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CURRENT NATIONAL AND INTERNATIONAL ACTIVITY IN BIODYNAMICS STANDARDS
DEVELOPMENT

Notes and Bibliography

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INTRODUCTION

Originating in 1964, a continuing effort to develop and refine consensus standards for the measurement and control of human exposure to mechanical vibration and shock is being made internationally by the International Organization for Standardization (ISO) Subcommittee ISO/TC 108/SC 4 (Human exposure to mechanical vibration and shock). At national level in the United States, a counterpart effort is the responsibility of ANSI S3.39(S2), which meets and conducts its work under the aegis of the Acoustical Society of America. The standards developed are commonly the basis for formulating industry and military standards, including relevant sections of MIL-STD-1472.

Existing ISO and American national standards, some in the process of revision, include guidelines for measuring and limiting human exposure to whole-body vibration in the range 0.1 to 80 Hz and hand-transmitted vibration at frequencies encompassing the range 8 to 1,000 Hz. Cognate ISO standards, presently in revision or at the stage of draft, define biodynamic terminology; coordinate systems and descriptive terms for force and motion inputs to the human body; human driving-point impedance and vibration transmissibility models; human impact exposure; and the taxonomy of motion- and vibration-sensitive human activity and task performance.

This presentation reviews current progress and some problems of defining criteria and standards for human mechanical vibration and shock exposure. A bibliography and a list of pertinent standards cited is included.

BIODYNAMICS STANDARDIZATION ACTIVITY IN THE US

With the exception of military standards development, this currently falls within the purview of American National Standards Institute (ANSI) working group S3.39(S2) on human exposure to mechanical vibration and shock (impact), which is the accredited United States counterpart to ISO/TC 108/SC 4 on the same topic. The group has been responsible for the issuing of American National Standards on

* Member, ANSI S3.39(S2); Convenor, ISO/TC 108/SC 4/WG 1 (Biodynamic terminology); Member US TAG for ISO/TC 159 (Ergonomics).

the evaluation of human exposure to whole-body vibration and to hand-transmitted vibration; and on biodynamic terminology. Published standards and other information are available from the Acoustical Society of America Standards Secretariat in New York*; and reports of cognate standardization activity in the United States and at international level are reported periodically in the Journal of the Acoustical Society of America.

An important function of this and cognate working groups (often depending substantially on the initiative of the chair and individual expert members) is the maintenance of liaison with other national (including industrial) and international standards-writing groups whose fields inevitably overlap, in order to minimize the likelihood of duplication and conflict of standardization efforts. (In the area of biodynamics and biomechanical anthropometry, for example, the work of ISO/TC 108/SC 4 and its US counterpart overlaps with the activities of ISO TC's 22, on road vehicles; 43 on acoustics; and 159 on ergonomics)

US military standardization is the prerogative of the Department of Defense. The current status and activity in military standards development in such areas as human engineering design criteria (MIL-STD-1472 series, which includes biodynamics standards), anthropometry of military personnel, and human factors engineering at large, is described in DOD's Human Factors Standardization Document Program Plan (Revision 5, 28 August 1987).

INTERNATIONAL STANDARDIZATION ACTIVITY IN BIODYNAMICS

Through ANSI and its corresponding counterpart groups, the United States is a participating member of International Organization for Standardization (ISO) Technical Committee ISO/TC 108 on mechanical vibration and shock; and of TC 108's several subordinate groups, including Subcommittee ISO/TC 108/SC 4 on human exposure to mechanical vibration and shock. The technical work of ISO/TC 108/SC 4, which meets approximately annually, is carried out by six working or ad hoc groups, covering such areas as biodynamic terminology; human exposure to whole-body vibration; human exposure to hand-transmitted vibration; human exposure to impact; human exposure to repetitive shocks superimposed on vehicle ride vibration; and biodynamic modeling. Collectively, these groups have produced several ISO standards listed below; and are revising these as well as developing newly-proposed standards as ISO-approved or proposed work items within the subcommittee's scope. Historically, it has been a common practice for ANSI in the United States (and corresponding national standardization bodies in other member countries of ISO) to adopt or modify these standards as national standards.

* Inquiries and correspondence regarding ISO/TC 108 and counterpart US national standardization activity should be addressed to Dr F Avril Brenig, Standards Manager, Acoustical Society of America Standards Secretariat, 335 East 45th Street, New York, NY 10017.

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Current activity of ISO/TC 108/SC 4 includes the revision or new development of the following and other biodynamic standards. A comprehensive (although not exhaustive) listing of pertinent ISO standards is provided below.

International Standard ISO 2631 (revision)

International Standard ISO 2631, Guide to the evaluation of human exposure to whole-body vibration, was reissued in 1978 as an attempt to achieve international consensus regarding the measurement and evaluation of human exposure to whole-body vibration in the frequency range 1 to 80 Hz. ISO 2631-1974 had superseded a confusing multiplicity of guidelines, many based on meager, biased or unreliable data, that had been written in many different countries for particular industries or applications.

ISO 2631-1978 prescribed standard methods of measuring and evaluating human exposure to whole-body vibration disturbing or potentially harmful to man at work or in transportation; and provided guidelines for restricting human exposure to such vibration in the range 1 to 80 Hz. That band was selected having regard to several practical considerations, including current engineering applications; the feasibility and limitations of instrumentation for evaluating dynamic environments impinging on man; and the availability of substantial data concerning the human frequency-response to whole-body vibration and suitable for incorporation into a consensus standard. Several countries, including the United States*, have adopted national standards incorporating essentially the same guidelines.

The central concept and quantitative formulation embodied in ISO 2631-1978 was the "Fatigue/Decreased Proficiency [FDP] Boundary". This is an adjustable guideline (essentially a human frequency-response function based on laboratory data reflecting the principal human resonance characteristics and correlated discomfort or performance decrements) for limiting human exposure to whole-body vibrational accelerations in the spinal (z) and transverse (x, y) axes respectively.

An important tenetIt was that the standard should be most conservative (ie, the tolerable acceleration boundary for any given combination of frequency, exposure-time and direction should be lowest) in the frequency bands of the principal body resonance phenomena: for those biomechanical phenomena are strongly correlated with physiological stress, disruption of task-performance, and discomfort; and highly probably with chronic disorders of occupational origin associated with severe whole-body vibration exposure on a daily basis.

* American National Standard ANSI S3.18-1979 is based on the same data and essentially differs only editorially from the ISO standard. The basic human vibration frequency response function of ISO 2631-1978 is similarly enshrined in the pertinent section of MIL-STD-1472.

The criterion of application of the "FDP" boundary* is prevention of decrements in task-performance or disruption of human activity by whole-body vibration. The standard provided a guide to acceptable levels of rms acceleration at the point of input to man (typically his seat or the floor or deck on which he stands) as a function of vibration frequency and exposure time on a daily basis. The text of the standard, which must be carefully consulted in order to interpret or apply the numerical guidelines legitimately, contains instructions for weighting the tolerable acceleration values when other criteria (eg, occupational safety and health) apply; when the spectrum or level of vibration varies for different periods of time during the exposure being evaluated (or the vibration is interrupted during the exposure); or when a measured spectrum contains non-sinusoidal (ie, multiple frequency or broadly distributed) vibration.

It has been demonstrated experimentally that this standard is protective (perhaps overly so) of human performance of various tasks during z-axis sinusoidal vibration in the range 2 to 32 Hz for exposures up to 8 hours; and field data indicate that, in working and military vehicles, for example, the ride is judged by independent criteria to be unsatisfactory or marginally acceptable for operational purposes when the applicable guidelines of ISO 2631-1978 are substantially exceeded (at least, for short-term exposures).

Nevertheless, this standard as presently promulgated has been the focus of cogent and justifiable criticism on several grounds. For example, the acceleration-weighting procedure recommended for different criteria of application (eg, safe exposure; comfort) is based on the arguable assumption that there is a simple hierarchical relationship between vibration-induced discomfort, performance decrement and occupational health hazard; and the weighting procedure for exposure time was based on very meager data or theory concerning the time-dependence of human response to vibration (particularly when physiologically mediated effects on long-term performance and health are involved).

Moreover, the standard ignores demographic and other circumstantial factors that may strongly influence human response to vibration on a group or individual basis; and makes no statement regarding population percentiles supposedly at risk or to be protected from whole-body vibration nuisance or hazard.

* In many places (including some editions of the standard itself), this has been incorrectly printed as "Fatigue-decreased Proficiency" (whereas "Fatigue/[or] Decreased Proficiency" [ie, task-performance] were the terms originally intended by the framers of the standard). This perpetuates the fallacy that vibration-induced decrements in task-performance are universally due to fatigue, whereas common observation shows that cannot be the case where the exposure is brief and the disruption of performance clearly due to mechanical effects.

Accordingly, current work of ISO/TC 108/SC 4 is directed towards revision and elaboration of the standard; and also to extending its scope to frequencies below 1 Hz, which are particularly associated with motion sickness and gross disruption of locomotion and task-performance in ships, aerospace and land vehicles. Part of the intent of a standard such as ISO 2631-1978 and its revisions is to encourage the collective international acquisition of further and better field and experimental data which can be used to create improved predictive biodynamic models and, ultimately, a more realistic and practicable standard.

ISO 2631 continues under active revision with the intention of reissuing it in the form of several sections having specific applications. Some sections (see listing below) have already been issued by ISO as International Standards; while others are at the stage of draft.

Supplementary standards, some of which are also listed in the accompanying bibliography, have been issued or are being developed for special situations, such as fixed buildings and offshore structures, ships, rail transportation and so on; or to formalize predictive biodynamical models of human response to whole-body vibration within the stated range.

Draft International Standard ISO 8727

This draft standard on biodynamic coordinate systems is presently being circulated internationally for comment and vote. It represents the fruition of an effort originating in the United States to establish a reliable and rationally based hierarchical system of anatomical, instrumentation, and reference orthogonal coordinate systems for use in biodynamics research and applications, where there is a need precisely to define vibrational and impact force and motion inputs to man and his analogs; and to measure the distribution of inertial forces within the body.

Draft Proposal ISO 5805

This draft proposal on the terminology of mechanical vibration and shock affecting man is a revision (now being circulated internationally for comment and vote) of ISO 5805-1981, and is intended to supplement the main dynamical terminology, ISO 2041, Mechanical vibration and shock - Vocabulary.

Draft Proposal XXXX (ISO Work Item WI 01-93)

This draft proposal for a standard taxonomy of vibration- and motion-sensitive human activity and performance is a new proposal (now being circulated internationally for comment) intended to supplement ISO 2631 and to be of general value in providing a framework for describing and predicting the effects of force and motion on human actions and work.

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Draft Proposal XXXX (ISO Work Item WI 05-94)

This draft proposal on the standard combined model for whole-body impedance and transmissibility includes the revision of ISO 5982 and ISO 7962. It is currently being circulated internationally for comment. The model is intended to provide a standard basis for specifying and comparing inertial responses of man and human analogs to vibrational force and motion inputs.

Proposed ISO Work Item on Reference Postures

This new proposal on standard reference postures for describing force and motion inputs to man is under consideration by ISO for adoption either as a new work item or as an annex to an existing standard or proposal. It is intended to provide a standard basis for preventing or resolving ambiguity in defining human posture and orientation with respect to force and motion inputs.

COGNATE STANDARDS AND DRAFTS

International

- ISO 1503, Geometric orientations and directions of movement.
- ISO 2041, Mechanical vibration and shock - Vocabulary.
- ISO 2631, Guide to the evaluation of human exposure to whole-body vibration.
- ISO 4865, Analog analysis and presentation of vibration and shock data.
- ISO/DIS 5347, Methods for the calibration of vibration and shock pickups.
- ISO/DIS 5348, Mechanical mounting of accelerometers (seismic pickups).
- ISO/DIS 5349.2, Guidelines for the measurement and assessment of human exposure to hand-transmitted vibration.
- ISO 5353, Earth-moving machinery - Seat index point.
- ISO 5805, Mechanical vibration and shock affecting man - Vocabulary.
- ISO 5982, Mechanical driving-point impedance of the human body.
- ISO 6165, Earth-moving machinery - Basic types - Vocabulary.
- ISO 6897, Guide for the evaluation of the response of occupants of fixed structures, especially buildings and off-shore structures, to low-frequency horizontal motion (0,063 to 1 Hz).
- ISO 7096, Earth-moving machinery - Operator seat - Transmitted vibration.
- ISO/DIS 7962, Vibration and shock - Mechanical transmissibility of the human body.
- ISO/DIS 8041, Human response vibration measuring instrumentation.
- ISO 8661, Pt 1, Measurement of vibrations in hand-held power-driven tools - Part 1: General.
- ISO 8661, Pt 2, Hand-held power-driven tools - Measurement of vibrations - Part 2 (Chipping hammers).
- ISO/DIS 8727, Standard biodynamic coordinate systems.
- ISO/DP XXXX, Standard taxonomy of motion- and vibration-sensitive human activity and performance.
- ISO/TC 108/SC4/WG1 N 77, Draft standard reference postures for description of human exposure to mechanical vibration and shock.

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Key to Abbreviations and Notes:

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| ISO | International Organization for Standardization |
| ISO/DIS | Draft International Standard |
| ISO/DP | Draft Proposal |
| ISO/TC.../SC | ISO Subcommittee |
| ISO/TC | ISO Technical Committee |
| WG | Working Group |
| XXXX | ISO/WG document not yet assigned a draft number. |

- * These references supersede most of those included in the course notes, except for ISO 1503, 2041, and ISO 2631-1978, which (while currently under revision within ISO) is still the prevailing standard.
- ** Mostly prepared and issued by ISO Technical Committee 108 - Mechanical Vibration & Shock; but some by ISO/TC 127 and others.

US National

ANSI S3.18-1979. Guide for the evaluation of human exposure to whole-body vibration [follows closely the guidelines in ISO 2631-1978, as does the relevant section of MIL-STD-1472]. Also identified as ASA 38-1979. Available from the Standards Secretariat, Acoustical Society of America, 335 E 45th St, New York, NY 10017-3483.

[Note: other ISO standards in the biodynamics field have been or may be adopted for consideration as bases for the formulation of counterpart American National Standards.]

ISO PUBLICATIONS ON STANDARDS WRITING AND ADMINISTRATION

[Note: these publications are issued by the ISO Central Secretariat in Geneva, Switzerland. In the United States they are obtainable through ANSI.]

- ISO Catalogue [of technical committees and standards], 1987 (issued annually).
- ISO Directives for the technical work of ISO, 1985 (reissued periodically).
- ISO Rules for the drafting and presentation of international standards, 1986.

BIBLIOGRAPHY: SUGGESTIONS FOR FURTHER READING ON HUMAN EXPOSURE TO VIBRATION

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DISCUSSION

PAPER: Current ANSI and ISO activity in Biodynamics
Standards Development

SPEAKER: J. Guignard, G. B. Associates

No questions.

DISCUSSION

1. The current study and its contribution to the field of
developmental psychology

2. The study of the relationship between
developmental psychology and other fields

3. The study of the relationship between
developmental psychology and other fields