



# **HUMAN VIBRATION**

**SHORT FORM INFORMATION PAPER**

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**COMPILED BY**

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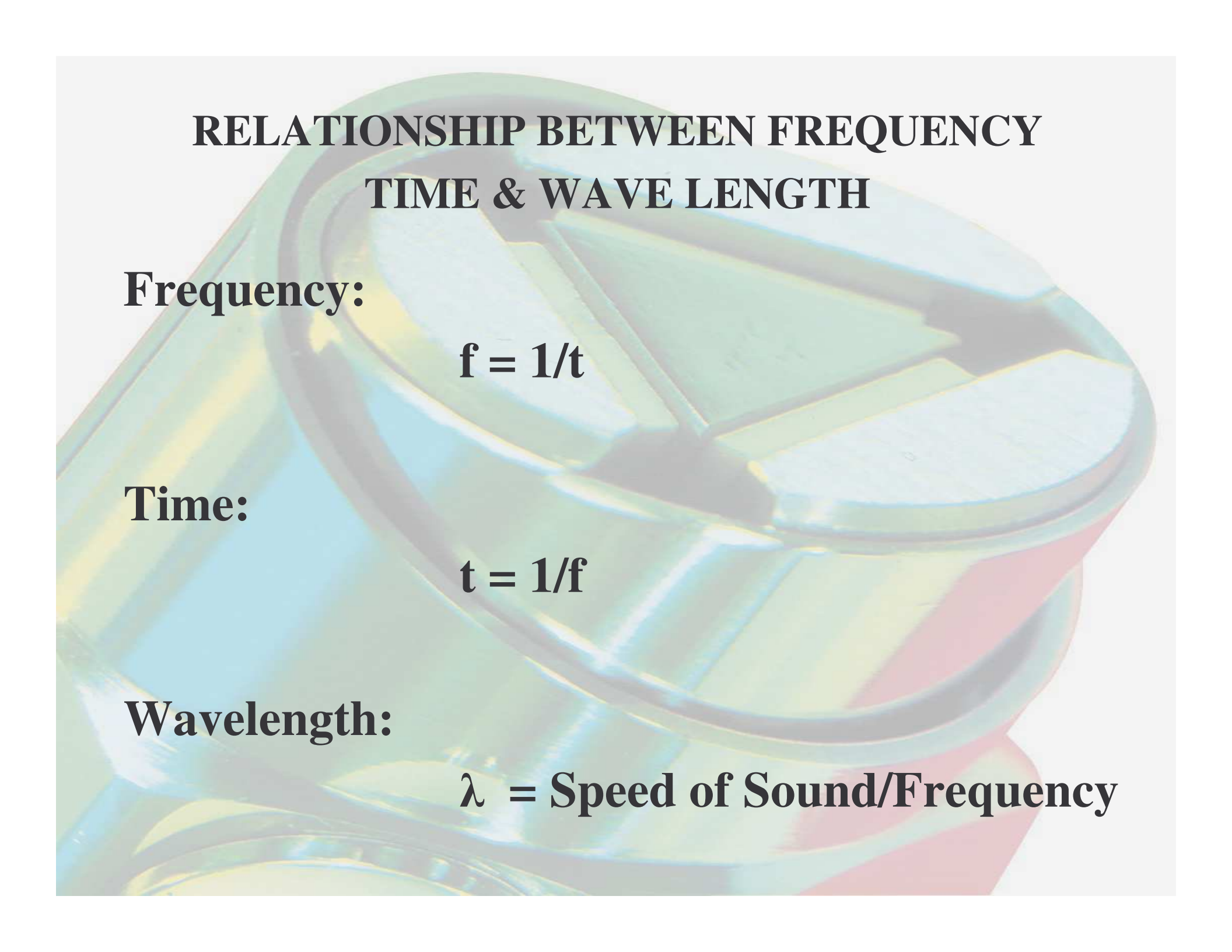


# **INTRODUCTION**

- **WHY HUMAN VIBRATION MEASUREMENTS**
- **LINK BETWEEN NOISE & VIBRATION**
- **VIBRATION**
- **HUMAN VIBRATION – NEW FIELD**

# TERMINOLOGY

- **RELATIONSHIP BETWEEN FREQUENCY , TIME & WAVE LENGTH**
- **ACCELERATION**
- **DISPLACEMENT**
- **DECIBEL**
- **RMS**
- **MAXIMUM PEAK**
- **ENERGY EQUIVALENT ACCELERATION**
- **HUMAN VIBRATION EXPOSURE**
- **VIBRATION DOSE VALUES**
- **WORKING DAY DOSE**
- **WEIGHTED ACCELERATION SUM (WHOLE BODY)**



# RELATIONSHIP BETWEEN FREQUENCY TIME & WAVE LENGTH

**Frequency:**

$$f = 1/t$$

**Time:**

$$t = 1/f$$

**Wavelength:**

$$\lambda = \text{Speed of Sound/Frequency}$$

# ACCELERATION

$$a = - (2\pi f)^2 \cdot d_0 \cdot \sin 2\pi ft$$

**Where:**

**a** = Acceleration in  $\text{m/s}^2$

**$d_0$**  = Peak Displacement

**F** = Frequency in Hz

# DISPLACEMENT



$$d = d_0 \cdot \sin 2\pi ft$$

# DECIBEL

$$\text{dB} = 20 \text{ Log } ( a / a_{\text{ref}} )$$

**Where:**

**a** = Measured Level in Acceleration in  $\text{m/s}^2$

**a<sub>ref</sub>** = Reference Level (1 in  $10^{-6} \text{ m/s}^2$ )

# **RMS LEVEL**



**Amplitude Level related to Energy**

**Content + Time History of Wave**



# **MAXIMUM PEAK**

**Maximum Amplitude Level Occurred**

**No Time History of Wave**

# CREST FACTOR

Maximum Peak

$$\text{C. F.} = \frac{\text{Maximum Peak}}{a_{\text{rms}}}$$

Maximum Peak

$$\text{C. F.} = \frac{\text{Maximum Peak}}{a_{\text{eq}}}$$

# ENERGY EQUIVALENT ACCELERATION

$$a_{eq}(T) = \sqrt{\frac{1}{T} \int_0^T a_{rms}^2 dt}$$

**Where:**

$a_{eq}$  = Energy Equivalent Acceleration

$a_{rms}$  = Instantaneous Root Mean Square Acceleration

$T$  = Integration Time in Seconds

# HUMAN VIBRATION EXPOSURE

$$a_{eq}(T) = \sqrt{\frac{[(an^1)^2 \cdot (effT^1)] + [(an^2)^2 \cdot (effT^2)] + \dots}{effT^1 + effT^2 + \dots}}$$

**Where:**

- $a_{eq}$  = Energy Equivalent Acceleration
- $an$  = Energy Equivalent Acceleration
- $T$  = Effective Time in Hours

# VIBRATION DOSE

t (hrs) Elapsed

$$\text{Dose} = \frac{t \text{ (hrs) Elapsed}}{\tau \text{ (hrs) Allowed}} \times 100 \%$$

**Where:**

**t = Elapsed Time in Hours**

**$\tau$  = Allowed Time in Hours**

# WORKING DAY DOSE

$$\text{Dose} = [t_1/\tau_1 + t_2/\tau_2 + t_3/\tau_3] \times 100 \%$$

**Where:**

**t** = Elapsed Time

**$\tau$**  = Allowed Time

# **WEIGHTED ACCELERATION SUM (WHOLE BODY)**

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$$\text{WAS} = \sqrt{(1,4 a_x)^2 + (1,4 a_y)^2 + (a_z)^2}$$

**Where:**

**WAS** = **Weighted Acceleration  
Sum**

**a** = **Instantaneous Acceleration**

# MEASURING EQUIPMENT



- **Different Makes/Models**
- **Transducers**
- **Connection Cable**
- **Environmental Conditions**



# **DIFFERENT MAKES/MODELS**

- **Brüel & Kjaer 4447**
- **Larson.Davis HVM-100**
- **Quest HAVPRO**
- **Rion VM-54**
- **Svantek 948**

# TRANSDUCERS



- **Triaxial Accelerometer**
- **Charge Mode**
- **Voltage Mode**

# CONNECTION CABLE

- **Tribo-Electric Noise**



# **ENVIRONMENTAL CONDITIONS**

- **Temperature**
- **Vibration**
- **Shock**

# MEASUREMENT METHODOLOGY

- **Instrument Settings**
- **Vibration Weighting Curves**
- **Whole Body Vibration Weighting Curves**
- **Hand-arm Vibration Weighting Curves**
- **Vibration Transfer to Transducer**
- **Instrument measured Vibration against Running Time**
- **Repeatability of the Measurements**
- **Uncertainty (Tolerance) of the Measurements**

# **INSTRUMENT SETTINGS**

- **Accelerometer Used**
- **X, Y and Z Accelerometer Sensitivities**
- **Display Units**
- **Mode Selection**
- **Averaging Time**
- **Level Ranges**
- **Acceleration Reference Value**
- **Store**

# VIBRATION WEIGHTING CURVES

(-3,0 dB Cutoff Points)

- **Fa Curve (0,4 Hz to 100 Hz)**
- **Fb Curve (0,4 Hz to 1250 Hz)**
- **Fc Curve (6,3 Hz to 1250 Hz)**
- **Ws Curve (Severity)**

# **WHOLE BODY VIBRATION WEIGHTING CURVES (-3,0 dB Cutoff Points)**

- **WB Curve (0,8 Hz to 6,3 Hz)**
- **Wc Curve (0,4 Hz to 12,5 Hz)**
- **Wd Curve (0,4 Hz to 3,15 Hz)**
- **We Curve (0,4 Hz to 1,6 Hz)**
- **Wg Curve (2 Hz to 12,5 Hz)**
- **Wj Curve (4 Hz to 100 Hz)**
- **Wk Curve (2,5 Hz to 20 Hz)**

# **HAND-ARM VIBRATION WEIGHTING CURVE**

- **Wh Curve (0,8 Hz to 10 000 Hz)**

# **TRANSDUCER CONNECTION**



- **X, Y and Z Alignment**
- **Method of Contact**



# **HV INSTRUMENT MEASURE VIBRATION LEVEL AGAINST RUNNING TIME**

- **Not Vibration Level against Frequency**
- **Not Vibration Level against Time**

# REPEATABILITY OF MEASUREMENTS

- **Calibrated Measuring Instrument (SANAS)**
- **Person performing the measurement**
  - Training
  - Experience
- **Procedure**
  - Check List for Overall Measurements
  - Check List for Operator of Machine
- **Instrument Settings**
- **Machine which is operated**
- **Environmental Conditions**



# **UNCERTAINTY OF MEASUREMENTS**

- **Uncertainty (Tolerance)**
- **Issued Certificate Uncertainty (Tolerance)**

# **OFFICIAL TRAINING**

- **Theoretical Training on all the Abovementioned Sections**
- **Theoretical Training on the Measuring Instrument Settings/Functions**
- **Practical Training on the Measurements**

# **PRACTICAL TRAINING ON THE MEASUREMENTS**

- **Human Vibration Association**
- **Sampling Method**
- **Practical Training**

# STANDARDS



- **Whole-Body Vibration**
- **Hand-arm Vibration**

# WHOLE-BODY VIBRATION

- **ISO 2631-1 of 1997:**  
**General Requirements**
- **ISO 2631-2 of 2003:**  
**Vibration in Buildings (1 Hz to 80 Hz )**
- **ISO 2631-4 of 2001:**  
**Rotational Motion on Passenger/Crew  
comfort in Fixed-guide Way Transport  
Systems**
- **ISO 2631-5 of 2004:**  
**Multiple Shocks**

# **WHOLE-BODY VIBRATION**

- **BS 684 of 1987:**  
**Measurement & Evaluation of Human Exposure to Whole-Body Mechanical Vibration & Repeated Shock**
- **2002/44/EC of 2006:**  
**EU Good Practice Guide to Whole-Body Vibration**

# **HAND-ARM VIBRATION**



- **ISO 5249-1:**  
**General Requirements**
- **ISO 5349-2:**  
**Practical Guidance for Measurements in the  
Workplace**

# **DEPARTMENT of MINERALS & ENERGY**

- **Application Date**
- **Inspectors**
- **Measuring Equipment**

# DEPARTMENT of LABOR



- **Application Date**
- **Inspectors**
- **Measuring Equipment**



# **DEPARTMENT of TRANSPORT**

- **Application Date**
- **Inspectors**
- **Measuring Equipment**

# CONCLUSION

- **Occupational Hygiene Sector**
  - Trained Personnel
  - Experienced personnel
- **Government Sectors (Departments)**
  - Legislation
  - Inspectors
  - Legislator (Law Enforcement)
  - SANAS (DTI)
- **Human Vibration Association**

A THOUGHT FOR THE DAY...

IF IT MOVES TRAIN IT

IF IT DOES NOT

CALIBRATE IT!



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