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American National Standard Guide for Describing the Characteristics of Resilient Mountings

Secretariat

Acoustical Society of America
American Society of Mechanical Engineers

Approved November 18, 1971

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Foreword

(This Foreword is not a part of American National Standard Guide for Describing the Characteristics of Resilient Mountings, S2.8-1972.)

This American National Standard provides suggestions on subject matter and format for describing resilient mountings, so that there will be a clear understanding by both the user and the manufacturer. Since the intention of this standard is to encourage better communication between the manufacturer and the user, it should be regarded as a guide rather than a rigid specification.

It is beyond the scope of this standard to present characteristics of resilient mountings. Rather, it is intended to outline, in standardized form, what data should be presented to enable the experienced designer to apply resilient mountings correctly. Also, the standard defines terminology in a further effort to ease the problem of communication between user and manufacturer.

The S2 Standards Committee on Mechanical Shock and Vibration, under whose jurisdiction this standard was developed, has the following scope:

Standards, specifications, methods of measurement and test, and terminology, in the fields of mechanical shock and vibration, but excluding those aspects which pertain to biological safety, tolerance and comfort.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American National Standards Institute, Inc, 1430 Broadway, New York, N.Y. 10018.

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American National Standard Guide for Describing the Characteristics of Resilient Mountings

1. Introduction

The user of resilient mountings is sometimes handicapped in applying mounting systems properly because sufficient technical information is not furnished by the manufacturer. Consequently, the user must conduct his own experimental evaluation of mountings and perhaps unknowingly duplicate work already performed by the manufacturer. Also, in military applications, the user may not be at liberty to divulge applicable information which might otherwise facilitate suggestions and recommendations by the mounting manufacturer. Hence, the user many times must acquire considerable proficiency in the art of applying resilient mountings, and in these instances, he needs appropriate technical information from the manufacturer.

On the other hand, some manufacturers of resilient mountings have experience covering a wide variety of mounting applications. The manufacturers, in most instances, are willing to use their background information for solving the users mounting problems. However, it frequently is difficult for the manufacturer to provide this service, because the user has not furnished sufficient information to the manufacturer regarding the application.

2. Purpose and Scope

2.1 Purpose. This standard sets forth suggestions as to subject matter and format for describing resilient mountings, so that there will be a clear understanding by both the user and the manufacturer. Since the intention of this standard is to encourage better communication between the manufacturer and the user, the material set forth herein should be regarded as a guide rather than a rigid specification.

2.2 Scope. It is beyond the scope of this standard to present characteristics of resilient mountings. Rather, it is intended to outline, in standardized form, what data should be presented to enable the experienced designer to apply resilient mountings correctly. Also, the standard defines terminology in a further effort to ease the problem of communication between user and manufacturer.

3. Definitions of Terms

Definitions of many terms used in discussing shock and vibration phenomena are given in American National Standard Acoustical Terminology, S1.1-1960. Significant and additional definitions pertinent to this document are as follows.

axial stiffness.[1] The load-deflection ratio of a mounting along its central axis symmetry.

base mounting system. A system which has the resilient mountings attached underneath the mounted item. See Fig. 1.

bottoming. Deflection which causes an abrupt change (usually discontinous) of the dynamic or static stiff-

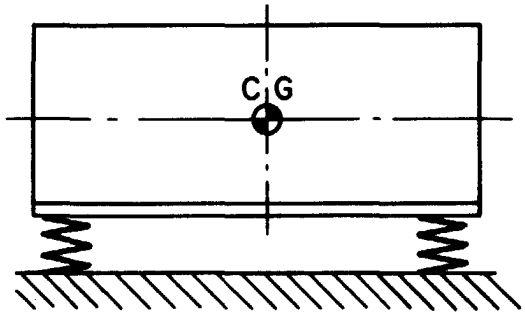

Fig. 1
Base Mounting System

[1] The stiffness may be dynamic or static, and the mounting must have an axis of symmetry.

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ness of the mounting, such as is caused by mass to mass contact.

breakaway force. The force required to overcome the static friction between adjoining surfaces.

NOTE: When the breakaway condition occurs, the running friction is usually much less than the static friction.

center-of-gravity mounting system. A system which has the following primary features: 1) resilient mountings located approximately in a plane passing through the center-of-gravity of the mounted item; 2) that the distance between the resilient mountings be approximately twice the radius of gyration of the mounted item; and 3) that the horizontal-to-vertical stiffness of the resilient mounting be equal. See Fig. 2.

damping. The dissipation of energy with time or distance. (See 1.62 of American National Standard S1.1-1960.)

deflection limit. The static or dynamic deflection beyond which the mounting will not efficiently perform its intended function.

drift (creep). The continuing deformation of a mounting under specified separate or joint effects of long term static, oscillatory or repeated shock loads.

dynamic stiffness. The ratio of the amplitude of the periodic force or torque through a mounting to the amplitude of the periodic translational or rotational displacement (in phase with that force) across the mounting when subject to steady-state vibration.

NOTE: The frequency and amplitude of such vibration should be stated since dynamic stiffness is generally affected by these factors.

elastic center. A point for which a translational force whose line of action passes through the elastic center will cause only translational motion of the mounting in the direction of the force, and rotational motion about the elastic center will result when coupled.

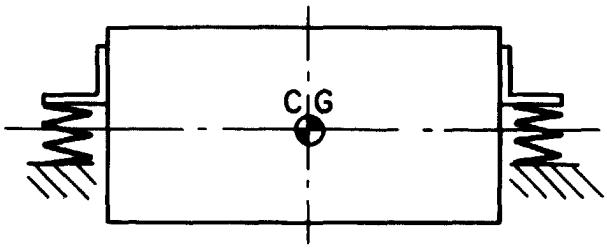

Fig. 2
Center-of-Gravity Mounting System

NOTE: Often resilient mountings are considered solely, but hose, piping, electrical cable, and other mechanical connections to equipment may cause significant effects.

equivalent viscous damping. The value of viscous damping assumed for the purpose of analysis of a vibratory motion such that the dissipation of energy per cycle at resonance is the same for the assumed or for the actual damping force. (See 3.34 of American National Standard S1.1-1960.)

fatigue resistance (mounting endurance). The number of cycles of vibration at a specified frequency and relative displacement amplitude or a specified peak transmitted force within which a mounting will continue to provide effective isolation.

installation clearance. The spacing provided between a flexibly mounted unit and any adjacent structure in order to prevent contact during maximum vibratory or shock motions.

load-deflection curve. A graphical presentation of the deflection of a mounting as a function of a slowly applied load.

load range. The difference between the minimum and maximum prescribed static or dynamic load for which a mounting will perform its intended function.

mechanical impedance. The complex ratio of force to velocity during simple harmonic motion; if the force and velocity are measured at the same point and in the same direction, the ratio is designated a driving-point impedance; if the force and velocity are measured at different points or in orthogonal directions at the same point, the ratio is designated a transfer impedance. (See 5.17 of American National Standard S1.1-1960.)

NOTE 1: Velocity is used in a general sense to denote either rectilinear or angular velocity. Similarly, force denotes both rectilinearly directed force or torque. Direction is used in a general sense to denote rectilinear or angular direction.

NOTE 2: In order to determine experimentally the transfer impedance between point *i* and point *j* of a lumped system, the force at *i* and the velocity at *j* must be measured while all points other than *j* are constrained to have zero velocity. In practice, it is difficult to achieve the zero-velocity condition required above, over even a limited frequency range. However, a zero-force condition can be realized at points other than *j* over relatively wide ranges of frequency. The zero-force condition at all points other than *j* is required when determining transfer mobilities experimentally.

NOTE 3: The real part of a mechanical impedance is a mechanical resistance and the imaginary part is a mechanical reactance.

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The mechanical impedance

$$Z = \frac{Fe^{j(\omega t + \phi)}}{ve^{j\omega t}} = R + jX = |Z|e^{j\phi}$$

where
R = magnitude of the mechanical resistance
X = magnitude of the mechanical reactance
The units of both are pound-seconds per inch (or equivalent).

mobility (mechanical admittance). Mobility is the complex ratio of velocity to force during simple harmonic motion. (See 5.10 of American National Standard S1.1-1960.)

NOTE: In order to determine experimentally the transfer mobility between point i and point j of a system, the force at i and the velocity at j must be measured while all points other than i are free of force.

mounting system. An item designed for the purpose of reducing vibration or shock; sometimes referred to as a "mounting base" or a "mounting rack"; it usually serves as a support and connecting link between the equipment being isolated and the foundation; it is the complete mounting assembly and often contains components such as resilient elements, damping elements, overload snubbers, interface plates for securing the mounting system, etc.

natural frequency. A frequency of free vibration of a system. (See 3.9 of American National Standard S1.1-1960.)

NOTE: For a multiple degree-of-freedom system, the natural frequencies are the frequencies of the normal modes of vibration.

overload capacity. The maximum load which can be applied to a mounting without producing permanent deformation or other permanent damage to the mounting and without impairing its efficiency as a mounting after the load is removed.

principal stiffness axis. An axis of a resilient mounting for which the mounting, when unconstrained, experiences a deflection collineal with the direction of the applied force; any axis of symmetry is a principal stiffness axis.

radial stiffness. The load-deflection ratio of a mounting along an axis normal to its central axis.

resilient mounting. Contains a flexible element intended to reduce the transmission of vibration, shock or noise; sometimes referred to as a unit mounting, vibration isolator, shock mounting; this reduction may be accomplished by the element working in tension, compression torsion, shear, or a combination of these.

NOTE: The resilient mounting may be only the resilient element of a mounting system and can take the form of a simple spring material such as rubber, wire mesh, etc.

resonance frequency (resonant frequency). The frequency at which reasonance exists. (See 3.5 of American National Standard S1.1-1960.)

NOTE: The resonance frequencies are at or near the natural frequencies of the system.

snubber. A device used to increase the stiffness of an elastic system (usually by a large factor) whenever the displacement becomes larger than a specified amount.

static stiffness. The ratio of force to displacement under slowly applied increasing and decreasing loads.

stiffness ratio. The ratio of the stiffness of a mounting along some other designated axis; for example, axial to radial; the axis must be designated.

torsional stiffness.[2] The moment-angular-deflection ratio of a mounting about a specified axis.

transmissibility. The nondimensional ratio of the response amplitude to the excitation amplitude of a system in steady-state forced vibration; the ratio may be one of forces, displacements, velocities, or accelerations. (See 3.28 of American National Standard S1.1-1960.)

viscous damping. The dissipation of energy that occurs when a particle in a vibrating system is resisted by a force that has a magnitude proportional to the magnitude of the velocity of the particle and direction opposite to the direction of the velocity of the particle. (See 3.33 of American National Standard S1.1-1960.)

4. Specifications

4.1 Information Supplied by the User. In the event application engineering is required by the using activity, the information below should be supplied to the mounting manufacturer as applicable.

NOTE: Table 1 should be used as a preliminary checklist.

4.1.1 Equipment Data

4.1.1.1 Equipment Drawing. A drawing should be furnished showing:

(1) The outline of the equipment.
(2) The overall dimensions.
(3) The location of the center of gravity.
(The method of obtaining the center of gravity

[2]The stiffness may be dynamic or static, and the mounting must have an axis of symmetry.

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Table 1
Information Supplied by the User

Category	Information To Be Supplied
(1) Equipment Data	
Drawing	Dimension Outline Locate attachments (mounts) Locate center of gravity Identify principal axis
Weight	Total Distribution
Moments of inertia	Three orthogonal axes about the center of gravity Principal directions
Frequencies	Primary resonance modes of major or fragile parts
Fragility	Vibration, shock, directions
Special features	Heavy parts Special tubes, etc Electrical connectors, grounding Tubing (flexibility) Cooling ducts Service access Impedance (mobility)
(2) Installation Data	
Space envelope	Type of vehicle Location Orientation Available space
Structural attachments	Location and strength
(3) Dynamic Characteristics (Input)	
Vibration	Source Frequency range and amplitude Random, periodic, sinusoidal Expected total time
Shock	Pulse characteristics, duration, amplitude, shape Directions (if applicable) Spectrum Expected repetition Source
Impedance values	Values of structure and equipment
Sustained acceleration	Acceleration amplitude Direction
(4) Environmental Conditions	
Temperature range	Min and Max
Altitude	In thousands of feet or torr
Attitudes	Degree of maximum inclination
Other	Humidity, salt spray, ozone, vacuum, radiation, oils, solvents, sand and dust, age

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should be given, that is, estimate, calculation, test. Attachments such as cable and connectors should be included.)

(4) Identification of the principal axis of inertia and the three mutually perpendicular axes with the origin at the center of gravity of the mounted unit. Orientation of the axes, with respect to the equipment, should be given by dimensions.

(5) The points at which the mountings are attached to the equipment shall be shown by a drawing. The user should permit as much flexibility as possible because an extremely rigid specification on mounting locations can preclude an optimum mounting arrangement.

4.1.1.2 Total Weight. The total weight of the equipment should be given. The method of obtaining the total weight should be indicated (that is, estimate, calculation, test).

4.1.1.3 Moments of Inertia and Products of Inertia. The moments of inertia and the products of inertia about the three axes through the center of gravity should be given. The method of obtaining the moments of inertia and products of inertia should be given (that is, estimate, calculation, test). Attachments such as cables and connectors should be included. [1],* Chapter 3.

4.1.1.4 Equipment Fragility. The allowable input vibration (sinusoidal or random, or both) and input shock that the equipment is known to be capable of withstanding, should be given. In the absence of fragility data or estimates, the resonance frequencies of major or fragile parts of the equipment should be given or a transfer function in terms of amplitude and frequency. [2]

4.1.1.5 Equipment Impedance (Mobility). The mechanical impedance (mobility) of the equipment attachment points should be provided for all directions of concern. In the absence of impedance data, the frequency and damping of the first major resonance of the equipment should be provided. [2]

4.1.1.6 Special Features. Special features peculiar to the equipment should be given in the equipment description and by drawings. Among such special features are:

(1) Electrical connectors, tubing, or piping which might mechanically "short-circuit" the mounting. (Type, size, stiffness, etc, should be indicated.)

(2) Required access area should be indicated.

(3) Minimum clearance required for cooling air flow should be indicated. (Any hot spots which might adversely affect mounting operation should be shown on the drawing, and the probable temperature range given.)

(4) Indicate any angular relative motion constraints and also any requirements for the ability of the mounting to return the device to its original position for gyroscopic devices.

(5) Special attention must be given to indicate servo-structure interaction, such as inertial properties, on resilient mountings for active servomechanisms.

4.1.1.7 Electrical Features. Provisions for grounding and applicable specifications should be indicated on the drawing and by supporting statements.

4.1.2 Installation Data

4.1.2.1 Preferred Space Envelope. The preferred space envelope showing the space available for the displacement of the mounted equipment should be shown by a drawing. If applicable, indicate feasibility of placing several items on one common mounting.

4.1.2.2 Structural Attachments and Locations. Bolts (including size, etc) and any special connectors for securing the equipment should be specified on the drawing. Feasible structural attachment points should be given. These points frequently determine the mounting systems in relation to attitude, base mounting, center-of-gravity mounting, etc. Locations of tapped holes, tolerances and any special material considerations should be indicated on the drawing. Information concerning attachment screws, tubing, and wave guides should be furnished.

4.1.2.3 Equipment Orientation. The normal equipment orientation with respect to the vertical should be shown. The directions of all major shock or vibration should be indicated and the shock or vibration environment should be explicity defined for each direction to the extent that it is known. (See 4.1.3.) Special or unusual orientations, such as changes in attitude with flight conditions, should be indicated.

4.1.2.4 Location. The location of the mounted equipment within a vehicle or application should be given when known.

4.1.2.5 Structural Impedance (Mobility). The mechanical impedance (mobility) of the structure to which the individual resilient mountings or mounting system will be installed should be provided for all directions of concern. In the absence of impedance data, the static stiffness and the frequency and damping of the first major resonance of the structure should be provided. [2]

4.1.3 Environmental Data. All available detailed information concerning the vibration and shock environment, should be given. Specifications or acceptance tests should be referenced, if applicable. Also, include information as to sources of excitation, such as:

(1) Reciprocating engine: Types, size, speed, gear-

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boxes (number of teeth on gears), accessory drive shaft, propellers (diameter, number of blades, etc).

(2) Turbines and compressors: Types, sizes, speed, gearboxes (number of teeth on gears), accessory drive shafts, number of blades on compressors, number of blades on diffuser.

(3) Motors and generators: Type, size, speed, gearboxes, (number of teeth on gears), number of poles, number of slots on rotor.

(4) Jet engines: Type, thrust, jet efflux velocity and diameter, compressor and turbine r/min and number of blades, distance and location from the mounting application.

(5) Rocket engines: Type, size, thrust, distance and location from the mounting application.

(6) Pumps: Type, Size, r/min, number of impeller blades and operating pressure.

4.1.3.1 Vibration. Periodic vibration should be described in terms of amplitude and frequency. Random vibration should be described in terms of power spectral density of force, acceleration, velocity or displacement.

4.1.3.2 Shock. The shock should be described in terms of a time history (for example, peak acceleration, wave shape, and time duration of a single pulse) or in terms of a shock spectrum. Some indication should be given by the user on whether the shock is a single event or a multiple event.

NOTE: In the case of a multiple event, the time between shock inputs should be provided if it is significantly small.

4.1.3.3 Steady (Sustained) Accelerations. The magnitude of any steady accelerations should be given together with the time duration. Special considerations such as zero-gravity should be included.

4.1.3.4 Other Environments. The user should supply the following environmental information and time spent at each exposure, as applicable, to ensure proper application.

(1) The upper and lower temperature limits during transportation, storage and use

(2) Transportation environments

(3) Altitude, if applicable

(4) Humidity, sand and dust, salt spray, ozones, oils, solvents, radiation, etc

(5) Toxicity requirements

4.2 Information Supplied by the Manufacturer of Mountings. The manufacturer should supply the information below as applicable to ensure proper use.

NOTE: Table 2 should be used as a preliminary check list.

4.2.1 Physical Data

4.2.1.1 Drawing. A drawing should be furnished by the manufacturer showing the following characteristics of his mounting unit or mounting system as applicable:

(1) Overall dimensions with tolerances.

(2) Location and size of mounting holes or studs with tolerances.

(3) Allowable direction(s) of sustained forces due to gravity, steady acceleration, propulsion, etc, and associated maximum allowable steady deflections in these directions.

(4) Maximum load, rated load, and unloaded position.

(5) Ultimate static displacements or installation clearance as applicable.

(6) Location of elastic center.

(7) Definition of the three principal directions by arrows or other means on the drawing.

(8) Weight of the mounting unit or mounting system as applicable.

4.2.1.2 Special Features. The manufacturer should describe special features of his mountings. The following are suggested types of features falling in this category which may be included on the drawing or on a separate data sheet.

(1) Snubbers (auxiliary devices or alternate designs).

(2) Damping devices.

(3) Suggested design of the surfaces attached to the mounting where the design of the surface contributes to the performance of the mounting.

(4) Recommended blocking for shipment.

(5) Direction of primary loading.

(6) Load range (maximum load, rated load, minimum load).

(7) Interlocking parts.

(8) Primary field of use (for example, aircraft, shipboard, transportation, cross country vehicles, etc).

(9) Special adaptations (designed to meet certain specifications, extreme temperatures, nuclear radiation, corrosive fluids, high intensity shock, etc).

4.2.2 Performance Data

4.2.2.1 Static Stiffness. The manufacturer should describe the stiffness characteristics of his mountings in three principal directions. The following items should be included as applicable.

(1) Load-deflection data; including loading and unloading information, and rate of load application and removal.

(2) Effect of temperature on load-deflection characteristics.

4.2.2.2 Dynamic Stiffness. The manufacturer should describe the dynamic stiffness characteristics of his mountings in three principal directions. If applicable, it should be shown how the stiffness characteristics vary with:

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Table 2
Information Supplied by the Mounting Manufacturer

Category	Information To Be Supplied
	(1) Physical Data
Drawing	Dimensions Location and size of holes and studs Loaded and unloaded dimensions Vertical and transverse displacement limits Location of elastic center Principal elastic directions Total weight
Material and finish	Type of resilient element Snubber characteristics Damper Structural material
Attachment means	Type of attachment (bolt, rivet, etc)
Preload	If applicable
Inclination limits	Maximum degree of inclination
Loads	Minimum and maximum operating loads Overload capacity
	List primary use such as heavy machinery, engines, fans, shipping containers, aircraft, shipboard, truck, etc
	(2) Performance Data
Dynamic	Transmissibility: Variation with the following: Frequency (for various masses per moun mounting) Minimum and maximum loads Amplitude Directions Temperature Constant acceleration (if applicable)
	Dynamic stiffness: Three principal directions Variation with frequency, amplitude, and steady preload
	Damping characteristic (as a function of frequency and temperature)
	Endurance: Repeat deflections
	Shock limits: Transmission characteristics
Static	Load–deflection data Ultimate strength Drift
	(3) Environmental
Temperature range	
Corrosion and deterioration protection	Salt spray, solvents, vapors, sand, dust, vacuum, radiation, and age
Altitude	
Ozone	If applicable

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(1) Frequency
(2) Vibratory amplitude
(3) Steady preload
(4) Temperature

NOTE: Transmissibility is a function of dynamic stiffness and damping of the mounting as well as system configuration. Therefore, a description of the actual test setup and conditions used to determine transmissibility should be given. These should include orientation of mountings relative to direction of excitation, number of mounts, and geometry of the mass-mounting-fixture system.

4.2.2.3 Damping. The manufacturer should describe the damping characteristics of his mounting in three principal directions as a function of frequency, amplitude, and temperature.

4.2.2.4 Fatigue Resistance. The manufacturer should describe the fatigue resistance of his mountings. This may be in terms of amplitude and frequency and total number of cycles or in terms of an S-N curve (stress vs number of cycles).

4.2.2.5 Strength. The manufacturer should present data on working strength, ultimate strength, etc (for example, under what loads will the mounting or its component parts assume permanent changes which affect its initial characteristics). If applicable, data should be given on the degree of shock the mounting can withstand without complete failure.

4.2.2.6 Drift. The manufacturer should present drift data where applicable and how the data were determined. If applicable, the data should include load, time, temperature, and any other environmental factors.

4.2.2.7 Shock. The manufacturer should indicate shock limits and transmission characteristics.

4.2.2.8 Special Performance. The manufacturer should point out any special features or purpose embodied in specific types of mountings (for example, state if designed specially for minimum noise transmission, shock attenuation, high temperature applications, sustained acceleration, high natural frequency, etc).

4.2.3 Environmental Data. The manufacturer should supply the following information on his mountings as applicable to guard against improper application:

(1) Temperature, upper and lower limits, and performance as a function of temperature.

(2) The ability of the mounting to withstand corrosion or deterioration caused by humidity, salt spray, fungus, ozone, oils and fuels, corrosive vapors, sunshine, nuclear radiation, etc.

(3) The ability to perform in an atmosphere containing sand and dust.

(4) The ability to perform at altitude.

(5) Aging effects, perdicted life, recommended storage environment, and effects of various environments on the life of the mounting.

5. References

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