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

Part 1: Measurement and evaluation

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

Partie 1: Mesurage et évaluation

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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.

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).

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

This second edition cancels and replaces the first edition (ISO 15230:2007), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— The document number is now ISO 15230-1.

— The introduction has been changed to explain the publication of ISO 15230 as standards series, now comprising two parts, ISO 15230-1 (the former ISO 15230) and new ISO/TR 15230-2.

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 the vibration effect to the hand-arm system.

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

Currently, many machine situations have been modelled by many basic physiological studies investigating the effect of vibration on the human body which use pushing force and gripping force to describe the coupling force between the hand and the machine handle.

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.

ISO 15230 consists of two parts:

— ISO 15230-1, *Mechanical vibration and shock — Coupling forces at the man-machine interface for hand-transmitted vibration — Part 1: Measurement and evaluation*, has the status of an ISO standard, defining measurement parameters and evaluation procedures.

— ISO/TR 15230-2, *Mechanical vibration and shock — Coupling forces at the man-machine interface for hand-transmitted vibration — Part 2: Guidelines for the evaluation of coupling forces*, is a technical report, aimed primarily at researchers. In ISO/TR 15230-2, the relationship between magnitude of the coupling force and the transfer of damaging vibrational energy into the hand-arm system is considered. This part 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 1: Measurement and evaluation

1 Scope

This document describes the coupling parameters between the hands of a machine operator and a vibrating surface of the machine.

The coupling between the hand and the vibrating surface can be described using different parameters and component parts of these parameters:

— force parameters, such as push, pull and grip;

— parameters such as pressure exerted on skin.

In addition, Annexes A, B, C, D and E provide guidelines for measuring procedures, the measurement of the force and pressure parameters, and information on the requirements for measuring instrumentation, as well as a calibration method.

This document does not deal with forces which act tangentially to the hand.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Symbols and abbreviated terms

4.1 Symbols

F	force
i	integer for summation
n	total number of elements to be summed
p_i	local pressure at surface element i
S	surface

t	time
T	duration of operation
α	hand-oriented angle of the dividing plane
β	machine-oriented angle of the dividing plane
δ	coefficient of the proportionality for the gripping force
γ	coefficient of the proportionality for the push force

4.2 Subscripts

BD	biodynamic force
c	contact
coup	coupling
f	feed
g	guiding
gr	gripping
l	lifting
m	mean value
max	maximum
n	normal
pu	push or pull
x, y, z	Cartesian coordinates

5 Parameters at man-machine interface

5.1 Pressure exerted on skin

5.1.1 Area element of surface

The area element of the surface, S_i, is given using Formula (1):

$$\vec{S}_i = S_i \cdot \vec{S}_{n,i} \tag{1}$$

with the unit vector, $\vec{S}_{n,i}$, in the normal direction to the area element. (See Figure 1.)

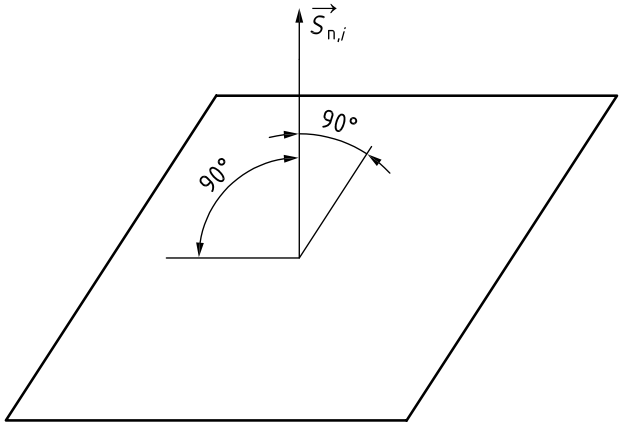


Figure 1 — Direction of the area elements, S_i

5.1.2 Local pressure

The local pressure, p_i, exerted on an area element of the surface, S_i, of the hand skin is given as the ratio between the perpendicular component of the area element contact force, $F_{c,i}$ (see 5.1.5), applied in the middle of this area element and the area of this surface, as given by Formula (2):

$$p_i = \frac{F_{c,i}}{S_i} \tag{2}$$

When reporting local pressure values, the area element surface should be reported.

NOTE Depending on the operator, hand location, tool and task, local pressure p_i usually ranges between zero and 0,8 N/mm^2. Values above this pressure range can be perceived as painful.

5.1.3 Mean pressure

The mean pressure, p_m, exerted on the surface of the hand in contact with the machine or a part of the machine is calculated as average pressure using Formula (3):

$$p_m = \frac{\sum_{i=1}^{n} p_i \cdot S_i}{\sum_{i=1}^{n} S_i} \tag{3}$$

5.1.4 Maximum local pressure

The maximum local pressure, p_{max}, is the highest pressure value measured on the hand surface in contact with the machine, calculated using Formula (4):

$$p_{max} = \max\{p_i\} \tag{4}$$

5.1.5 Elemental contact force

The elemental contact force, $F_{c,i}$, is given by Formula (5):

$$F_{c,i} = p_i \cdot S_i \tag{5}$$

where

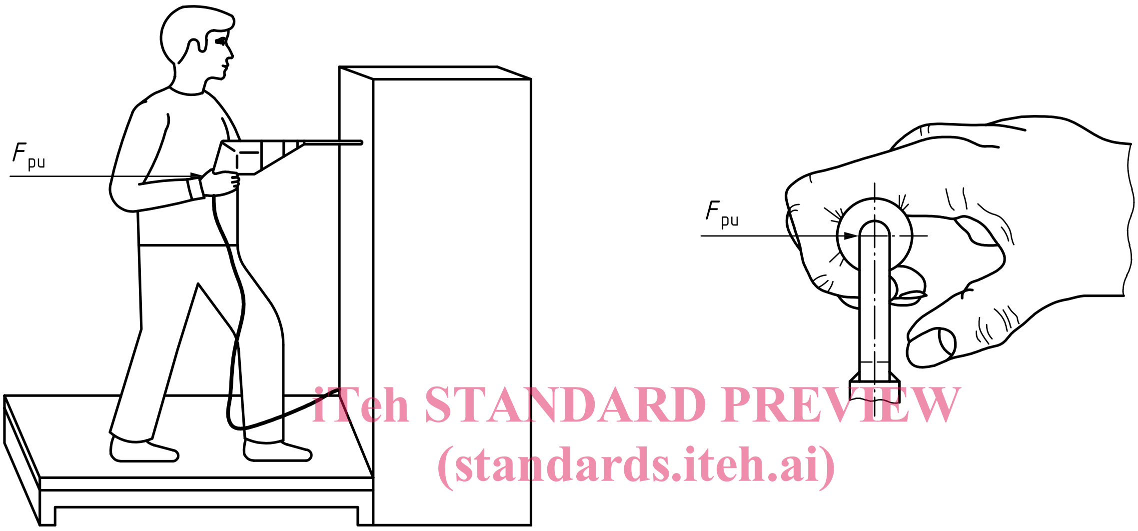
p_i is the pressure over the i^{th} surface element;

S_i is the elemental surface area of the hand skin.

The direction of $F_{c,i}$ is normal to the vibrating surface.

5.2 Push/pull force

The push force, F_{pu}, is the force exerted by the operator away from his shoulder on the vibrating surface via each hand and not compensated within the coupling surface of the hand. The pull force, F_{pu}, is the force exerted by the operator towards his shoulder via each hand. (See Figure 2.)



a) Push force **b) Pull force**

Figure 2 — Example of F_{pu} as push force and pull force

NOTE 1 In some cases, the operation involves both push and pull forces. The push and pull forces can act at different positions on the hand. However, both forces are denoted by F_{pu}.

NOTE 2 Push force F_{pu} can be a very significant force, such as the required pushing of a drill, and needs always to be considered.

5.3 Guiding force

The guiding force, F_g, is the force exerted by the operator on the vibrating surface via either hand in a horizontal or nearly horizontal plane tangentially to the push and/or pull force and not compensated within the coupling surface of the hand. This force is mostly necessary to hold or to move the machine, workpiece or control lever. (See Figure 3.)

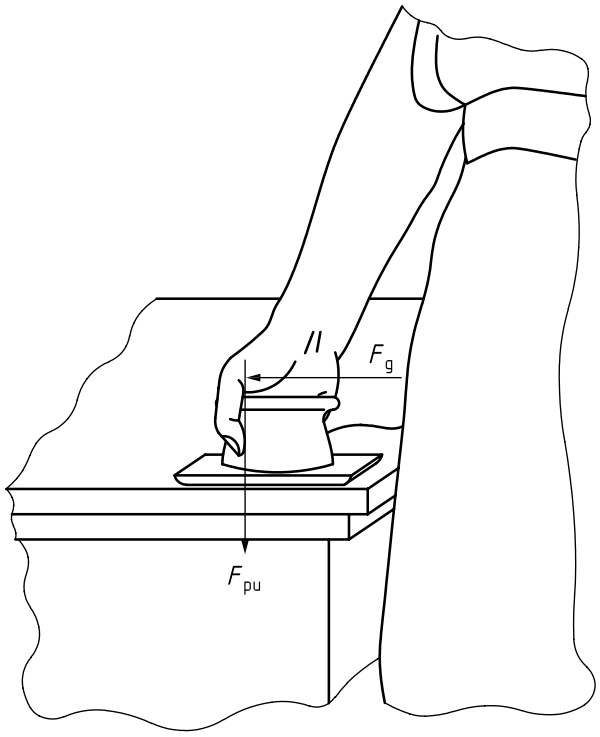
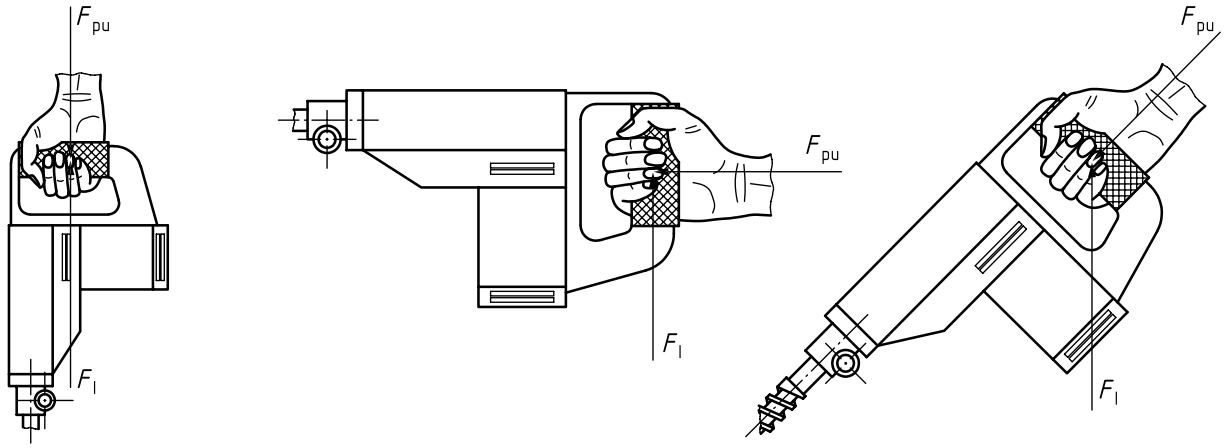


Figure 3 — Example of guiding force, F_g, with indication of push force, F_{pu}

NOTE F_g has the potential to be a low magnitude force when the surface is horizontal.

5.4 Lifting force

The lifting force, F_l, is the force which is necessary to counteract the machine mass. (See Figure 4.)



a) **b)** **c)**

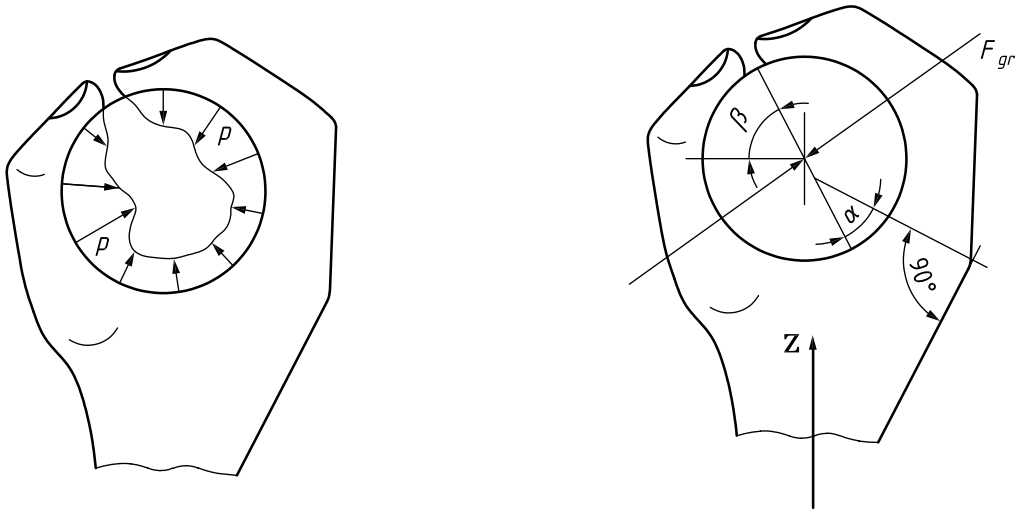
Figure 4 — Example of lifting force, F_l, with indication of push force, F_{pu}

NOTE In some cases, it is possible for lifting force, F_l, to equal push/pull force, F_{pu} [see Figure 4 a)].

5.5 Gripping force

The gripping force, F_{gr}, is half the sum of the force components acting towards an axis inside the handle without push, pull or lifting forces. Simplified, the gripping force is the clamp-like force exerted by the

hand of the operator when enclosing the handle. The force is compensated within the hand by a gripping force acting in the opposite direction towards a dividing plane. (See Figure 5.)



a) Pressure field, p **b) Clamp-like force**

Key

α hand-oriented angle of the dividing plane

β machine-oriented angle of the dividing plane

NOTE The Z axis is along the forearm.

Figure 5 — Example of gripping force, F_{gr}, as clamp-like force

NOTE 1 When the operator is gripping a cylindrical handle, the direction of the main gripping force is generally parallel to the Z axis as defined in ISO 8727.

NOTE 2 Because the grip contact pressure is usually unevenly distributed around the handle, the magnitude of the gripping force is generally a function of the reference axis or dividing plane. The orientation of the maximum or minimum gripping force generally depends on handle dimensions, hand sizes and hand-grip posture. For simplicity's sake, the gripping force in the forearm-based Z axis shown in Figure 5 b) is conventionally used in the measurement and/or control of the gripping force in laboratory studies.

5.6 Feed force

The feed force, F_f, is the external force acting on the machine. (See Figure 6.)