IS A STANDARD OPTIONAL? - follow the pathway.

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1 Introduction

Is a **S**tandard **O**ptional? Well that may very much depend on the standard. Follow the pathway towards BS 6472, the guide to the evaluation of human exposure to vibration in buildings. Many standards covering human response to vibration need to be considered, in fact many are **ISO** standards.

The International Organisation for Standardisation (ISO) is a worldwide legal federation of national standards bodies. An International Standard (IS) embodies the essential principles of global openness and transparency, consensus and technical coherence. The publication as an IS requires approval by at least 75 % of the member bodies casting a vote. All standards are reviewed every 5 years and either approved or a revision is recommended.

In fact ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardisation.

ISO also collaborates closely with the European Committee for Standardisation (CEN), the member countries of which are bound to comply with European Internal Regulations, to generate standards within the European Community. Where such a common international standard is required a joint CEN/ISO working group can be ISO or CEN lead.

Within ISO there are also Technical Specifications (ISO/TS), Public Available Specifications (ISO/PAS) and Technical Report (ISO/TR), which represent lower levels of consensus and specification and therefore do not have the same status as an International Standard.

2 Mechanical vibration and shock

The scope of the work undertaken by the Technical Committee ISO/TC 108, *Mechanical vibration and shock*, covers the broad area of mechanical vibration and shock and their effects on humans, machines, vehicles and structures.

More specifically ISO/TC 108 produces documents pertaining to terminology and nomenclature, calibration of transducers, measurement and analysis instrumentation, including signal processing methods, and the assessment of their effects. Of particular interest for today's meeting are the subcommittees ISO/TC 108/SC 3 covers the *Use and calibration of vibration and shock measuring instruments* and ISO/ TC 108/SC 4 covers *Human exposure to mechanical vibration and shock*.

The UK national body is the British Standards Institute (BSI). The General Mechanical Engineering committees (GME's) of BSI have Technical Committee GME/21 covering *Mechanical vibration, shock and condition monitoring*. Subcommittee GME/21/2 covers *Vibration and shock measuring instruments and testing equipment* and subcommittee GME/21/6 covers *Human exposure to mechanical vibration and shock*.

3 Human exposure to whole-body vibration

To evaluate human whole-body vibration the International Standard ISO 2631-1:1997, *Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – General requirements*, defines methods of quantification. It is applicable to motions transmitted to the human body as a whole through the supporting surfaces: the feet of a standing person, the buttocks, back and feet of a seated person or the supporting area of a recumbent person. This type of vibration is found in vehicles, in machinery, in buildings and in the vicinity of working machinery.

Two specific areas of human exposure to vibration, namely rail transport and in buildings, have given rise to additional parts to ISO 2631. These are ISO 2631-4:2001, *Guidelines for the evaluation of the effects of vibration and rotational motion on passengers and crew comfort in fixed-guideway transport systems* and ISO 2631-2:2002, *Vibration in buildings (1 Hz to 80 Hz)*.

The transmitted vibration motion is frequency weighted as well as band limited to attenuate frequencies outside the nominal frequency range. The nominal frequency range in ISO 2631-1 and ISO 2631-4 is 0.5 Hz to 80 Hz for health, comfort and perception and in ISO 2631-1 it is 0.1 Hz to 0.5 Hz for motion sickness.

The recommended frequency weighting curves for evaluation with respect to health, comfort and perception are tabulated below.

ISO 2631	Freqency weighting	Health	Comfort	Perception
Part 1	W_k	z-axis, seat surface	z-axis, seat surface z-axis, standing x-, y-, z-axes, feet (sitting) vertical recumbent	z-axis, seat surface z-axis, standing vertical recumbent
Part 1	W_d	x-axis, seat surface y-axis, seat surface	x-axis, seat surface y-axis, seat surface x-, y-axes, standing y-, z-axes seat-back horizontal recumbent	x-axis, seat surface y-axis, seat surface x-, y-axes, standing horizontal recumbent
Part 4	W_b		x-, y-, z-axes, feet (sitting) x-, y-, z-axes, feet (standing) x-, y-, z-axes, seat surface x-, y-, z-axes, seat-back x-, y-, z-axes, recumbent	

Table 1. Guidance for the application of weightings in ISO 2631 parts 1 and 4.

The ISO standard for human responses to buildings vibrations, ISO 2631-2:2002, uses the weighting W_m, formally designated W.B.combined. The same weighting is applicable for undefined posture. As far as the UK was concerned this standard contained insufficient information to allow the proper evaluation of human comfort or annoyance and the posture was relevant.

A British Standard, BS 6472:1992, *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)* to meet the shortcomings of ISO 2631-2:1989 was issued. BS 6472:1992 distinguished between the three axes of vibration, to evaluate the human response, using the weightings specified in BS 6841:1987, *Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*.

BS 6841 introduced vibration dose value for assessing repeated shocks and intermittent vibrations.

In BS 6472:1992 it states that the performance characteristics for appropriate instrumentation, for measuring acceleration, can be obtained in BS 6841:1987 and BS 7482:1991 Parts 1 and 3.

The main standards to meet BS 6472:1992 are BS 7482-1:1991, *Instrumentation for the measurement of vibration exposure of human beings – Part 1. Specification for general requirements for instrumentation for measuring the vibration applied to human beings* and BS 7482-3:1991, *Instrumentation for the measurement of vibration exposure of human beings – Part 3. Specification for instrumentation for measuring vibration exposure to the whole body.*

4 Whole-body vibration instrumentation

BS 6472:1992 specifies that the appropriate measuring instrument for whole-body vibration has to meet the performance characteristics in BS 7482-3:1992. BS 6472:1992 states that for evaluating building vibrations with respect to annoyance and comfort the overall weighted values are preferred. The preferred assessment should be on the basis of vibration dose value (VDV), not the estimated vibration dose value (eVDV) from the rms value.

It is interesting that in BS 6841:1987, for evaluating vibration and repeated shocks, there is a note that the phase characteristics of frequency weightings may affect the crest factors. Where VDV is calculated any phase errors in the implementation of the weighting can give rise to errors, especially with impulsive vibrations.

Progress in specifying measuring instrumentation to include a hierarchy of testing requirements, comprising pattern evaluation, periodic verification and in-situ checks, are recent changes. Also there is the need to allow for uncertainties in the testing of instruments. Advances in electronics have lead to improvements in specifications.

To meet these changes to ISO 8041:1990 a joint working group from ISO and CEN was set up, and led by ISO, to completely technically revise the International Standard. BS EN ISO 8041:2005, *Human response to vibration – Measuring instrumentation* was issued to replace the 1990 edition, incorporating the 1999 amendment and 1993 corrigendum.

5 BS EN ISO 8041:2005

The biggest technical change was to improve the specification to human response to vibration measurement, incorporating allowances for uncertainty in test procedures, to have only one class of instrument and specify a vibration field calibrator. Electrical tests were expanded to include phase as well as magnitude and the linear operating range to be at least 60 dB. Mechanical vibration tests to include the transducer are now incorporated such that the complete meter is tested.

The signal burst response testing now uses a saw-tooth signal, replacing earlier sinusoidal signals, to ensure that the signal burst contains combinations of frequencies with known phase relationships. This testing is important where phase errors in weightings give rise to errors on peak and VDV measurements.

Advances in Transducer Calibration, with the issuing of the ISO 16063 series of standards replacing the ISO 5347 series, have improved the methods in use and reduced uncertainties. The mechanical vibration testing of the vibration instrument requires the transducer to be mounted for calibration in accordance with ISO 16063-21:2003, *Methods for the calibration of vibration and shock transducers – Part 21: Secondary vibration calibration by comparison to a reference transducer*.

The specification for a vibration field calibrator, Annex A (normative) gives the preferred values for whole-body calibration as 1 m/s^2 ± 3 % at 15.915 Hz ± 0.5%.

6 TRANSDUCERS AND MOUNTING

In BS EN ISO 8041:2005 Annex E (informative), Table E1 specifies the transducer, for whole-body vibration in buildings, as having the maximum total size comprising transducers and mounting system as 200 x 200 mm and 50 mm height with a maximum total mass of 1 kg. It should be noted that where a transducer is located on a lightly loaded floor an additional mass may need to be added.

For whole-body vibration on seats the transducer is specified in ISO 10326-1:1992, *Mechanical vibration – Laboratory method for evaluating vehicle seat vibration – Part 1: Basic requirements.* This transducer is often supplied with an instrument for measuring whole-body vibration. Care needs to be taken to ensure any piezoelectric transducer is compatable with the measuring instrument especially with respect to the $^1/_f$ response, typically 2.5 % per decade.

The Transducer calibration series ISO 16063 has a number of parts with Primary Calibrations as Parts 1X, Secondary Calibrations as Parts 2X, Transducer tests as Parts 3X and other vibration devices as Parts 4X.

Guidelines for transducer mounting are contained in BS ISO 5348:1998 *Mechanical vibration and shock – Mechanical mounting of accelerometers.*

7 Conclusion

There are a large number of International Standards that relate to human whole-body vibration, many of which have been issued in recent years.

To fulfil any assessment of vibration and shock, the measurement of the mechanical vibration has to follow a pathway from transducer input to instrument display. Human response to vibration and shock for whole-body vibration in buildings is no different to any measurement or analysis.

Follow the pathway, in terms of standards, means retraceable or better still traceability. The way to have traceability is to apply standards that will provide an unbroken link from the displayed measurement to the physical input. In the case of human exposure to whole-body vibrations in buildings, to comply with BS 6472, the traceability starts with BS ISO 16063-11:1999 and ends with BS EN ISO 8041:2005.

8 Standards

To meet the traceability from the rectilinear vibration of a floor to assessing the human response for comfort or annoyance the following International Standards need to be used in conjunction with the revised BS 6472-1.

BS ISO 16063-11:1999, Methods for the calibration of vibration and shock transducers – Part 11: Primary vibration calibration by laser interferometry.
BS ISO 16063-21:2003, Methods for the calibration of vibration and shock transducers – Part 21: Secondary vibration calibration by comparison to a reference transducer.
ISO 2631-1:1997, Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration - Part 1: General requirements
BS ISO 2631-4:2001, Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 4: Guidelines for the evaluation of the effects of vibration and rotational motion on passenger and crew comfort in fixed-guideway transport systems.
BS EN ISO 8041:2005, Human response to vibration – Measuring instrumentation.