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Mechanical vibration and shock — Mechanical impedance of the human hand-arm system at the driving point

Vibrations et chocs mécaniques — Impédance mécanique du système main-bras au point d'entrée

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10068 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 10068:1998), of which it constitutes a technical revision. The second edition includes the results of measurements of hand-arm impedance conducted since publication of the first edition, and it includes new models for apparent mass and mechanical impedance. The models now possess anatomic compatibility, and identify components for the fingers, palm, wrist and arm, and upper body. A model of the hand-arm system is provided when a glove is worn to estimate the transmissibility of vibration from a vibrating handle to the surface of the hand. The frequency dependency of the vibration power absorbed by the hand-arm system and by structures within the hand-arm system (i.e. fingers, palm and wrist, and arm) is also included. Information on methods for measuring the mechanical impedance of the hand-arm system is also provided in an annex.

Introduction

The mechanical impedance of the human hand-arm system at the driving point provides a measure of the overall biodynamic properties of the hand-arm system in specified conditions. When the hands are coupled to a vibrating tool or machine, the dynamic behaviour of the tool or machine could be affected by the biodynamic properties of the hand-arm system. Therefore, the mechanical impedance can be used to help design or develop:

a) power tools, and tool handles;

b) vibration-reducing and protective devices;

c) testing apparatus with which to measure the handle vibration of power tools.

Values of the mechanical impedance can be used to establish mechanical-equivalent models of the hand-arm system. The models can be used to analyse the vibration of tools and anti-vibration devices, and to guide the construction of testing apparatus. The models can also be used to estimate biodynamic responses such as vibration power absorption and biodynamic forces acting at the hand-tool interfaces. Such knowledge can be used to help understand the mechanisms of vibration-induced disorders and discomfort, and to help develop frequency weightings for assessing these effects. The establishment of typical values for human hand-arm impedance will foster these applications.

The response of the hand-arm system to vibration depends not only on the mechanical properties of the hand and arm, but also on the coupling between the hand and the vibrating surface. The major factors that could influence the response are as follows:

— direction of vibration with respect to the hand-arm system;

— geometry of the object grasped;

— forces exerted by the hand on the object;

— hand and arm postures;

— individual differences, such as tissue properties and anthropometric characteristics of the hand-arm system;

— vibration magnitude, because of the nonlinear properties of tissues.

The forces exerted by the hand are usually described in terms of the grip force and feed force. The latter is often called the “thrust”, “push” or “press” force.

In this International Standard, typical values for the mechanical impedance of the hand-arm system measured at the driving point of one bare hand are provided. They have been derived from the results of impedance measurements performed on groups of live male subjects by different investigators. Insufficient data are available from independent sources to specify hand-arm impedances for females.

There are large differences between the mean values of impedance reported in studies conducted independently, under nominally equivalent conditions. The variations have dictated the form in which the standardized male hand-arm impedance is presented. The most probable values of impedance modulus and phase are defined, as a function of frequency, by upper and lower envelopes, which encompass the mean values of all accepted data sets at each frequency. The envelopes have been constructed from segmental cubic spline functions, and define, at each frequency, the range of accepted values of the male hand-arm impedance. The mean of the accepted data sets, and standard deviation of the mean, are defined as a function of frequency, and represent the target values for all applications of this International Standard.

No impedance modulus or phase presented as a function of frequency in this International Standard corresponds precisely to the mean value measured in a single investigation involving human subjects, at all frequencies.

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1 Scope

This International Standard specifies the mechanical impedance of the human male hand-arm system at the driving point. Values of the impedance, expressed as modulus and phase, are provided for three orthogonal, translatory directions of excitation that correspond to the x_h-, y_h- and z_h-axes of the basicentric coordinate system.

NOTE 1 The basicentric coordinate system is defined in ISO 5349-1[2] and ISO 8727.[5]

The x_h-, y_h- and z_h-components of impedance are defined as a function of frequency, from 10 Hz to 500 Hz, for specified arm positions, grip and feed forces, handle diameters, and intensities of excitation. The components of impedance in the three directions are treated as being independent.

This International Standard can be used to define typical values of the mechanical impedance of the hand-arm system at the driving point, applicable to males under the circumstances specified. This International Standard can provisionally be applied to females.

Reference values of the mechanical impedance at the driving point are provided as a function of frequency for a specified grip and feed force.

NOTE 2 See Annex A.

These impedance values are intended for the determination of the transmissibility of resilient materials when loaded by the hand-arm system.

Mathematical representations of the hand-arm system that model the mean values of apparent mass or impedance are provided.

NOTE 3 See Annexes B to D.

A gloved hand-arm model is described, and the frequency dependence of vibration power absorption in the hand-arm system is also provided.

NOTE 4 See Annexes E and F.

To help conduct further measurement of the mechanical impedance, especially for circumstances that are not specified in this International Standard, information on the measurement of mechanical impedance is provided.

NOTE 5 See Annex G.