INTERNATIONAL STANDARD

ISO 10326-2

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Mechanical vibration — Laboratory method for evaluating vehicle seat vibration —

Part 2:
Application to railway vehicles

Vibrations mécaniques — Méthode en laboratoire pour l'évaluation des vibrations du siège de véhicules —

Partie 2: Application aux véhicules ferroviaires

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Contents

Page

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 3.

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 part of ISO 10326 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10326-2 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*.

ISO 10326 consists of the following parts, under the general title *Mechanical vibration — Laboratory method for evaluating vehicle seat vibration*:

— *Part 1*: *Basic requirements*

— *Part 2: Application to railway vehicles*

Annex A of this part of ISO 10326 is for information only.

Introduction

Although the vibration felt by passengers in railway vehicles is always of low magnitude, the fact nevertheless remains that acceleration at the seat-buttock and seat-backrest interfaces can sometimes be greater than excitations transmitted by the vehicle frame. Consequently, the aim of experiments to be carried out with railway seats must fundamentally be to refine existing knowledge about their overall dynamic behaviour and that of their different components: seat frame, suspension system, linings, coverings, etc. In the long run, the knowledge put together should provide useful guidance in choosing the optimum components, and for improving passenger comfort further in the process.

Laboratory tests can be performed under clearly defined and reproducible excitation conditions. They consequently represent an essential study method complementary to the investigations performed in the field.

The vibration at the base of railway seats is of the random, broad-band type. The spectra, which are of complex form and non-stationary, depend on the vehicle itself, on its load, on wheel profile conditions, on track geometry and quality, etc. In this part of ISO 10326, therefore, it is stipulated to excite the seat, occupied by a test person, by means of broad-band pseudo-random vibration successively in the three directions X, Y and Z. The vibration spectra are of sufficiently simple form and of sufficient magnitude to cover the majority of actual spectra observed on track, whilst nevertheless remaining quite different from the latter.

As a result, the magnitudes measured at the different response points of the man-seat system during laboratory tests could under no circumstances be used for comparison with limits or acceptable values. By contrast, it is stipulated using the measurements to determine the frequency response function of the man-seat system at seat pan and backrest level in the three directions x, y and z. These frequency response functions suffice for characterizing the vibratory behaviour of the seat with its occupant. The directions of excitation, favourable or harmful frequencies, and corresponding gains are thus clearly demonstrated. These inputs are relevant to a comparison of seats with different construction arrangements.

Frequency response functions may be used to evaluate, by the automatic calculation method, the qualitative behaviour of a given seat subjected to excitation similar to that it would encounter in service on a real vehicle. To this end, they must be ascertained not only in modulus but also in phase terms. Direct and cross ratios are just as relevant, as couplings can exist between vertical, lateral and longitudinal movements. The test code described in this part of ISO 10326 allows for these interactions.

Such calculations are, however, truly valid only on the assumption that the man-seat system considered is sufficiently linear. To check this assumption under laboratory conditions, this part of ISO 10326 stipulates an extra testing phase during which the seat is excited in a purely sinusoidal, high-amplitude mode at the different frequencies encountered during tests under random excitations, and corresponding to the peaks of the frequency response function.

The frequency range relevant to railway conditions is limited to 0,5 Hz to 50 Hz. Railway seats transmit vibration with frequencies lower than 0,5 Hz without modifying them. However, vibration with frequencies of over 50 Hz, as sustained by seats in service, is generally of too small a magnitude to be felt by seated passengers.

Mechanical vibration — Laboratory method for evaluating vehicle seat vibration —

Part 2:
Application to railway vehicles

1 Scope

This part of ISO 10326 defines specifications covering laboratory tests for seats designed for passengers and crew in railway tractive and trailer vehicles.

It concerns tri-axial rectilinear vibration within the frequency range 0,5 Hz to 50 Hz. It specifies the input test vibration to be used at seat testing.

This part of ISO 10326 makes it possible to characterize, in the form of frequency response functions, the manner in which vibration is transmitted to the seat occupant. However, this characterization is fully valid only when the man-seat system can be considered to be sufficiently linear.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10326. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10326 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2041, *Vibration and shock — Vocabulary*.

ISO 2631-1, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*.

ISO 5347 (all parts), *Methods for the calibration of vibration and shock pick-ups*.

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

ISO 8041, *Human response to vibration — Measuring instrumentation*.

ISO 10326-1:1992, *Mechanical vibration — Laboratory method for evaluating vehicle seat vibration — Part 1: Basic requirements*.

ISO 13090-1, *Mechanical vibration and shock — Guidance on safety aspects of tests and experiments with people — Part 1: Exposure to whole-body mechanical vibration and repeated shock*.

ISO 16063 (all parts), *Methods for the calibration of vibration and shock transducers*.

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this part of ISO 10326, the terms and definitions given in ISO 2041 apply.

3.2 Symbols and abbreviated terms

The following symbols and abbreviated terms are used in this part of ISO 10326:

a_{rms}	root-mean-square value of acceleration, m/s^2
$a(t)$	instantaneous value of an acceleration time history, m/s^2
$a(t, B_\mathrm{e}, f)$	instantaneous value of the acceleration time history $a(t)$, filtered in the frequency range $(f - B_\mathrm{e}/2)$ to $(f + B_\mathrm{e}/2)$, m/s^2
$b(t)$	instantaneous value of an acceleration time history, m/s^2
$b(t, B_\mathrm{e}, f)$	instantaneous value of the acceleration time history $b(t)$, filtered in the frequency range $(f - B_\mathrm{e}/2)$ to $(f + B_\mathrm{e}/2)$, m/s^2
$b'(t, B_\mathrm{e}, f)$	instantaneous value of the acceleration time history $b(t)$, filtered in the frequency range $(f - B_\mathrm{e}/2)$ to $(f + B_\mathrm{e}/2)$, with phase shifted by $\pi/2$, m/s^2
B	acceleration measuring point on the backrest of a seat occupied by a subject
B_e	resolution bandwidth of a frequency analysis, Hz
$C_{\mathrm{ab}}(f)$	real part of $G_{\mathrm{ab}}(f)$, (m/s^2)^2/Hz
d	displacement amplitude at a single frequency, m
f	frequency, Hz
f_r	frequency corresponding to a peak of the frequency response function, Hz
$G_\mathrm{a}(f)$	acceleration power spectral density function of the time history $a(t)$, being the mean-square value of acceleration per unit frequency bandwidth, (m/s^2)^2/Hz
$G_{\mathrm{ab}}(f)$	cross power spectral density function of two acceleration time histories, $a(t)$ and $b(t)$, being a complex function, also called acceleration cross spectral density, (m/s^2)^2/Hz
$\lvert G_{\mathrm{ab}}(f)\rvert$	modulus of $G_{\mathrm{ab}}(f)$, (m/s^2)^2/Hz
$G_\mathrm{b}(f)$	acceleration power spectral density function of the time history $b(t)$, being the mean-square value of acceleration per unit frequency bandwidth, (m/s^2)^2/Hz
$H(f)$	frequency response function, being a dimensionless complex function of frequency
P	acceleration measuring point on the test platform
PSD	power spectral density
$Q_{\mathrm{ab}}(f)$	imaginary part of $G_{\mathrm{ab}}(f)$, (m/s^2)^2/Hz

S acceleration measuring point on the seat pan of the seat occupied by a subject

t time, s

T duration of signal measurement and analysis, s

T_R transmissibility (dimensionless)

x, y and z letters used in characterizing the direction of vibration at seat pan and backrest, points S and B

X, Y and Z letters used in characterizing the direction of platform vibration at point P

$\gamma^2_{ab}(f)$ coherence function between the two accelerations $a(t)$ and $b(t)$, being a dimensionless function in the range 0 to 1

$\Theta_{ab}(f)$ phase of $G_{ab}(f)$, being a real function, rad

The following subscripts are used in this part of ISO 10326:

i direction of platform vibration, taking the values X, Y or Z

k direction of vibration at points S or B, taking the values x, y or z

rms root-mean-square value

s subscript denoting that the results of three consecutive tests have been averaged

w subscript characterizing a parameter calculated on the basis of frequency-weighted signals

α subscript characterizing the location of an acceleration measuring point: S (seat pan) and B (backrest)

4 Direction of vibration

The coordinate axes x, y and z for the evaluation of human exposure to whole-body vibration in accordance with this part of ISO 10326 are defined in ISO 2631-1 by the orthogonal biodynamic coordinate system shown in Figure 1. For the purposes of this part of ISO 10326, two such basicentric coordinate systems are used, with their origins at the interface at the buttocks and the seat cushion, and at the interface of the back of a seated person and the backrest of the seat. Their axes are approximately parallel to the axes shown in Figure 1.

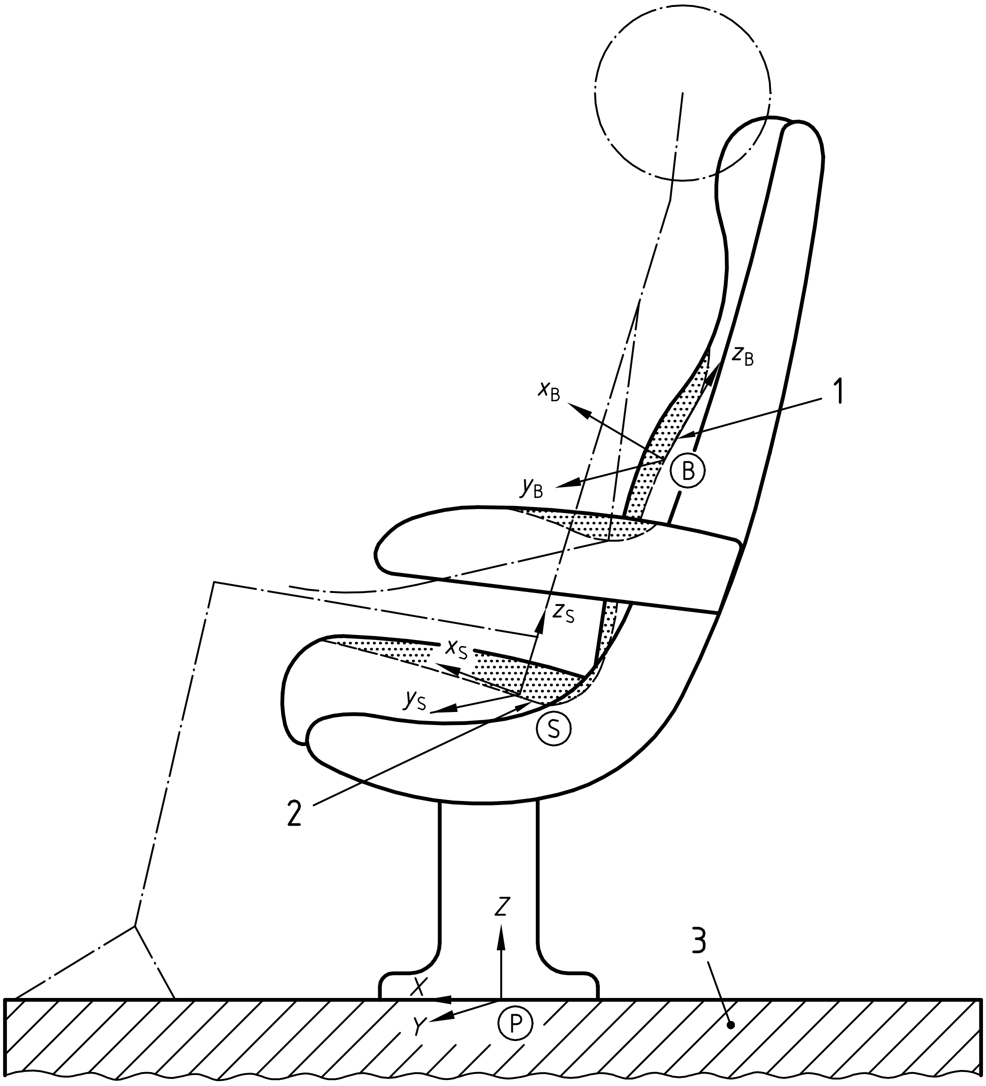
The coordinate axes for describing rectilinear vibration of the vehicle are defined by an orthogonal coordinate system parallel to the principal axes of the vehicle. The X-axis is parallel to the longitudinal axis, the Y-axis parallel to the transverse axis and the Z-axis upwards perpendicular to the plane defined by the X and Y axes. The coordinate system for the description of the vehicle vibration is usually not parallel to the coordinate systems for the seat occupant because of practical reasons such as seat cushion angles or actual position of the seat with respect to the longitudinal axis of the vehicle.

5 Characterization of vibration and of its transmission

5.1 Characterization of vibration

5.1.1 General

Three quantities shall be used to describe the vibration, root-mean-square acceleration, acceleration power spectral density and acceleration cross spectral density.



Key

1 Mounting disc

2 Seat pan

3 Platform

NOTE The arrows indicate the positive directions.

Figure 1 — Directions of vibration measurements

5.1.2 Root-mean-square acceleration, a_{rms}

The root-mean-square value of the acceleration signal, a_{rms}, shall be calculated by a method equivalent to that described by the following equation:

$$a_{rms} = \left(\frac{1}{T} \int_0^T a^2(t)\,dt \right)^{1/2} \quad (1)$$

5.1.3 Acceleration power spectral density, $G_a(f)$

The acceleration power spectral density, $G_a(f)$, shall be estimated by a method equivalent to that described by the following equation:

$$G_a(f) = \frac{1}{B_e \cdot T} \int_0^T a^2(t, B_e, f)\,dt \tag{2}$$

5.1.4 Acceleration cross spectral density, $G_{ab}(f)$

This parameter is used for connecting two acceleration signals, one $a(t)$ or input acceleration for seat excitation, the other $b(t)$ or output acceleration response of man-seat system at a given interface point. The cross power spectral density, $G_{ab}(f)$, shall be estimated by a method equivalent to that described by the following equation:

$$G_{ab}(f) = C_{ab}(f) - j\,Q_{ab}(f) = \left| G_{ab}(f) \right| e^{-j\Theta_{ab}(f)} \tag{3}$$

where

$$C_{ab}(f) = \frac{1}{B_e \cdot T} \int_0^T a(t, B_e, f) \cdot b(t, B_e, f)\,dt$$

$$Q_{ab}(f) = \frac{1}{B_e \cdot T} \int_0^T a(t, B_e, f) \cdot b'(t, B_e, f)\,dt$$

$$\left| G_{ab}(f) \right| = \sqrt{C_{ab}^2(f) + Q_{ab}^2(f)}$$

$$\Theta_{ab}(f) = \arctan \frac{Q_{ab}(f)}{C_{ab}(f)}$$

5.2 Characterization of vibration transmission

5.2.1 General

The following parameters shall be used to characterize the transmission of vibrations from their input at the seat fastening point, acceleration signal $a(t)$, up to their output at a man-seat interface point, acceleration signal $b(t)$.

5.2.2 Frequency response function, $H(f)$

This is a dimensionless complex function of frequency f. It shall be calculated by means of a method equivalent to that described by the following equation:

$$H(f) = G_{ab}(f)/G_a(f) \tag{4}$$

5.2.3 Coherence function, $\gamma_{ab}^2(f)$

This is a dimensionless real function of frequency f. It shall be calculated by means of a method equivalent to that described by the following equation:

$$\gamma_{ab}^2(f) = \frac{\left| G_{ab}(f) \right|^2}{G_a(f) \cdot G_b(f)} \tag{5}$$

5.2.4 Transmissibility, T_R

This is a real, dimensionless value defined as the ratio of the root-mean-square acceleration measured at the man-seat interface, to the same value measured at the seat mounting plate (platform).

NOTE 1 The transmissibility is strongly dependent on the input vibration, in particular on its power spectral density function.

NOTE 2 For the transmissibility at the single (resonance) frequency of a seat, ISO 10326-1 uses the symbol T.

5.2.5 Weighted transmissibility, T_{Rw}

This is the transmissibility calculated on the basis of accelerations weighted according to ISO 2631-1. The frequency weighting curves and their tolerances shall be in accordance with ISO 8041.

NOTE For the weighted transmissibility at point S in the vertical direction, T_{Rw} is identical to the SEAT factor defined in ISO 10326-1.

6 General observations

The laboratory testing method described in this part of ISO 10326 calls for the use of a test bench whereby unidirectional, rectilinear vibration can be applied at the fastening points of a seat to be tested, with an occupant, successively in the directions X, Y and Z.

This part of ISO 10326 defines the method to be used in characterizing the vibration transmission from the base of the excited seat (point P in Figure 1) in a single direction X, Y or Z, up to two points located at the man-seat interfaces, one point (point S) on the seat pan, the other point (point B) on the backrest. At each of these two points, responses shall be measured simultaneously in the three directions x, y and z, and the corresponding frequency response functions, transmissibilities as well as weighted transmissibilities shall be calculated.

The input test vibration to be used at seat testing is specified in clause 11.

7 Measurement positions

Nine accelerations shall be measured in accordance with the layout in Figure 1:

— three input accelerations on the vibrating platform, at point P;

— three output accelerations on the seat pan at point S;

— three output accelerations on the backrest at point B.

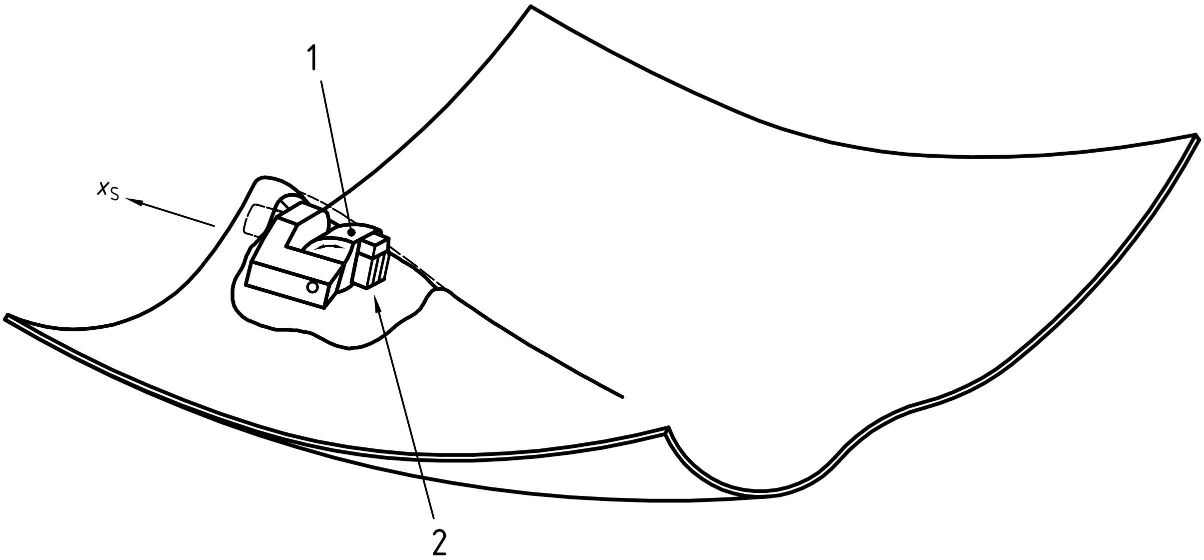
Point P shall be located on the platform less than 100 mm away from the vertical projection of point S.

8 Instrumentation

The measuring equipment shall be in accordance with ISO 10326-1:1992, clauses 4 and 5, and a type 1 instrumentation in accordance with ISO 8041.

For measurement at point S, a seat pan in thin semi-rigid material, shaped to conform with the diagrams in Figures 2 and 3, shall be placed at the seat interface of the seat occupant. The shape of the seat pan and its material shall be capable of adapting to the morphology of the occupant, so as not to cause any discomfort to the latter. The seat pan shall incorporate at point S an adjustable device for simultaneously measuring accelerations along the three orthogonal axes x_S, y_S and z_S as given in Figure 1.

The accelerometer should as far as is practical be positioned at the point S. However, it is acceptable to have it towards the front, where it is more comfortable for the subject and allows access to the transducer tilting device.



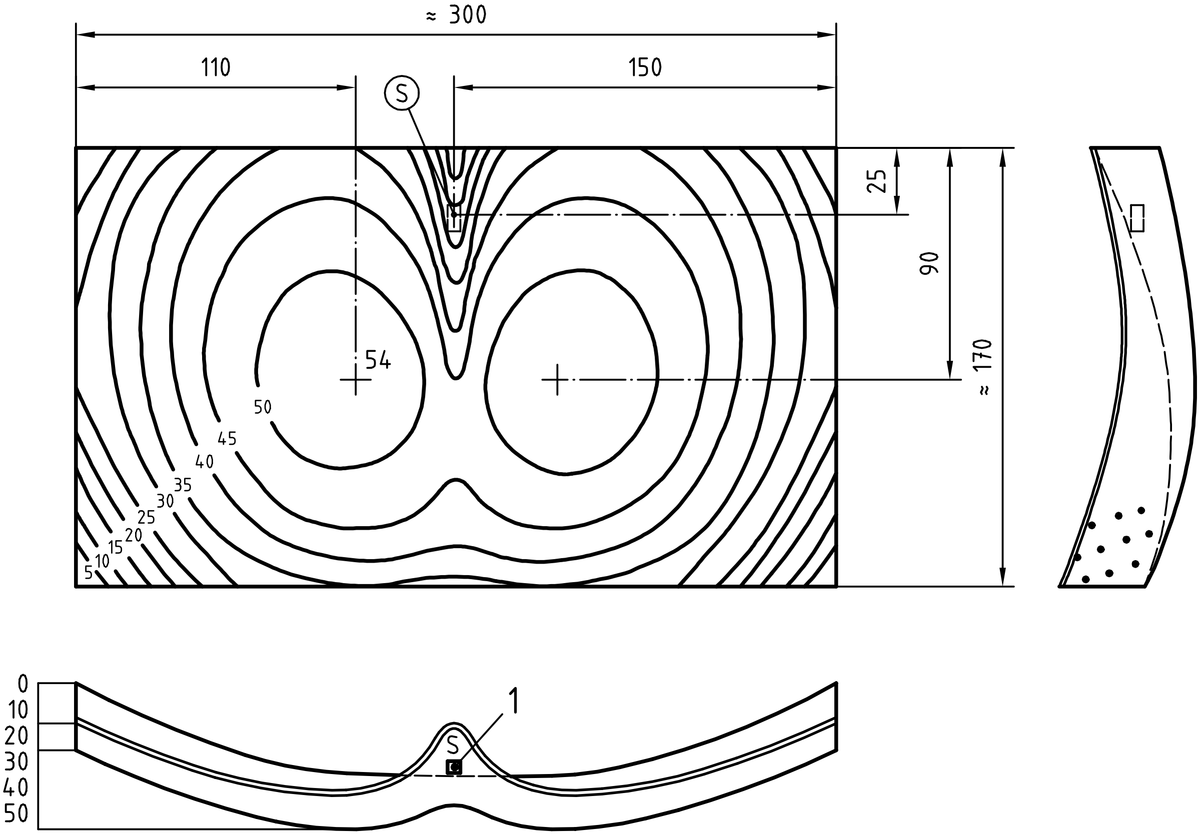
Key

1 Transducer tilting device

2 Point S transducer

Figure 2 — Seat pan

Dimensions in millimetres



Key

1 Transducer

NOTE The seat pan is perforated with one perforation of diameter 1 mm per 1 cm^2 (approx.).

Figure 3 — Seat pan detail

9 Safety requirements

The safety precautions given in ISO 13090-1 shall be followed.

10 Test seats and test persons

10.1 Test seats

The seat used for the test shall be representative of the serial production models. If required, and in accordance with indications provided by the seat manufacturer, the seat may be run-in before testing and shall be adjusted to the stature and mass of the subject if means are provided for either of these.

When the seat incorporates fastening devices to the vehicle, it shall be fastened to the test platform by means of these devices, so as to ensure that the influence of stiffness and damping characteristics of the fasteners will be included in the test.

When the seat does not incorporate such fastening devices, it shall merely be placed on the test platform.

When the seat, once aboard the vehicle, rests on one or several points located outside the floor area, for example on vertical walls, an appropriate assembly shall be used on the test platform. This assembly shall be sufficiently rigid for its accelerations to coincide with those of the platform itself.

When the seat has a built-in position adjusting device, the normal position defined as being that used in service most frequently by the occupant shall be laboratory-tested.

Preliminary running-in shall be carried out in laboratory. To this end, an inert mass of 75 kg ± 1 % shall be placed on the seat pan at the spot defined in 10.2. The seat shall be subjected, for 2 h, to sinusoidal vertical excitation with a frequency equal to the lowest among the resonance frequencies of this system. Their amplitude shall be adjusted to obtain an r.m.s. acceleration of the mass of 3 m/s^2.

10.2 Test persons

The tests shall be carried out with two persons occupying the seat one at the time, even if the seat is of the multi-seat type.

Before the test, the test person shall find a position which he/she can maintain throughout the test. In the particular case of a driver's seat, the test person shall take the normal posture for his/her work station.

The feet of the test person shall rest flat on the platform or, if necessary, on a rigid device integrated with the latter. The back shall naturally rest against the backrest with the elbows resting on the armrest, when the seat is so equipped, and the hands resting flat on the thighs.

In the specific case of a multi-seat unit, the test person shall position himself/herself at the place where vertical seat pan accelerations under vertical excitation have the highest root-mean-square value. This place shall be determined by preliminary tests.

The test person shall have occupied the seat for a sufficiently long time before the start of the testing. This shall ensure deformation and possible time yield of seat pan materials as well as stabilization of the temperature of seat pan and backrest accelerometers. A period of some 10 min is frequently necessary for this purpose.

Two test persons shall be used successively. Their mass shall be equal to respectively $55\,\text{kg}\,{}^{0}_{-5}\,\%$ and $90\,\text{kg}\,{}^{5}_{0}\,\%$. In order to meet these mass requirements, the mass of each test person may be increased by as much as 10 % by ballast carried in a belt around the waist.

11 Input test vibration

11.1 General

The dynamic behaviour of the man-seat system under test shall be studied under the effect of broad-band pseudo-random vibration of specific amplitude. It shall also be investigated under the effect of sinusoidal vibration in order for possible non-linearities to be detected.

11.2 Pseudo-random excitation

11.2.1 Generation of the excitation signal

The excitation signal of the vibrating table shall be of the pseudo-random type.

This type of excitation prevents any spectral leakage in the analysis. The spectrum can easily be shaped so as to excite only those frequencies in the frequency range of interest. In particular it can be used to compensate for the frequency response of the test facility and so provide a flat spectrum within the frequency range of interest, as required by equations (6) and (7). Moreover, the evaluation can be performed by averaging the results of a small number of sequences.

The excitation signal shall be formed by 18 consecutive equally long sequences, each lasting 5 s or more, depending on the frequency resolution; 5 s is the minimum time to satisfy the requirement for a resolution bandwidth of 0,2 Hz. The total duration of an excitation shall therefore be at least 18 × 5 s = 90 s.

The time history of each sequence of the excitation signal shall be formed by a sum of pure sinusoidal components, the number of which depends on the frequency resolution. The amplitude of each component shall follow from the power spectral density given by equations (6) and (7). The phase of each component shall be a random variable comprised between 0 and 2π with uniform density probability.

Annex A shows, by way of example, a detailed flowchart of the control signal generating process.

11.2.2 Power spectral density

The power spectral density of the excitation generating the accelerations for each of the directions X, Y and Z shall be as defined by the following equations in the frequency range 0,5 Hz to 50 Hz.

$$G(f) = 0{,}05\, f^4\ (\text{m/s}^2)^2/\text{Hz}^5 \qquad \text{for } f < 1\ \text{Hz} \qquad (6)$$

$$G(f) = 0{,}05\ (\text{m/s}^2)^2/\text{Hz} = \text{const} \qquad \text{for } 1\ \text{Hz} \leqslant f \leqslant 50\ \text{Hz} \qquad (7)$$

The resolution bandwidth shall be 0,2 Hz or less.

11.2.3 Root-mean-square acceleration

The value of the root-mean-square acceleration in the frequency range 0,5 Hz to 50 Hz shall be 1,6 m/s^2.

11.2.4 Tolerances

When performing the tests, the tolerances to be observed for the power spectral density of accelerations measured on the vibrating table at point P shall be at maximum ± 20 % of the prescribed value at each frequency over the whole frequency range 0,5 Hz to 50 Hz. The tolerance to be met is ± 0,16 m/s^2 on the root-mean-square value.

11.3 Sinusoidal excitation

The seat shall also be excited under pure sinusoidal conditions, at those frequencies for which the moduli of the frequency response functions, determined during the tests under pseudo-random excitation, go through maximum values.

Failing this, the seat shall be excited at the frequencies 1,5 Hz and 10 Hz.

Two amplitudes of acceleration shall be used successively: (0,5 ± 0,1) m/s^2 and (1 ± 0,1) m/s^2.

Annex A shows, by way of example, a detailed flowchart of the control signal generating process.

12 Parameters adopted for characterizing the vibration transmission

12.1 Pseudo-random excitation

For each of the measuring points S and B, the following parameters characterizing the transmission of the vibration shall be determined:

— the frequency response function $H(f)_{\alpha ik}$ (shall be given in modulus and phase every 0,2 Hz or less, from 0,5 Hz to 50 Hz);

— the coherence function $\gamma^2(f)_{\alpha ik}$;

— the transmissibility $T_{R\alpha ik}$; and

— the weighted transmissibility $T_{Rw\alpha ik}$.

It may occur that the coherence function values associated with some frequency response functions are relatively low. This is generally the case when the seat response accelerations as measured in a direction differing from that of the vibrating table excitation are occasionally quite weak. In the case of frequencies where the coherence associated with a frequency response function is less than 0,6, the value adopted for the frequency response function shall be nil. The calculated value, modulus and phase, however, shall be reported in the test results.

12.2 Sinusoidal excitation

For each value f_r of the frequency which, under pseudo-random excitation, produced a well-pronounced peak in the $H(f)$ modulus graph, two new values shall be calculated for the frequency response function modulus $H(f_r)_{\alpha ik}$ under sinusoidal excitations with amplitudes of 0,5 m/s^2 and 1 m/s^2 respectively.

The difference between these two values of the frequency response function modulus $H(f_r)$ shall be calculated. This difference shall be expressed as a percentage of the higher value.

A difference in excess of 30 % can be held as signifying non-linear behaviour for the frequency concerned and for the response and excitation directions involved.

13 Test procedure

13.1 Initial procedure

The seat shall be mounted on the test platform, run-in and adapted to the test person. The inclination of the seat transducers shall be adjusted to coincide with the directions given in Figure 1 (see clause 4).

The components of the measuring chain shall be selected, placed into position and connected. Accelerometers shall be calibrated according to the specifications given in the relative parts of ISO 5347 and ISO 16063, and shall be mounted, especially at point P, in accordance with the recommendations given in ISO 5348.

13.2 Tests under pseudo-random excitation

The first test person shall position himself/herself on the seat.

The tests shall be successively carried out under X, Y and Z directions of excitation.

The excitation for a given direction shall be in conformity with the specifications given in clause 11. The corresponding test shall last 90 s as a minimum. Each test shall be repeated until the moduli of the frequency response functions from three consecutive tests do not differ more than ± 5 % of their arithmetic mean over the whole frequency range 0,5 Hz to 50 Hz. The frequency response functions, coherence functions and transmissibilities averaged over these three tests constitute the final results and shall be expressed in the form $H_{\mathrm{s}}(f)_{\alpha \mathrm{ik}}$, $\gamma_{\mathrm{s}}^{2}(f)_{\alpha \mathrm{ik}}$ and $T_{\mathrm{Rs}\alpha \mathrm{ik}}$.

The second test person shall position himself/herself on the seat and a new test series shall be carried out in accordance with the specifications described above.

13.3 Tests under sinusoidal excitation

The sinusoidal excitations in accordance with 11.3 shall be applied.

Each test shall be repeated until the moduli of the frequency response functions from three consecutive tests do not differ more than ± 5 % of their arithmetic mean. The mean values obtained constitute the final results and shall be expressed as frequency response function modulus $H_{\mathrm{s}}(f_{\mathrm{r}})_{\alpha \mathrm{ik}}$.

14 Test report

14.1 Seat

The devices for mounting the seat and fastening it to the test platform shall be accurately described. The measuring points on the seat pan and the backrest shall be stated in detail.

14.2 Test persons

The mass, height, gender and age of each of the two subjects shall be indicated.

The place occupied during tests shall be reported in the case when a multi-seat unit is used.

14.3 Measuring chain

The measuring chain shall be described in accordance with the requirements given in ISO 10326-1.

14.4 Results

The test results shall be presented in accordance with the following specifications.

The results of tests under pseudo-random excitation shall be presented in numerical and graphic form.

Each frequency response function modulus, frequency response function phase and coherence function shall be described by a set of values, each of which being associated with a frequency varying between 0,5 Hz and 50 Hz by step of 0,2 Hz or less.

The graphs shall be presented in accordance with Figure 4.

The transmissibility values shall be reported as well as the root-mean-square acceleration values used for calculating them.

The results of tests under sinusoidal excitation shall be presented in accordance with Table 1.

Longitudinal pseudo-random excitation (X-direction)

Test person No. 1

Mass:	55 kg	Height:	1,66 m
Gender:	female	Age:	32 years

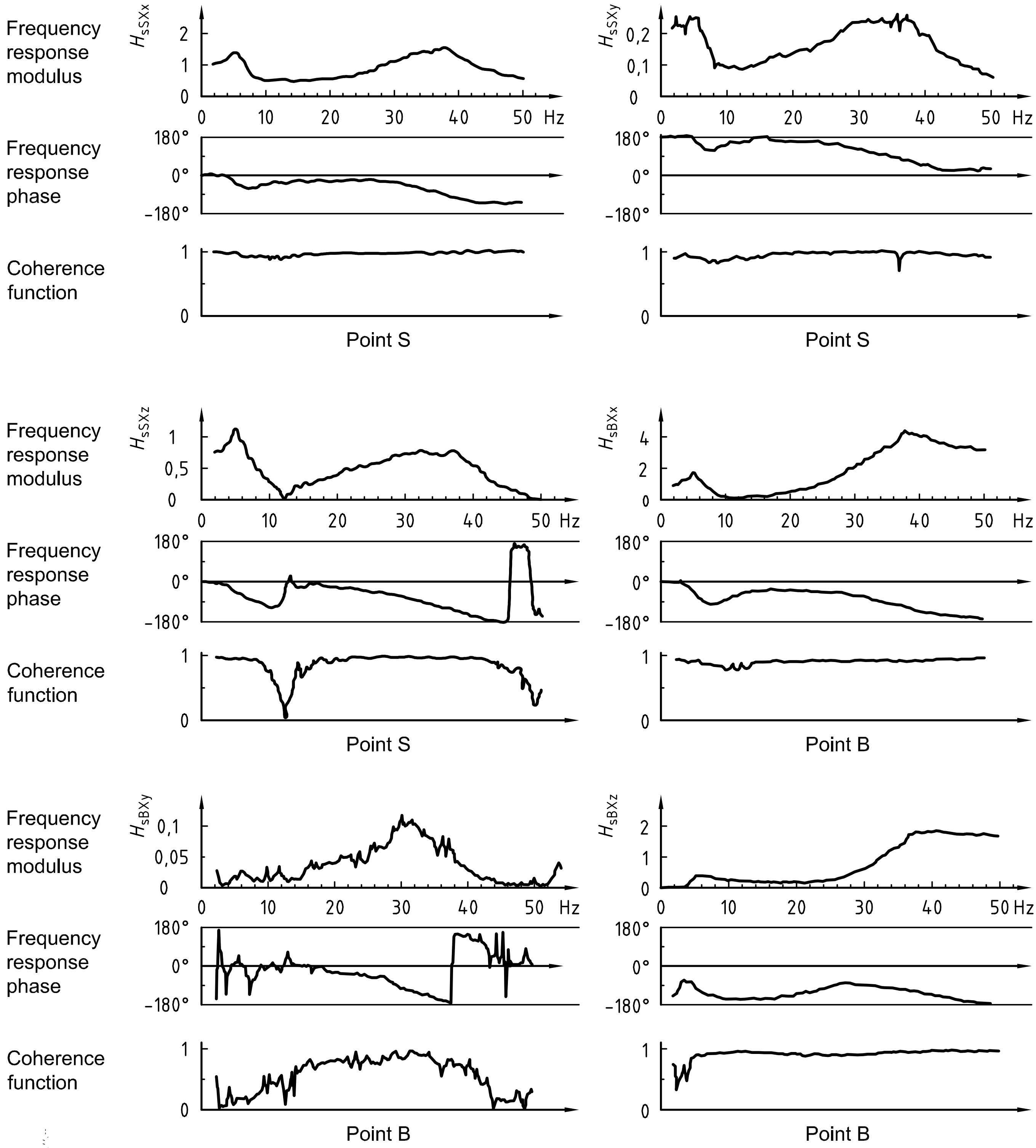


Figure 4 — Results from test under pseudo-random excitation (general example)

Table 1 — Results from test under sinusoidal excitation (general example)

Frequency response modulus at frequency f_r (which results from test under pseudo-random excitation) [a]	5 Hz	36 Hz
H_{sSXx}		
With sinusoidal excitation amplitude 0,5 m/s^2	1,38	1,59
With sinusoidal excitation amplitude 1 m/s^2	1,07	1,55
Difference as percentage of the higher value, %	22	3
H_{sSXy}		
With sinusoidal excitation amplitude 0,5 m/s^2	0,24	0,25
With sinusoidal excitation amplitude 1 m/s^2	0,23	0,21
Difference as percentage of the higher value, %	4	16
H_{sSXz}		
With sinusoidal excitation amplitude 0,5 m/s^2	1,13	0,78
With sinusoidal excitation amplitude 1 m/s^2	1,04	0,67
Difference as percentage of the higher value, %	8	14
H_{sBXx}		
With sinusoidal excitation amplitude 0,5 m/s^2	2,02	4,64
With sinusoidal excitation amplitude 1 m/s^2	2,39	4,84
Difference as percentage of the higher value, %	15	4
H_{sBXy}		
With sinusoidal excitation amplitude 0,5 m/s^2	0,055	0,12
With sinusoidal excitation amplitude 1 m/s^2	0,050	0,13
Difference as percentage of the higher value, %	9	8
H_{sBXz}		
With sinusoidal excitation amplitude 0,5 m/s^2	0,53	1,78
With sinusoidal excitation amplitude 1 m/s^2	0,46	1,99
Difference as percentage of the higher value, %	13	11

[a] Longitudinal sinusoidal excitation (X-direction)
Test person No. 1
Mass: 55 kg Height: 1,66 m
Gender: female Age: 32 years

Annex A
(informative)

Example of excitation generating process

A.1 General

This annex gives examples of the methods that may be used in generating command signals to the test-machine jacks.

The following two excitation methods are used:

— pseudo-random excitation; and

— sinusoidal excitation at only those resonance frequencies which appear during tests with pseudo-random excitation.

A.2 Pseudo-random excitation

This excitation must be the sum of pure, randomly phase-shifted sinusoidal excitations.

If the resolution bandwidth B_e is 0,2 Hz, the excitation may cover the frequency range 0,4 Hz to 50 Hz.

The excitation spectrum is therefore made up of (50 Hz – 0,4 Hz)/0,2 Hz + 1 = 249 lines.

This part of ISO 10326 defines the excitation by its acceleration power spectral density $G_a(f)$; see 11.2.

A displacement signal is generally used to control the test machine. If in the amplitude spectrum of this displacement (with frequency resolution B_e) the line at frequency f has a displacement amplitude d, then the corresponding acceleration power spectral density, $G_a(f)$, has the following value:

$$G_a(f) = d^2 \times 8\ \pi^4 f^4 / B_e \tag{A.1}$$

Consequently, d follows from:

$$d = \frac{\sqrt{2\ B_e\ G_a(f)}}{4\ \pi^2\ f^2} \tag{A.2}$$

where $G_a(f)$ is as given by equations (6) and (7).

The test may be performed on the basis of the flowchart shown in Figure A.1.

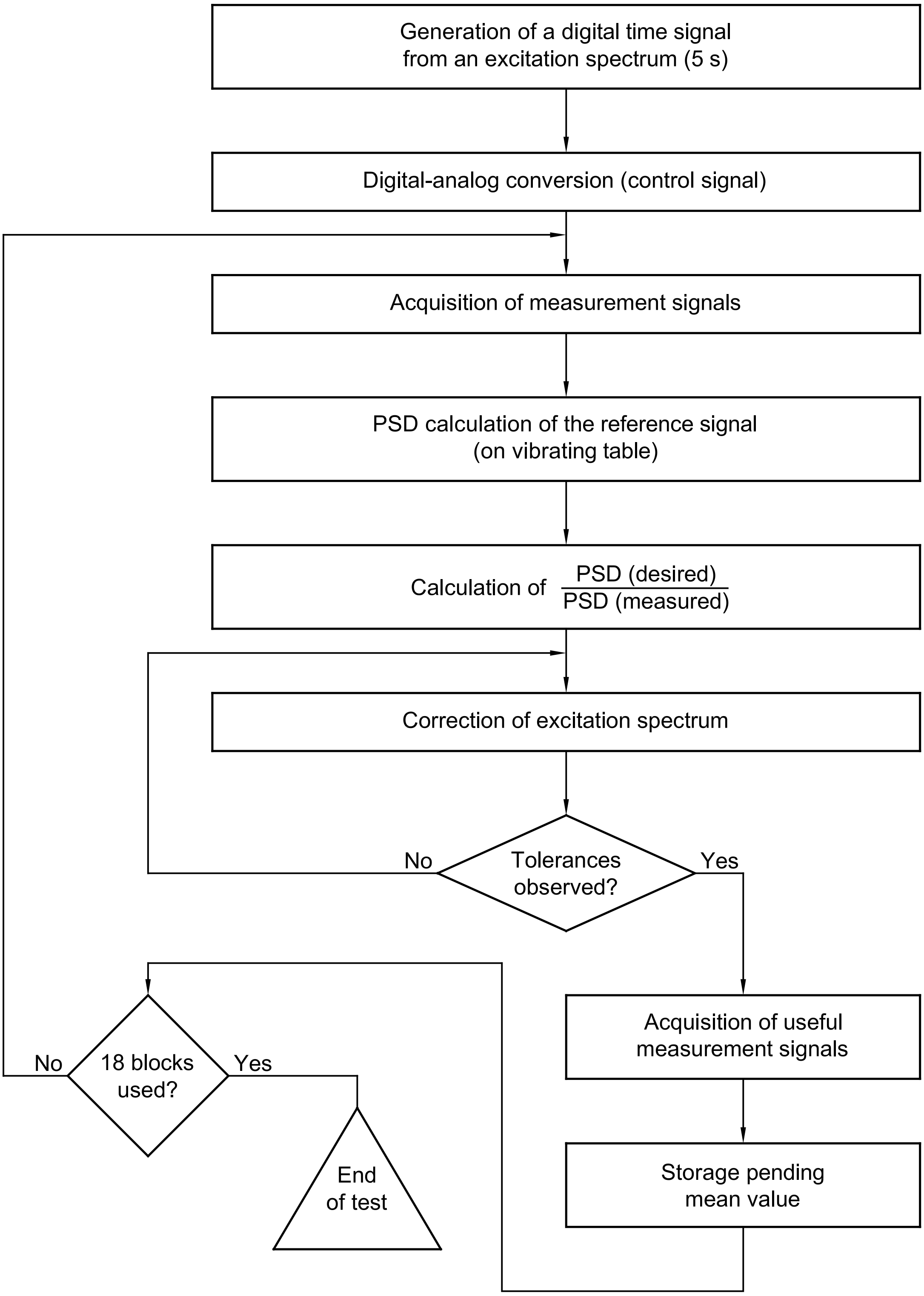


Figure A.1 — Flowchart for test procedure with pseudo-random excitation

A.3 Sinusoidal excitation

Each test may be carried out according to the flowchart shown in Figure A.2.

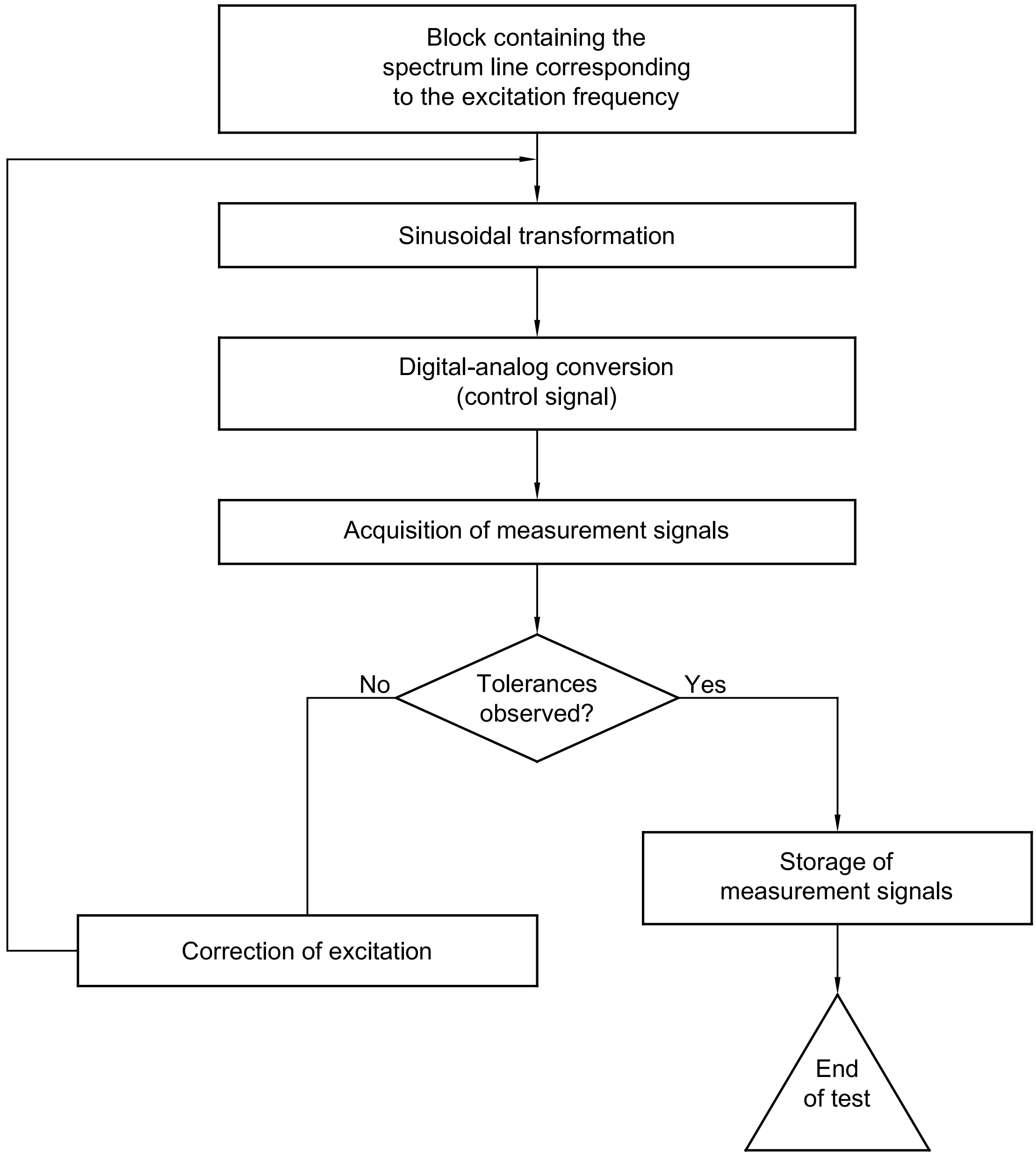


Figure A.2 — Flowchart for test procedure with sinusoidal excitation

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