MIL-STD-167 (SHIPS)
20 DECEMBER 1954
SUPERSEDING
MIL-T-17113 (SHIPS) (IN PART)
25 JULY 1952

MILITARY STANDARD

MECHANICAL VIBRATIONS OF SHIPBOARD EQUIPMENT

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON, D.C.

MECHANICAL VIBRATIONS OF SHIPBOARD EQUIPMENT

MIL-STD-167(SHIPS)

1. This standard has been approved by the Bureau of Ships, and is published to establish requirements for vibrations of most Naval machinery and equipment.

2. Recommended corrections, additions, or deletions should be addressed to Chief of the Bureau of Ships, Navy Department, Washington 25, D.C.

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1. SCOPE

1.1 Scope. - This standard covers the requirements of most naval machinery and equipment as regards both internally excited vibrations, and externally imposed vibrations. In some special equipment or installations, such as antennas, and large machinery items, it may be necessary to deviate from this standard. In such cases, special modifications shall be approved by the bureau or agency concerned.

1.2 Purpose. - The purpose of this standard is to aid in the choice of and ensure consistency in vibration requirements for equipment. The bureau or agency concerned should refer only to those sections of this standard applicable to their equipment, that is, electronic equipment procurement specifications would refer to only type I vibration requirements; but a specification for a diesel propulsion system may possibly refer to types III, IV and V vibration requirements.

1.3 Classification. - Mechanical vibration encountered on shipboard machinery and equipment shall be classified under the following types:

Type I - Enviromental vibration. - This type applies to all equipment intended for shipboard use, which must be capable of withstanding the environmental vibration conditions which may be encountered aboard naval vessels. All equipment sensitive to this excitation should be subjected to environmental vibration tests.

Type II - Internally excited vibration. - This type applies to all rotating machinery which must operate smoothly from the standpoint of mechanical suitability. This does not apply to suitability from a noise standpoint, nor does it apply to reciprocating machinery.

Type III - Torsional vibration. - This type applies to all reciprocating machinery installations as well as to propulsion shafting systems employing reduction gears.

Type IV - Longitudinal vibration. - This type applies to all propulsion shafting installations.

Type V - Lateral (whipping) vibration. - This type applies to all turbine and propulsion shafting installations.

2. REFERENCED DOCUMENTS

2.1 The following specification, of the issue in effect on date of invitation for bids, form a part of this specification:

SPECIFICATIONS

MILITARY

MIL-M-17185 - Mounting, Resilient, Tests for General Specification (Shipboard Application).

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

3. GENERAL REQUIREMENTS

3.1 Type I - Environmental vibration. - This part of the standard requires equipment to be subjected to a simulated environmental vibration often encountered aboard naval vessels. The displacement amplitudes and frequencies specified are consistent with levels of vibration observed on main structural members of numerous vessels. Many items of equipment are subjected to more severe vibrations, by virtue of resonant mounting arrangements. However, since such resonant installations are considered abnormal, the aggravated levels of vibration are not used as a criterion. It is expected that abnormal installations, where the amplitudes of vibration are magnified, would be corrected. The equipment would then be subjected to normal hull vibration.

3.1.1 Definitions. -

3.1.1.1 Amplitude of vibration. - All references to amplitude of vibration in this section refer to displacement amplitude, as distinguished from velocity or acceleration amplitude. Amplitude is defined as the maximum displacement of sinusoidal motion from the position of rest, or one half the total excursion. Its value is expressed in plus or minus inches or plus or minus mils (0.001 inch).

3.1.1.2 Resonance is a condition of maximum magnification of the applied vibration. It is usually manifested by visibly increased vibration of the equipment under test. However, a resonance of an internal component of the equipment, with no outward manifestation, is also possible. In this case, if the equipment is electrical or electronic, the resonance may be detected by observing some output function of the equipment, such as voltage or current.

3.1.2 Environmental vibration. - All machinery and equipment installed aboard naval vessels will ordinarily be subject to varying frequencies and amplitudes of vibration, possibly for long periods of time, during which the machinery and equipment must continue to perform its normal function. Principal causes of steady-state shipboard vibration are (a) propeller blade excitation, and (b) unbalanced forces of propeller and shafting. In most vessels the vibration frequencies encountered vary from zero to approximately 1500 c.p.m. (25 c.p.s.). In several of the latest submarines, exciting frequencies of up to 2000 c.p.m. (33 c.p.s.) are expected. The severity of vibration depends upon amplitude, frequency, type of ship, and location of equipment within ship's structure. In severe steady-state conditions, amplitudes of vibration of as much as plus or minus 0.030 inches have been measured at the bases of various equipments. These maximum amplitudes and frequencies determine the simulated environmental vibration tests specified in 3.1.4.

3.1.3 Basis of acceptability. - Acceptability will be contingent upon the ability of the equipment to withstand tests specified in 3.1.4 and the ability to perform its principal functions during and after vibration tests. Minor damage or distortion will be permitted during test providing such damage or distortion does not in any way impair the ability of the equipment to perform its principal functions. Because of the numerous types of equipment covered by this standard, a definite demarcation between major and minor failures cannot be specified. Therefore, such decisions must necessarily be left to the judgement of the test engineer. In general, a major failure is one which would cause maloperation or malfunction of the item of equipment for a long period. Nonrepetitive failures of such parts as vacuum tubes, condensers, and wiring, which can be easily replace or repaired are generally considered minor failures. As such, the repair could be made and the test continued, with no penalty to the remainder of the equipment. Sometimes the critical use of the equipment will determine the category of failure, that is, a failure of a component in a lighting circuit may be considered minor. The same failure in a reactor control circuit may be major. Thus, the test engineer or bureau or agency concerned shall be responsible for specifying a major or minor failure. Unless otherwise specified, by the bureau or agency concerned, the contractor shall repair, at his own expense, any and all damage resulting from the tests. Failure to test the equipment in accordance with 3.1.4 because of unavailability of suitable testing machines, does not release the contractor from providing equipment which could withstand the environmental conditions simulated by 3.1.4.

3.1.3.1 Exception. - If, in the opinion of the test engineer, there is any doubt that the equipment under test could satisfactorily withstand the vibration conditions applied for a period in excess of the time specified in 3.1.4, this fact shall be included in the official report, required by 3.1.4.4.

3.1.4 Test procedures. - The test outlined under this section is intended to locate resonances of the equipment and impose a 2-hour endurance test at the most damaging amplitude and frequency. However, this test does not constitute an accelerated life test, in the sense that compliance with the standard would automatically ensure continuous satisfactory operation of the equipment.

3.1.4.1 Testing machine. - Vibration tests shall be made by mean of any testing machine capable of meeting the conditions specified in 3.1.4.3. Means shall be provided for controlling the direction of vibration of the testing machine and for adjusting and measuring its frequencies and amplitudes of vibration to keep them within prescribed limits. If the lower frequency limit of 5 cycles per second (c.p.s.) specified in 3.1.4.3.1 cannot be reached, the available machine may be used upon approval of the bureau or agency concerned provided the natural frequencies of the equipment in translational and rocking modes of vibration do not lie below the lowest frequency of the available testing machine. This may sometimes be determined by bumping the equipment to see whether low frequency resonances exist. In no case shall a vibration testing machine be used which has a minimum frequency greater than 10 c.p.s.

3.1.4.2 Methods of attachment. -

3.1.4.2.1 Shipboard equipment. - For all tests, the equipment shall be secured to the mounting bracket of the testing machine in the same manner that it will be secured on shipboard. In case alternate methods of mounting are specified, tests shall be made using each method of mounting specified by the bureau or agency concerned. For equipment designed to be secured to a deck and a head-brace support, a vertical bracket shall be used to simulate a bulkhead. The bracket shall be sufficiently rigid to insure that its motion will be essentially the same as the motion of the platform of the testing machine. When the equipment is intended to be installed on resilient mountings, these mountings shall be provided by the contractor or installing activity as appropriate.

3.1.4.2.2 Shipboard portable or test equipment. - Portable or test equipment, which is designed for permanent or semipermanent attachment to ship structure shall be attached to the vibration testing machines in the same manner it is attached to the ship. Equipment which is not designed for permanent or semipermanent attachment shall be secured to the testing machines by means of suitable straps.

3.1.4.2.3 Orientation for vibration test. - Equipment shall be installed on vibration testing machines in such manner that the direction of vibration will be in turn along each of the three rectilinear orientation axes of the equipment as installed on shipboard - vertical, athwartships, and fore-and-aft. On a horizontal vibration testing machine, the equipment may be turned 90° in the horizontal plane in order to vibrate it in each of the two horizontal orientations. At no time shall the equipment be installed in any other way than its normal position.

3.1.4.2.4 Resilient mountings. - When equipment is to be installed aboard ship on resilient mountings, the vibration tests shall be performed with identical mountings attached to the equipment. Unless otherwise specified, by the bureau or agency concerned, the mountings shall be furnished by the equipment manufacturer. Since mountings are primarily used when required for shock protection or submarine installations, the mountings shall have been previously evaluated in accordance with Specification MIL-M-17185. Where mountings are to be Government furnished or supplied by the shipbuilder or installing activity, the equipment manufacturer shall specify the type of mountings and provide detail sketches showing the locations and method of attachment to the equipment.

3.1.4.3 Vibration tests. - Each of the tests outlined herein shall be conducted separately in each of the three principal directions of vibration. All tests in one direction shall be completed before proceeding to tests in another direction. The equipment shall be secured to the vibration table as specified in 3.1.4.2 and shall be energized to perform its normal functions. All amplitudes of vibration specified herein are average amplitudes of the vibration table. The test shall be discontinued upon evidence of any failure of the equipment to meet the requirements of 3.1.3. If it is found necessary to repair any damage severe enough to constitute a failure of the equipment, the entire test shall be repeated, unless otherwise directed by the bureau or agency concerned. The manufacturer may, at his option, substitute an entirely new equipment for retest. If this option is taken, it shall be noted in the test report furnished in accordance with 3.1.4.4.

3.1.4.3.1 Exploratory vibration test. - To determine the presence of resonances in the equipment under test, the equipment shall be secured to the vibration table and vibrated at frequencies from 5 c.p.s. (or lowest attainable frequency) to 33 c.p.s., at a table vibratory amplitude of 0.010 plus or minus 0.002 inch. The change in frequency shall be made in discrete frequency intervals of 1 c.p.s. and maintained at each frequency for about 15 seconds. The frequencies at which resonances occur shall be noted.

3.1.4.3.2 Variable frequency test. - The equipment shall be vibrated from 5 c.p.s. (or lowest attainable frequency) to 33 c.p.s., in discrete frequency intervals of 1 c.p.s., at the amplitudes shown in table I. At each integral frequency, the vibration shall be maintained for 5 minutes.

3.1.4.3.3 Endurance test. - The equipment shall be vibrated for a total period of at least 2 hours, at the resonant frequencies chosen by the test engineer. If no resonance was observed, this test shall be performed at 33 c.p.s., unless excepted by 3.1.4.3.4. The amplitudes of vibration shall be in accordance with table I.

Table I - Amplitudes of vibration.

Frequency range (c.p.s.)	Table amplitude plus or minus inch
5 to 15	0.030 ± 0.006
16 to 25	$.020 \pm .004$
26 to 33	$.010 \pm .002$

3.1.4.3.4 Exception. - Equipment intended for installation on a particular class of vessel, need not be vibrated at the frequency range higher than the exciting frequency of the vessel. For example, if equipment is to be installed on a vessel with a maximum exciting frequency of 18 c.p.s., the equipment has to be vibrated at only the first two ranges shown in table I.

3.1.4.4 Test report. - The test report to be furnished the bureau or agency concerned by the testing laboratory shall include detailed descriptions of any damage or malfunctioning incurred and a what stage in the tests it occurred. When possible, photographs of physical damage shall be include. Recommendations are desired as to what corrective measure, if any, should be taken. At the discretion of the test engineer, it shall also include other pertinent information, such as the overall dimensions of the equipment, its weight, approximate location of the center of gravity, and a sketch or photograph of the methods used in mounting it on the test machines.

3.2 Type II - Internally excited vibration. - This section of the standard covers the balance and vibration requirements to be specified in the procurement of new machinery. The limitations set forth herein may also be used as criteria on overhaul tolerances, but should not constitute a criterion for the need for overhaul, that is, if a turbo-generator set is vibrating plus or minus 10 mils it would be obvious that an overhaul would be in order. In such case, the balance and vibration tolerances of this standard may be used as overhaul tolerances, but if the turbo-generator set is vibrating at a level slightly above the curve of figure 1, it need not be removed for overhaul, merely because the level exceeds the curve value.

3.2.1 Definitions. -

3.2.1.1 Static balance of a rotating body exists when the center of gravity of the body lies on the rotational axis. A static unbalance results in a force unbalance which tends to displace the body from its axis of rotation. Force unbalance can be corrected by single-plane correction.

3.2.1.2 Dynamic balance of a rotating body exists when the summation of the moments about the bearings equal zero. A dynamic unbalance results in a moment which causes a rotating body to oscillate about an inertia axis perpendicular to its axis of rotation. When a body has a dynamic or moment unbalance, it can be satisfactorily removed only by two-or-more plane correction. When a body is in dynamic balance, it is also in static balance.

3.2.1.3 Correction planes. - A correction plane is one perpendicular to the axis of rotation of a body, within which plane weights are added or removed in order to reduce unbalance.

3.2.2 Basis of acceptability. - All rotating machinery shall be balanced to minimize vibration, bearing wear, and noise. The types of correction, as shown in table II shall depend on the speed of rotation and relative dimensions of the rotor.

Table II - Types of correction.

Length/diameter[1]	Speed r. p. m	Type of correction
Less than 0.5	0 - 1000	One plane (static)
	Greater than 1000	Two plane (dynamic)
Greater than 0.5	0 - 150	One plane (static)
	Greater than 150	Two plane (dynamic)

[1] The length and diameter refer to dimensions of rotor mass, exclusive of supporting shaft.

3.2.2.1 The limits of allowable unbalance shall conform to 3.2.3.2. In addition, the limits of vibration shall conform to figure 1. The method of applying balance correction shall be designated in the specification covering the particular piece of equipment.

3.2.3 Procedure. -

3.2.3.1 Balancing methods. - Except for machinery operating below 150 r.p.m., all balancing shall be accomplished by means of balancing equipment which requires rotation of the work piece. This may be either shop or portable type balancing equipment. The minimum detectable unbalance of the balancing machine used shall be below the residual unbalance specified by 3.2.3.2. For machinery rated at lower than 150 r.p.m., the rotor may be balanced by symmetrically supporting the rotor on two knife edges and applying correction to attain a static balance.

3.2.3.2 Balance limits. - When balanced in accordance with 3.2.3.1 the residual unbalance, in each plane of correction, of any rotating part shall not exceed the value determined by:

$U = \frac{4W}{N}$ for speeds in excess of 1000 r.p.m.

or $U = \frac{5630W}{N^2}$ for speeds between 150 r.p.m. and 1000 r.p.m.

or $U = 0.25W$ for speeds below 150 r.p.m.

where
U = maximum allowable residual unbalance in oz.-inches
W = weight of rotating part in pounds
N = maximum operating r.p.m. of unit

3.2.3.3 Vibration test. - When mounted as specified in 3.2.3.3.2 and measured in accordance with 3.2.3.3.3, the residual vibration amplitude shall not exceed the values shown on figure 1. In *most machinery, the residual vibration will be principally at rotational frequency (first order). In these cases, the measurement may be limited to the evaluation of first order vibration only. In the* case of complex machinery, which include reduction gearing, impellers, or other vibration exciting sources, it is expected that higher orders of vibration may exist. In such cases, measurements must indicate that either:

(a) *The overall vibration velocity level is less than plus or minus 0.3 inch/sec* with a maximum allowable displacement of plus or minus 2.5 mils, or
(b) The displacement amplitudes at all component frequencies shall fall below the level of figure 1.

3.2.3.3.1 The procurement specification for the item of equipment shall specify whether vibration measurements may be limited to first order, or be extended to cover higher orders. In general, machinery such as motors, generators and simple rotating devices with no gears would have a principal vibration of only first order. Machinery such as gear driven units, units with internal gearing, rotary pumps or compressors and fans and blowers would often have higher orders of vibration, in addition to the first order.

3.2.3.3.2 Mounting. - After balancing, the unit shall be completely assembled and, if practicable, mounted elastically at a natural frequency less than one-quarter of the minimum rotational frequency of unit. To accomplish this, the minimum static deflection of the mounting should be determined by figure 2, but in no case shall the deflection exceed one-half the original height of the elastic element. On machinery that cannot be *mounted as described, the unit shall be mounted* on a foundation the same as, or commensurate with, the shipboard mounting for which it is intended, unless otherwise approved by the bureau or agency concerned.

3.2.3.3.3 Measurements. - On all machinery except turbines, amplitudes of vibration shall be measured on the bearing housing in the direction of maximum amplitudes. In the case of turbines, amplitudes of vibration shall be measured on the rotating shaft, adjacent to the bearings. Care should be exercised to ensure that the shaft is smooth and concentric. Eccentricity of shaft or high spots on the shaft may easily result in erroneous readings. Amplitudes of vibration shall be held within the limits shown on figure 1. On constant speed units, measurements shall be made at the operating speed. In the case of variable speed units, measurements shall be made at maximum speed and at all critical speeds within operating range.

3.2.3.3.4 Instruments. - Amplitude and frequency measurements shall be made with a suitable vibration instrument with a sensitivity consistent with the amplitude and frequency specified by figure 1.

3.2.3.3.4.1 When it is known that a unit is vibrating at principally one frequency, any of the following types of instrumentation would suffice:

(a) Beam type vibrometer, such as Davey, or General Electric.
(b) Vibration meter, such as MB, Calidyne, or Consolidated.
(c) Mechanical recording vibrograph, such as Askania, General Electric or Westinghouse.
(d) Reed type frequency vibrometer (this would be necessary if the vibration instrument used does not also define the frequency).

3.2.3.3.4.2 In the case of more complex equipment the following types of instrumentation would be necessary:

(a) Mechanical recording vibrograph, such as Askania, Geiger, General Electric or Westinghouse.
(b) Electronic vibration meter, such as MB, Calidyne, or Consolidated, together with oscilloscope, recording device, or frequency analyzer.

3.2.3.3.5 Exception. - In the case of complex machinery items, such as assemblies employing reduction gears, the allowable amplitudes shown on figure 1 may be too high for proper operation of the equipment. In such case, allowable amplitudes based on manufacturing tolerances and clearances, and operational requirements, will be specified by the bureau or agency concerned.

3.3 Type III - Torsional vibration. -

3.3.1 Definitions. -

3.3.1.1 Mass elastic system. - The mass elastic system is defined as the equivalent oscillating system which retains as closely as possible the dynamic characteristics of the actual system. This equivalent system consists of a series of mass moments of inertia of rotating and reciprocating elements interconnected by torsionally flexible elements. Auxiliary drive elements such as camshafts, pumps, and blowers, are as much a part of the mass elastic system as are the shafting, couplings, and masses of the main drive elements.

3.3.1.2 Torsional vibration. - A torsional vibration is a vibration that is characterized by angular displacement of the mass elastic system relative to its axis of rotation.

3.3.1.3 Vibratory amplitude. - Vibratory amplitude is that angular displacement induced by the torsional vibration of a mass elastic system.

3.3.1.4 Vibratory torque. - Vibratory torque is that torque induced by the torsional vibration of a mass elastic system.

3.3.1.5 Vibratory stress. - Vibratory stress is that stress induced by the torsional vibration of a mass elastic system.

3.3.1.6 Mode. - Mode is the manner or pattern of vibration and is described by its natural frequency and relative amplitude curve.

3.3.1.7 Node. - A node is a point of zero vibratory amplitude.

3.3.1.8 Order. - Order is the number of cycles of vibration occurring during each revolution of the reference shaft.

3.3.1.9 Operating speed range. -

(a) For a constant speed unit, the operating speed range is from 80 percent to the overspeed trip setting.
(b) For a variable speed unit, the operating speed range is 80 percent of minimum operating speed to the overspeed trip setting, unless otherwise specified, by the bureau or agency concerned.

3.3.2 Basis of acceptability. - Acceptability of the system is contingent upon compliance with the requirements specified herein.

3.3.2.1 Limits. - The mass elastic system shall have no excessive torsional vibratory stresses below the top operating speed of the unit nor excessive vibratory torque across gears within the operating range of the unit. In no case, however, shall the amplitude of torsional vibration be sufficient to adversely affect operation of the unit or its synchronization with other units, as in the case of generator sets.

3.3.2.1.1 Stresses within speed range. - Within the operating speed range, excessive torsional vibratory stress is that stress in excess of S_v where, for

steel $S_v = \frac{\text{Ultimate Tensile Strength}}{25}$ and for cast iron or other material

$S_v = \frac{\text{Torsional Fatigue Limit.}}{6}$ If fatigue tests have been conducted on full-scale specimens of the material used, then the contractor may use $S_v = 1/2$ Torsional Fatigue Limit as the limiting permissible stress. The source of the fatigue limit value and, if requested, the fatigue test data, shall be reported to the bureau or agency concerned.

3.3.2.1.2 Stresses below speed range. - Below the operating speed range, excessive torsional vibratory stress is that stress in excess of 1-3/4 times the S_v value given in 3.3.2.1.1.

3.3.2.1.3 Torque. - For diesel installations excessive vibratory torque, at any operating speed, is that vibratory torque greater than 75 percent of the driving torque at the same speed, or 25 percent of full load torque, whichever is smaller. In the case of turbine drives, only 10 percent of full load torque is allowed instead of the aforementioned 25 percent.

3.3.2.2 Mathematical analysis. - A complete mathematical analysis, indicating probable compliance with the limits of 3.3.2.1 shall be submitted to the bureau or agency concerned for approval, prior to construction of the unit. These calculations should be prepared by engine builder, design agent, or shipbuilder as required by the contract or order. Approval of such mathematical analysis, however, will not release the contractor from the responsibility of proving conformance by actually torsiographing assembled units.

3.3.2.2.1 Description of analysis. - The mathematical analysis shall include:

(a) A description of the system relating information pertinent to analysis such as operating speed range, gear ratios, and name plate data.
(b) A labeled assembly drawing showing arrangement of the elements in the unit and dimensions of shafting.
(c) A labeled line diagram of the mass elastic system indicating values of masses and stiffnesses, including basic assumption, where applicable.
(d) Natural frequencies of all important modes of vibration.

(e) For each mode, stress per degree (or per radian) calculations for the most highly stressed sections of shafting. The calculation shall indicate the sections at which the maximum stresses exist.
(f) Relative amplitude curves (mode shapes).
(g) Estimates of all important vibratory amplitudes, stresses and gear torques of the unit including calculations and assumptions used to make the estimates.

3.3.2.3 Torsional vibration tests. -

3.3.2.3.1 Normal tests. - To prove compliance with the limits of 3.3.2.1, a torsional vibration test of a complete unit shall be conducted and a test report shall be submitted to the bureau or agency concerned for approval. Unless otherwise specified, in the equipment specifications all elements of the complete unit shall be included in the tested unit. Based on the results of mathematical analysis (see 3.3.2.2) the torsiograph test may be waived by the bureau.

3.3.2.3.2 Simulated installation tests. - A torsional vibration test, on a test stand installation, simulating the actual shipboard installation, may be permitted provided that a mathematical analysis (see 3.3.2.2) of the test stand installation be submitted.

3.3.2.3.3 Auxiliary branches. - When specified or when requested by the bureau or agency concerned after receipt of the mathematical analysis, torsional vibration tests shall be made of the auxiliary driven elements, such as blowers and pumps.

3.3.2.3.4 Instrumentation. - Suitable instrumentation, consistent with the amplitudes and frequencies anticipated, shall be used for all torsional vibration testing.

3.3.2.3.5 Report. - The test report shall include:

(a) A description of the installation and test conditions, including such material as nameplate data, operating speeds, and loads.
(b) A description of instrumentation utilized and locations of measurements.
(c) A graph, plotting amplitudes versus r.p.m. for all important orders of vibration. Points are to be plotted at suitable increments, from as low a speed as possible to top operating speed to clearly define all criticals.
(d) Maximum vibratory shaft stresses and vibratory gear torques encountered shall be determined.

3.4 Type IV - Longitudinal vibration. -

3.4.1 Definitions. -

3.4.1.1 Longitudinal vibration. - Longitudinal vibration is a vibration characterized by linear displacement of the major elements in an axial direction.

3.4.1.2 Mass elastic system. - Mass elastic system is the equivalent oscillating system which retains as closely as possible the dynamic characteristics of the actual system. This equivalent system consists of such masses as the propeller, thrust bearing, and reduction gear, interconnected by the flexible elements of shafting and foundations.

3.4.2 Basis of acceptability. -

3.4.2.1 Mathematical analysis. - A complete mathematical analysis of the longitudinal vibratory characteristics of the mass elastic system shall be submitted to the bureau or agency concerned for approval. All mass elastic factors and assumed foundation elastic constants shall be clearly shown. These analyses shall clearly demonstrate that the propulsion system is free from any longitudinal critical in the range of 50 to 115 percent of maximum r.p.m., unless otherwise approved by the bureau or agency concerned.

3.4.2.2 Limit. - If the mathematical analysis indicates the presence of a critical below 50 percent of maximum r.p.m., vibration measurements shall be made to determine the maximum amplitudes of vibration. A system shall be considered acceptable only if the amplitudes of vibration at the critical speeds are of such amplitude and phase as to be nondamaging to the gears and thrust bearings.

3.5 Type V - Lateral (whipping) vibration. -

3.5.1 Definition. -

3.5.1.1 Lateral vibration. - Lateral vibration is the vibratory deflection of a rotating shaft in a direction transverse to the axis of rotation.

3.5.2 Basis of acceptability. -

3.5.2.1 Mathematical analysis. - A complete mathematical analysis of the lateral vibratory characteristics of the rotating system shall be submitted to the bureau or agency concerned for approval. This analysis shall clearly demonstrate that the system is free from any lateral critical below 115 percent of the maximum rated speed unless otherwise approved by the bureau or agency concerned.

NOTE: Type I of this standard supersedes that part of Specification MIL-T-17113 covering vibration.

Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.

Copies of this standard for military use may be obtained as indicated in the foreword to the Index of Military Specifications and Standards.

Both the title and identifying symbol number should be stipulated when requesting copies of military standards.

Custodian:
Bureau of Ships

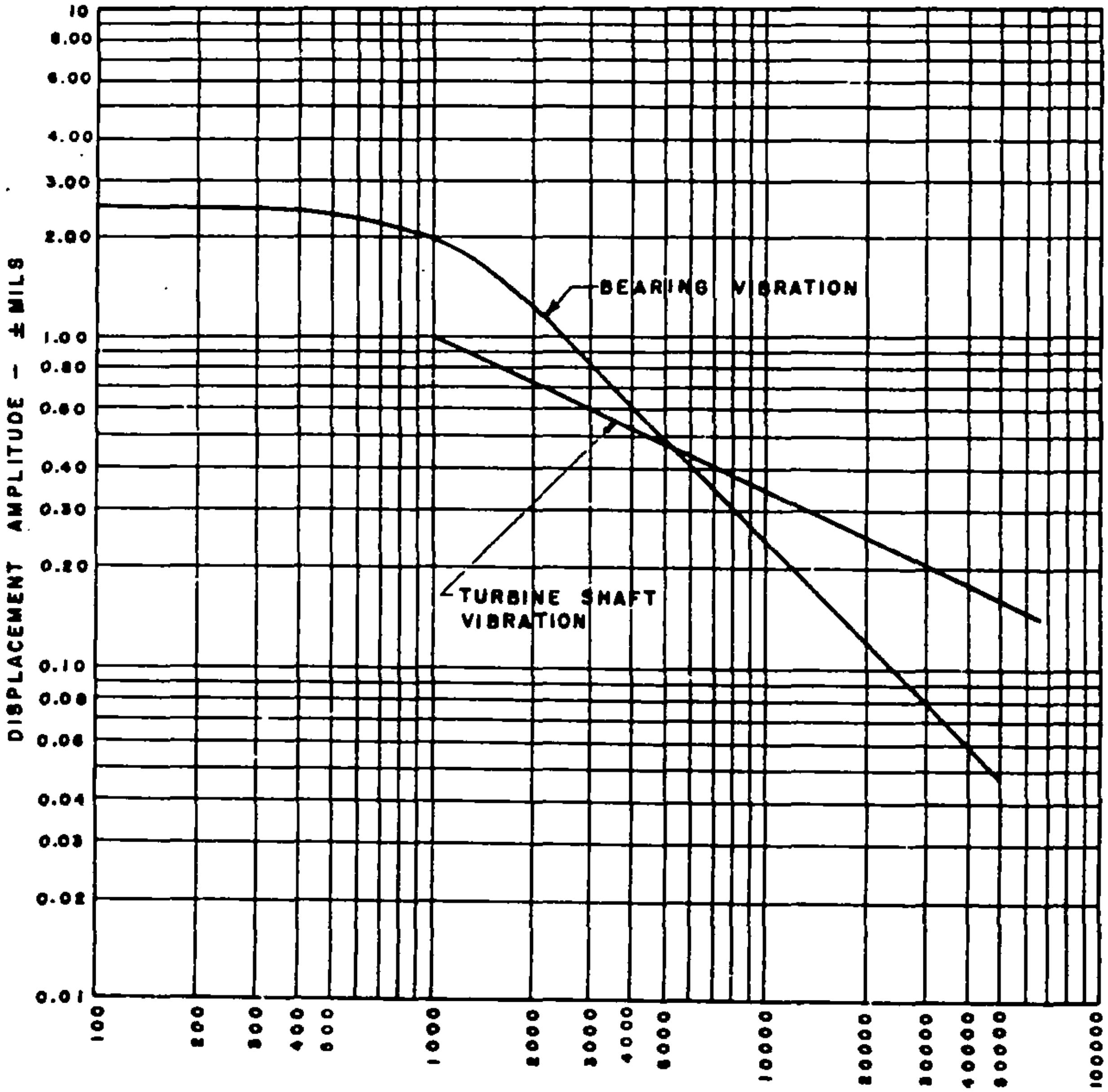

Figure 1.—Maximum allowable vibration.

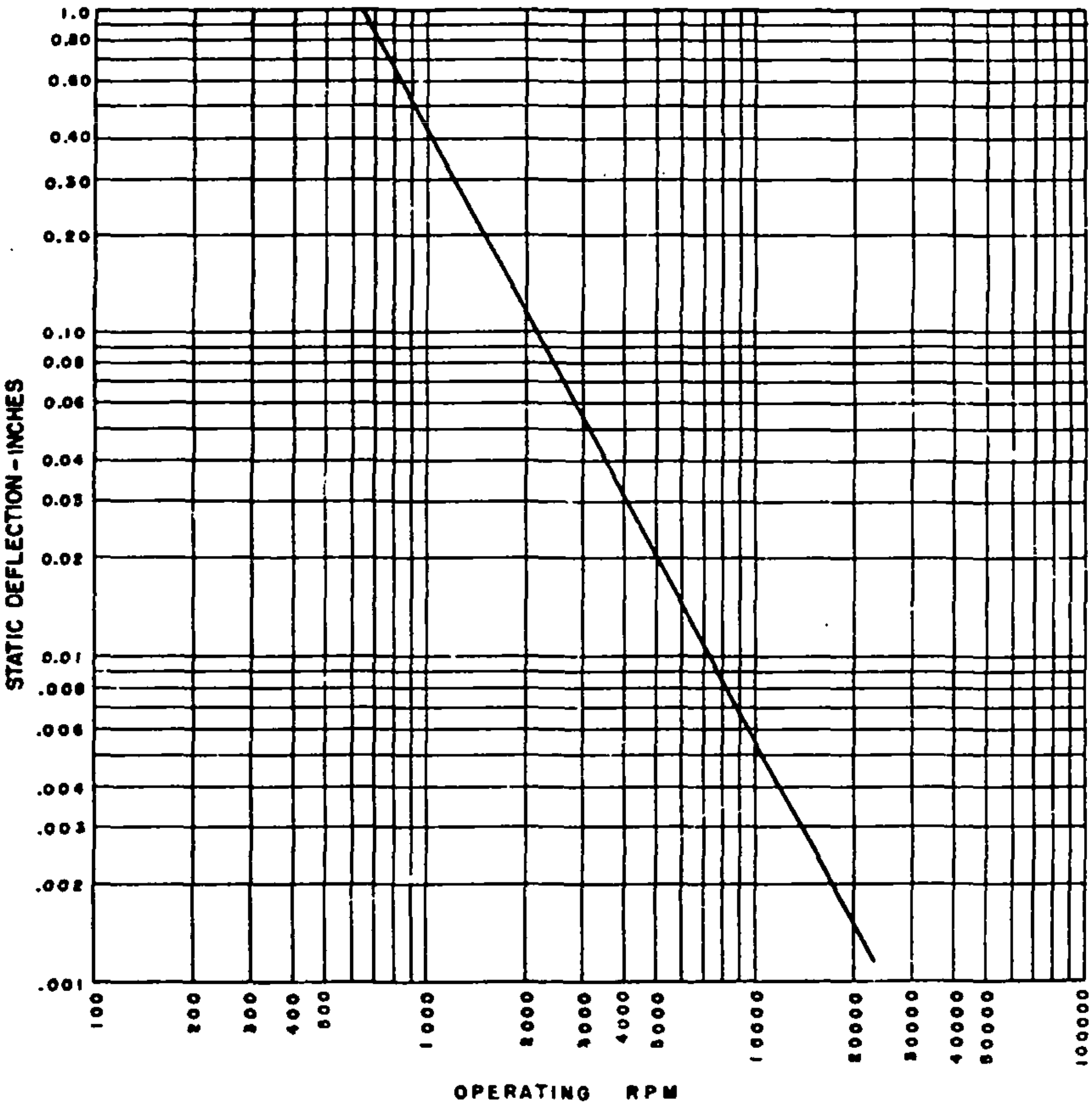

Figure 2.—Static deflection of mounting.