INTERNATIONAL STANDARD

ISO 13091-1

First edition
2001-05-15

Mechanical vibration — Vibrotactile perception thresholds for the assessment of nerve dysfunction —

Part 1: Methods of measurement at the fingertips

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Vibrations mécaniques — Seuils de perception vibrotactile pour l'évaluation des troubles neurologiques

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Partie 1: Méthodes de mesure à la pulpe des doigts

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Reference number
ISO 13091-1:2001(E)

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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 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 13091 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13091-1 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 4, *Human exposure to mechanical vibration and shock*.

ISO 13091 consists of the following parts, under the general title *Mechanical vibration — Vibrotactile perception thresholds for the assessment of nerve dysfunction*:

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— *Part 1: Methods of measurement at the fingertips*

— *Part 2: Analysis and interpretation of measurements at the fingertips*

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Introduction

The early detection of peripheral neuropathies in the upper extremities, which are often manifest as changes in tactile function, is of considerable interest. Such neuropathies may occur as a result of disease, or from occupations in which workers are exposed to neurotoxic agents or to mechanical vibration.

The tactile performance of the fingers is known to depend on neural activity in up to four populations of specialized nerve endings. These mechanoreceptor types are commonly described by their response to mechanical indentation of the skin surface (i.e. SAI: slowly adapting, type I; SAII: slowly adapting, type II; FAI: fast adapting, type I; and FAII: – fast adapting, type II). The SAI receptor acuity primarily determines the resolution of the spatial features of a surface, such as ridges and texture. These receptors respond to pressure. FAI and FAII receptor acuity is primarily responsible for information obtained from the motion of surfaces across the skin surface or, conversely, moving fingertips across surfaces. Such information is used to provide information on surface finish, or smoothness, and to maintain an appropriate grip of objects (which is controlled by the detection of micro-slips). SAII receptors primarily signal skin stretch. Separate responses from SAI, FAI and FAII receptor populations can be determined psychophysically by using precisely defined measurement conditions and vibrotactile stimulation at different frequencies. In some circumstances, such as selective loss of receptor function, it may not be possible to obtain separate thresholds from each population.

Standardized methods for measuring vibrotactile perception thresholds are required to obtain meaningful results, and to compare results obtained using different apparatus. Without standardization, the thresholds obtained by different measurement methods may differ substantially, and often unpredictably, and so cannot be compared. Requirements for measurement methods and instruments stem from the properties of the mechanoreceptor populations from which they are designed to elicit responses. The overall goal of this part of ISO 13091 is to define optimized testing methods and measurement procedures.

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This part of ISO 13091 describes methods that are designed to yield equivalent results for measuring vibrotactile perception thresholds (VPTs) at the fingertips. The methods are applicable to healthy and diseased persons, and are suitable for detailed clinical evaluation and for rapid screening. Values are recommended for all measurement parameters. Some parameters are specified by a central value with broad “tolerances” in recognition that different values are currently in use. The central values given are the preferred values. Using the methods described, the VPT at one test frequency can be determined in approximately 1 min once the subject has been trained in the measurement procedure (which may be completed in approximately 5 min). This information may be considered sufficient for some screening applications. ISO 13091-2 considers the analysis and interpretation of VPTs obtained using the methods specified in this part of ISO 13091.

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Mechanical vibration — Vibrotactile perception thresholds for the assessment of nerve dysfunction —

Part 1: Methods of measurement at the fingertips

1 Scope

This part of ISO 13091 specifies

— methods for measuring vibrotactile perception thresholds (VPTs) at the fingertips,

— procedures for conducting the measurements, and

— the reporting of results.

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Measurement methods are defined in this part of ISO 13091 for obtaining perception thresholds at the fingertips mediated, separately, by SAI, FAI and FAII mechanoreceptor populations. The methods are designed to be applicable to healthy and diseased persons, and to be suitable for clinical assessment and for screening purposes.

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The measurement of temporary shifts in vibrotactile perception threshold, or of thresholds at body sites other than the fingertip, is outside the scope of this part of ISO 13091.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13091. 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 13091 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 5805, *Mechanical vibration and shock — Human exposure — Vocabulary*.

IEC 60601-1, *Medical electrical equipment — Part 1: General requirements for safety*.

3 Terms and definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this part of ISO 13091, the terms and definitions given in ISO 2041 and ISO 5805 apply, together with the following.

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3.1.1
pure tone
oscillatory signal whose instantaneous magnitude is a sinusoidal function of time (i.e. at a single frequency)

3.1.2
tone burst
intermittent pure-tone signal

3.1.3
gliding tone
pure tone in which the frequency changes continually with time

3.1.4
equivalent frequency
frequency selected as representing the measurement “frequency” when frequency is changed with time during the measurement of vibrotactile perception

3.1.5
total harmonic distortion
percentage pure-tone distortion expressed as 100 times the square root of the ratio of the sum of the squared amplitudes of harmonic components within a defined bandwidth to the squared amplitude of the fundamental

3.1.6
masking
mask, verb
process by which the perception threshold for one stimulus is raised by the presence of another (masking) stimulus of the same or different frequency

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3.1.7
forward masking
process by which perception of the test stimulus currently being presented to a subject is rendered undetectable by a previous test stimulus of the same or different frequency

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3.1.8
mechanoreceptor
nerve ending specialized for transforming mechanical deformation of the skin into nerve impulses

3.1.9
mechanoreceptor-specific vibrotactile perception threshold
receptor-specific vibrotactile perception threshold
vibrotactile perception threshold at which the stimulus is mediated by one population of mechanoreceptors at the point of stimulation

3.1.10
neutral position
position naturally adopted by the hand when the hand and arm hang freely from the shoulder, when standing erect

NOTE This position normally involves no flexion or extension of the wrist.

3.1.11
stimulator
means for generating static indentation of the skin surface and/or continuous or intermittent oscillatory motion of the skin surface

3.1.12
probe
means by which external motional and oscillatory stimuli are coupled to the skin surface

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3.1.13
surround
static, rigid, flat surface on which a fingertip rests, containing a hole through which a probe may contact the skin surface

3.1.14
contact force
static and dynamic components of the force with which a stimulating or sensing probe contacts the skin

3.1.15
indentation of skin
distance moved by the probe tip from the position of initial contact with the skin surface (where the contact force is zero) to the position at which thresholds are determined

3.1.16
aural cue(s)
sound caused by vibration of the stimulator

3.1.17
physiological "noise"
human body motion, including vibration, naturally occurring from physiological functions such as blood flow, heart beat, muscle tremor and respiration

3.1.18
background vibration
residual vibration at the fingertip, in the absence of the stimulus, when the subject is positioned to commence threshold measurements with the stimulating probe in contact with the fingertip

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NOTE Background vibration can be caused by room vibration, the measurement apparatus and physiological "noise".

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3.1.19
psychometric function
function expressing the relationship between the proportion, or percentage, of positive responses indicating a stimulus has been detected by a subject and a physical measure of the magnitude of the stimulus

3.1.20
psychophysical algorithm
measurement procedure in which physical stimuli are presented to a subject to elicit a predetermined sensory response, such as perceiving the presence or character of an externally applied skin motion

3.1.21
threshold
onset of the perception of a stimulus, or the loss of perception of a stimulus

3.1.22
ascending threshold
threshold obtained when stimuli of successively increasing intensity are applied to the skin until the stimulus is detected

3.1.23
descending threshold
threshold obtained when stimuli of successively decreasing intensity are applied to the skin until the stimulus is no longer detected

3.1.24
vibrotactile perception threshold
skin surface acceleration level at which there is a 50 % positive response rate for detecting a pure-tone oscillatory stimulus in the psychometric function

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3.1.25
threshold shift
change in vibrotactile perception threshold from a previously established baseline value that persists in time

NOTE The baseline value can be, for example, a previous vibrotactile perception threshold obtained from the same subject. The baseline value can also be the mean threshold obtained from healthy persons of similar age without sign, symptom or history of peripheral neurological disease, or of exposure to neurotoxic agents or to hand-transmitted vibration. This subject is considered in ISO 13091-2.

3.1.26
temporary threshold shift
temporary elevation in the perception threshold (i.e. loss in acuity) that disappears with time

3.1.27
up-down algorithm
psychophysical measurement procedure in which two limiting thresholds (ascending and descending) are determined by presenting to a subject a sequence of short-duration stimuli, each of constant but different intensity

NOTE The procedure commonly involves applying a sequence of stimuli with successively increasing intensity to the skin until the subject signals that a stimulus has been detected (ascending threshold). Successive stimuli are then decreased in intensity until the subject signals that the stimulus can no longer be felt (descending threshold). A “staircase” algorithm is an up-down algorithm in which the sequence of stimuli are increased, and decreased, in steps of equal magnitude.

3.1.28
von Békésy algorithm
psychophysical measurement procedure in which a continuous stimulus with changing intensity, often accompanied by a change in frequency with time (gliding tone), is used to determine sequentially ascending and descending thresholds

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3.2 Symbols and abbreviated terms

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The following symbols and abbreviated terms are used in this part of ISO 13091:

FAI fast adapting, type I mechanoreceptors

FAII fast adapting, type II mechanoreceptors

SAI slowly adapting, type I mechanoreceptors

VPT vibrotactile perception threshold

$t_a(r)$ a sequence of ascending threshold levels

$t_d(r)$ a sequence of descending threshold levels

where

$r = 1, 2, 3, ..., n$

n is the number of ascending and descending threshold pairs, e.g. $t_a(1)$ and $t_d(1)$, $t_a(2)$ and $t_d(2)$, ..., $t_a(n)$ and $t_d(n)$.

4 Measurement methods

4.1 General

Requirements for measurement methods and procedures originate from the properties of the mechanoreceptor populations from which they are designed to elicit responses, and are summarized in Table 1.

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Table 1 — Summary of requirements for measurement methods

Stimulus (see 4.2)	SAI	FAI	FAII
Frequency[a], Hz	4,0	31,5	125
— other frequencies, Hz	3,15; 5,0	20; 25	100; 160
Intermittent			
— burst duration	< 10 s	< 10 s	0,6 s to 10 s
— quiescent duration[b]	⩾ 0,6 s	⩾ 0,6 s	⩾ 0,6 s
Continuous			
— maximum duration	50 s	50 s	50 s
— minimum rest, same site and receptor	30 s	30 s	30 s
Subject positioning (see 4.3)			
— support	forearm, hand and finger; seat with back rest		
Skin surface conditions (see 4.4)			
— skin temperature	27 °C to 35 °C, confirmed by measurement		
— test room temperature	20 °C to 30 °C		
Stimulating probe (see 4.5)			
— geometry, finish, diameter	flat-ended cylinder, 0,2 mm ⩽ edges radii ⩽ 0,7 mm smooth to touch, 4,0 mm ± 2,1 mm diameter		
Skin-stimulator contact (see 4.6)	Method A, no surround	Method B, with surround	
— skin indentation	1,5 mm ± 0,8 mm	1,5 mm ± 0,8 mm	
— probe-surround gap	—	1,5 mm ± 0,6 mm	
— surround force	—	0,7 N to 2,3 N	
Psychophysical algorithm (see 4.7)			
— independent of stimulus	variant of up-down, or von Békésy		
Subject's response (see 4.8)			
— detection	automatic and unambiguous		
— inconsistency	automatic detection		
Skin motion (see 4.9)			
— probe, at skin surface	r.m.s. magnitude of stimuli, and background vibration (and frequency if gliding tones used)		
System check (see 4.10)			
— before VPT test	performance of measurement system to be confirmed		

[a] The minimum requirement is for one measurement frequency.

[b] And not less than half the stimulus duration.

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