Rob Brauch
Casella CEL, Inc.

Involved in the design and manufacture of advanced instrumentation for Industrial Hygiene applications since 1978.

Member of the American Industrial Hygiene Association and served as Chair of Noise Committee.

Presented and co-moderated the Noise Section of the NIOSH DREAM (Direct Reading Exposure Assessment Methods) Workshop in Arlington, VA.

Formal Survey:

69.5% self report “less than basic” understanding of WBV...

Numbers affected - UK survey

RESULTS: From the 12,907 responses it was estimated that 7.2 million men and 1.0 million women in Great Britain are exposed to vibration at work in occupations in which the vibration is predominantly transmitted to the upper limb (hand and arm). The occupations in which the estimated exposures most often exceeded 15 ms

The eVDV of > 374,000 men and 9000 women was estimated to exceed a proposed British Standard action level of 15 ms

Occupations in which the estimated exposures most often exceeded 15 ms

The highest estimated median occupational eVDVs were found in forklift truck drivers, drivers of road goods vehicles, bus and coach drivers, and technical and wholesale sales representatives, among whom a greater contribution to total dose was received from occupational exposures than from non-occupational ones, but in many other occupations the reverse applied.

Litigation and Compensation


THOMPSONS’ CASES Whole body vibration syndrome

Those of us who have heard of the phrase “whole body vibration syndrome” will be pleased to know that we have recently recovered compensation in such a case. The claim was brought by a worker of the MoD who worked in a tank driving school for over 10 years. The claim was for vibration induced deafness, as a result of his exposure to whole body vibration. We obtained medical evidence that the vibration had caused a pre-existing back condition. The employer denied liability but eventually settled, the damages being paid both by Jarvis the defendants in respect of their post privatisation period of employment, and on behalf of British Rail to cover the earlier years. The settlement was for £3,000 on a compromise basis.

In the US, approximately 8 million workers are exposed to vibration in the workplace; nearly 7 million are exposed to WBV...

In addition to lost income you will likely incur medical expenses, travel expenses to your hospital and GP and perhaps need family or friends to help you in the home (a rate can be charged for this).

2. Pain and Suffering

Every type of injury, including HAVS, will cause you pain and suffering for which you are entitled to receive compensation. The amount of compensation you can claim will depend on the severity and duration of your symptoms.

3. Legal Costs

So long as your claim for pain and suffering is over £1,000 - you are entitled to claim your legal costs in pursuing a claim. This sum will be paid direct to your solicitor and strictly speaking is not called compensation, but is known as legal costs.

Examples of how much your Hand Arm Vibration claim is worth

The amounts of compensation you are entitled to for Hand Arm Vibration, Vibration White Finger or Reynaud’s Syndrome is very similar and some examples for a claim settling in 2010, include:

1. Hand arm vibration affecting the fingers

If your vibration white finger affects one or more fingers, but does not cause a disability which will affect the use of the whole of your hand you can expect a hand arm vibration claim settlement of between:

£2,000 - £11,000

2. Disability to one or both hands

If your Reynaud’s Syndrome causes disability to one or both hands, such that it hampers your ability to use your hands you could expect compensation amounts of:

£11,000 - £25,000
Litigation and Compensation

Vibration and Finger Syndrome: VWF or dead finger refers to Reynaud’s Syndrome when it only affects the fingers and thumb on the hand. If one of these disorders was brought on from the excessive continuous use of vibrating machines at the workplace - it is known as an industrial disease.

What type of compensation will form part of your hand-arm vibration claim?

There are three main types of compensation that can form part of your hand-arm vibration claim, which include:

1. Health Effects
2. Material Effects
3. Time to injury presentation (HAV)

Health Effects of Chronic Vibration

Low back pain / M/E/D's (NIOSH 1998)
Neck-shoulder disorders
Digestive and Circulatory disorders
Cochleo-vestibular
Reproductive effects

Health Effects of Chronic Vibration

Low back pain / M/E/D's
Neck-shoulder disorders
Digestive and Circulatory disorders
Cochleo-vestibular effects
Reproductive effects

Whole Body Vibration

Health Effects

Material Effects

“Vibration is of major mechanical significance because it affects the duration of a material's fatigue life. Fatigue, which is defined as a loss of strength due to intermittent stresses over time, can lead to material failure as a result of stresses which are small in comparison to those required for a static stress failure.”

Time to injury presentation (HAV)

Ancestral S/N: 2006 and ISO 5349

DELV

DELV
Biomechanics and metabolic effect

It was found that there is a greater increase in oxygen uptake with combined rotation and vibration. In the industrial environment, especially those with awkward postures, vibration will lead to muscular fatigue and to increased metabolic cost.

Health Effects:

Whole-body vibration (WBV) is a type of biomechanical exposure and can be a factor in the development of health problems. It involves vibrations transmitted to the body through the lower limbs, which can cause changes in the musculoskeletal system, including the muscles, joints, and the cardiovascular system. Exposure to whole-body vibration for long periods can lead to health issues such as musculoskeletal disorders, cardiovascular problems, and neurological effects. The effects of WBV can vary depending on the frequency, amplitude, and duration of the vibration exposure.

Biodynamic Modeling

The image shows a diagram related to biodynamic modeling, which is the study of the dynamic behavior of the human body in response to external forces. This includes understanding how the body responds to vibrations and how these responses can affect overall health.

Animal Research

Animal studies have been conducted to investigate the effects of whole-body vibration on the body. These studies often focus on the effects on the musculoskeletal system, including changes in muscle structure and function. The figure shows a graph depicting the relationship between disk pressure and frequency, which is relevant to understanding the effects of vibrations on the musculoskeletal system.

Whole-body Vibration - Dr. Griffin

Dr. Griffin's presentation discusses the implications of whole-body vibration on health. The slides highlight the need for further research to understand the effects of vibration on the body, particularly in the context of occupational exposure.

Misinformation abounds!

The term WBV is often associated with both positive and negative effects on health. The presentation by Dr. Griffin challenges the notion that WBV is uniformly harmful or beneficial, emphasizing the need for more comprehensive research to establish definitive conclusions.
Human Vibration Roadmap

Other Relevant Standards:
- ISO 8041:2005 Measuring instrumentation (performance specification)
- ISO 5982:2001 Mechanical vibration and shock -- Range of idealized values to characterize seated-body biodynamic response under vertical vibration

Measurement Standards and Regulatory Guidelines
- Example - WB Exposure Limit Values:
  EU Directive = ACGIH TLV

Whole Body Vibration

MEASUREMENT STANDARDS

Measurement Standards and Regulatory Guidelines / Directives
Most often, similar recommendations are referenced in both - but not always!

ISO 2631 (1997)
Mechanical vibration and shock -- Evaluation of human exposure to whole-body vibration
  Part 1: General requirements
  Part 2: Vibration in Buildings
  Part 5: Method for Evaluation of Vibration Containing Multiple Shocks
  ANSI S.18 (1979, R2002)
  Guide for the evaluation of Human Exposure to Whole Body Vibration

List of Relevant Standards
- ISO 2631 (Parts 1-5)
  Mechanical Vibration and Shock: Evaluation of Human Exposure
- BS 6841:1987
  Guide to measurement and evaluation of human exposure to whole-body mechanical vibration and shock
- ANSI S.18:2002
  (adoption of ISO 2631)

Measurement Standards and Regulatory Guidelines
Example - Hand Arm Exposure Limit Values:
ISO 5349 = ANSI S.2.70
ISO 5349 = EU Directive
Therefore:
ANSI S.2.70 = EU Directive

ISO Standards - WBV

ISO 2631-2:2003
Mechanical vibration and shock -- Evaluation of human exposure to whole-body vibration -- Part 2: Vibration in buildings (1 Hz to 80 Hz)

ISO Standards - WBV

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

ANSI S 3.18 (2002)

With respect to section 7.11(b), Appendix B of ANSI S 3.18-2002/ISO 2631-1:1997, Mechanical Vibration and Shock -- Evaluation of Human Exposure to Whole-Body Vibration, addresses the health effects of vibration on the human body and defines a "health caution guidance zone" for daily exposures of 4 to 8 hours, as follows:

Within the zone - caution is indicated with respect to potential risks for adverse health effects

Above the zone - adverse health risks are likely

Below the zone - adverse health effects have not been clearly documented and/or objectively observed

ANSI S 3.18 (2002)

Daily Exposure Duration Volume of the dominant, frequency-weighted (rms) component acceleration, m/s²

No clear effects Caution Health risks likely

4 hours Less than 0.6 0.6 to 1.1 Greater than 1.1

8 hours Less than 0.5 0.5 to 0.9 Greater than 0.9

ANSI S 3.18 (2002)

ISO Standards - WBV

ISO 5982

Overview of ISO 2631

Whole Body Vibration - ISO 2631

- The exposure limit
- This is used to assess the maximum possible exposure allowed for whole-body vibration.
- Also, "severe discomfort boundaries" for 8-hour, 1-hour and 30-minute WBV exposures in the 0.1 Hz to 0.63 Hz range are given.
- Exposure limits are given as acceleration for one third octave band frequencies and three directions of exposure:
**Whole Body Vibration**

**VIBRATION FUNDAMENTALS**

**The Nature of Vibration**

Vibration can be described as the periodic movement (acceleration +/-) of an object in relation to its original resting point, i.e., a motion which starts in one spot and moves back and forth.

**Types of Vibration**

**Free Vibration** occurs when a mechanical system is set off with an initial input and then allowed to vibrate freely. Examples include pulling a child back on a swing and letting go, or hitting a tuning fork and letting it ring. The system will vibrate at one or more of its "natural frequencies" and damp down to zero.

**Forced Vibration** occurs when an alternating force or motion is applied to a mechanical system. Examples include an unbalanced machine, whose vibration can be felt during an earthquake. In forced vibration, the frequency of the vibration is a combination of the force modified by the resonance of the mechanical system.

**The Nature of Vibration**

They may be impulsive such as those from a power boat hitting waves.

**Acceleration Units of Measurement**

\[ g : \text{a unit equal to that produced by Earth’s gravity on a free-falling object} \]

\[ 1g = 9.807 \text{ m/s}^2 \]

**Acceleration Levels Quantified**

Direction, Amplitude, Frequency

Direction of motion: x, y, z
Quantifying Acceleration Levels

The Nature of Vibration RESONANCE

Human Body: Resonant Frequencies

Every object (or mass) has a resonant frequency.
- When an object is vibrated at its resonant frequency, the maximum amplitude of its vibration will be greater than the original amplitude (i.e., the vibration is amplified).
- Vibrations in the frequency range of 0.5 Hz to 80 Hz have significant effects on the human body.
- Individual body members and organs have their own resonant frequencies and do not vibrate as a single mass, with its own natural frequency. This causes amplification or attenuation of input vibrations by certain parts of the body due to their own resonant frequencies.

Frequency Bands (Octave, 1/3 Oct)

Resonance in Action

Human Body: Resonant Frequencies

- The most effective resonant frequencies for vertical vibration lie between 4 and 8 Hz.
- Vibrations between 2.5 and 5 Hz generate strong resonance in the vertebrae of the neck and lumbar region with amplification of up to 240%.
- Vibrations between 4 and 6 Hz set up resonances in the trunk with amplification of up to 200%.
- Vibrations between 20 and 30 Hz set up the strongest resonance between the head and shoulders with amplification of up to 350%.
- Whole body vibration may create chronic stresses and sometimes even permanent damage to the affected organs or body parts.

Vibration RESONANCE

Human Body: Resonant Frequencies

Body Resonance Modeling
Types of Accelerometers

How Accelerometers work

Regulations + Compliance varies

STANDARDS, GUIDELINES, REGULATIONS

Measurement Standards: WBV

Standards, Directives & Guidelines

Measurement Standards: WBV

Exposure Related:
ISO 2631
Mechanical vibration and shock -- Evaluation of human exposure to whole-body vibration
• Part 1: General requirements - ANNEX & “Guide to the effects of Vibration on Health”
• Part 2: Vibration in Buildings
• Part 5: Method for Evaluation of Vibration Containing Multiple Shocks
ANSI S3.18 (1979)
Guide for the evaluation of Human Exposure to Whole Body Vibration

Types of Accelerometers

Whole Body Vibration

MEASUREMENT STANDARDS

• Measurement Standards
Typically define HOW the measurement should be performed; define the methods to be used and metrics that result

• Regulatory Compliance Directives/Guidelines
Define responsibilities of employers and workers for ensuring a safe workplace
Recognize and reference accepted action levels and exposure limits

OSHA General Duty Clause

Recommended ACGIH’s TUV’s

often used in United States

Exposure Directive
Machinery Directive

enforced in European Union:
What the Standards Provide

A way to perform repeatable measurements with acceptable levels of uncertainty

- Measuring equipment for vibration exposure
- Frequency-weighting filter characteristics
- Location and orientation of sensor(s)
- Mounting of sensors
- Quantity to be measured
- Information to be reported

They may also give you:

- Relationship between vibration exposure and effects on health
- Other guidance regarding health effects of vibration
- Technical Requirements of the measurement systems

Measurement Standards provide

Terms / Definitions / Conventions

The purpose of this part of ISO 2631 is to define a method of quantifying whole-body vibration in order to assess its health effect. Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

They also may give you:

- Relationship between vibration exposure and effects on health
- Other guidance regarding health effects of vibration

Integration and Characterization of Vibration Exposure

The purpose of this part of ISO 2631 is to define a method of quantifying whole-body vibration containing multiple shocks. Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

Measurement Standards provide

Integration and Characterization of Vibration Exposure: WB Scaling Factor

The frequency weightings shall be applied for seated persons as follows with the multiplying factors k as indicated:

\[
\begin{align*}
\text{x-axis:} & \quad (w_d, \text{Freq}), k = 1.4 \\
\text{y-axis:} & \quad w_d, k = 1.4 \\
\text{z-axis:} & \quad w_k, k = 1
\end{align*}
\]

Standards also provide

Methods and techniques for accurate and repeatable exposure assessment in the field

Standards also illustrate

Equipment specification for accurate and repeatable exposure assessment in the field

Standards also offer

Application-specific performance requirements

Standards also define

Annex C

Instrument documentation

6.1 General Information

a) Reference to the International Standard:

The purpose of this part of ISO 2631 is to define a method of quantifying whole-body vibration in order to assess its health effect. Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

b) Date of publication:

Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

6.2 Design features

a) Description of the instrument to be used for the measurement of whole-body vibration:

Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

b) Description of the equipment used for the measurement of whole-body vibration:

Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

6.3 Operational instructions

a) Description of the operational instructions:

Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

b) Description of the operational instructions for the measurement of whole-body vibration:

Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.

6.4 Other information

a) Description of the other information:

Whole-body vibration is a movement of the human body that can be caused by a variety of factors. It is usually caused by mechanical vibrations that result in whole-body movement. The energy associated with this movement is transferred to the body through the musculoskeletal system. Whole-body vibration can cause various health effects, such as discomfort, fatigue, and even serious health problems. The ISO 2631 standard provides a method for quantifying whole-body vibration and assessing its health effect.
Standards also provide
Methods and techniques
Transducers shall be located so as to indicate the vibration at the interface between the human body and the source of its vibration.

Vibration which is transmitted to the body shall be measured on the surface between the body and that surface.

Figure B.6(c) — Magnitude of frequency weighting \(W\) for hand-arm vibration, all directions, stationary or moving part

Figure B.6(d) — Magnitude of frequency weighting \(W\) for whole-body vibration, a worker seated, standing or unmounted part

Exposure limits
EU Directive 2002/44/EC

Exposure limit values and action values

(a) the daily exposure limit value standardized to an eight-hour reference period shall be \(1.15 \, \text{m/s}^2\) (SDLV) or, at the choice of the Member State concerned, a vibration dose value (VDV) of \(21 \, \text{m/s}^2\)

(b) the daily exposure action value standardized to an eight-hour reference period shall be \(0.5 \, \text{m/s}^2\) (SDAV) or, at the choice of the Member State concerned, a vibration dose value of \(9.1 \, \text{m/s}^2\)

Workers’ exposure to whole-body vibration shall be assessed or measured on the basis of the provisions of Point 1 of Part B of the Annex.
ISO 2631 DEAV and DELV
DEAV: 0.5 m/s² average level for 8h - any axis
DELV: 1.15 m/s² average level for 8h
VDV: measure of impulse + shock
9.1 and 21 m/s¹.⁷⁵ (DEAV/DELV)

The truth about Vibration exposure measurement
There are differences between recommended exposure limit values, even between measurement standards and regulatory guideline and directives
Focus has been on using a single (HA) or dual (WB) ‘broadband’ weighting curve(s)

Whole Body Vibration
REGULATORY GUIDELINES

ACGIH TLV
ACGIH:
Frequency values in 1/3 octave bands - to be integrated for frequency weighted acceleration value
Values for X,Y, are scaled at 1.4 amplitude; z at 'face value'. Acceleration values are integrated for a resultant rms value of vibration level.
2009: Refers to EU 0.5 m/s² action level
If ratio of peak to rms level >6:1, then use ⁴th power integration

WB weighting curves

Why Spectral Data is Important:
Many factors contribute to the effects of vibration on humans, including the characteristics of the motion and the exposed individual, the activities of the exposed individual, and various elements of the environment.

Why Signal Capture is Important:

Health Guidance Caution Zone
Vibration Exposure Directives

ACGIH TLV and EU DELV
ACGIH:
Refers to EU .5 m/s² action level only; weighted and scaled integrated rms of all three axes.
If crest factor above 6:1, use 4th power.

EU DELV:
1.15 m/s² on any of the three axes (x,y,z)
X,Y Axes are scaled to 1.4
If crest factor >9:1, then use VDV.

Employer Obligations
"...the employer shall assess and, if necessary, measure the levels of mechanical vibration to which workers are exposed."

1. Estimate, using Manufacturer’s supplied (or other) vibration level data.
2. Measure the Vibration level as the work is performed.

Allowable Exposure Limit

Whole Body Vibration

Equipment Manufacturers Directives
DIRECTIVE 2006/42/EC
OF THE EUROPEAN PARLIAMENT

Vibration levels must be disclosed by Manufacturers.
Manufacturers' Requirements

Vibration

Machinery must be designed and constructed in such a way that risks resulting from vibrations produced by the machinery are reduced to the lowest level, taking account of technical progress and the availability of means of reducing vibrations, in particular at source.

The level of vibration emission may be assessed with reference to comparative emission data for similar machinery.

New Equipment Requirements

Seating

Where appropriate and where the working conditions so permit, work stations constituting an integral part of the machinery must be designed for the installation of seats.

If the operator is intended to sit during operation and the operating position is an integral part of the machinery, the seat must be provided with the machinery.

The operator’s seat must enable him to maintain a stable position.

Furthermore, the seat and its distance from the control devices must be capable of being adapted to the operator.

If the machinery is subject to vibrations, the seat must be designed and constructed in such a way as to reduce the vibrations transmitted to the operator to the lowest level that is reasonably possible.

Where there is no floor beneath the feet of the operator, footrests covered with a slip-resistant material must be provided.

Manufacturers' disclosure

3.6.3.1. Vibrations

— the highest root mean square value of weighted acceleration to which the whole body is subjected, if it exceeds 0.5 m/s². Where this value does not exceed 0.5 m/s², this must be mentioned — the uncertainty of measurement

These values must be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced.

Risk Assessment

The risk assessment should:

- Identify where there may be a health or safety risk for which whole-body vibration is either the cause or a contributory factor;
- Estimate workers' exposures and compare them with the exposure action value and exposure limit value;
- Identify the available risk controls;
- Identify the steps you plan to take to control and monitor whole-body vibration risks; and
- Record the assessment, the steps that have been taken and their effectiveness.

Building an Exposure Model

T-Beam: Task Based Exposure Assessment Method

Variables such as 'seat time', and can include complex variations of:
- Operator Technique (speed, aggressiveness)
- Vehicle Condition (tire pressure, balance)
- Surfaces encountered (Gravel vs. Asphalt)

Estimating Duration and Level

Observe / record the duration of exposure, considering continuous vs. intermittent operation

Obtain representative data of vibration levels:
- Manufacturer's supplied data (Relatively high uncertainty)
- Other representative data

Other data: WB Vibration levels

Reference Condition Testing (EN)

NEW equipment, CONTROLLED conditions

Whole Body Vibration

RISK ASSESSMENT

Estimating Duration and Level

Observe / record the duration of exposure, considering continuous vs. intermittent operation

Obtain representative data of vibration levels:
- Manufacturer's supplied data (Relatively high uncertainty)
- Other representative data

Other data: WB Vibration levels
Some Vehicle Data - WBV

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Model</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford Taurus</td>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>Jeep Cherokee Sport</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Toyota Tundra SR5</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>Ford F-250</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>Harley-Davidson Electra Glide Classic</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Yamaha Kodiak 400-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ski-Doo Challenger 21 Montique</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All vehicles were tested with their standard factory-installed seats and were operated under a range of normal operating conditions and speeds typical of intended vehicle use.

Other Sources of Level Data

- Other Sources of Level Data
  - MINISTERY OF DEFENSE
    - Electronic Systems Test
  - VEHICLE IMPACT
  - MINISTRY OF TRANSPORTATION
    - Train Irritation Level
      - Seating
      - Standing
    - Railroad Vibration
  - AGRICULTURE
    - Tractor Level
  - ENERGY
    - Power Plant
  - RECREATION
    - Recreational Vibration
  - HEAT PLANT
    - Steam Plant
  - HEARING PROTECTION
    - Hearing Protection
  - MANUAL WORK
    - Hand-arm Vibration
  - BASIC VIBRATION
    - Basic Vibration

The HSE Points System

- Tool for Assembling Exposure Models
  - Exposure model
  - Measurement Terminology

Whole Body Vibration

EXPOSURE MEASUREMENT

EXPOSURE MEASUREMENT

Measurement Terminology

- MTAV: Maximum value for the mobile RMS acceleration
- Time constant: used for the calculation of mobile RMS acceleration
- Vi: Vibration dose in m/s
- v: Overall whole-body vibration acceleration
- aequ: Overall whole-body vibration acceleration
- Aeq: Daily exposure value
- SEAT: Seat efficiency factor
- fc: Peak factor at the band limit
- fwc: Frequency-weighted peak factor
- Overall results: Results calculated over the entire period (v, aequ, Aeq, ...).
Formulae

\[ a_{\text{rms}} = \text{frequency-weighted RMS acceleration (Wk, Wh filters)} \text{ in m/s}^2 \]

\[ a_{\text{rms}} = \frac{1}{T} \int_{0}^{T} a(t)^2 \, dt \]

with\[ a(t) \text{ instant acceleration} \]
\[ T \text{ measurement duration} \]

\[ a_{\text{rms}} = \sqrt{\frac{\int_{0}^{T} a(t)^2 \, dt}{T}} \]

\[ a_{\text{rms}} = \text{integral RMS acceleration} \]
\[ a_{\text{rms}} = \text{total RMS acceleration} \]

Typical system specifications:

Various instrument systems provide different levels and detail of data recording and reporting.

**Vocabulary**

- **a**: Band limit frequency-weighted RMS acceleration in m/s²
- **ax**, **ay**, **az**: Band limit frequency-weighted RMS acceleration in m/s²
- **awx**, **awy**, **awz**: Frequency-weighted RMS acceleration (Wk, Wh filters) in m/s²

**Filters**

- **Wh**: Filter for hand-arm measurements (valid for all 3 axes)
- **Wd**: Filter for whole-body measurements (x and y axes)
- **Wk**: Filter for whole-body measurements (z axis)

Overall Data

Time Domain data

Signal capture on exceedance

Prevention

Group: Management
- Seek technical advice
- Seek medical advice
- Warn exposed persons
- Review exposure times
- Provide guidance on machine maintenance

Group: Machine manufacturers
- Design to minimize whole-body vibration
- Provide guidance on machine maintenance
- Provide warning of dangerous vibrations

Group: Exposed persons
- Use machines properly
- Adapt workstations to fit
- Use anti-vibration footrests
- Use vibration-damping products
- Seek medical advice if symptoms appear
- Seek medical advice if severe symptoms

Source: Adapted from Griffin 1990.

Risk / Exposure ASSESSMENT

Exposure Model

Monitor / Train

Maintain / Repair

Replace / Reduce

Whole Body Vibration INJURY PREVENTION

Prevention
Research in North America: NIOSH

NIOSH research lab

Vibration Exposure is a recognized health issue
Measurement Standards, Exposure Limits and Guidelines exist for assessing risk
Best Practice has been established but continues to evolve
Technology has been developed to allow continuous exposure monitoring

Summary

Active Control

Concordia University / IRSST

To learn more:
Guide to good practice on Whole-Body Vibration
New edition guide to good practice with a view to implementation of Directive 2002/44/EC on the minimum health and safety requirements

WBV Related Resources
http://www.cdc.gov/niosh/health/vibration/
http://www.cbs.gov/niosh/1407.html
http://www.agsi.org/
http://www.iea.org/technaea.htm
http://www.ansi.org/
http://www.cen.eu/cenorm/homepage.htm

Best Practice makes Prevention Possible!
Thank you for your attention

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