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Mechanical vibration and shock — Parameters to be specified for the acquisition of vibration data

Vibrations et chocs mécaniques — Paramètres à spécifier pour l'acquisition de données vibratoires

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21289 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.

Introduction

Use of this International Standard is recommended to minimize errors and ambiguities in vibration measurement due to inadequate or confusing definition of essential parameters. The specified parameters provide information to enable a measurement to be conducted and data to be provided, assuming that proper practices and all applicable sub-specifications have been followed. Proper use of this International Standard will improve the quality of databases for vibration condition monitoring and assessment of machines and structures. It will also facilitate improved comparison of vibration test data conducted by different organizations, using different methods, or over long periods of time.

Mechanical vibration and shock — Parameters to be specified for the acquisition of vibration data

1 Scope

This International Standard identifies a set of parameters to be specified, as applicable, for vibration measurements, analysis, reporting and archiving. It is intended for use in the testing of structures, machines, vehicles, sensitive equipment and other dynamic systems.

This International Standard applies to measurements made by modern data acquisition systems, including digital signal processors, using readily available commercial instrumentation. It can be applied to a variety of common vibration measurement types, including time history, spectrum and frequency-response function measurements.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 18431-2, *Mechanical vibration and shock — Signal processing — Part 2: Time domain windows for Fourier Transform analysis*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041 apply.

4 Abbreviated terms

ASCII, American standard code for information interchange

UFF, universal file format

EU, engineering unit

5 Parameters to be specified

5.1 General parameters

5.1.1 Concerned parties

The organizations or individuals involved in the vibration testing, and their roles and responsibilities, shall be identified.

EXAMPLE Concerned parties may include the individuals and/or organizations that request, require, conduct, witness, review and/or certify the vibration test and/or the resulting data.

5.1.2 Test objectives

A statement of the test objectives shall be supplied.

5.1.3 Test object

The object under test shall be defined and described with sufficient detail to enable later identification of the object. The test object may be a structure, machine, vehicle, sensitive equipment item, or other dynamic mechanical system. In the case of a series of tests of related subsystems, each subsystem shall be defined and distinguished from other related subsystems. If the test object is to be tested prior to, and following, modification(s), this shall be indicated as varying test conditions as indicated in 5.1.8. To facilitate digital data storage and for filenames, etc., the test object and/or subsystems shall be assigned a name or code to distinguish them from other test objects and subsystems.

5.1.4 Location of test

The location or locations of the test shall be specified, to include geographic location, as well as specific test site.

EXAMPLE The test location may include the country, city, province, or other geographical description as well as the test laboratory, test range, or site location of field testing.

5.1.5 Date(s) of test

The test date(s) shall be specified. This shall include year, month, day and time of day of all test events.

5.1.6 Value to be measured

The value to be measured and the corresponding EU shall be specified for each measurement conducted during the test. The EU shall be an SI unit. The method of recording and reporting the value shall also be specified.

EXAMPLE 1 The value to be measured may be acceleration, velocity, strain, force, or any other physical quantity describing the severity of vibration, including the ratio, sum or other arithmetic combination of physical quantities such as mobility. The value to be measured may also be a frequency of interest such as a resonance frequency.

EXAMPLE 2 Various methods of recording and reporting measurement values are possible, including amplitude, peak value, average value, root-mean-square value and level.

5.1.7 Boundary conditions

The boundary conditions of the test, describing the relationship of the test object to its physical surroundings, shall be specified. If applicable, additional data describing the boundary conditions, such as mounted natural frequency or attachment impedance, shall be specified.

EXAMPLE Typical boundary conditions include:

— *in situ*, in which the test object is situated in its normal or usual surroundings;

— resiliently supported, in which the test object is supported by resilient mountings to dynamically isolate the test object from its surroundings and to approximate free boundary conditions;

— rigidly supported, in which the test object is attached to a bed plate or other stiff, massive object to approximate a fixed boundary;

— fixtured, in which the test object is attached to a specially designed test structure or apparatus that is intended to simulate an *in situ* condition in the laboratory or other controlled test site other than its normal surroundings.

5.1.8 Test and environmental conditions

For each measurement series, the test object may be subjected to varying test conditions in order to characterize the vibration response under these different conditions. For each test condition, a written description of the condition shall be supplied, including quantification by secondary, non-vibration measurements where appropriate. An alphanumeric code should be generated for each test condition, as a modifier to be added to the test object code defined in 5.1.3. In certain cases, measurements may be made during changing conditions, for which the starting condition, ending condition and condition program should be specified.

EXAMPLE The test object may be tested under varying environmental factors (temperatures, pressures, etc.), operating conditions (rotational speeds, controlled excitation signals, throttle conditions), and/or before and after events (damage, cycling, ageing, balancing or treatments such as painting or lubrication).

5.1.9 Measurement locations on the object

Each measurement shall be assigned a spatial location on the test object. This location shall be defined by its relative distance from a reference location on the test object, by distance from the origin of a defined co-ordinate system for the test object, by diagram or by a combination of indicators such that no ambiguity can result. For the case of measurements that cannot be described by a single point in space, such as measurement from film-type sensors, a description of the location and area of coverage is required. A unique, unambiguous alphanumeric code distinguishing each location should be devised to abbreviate the description of each location for use in tables, data storage filenames, etc.

NOTE Measurement locations may be chosen to be consistent with standard databases such as discussed in ISO 13373-1:2002, Annex D.

5.1.10 Measurement degree of freedom and frame of reference

Each measurement location shall be assigned a degree of freedom in a frame of reference. Each spatial location may have up to six degrees of freedom, namely three mutually orthogonal translation degrees of freedom and three mutually orthogonal rotational degrees of freedom. For each degree of freedom, the frame of reference, defining the meaning of positive and negative magnitude, shall be specified. It is preferable to relate the degrees of freedom and polarity to a global co-ordinate system consistent with the co-ordinate system used to define the measurement locations; however, in some cases, local co-ordinate systems may be preferable.

NOTE Measurement degrees of freedom and frame of reference may be chosen to be consistent with standard databases such as discussed in ISO 13373-1:2002, Annex D.

5.1.11 Test documentation requirements

Requirements for test documentation shall be specified.

EXAMPLE Test documentation may include a test plan, notification of test, final test report, and any other required documentation.

5.1.12 Applicable test standards

Applicable test standards governing the vibration test shall be specified.

5.2 Test equipment parameters

5.2.1 Data acquisition system

A list identifying components of the data acquisition system used to collect the vibration data shall be specified. The list shall include manufacturer and model number of all data acquisition equipment. Serial number and dates of calibration shall also be provided.

EXAMPLE Data acquisition components may include equipment such as digital signal analysers, signal conditioners, preamplifiers, recording system and filters.

5.2.2 Transducers

A list of transducers used to collect the vibration data shall be specified. The list shall include transducer type, manufacturer, model number, attachment method, serial number, and date of calibration. Manufacturer's specification sheets shall also be provided if applicable.

NOTE Manufacturer's specification sheets typically contain information such as size, mass, accuracy and repeatability, linearity, sensitivity, frequency range, cross-axis sensitivity, initial calibration method and date of calibration, which may be important factors in transducer selection and application.

5.2.3 Vibration excitation

The vibration excitation shall be specified. This shall include whether the excitation is due to self-induced vibration or from a vibration generator system. If provided by a vibration generator system, the system manufacturer, model number, serial number, and date of calibration shall be provided. Other specifications shall be provided as applicable.

EXAMPLE Specifications may include type of vibration generator system (electrodynamic, mechanical direct-drive, hydraulic, unbalanced mass, piezoelectric, impact hammer or other), force output, displacement, linearity, size, mass and attachment method.

5.2.4 Other equipment not related to vibration measurements

A list of other equipment required to conduct the vibration test, but not related to the vibration measurement, shall be made. The list shall contain manufacturer and model number of all equipment. If applicable, serial numbers and dates of calibration shall be provided. Any special requirements for the equipment shall be specified.

EXAMPLE Other equipment may include equipment required to provide control of test conditions, for the acquisition of non-vibration for quantification of test conditions or to allow proper operation or control of the test object.

5.3 Data acquisition and processing parameters

5.3.1 Data products

The data products, describing the data to be collected, stored, plotted, or arranged, shall be specified.

EXAMPLE The data products may include time history, spectrum, frequency response function, coherence function or other types, including specially designed data products unique to the measurement being specified.

NOTE 1 Data products are the result of applying signal processing methods to vibration data. In some cases, real-time signal processing methods are applied to measured data as they are collected, resulting in data products from the vibration test. In other cases, vibration data are recorded and post-processed to provide data products after testing has been completed. In the second case, greater flexibility is achieved, since data can be reprocessed using different parameters if required.

NOTE 2 See ISO 18431-1 for additional standards applicable to signal processing parameters for vibration testing.

5.3.2 Data acquisition time parameters

Data acquisition parameters defining the time sequencing of the measurements shall be specified.

EXAMPLE Common time parameters include the starting time of the measurement, total time duration of the measurement, and block size or block length.

NOTE For some tests, the starting time may coincide with a specific event, such as an impulse, or relative to a machine's operation cycle or be the result of a trigger (see 5.3.4). For others, the start time may be arbitrary.

5.3.3 Sampling frequency

If the data are to be acquired digitally, a sampling frequency shall be specified.

NOTE This is also sometimes specified as a sampling interval.

5.3.4 Trigger event

If the time data are to be initiated by a significant event that provides a reference signal, known as a trigger event, this shall be specified.

EXAMPLE Time series may be collected with the beginning of the time record corresponding to a seismic event, impact, cylinder fire, etc.

In some cases, a trigger delay is necessary, in which case data acquisition begins a set amount of time after the trigger event.

In other cases, a pre-trigger is necessary, in which case data acquisition begins prior to the trigger event. In digital acquisition systems, this is achieved by buffering of input data.

5.3.5 Window function

Parameters for time domain windowing of the data shall be specified according to ISO 18431-2. If time domain window functions are used, the window type and window parameters shall be specified.

5.3.6 Averaging

If applicable, the use of data averaging shall be specified and the total number of averages to be taken shall be specified. If overlap processing is used, this shall be specified along with the percent overlap.

5.3.7 Filtering

If digital and/or analog filtering is used, filter parameters shall be specified.

EXAMPLE Filter parameters can include a general type of filter (low-pass, high-pass, band-pass, octave-bandwidth, one-third-octave, proportional bandwidth, etc.) as well as specific parameters such as pass-band, critical frequency, centre frequency, bandwidth, upper and lower cut-off frequencies and frequency response.

5.3.8 Excitation time history

For experiments requiring vibration generator systems, it is also necessary to specify the excitation time history.

EXAMPLE Excitation time histories can include sinusoidal, random noise, sine sweep, impulse, etc.

5.3.9 Reference measurements

A common reference measurement or set of reference measurements shall be specified, as applicable.

EXAMPLE Typical reference measurements include input force (used in calculation of frequency response functions) or a subset of response measurements used in calculating a set of cross-spectral density functions with a larger set of response measurements.

5.3.10 Frequency range of interest

For spectrum measurements, the frequency range of interest shall be specified.

5.3.11 Frequency resolution

For spectrum measurements, the frequency resolution shall be specified.

5.3.12 Bandwidth averaging

Certain spectrum functions include band-averaging and bandwidth amplitude corrections. In this case, it is necessary to specify the bandwidth and amplitude bandwidth correction.

EXAMPLE Typical bandwidth averages include octave, 1/3-octave, 1/10-octave, etc.

NOTE Due to different time constants and acquisition times, results of octave or fractional-octave analysis obtained by band-averaging are generally not equivalent to results obtained with octave-band and fractional-octave band filters according to IEC 61260.

5.3.13 Digital resolution

If the data are to be digitally recorded, the digital resolution of the analog to digital conversion shall be specified in bits.

EXAMPLE Common digital resolutions are 16 bit, 24 bit, etc.

5.4 Data analysis parameters

5.4.1 Criteria for data quality

Data quality criteria shall be specified, such that a determination can be made from the data products that the data are of acceptable quality to meet the test objectives.

EXAMPLE 1 Signal to noise ratio, coherence, repeatability, reciprocity, and phase stability are examples of analysis methods to which quality criteria can be applied.

EXAMPLE 2 Data quality may also be determined by comparison to past measurements, comparison to analytical simulations or experience of the data analyst.

5.4.2 Analyses to be conducted

If the vibration data are to be used in post-processing analyses to determine or to diagnose the vibration characteristics of the test object, the intended analyses shall be specified.

EXAMPLE Vibration data may be collected to support analysis such as experimental modal analysis, parameter estimation, time-frequency analysis, frequency-wavenumber analysis, order tracking, principal component analysis, transfer-path analysis or other methods, including new techniques whose validation is the objective of the vibration test.

5.4.3 Criteria for acceptability of test object

If the objective of the test is to determine the acceptability of the test objects as related to the vibration test, criteria shall be specified to determine whether the test object is acceptable.

EXAMPLE 1 Acceptability of the test object can result from the object's ability to withstand a prescribed vibration limit, to produce levels of vibration within a prescribed range, or to exhibit certain vibration characteristics as a function of time, frequency, or space.

EXAMPLE 2 Criteria can be derived from applicable standards, analysis, or past experience.

5.5 Data archiving parameters

5.5.1 Test report

If required, format for a test report (see Clause 6) shall be specified.

5.5.2 Test data media

The media used to archive the test data shall be specified.

EXAMPLE Data can be stored digitally in various media formats, on analog tape, on paper copy or in combination.

5.5.3 Digital data format

If data are archived digitally, the file format and data arrangement shall be specified. If applicable, commercial or other computer software required for retrieval of data shall be specified.

EXAMPLE Common data file formats include ASCII text, UFF, and spreadsheet files.

NOTE Data arrangement describes the number format (real and imaginary versus amplitude and phase, decibel versus linear amplitude, floating point versus scientific) as well as organizational structure of data into a matrix, vector, or multiple file system to discriminate different channels, sensors, measurement events, or other test parameters.

6 Vibration test reporting

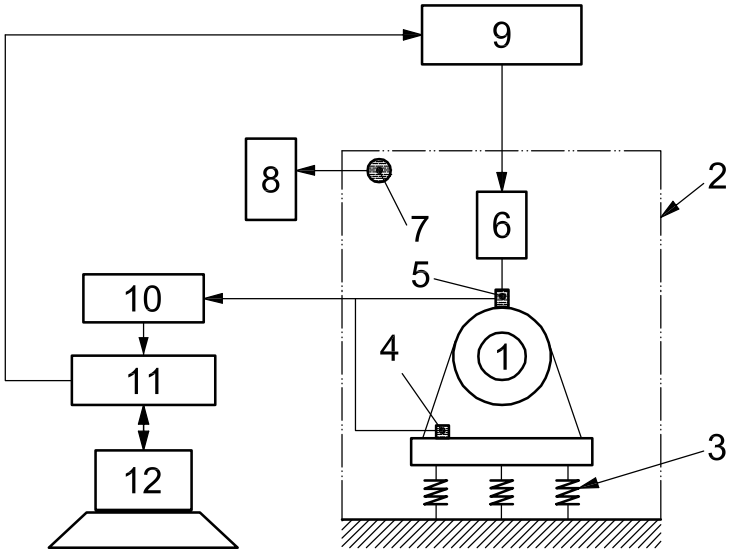
6.1 Reporting of general parameters

6.1.1 General information to be provided

All applicable general parameters as described in Clause 5 shall be included in test reports.

6.1.2 Test diagram

A diagram of the overall test set-up shall be prepared. The diagram shall indicate the physical configuration of the test object and all test equipment, transducers, exciters, or other physical features of the test. An example test diagram is shown in Figure 1.



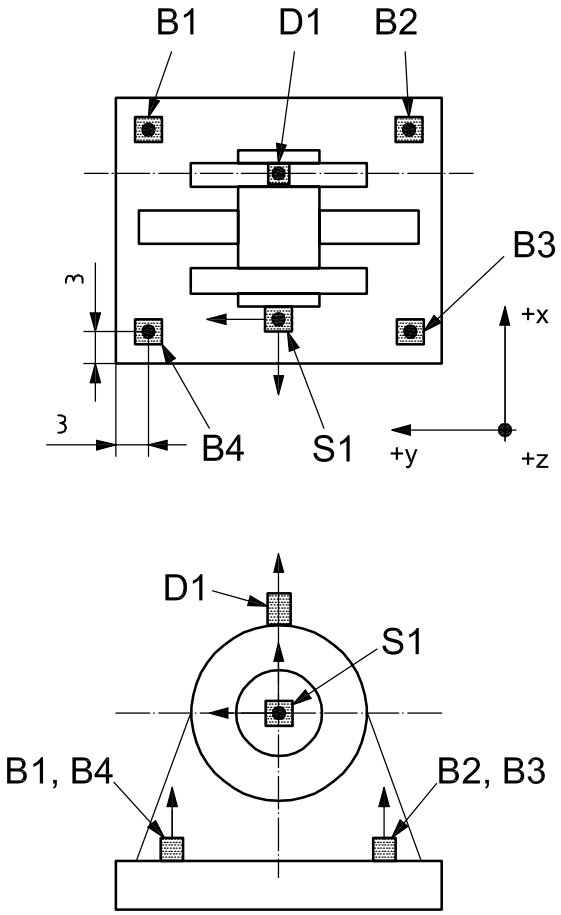
Key

1 test object
2 environmental control chamber
3 resilient mounts
4 accelerometer (typical)
5 force gauge
6 electrodynamic vibration generator
7 thermocouple
8 data logger
9 power amplifier
10 multi-channel signal conditioner
11 multi-channel digital data acquisition system/signal generator
12 computer control unit

Figure 1 — Example test diagram

6.1.3 Measurement location diagram

A diagram of the measurement locations on the test object shall be prepared. This shall indicate measurement locations, and shall identify the co-ordinate system and reference location used. An example test diagram is shown in Figure 2.



Key

B1, B2, B3, B4, D1, S1 measurement locations

NOTE See Table 1.

Figure 2 — Example measurement location diagram

6.1.4 Channel table

A table shall be prepared showing each measurement made and its channel assignment in the acquisition system. As applicable, the table shall also include, for each channel, the measurement, type, location, direction, model and serial number of transducer, sensitivity, applied gains or attenuation, notes, or other pertinent measurement information necessary to reconstruct the flow of data through the measurement system. An example channel table is presented in Table 1.

Table 1 — Example channel table

Channel	Location	Direction	Sensor Type EU	Model number	Serial number	Sensitivity mV/EU	Gain dB
1	D1	+z	Force (N)	K431	1625	10,1	0
2	S1	−x	Acceleration (m/s^2)	M52	1004	503,4	+10
3	S1	+y	Acceleration (m/s^2)	M52	1675	501,2	+10
4	S1	+z	Acceleration (m/s^2)	M52	1987	500,5	+10
5	B1	+z	Acceleration (m/s^2)	M52	2499	101,4	0
6	B2	+z	Acceleration (m/s^2)	M54	2510	100,3	0
7	B3	+z	Acceleration (m/s^2)	M54	2523	98,1	0
8	B4	+z	Acceleration (m/s^2)	M54	2578	99,5	0

6.1.5 Test matrix

A test matrix, indicating in tabular form the conditions and types of tests conducted, shall be prepared. This shall include, as applicable, varying test conditions, measurement conditions, excitation conditions, or other significant variations of the tests conducted. An example test matrix is presented in Table 2.

Table 2 — Example test matrix

Test ID	Temperature °C	Excitation	Test condition
T1E1C1	24	Broadband random, 0 to 100 Hz	Environmental condition 1
T1E1C2	24	Broadband random, 0 to 100 Hz	Environmental condition 2
T1E2C1	24	Broadband random, 0 to 2 000 Hz	Environmental condition 1
T1E2C2	24	Broadband random, 0 to 2 000 Hz	Environmental condition 2
T2E1C1	40	Broadband random, 0 to 100 Hz	Environmental condition 1
T2E1C2	40	Broadband random, 0 to 100 Hz	Environmental condition 2
T2E2C1	40	Broadband random, 0 to 2 000 Hz	Environmental condition 1
T2E2C2	40	Broadband random, 0 to 2 000 Hz	Environmental condition 2

6.2 Reporting of test equipment parameters

6.2.1 Equipment and equipment specification sheets

All applicable test equipment parameters as described in 5.2 shall be included in test reports. The organization responsible for the tests shall keep manufacturer specification sheets for all applicable test equipment for a minimum of 10 years after completion of the test.

6.2.2 Calibration certificates

All equipment relevant to the results of the test, such as transducers, exciters, and the data acquisition system, shall be reported. Calibration data shall include at a minimum the date of last calibration and date of expiry. The organization responsible for the test shall keep calibration certificates for a minimum of 10 years after completion of the test. Calibration certificates shall include, at a minimum, the date of calibration, date of expiry, the name of the organization or individual certifying calibration, calibration method, and calibration result.

6.3 Reporting of data acquisition and signal processing parameters

All applicable data acquisition and signal processing parameters as described in 5.3 shall be included in test reports.

6.4 Reporting of data analysis parameters

All applicable data analysis parameters as described in 5.4 shall be included in test reports.

6.5 Reporting of data archiving parameters

All applicable data archiving parameters as described in 5.5 shall be included in test reports.

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