INTERNATIONAL STANDARD

ISO 2631-5

Second edition
2018-07

Corrected version
2022-01

Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration —

Part 5: Method for evaluation of vibration containing multiple shocks

Vibrations et chocs mécaniques — Évaluation de l'exposition des individus à des vibrations globales du corps —

Partie 5: Méthode d'évaluation des vibrations contenant des chocs répétés

Reference number
ISO 2631-5:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ... **iv**
Introduction ... **v**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms, definitions and symbols ... **2**
4 Delineation of the two exposure regimes ... **3**
5 Description of the model ... **4**
5.1 Vibration measurement ... 4
5.1.1 General considerations ... 4
5.1.2 Measurement location and specific hardware requirements ... 4
5.1.3 Signal conditioning ... 5
5.1.4 Measurement duration ... 6
5.2 Determination of spinal response ... 6
5.3 Calculation of spinal response dose ... 9
Annex A (informative) **Alternative model for the determination of spinal response during exposures without loss of contact with seat surface** ... **10**
Annex B (informative) **General relationship between acceleration dose and health effects** ... **16**
Annex C (informative) **Assessment of health effects for exposures that are described in Clause 5** ... **17**
Annex D (informative) **Example of digital implementation of transfer function for exposures that are described in Clause 5** ... **21**
Annex E (informative) **Assessment of health effects for exposures without loss of contact with seat surface** ... **23**
Bibliography ... **29**

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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*.

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.

This second edition cancels and replaces the first edition (ISO 2631-5:2004), which has been technically revised. The main changes compared to the previous edition are an improved description of the physiological response function for the exposure and improved guidance on the associated risk.

A list of all the parts in the ISO 2631 series can be found on the ISO website.

This corrected version of ISO 2631-5:2018 incorporates the following corrections:

— Figure 1: subclause numbers in the "Severe conditions" box were corrected as follows:
  — "Measurement (5.1)";
  — "Signal conditioning (5.1.3)";
  — "Evaluation (5.2, 5.3)";
  — "Risk injury (Annexes B and C)".

Introduction

The purpose of this document is to define a method of quantifying whole-body vibration containing multiple shocks in relation to human health in the seated posture. In biodynamics, the term “shock” is used to describe a wide range of short-time, high-magnitude exposures. It covers the range of severity starting at mild shocks resulting only in annoyance and brief discomfort up to magnitudes of shock sufficient to cause pain, injury or substantial physiological distress.

The methods described in this document can be appropriate for assessing the risk of chronic injury from exposure to repeated shock as can be experienced in military, commercial or recreational off-road vehicles, including agricultural vehicles, heavy plant equipment and high-speed marine craft. The methods are not intended to assess the probability of acute damage from a single impact.

The assessment methods described are based on the predicted biomechanical response of the bony vertebral endplate (hard tissue) in an individual who is in good physical condition with no evidence of spinal pathology. However, the risk assessment methods and related models described in this document have not yet been systematically epidemiologically validated. The methods provide nevertheless a quantitative description of the exposure, which is necessary to assess relative differences between exposures, e.g. the effects of some protective measures and different exposure conditions.

This document solely addresses lumbar spine response on the basis of studies indicating that the lumbar spine can be adversely affected by exposures to whole-body vibration[6][7][8][9][10][11][38][39][47][48][54][55] which also contain multiple shocks. Other adverse health effects of exposure to repeated shock, such as damage to parts of the body other than the lumbar spine, or types of short or long term health effects other than damage to the vertebral end plates, are not specifically considered by this document. Such end plate damage often cannot be differentiated by damages caused by other exposures (heavy lifting) and diseases.

This document considers only the effects of compressive loads from multiple shocks. To this end, a seat-to-lumbar spine transfer function of the measured acceleration has been developed for a default posture, body height and lumbar spine level. Another method to describe the spinal response is given in Annex A, which is valid only for a limited range of acceleration magnitudes but includes the effect of different postures, body heights and lumbar spine levels.

A standardized approach to the prediction of injury for non-vertical or combined axes shocks is complicated by the range of different postures and body restraint systems that can be employed in different vehicles and the limitations of current capabilities for predicting injury from non-vertical shock. Shocks involving horizontal, rotational or multi-axial motion are known to occur in practice and can present a significant risk of injury.

The risk of injury in the lumbar spine depends on an exposure dose, which is a combination of an exposure quantity and a duration. A manifest injury can take several years to develop. Due to the complexity of the measurement of multiple shocks, it is at the moment not possible to measure the exposure of the lifetime dose directly. Instead, the exposure is measured in representative situations and the dose is extrapolated from this measurement to a recorded exposure duration in the past or an anticipated exposure duration in the future. To monitor constantly the lifetime dose at a workplace, alternative measurement equipment will need to be developed, e.g. dosemeters.

Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration —

Part 5: Method for evaluation of vibration containing multiple shocks

1 Scope

This document addresses human exposure to multiple mechanical shocks, and it formulates requirements for the measurement of multiple shocks. The results of these measurements are then analyzed to provide information for the assessment of the risk of adverse health effects to the vertebral end-plates of the lumbar spine for seated individuals due to compression. Other injuries could develop even when there is no injury to the end plate.

NOTE 1 Multiple mechanical shocks are shocks of different magnitude and shape that occur frequently at regular and irregular intervals during the measurement period.

NOTE 2 As proposed in the annexes, the assessment of the current injury risk is based on measured representative exposures in combination with the individual exposure history. Prospective risks can be assessed by anticipated exposure durations. Manufacturers of measurement equipment are encouraged to develop a possibility for an on-site evaluation of the exposure.

Two exposure regimes are distinguished in this document: one for severe conditions and one for less severe conditions.

NOTE 3 Clause 4 contains the delineation of the two regimes.

This document is applicable for unweighted vertical accelerations that have peak values up to 137,3 m/s^2 (14 g) measured at the seat-occupant interface beneath the ischial tuberosities over a 0,01 Hz to 80 Hz measurement bandwidth.

NOTE 4 The measurement bandwith is defined in 5.1.

Caution is necessary when applying the method to severe exposures, particularly since peak accelerations of 137,3 m/s^2 (14 g) are close to the physical limit that a spine can tolerate.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes 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 2631-1:1997, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 5805, *Mechanical vibration and shock — Human exposure — Vocabulary*

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