, main reduction gears, and ship service turbine generator sets are not covered by this standard and will be found in the applicable equipment document

1.3 Implementation - In implementing this standard information required by 5 16 shall be included in the equipment specification.

1.4 Approach -

1.4.1 Measurement - The basic method for airborne noise testing is the determination of sound power Sound pressure measurements may be specified in equipment specifications for certain items, such as large equipment where test conditions preclude valid calculations, or small equipment where costs of testing significantly affect the cost of the equipment. The basic method for structureborne noise testing is the measurement of the vibrational acceleration of resiliently mounted equipment at its mounting points

1.4.2 Acceptance criteria - Four airborne noise acceptance criteria are defined in terms of octave band sound power levels (see 5. 2. 4) that each item of equipment may be permitted to generate Three structureborne noise acceptance criteria are defined in terms of one-third octave band vibrational acceleration levels above mountings (see 5. 3 4)

2. REFERENCED DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein

SPECIFICATIONS

MILITARY

MIL-M-17185 - Mounts, Resilient, General Specifications and Tests For Shipboard Application.
MIL-M-17191 - Mounts, Resilient; Portsmouth Bonded Spool Type.
MIL-M-17508 - Mounts, Resilient, Naval Engineering Experiment Station Types 6E2000, 6E900, 7E450, 6E150 and 6E100
MIL-M-19379 - Mounts, Resilient, Mare Island Types 11M15, 11M25, and 10M50.
MIL-M-19863 - Mount, Resilient, Type 5B5000
MIL-M-21649 - Mount, Resilient, Type 5M10, 000-H

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage

2.2 Other publications - The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated the issue in effect on date of invitation for bids or request for proposal shall apply

AMERICAN STANDARDS ASSOCIATION (ASA)

S1.1 - Acoustical Terminology (Including Mechanical Shock and Vibration)
S1 2 - Physical Measurement of Sound, Method for the
S1.4 - General Purpose Sound Level Meters, Specification for
S1 6 - Acoustical Measurements Preferred Frequencies for
S2.2 - Calibration of Shock and Vibration Pickups, Methods for the

Z24 10 - Octave-Band Filter Set for Analysis of Noise and Other Sounds Specification for
Z24 11 - Free Field Secondary Calibration of Microphones Method for the

(Application for copies should be addressed to the American Standards Association 10 East 40th Street New York, New York 10016)

3 DEFINITIONS

3 1 Airborne noise —Airborne noise is undesired sound in air

3 2 Structureborne noise —Structureborne noise is undesired vibration in or of solid bodies such as machinery, foundations, or ship structures

3 3 Decibel —The decibel (db) is the dimensionless unit of level for expressing the ratio of two values of power, one of these values may be a standard of reference The number of decibels is 10 times the logarithm to the base 10 of the power ratio, that is, db = $10 \log_{10} (W_1 / W_2)$ in accordance with ASA S)

Under commonly accepted conditions quantities proportional to power include the square of root mean square (rms) values of either the pressure velocity, acceleration voltage or current for example in electricity

$$W_1 = I_1^2 R, \quad W_2 = I_2^2 R$$

$$db = 10 \log_{10} \frac{W_1}{W_2} = 10 \log_{10} \frac{I_1^2 R}{I_2^2 R} = 20 \log_{10} \frac{I_1}{I_2}$$

Note Whenever a level is expressed in db relative to a standard of reference that standard of reference shall be explicitly stated

3 4 Sound power level —Sound power level is the sound power emitted by a source expressed in decibels relative to a reference power of 10^{-12} watts The symbol for sound power is L_w thus,

$$L_w \text{ (db)} = 10 \log_{10} \frac{\text{power (watts)}}{10^{-12} \text{ (watts)}}$$

It is a quantity that is calculated from sound pressure level measurements in a known acoustic environment

Note The reference for sound power level of 10^{-12} watts conforms with the more common practice

3 5 Sound pressure level —Sound pressure level, in decibels of a sound is 20 times the logarithm to the base 10 of the ratio of the rms pressure of this sound to the reference pressure of 0 0002 dynes square centimeter (approximately 0002 microbar) The symbol for sound pressure level is L_p

$$L_p \text{ (db)} = 20 \log_{10} \frac{\text{measured rms pressure (dynes cm}^{-2})}{0\ 0002 \text{ (dynes cm}^{-2})}$$

3 6 Vibrational acceleration level —The acceleration level of a vibration in decibels is 20 times the logarithm to the base 10 of the ratio of rms acceleration of this vibration to the reference acceleration of 10^{-3} cm sec^{-2} The symbol for vibrational acceleration level is L_a

$$L_a \text{ (db)} = 20 \log_{10} \frac{\text{measured rms acceleration (cm sec}^{-2})}{10^{-3} \text{ (cm sec}^{-2})}$$

3 7 Vibrational velocity level —The velocity level of a vibration in decibels is 20 times the logarithm to the base 10 of the ratio of the rms velocity of this vibration to the reference velocity of 10^{-6} cm sec

The symbol for vibrational velocity level is L_v

$$L_v \text{ (db)} = 20 \log_{10} \frac{\text{measured rms velocity (cm/sec)}}{10^{-6} \text{ (cm/sec)}}$$

This definition is inserted for continuity with prior practice although vibrational acceleration level is the preferred quantity

3 8 Band level – Band level is the total level of all noise in a specified frequency band

3 8 1 Broadband – The term broadband refers to the unfiltered response of the particular noise measuring system

3 8 2 Octave band – An octave band is a band of frequencies in which the ratio of the extreme frequencies is equal to 2 1 The preferred octave band centers extend from 31 5 cycles per second (cps) to 8000 cps The octave bands given in ASA Z24 10 extending from 37-75 cps to 4800-9600 cps are acceptable in lieu of the above

Note The width of an octave band is approximately 71 percent of its band center frequency

3 8.3 One-third octave band – A one-third octave band is a band of frequencies in which the ratio of the extreme frequencies is equal to the cube root of 2, that is, $f_h/f_l = \sqrt[3]{2} = 1\ 260$ where f_h and f_l are the nominal cutoff frequencies of the band The preferred one-third octave bands are those whose band centers have been adjusted so that the ratio of successive band centers is $\sqrt[10]{10} = 1\ 259$. Center frequencies of the preferred one-third octave bands shall be in accordance with ASA S1. 6.

Note The width of a one-third octave band is approximately 23 percent of its band center frequency

3 8 4 Narrow band – For this standard a narrow band is a band whose width is not less than one percent nor more than eight percent of the band center frequency Constant width bands, whose band widths expressed in percentage of their band center that fall within the above definition, may be used

3 8 5 Band center frequency – Band center frequency is the geometric mean between the extreme frequencies of the band

$$f_c = \sqrt{f_h f_l}$$

where f_c is the band center frequency and f_h and f_l are the nominal high and low cutoff frequencies of the band

3 9 Narrow band analysis – Narrow band analysis is performed to determine the frequency components of a noise signal Results are expressed as the level of the content of the band

3 10 Equipment – Equipment includes any subsystem, or part thereof, including electrical, electronic, mechanical, and hydraulic components, which may produce noise. Equipment is classified as to airborne noise by grade Equipment is classified as to structureborne noise by type

3 10 1 Grade A equipment – Grade A equipment is any item of equipment which will be placed in spaces where intelligible speech communication is frequently required and minimum vocal effort by the speaker is a consideration

3 10 2 Grade B equipment – Grade B equipment is any item of equipment which will be placed in spaces where comfort of personnel in their quarters is the principle consideration.

3 10 3 Grade C equipment – Grade C equipment is any item of equipment which will be placed in spaces whose function requires minimum annoyance to working personnel

3 10 4 Grade D equipment – Grade D equipment is any item of equipment which will be placed in spaces where deafness avoidance is the prime consideration and intelligible speech communication is not normally required

3 10 5 Type 1 equipment – All compressors and internal combustion engines are type 1 equipment

3 10 6 Type 2 equipment – All pumps are type 2 equipment

3 10 7 Type 3 equipment – All other equipments are type 3

4 GENERAL STATEMENT

4 1 This standard shall apply in case of conflict with documents referenced herein

5 DETAILED REQUIREMENTS

5 1 Environmental effects – For purposes of this standard no corrections for band width and ambient noise levels are permitted Instrumentation shall be of a type having low response to ambient magnetic, electric and acoustic fields No corrections for these effects will be permitted in the measurements made of machinery noise By "low" is meant that system response to the ambient fields alone, expressed in whatever measurement unit used, will be at least 10 db below the limit specified For airborne and structureborne noise tests, and for calibration, the temperature and relative humidity effects shall be known and data correction made where necessary

5 2 Airborne noise –

5 2 1 Airborne noise limits – Airborne noise limits shall be expressed as maximum permissible sound power or sound pressure levels of specified octave bands

5 2 2 Instruments –

5 2 2 1 Broadband measuring instruments – Sound pressure level shall be measured with an omnidirectional microphone and sound level meter conforming in all respects to those specified in ASA S1 4 If tape recorders are used to preserve the broadband noise output of transducers for later analysis, the complete system shall have a response known within plus or minus 2 db over the required frequency range

5 2.2 2 Octave band analysis instruments – Octave band sound pressure levels shall be measured by the instruments used in 5 2 2 1 (microphone and sound level meter) with the addition of a graphic level recorder and octave band filters meeting the requirements of ASA Z24 10 and covering the band center frequency range 31 5-8000 cps The complete system shall have a response known within plus or minus 2 db under the conditions specified in 5.2 2 1

5 2 3 Airborne measurement procedures –

5 2 3 1 Sound power level determinations – Sound power level determinations, shall be obtained in accordance with ASA S1 2

5 2 3.2 Sound pressure level measurements – Sound pressure level measurements, shall be obtained in accordance with the following procedures

(a) The microphone shall be placed at a distance of 3 feet from the nearest surface of the equipment undergoing tests in each of the following positions

(1) On each side, at the same height as the equipment horizontal centerline

(2) At each end, along the equipment centerline

(3) Above the equipment, over the centerline

For motor generators or motor driven auxiliaries, make separate measurements for the motor and the generator or auxiliary ends

(b) To ensure measuring the maximum noise level in the vicinity of each position described above, the microphone shall be moved about in a one cubic foot volume outward from the equipment at the positions stated in (a) above The location in each volume at which the maximum broadband level occurs shall be used as the measurement position At each position, the microphone shall be free of effects from vibration and disturbing electric or magnetic fields (see 5 1) There shall be no observer, instrument, or reflecting surface, other than the floor nearer than 3 feet to the microphone In the case of 5 2.3 2 (a) (1) and (3), if the machine has air openings, the microphones shall be placed as close to each air inlet and outlet as possible without placing them in the path of direct air flow, otherwise at mid-length of the machine

(c) Octave band levels shall be measured at each microphone position

5 2 4 Airborne acceptance criteria —The octave band sound power levels specified in table I shall be used as the basis of acceptance for airborne noise of equipment The supplier may perform narrower band analysis to identify any offending frequencies to aid in his corrective measures

Table I - Airborne noise acceptance levels

Airborne grade	Sound power levels, ref 10^{-12} watts for center frequencies of standard octave bands (cps)								
	31 5	63	125	250	500	1000	2000	4000	8000
A	-	-	-	-	Average for three bands 71			-	-
B	97	96	86	83	80	78	77	76	75
C	92	85	79	75	72	69	67	65	64
D	122	117	112	107	97	92	92	92	92

5 2 4 1 Acceptance criteria for airborne noise that are not in accordance with this standard shall be approved by the Bureau of Ships

5 3 Structurborne noise —

5 3 1 Structureborne noise limits —Structureborne noise limits in terms of vibrational acceleration levels (or vibrational velocity levels) shall be expressed as one or more of the following

(a) Maximum permissible one-third octave band vibration levels

(b) Maximum permissible levels of specified frequencies such as rotational, twice electrical line frequency, slot frequency, gear mesh frequency, and so forth

5 3 2 Instruments. —

5.3 2 1 Broadband measuring instruments —Structureborne noise shall be measured using accelerometers, preamplifier (if needed), sound level or vibration meter, and connecting cables having a complete system response which is known within plus or minus 2 db over the frequency range between the fundamental forcing frequency of the machine or 25 cps, whichever is lower, and 8000 cps.

5 3 2 2 One-third octave band analysis instruments —One-third octave band vibration levels shall be measured by the instruments used in 5 3 2.1 (accelerometers, preamplifier, if used, sound level or vibration meter) with the addition of one-third octave band filters, a graphic level recorder and connecting cables The filters shall cover band centers from the fundamental forcing frequency of the machine or 25 cps, whichever is lower to 8000 cps, and have rejection characteristics beyond the nominal band edges at least as good as those specified in ASA Z24 10 for octave band filters The graphic level recorder shall provide a permanent trace The scale factor required to convert the recorder traces to 'true' noise levels shall be marked on the traces The complete system shall have a response known within plus or minus 2 db for

each one-third octave band under the conditions specified in 5 3 2 1, for all levels and frequencies of interest The scanning rate shall not be less than 5 seconds per band

5 3 2 3 Narrow band analysis instruments —The system shall include the instruments of 5 3 2 1 (accelerometer, pre-amplifier, if used, sound level or vibration meter) with the addition of a narrow band analyzer, a graphic level recorder, and connecting cables The graphic level recorder shall provide a permanent trace The complete system shall have a response known within plus or minus 2 db under the conditions specified in 5 3 2 1 and cover the frequency range from the fundamental forcing frequency of the machine or 25 cps, whichever is lower, to 8000 cps The scale factor required to convert the recorder traces to "true" noise levels shall be marked on the traces The graphic level recorder writing speeds and analyzer sweep rates shall be selected to insure the required measurement accuracy and repeatability including speeds slow enough to record maximum values when there are fluctuations Analyzer sweep rate shall not exceed $(f_h - f_l\ 2)^2$ or 200 cycles per second, second whichever is slower

5 3 3 Structureborne measurement procedures —The procedure in making structureborne noise measurements is to select locations for triaxial assemblies of transducers, attach transducers, select the noisiest broadband location and direction, and measure and analyze the noise at that location and direction

5 3 3 1 Selection of transducer locations —Transducers shall be attached either on the feet or flanges, or on the subbase, at a minimum of two diagonally opposite locations on equipment For example, on a motor driven auxiliary supported by a common subbase, the diagonally opposite locations would be two corners of the subbase directly above the resilient mountings and as close to the mounting bolts as is feasible For a flanged unit, the locations would be at resilient mountings on diametrically opposite sides of the flange

Note The selection of the measurement location requires careful consideration of the following objectives

(a) To select locations truly representative of the noise producing effects of the equipment as installed in the ship

(b) To select, as well as can be determined, locations which will be accessible after shipboard installation

(c) To avoid locations which are unduly flexible

5 3 3 2 Transducer attachment —Transducers shall be attached as follows

(a) Transducers shall be attached to blocks, which are to be brazed or welded to equipment, or subbase, as close as possible to the mounting points of the equipment to be tested

(b) The blocks shall be made of steel and shall be as small as possible The block surfaces on which transducers are mounted shall be plane and shall have a surface finish of 125 micro-inches rms or better and be mutually perpendicular within one degree

(c) Three holes in the mounting blocks shall be drilled and tapped to a depth of at least 1/4 inch with 10-32 NF threads to accommodate triaxial arrays of transducers which shall be attached to the blocks with insulated steel studs The holes shall be perpendicular to the finished surfaces within plus or minus 1 degree

(d) Just before transducers are mounted on a block, all mating surfaces shall be cleaned of all dirt, grease, and other foreign matter in preparation for mounting The surfaces of the attachment area and the studs shall be lightly covered with clean oil or grease

(e) The mounting blocks shall not be removed and shall be preserved with a rust inhibiting coating after completion of testing

(f) If brazing or welding cannot be accomplished, the mounting blocks shall be attached to the location with a thin layer of epoxy resin cement Blocks attached by cement shall be removed upon completion of test The transducers may be attached directly to the equipment being tested only where there is insufficient space to accommodate the mounting blocks

(g) Locations for transducer positions shall be marked where mounting blocks cannot be permanently placed

(h) Care shall be taken to avoid interfering electrical loops

5 3 3 3 Broadband measurements – The instruments shall be in accordance with 5 3 2 1 Broadband structureborne noise measurements shall be made at each location in the vertical, transverse, and axial directions with respect to the equipment tested

5 3 3 4 One-third octave band measurements – The instruments shall be in accordance with 5 3 2 2 One third octave band measurements shall be made at the location and in the direction in which the maximum broadband structureborne noise is observed in accordance with 5 3 3 3 The complete frequency range of interest shall be scanned and recorded twice If any one-third octave band indicates a difference between recorded levels of more than 3 db between the two scans the level in this band shall be recorded for at least one minute The level reported for each band shall be the maximum level recorded (excluding spurious signals) The scale factors required to convert levels to true levels shall be submitted with the data

5 3 3 5 Narrow band measurements – The instruments shall be in accordance with 5 3 2 3 with a band pass characteristic as defined in 3 8 4 A narrow band analysis shall be taken at the same location and direction as the one-third octave band measurements for every one-third octave band that exceeds specified levels

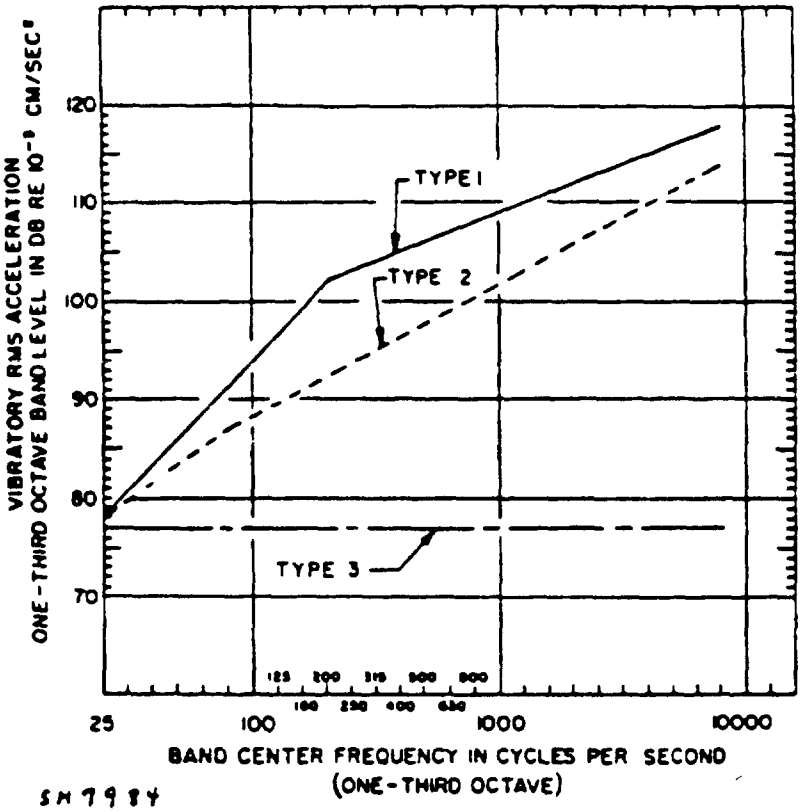
Note If maximum permissible levels are given in equipment specifications for specified forcing frequencies, narrow band measurements shall be made at the specified frequencies at the locations and in the directions given in 5 3 3 3 In this case, narrow band analysis may be done manually The analyzer shall be tuned to the peak response in the vicinity of each calculated forcing frequency, the level of the signal recorded for one minute, and the maximum level reported

5 3 4 Structureborne acceptance criteria – One-third octave band levels shown on figure 1 shall be used as the basis for acceptance of structureborne noise of equipment If one-third octave band levels exceed the specified limits from between the fundamental forcing frequency of the machine or 25 cps, whichever is lower, and 500 cps, a narrow band analysis may be taken as the basis for acceptance of the structureborne noise of the equipment for this region the analysis shall show no peaks over the limits specified for the one-third octave band or bands in question

5 3 4 1 Acceptance criteria for structureborne noise that are not in accordance with this standard shall be approved by the Bureau of Ships

5 4 Mounting equipment for test – For both airborne and structureborne measurements, equipment shall be oriented in a normal operating position and shall be tested resiliently mounted regardless of whether or not resilient mountings are used in service Equipment that is resiliently mounted in service shall be tested using the same type resilient mountings as installed on board ship In cases where pipes are connected to the equipment, a flexible connection shall be inserted in each pipe run between the equipment under test and any external piping The vertical natural frequency of the mounted assembly shall be less than or equal to 1/4 of the lowest forcing frequency within the equipment Resilient mountings conforming to MIL-M-17191, MIL-M-17506, MIL-M-19379, MIL-M-19863, or MIL-M-21649 shall be used where possible. The complete assembly should be supported on reinforced concrete or cast metal floor which is preferably in direct contact with the ground Any pedestals required to accommodate the resilient mountings preferably should be of steel reinforced concrete If mountings specified above cannot be used, the mountings used shall be in accordance with MIL-M-17185, and their use shall be approved by the bureau or agency concerned

5 4 1 Equipment which has a relatively light framework or structure (for example, controllers, control cubicles, non-rotating or non-reciprocating equipment) and which is to be solidly mounted (that is, no resilient mounts) on shipboard shall be mounted on a test fixture for structureborne noise tests The equipment shall be mounted on the fixture by the designed points of attachment of the equipment The fixture shall be stiff between points of attachment and damped to eliminate resonances within itself If the equipment being tested contains internal sound isolation mounts, the mass of the fixture shall be great enough to permit these internal mounts to function properly The combined assembly of equipment and test fixture shall be resiliently mounted and oriented in its normal operating position



CORRECTION FACTORS

FOR TYPE 2 NON-SEA CONNECTED PUMP, ADD 5DB TO THE STATED ACCEPTANCE CRITERIA

FOR SOLIDLY MOUNTED EQUIPMENT SUBTRACT 20db FROM THE CURVES

FOR FUNDAMENTAL FREQUENCIES BELOW 25CPS, EXTRAPOLATE TO THE REQUIRED LEVEL

Figure 1 - Structureborne noise acceptance levels

5 5 Acceptability of instruments —Instrumentation used for noise measurement and analysis shall have been calibrated and found to meet the requirements specified herein

5 5 1 Laboratory calibration —A laboratory calibration shall be made of all noise measuring instrument systems within six months prior to each use, or after exposure to mechanical shock, or other unusual disturbing conditions, or upon demand by the Government inspector Within 6 months prior to each use, a calibration, traceable to the National Bureau of Standards, shall be made of all calibration instrumentation

5 5 1 1 Transducer calibration The method of calibration of field transducers shall be as specified in ASA S2 2 and ASA Z24 11, as applicable Structureborne noise transducers shall be calibrated, including their insulated mounting stud(s) (if used), while fastened to a steel surface Secondary standard transducers shall be kept under controlled conditions in the manufacturer s laboratory and used only for comparison with field transducers

5 5 1 2 Noise measuring system electrical calibration —A calibration of the complete noise measuring system including transducer or simulated transducer, pre-amplifier, amplifiers, meter, analyzer, graphic level recorder, magnetic tape recorder, as applicable and so forth, shall be made Cables and connectors shall have the same electrical characteristics as those used in the field tests

5 5 1 2 1 Frequency response —Known voltages at known frequencies shall be introduced into the system to simulate the transducer output and the level shall be recorded The frequencies selected shall be

(a) For analyzer with fixed filter sets, at the band centers

(b) For analyzers with tunable filter sets used to scan continuously a band of frequencies, at the beginning, end, and at least two intermediate frequencies (including 400 cps if within the scanning range) in each frequency range scanned

5 5 1 2 2 Linearity —At a low frequency, at 400 cps, and at a high frequency, calibration shall be made at the following voltages

(a) Equal to the lowest transducer output required by the applicable equipment specification

(b) Ten times that in (a)

(c) One-hundred times that in (a)

(d) One-thousand times that in (a)

5 5 1 2 3 The laboratory calibration of systems and transducers specified in 5 5 1 2 1 and 5 5 1 2 2 shall be accurate within the limits specified in 5 2 2 1, 5 2 2 2, 5 3 2 1, 5 3 2 2 and 5 3 2 3 Whenever any component of this system is changed, this calibration shall be performed only for the new component, and a field calibration (see 5 5 2) shall be made with the new component in the system

5 5 2 Field calibration —For each work shift, prior to testing, an electrical calibration check shall be made of the noise measuring system exclusive of the transducer by introducing a known voltage and recording the level at the following frequencies

(a) For analyzer with fixed filter sets at representative band centers

(b) For analyzers with tunable filter sets, at representative frequencies within each range of frequencies scanned

In addition to system electrical field calibrations required above, the noise measuring system including the transducer shall be checked by comparison using a transducer calibrator Total system calibrations using transducer calibrators shall be conducted at the beginning (initial) and end (final) of each day of testing If tests on a piece of equipment continue for more than one day, the final system calibration may be deferred until all tests have been completed on that unit If tests commence within one day on another unit, the final system calibration for the previous unit may serve as the initial calibration for the next unit The field calibration shall be accurate within the limits specified in 5 2 2 1, 5 2 2 2, 5 3 2 1, 5 3 2 2 and 5 3 2 3

5 6 Operating conditions —The operating conditions such as load, speed, and voltage under which equipment is to be tested for airborne and structureborne noise shall be as specified in the equipment specification

5 7 Special test requirements —If test requirements other than those specified herein are required in certain cases, these special test requirements shall be specified in the equipment specification

5 8 Equipment designation —The equipment specification shall specify the airborne grade and the structureborne type of equipment that is to be tested (see 3 10)

5 9 Reports —

5 9 1 Detailed report —A detailed test report for the first equipment tested on each contract or order shall be submitted to the procuring activity This test report shall include

(a) Test identification
  (1) Testing activity
  (2) Date
    a Test
    b Analysis
  (3) Ship
  (4) Contract No (equipment)
(b) Equipment information
  (1) Item name
    a. Driven serial No
    b Manufacturer
    c Driver serial No
    d Manufacturer
    e Driver rpm
    f Driver hp
    g Phase
    h. Volts Amps
  (2) Compartment
  (3) Weight including subbase
  (4) Test (horizontally) (vertically)
(c) Test conditions
  (1) Throttling condition (if any)
  (2) Suction conditions
  (3) Discharge
  (4) Load (full, half, and so forth)
  (5) Flow rate
  (6) Fluid temperature
  (7) Operating rpm
(d) Mounting information
  (1) Mount manufacturer
  (2) Model No
  (3) Mount load rating (pounds)
  (4) Number of mounts
(e) Sketch of test set-up
  (1) Show the location resilient mounts, transducers, center of gravity, microphone and pedestals or fixtures that support equipment
  (2) Describe geometric position of test unit relative to floor, walls and ceiling of test room and acoustic center of sound source, assumed or measured
  (3) State method of attachment of transducers, make and model number
  (4) Describe type of room (that is, anechoic, reverberant, and so forth), dimensions of the test room, and description of the walls, ceiling, and floor
  (5) Block diagrams and identification of make and model number of measurement and analysis instruments used
(f) Calibration data
  (1) Date and place of most recent laboratory calibration

(2) Date and place of most recent field calibration (if different from laboratory calibration date)

(g) Test data

(1) Tabular or graphic records of airborne and structureborne measurements uncorrected, including ambient for all frequency bands used, noting corrections to data for comparison to specifications

(2) Tabulation of measured levels exceeding specification and the corresponding specification level

5 9 2 Short report. —A short report for each equipment tested, except the equipment covered by 5 9 1, shall be submitted to the procuring activity. This test report need contain only items (a), (b), (c) and (g) of 5 9 1.

5 10 Warning plate. —All equipment which meets the criteria of this standard shall be prominently identified by affixing a warning plate bearing the legend "NOISE TESTED EQUIPMENT—HANDLE WITH EXTREME CARE."

5 11 Drawing information. —In addition to the information required on drawings by the applicable equipment specification the assembly drawings shall contain specific notes as to assembly procedures and tolerances to be maintained during overhaul so that machines may be restored to designed level of quietness. The location of all attachment points for pickups used in measuring structureborne noise shall be shown on the drawings, and suitable means shall be indicated for the protection and preservation of these attachment points.

5 12 Selection of units. —Noise tests for compliance with airborne and structureborne noise acceptance requirements shall be made on every unit with the following exception. For non-rotating, non-reciprocating, type 3 equipment, if the first three units of a design are below the required limits by 10 db or more at all frequencies, following units shall be selected for test in accordance with the sampling procedures for the applicable selective testing specified in the equipment specification.

5 13 Shock protection. —Equipment tested for airborne and structureborne noise in accordance with this standard shall be shipped on mountings with captive features approved under MIL-M-17185.

5 14 Marking. —In addition to any marking required by the equipment specification shipping containers shall be stenciled in red, on two sides and both ends with the following:

"CRITICAL, CLOSE TOLERANCE OPERATING
EQUIPMENT. HANDLE WITH EXTREME
CARE DO NOT SUBJECT TO UNNECESSARY
SHOCK OR JARS".

The letters shall be a minimum of 1-1 2 inches high, except for small containers with insufficient space for this size letters, in which case the letters shall be of such size as to be legible in normal handling. Arrows, as indicated in MIL-STD-129 and the words "THIS SIDE UP" shall be marked on all containers.

5 15 Unpacking instructions. —Unpacking instructions shall be provided and shall be sealed in waterproof envelopes which shall be securely attached to the outside of each container in the most protected location. The words "UNPACKING INSTRUCTIONS" shall be stenciled on each container to indicate location of such instructions.

5.16 Documentation. —

5.16 1 When this standard is invoked the equipment specification shall require that the following data be furnished with bids:

(a) A detailed list of exceptions to requirements of the equipment specification which the bidder proposes to take in order to improve the quietness of the equipment. An estimate of the amount of improvement in quietness and change (if any) in other characteristics shall accompany each proposed exception.

(b) Outline of the noise test facilities to be employed for airborne and structureborne noise, and any additional facilities proposed for installation to comply with the test requirements of the equipment specification

5 16 2 When this standard is invoked, the equipment specification shall define the following, if applicable

(a) If airborne testing is to be done in accordance with sound pressure procedures (see 1 4 1)

(b) Grade and type of equipment to be airborne and structureborne noise tested (see 3 10)

(c) If equipment is to be mounted on test fixture (see 5 4 1)

(d) Equipment operating conditions during noise tests (see 5 6)

(e) Special test requirements (see 5 7)

Notice —Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer

Preparing activity
(Navy SH
(Project MISC-N200(SH))

MILITARY STANDARD

AIRBORNE AND STRUCTUREBORNE NOISE MEASUREMENTS AND ACCEPTANCE CRITERIA of SHIPBOARD EQUIPMENT

TO ALL HOLDERS OF MIL-STD-740B(SHIPS)

1. THE FOLLOWING PAGES OF MIL-STD-740B(SHIPS) HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
1	13 January 1965	(Reprinted without change)	
2	21 June 1965	2	13 January 1965
3		(Reprinted without change)	
4	21 June 1965	4	13 January 1965
5	21 June 1965	5	13 January 1965
6	21 June 1965	6	13 January 1965
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2. RETAIN THIS NOTICE AND INSERT BEFORE THE TABLE OF CONTENTS.

3. Holders of MIL-STD-740B(SHIPS) will verify that page changes and additions indicated above have been entered. The notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or canceled.

Preparing activity
Navy - SH
(Project MISC-N212Sh)

1. SCOPE and APPROACH

1.1 Scope - This standard covers acceptable instrumentation and procedures for the measurement of and acceptance criteria for, airborne and structureborne noise of Naval shipboard equipment.

1.2 Application. - This standard is intended to supplement equipment, shipbuilding and purchase specifications, and similar documents, applicable to all Naval shipboard equipment required to be quieter than equipment produced by normal production practices, except that structureborne noise requirements for main propulsion turbines, main reduction gears, and ship service turbine generator sets are not covered by this standard and will be found in the applicable equipment document.

1.3 Implementation. - In implementing this standard information required by 5.16 shall be included in the equipment specification

1.4 Approach. -

1.4.1 Measurement. - The basic method for airborne noise testing is the determination of sound power Sound pressure measurements may be specified in equipment specifications for certain items, such as large equipment where test conditions preclude valid calculations, or small equipment where costs of testing significantly affect the cost of the equipment. The basic method for structureborne noise testing is the measurement of the vibrational acceleration of resiliently mounted equipment at its mounting points

1.4.2 Acceptance criteria. - Four airborne noise acceptance criteria are defined in terms of octave band sound power levels (see 5.2.4) that each item of equipment may be permitted to generate. Three structureborne noise acceptance criteria are defined in terms of one-third octave band vibrational acceleration levels above mountings (see 5.3.4).

2. REFERENCED DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein:

SPECIFICATIONS

MILITARY

MIL-M-17185 - Mounts, Resilient; General Specifications and Tests for Shipboard Application.
MIL-M-17191 - Mounts, Resilient; Portsmouth Bonded Spool Type.
MIL-M-17508 - Mounts, Resilient; Naval Engineering Experiment Station Types 6E2000 6E900, 7E450, 6E150 and 6E100.
MIL-M-19379 - Mounts, Resilient; Mare Island Types 11M15, 11M25, and 10M50.
MIL-M-19863 - Mount, Resilient, Type 5B500C.
MIL-M-21649 - Mount, Resilient; Type 5M10, 000-H.

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.

2.2 Other publications. - The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated the issue in effect on date of invitation for bids or request for proposal shall apply:

AMERICAN STANDARDS ASSOCIATION (ASA)

S1.1 - Acoustical Terminology (Including Mechanical Shock and Vibration).
S1.2 - Physical Measurement of Sound, Method for the
S1.4 - General Purpose Sound Level Meters, Specification for
S1.6 - Acoustical Measurements, Preferred Frequencies for
S2.2 - Calibration of Shock and Vibration Pickups, Methods for the

Z24.10 - Octave-Band Filter Set for Analysis of Noise and Other Sounds, Specification for
Z24.11 - Free Field Secondary Calibration of Microphones, Method for the

(Application for copies should be addressed to the American Standards Association, 10 East 40th Street, New York, New York 10016.)

3. DEFINITIONS

3.1 Airborne noise. - Airborne noise is undesired sound in air.

3.2 Structureborne noise. - Structureborne noise is undesired vibration in or of solid bodies such as machinery, foundations, or ship structures.

3.3 Decibel. - The decibel (db) is the dimensionless unit of quantities proportional to level for expressing the ratio of two values of power; one of these values may be a standard of reference. The number of decibels is 10 times the logarithm to the base 10 of the power ratio, that is, $db = {}_{10}\log_{10}(W_1 W_2)$ in accordance with ASA S1.1. Under commonly accepted conditions, quantities proportional to power include the square of root mean square (rms) values of either the pressure, velocity, acceleration voltage, or current for example, in electricity.

$$W_1 = I_1^2 R, \quad W_2 = I_2^2 R$$

$$db = 10 \log_{10} \frac{W_1}{W_2} = 10 \log_{10} \frac{I_1^2 R}{I_2^2 R} = 20 \log_{10} \frac{I_1}{I_2}$$

Note: Whenever a level is expressed in db relative to a standard of reference, that standard of reference shall be explicitly stated.

3.4 Sound power level. - Sound power level is the sound power emitted by a source expressed in decibels relative to a reference power of 10^{-12} watts. The symbol for sound power is L_w, thus,

$$L_w(db) = 10 \log_{10} \frac{\text{power (watts)}}{10^{-12} \text{ (watts)}}$$

It is a quantity that is calculated from sound pressure level measurements in a known acoustic environment.

Note: The reference for sound power level of 10^{-12} watts conforms with the more common practice.

3.5 Sound pressure level. - Sound pressure level, in decibels, is equal to twenty times the logarithm to the base 10 of the ratio of the rms pressure of this sound to the reference pressure of 20 micronewtons/square meter (equal to 0.0002 dynes/square centimeter or 0.0002 microbar). The symbol for sound pressure level is L_p.

$$L_p \text{ (db)} = 20 \log_{10} \frac{\text{measured rms pressure (dynes/cm}^2\text{)}}{0.0002 \text{ (dynes/cm}^2\text{)}}$$

3.6 Vibrational acceleration level. - The acceleration level of a vibration in decibels is 20 times the logarithm to the base 10 of the ratio of rms acceleration of this vibration to the reference acceleration of 10^{-3} cm/sec^2. The symbol for vibrational acceleration level is L_a.

$$L_a \text{ (db)} = 20 \log_{10} \frac{\text{measured rms acceleration (cm/sec}^2\text{)}}{10^{-3} \text{ (cm/sec}^2\text{)}}$$

3.7 Vibrational velocity level. - The velocity level of a vibration in decibels is 20 times the logarithm to the base 10 of the ratio of the rms velocity of this vibration to the reference velocity of 10^{-6} cm/sec.

The symbol for vibrational velocity level is L_v.

$$L_v \text{ (db)} = 20 \log_{10} \frac{\text{measured rms velocity (cm/sec)}}{10^{-6} \text{ (cm/sec)}}$$

This definition is inserted for continuity with prior practice although vibrational acceleration level is the preferred quantity.

3.8 Band level. - Band level is the total level of all noise in a specified frequency band

3.8.1 Broadband - The term broadband refers to the unfiltered response of the particular noise measuring system.

3.8.2 Octave band. - An octave band is a band of frequencies in which the ratio of the extreme frequencies is equal to 2 1. The preferred octave band centers extend from 31.5 cycles per second (cps) to 8000 cps. The octave bands given in ASA Z24.10 extending from 37-75 cps to 4800-9600 cps are acceptable in lieu of the above.

Note. The width of an octave band is approximately 71 percent of its band center frequency

3.8.3 One-third octave band. - A one-third octave band is a band of frequencies in which the ratio of the extreme frequencies is equal to the cube root of 2; that is, $f_h/f_\ell = \sqrt[3]{2} = 1.260$ where f_h and f_ℓ are the nominal cutoff frequencies of the band. The preferred one-third octave bands are those whose band centers have been adjusted so that the ratio of successive band centers is $\sqrt[10]{10} = 1.259$. Center frequencies of the preferred one-third octave bands shall be in accordance with ASA S1.6.

Note: The width of a one-third octave band is approximately 23 percent of its band center frequency.

3.8.4 Narrow band. - For this standard a narrow band is a band whose width is not less than one percent nor more than eight percent of the band center frequency. Constant width bands, whose band widths expressed in percentage of their band center that fall within the above definition, may be used.

3.8.5 Band center frequency. - Band center frequency is the geometric mean between the extreme frequencies of the band.

$$f_c = \sqrt{f_h f_\ell}$$

where f_c is the band center frequency and f_h and f_ℓ are the nominal high and low cutoff frequencies of the band.

3.9 Narrow band analysis. - Narrow band analysis is performed to determine the frequency components of a noise signal. Results are expressed as the level of the content of the band.

3.10 Equipment. - Equipment includes any subsystem, or part thereof, including electrical, electronic, mechanical, and hydraulic components, which may produce noise. Equipment is classified as to airborne noise by grade. Equipment is classified as to structureborne noise by type.

3.10.1 Grade A equipment. - Grade A equipment is any item of equipment which will be placed in spaces where intelligible speech communication is frequently required and minimum vocal effort by the speaker is a consideration.

3.10.2 Grade B equipment. -Grade B equipment is any item of equipment which will be placed in spaces where comfort of personnel in their quarters is the principle consideration.

3.10.3 Grade C equipment. - Grade C equipment is any item of equipment which will be placed in spaces whose function requires minimum annoyance to working personnel.

3.10.4 Grade D equipment. - Grade D equipment is any item of equipment which will be placed in spaces where deafness avoidance is the prime consideration and intelligible speech communication is not normally required.

3.10.5 Type 1 equipment. - All compressors and internal combustion engines are type 1 equipment

3.10.6 Type 2 equipment. -All pumps are type 2 equipment.

3.10.7 Type 3 equipment. - All other equipments are type 3.

3.11 Frequency - The frequency of a function periodic in time is the reciprocal of the period. The unit of frequency is the hertz (H_z). One H_z is equal to one cps.

4. GENERAL STATEMENT

4.1 This standard shall apply in case of conflict with documents referenced herein.

5. DETAILED REQUIREMENTS

5.1 Environmental effects. - For purposes of this standard no corrections for band width and ambient noise levels are permitted. Instrumentation shall be of a type having low response to ambient magnetic, electric and acoustic fields. No corrections for these effects will be permitted in the measurements made of machinery noise. By "low" is meant that system response to the ambient fields alone, expressed in whatever measurement unit used, will be at least 10 db below the limit specified. For airborne and structureborne noise tests, and for calibration, the temperature and relative humidity effects shall be known and data correction made where necessary.

5.2 Airborne noise. -

5.2.1 Airborne noise limits. - Airborne noise limits shall be expressed as maximum permissible sound power or sound pressure levels of specified octave bands.

5.2.2 Instruments. -

5.2.2.1 Broadband measuring instruments. -Sound pressure level shall be measured with an omni-directional microphone and sound level meter conforming in all respects to those specified in ASA S1.4. If tape recorders are used to preserve the broadband noise output of transducers for later analysis, the complete system shall have a response known within plus or minus 2 db over the required frequency range.

5.2.2.2 Octave band analysis instruments. - Octave band sound pressure levels shall be measured by the instruments used in 5.2.2.1 (microphone and sound level meter) with the addition of a graphic level recorder and octave band filters meeting the requirements of ASA Z24.10 and covering the band center frequency range 31.5-8000 cps. The complete system shall have a response known within plus or minus 2 db under the conditions specified in 5.2.2.1.

5.2.3 Airborne measurement procedures. -

5.2.3.1 Sound power level determinations. - Sound power level determinations, shall be obtained in accordance with ASA S1.2.

5.2.3.2 Sound pressure level measurements. - Sound pressure level measurements, shall be obtained in accordance with the following procedures:

(a) The microphone shall be placed at a distance of 3 feet from the nearest surface of the equipment undergoing tests in each of the following positions:

(1) On each side, at the same height as the equipment horizontal centerline

(2) At each end, along the equipment centerline.

(3) Above the equipment, over the centerline.

For motor generators or motor driven auxiliaries, make separate measurements for the motor and the generator or auxiliary ends.

(b) To ensure measuring the maximum noise level in the vicinity of each position described above, the microphone shall be moved about in a one cubic foot volume outward from the equipment at the positions stated in (a) above. The location in each volume at which the maximum broadband level occurs shall be used as the measurement position. At each position, the microphone shall be free of effects from vibration and disturbing electric or magnetic fields (see 5.1). There shall be no observer, instrument, or reflecting surface, other than the floor nearer than 3 feet to the microphone. In the case of 5.2.3.2 (a) (1) and (3), if the machine has air openings, the microphones shall be placed as close to each air inlet and outlet as possible without placing them in the path of direct air flow; otherwise at mid-length of the machine.

(c) Octave band levels shall be measured at each microphone position.

5.2.4 Airborne acceptance criteria. - The octave band sound power levels specified in table I shall be used as the basis of acceptance for airborne noise of equipment. The supplier may perform narrower band analysis to identify any offending frequencies to aid in his corrective measures.

Table I - Airborne noise acceptance levels.

Airborne grade	Sound power levels, ref. 10^{-12} watts for center frequencies of standard octave bands Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
A					Numerical average of 500, 1000 and 2000 Hz bands - 71 db				
B	97	91	86	82	79	78	77	76	75
C	92	84	79	74	71	68	67	65	64
D	122	117	112	107	97	92	92	92	92

5.2.4.1 Acceptance criteria for airborne noise that are not in accordance with this standard shall be approved by the Bureau of Ships.

5.3 Structureborne noise -

5.3.1 Structureborne noise limits. -Structureborne noise limits in terms of vibrational acceleration levels (or vibrational velocity levels) shall be expressed as one or more of the following:

(a) Maximum permissible one-third octave band vibration levels.

(b) Maximum permissible levels of specified frequencies such as rotational, twice electrical line frequency, slot frequency, gear mesh frequency, and so forth.

5.3.2 Instruments. -

5.3.2.1 Broadband measuring instruments. - Structureborne noise shall be measured using accelerometers, preamplifier (if needed), sound level or vibration meter, and connecting cables having a complete system response which is known within plus or minus 2 db over the frequency range between the fundamental forcing frequency of the machine or 25 cps, whichever is lower, and 8000 cps.

5.3.2.2 One-third octave band analysis instruments. - One-third octave band vibration levels shall be measured by the instruments used in 5.3.2.1 (accelerometers, preamplifier, if used, sound level or vibra-

tion meter) with the addition of one-third octave band filters, a graphic level recorder and connecting cables. The filters shall cover band centers from the fundamental forcing frequency of the machine or 25 cps, whichever is lower to 8000 cps, and have rejection characteristics beyond the nominal band edges at least as good as those specified in ASA Z24.10 for octave band filters. The graphic level recorder shall provide a permanent trace. The scale factor required to convert the recorder traces to "true" noise levels shall be marked on the traces. The complete system shall have a response known within plus or minus 2 db for each one-third octave band under the conditions specified in 5.3.2.1, for all levels and frequencies of interest. The scanning rate shall not be less than 5 seconds per band.

5.3.2.3 Narrow band analysis instruments. - The system shall include the instruments of 5.3.2.1 (accelerometer, pre-amplifier, if used, sound level or vibration meter) with the addition of a narrow band analyzer, a graphic level recorder, and connecting cables. The graphic level recorder shall provide a permanent trace. The complete system shall have a response known within plus or minus 2 db under the conditions specified in 5.3.2.1 and cover the frequency range from the fundamental forcing frequency of the machine or 25 cps, whichever is lower, to 8000 cps. The scale factor required to convert the recorder traces to "true" noise levels shall be marked on the traces. The graphic level recorder writing speeds and analyzer sweep rates shall be selected to insure the required measurement accuracy and repeatability including speeds slow enough to record maximum values when there are fluctuations. Analyzer sweep rate shall not exceed $(f_h - f_\ell/2)^2$ or 200 cycles per second/second whichever is slower.

5.3.3 Structureborne measurement procedures. - The procedure in making structureborne noise measurements is to select locations for triaxial assemblies of transducers, attach transducers, select the noisiest broadband location and direction, and measure and analyze the noise at that location and direction.

5.3.3.1 Selection of transducer locations. - Transducers shall be attached either on the feet or flanges, or on the subbase, at a minimum of two diagonally opposite locations on equipment. For example, on a motor driven auxiliary supported by a common subbase, the diagonally opposite locations would be two corners of the subbase directly above the resilient mountings and as close to the mounting bolts as is feasible. For a flanged unit, the locations would be at resilient mountings on diametrically opposite sides of the flange.

Note: The selection of the measurement location requires careful consideration of the following objectives:

(a) To select locations truly representative of the noise producing effects of the equipment as installed in the ship.

(b) To select, as well as can be determined, locations which will be accessible after shipboard installation.

(c) To avoid locations which are unduly flexible.

5.3.3.2 Transducer attachment. - Transducers shall be attached as follows:

(a) Transducers shall be attached to blocks, which are to be brazed or welded to equipment, or subbase, as close as possible to the mounting points of the equipment to be tested.

(b) The blocks shall be made of steel and shall be as small as possible. The block surfaces on which transducers are mounted shall be plane and shall have a surface finish of 125 micro-inches rms or better and be mutually perpendicular within one degree.

(c) Three holes in the mounting blocks shall be drilled and tapped to a depth of at least 1/4 inch with 10-32 NF threads to accommodate triaxial arrays of transducers which shall be attached to the blocks with insulated steel studs. The holes shall be perpendicular to the finished surfaces within plus or minus 1 degree.

(d) Just before transducers are mounted on a block, all mating surfaces shall be cleaned of all dirt, grease, and other foreign matter in preparation for mounting. The surfaces of the attachment area and the studs shall be lightly covered with clean oil or grease.

(e) The mounting blocks shall not be removed and shall be preserved with a rust inhibiting coating after completion of testing.

(f) If brazing or welding cannot be accomplished, the mounting blocks shall be attached to the location with a thin layer of epoxy resin cement. Blocks attached by cement shall be removed upon completion of test. The transducers may be attached directly to the equipment being tested only where there is insufficient space to accommodate the mounting block. When transducers are attached directly, the point of attachment on the equipment shall be one having relatively high stiffness and the accelerometer used for measurements shall be one having low sensitivity to structural bending strains.

(g) Locations for transducer positions shall be marked where mounting blocks cannot be permanently placed.

(h) Care shall be taken to avoid interfering electrical loops.

5.3.3.3 Broadband measurements. - The instruments shall be in accordance with 5.3.2.1. Broadband structureborne noise measurements shall be made at each location in the vertical, transverse, and axial directions with respect to the equipment tested.

5.3.3.4 One-third octave band measurements. - The instruments shall be in accordance with 5.3.2.2. One third octave band measurements shall be made at the location and in the direction in which the maximum, broadband, structureborne noise is observed in accordance with 5.3.3.3. The complete frequency range of interest shall be scanned and recorded twice. If any one-third octave band indicates a difference between recorded levels of more than 3 db between the two scans, the level in this band shall be recorded for at least one minute. The level reported for each band shall be the maximum level recorded (excluding spurious signals). The scale factors required to convert levels to "true" levels shall be submitted with the data.

5.3.3.5 Narrow band measurements. - The instruments shall be in accordance with 5.3.2.3 with a band pass characteristic as defined in 3.8.4. A narrow band analysis shall be taken at the same location and direction as the one-third octave band measurements for every one-third octave band that exceeds specified levels.

Note: If maximum permissible levels are given in equipment specifications for specified forcing frequencies, narrow band measurements shall be made at the specified frequencies at the locations and in the directions given in 5.3.3.3. In this case, narrow band analysis may be done manually The analyzer shall be tuned to the peak response in the vicinity of each calculated forcing frequency, the level of the signal recorded for one minute, and the maximum level reported.

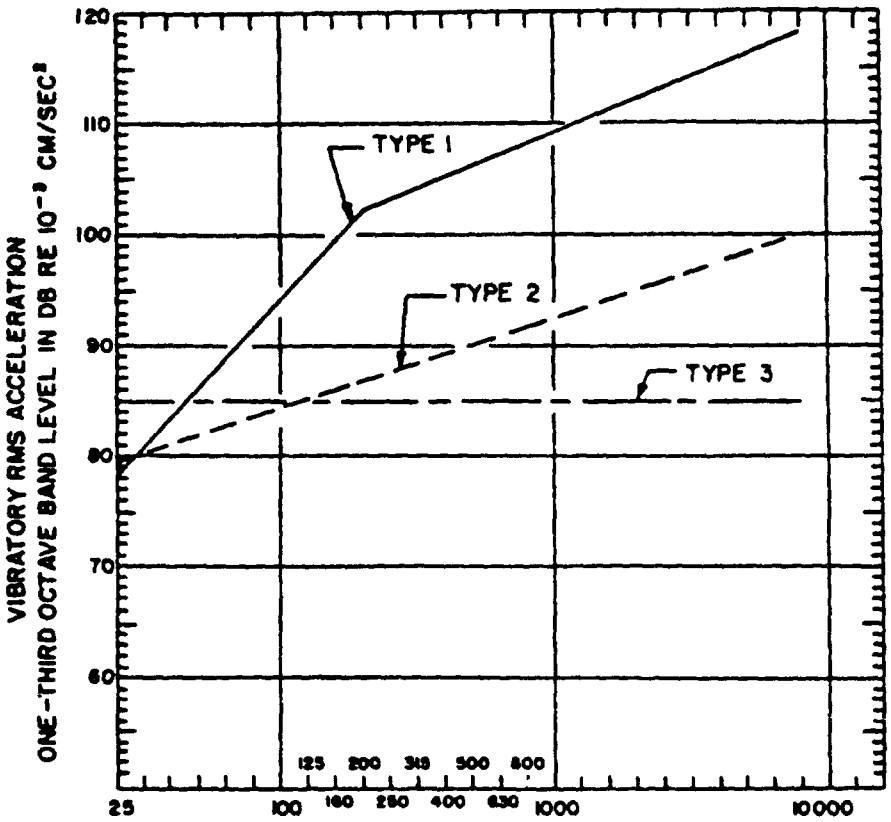
5 3 4 Structureborne acceptance criteria.- One-third octave band levels shown on figure 1 shall be used as the basis for acceptance of structureborne noise of equipment. If one-third octave band levels exceed the specified limits from between the fundamental forcing frequency of the machine or 25 cps, whichever is lower, and 500 cps, a narrow band analysis may be taken as the basis for acceptance of the structureborne noise of the equipment for this region; the analysis shall show no peaks over the limits specified for the one-third octave band or bands in question.

5.3.4.1 Acceptance criteria for structureborne noise that are not in accordance with this standard shall be approved by the Bureau of Ships.

5.4 Mounting equipment for test. - For both airborne and structureborne measurements, equipment shall be oriented in a normal operating position and shall be tested resiliently mounted regardless of whether or not resilient mountings are used in service. Equipment that is resiliently mounted in service shall be tested using the same type resilient mountings as installed on board ship. In cases where pipes are connected to the equipment, a flexible connection shall be inserted in each pipe run between the equipment under test and any external piping. The vertical natural frequency of the mounted assembly shall be less than or equal to 1/4 of the lowest forcing frequency within the equipment. Resilient mountings conforming to MIL-M-17191, MIL-M-17508, MIL-M-19379, MIL-M-19863, or MIL-M-21649 shall be used where possible. The complete assembly should be supported on reinforced concrete or cast metal floor which is

preferably in direct contact with the ground. Any pedestals required to accommodate the resilient mountings preferably should be of steel reinforced concrete. If mountings specified above cannot be used, the mountings used shall be in accordance with MIL-M-17185, and their use shall be approved by the bureau or agency concerned.

5.4.1 Equipment which has a relatively light framework or structure (for example, controllers, control cubicles, non-rotating or non-reciprocating equipment) and which is to be solidly mounted (that is, no resilient mounts) on shipboard shall be mounted on a test fixture for structureborne noise tests. The equipment shall be mounted on the fixture by the designed points of attachment of the equipment. The fixture shall be stiff between points of attachment and damped to eliminate resonances within itself. If the equipment being tested contains internal sound isolation mounts, the mass of the fixture shall be great enough to permit these internal mounts to function properly. The combined assembly of equipment and test fixture shall be resiliently mounted and oriented in its normal operating position.



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CORRECTION FACTORS

FOR FUNDAMENT FREQUENCIES BELOW 25CPS, EXTRAPOLATE TO THE REQUIRED LEVEL

FOR TYPE 2 NON-SEA CONNECTED PUMP, ADD 5DB TO THE STATED ACCEPTANCE CRITERIA.

FOR SOLIDLY MOUNTED EQUIPMENT SUBTRACT 20DB FROM THE CURVES

LIFE SUPPORT EQUIPMENT (I E OXYGEN GENERATOR, CO_2 SCRUBBER H_2-CO BURNER AND DISTILLING UNITS), SUBTRACT 20DB FROM TYPE 3

FOR VANEAXIAL FANS; SHALL BE AT THE FOLLOWING ACCEPTANCE CRITERIA'
FOR LESS THAN 2HP SUBTRACT 25DB FROM TYPE 3
FOR 2HP UP TO 12HP SUBTRACT 15DB FROM TYPE 3
ABOVE 12HP SUBTRACT 5DB. FROM TYPE 3

Figure 1. Structureborne noise acceptance levels.

Supersedes page 8 of 13 January 1965.