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Mechanical vibration — Laboratory method for evaluating vehicle seat vibration —

Part 3: Specification of dynamic dummies for Z-axis motion

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

Partie 3: Spécifications des mannequins dynamiques pour le mouvement dans l'axe Z

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Foreword

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This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 4, *Human exposure to mechanical vibration and shock*.

A list of all parts in the ISO 10326 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Vehicle seats play an important role in reducing the vibration transmitted to occupants. While conventional seats are widely used in transport vehicles such as cars, buses, trains, and airplanes, suspension seats are commonly adopted to cope with severe vibration environments in earth-moving machinery, agricultural wheeled tractors, and industrial trucks.

It is often required that the dynamic performance of vehicle seats be tested in the laboratory. The International Organization for Standardization and the European Committee for Standardization have published several standards defining laboratory methods for evaluating the dynamic performance of different types of vehicle seats. Such standards include ISO 7096[4] for earth-moving machinery, ISO 5007[1] for agricultural wheeled tractors, and EN 13490[5] for industrial trucks. They require that the seat effective amplitude transmissibility (SEAT) factor, an important dynamic performance index of vehicle seats, be obtained experimentally using both a light and a heavy participant, see Annex D.

As has been recognized in the practical use of the mentioned standards, finding suitable participants for vibration tests of vehicle seats is frequently neither easy nor convenient. The use of participants also raises safety and ethics concerns. These issues have motivated the design and development of dynamic dummies that can replace participants for vibration tests of vehicle seats.

Regardless of its shape and structure, a dynamic dummy that complies with this document is considered to meet the minimum requirements for the purpose. In particular, actual operating conditions may impose more restrictive requirements.

Conformity with this document should not be interpreted as a confirmation that the dynamic dummies passing the validation test necessarily yields seat vibration transmissibility characteristics duplicating those that are obtained when using participants.

Mechanical vibration — Laboratory method for evaluating vehicle seat vibration —

Part 3: Specification of dynamic dummies for Z-axis motion

1 Scope

This document specifies dynamic dummies used as replacements for participants in vibration tests of vehicle seats in laboratory.

This document is applicable to seats installed in earth-moving machinery, agricultural wheeled tractors, and industrial trucks.

This document specifies technical requirements, acceptance criteria, and a validation test for dynamic dummies representing the human body in two mass groups: lightweight (52 kg to 55 kg) and heavyweight (98 kg to 115 kg). It only applies to passive and active dynamic dummies used for vibration tests of vehicle seats in the Z-axis (vertical) direction.

This document defines, for the two mass groups, the biodynamic response characteristics that the dynamic dummies are required to reproduce to represent those of the participants to be replaced. This document gives guidance on conducting future research to explore the degree of convergence that can be reached when the dynamic performance of seats is measured with participants and with dynamic dummies conforming to this document.

NOTE 1 For seat testing, results have shown that the benefit of using a dynamic dummy is highly dependent on the excitation and dynamic characteristics of the seats. Depending on the type of vibration excitation applied, studies have suggested that the use of dynamic dummies can show benefit over an inert mass of equivalent weight only when testing suspension seats with higher natural frequency (>2 Hz).

NOTE 2 The use of dynamic dummies has been reported to tend to overestimate the vibration isolation performance of seats compared with that measured with participants. Several factors can be in cause and require further investigation, one of them being the influence of the legs possibly not being adequately considered when using dynamic dummies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitute requirements 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 5805, *Mechanical vibration and shock — Human exposure — Vocabulary*

ISO 8041-1, *Human response to vibration — Measuring instrumentation — Part 1: General purpose vibration meters*

ISO 10326-1:2016, *Mechanical vibration — Laboratory method for evaluating vehicle seat vibration — Part 1: Basic requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041, ISO 5805, and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
apparent mass
M(*f*)
complex ratio of applied periodic excitation force at frequency *f*, *F*(*f*), to the resulting vibration acceleration at that frequency, *a*(*f*), measured at the same point and in the same direction as the applied force

$$M(f)=\frac{F(f)}{a(f)}$$

Note 1 to entry: The apparent mass is a complex quantity (i.e. it possesses real and imaginary parts) from which the modulus and phase can be computed.

Note 2 to entry: For the purposes of this document, force and acceleration are measured at the same point, this being the point of introduction of vibration. Accordingly, only direct apparent mass (also known as driving point apparent mass) is considered in this document.

Note 3 to entry: In the case of non-harmonic vibration, apparent mass is determined from the force and acceleration spectra.

[SOURCE: ISO 5982:2019, 3.1, modified — Note 2 to entry has been adapted.]

3.2
dynamic dummy
test device or mechanically realizable human analogue model that simulates one or more of the dynamic characteristics of the human body

[SOURCE: ISO 5805:1997, 5.5, modified — Note to entry has been deleted.]

3.3
passive dynamic dummy
dynamic dummy (3.2) that cannot adaptively change its parameters.

Note 1 to entry: A passive dynamic dummy can reproduce the apparent mass of a small number of notional human bodies.

Note 2 to entry: A passive dynamic dummy can be constructed with passive (namely, unpowered) mechanical components such as masses, springs, and dampers.

Note 3 to entry: An example of passive dynamic dummy is shown in Figure 1. See Annex B for more information.

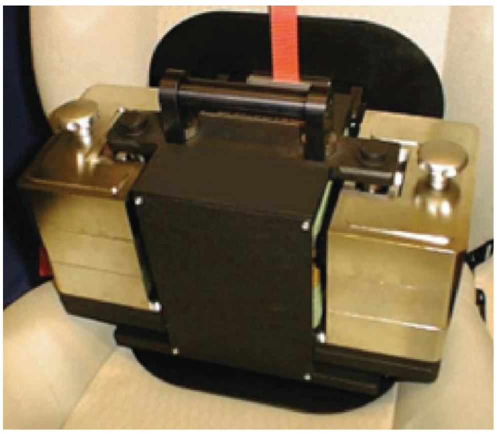


Figure 1 — Example of passive dynamic dummy

3.4
active dynamic dummy
dynamic dummy (3.2) that can adaptively change its parameters

Note 1 to entry: An active dynamic dummy can reproduce the apparent mass of a larger number of notional human bodies than a passive dynamic dummy can.

Note 2 to entry: An active dynamic dummy can be constructed with active (namely, powered) mechanical components such as actuators and control systems.

Note 3 to entry: Examples of active dynamic dummies are shown in Figure 2. See Annex C for more information.

Figure 2 — Examples of active dynamic dummies

4 Symbols and abbreviated terms

$a(t)$ acceleration time history in the Z-axis (vertical) direction, m·s^{-2}

$F(t)$ force time history in the Z-axis (vertical) direction, N

f frequency, Hz

$M(f)$ apparent mass at the dummy–seat interface in the Z-axis (vertical) direction, kg

$G_{aF}(f)$ cross power spectral density of acceleration and force at the dummy–seat interface, N(m·s^{-2})/Hz

$G_{\mathrm{aa}}(f)$ auto power spectral density of acceleration at the dummy–seat interface, (m·s^{-2})^2/Hz

t time, s

5 Measuring instrumentation and vibration equipment

Measuring instrumentation shall be in accordance with ISO 8041-1 and ISO 10326-1:2016, Clauses 5. Vibration equipment shall be in accordance with ISO 10326-1:2016, Clause 6.

The minimum signal bandwidth shall be from 0,5 Hz to 20 Hz.

Acceleration shall be measured with an accelerometer attached to the centre of a semi-rigid mounting disc in accordance with ISO 10326-1:2016, 5.2.3.

Force shall be measured with a force transducer.

6 Requirements for dynamic dummies

6.1 Mass

The purpose of a dynamic dummy is to replace as an alternative the participants for vibration tests of vehicle seats when applying ISO 7096[4], ISO 5007[1] and EN 13490[5]. In terms of body mass, two groups of participants are considered in the mentioned standards: lightweight (52 kg to 55 kg), and heavyweight (98 kg to 115 kg).

Considering that the sitting mass of the occupant of a seat (namely, the fraction of the mass of the occupant of a seat supported by the seat itself) is approximately 75 % of the body mass of the occupant, the mass of the dynamic dummy shall be between 39,0 kg and 41,3 kg for the lightweight group, and between 73,5 kg and 86,3 kg for the heavyweight group.

6.2 Mechanical components

Mechanical components such as masses, springs and dampers can be used in the construction of a dynamic dummy to approximate the apparent mass of some notional human bodies. The properties of such mechanical components can be optimised by referring to the pertinent characteristics of the corresponding notional human bodies. Springs shall have low internal friction to approximate the ideal behaviour. Bearings and guides may be used in the dummy structure to provide kinematic pairs between moving and stationary parts. The mechanical properties of these components may change over time which may affect the dynamic performance of the dummy. The dummy shall be checked regularly following the method in Clause 7.

6.3 Seat contact

The dynamic dummy shall have appropriate supporting structures to establish contact with seat cushion and seat back. The bottom supporting structure of the dynamic dummy shall rest on the seat cushion; its shape can be either flat (e.g. similar to the one of the SIP device defined in ISO 5353[2]) or contoured. The back supporting structure of the dynamic dummy shall rest on the seat back to provide stability and to prevent the dynamic dummy from falling during vibration tests. The area of the dummy–seat cushion interface shall be similar to the area of a person–seat cushion interface. Friction at the dummy-seat interface shall be controlled so that no sliding motion occurs.

A seat belt or harness may be used to stabilise the dummy on the seat. The seat belt or harness shall only be used between the frame of the dynamic dummy and the seat, but it shall not constrain the movement of the moving parts of the dynamic dummy and shall not generate additional compressive deformation of either seat cushion or seat back.

To obtain a good fit, the dynamic dummy can be placed on the seat following the procedure recommended in ISO 5353:1995, 5.3.2.

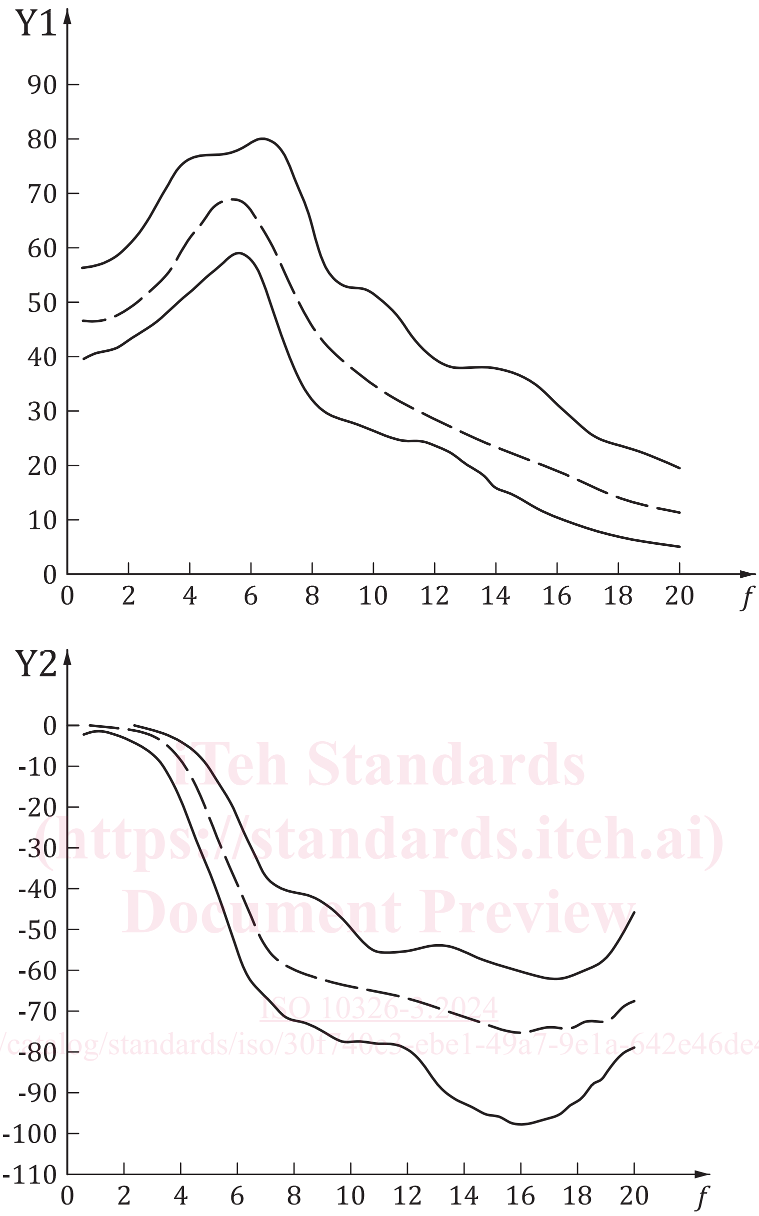
6.4 Apparent mass

The dynamic dummy shall reproduce the idealized Z-axis (vertical) apparent mass at seat cushion of a lightweight participant (52 kg to 55 kg) and/or a heavyweight participant (98 kg to 115 kg) sitting on a rigid seat with flat horizontal seat cushion and flat vertical seat back under Z-axis (vertical) vibration.

Figure 3 shows modulus and phase of the mean (target) and range of idealized Z-axis (vertical) apparent mass at seat cushion of the lightweight (52 kg to 55 kg) group sitting on a rigid seat with flat horizontal seat cushion and flat vertical seat back under Z-axis (vertical) vibration. The corresponding numerical data are listed in Table A.1.

Figure 4 shows modulus and phase of the mean (target) and range of idealized Z-axis (vertical) apparent mass at seat cushion of the heavyweight (98 kg to 115 kg) group sitting on a rigid seat with flat horizontal seat cushion and flat vertical seat back under Z-axis (vertical) vibration. The corresponding numerical data are listed in Table A.2.

The apparent mass reproduced by a dynamic dummy shall lie within the pertinent range of idealized values in the frequency band from 0,5 Hz to 20 Hz as shown in Figures 3 and 4.



Key

Y1 modulus of apparent mass, kg

Y2 phase of apparent mass, degree

f frequency, Hz

——— range of idealized values

— — — mean of idealized values

Figure 3 — Modulus and phase of the mean (target) and range of idealized Z-axis (vertical) apparent mass at seat cushion of the lightweight (52 kg to 55 kg) group