S (I-A) Tuesday, October 15, 2025; 8:30 am – 10:45 am Awareness of Vibration and Sound Hazards of Power Tools

Vibration and Sound are evaluated according to page 20 of the AS 6228A standard

Vendor’s declared values might be used as initial estimate but should be subject to verification.

(Suitable penalties for significant misstatement would need to be applied, potentially including

product disqualification.)

Sound evaluated at the10% level. Report sound levels obtained in a representative setting in decibels un-weighted (dB) and

weighted dBA. Octave band data are preferred. Vendor’s declared values might be used as initial estimate but should be subject to verification.

VIBRATION EXPOSURE IS PART OF AS 6228A EVALUATION

Every day, human beings interact with machinery. Contact with vibration is commonplace!

US DEPARTMENT OF DEFENSE (DOD)

1) In the U.S., about 2.5 million workers are exposed daily to hand-arm transmitted through the regular use of power tools.
2) Occupational exposure from many pneumatic, electric, hydraulic or gasoline powered vibrating hand-tools have been causally linked to hand-arm vibration syndrome (HAVS).
3) HAVS is is characterized is by a loss of sensation and blood supply to the hands and fingers.
4) HAVS is often misdiagnosed, and it is underreported.
5) A conservative estimate of the prevalence of HAVS in the U.S. ranges from 20-50% for certain groups of power tool users. This is believed to be a conservative estimate.

http://www.mcieast.marines.mil/Portals/33/Documents/Safety/OSH/Hand-Arm-Vibrtion-Syndrome.pdf

1) Even by conservative estimates, as many as 1.25 million power tool users may be at risk for developing HAVS.

VIBRATION WHITE FINGER SYNDROME IS KNOWN AS SECONDARY RAYNAUD'S PHENOMENON

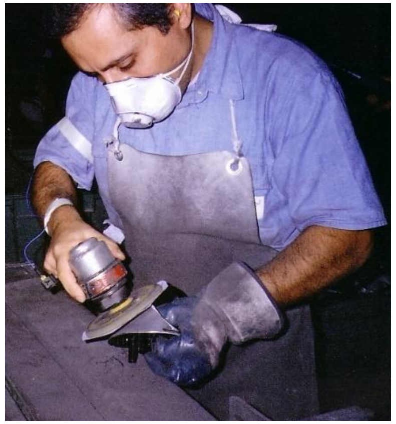
- **Results in cold-induced spasms of the blood vessels in the fingers and hands**
- **Symptoms include:**
  - Cold fingers especially in cold climates
  - Tingling or numbness
  - Blanching or whitening of fingers
  - Can lead to permanent damage

RECOMMENDED HAV LIMITS

Vibration exposure time (hrs)	TLV (m/s^2)	Action Level (m/s^2)
8	5.00	2.50
6	5.77	2.89
4	7.07	3.54
2	10.00	5.00
1	14.14	7.07

Maximum allowable level for 8 hr avg. exposure:

EU Directive TLV: 5 m/s^2
EU Directive AL: 2.5 m/s^2



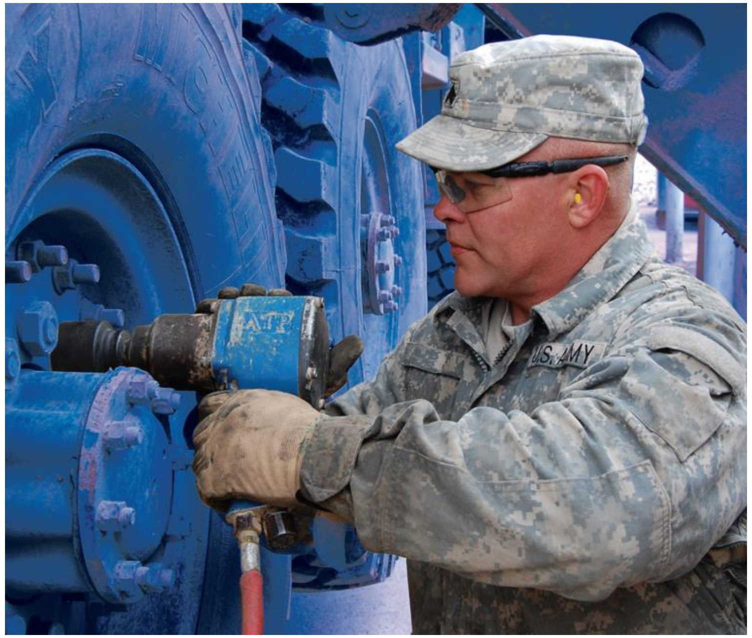
ACGIH HandArmVibration_2018-10-24.pdf and ANSI S2.70 (2006)

WHAT TO DO?

A. **Identify areas of concern**
   a) Implement as SAE AS 6228A purchasing program
   b) Power tools in use and/or medical diagnosis of injury
   c) Have workers report tingling or “pins and needles” feeling
   d) Document cases of HAV syndrome
   e) Noisy areas coincide with vibrating tools

B. **Mfg. Determine exposure**
   a) Measure by ISO 28927
   b) Model by SAE AS 6228A Review/Army Vib. Hndbk

C. **Control the risk**
   a) Limit exposure time, i.e., “trigger time”
   b) Lower vibration transmission
   c) Keep workspace/hands warm
   d) Vibration isolation - gloves, anti-vibration wraps



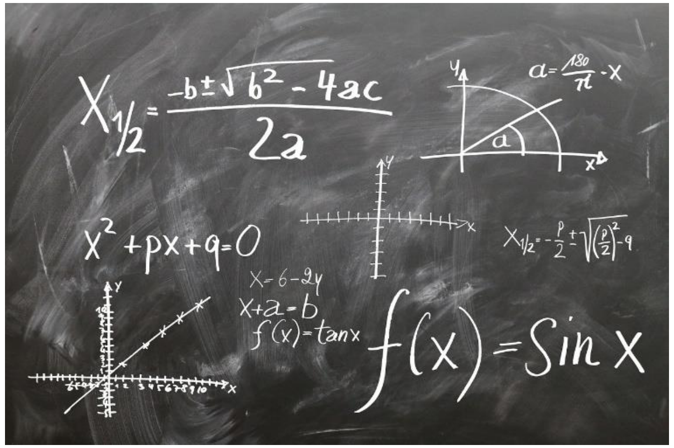
ASSESSMENT QUESTIONS (AS 6228A)

- Does your business use hand-held, hand-guided or hand-fed powered equipment?
- Using rotary action tools (e.g. grinders, polishers)?
- Using impact or percussive tools (i.e. hammer-action tools)?
- Manufacturers or suppliers warn of a risk from vibration? (Provide vibration and noise data).
- Tools cause tingling or numbness in the hands during or after use?
- Workers have reported symptoms of hand-arm vibration syndrome?
- With vibration comes noise exposures as well, right?

ANTI-VIBRATION GLOVES Require Careful Prescribing based on frequency

When describing the effectiveness of gloves, it may be better to say that the conditions under which gloves provide protection is still being investigated. The reliability of gloves depends on the material they are made of and the dominant frequency of the tool being used.

MODELING VIBRATION EXPOSURE (AS 6228A)



Use of pre-determined tool vibration data to assess exposure risk

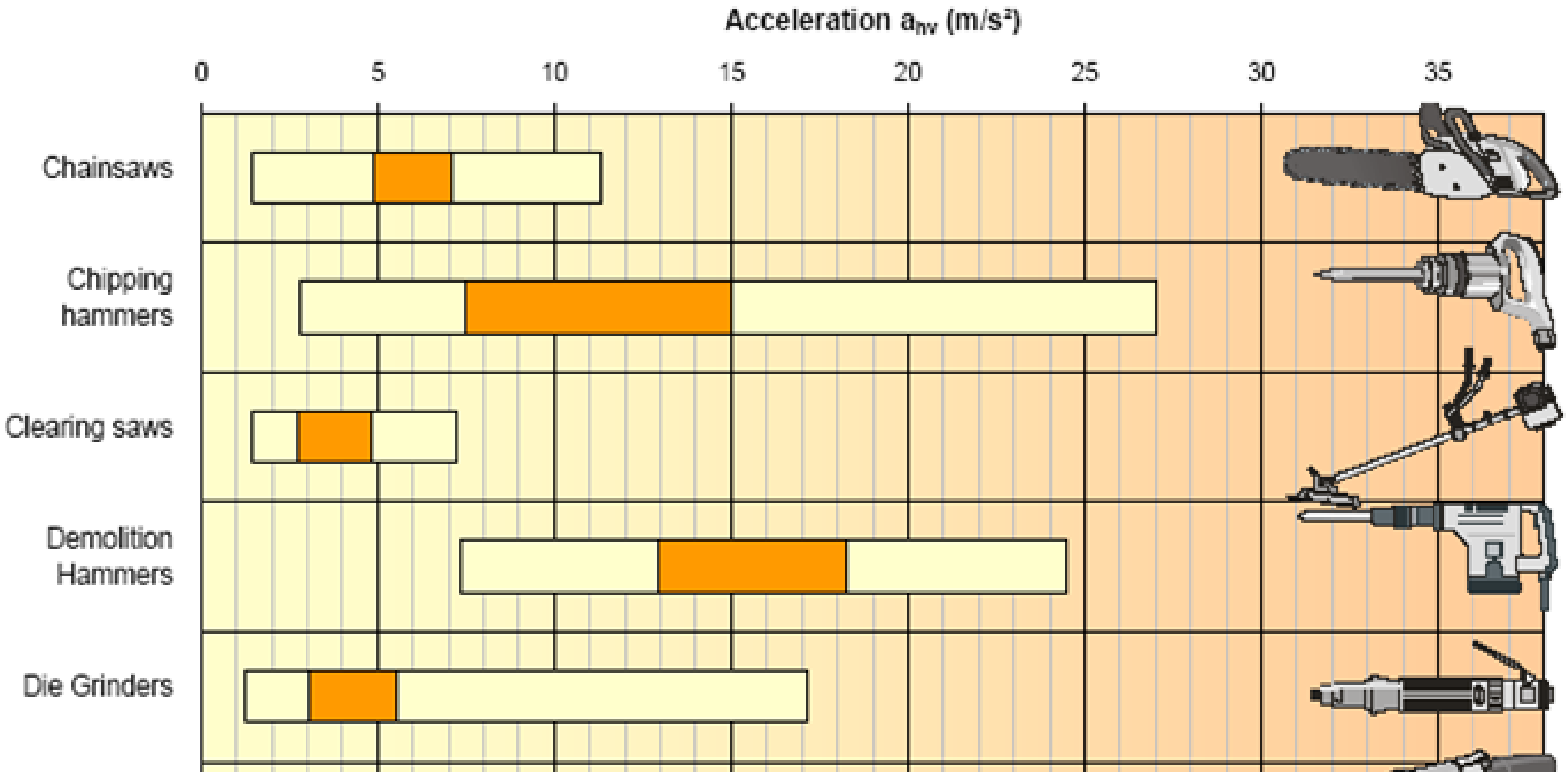
Benefits

- Informed buying choice
- Easy
- Low cost

Challenges

- Lack of data
- Inaccurate
- Not representative of actual conditions

MEASUREMENT VARIATION

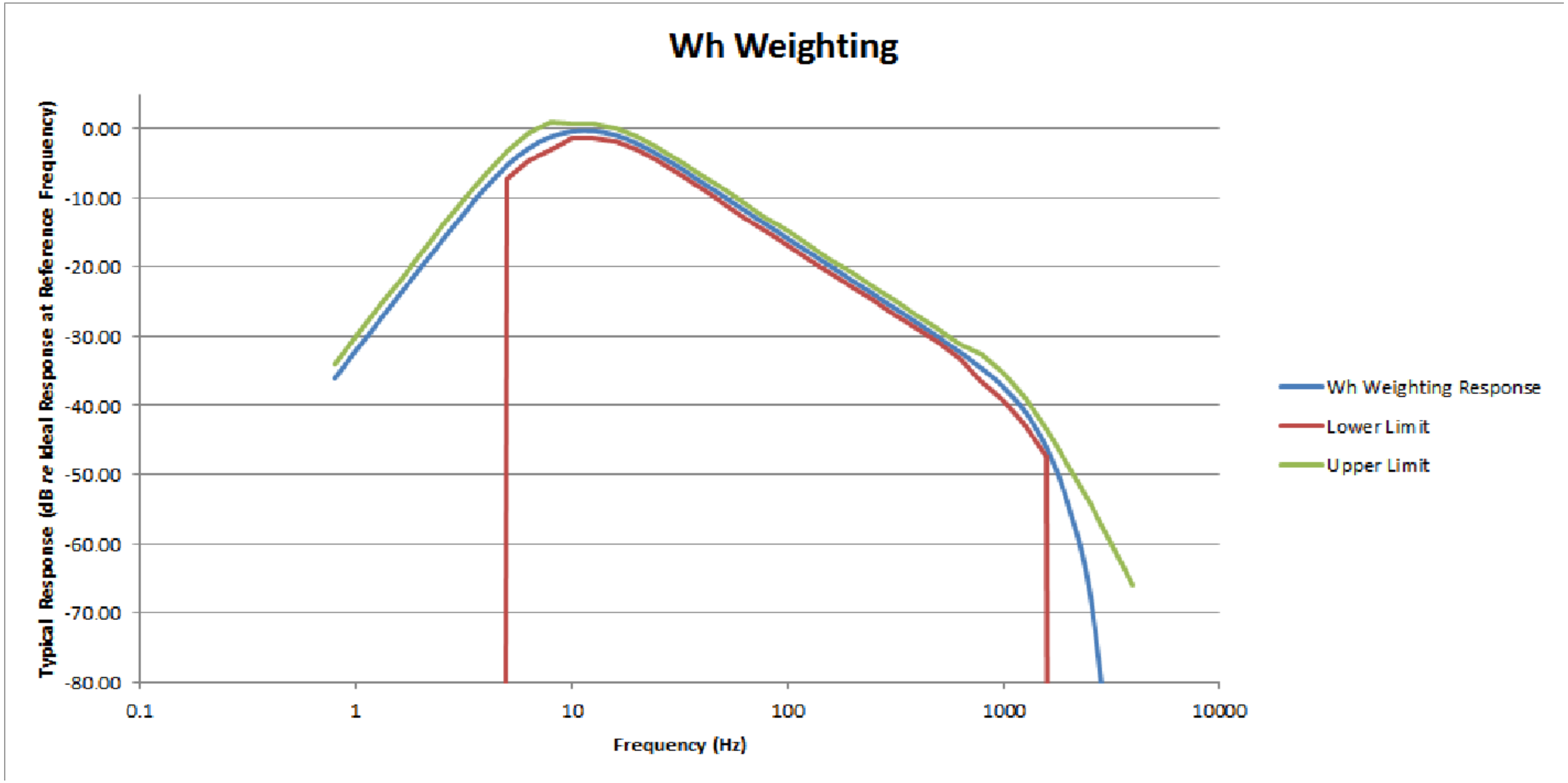


CEN/TR 15350 advises that for estimating risk, the manufacturer’s declared emission value should in most cases be multiplied by a factor depending on the type of tool:

Pneumatic tools: ×1.5 to ×2
Electric tools: ×1.5 to ×2

FREQUENCY WEIGHTING (HAND-ARM)

Designation	Description	Definition
W_h	Hand arm vibration (all)	ISO 8041, ISO 5349-1, ANSI S2.70



STANDARDS

- **ISO 8041**
  - **Whole Body** – ISO 2631-1, 2, 4 & 5 (Wb, Wc, Wd, Wj, Wk, Wm)
    - **Earth Moving Equipment** – ISO 7096
    - **Ships** – ISO 6954 (Wm)
    - **Seats** – ISO 10362
  - **Hand Arm** – ISO 5349-1 & 2 (Wh)
    - **Handle Vibration** – ISO 8662-1
    - **Gloves** – ISO 10819
    - **Forest Machinery – Handles** – ISO 22867
    - **Hand-held Portable Tools** – ISO 28927

EXAMPLE MEASUREMENT SYSTEM

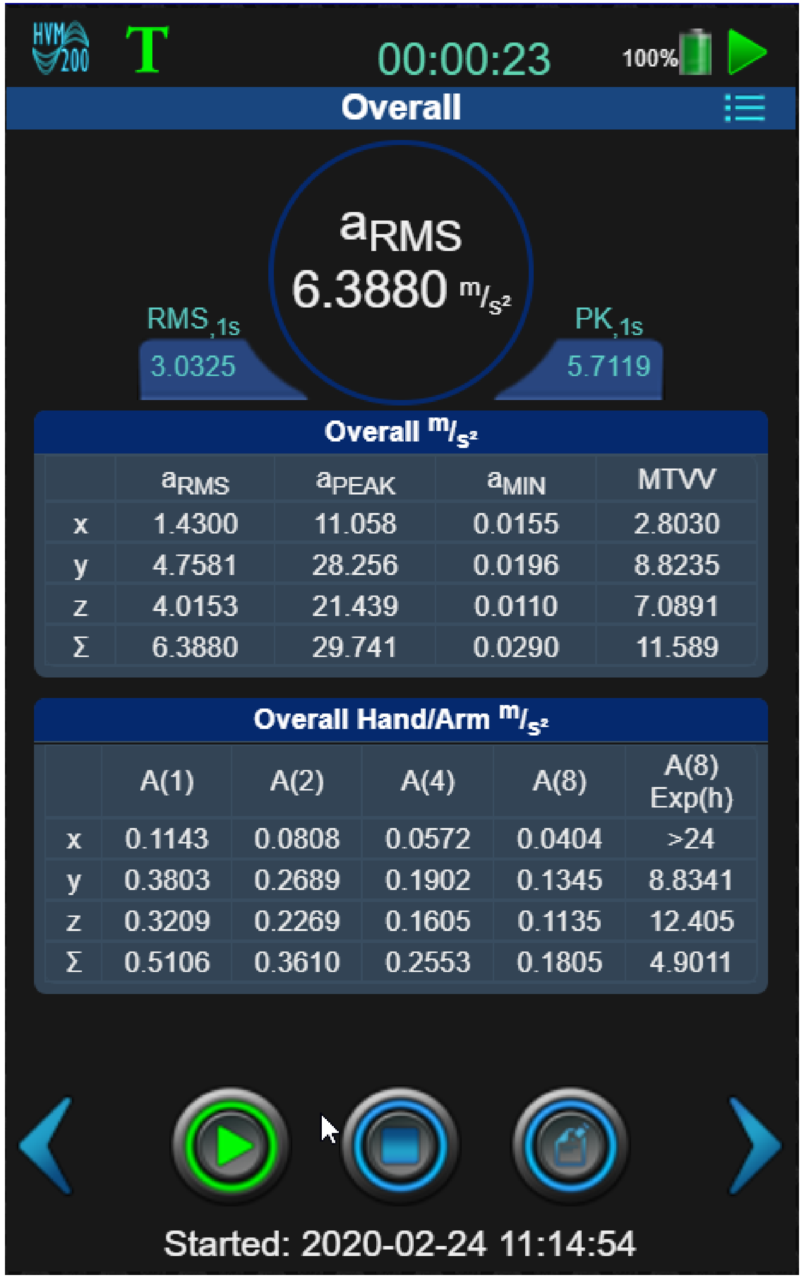
The Larson Davis HVM200 is an instrument designed for measurement of human exposure to vibration

- Complete with instrument, sensor, & software
- Control using app and Wi-Fi

WHAT IS MEASURED? METRICS

- A_{rms} = rms or “average”
- A(8) = acceleration normalized to 8 hours
- VDV = Vibration Dose Value

  Emphasizes impulses
- Exposure time



SAMPLE DATA

	x	y	z	Sum	Units
a_{RMS}	0.5308	0.0453	0.2576	0.5918	m/s²
MTVV	0.7506	0.0546	0.3603	0.8344	m/s²
a_{PEAK}	2.6416	0.2351	1.2674	2.9392	m/s²
a_{MIN}	0.4681	0.0357	0.2248	0.5205	m/s²
A(1)	0.0177	0.0015	0.0086	0.0197	m/s²
A(2)	0.0125	0.0011	0.0061	0.0139	m/s²
A(4)	0.0088	0.0008	0.0043	0.0099	m/s²
A(8)	0.0063	0.0005	0.0030	0.0070	m/s²
A(8) Action	>24	>24	>24	>24	hours
A(8) Exposure	>24	>24	>24	>24	hours
Exposure Points				0	Points

HSE MODELING SPREADSHEET

HSE Health & Safety Executive

HAND-ARM VIBRATION EXPOSURE CALCULATOR

Version 3 June 2005

	Vibration magnitude m/s² r.m.s.	Exposure points per hour	Time to reach EAV 2.5 m/s² A (8)		Time to reach ELV 5 m/s² A (8)		Exposure duration		Partial exposure m/s² A (8)	Partial exposure points
			hours	minutes	hours	minutes	hours	minutes		
Tool or process 1	5.4	58	1	43	6	52	1	15	2.1	73
Tool or process 2	7.3	107	0	56	3	45	0	20	1.5	36
Tool or process 3	2.6	14	7	24	>24		3	5	1.6	42
Tool or process 4	1.3	3	>24		>24		2	15	0.7	8
Tool or process 5										
Tool or process 6										

Daily exposure m/s² A (8)	Total exposure points
3.1	158

Instructions for use:

Enter vibration magnitudes and exposure durations in the white areas.
To calculate, press the Enter key, or move the cursor to a different cell.
The results are displayed in the yelllow areas.
To clear all cells, click on the 'Reset' button.
For more information, click the HELP tab below.

Reset

LIMIT EXPOSURE TIME

If vibration levels too high:

- Rotate workers on high vibration tool
- Break work into multiple shifts
- Select tools with lower vibration and noise levels, if possible, according to AS 6228A

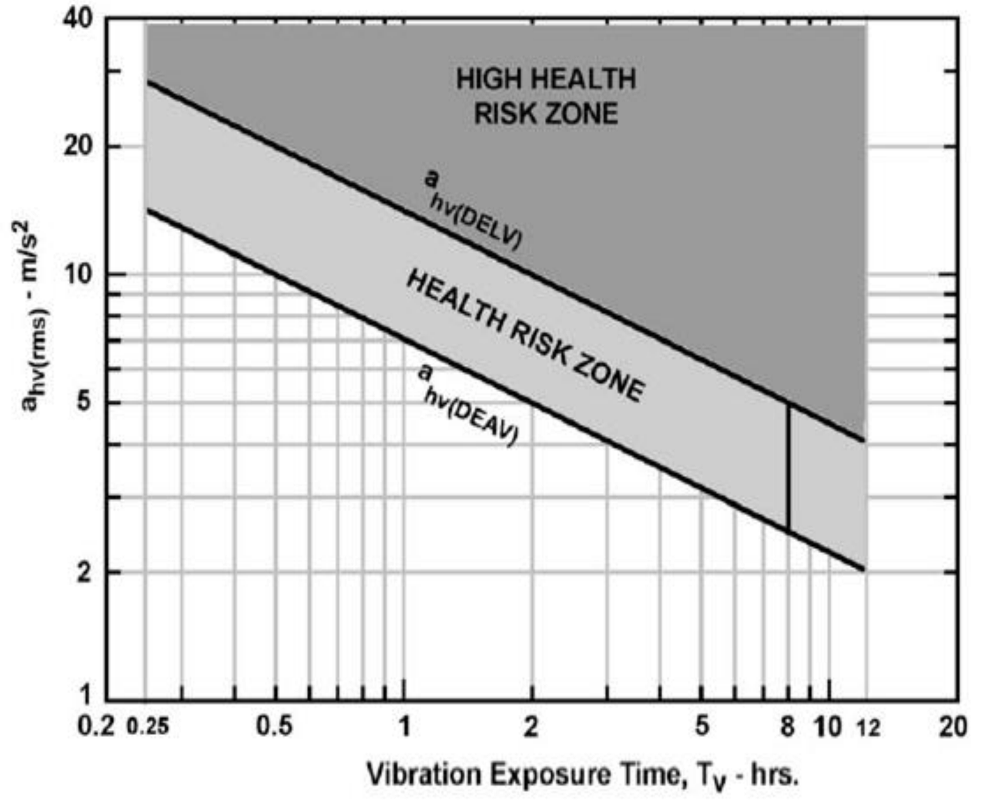
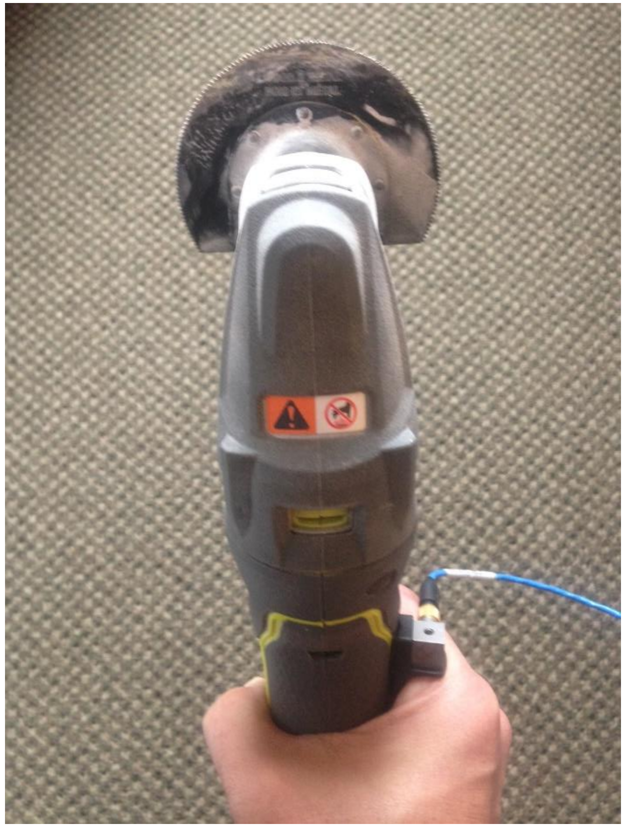


Figure A.1 — Plots of the $a_{hv(DEAV)}$ and $a_{hv(DELV)}$ values for vibration exposure times other than 8 hours

HOW TO LOWER VIBRATION LEVELS

If vibration levels are too high

- Training on proper use of tool
- Ensure tool properly maintained
- Replace tool with model producing less vibration
- Consider vibration isolation like gloves (frequency dependent on glove material and the tools used)

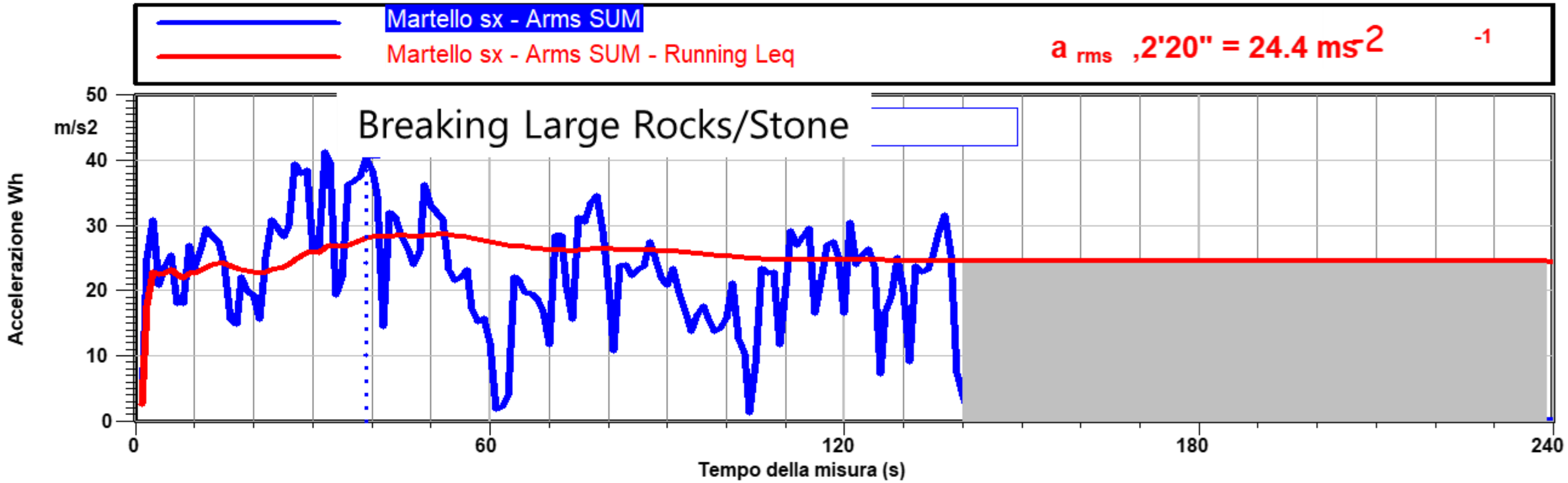


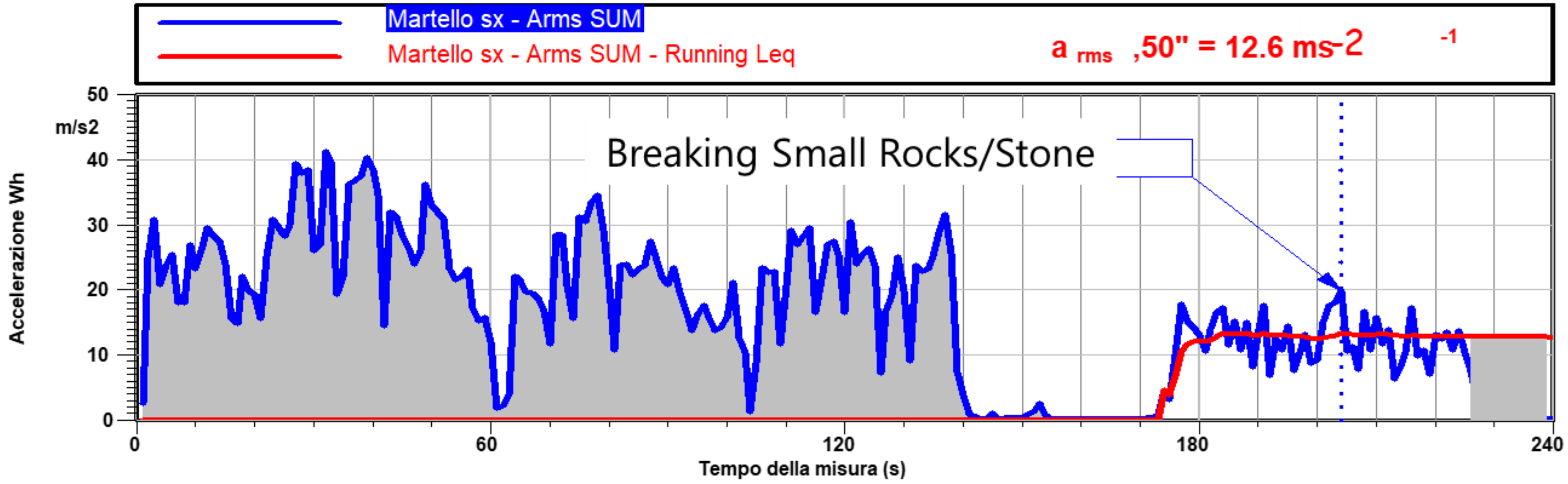
EXAMPLE
HAND-ARM, TOOL USAGE

Breaking Large
Rocks/Stone

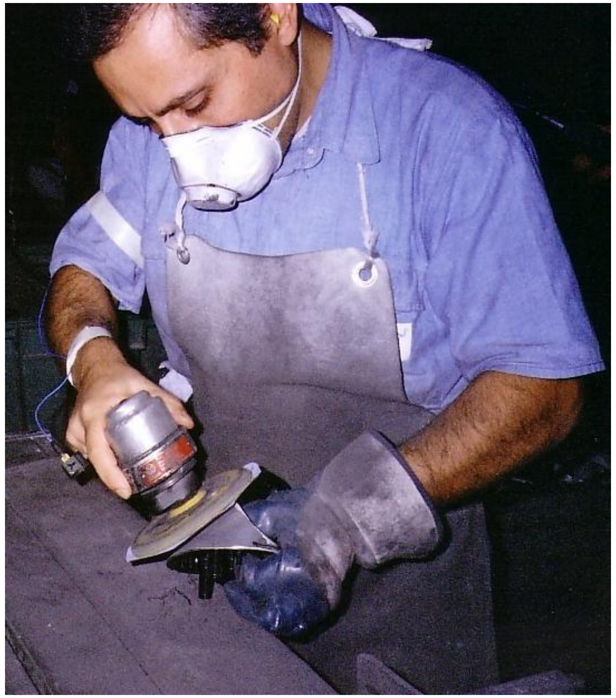
Breaking Small
Rocks/Stone

EXAMPLE
HAND-ARM, TOOL USAGE

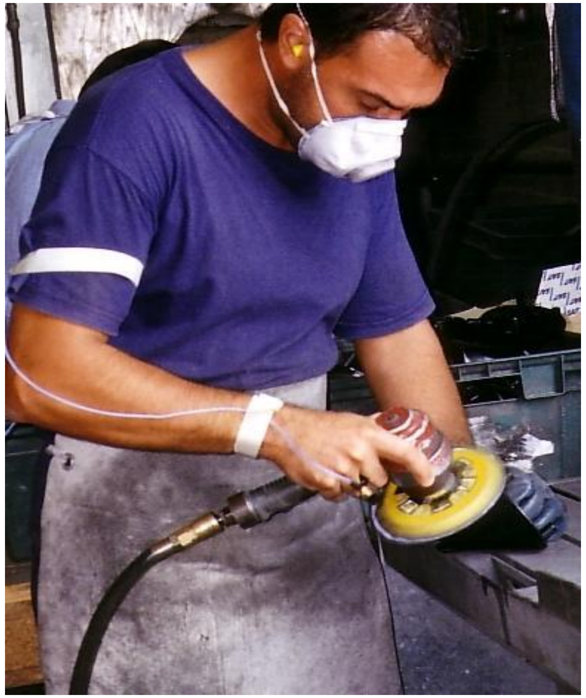




EXAMPLE
HAND-ARM, WORKER EXPERIENCE

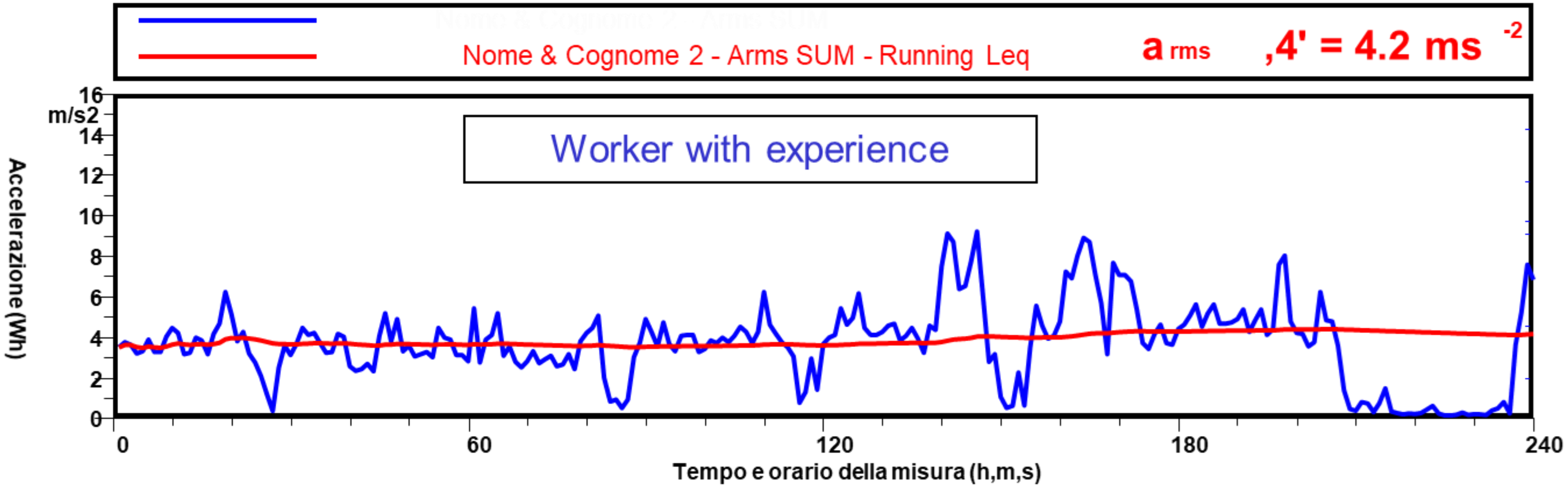


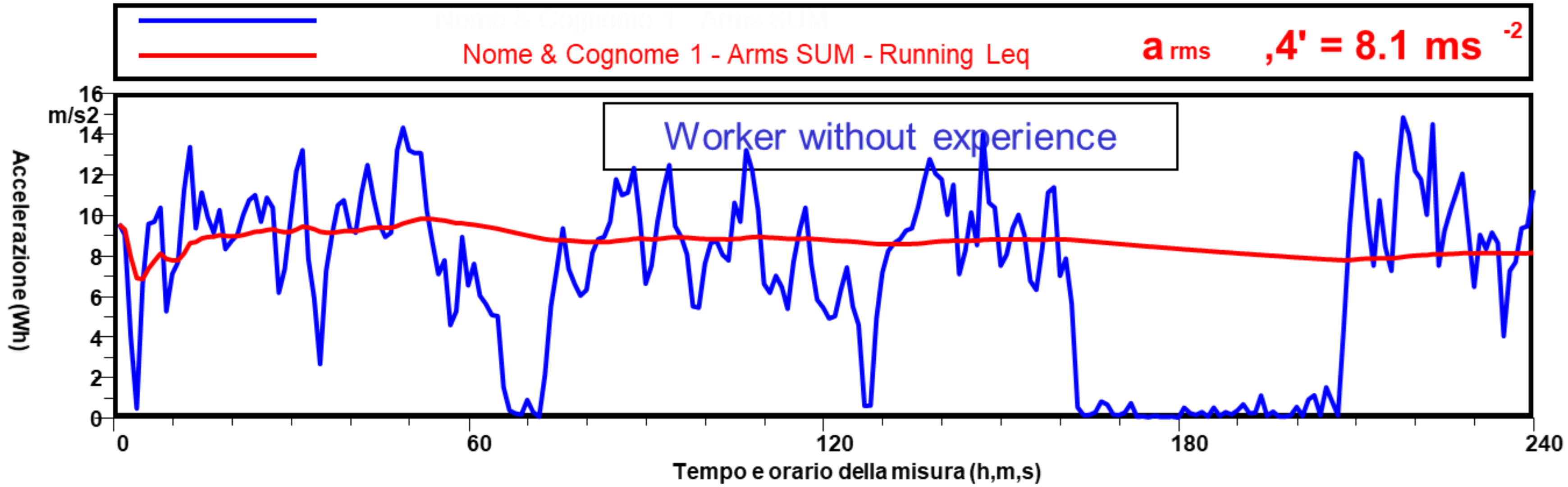
Worker with experience



Inexperienced worker

EXAMPLE
HAND-ARM, WORKER EXPERIENCE



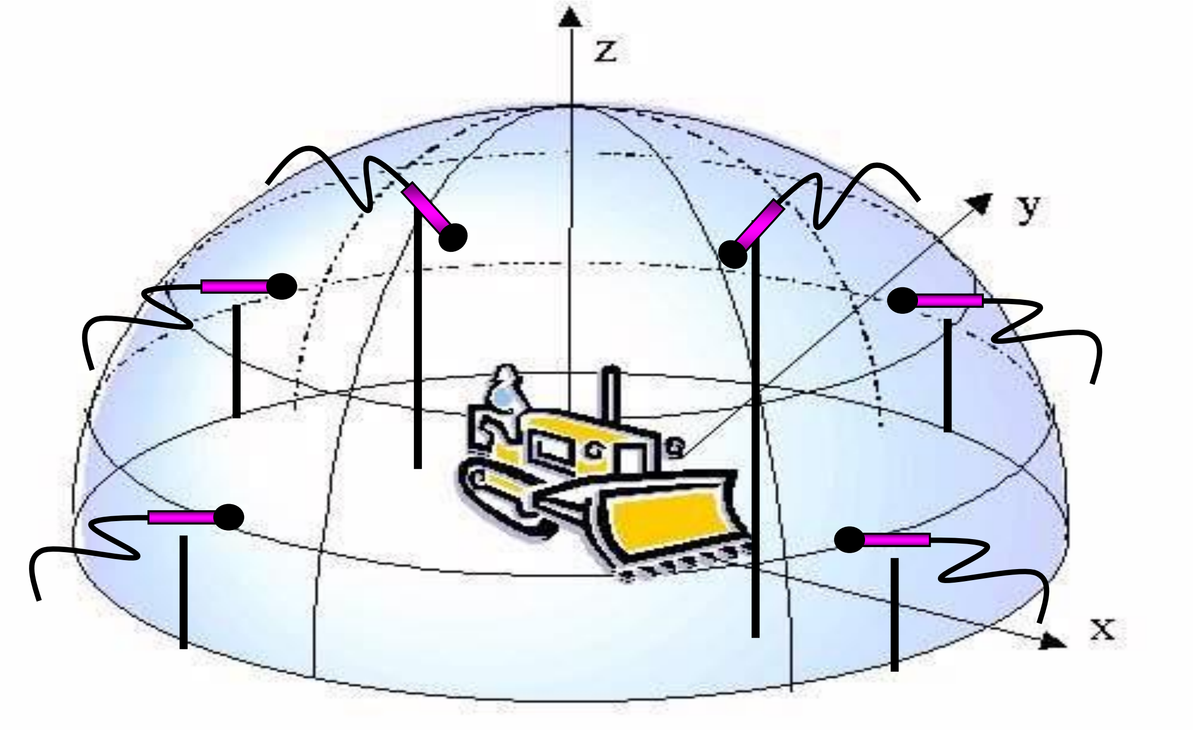


QUESTIONS?

Comparison of Sound Measurements

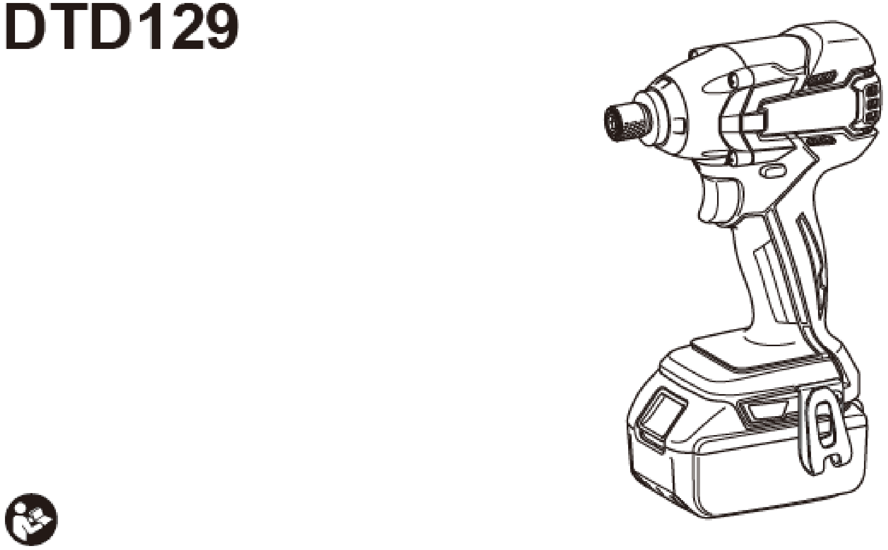
Measurement	Sound Pressure	Sound Power
Description	Pressure (loudness) of sound measured at a specific place (usually the operator's ear).	Total power of sound. Obtained by measuring sound all around a noisy object and calculating how much energy is required to create this sound.
Units	dBA (relative pressure).	Watts (total power of the sound produced by a machine).
Weighting (adjusting for pitch)	Typically reported in dBA similar to the frequency perception of the human ear.	Not adjusted for pitch (frequency).
Comparison	Can be compared to measuring how bright the light from a lamp is at a given point.	Can be compared to the electrical energy consumed by a light in watts.
Advantages	Tells you how loud it is under specific conditions. Easy to understand. Relatively easy to measure.	Can be used to predict noise through calculation. Show how much noise is being generated to compare different machines.
Limitations	Noise created by a given source (tool) can vary in different settings. For example, a reverberant room increases the total level of noise due to reflection.	Sound power can be more difficult to measure. It requires complex calculations to evaluate noise created by a specific sound power level in different settings.

SOUND POWER



POWER TOOL EXAMPLE

DTD129



Noise

The typical A-weighted noise level determined according to EN62841:

Sound pressure level (L_{pA}) : 94 dB (A)
Sound power level (L_{WA}) : 105 dB (A)
Uncertainty (K) : 3 dB (A)

Wear ear protection

Vibration

The vibration total value (tri-axial vector sum) determined according to EN62841:

Work mode : impact tightening of fasteners of the maximum capacity of the tool
Vibration emission (a_h) : 15.0 m/s^2
Uncertainty (K) : 1.5 m/s^2

SOUND POWER AND SOUND POWER LEVEL

Sound Power presented as Watts: W

Sound Power Level presented as dB

$$dB_{watts} = 10 \times \log\left(\frac{W}{10^{-12}}\right)$$

Sound power allows us to determine the sound pressure level at a given distance

$$Lp = Lw - |10 \times \log(\frac{Q}{4\pi * r^2})|$$

$Lp = Sound\ Pressure\ Level$

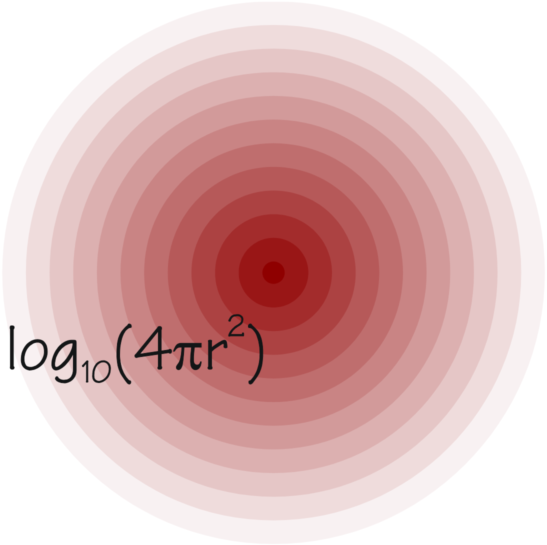
$Lw = Sound\ Power\ Level$

$Q = Directivity\ Factor\ \ (1\ for\ full\ sphere\ radaition, 2\ for\ half\ sphere)$

$r = Distance\ from\ sound\ source$

FULL SPHERE RADIATION

Theory:



$$\frac{W}{4\pi r^2} = \frac{p^2}{\rho c} \qquad \text{therefore, } W = \frac{p^2}{\rho c} 4\pi r^2$$

$$L_W = 10 \log_{10}(W/W_o) = 10 \log_{10}(p^2/p_o^2) + 10 \log_{10}(4\pi r^2)$$

$$L_W = 10 \log_{10}(W/W_o) = L_p + 10 \log_{10}(4\pi r^2)$$

$$L_p = L_W - 20 \log_{10}(r) - 10 \log_{10}(4\pi)$$

Practice: aircraft, siren on tall building, industrial stack

$$L_P = L_W - 20 \log_{10}(r) - 11 \quad [dB]$$

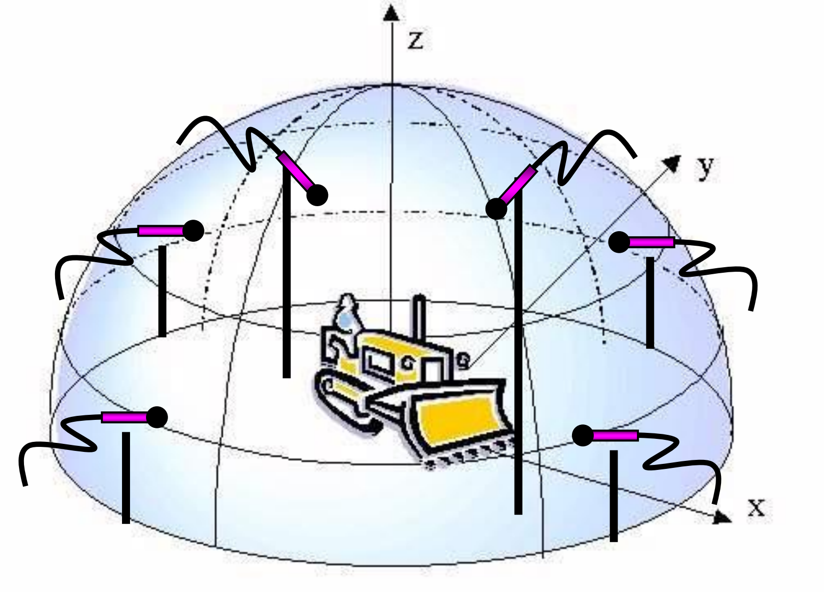
Sound Pressure Level

Sound Power Level

r in meters

It works out that the sound pressure level is equal to the sound power level at 0.2821 meters or 11 inches from the source (for full sphere radiation)

DETERMINING SOUND POWER



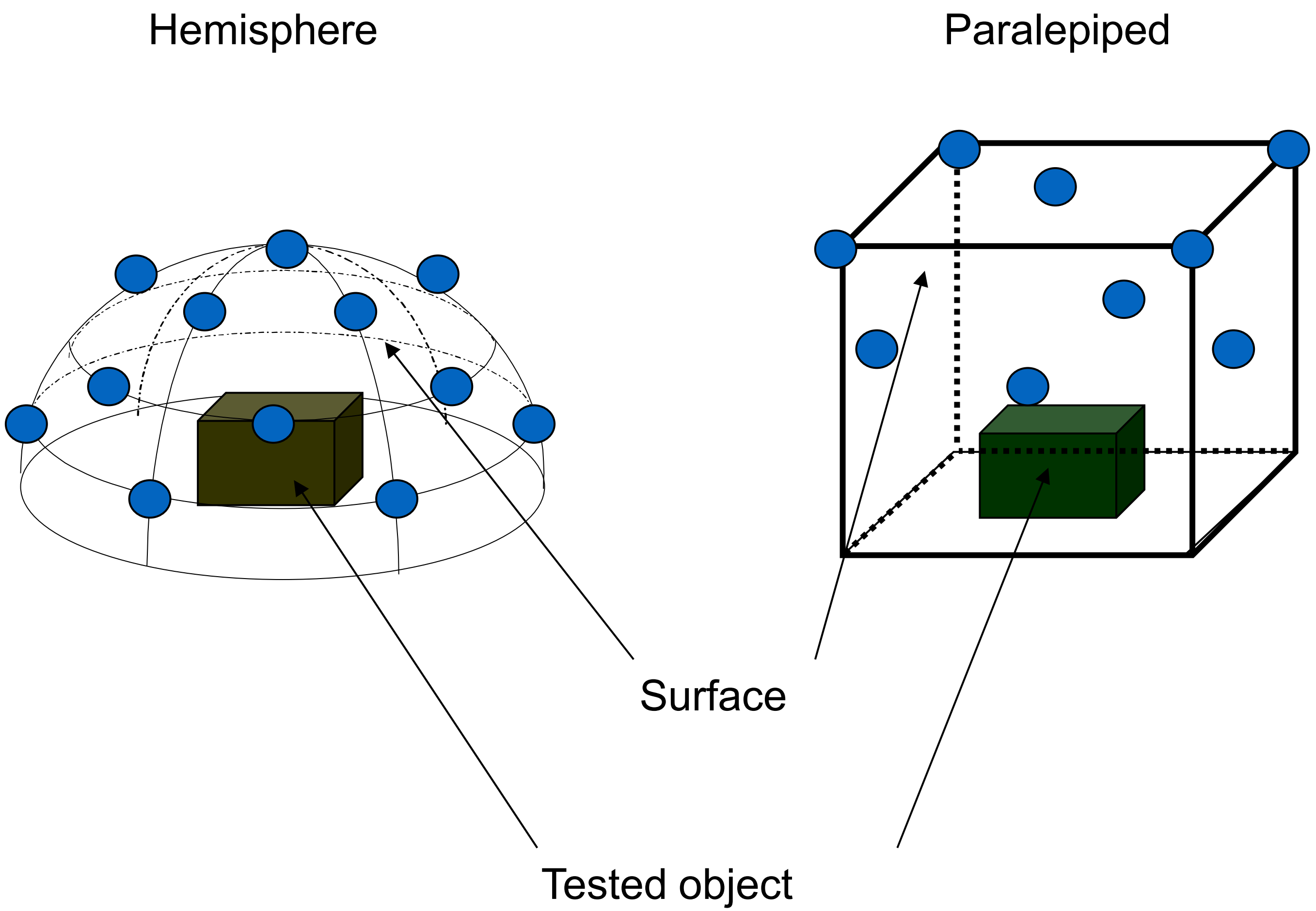
Method 1: Sound pressure Level measurements at multiple locations around the source

(ISO 3744)

Method 2: “Scan” over the source with a sound intensity probe

(ISO 9614)

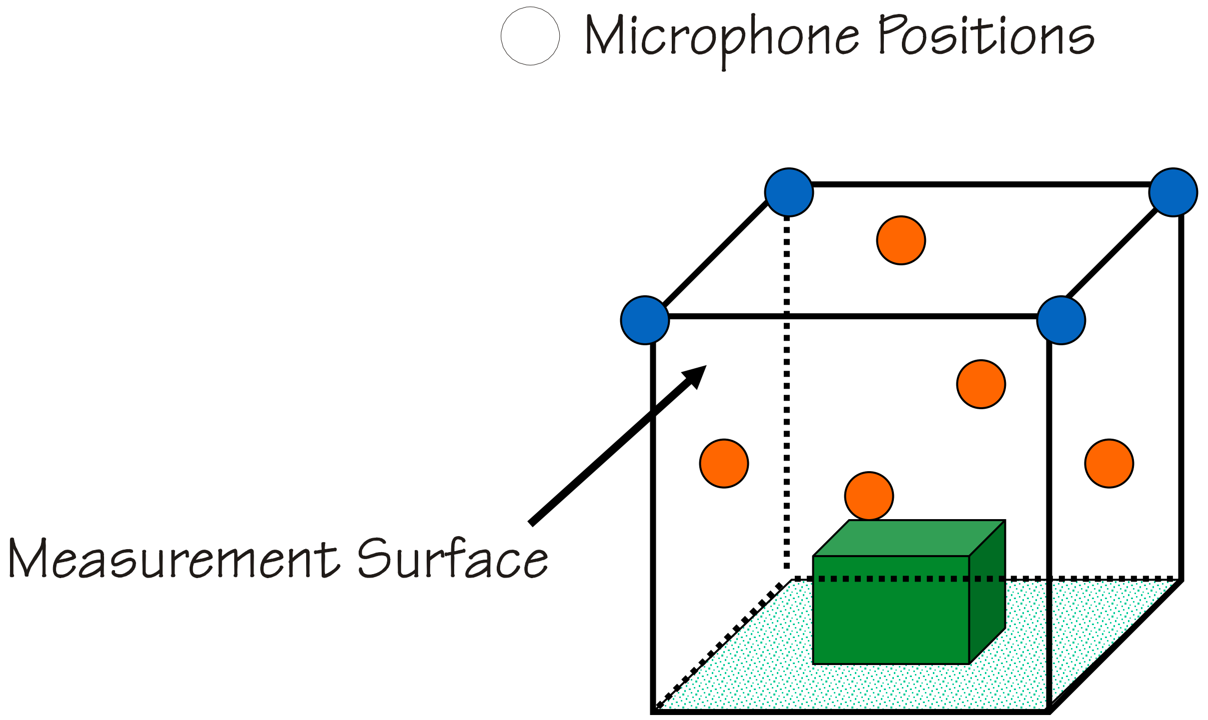
Sound Power set-ups



Sound Power Setup ISO 3744 – Example for a small machine

- Key microphone positions in the center of each face and at each corner not on the ground

- Additional microphone positions may be needed depending on the size and dimensions of the noise source



Sound Power Calculation ISO 3744

$$L_w = \overline{L_p} - K_1 - K_2 + 10\log_{10}\left(\frac{S}{S_0}\right)$$

$L_w = Sound\ Power$

$\overline{L_p} = Surface\ Averaged\ Sound\ Pressure\ Level$

$K_1 = Background\ Noise\ Correction\ Factor$

$K_2 = Environmental\ Correction\ Factor$

$S = Surface\ Area\ of\ Measurement\ Surface$

$S_o = Reference\ Surface\ Area = 1\ m^2$

Limitations of Sound Pressure Level Technique

- Typically done in a semi-anechoic chamber
- Background sound pressure level should be at least 6-10 dB lower than the noise generated by the device under test.

Taking Sound Intensity Measurements

- Define the surface around the source and sweep or scan the intensity probe at a constate rate over the surface – like “painting” with the probe
- Two microphones allow for the determination of sound pressure level and particle velocity. Multiplying the sound pressure and particle velocity and then time averaging provides acoustic intensity
- Multiply the average intensity by the area to get sound power. Sound power contributions from multiple surfaces can be added
- The probe ultimately only captures the sound energy leaving the measurement surface. Energy from sources outside of the surface will enter and leave the surface so their sound power contribution will be zero. This means we can measure the sound power of a source with other noises going on around it