TECHNICAL SPECIFICATION

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Mechanical vibration and shock — Coupling forces at the man-machine interface for hand-transmitted vibration —

Part 2: Evaluation of coupling forces

Vibrations et chocs mécaniques — Forces de couplage à l'interface homme-machine en cas de vibrations transmises par les mains —

Partie 2: Évaluation des forces de couplage

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Contents

Page

Foreword

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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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by 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 15230 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

The coupling forces between the hand-arm system and a hand-held or hand-guided machine during its use are very important factors. Although these forces are of interest for both vibrating and non-vibrating machines, the primary focus of this document is to provide a set of descriptions of the forces at the man-machine interface that are primarily for the hand-arm system in contact with a vibrating surface of a machine.

The coupling forces involved in the operation of a vibrating machine generally consist of two different components. The first component is the force applied by the hand-arm system which is used to provide necessary control and guidance of the machine and to achieve desired productivity. This quasi-static force (frequency below 5 Hz) is the focus of this document. The second component is the biodynamic force which results from the biodynamic response of the hand-arm system to a vibration.

Different couplings of the hand to a vibrating surface can affect the human body in two different ways:

a) The relationship between the measured handle vibration and the resultant transmission of vibration to the hand-arm system might be altered. This alteration modifies the exposure and possibly also the vibration effect to the hand-arm system, although no epidemiological evidence is available at present.

b) The coupling can result in a synergistic effect with vibration exposure which could affect anatomical structures, such as the vascular system, nerves, joints and tendons.

Currently, many human-machine interactions have been modelled by measuring the physiological responses of the human body to vibration while operating a tool or machine using various push and grip forces. Push and grip forces are the factors that have been used to describe the coupling forces.

This document can assist in the reporting of coupling data in epidemiological or laboratory research. It is expected that in the future, measurements of the coupling forces will be made in addition to measurements at the workplace for the determination and evaluation of human exposure to mechanical vibration.

The ISO 15230 series consists of two parts:

— ISO 15230-1, having the status of an ISO standard, defining measurement parameters and evaluation procedures.

— ISO/TS 15230-2, being a technical specification, aimed primarily at researchers. In this document, the relationship between magnitude of the coupling force and the transfer of damaging vibrational energy into the hand-arm system is considered. This document provides a method for adjusting evaluations of exposures to hand-arm vibration according to the measured coupling force.

Mechanical vibration and shock — Coupling forces at the man-machine interface for hand-transmitted vibration —

Part 2:
Evaluation of coupling forces

1 Scope

This document describes a coupling-force-dependent weighting of the r.m.s. value to the frequency-weighted acceleration, a_{hw}.

The procedure only applies to normal gripping situations (embracing a handle). If only part surfaces of the hand are exposed to vibration, the procedure is not applicable.

The evaluation methods defined in this document are intended to enable research.

This document provides guidance on an additional procedure to that defined in ISO 5349-1 for measuring and reporting hand-transmitted vibration exposures by taking into account the coupling force exerted on the vibrating surface.

This document is intended to facilitate future research on hand-arm vibration risks and to complement data collected using the ISO 5349-1 methodology.

This document does not apply as an alternative to ISO 5349-1. The data derived from this document does not apply to perform tasks in accordance with national regulations, guidelines or recommendations for workplace vibration or machinery vibration emissions. This document does not apply to the legal obligations related to the protection of workers from hand-arm vibration in the workplace and the declaration of vibration emissions from machinery.

The methodology defined in this document is based only on biomechanical relationships between vibration transmission to the hand-arm system as a function of total forces. The influence of contact force and pressure on the surface of the hand remains unconsidered and requires further research.

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 5349-1, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements*

ISO 5349-2, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 2: Practical guidance for measurement at the workplace*

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

ISO 15230-1, *Mechanical vibration and shock — Coupling forces at the man-machine interface for hand-transmitted vibration — Part 1: Measurement and evaluation*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 15230-1 and the following apply.

ISO and IEC maintain terminological 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
coupling factor
c_{cp}
value used to adjust the frequency-weighted acceleration, a_{hw} as a function of the coupling force, F_{cp}

3.2
coupling-force-adjusted frequency-weighted acceleration
a_{hwF}
frequency-weighted acceleration, a_{hw}, after adjustment by the *coupling factor* (3.1), c_{cp}

3.3
coupling-force-adjusted vibration total value
a_{hvF}
vibration total value, a_{hv}, after adjustment by the coupling factor, c_{cp}

3.4
coupling-force-adjusted daily vibration exposure
$A(8)_F$
daily vibration exposure calculated from the *coupling-force-adjusted vibration total values* (3.3)

4 Symbols and abbreviated terms

For the purpose of this document, the symbols and abbreviations defined in ISO 5349-1 and ISO 15230-1 and the following indices apply.

cp subscript coupling F subscript coupling-force-adjusted

5 Measuring procedure and evaluation process

5.1 Measurements

Measurements of both hand transmitted vibration and coupling force shall be made during the same or similar work activities. Where possible the measurements of coupling forces and frequency-weighted acceleration should be simultaneous, in order to account for possible dependencies between the two parameters.

The frequency-weighted acceleration, a_{hw}, shall be measured in accordance with ISO 5349-2 using instrumentation that meets the requirements of ISO 8041-1 for hand-transmitted vibration instrumentation. Measurements shall be made at, or very close to, the gripping zone(s), i.e. where the operator grips the machine or vibrating element.

The coupling force shall be measured in accordance with ISO 15230-1.

5.2 Processing of the results

In the case of a sequence of several individual measurements of one work task, the arithmetic mean of the magnitudes of individual measured values of the frequency-weighted acceleration, a_{hw}, and that of coupling force, F_{cp}, shall be determined.

Individual measurements of coupling forces shall only be made during activities where there is vibration exposure.

The arithmetic mean is formed of all the components of force relevant to the task in question:

a) In the case of simultaneous measurement of forces and frequency-weighted acceleration, forces are only registered and averaged over the period of time during which the vibration is also being measured.

b) In the case of non-simultaneous measurements of forces and frequency-weighted acceleration, care shall be taken to register and take the mean of the forces only for such task periods as are relevant to the measurement of the vibration.

Logging coupling force with time is recommended in order to recognise atypical situations, e.g. negative feed forces during drilling. Alternatively, the statistical distribution of the measured coupling forces can be obtained in order to assess the validity of measurements and determine the mean feed force value.

6 Calculation of acceleration values weighted by the coupling force

6.1 Coupling-force-adjusted frequency-weighted acceleration

Methods for calculating the coupling factor from the coupling force are given in Annex A and Annex B.

The coupling-force-adjusted frequency-weighted acceleration, a_{hwF}, is then calculated from the coupling factor, c_{cp}, and the frequency weighted acceleration, a_{hw}, using Formula (1):

$$a_{hwF} = a_{hw} \cdot c_{cp} \tag{1}$$

NOTE For some power tools and machines an increase in hand grip, and hence increase in coupling force, causes a reduction in handle vibration (e.g. tools with vibration-isolating handles). Formula (1) is not applicable in these circumstances.

6.2 Coupling-force-adjusted vibration total value and daily vibration exposure

The coupling-force-adjusted vibration total value, a_{hvF}, can be calculated for each exposure section from the coupling-force-adjusted frequency-weighted acceleration, a_{hwF}, in one, two or all directions of vibration. The coupling-force-adjusted partial vibration exposure values are obtained by taking into account the relevant duration of exposure. The root-sum-of-square of these partial values is equal to the coupling-force-adjusted daily vibration exposure, $A(8)_F$.

7 Test report

In addition to the reporting information required by ISO 5349-1 and recommended in ISO 5349-2, the following information shall be reported:

a) sample;

b) a reference to this document, i.e. ISO/TS 15230-2:2023;

c) work task and machine activity during coupling force measurement;

d) coupling force measurement or evaluation method;

e) location and orientation of the coupling force measurement system;

f) coupling force measurement period;

g) coupling force values;

h) coupling factor;

i) coupling-force-adjusted vibration total value;

j) coupling-force-adjusted daily vibration exposure;

k) uncertainty of evaluation;

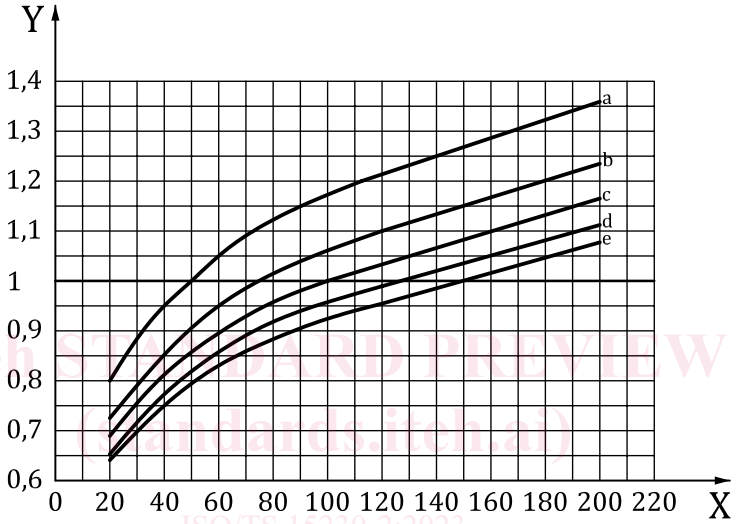
l) the date of the test.

Annex A
(informative)

Method for calculating the coupling factor

A.1 Relation between coupling factor and coupling force

Tentative relations between coupling factor and coupling force are shown in Figure A.1.



Key

X coupling force, F_{cp} in N
Y coupling factor, c_{cp}
a $c_{cp} = 1$ at $F_{cp} = 50$ N
b $c_{cp} = 1$ at $F_{cp} = 75$ N
c $c_{cp} = 1$ at $F_{cp} = 100$ N
d $c_{cp} = 1$ at $F_{cp} = 125$ N
e $c_{cp} = 1$ at $F_{cp} = 150$ N

Figure A.1 — Coupling factor as a function of coupling force for different forces with unity coupling factor

The change in coupling factor with coupling force is estimated for different coupling forces at which the coupling factor is unity. Other coupling forces at which the coupling factor is unity may be obtained by interpolation, or by using the closest value provided in Figure A.1.

The relations have been derived from studies in which the transmission of vibration to the wrist and elbow was recorded as subjects grasped a cylindrical handle (see Annex C). The baseline, or reference, coupling force at which the coupling factor is unity may be the force that is representative of the coupling of the hand to the vibrating power tool, handle or work piece during typical operation of the tool or process, as required by the provisions of ISO 5349-1 and ISO 5349-2. Alternatively, it may be the force that is recorded by a single operator during the performance of a selected work task.