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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Mechanical vibration and shock — Mechanical mounting of accelerometers

Vibrations et chocs mécaniques — Fixation mécanique des accéléromètres

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5348 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Mechanical vibration and shock — Mechanical mounting of accelerometers

0 Introduction

The method most commonly used for determining the vibratory motion, v_S , of a structure or body S is that using an electro-mechanical transducer T.

Vibration monitoring transducers fall into two broad classes: contacting and non-contacting transducers. Non-contacting structural response transducers are placed in close proximity to the structure and include such generic types as eddy current probes and optical proximity probes. Contacting transducers are placed in mechanical contact with the structural system and include such generic types as piezoelectric and piezoresistive accelerometers and seismic velocity transducers. This International Standard is concerned with contacting type accelerometers which enjoy wide current popularity. The concern with using such transducers is that the mechanical connection between the accelerometer and the test structure alters the response of the structure. This International Standard attempts to isolate parameters of concern in the selection of a method to mount the accelerometer to the structure.

This International Standard deals with accelerometers which are connected to the surface of the structure in motion by means of a mechanical mounting F, as illustrated in the simplified diagram shown in figure 1.

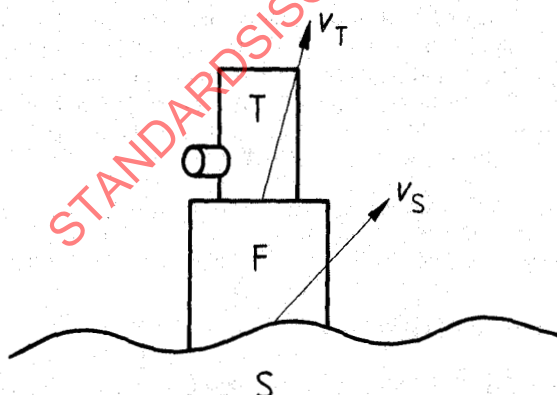


Figure 1 — Accelerometer mounting

The information supplied by such a transducer is the electric signal, u , generated by the action of its own motion, v_T .

The information desired is the vibratory motion, v_S , of the structure S.

The electric signal, u , generated by the transducer deviates from what it would have been, if that particular accelerometer effectively measured the vibratory motion, v_S , of the structure, owing to non-ideal transfer of motion from S to the sensitive elements of the accelerometer T.

Deviations may also occur owing to misalignment of the sensitive axis of the transducer, base bending, temperature transients, mounting torque, and cable whip.

The mechanical mounting will change the useful frequency range for a given accuracy with regard to amplitude as well as phase response (see 5.4.5).

1 Scope and field of application

This International Standard describes the mounting characteristics of accelerometers to be specified by the manufacturer and makes recommendations to the user for mounting accelerometers. The application of this International Standard is limited to the mounting of electromechanical transducers of the type which are mounted on the surface of the structure in motion and does not cover other types, such as relative motion pick-ups.

2 References

ISO 2041, *Vibration and shock — Vocabulary*.

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*.

ISO 5347-0, *Methods for the calibration of vibration and shock pick-ups — Part 0: Basic concepts*.

3 Definitions

For the purposes of this International Standard, the terms and definitions given in ISO 2041 are applicable.

4 Characteristics to be specified by manufacturers of accelerometers

The manufacturer shall specify the following characteristics:

- a) the mounting surface and flatness tolerance of the accelerometer to which pertinent data supplied refer;
- b) the geometrical dimensions of the accelerometer, including:
 - the position of the centre of gravity for the accelerometer as a whole,
 - the position of the centre of gravity for the seismic mass of the accelerometer;
- c) the mounting technique used during calibration;
- d) the normal and maximum (i.e. for less than 2 % change in the useful frequency range) mounting torque;
- e) temperature limitations of the accelerometer and fastening device;
- f) pertinent mechanical characteristics:
 - total mass,
 - material of base,
 - the unmounted fundamental frequency of the accelerometer,
 - the frequency response characteristic under well-defined mounting conditions, describing the object on which the transducer is mounted in terms of mass, material and dimensions,
 - the maximum transverse sensitivity, and the frequency at which it was determined;
- g) a description of the various fastening devices provided for the accelerometer, i.e.
 - diameter,
 - thread,
 - material;
- h) the frequency response curves of the accelerometer with the type of mechanical mounting recommended by the manufacturer and the effect of special mounting devices supplied with the accelerometer, in particular:
 - axial stiffness, with account taken of the state of the surface of the structure in contact with the accelerometer and the tightening torque of the accelerometer,
 - transverse deflection stiffness, on the same basis.

5 Considerations in the selection of a mounting method

5.1 General considerations

A contact accelerometer will achieve optimal performance only if the following general procedures are followed :

- a) the accelerometer shall perform as nearly as possible the same motion as the structure under test at the accelerometer attachment;
- b) the motion of the structure shall be changed as little as possible by the addition of the accelerometer;
- c) the ratio of the signal from the accelerometer to the motion of the accelerometer shall not be distorted by operating too near to its mounted fundamental resonance frequency.

In order to achieve these ideal conditions, it is necessary to ensure that

- a) the accelerometer and its mounting are as rigid and firm as possible (the mounting surfaces shall be as clean and flat as possible);
- b) the mounting introduces minimum distorting motions of its own (for example, simple symmetrical mountings are best);
- c) the mass of the accelerometer and mounting are small in comparison with that of the structure under test (see ISO 2954).

5.2 Specific considerations

5.2.1 Frequency range of operation

The accelerometer shall be used well below its fundamental resonance frequency. If it is possible to use the manufacturers' recommended mounting, then operation at frequencies not greater than 20 % of their quoted mounted resonance should, in the case of undamped accelerometers, ensure in most cases that errors of only a few per cent on the amplitude response occur. If an estimate of the approximate error is required, it may be made on the basis of an equivalent linear spring-mass system with a given value of damping.

NOTE — For single shock measurements, one may expect errors of less than a few per cent if the mounted fundamental resonance frequency is ten times greater than the inverse of the pulse duration.

5.2.2 Mounting torque

When screw thread mounting is used, the mounting torque shall be as recommended by the manufacturer.

5.2.3 Cables

Loose cables may introduce tribo-electric effects. Stiff cables can cause case strain when used with accelerometers with axial connectors. Careful clamping of the cables is required to avoid such problems (see figure 2).

5.3 Determination of the mounted fundamental resonance frequency

It is very useful, though at times difficult in practice, to determine accurately the mounted fundamental resonance frequency of the accelerometer mounted on the structure under test. The following method may be of use in finding the approximate resonance, thus ensuring that an adequate margin exists between it and the test frequency.

5.3.1 Vibration excitation method

A suitable steel reference block with well-defined shape and surface finish is recommended, e.g. a stainless steel block of mass 180 g. The motion of the reference block is monitored close to the mounting surface of the accelerometer being tested using an accelerometer with a resonance frequency higher than the first bending mode of the steel block itself. The excitation force can be generated electro-dynamically. The influence of the quality of mounting surfaces and materials may be investigated by introducing typical samples between the steel surface and the accelerometer being tested (see figure 3). For typical mountings and mounted frequency curves, see figures 5 to 10.

NOTE — For the method of determining the fundamental (resonance) frequency, see ISO 5347-0.

5.3.2 Shock excitation methods

The ballistic pendulum, the drop test and a simple hammer blow are three ways of using shock excitation. In the first, the accelerometer is attached to an anvil mass suspended as a pendulum while a second hammer mass, similarly suspended, is used to provide the blow. In the drop test, the accelerometer is attached to a hammer which is guided in its vertical fall on to a stationary anvil to provide the shock. The attachment of the accelerometer to the mass shall be similar to the actual test body attachment. While it may be impossible to represent the test body by the mass of the anvil or hammer, it shall be made of the same material and of sufficient size to be a reasonable representation of the test body with regard to stiffness. The hammer blow applied near the mounted accelerometer on the actual structure may provide the necessary information, if structural resonance in the measuring object can be disregarded.

The accelerometer output produced by the shock under suitable conditions will have the resonance frequency superimposed (see figure 4). Some experimentation is required with the energy of shock (i.e. the height from which the mass is released) and the stiffness of the impact surface (for example, steel or lead lined) to obtain a suitable period of impact to display the resonance effect. Care shall also be taken to see that the lowest resonance is excited during the shock. The use of a suitable single-event recorder storage device or photographing technique enables the frequency of the resonance ripple to be determined. These methods are particularly suited for high frequencies.

Repeated well-defined shocks may give additional information on the stability of the mounting.

5.4 Recommendations for particular types of mountings

5.4.1 General

The mounting surface shall be carefully examined for cleanliness and smoothness and, if necessary, it shall be machined flat. Any lack of alignment between the sensitive axis of the accelerometer and the direction of measurement shall be minimized, as otherwise this will lead to errors similar to those introduced by transverse sensitivity. These errors will be particularly large if the transverse motion is much greater than the axial motion.

The condition of the mounting surface and method of mounting shall be stated in any report.

Generally speaking, the recommended mounting methods for the transducer shall be followed in order to make the manufacturer's data applicable.

5.4.2 Stud mounting

5.4.2.1 Surfaces shall be clean, flat and machined smooth to manufacturer's tolerances where specified. The axes of the stud mounting holes shall be square to the mounting surface.

5.4.2.2 The manufacturer's recommended mounting torque shall be used to obtain a firm fixing without damaging the accelerometer.

5.4.2.3 A thin film of oil or grease between the surfaces helps to achieve good contact and thus maximum stiffness (see figure 5).

5.4.2.4 The stud shall not bottom in the mounting holes as rigidity may be lost owing to a small gap between the surfaces.

5.4.3 Cementing

This is used where the structure under test cannot be drilled or where electrical isolation of the accelerometer is necessary or where the surface flatness is insufficient. A cementing stud, threaded at one end and with a flat disc at the other end for cementing to the structure, is often used.

5.4.3.1 The surface shall be cleaned to the cement manufacturer's recommendations.

5.4.3.2 In general, a thin layer of cement is recommended, as this represents a stiffer spring.

5.4.3.3 Hard cements of the catalytic or thermo-setting variety are preferred to solvent drying cements (the latter tend to remain soft internally and thus lower the resonance frequency) (see figure 6).

5.4.4 Mounting fixtures

Mounting fixtures, including electrical isolating studs, should be constructed

- a) as light as possible;
- b) as stiff as possible;
- c) with as low a movement of inertia as possible;
- d) preferably to be symmetrical.

If the use of a complicated bracket is unavoidable, an investigation of its vibration modes and resonance frequencies is desirable.

Brackets shall be avoided if possible. When necessary, it is recommended that a small stiff metal cube be used, rigidly mounted to the structure, with machined surfaces drilled and tapped to accept stud mounting.

5.4.5 Miscellaneous mountings

Many routine tests can be successfully carried out by fixing the accelerometer with a thin layer of hard-setting wax (see figure 10), by using double-sided pressure-sensitive tape (see figure 7) or by using magnetic attachment (see figure 9). These methods are severely restricted in amplitude and frequency range. In doubtful cases, the fundamental resonance frequency shall be investigated experimentally. Hand-held accelerometers are not generally recommended, except for exploratory purposes (see figure 8).

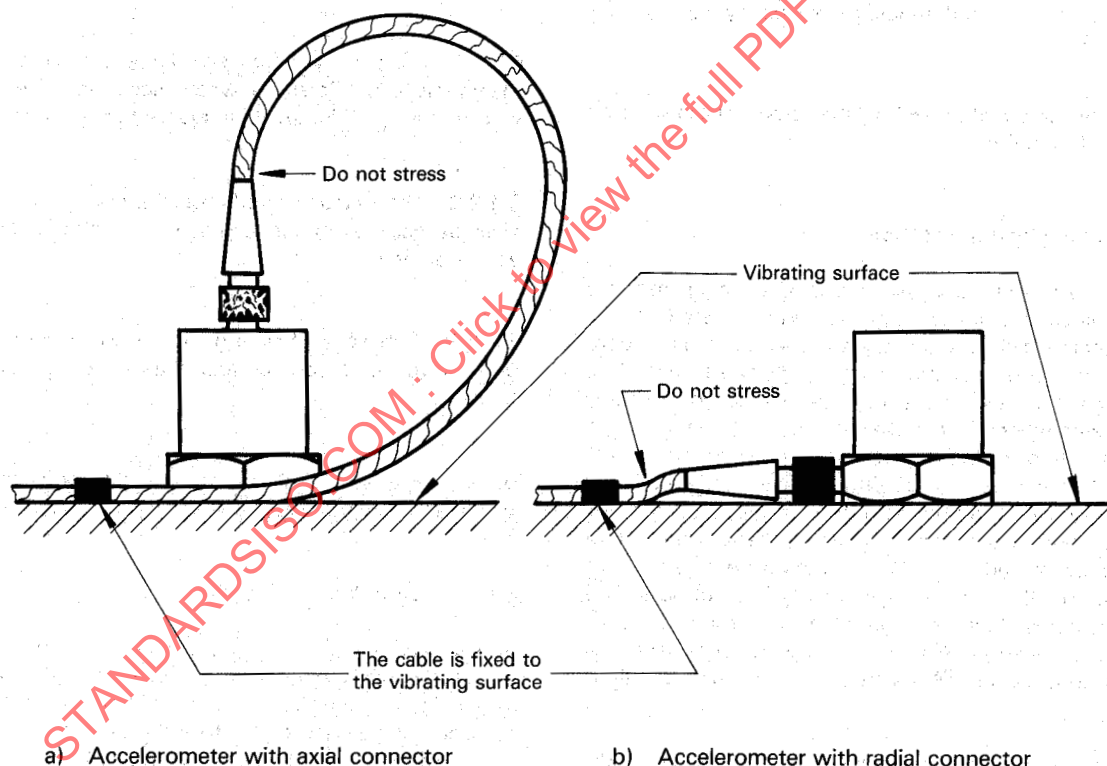


Figure 2 — Accelerometers with axial and radial connectors

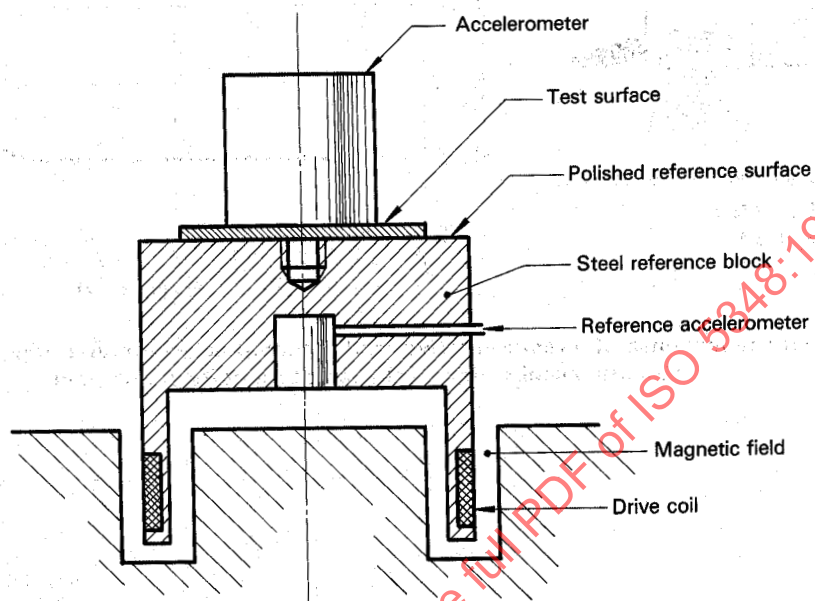


Figure 3 — Accelerometer test arrangement

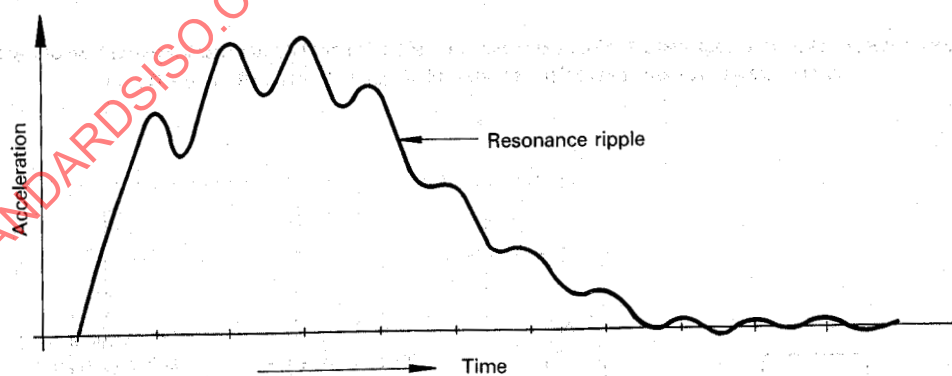


Figure 4 — Accelerometer response to shock

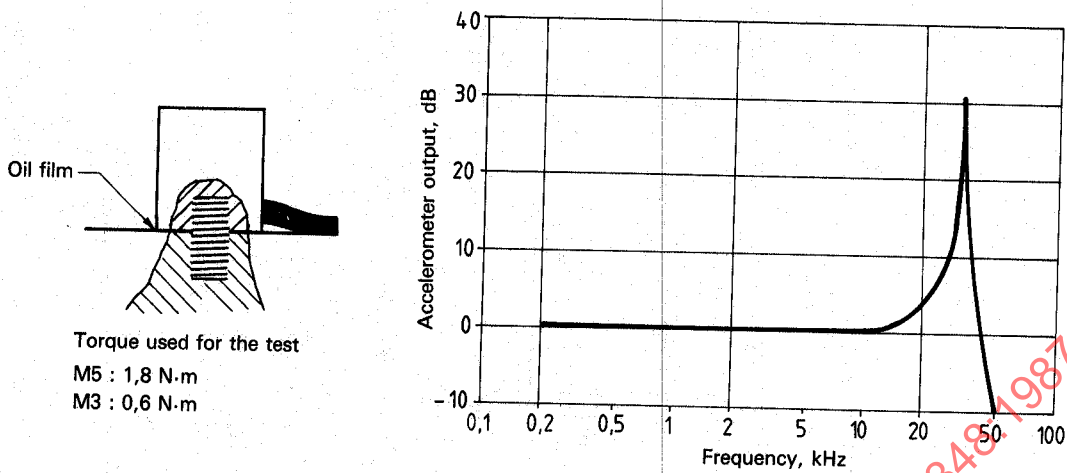


Figure 5 — Frequency response of a representative stud-mounted accelerometer with oil film relative to the absolute acceleration of the structure at its attachment

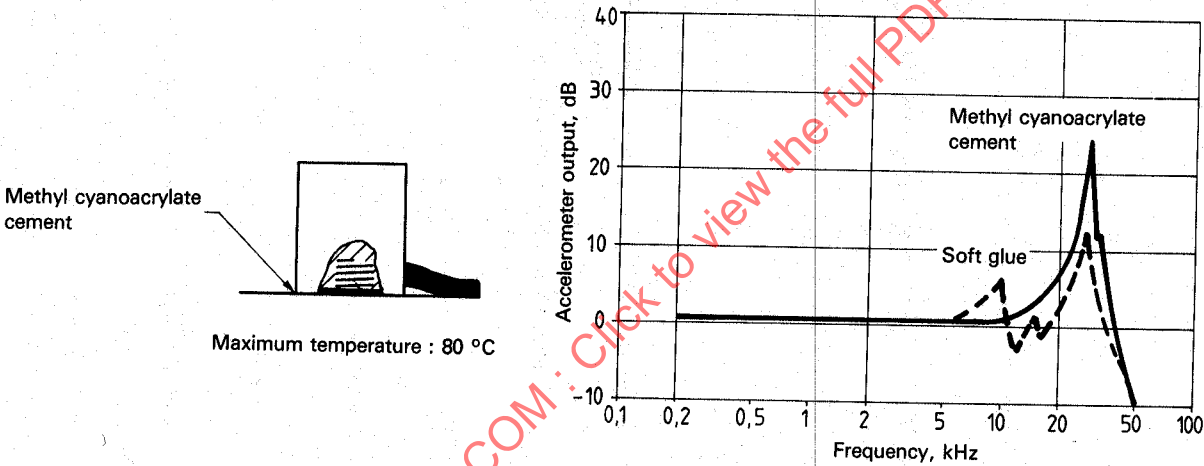
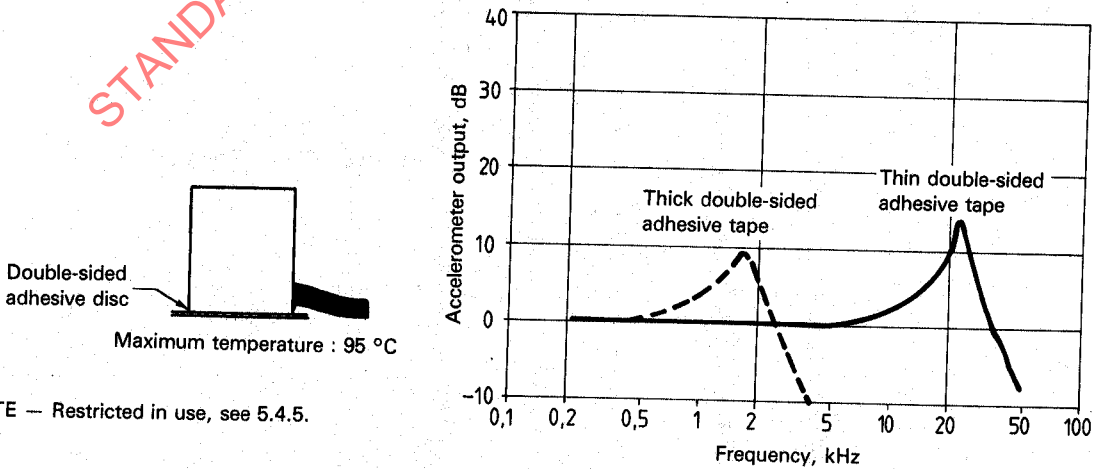
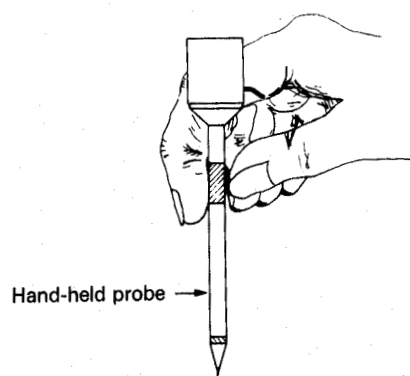


Figure 6 — Frequency response of a representative cement-mounted (methyl cyanoacrylate) accelerometer relative to the absolute acceleration of the structure at its attachment



NOTE — Restricted in use, see 5.4.5.

Figure 7 — Frequency response of an accelerometer mounted by double-sided adhesive tape relative to the absolute acceleration of the structure at its attachment



NOTE — Restricted in use, see 5.4.5.

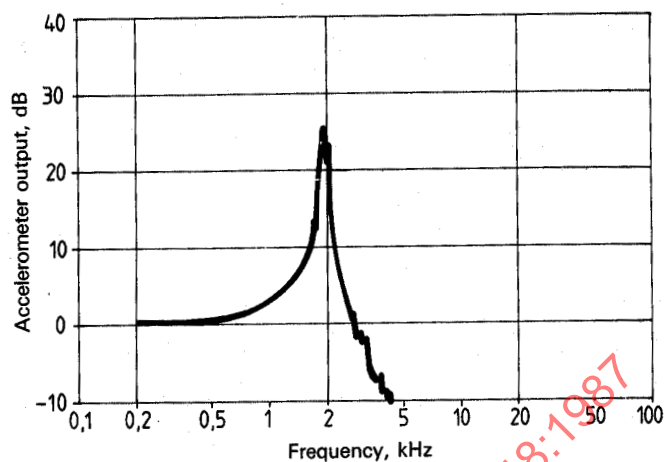
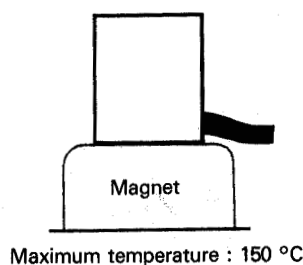


Figure 8 — Frequency response of a hand-held probe relative to the absolute acceleration of the structure at the contact point



Maximum temperature : 150 °C

NOTE — Restricted in use, see 5.4.5.

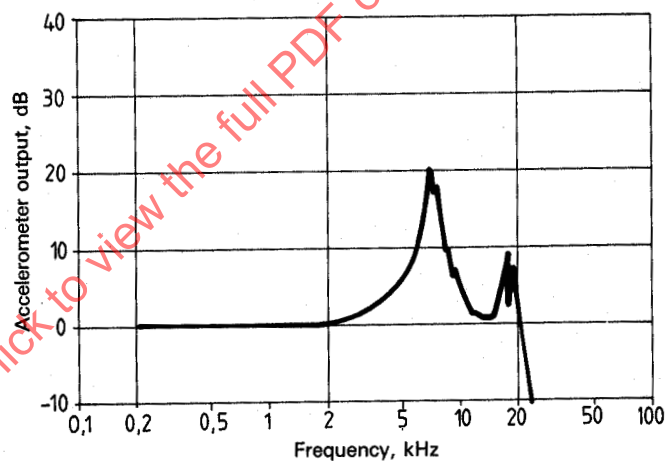
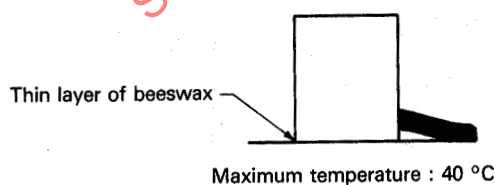


Figure 9 — Frequency response of a magnetically mounted accelerometer relative to the absolute acceleration of the structure at its attachment



Maximum temperature : 40 °C

NOTE — Restricted in use, see 5.4.5.

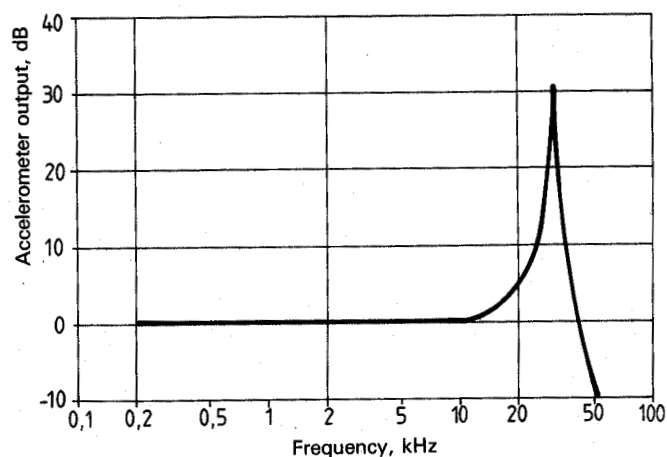


Figure 10 — Frequency response of an accelerometer mounted with a thin layer of beeswax relative to the absolute acceleration of the structure at its attachment