INTERNATIONAL STANDARD

ISO 8569

Second edition
1996-07-01

Mechanical vibration and shock — Measurement and evaluation of shock and vibration effects on sensitive equipment in buildings

Vibrations et chocs mécaniques — Mesurage et évaluation des effets des chocs et des vibrations sur les équipements sensibles dans les bâtiments

Reference number
ISO 8569:1996(E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8569 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures.*

This second edition cancels and replaces the first edition (ISO 8569:1989), which has been technically revised.

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

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Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Mechanical vibration and shock — Measurement and evaluation of shock and vibration effects on sensitive equipment in buildings

1 Scope

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

To facilitate comparison of data (e.g. comparison of shock and vibration levels measured in different countries on equipment from different manufacturers), a database reporting system is discussed. The reporting system presented will aid in the establishment of limiting values for specific equipment and also for classification of their environmental conditions.

The types of shock and vibration considered in this International Standard are those transmitted from floors, tables, walls, ceilings or the isolation system to a unit of equipment. The vibration and shock response of individual mechanical or electronic parts inside the unit are not considered.

The classification system of environmental conditions established from the database should serve as a guide for those who construct, manufacture and use shock- and vibration-sensitive equipment and for building contractors. The types of sensitive equipment envisaged include:

a) stationary computer systems (including the peripherals);

b) stationary telecommunication equipment;

c) stationary laboratory instruments, such as electron microscopes, mass spectrometers, gas chromatographs, lasers and X-ray apparatus of general character;

d) mechanical high-precision instruments (tools), such as equipment for microelectronic production;

e) optical high-precision instruments, photo-reproduction instruments and E-beams;

f) electromechanical systems in train traffic control centres;

g) security equipment (fire detection) and equipment for access control.

The types of shock and vibration considered in this International Standard can be generated by:

a) external sources (e.g. traffic or building and construction activities such as blasting, piling and vibratory compaction); the vibration response to sonic booms and acoustic excitations is also included;

b) equipment for indoor use, such as punch presses, forging hammers, rotary equipment (e.g. air compressors, air-conditioner pumps) and heavy equipment transported or operated inside a building;

c) human activities in connection with the service or operation of the equipment;

d) natural sources, such as earthquakes, water and wind;

e) internal sources; i.e. vibration generated by the equipment itself.

The frequency range of interest is 0,5 Hz to 250 Hz. (The frequency range of interest for earthquake-induced vibration is 0,5 Hz to 35 Hz.) Normally the dominant frequencies are less than 100 Hz, because they represent the response of the elements of the building.

The vibration amplitude and duration depend mainly upon the source, its distance from the sensitive equipment and the response of the elements of the building supporting the sensitive equipment. Expressed in terms of particle velocity, which is the parameter used currently in building vibration evaluation, the values are in the range of 10^{-4} m/s to 2×10^{-2} m/s.

The vibration values of interest for transient and continuous vibration from different sources are given for information in annex B.

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 2041:1990, *Vibration and shock — Vocabulary.*

ISO 4866:1990, *Mechanical vibration and shock — Vibration of buildings — Guidelines for the measurement of vibrations and evaluation of their effects on buildings.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 2041 apply.

4 Measurement methods

4.1 Field survey

A field survey should be made in order to assess the vibration severity, often in comparison with values specified by manufacturers or regulatory authorities. The minimum requirement for measurement is that the shock or vibration is characterized by continuous registration of the peak particle velocity values and/or the peak acceleration values, with the assumption that the base frequency content can be determined.

4.2 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 should be recorded and analysed in three orthogonal axes. Measurements should be made with the shock- and vibration-sensitive equipment in place, or with a dummy having the same mass and similar dynamic behaviour as those of the equipment under consideration. The effective mass of the equipment on raised floors or tables may significantly change the response levels and frequencies. If the mass of the equipment is very small, it has no influence on the behaviour of the floor.

For ultrasensitive equipment (e.g. E-beams), measurements should be carried out whenever possible on the sensitive equipment, on its isolation system and on the floor nearby in order to define the transfer function and the effect of the isolation system.

The equipment itself may generate vibration which produces excitation in other units in the immediate area. Vibration can also arise from ventilation equipment and from persons walking, especially on raised floors.

Whenever possible it is recommended that the vibration and shock be measured with the sensitive equipment in both operating and non-operating modes in order to distinguish between the various possible sources.

For a comparison of target source vibration with limiting values given by the manufacturer, references can be obtained by measuring the environmental vibration under normal working conditions.

4.3 Pick-up positions and mounting

The pick-ups should be mounted as close as possible to the points of contact of the equipment or its support with a floor or a wall (less than 0,2 m away). If there is a soft covering (e.g. 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.

In order to define the transfer function between the source and the sensitive equipment, pick-ups shall be mounted in positions situated approximately on the same vertical line of the floor, raised floor, the isolation system and the equipment itself.

The pick-ups and cables should be mounted in such a way that accurate results are obtained over the total frequency range of interest.

4.4 Instrumentation techniques and specification

Velocity pick-ups or accelerometers may be used. It is recommended to use battery-powered amplifiers to reduce noise due to ground-loop currents. Mica washers and insulation studs may be used for electrical insulation of the accelerometer base from the mounting surface.

Time history recording and analysis should take into account the following requirements:

a) vibration data records or graphics shall be long enough (several cycles of the source) to allow averaging during analysis;

b) shock data records or graphics shall include the initial pulse and shall continue until any response decay occurs;

c) repetitive shock pulse records or graphics shall include at least 10 pulses to enable determination of the repetition rate.

Data analysis should include spectral analysis of the recorded data.

The pick-up mounting and all instrumentation shall have an adequate response and range to anticipate the overall expected frequency and amplitude range.

4.5 Calibration and accuracy

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

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.

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

The signal-to-noise ratio shall be at least 6 dB at the low end of the signal range.

5 Data-reporting system

For the various types of investigation, as described in 4.1 and 4.2, the reporting method should be as consistent as possible. For field surveys (see 4.1), it may be sufficient to record the peak velocity or acceleration values and to give information about the mounting method and the position of the pick-ups, together with the normal reporting method for the survey of buildings subjected to vibration and shock (see ISO 4866). For engineering analysis (see 4.2), it is desirable to collect and report data according to the method given below.

5.1 Items to be considered

The following items should be considered:

a) parameters to be measured;

b) data and information to be recorded for analysis;

c) instrumentation and measurement techniques;

d) data analysis techniques;

e) data-reporting format;

f) responsibility for coordinating the database information.

5.2 Parameters to be measured

5.2.1 Shock

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

a) acceleration or velocity variation, including maximum values;

b) duration of the maximum half-wave;

c) pulse shape;

d) repetition rate, if applicable.

5.2.2 Vibration

Vibration amplitudes shall be given with the same parameter in all frequency ranges to facilitate measurement and comparison of data. As the values have to be compared to those of the building (outside or inside source propagation), particle velocity is the preferred parameter.

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

a) velocity variation, including

— the maximum values,

— the average values in given time intervals;

b) duration;

c) frequency spectral analysis, including the dominant frequencies.

5.3 Data and information to be recorded

The data and information to be recorded are as follows:

a) the parameters specified in 5.2;

b) description of the equipment installation, including

- room size and layout, and site location,
- building construction type and floor plan,
- equipment make, machine type and age,
- mounting of equipment (i.e. floor, table, wall; for telecommunication equipment, shimmed or not shimmed),
- vibration isolators;

c) definition of any equipment failures;

d) description of the construction activity or other source of shock and vibration conditions;

e) description of the shock- and vibration-measuring instrumentation, including:

- instrument model and manufacturer, including calibration equipment, pick-ups, amplifiers, recorders and analysers,
- pick-up location and direction of axes,
- pick-up, including cable and mounting,
- frequency response.

6 Data analysis

6.1 The preferred method is spectral analysis to obtain plots of velocity versus frequency and power spectral density. For vibration, the characteristic frequencies and their peak values should also be determined.

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

6.3 Data should be reported using the format shown in annex A.

Annex A
(informative)

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

A.1 Form for vibration and shock database information

Vibration/shock database information	Record identification
Installation information Business name: Street address: City, state, country and postal code: Type of building construction: Floor construction in equipment room: Building floor plan (attach):	
Equipment information 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:	
Instrumentation information *Pick-up* Manufacturer: Model: Type: Location (see data chart, sketch or photographs): Mounting method, including effect on accuracy of data over frequency range of interest: *Amplifier* Manufacturer: Model: Type: *Recorder* Manufacturer: Model: Type: *Analyser* 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, analog or digital): *Calibrator* Manufacturer: Model: Type: *Calibration* Overall, pick-up to recorder or analyser output (include statement of accuracy): *Frequency response* Overall, pick-up to recorder or analyser output:	

A.2 Data chart format

Data	Data identification[1)]
Input activity/source[2)]: Maximum observed acceleration or velocity[3)]: Acceleration or velocity level[4)]: Frequency[5)]: 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) This is the maximum acceleration or velocity observed in a time history or spectral analysis.

4) This is acceleration or velocity for a random vibration over the frequency range analysed. Specify the analyser bandwith.

5) This is the frequency of the spectral line for a peak acceleration or velocity reading, or the analysis range for an acceleration r.m.s. summation.

6) This is the length of the primary pulse in a shock input, not including any subsequent ringing.

Annex B
(informative)

Examples of typical vibration values due to blasting

The introduction of shock- and vibration-sensitive equipment and their accessories has become a problem for the building construction industry. Manufacturers of accessories specify 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 (see reference [4]) was 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 B.1 shows some typical vibration values measured during construction work where blasting was taking place. The measurement points 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.