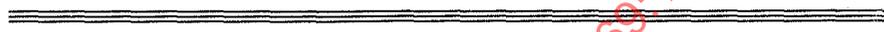


INTERNATIONAL STANDARD

ISO 8569

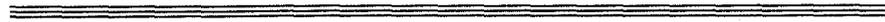
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Mechanical vibration — Shock-and-vibration-sensitive electronic equipment — Methods of measurement and reporting data of shock and vibration effects in buildings

Vibrations mécaniques — Equipements électroniques sensibles aux chocs et aux vibrations — Méthodes de mesurage et de présentation de données relatives aux effets des chocs et des vibrations dans les bâtiments

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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 8569 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*.

Annexes A to D of this International Standard are for information only.

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Introduction

This International Standard is intended to give provisional guidelines for the measurement and evaluation of shock and vibration affecting shock-and-vibration-sensitive electronic equipment.

To facilitate the comparison of data (for example the comparison of shock and vibration levels measured in different countries on equipment from different manufacturers) a database reporting system is considered. The reporting system presented will aid in the establishment of limit levels for specific equipment.

Further information regarding the methods of measurement and evaluation is given in annexes A, B and C.

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Mechanical vibration — Shock-and-vibration-sensitive electronic equipment — Methods of measurement and reporting data of shock and vibration effects in buildings

1 Scope

1.1 This International Standard defines methods of measuring and reporting shock and vibration data for shock-and-vibration-sensitive electronic equipment (in the operating and non-operating modes) in buildings. The shock and vibration data obtained may then be used to establish a database.

Electronic components are not dealt with in this International Standard.

The types of shock and vibration considered are those transmitted from floors, tables, walls or ceilings into an equipment unit. The vibration and shock of individual mechanical or electronic parts inside the unit are not considered.

1.2 The database established using the methods described in this International Standard should serve as a guide for constructors, users, suppliers and manufacturers of shock-and-vibration-sensitive electronic equipment. The types of equipment envisaged include

- a) commercial stationary computer systems (including the peripherals);
- b) commercial stationary telecommunication equipment;
- c) commercial stationary laboratory electronic instruments, such as electron microscopes, mass spectrometers, gas chromatographs, lasers, X-ray apparatus and electronic apparatus of general character.

Whenever possible it is recommended that the vibration and shock is measured with the sensitive equipment in both the operating and the non-operating mode in order to distinguish between the various possible sources. The types of shock and vibration considered herein can be generated by:

- a) external sources, for example traffic or building and construction activities such as blasting, piling and vibratory compaction (sonic booms and acoustic excitations are also included);
- b) equipment for indoor use, such as punch presses, forging hammers, rotary equipment (air compressors, air conditioners, pumps, etc.) and heavy equipment transported or operated inside a building;
- c) natural sources, such as earthquakes, water and wind;
- d) human activities in connection with the service or operation of equipment.

The frequency range of interest is 0,1 Hz to 1 000 Hz. (The frequency range of interest for earthquake-induced vibrations is 0,1 Hz to 35 Hz.)

The vibration levels of interest, expressed in terms of acceleration values, are in the range from 0,01 m/s² to 250 m/s². The upper limit may be produced by high-frequency vibrations or shocks. Limits for low-frequency vibrations are normally expressed in terms of displacement. The durations considered for shocks are in the range 0,5 ms to 25 ms.

Blasting induces a complex vibration wave-form. The response of buildings to such a vibration is in the frequency range from about 5 Hz to 300 Hz.

The vibration levels of interest for transient vibration from blasting are given for information in annex A.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4866 : —¹⁾, *Mechanical vibration and shock — Measurement and evaluation of vibration effects on buildings — Guidelines for the use of basic standard methods.*

ISO 5348 : 1987, *Mechanical vibration and shock — Mechanical mounting of accelerometers.*

3 Methods of measurement

3.1 Preliminary assessment

Situations may arise where an assessment of shock and vibration problems has to be made by desk study alone, i.e. usually before field measurements are carried out. Empirical methods can be used to estimate the response, given data on the source parameters and building and/or equipment response characteristics such as fundamental frequency and damping.

1) To be published.

3.2 Field survey

A field survey should be made in order to assess the vibration severity, often in comparison with coded or regulatory values. The minimum requirement for measurement is that the shock or vibration is characterized by a continuous registration of the peak particle velocity values and/or the peak acceleration values with the assumption that the base frequency content can be estimated fairly precisely. Frequency information should be provided whenever possible to aid in the analysis.

Measurements should be of an accuracy compatible with the uncertainties implicit in the shock and vibration indices and empirical relationship used.

3.3 Engineering analysis

In order to determine the vibration and shock conditions to which equipment may be exposed, accurate and comprehensive measurements in the field shall be made. The time history shall be recorded for analysis. The measurement should be made with the shock-and-vibration-sensitive equipment, or with a dummy having the same mass and similar dynamic behaviour as those of the equipment under consideration, in place. The effective mass of the equipment on raised floors or tables may significantly change the input levels and frequencies. If the "dynamic mass" of the equipment is very small, for example as for a personal computer, it has no influence on the behaviour of the floor.

Also, the equipment itself may generate vibration which produces excitation in other units in the immediate area.

Annex B gives further information regarding the instrumentation and analysis methods required to obtain the data necessary to quantify adequately the vibration and shock conditions.

3.4 Position and mounting

The pick-ups should be mounted at a maximum distance of 0,05 m from the points of contact of the equipment with a floor or wall. If there is a soft covering (for example a rug) on the

floor, the pick-up should be mounted on the floor under the covering whenever possible. When the floor is not rigid enough to transmit the frequency under consideration without significant attenuation, the mounting should be on the equipment itself (for example at the lower part of the frame, close to the caster or glide or other support).

Preliminary measurements should be made to determine the input variation among the supports between the equipment and the supporting surface. The data recorded and reported should show the worst case and the best case and whether there are significant variations. Portable r.m.s. or peak-reading accelerometers (see ISO 5348) or their equivalent may be used to carry out the preliminary measurements. The effect of the pick-up mounting system on the accuracy of the data should be evaluated and included with the reported data.

If an orthogonal system of pick-ups is used, the axes should coincide with the axes of the equipment unit being monitored.

The pick-ups and cables should be attached to the measuring point in such a way that accurate results are obtained over the total frequency range of interest. Epoxy cement or cyanoacrylate cement or studs are preferred means of attachment. Magnets, thin double-sided adhesive tape or beeswax may be used only if they transmit signals with an error of less than 10 % over the frequency range of interest (see B.5.4).

4 Database reporting system

For the various types of investigation, as described in 3.2 and 3.3, the reporting method should be as consistent as possible. For field surveys (3.2) it may be sufficient to record the peak velocity or acceleration values and information about the mounting method and mounting place together with the normal reporting method for the survey of buildings subjected to vibration and shock (see ISO 4866). For engineering analysis (3.3), it is desirable to collect and report data according to the method given in annex C. The proposed format for reporting data will aid in the establishment of future threshold levels for shock-and-vibration-sensitive equipment.

Annex A (informative)

Examples of typical vibration values due to blasting

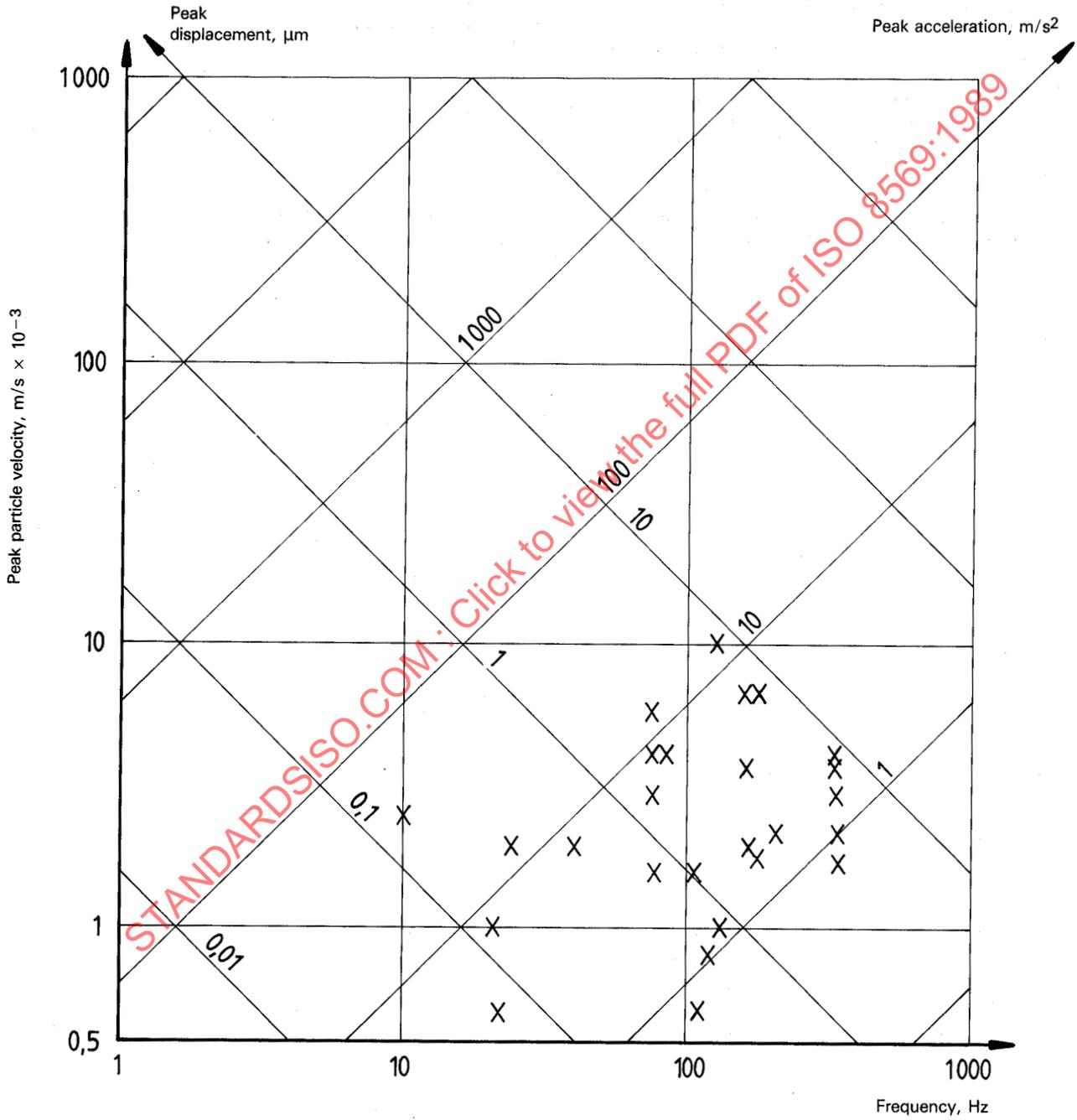
The rapid introduction of shock-and-vibration-sensitive equipment and their accessories has become a problem for the building construction industry. Manufacturers of accessories prescribe very low maximum vibration values for their equipment. As a result, the building construction industry is often limited in its choice of methods for excavation and improvement of the ground for foundation work in areas near existing sensitive equipment.

An investigation^[1] has been carried out to investigate the guidelines and shock and vibration criteria proposed by

manufacturers, suppliers and users of shock-and-vibration-sensitive electronic equipment, such as computers, disc drives and telephone switches.

Figure A.1 shows some typical vibration values measured during construction work where blasting was taking place. The points of measurement were situated on a computer frame or on the floor close to a computer. The peak particle velocity (or acceleration) is plotted as a function of the dominant frequency.

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NOTE — Measurements were made on the frame of or on the floor close to a computer

Figure A.1 — Typical vibration values caused by blasting

Annex B (informative)

Guidelines for an engineering analysis type of investigation of vibration and shock conditions

B.1 Objective

The objective is to establish a common database for collecting, recording and analysing shock and vibration conditions due to construction activities and other events for shock-and-vibration-sensitive equipment.

B.2 Items to be considered

The following items should be considered:

- a) the parameters to be measured;
- b) the data and information to be recorded for analysis;
- c) instrumentation and measurement techniques;
- d) data analysis techniques;
- e) database reporting format;
- f) the responsibility for co-ordinating the database information.

B.3 Parameters to be measured

B.3.1 Shock

The time history (for all three axes) should be recorded and should include the following measurements:

- a) acceleration or velocity variation, including
 - 1) the maximum values,
 - 2) the average values over their time of occurrence,
 - 3) the distribution of the maximum and average values;
- b) duration;
- c) pulse shape;
- d) repetition rate, if applicable.

B.3.2 Vibration

The time history (for all three axes) should be recorded and should include the following measurements:

- a) acceleration or velocity variation, including
 - 1) the maximum values,

- 2) the average values over their time of occurrence,
 - 3) the distribution of the maximum and average values;
- b) duration;
 - c) frequency analysis, including
 - 1) the frequency range,
 - 2) the characteristic frequencies.

B.4 Data and information to be recorded

The data and information to be recorded are as follows:

- a) the parameters specified in clause B.3;
- b) a description of the equipment installation, including
 - 1) room size and layout, and site location,
 - 2) building construction type and floor plan,
 - 3) equipment make, machine type and age,
 - 4) mounting of equipment (i.e. floor, table, wall; for telecommunication equipment, shimmed or not shimmed),
 - 5) vibration isolators;
- c) a definition of any equipment failures;
- d) a description of the construction activity or other source of shock and vibration conditions;
- e) a description of the shock-and-vibration-measuring instrumentation, including
 - 1) instrument model and manufacturer, including calibration equipment, pick-ups, amplifiers, recorders and analysers,
 - 2) pick-up location and directions of axes,
 - 3) pick-up, including cable and mounting,
 - 4) frequency response.

B.5 Instrumentation techniques and specifications

B.5.1 Accelerometers and velocity pick-ups, and at low frequencies displacement pick-ups, may be used. It is recommended to use battery powered amplifiers to reduce noise due to ground loop currents. Mica washer and isolating studs may be used for electrical isolation of the accelerometer base from the mounting surface.

B.5.2 The time history recording and analysis should take into account the following requirements:

- a) Vibration data records or graphics should be long enough to allow averaging during analysis.
- b) Shock data records or graphics shall include the initial pulse and shall continue until any response decays.
- c) Repetitive shock pulse records or graphics should include at least 10 pulses to enable determination of the repetition rate.

B.5.3 Data analysis should be conducted off-line, using laboratory equipment to carry out the spectral analysis of the recorded data.

B.5.4 The pick-up mounting and all instrumentation shall have an adequate frequency response and range as follows:

- a) The anticipated overall range of frequencies of the data is 0,1 Hz to 1 000 Hz.
- b) The data system frequency response should be 15 kHz for a shock pulse of 0,5 ms (the upper cut-off frequency should be 5 kHz for a shock pulse longer than 3 ms and 2 kHz for a shock pulse longer than 6 ms).
- c) The overall amplitude range of interest of acceleration is 0,01 m/s² to 250 m/s².
- d) The accelerometer mounting shall be rigid. The accelerometer shall transmit signals with an error of less than 10 % over the frequency range of interest.
- e) The instrumentation shall be calibrated in the laboratory.

f) Two or more different sets of pick-ups and amplifiers may be needed to cover adequately the ranges specified above.

B.6 Calibration and accuracy

B.6.1 Calibrate the entire system from the pick-up to the recorder as a unit.

B.6.2 Perform the calibration using a known source. Note the calibrated output signal from each of the pick-up/amplifier/data channel combinations used on the time history record to provide an amplitude reference for each data channel.

B.6.3 The accuracy of the entire data channel shall be within 10 % of the true value.

B.6.4 The signal-to-noise ratio shall be at least 5 dB at the low end of the signal range.

B.7 Data analysis

B.7.1 The preferred method of analysis is to use a spectrum analyser to obtain plots of acceleration (in metres per second squared) versus frequency (in hertz) and power spectra density. For vibration, the acceleration values should be the r.m.s. average values over the time history recorded. The characteristic frequencies and their peak values should also be determined. According to the application, a spectral analyser (for example with a resolution of at least 400 lines or with a constant relative bandwidth) should be used for analysis.

B.7.2 Short-duration transient vibration events should be analysed separately over their time of occurrence for r.m.s. and/or peak values and frequency.

B.7.3 For shock analysis, a time history plot (acceleration, duration and pulse shape) is required. It is recommended also that the shock response spectra are computed.

B.7.4 Data should be reported using the format shown in annex C.

Annex C (informative)

Format for reporting data obtained during an engineering analysis type of investigation

C.1 Form for vibration and shock database information

| Vibration/shock database information | Record identification |
|--|-----------------------|
| <p>Installation information</p> <p>Business name: Street address: City, state, country and postal code: Type of building construction: Equipment-room floor construction: Building floor plan (attach):</p> | |
| <p>Equipment information</p> <p>Manufacturer: Equipment model, type, age and mounting (i.e. floor, wall or table, and for telecommunication racks, shimmed or not shimmed): Malfunctions due to shock and vibration conditions:</p> | |
| <p>Instrumentation information</p> <p><i>Pick-up</i> Manufacturer: Model: Type: Location (see data chart, sketch or photographs): Mounting method, including effect on accuracy of data over frequency range of interest:</p> <p><i>Amplifier</i> Manufacturer: Model: Type:</p> <p><i>Recorder</i> Manufacturer: Model: Type:</p> <p><i>Analyser</i> Manufacturer: Model: Type: Analysis frequency range and number of spectral lines: Window shape for spectral analysis of continuous vibration (blockwise processing, fast-Fourier-transform method) or analysis frequency range and percentage bandwidth (bandpass filtering, analogue or digital):</p> <p><i>Calibrator</i> Manufacturer: Model: Type:</p> <p><i>Calibration</i> Overall, pick-up to recorder or analyser output (include statement of the accuracy):</p> <p><i>Frequency response</i> Overall, pick-up to recorder or analyser output:</p> | |

C.2 Data chart format

NOTES

- 1 Calibration is preferred in units of volts (or millivolts) per metre per second squared. However, calibration in velocity or displacement units is acceptable.
- 2 Data should preferably be reported in units of metres per second squared.

| Data | Data identification ¹⁾ |
|--|-----------------------------------|
| Input activity/source ²⁾ : Maximum observed acceleration level ³⁾ (m/s ² peak): Acceleration level for random vibration ⁴⁾ (m/s ² r.m.s. average): Frequency ⁵⁾ (Hz): Shock duration ⁶⁾ : Shock/vibration type: Name, address and telephone number of person taking the data: | |
| 1) Data identification is a sequential number assigned to each successive reading. Descriptive information, drawings or photographs should be attached to the data chart to indicate the actual point and axis of measurement. The same data identification number should be shown on any attached time histories or analyser hard copies. 2) Frequency information shall be supplied to enable data conversion between acceleration, velocity or displacement. 3) The maximum acceleration level observed in a time history or spectral analysis. 4) The acceleration level for a random vibration over the frequency range analysed. Specify the analyser bandwidth. 5) The frequency of the spectral line for a peak acceleration reading or the analysis range for an acceleration r.m.s. summation. 6) Shock duration is the length of the primary pulse in a shock input, not including any subsequent ringing. | |

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