Noise

Vibrations

Physical agents
Noise, vibrations

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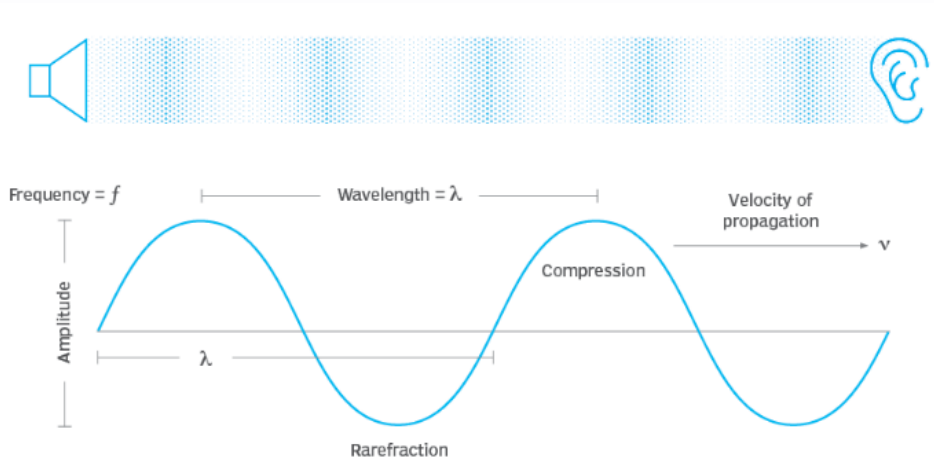
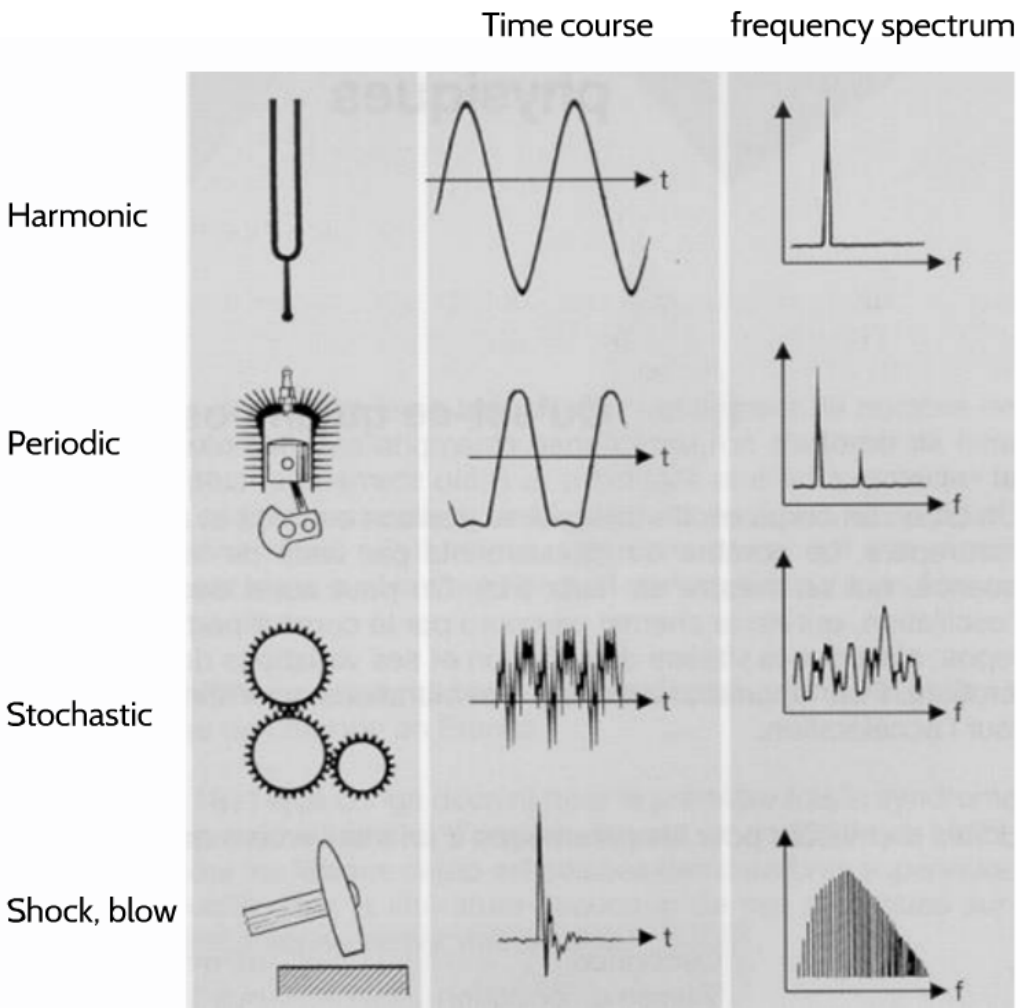
Noise

Definition

The sound is produced by tiny oscillations in air pressure (alternating compressions and depressions)

Frequency: number of periods per second (Hz)





Definition

Noise is measured in decibels [dB] (logarithmic scale)

$$[\mathrm{dB}] = 20 \cdot \log \frac{P}{P_0}$$

P : measured acoustic pressure

P_0: reference acoustic pressure

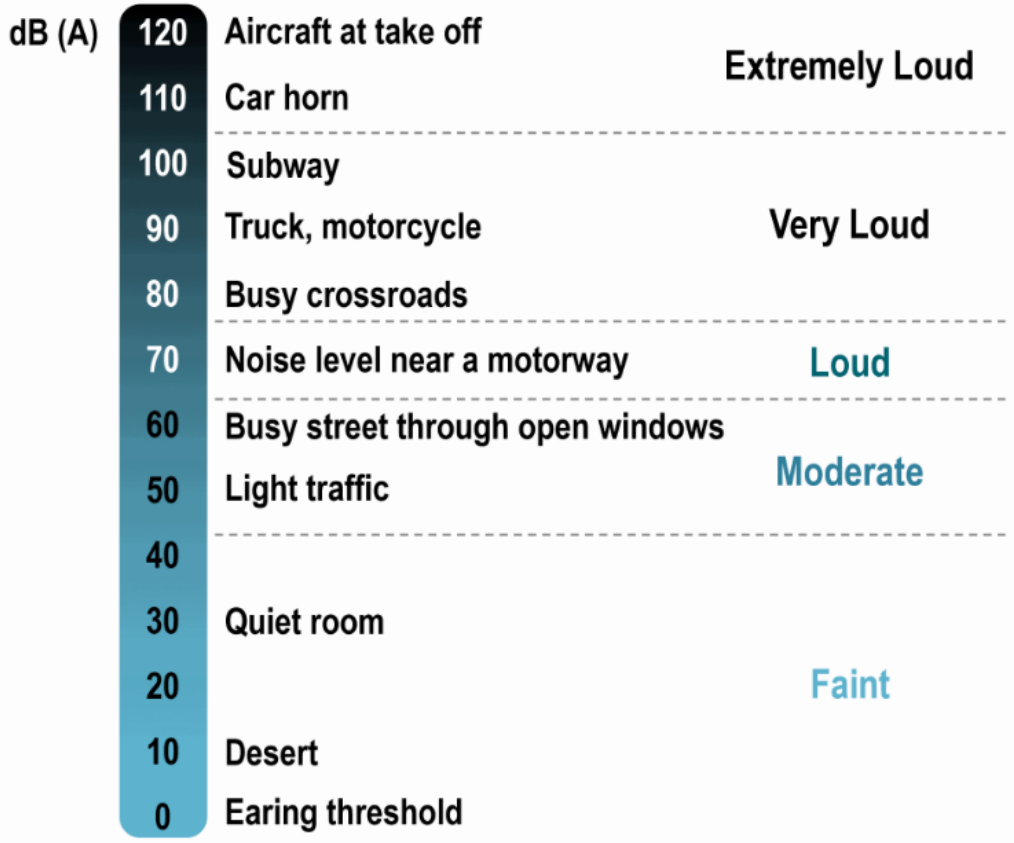
$2 \cdot 10^{-5}$ Pa (hearing threshold)

$$[\mathrm{dB}] = 10 \cdot \log \frac{W}{W_0}$$

W : measured acoustic power

W_0: reference acoustic power

10^{-12} w



Noise, addition of sources

Addition of two sources of the same power, increase of 3 dB

The perceptible difference is not proportional to the increase in sound power.

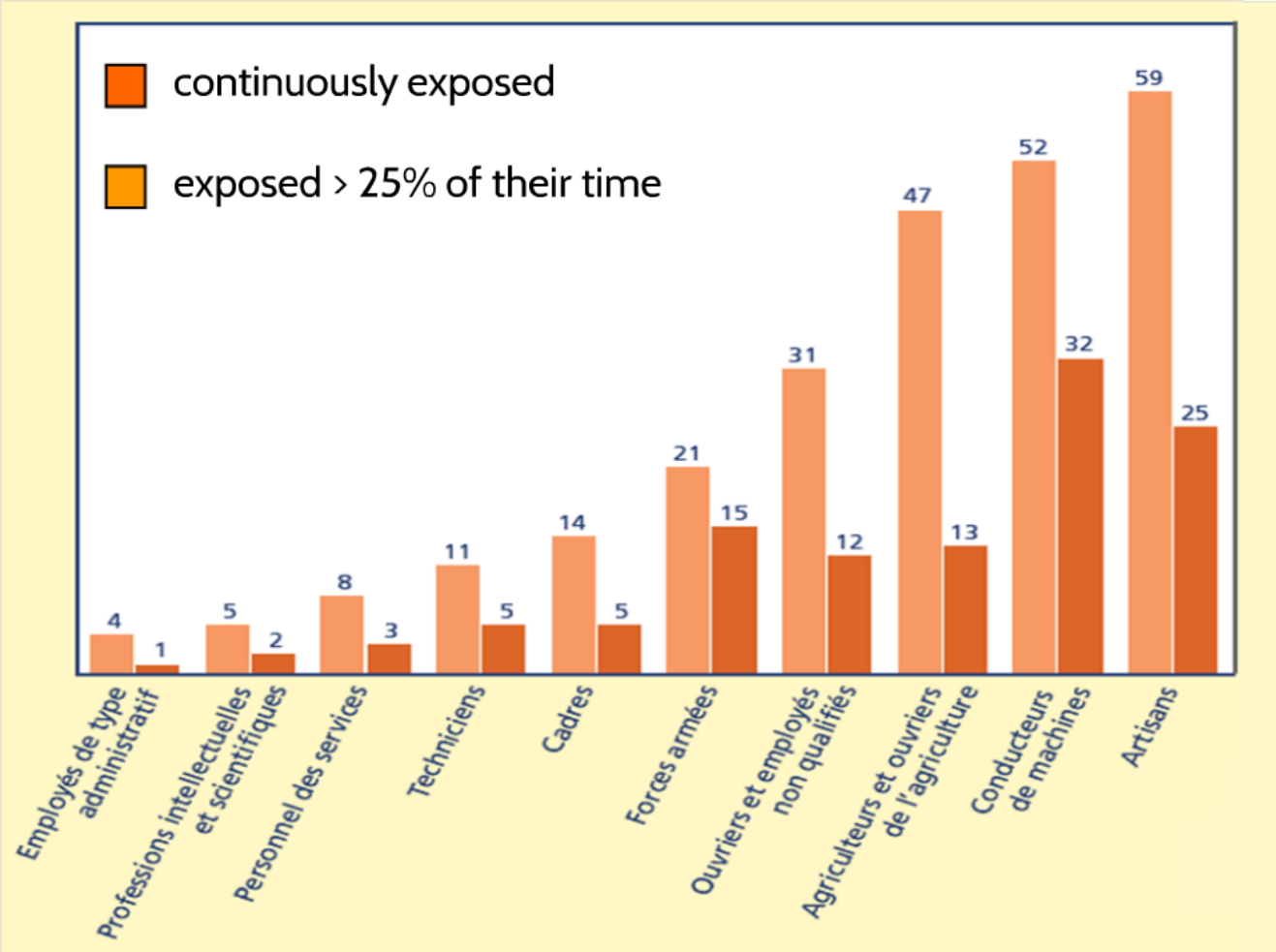
Increased perception	Noise level increase	Nbre of sources (noise power)
2 x louder	+ 10 dB	 x10
Significantly louder	+ 6 dB	 x4
Barely perceptible	+ 3 dB	 x2
Reference	+ 0 dB	 x1

General formula for noise addition

$$L_{tot} = 10 \log [10^{L1/10} + 10^{L2/10} + 10^{L3/10} + \ldots\ldots] \text{ dB}$$

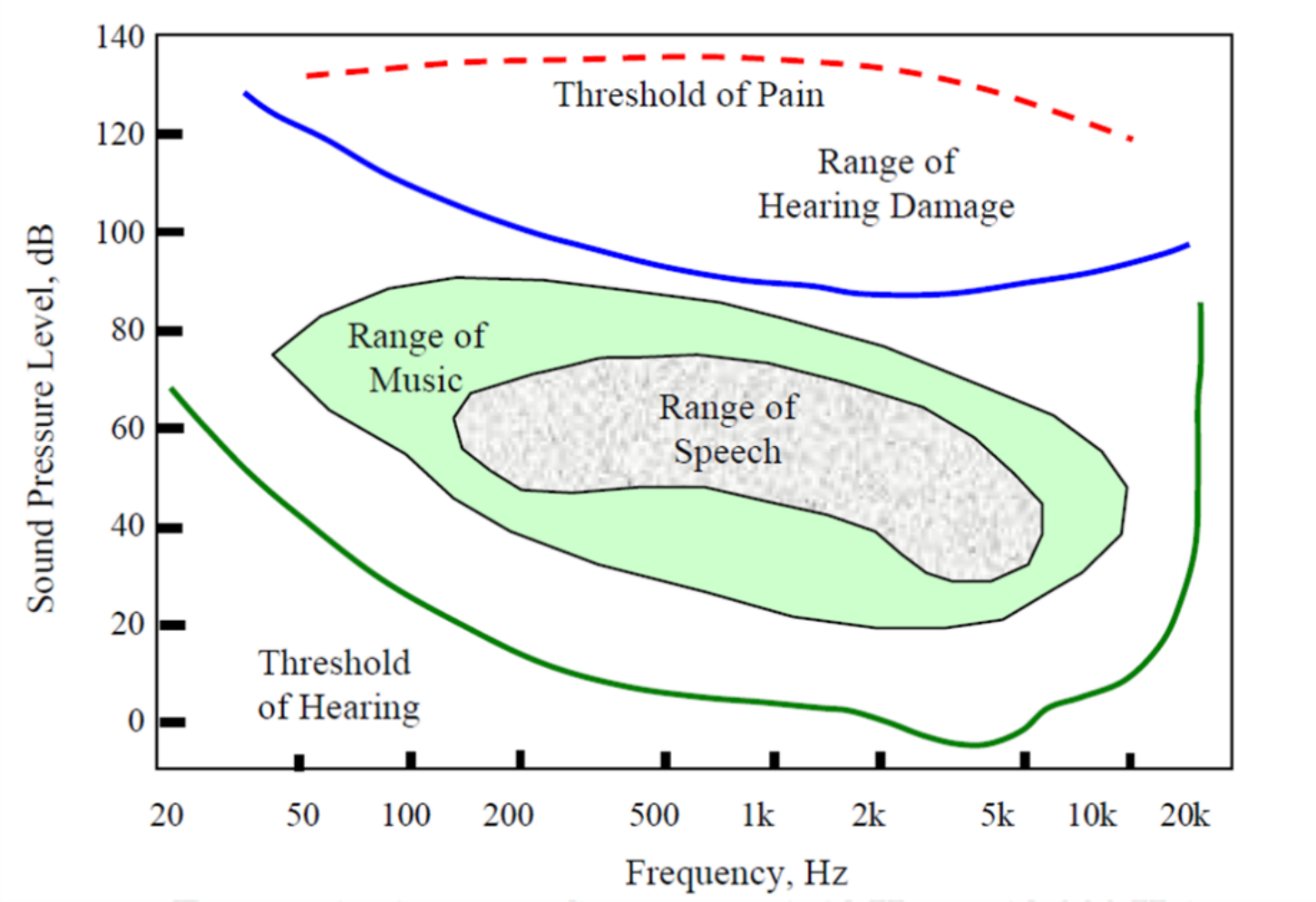
Exposure to noise

Percentage of EU workers exposed to noise, by category of workers (2000)



Audible frequencies

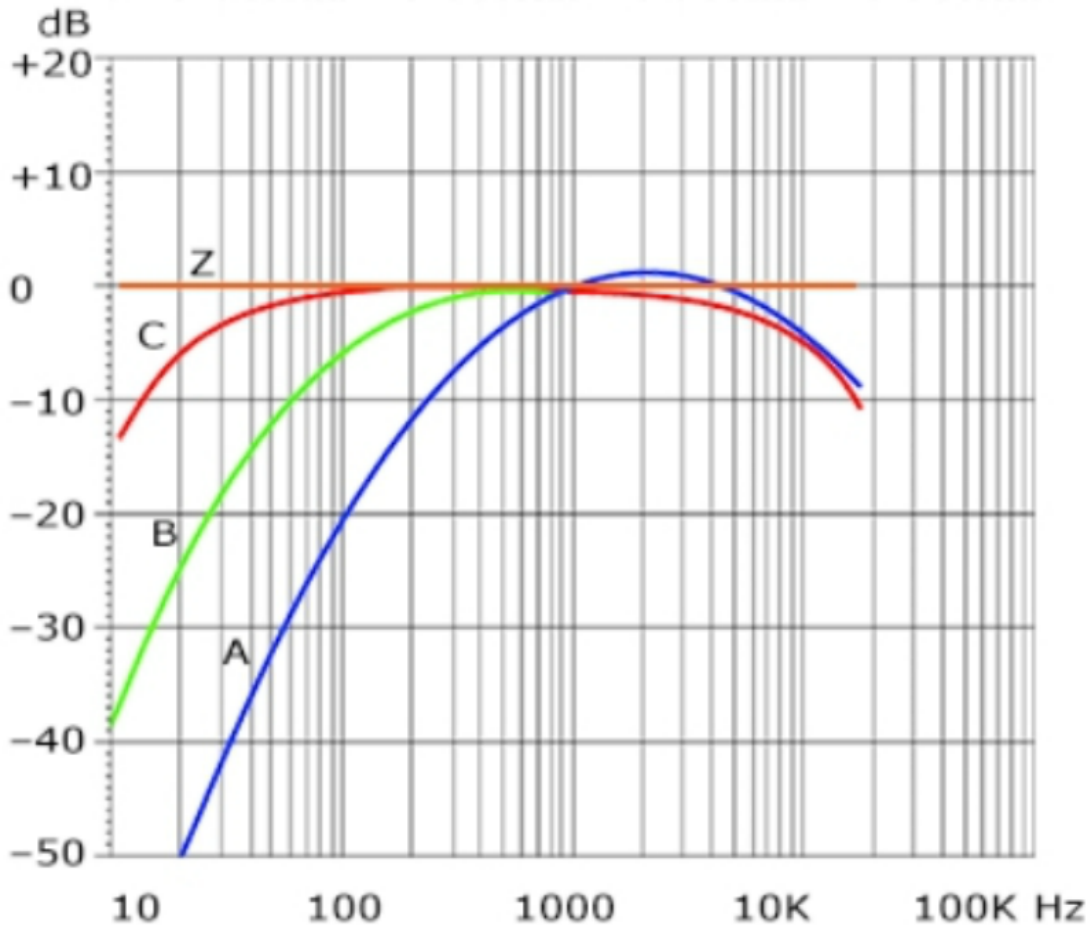
The human ear (intact) hears sounds going from 20 to 20'000 Hz



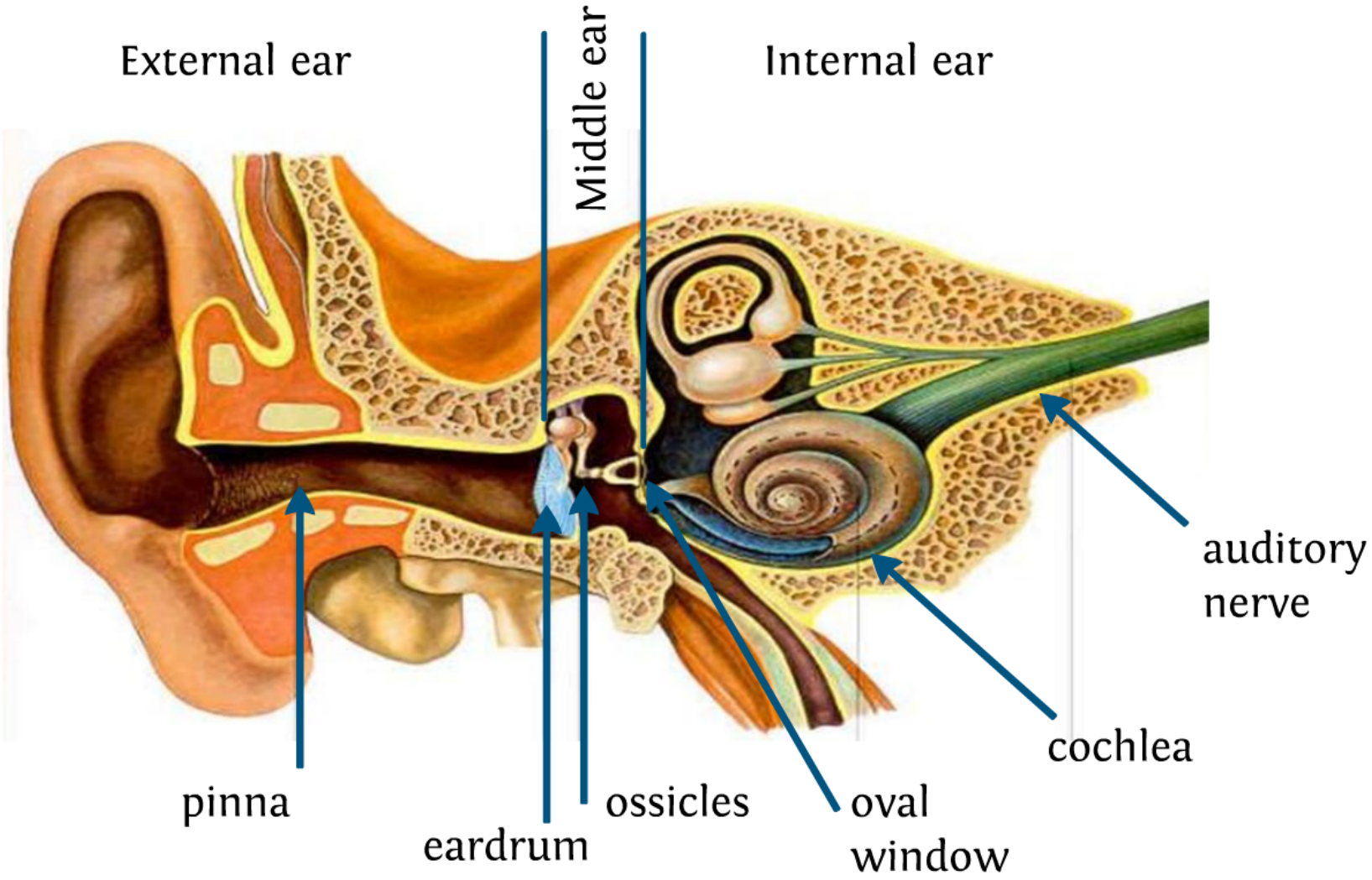
Acoustic weighting

Weighting filters

- Filters A-C, sensitivity of human ear
- Z zero filter

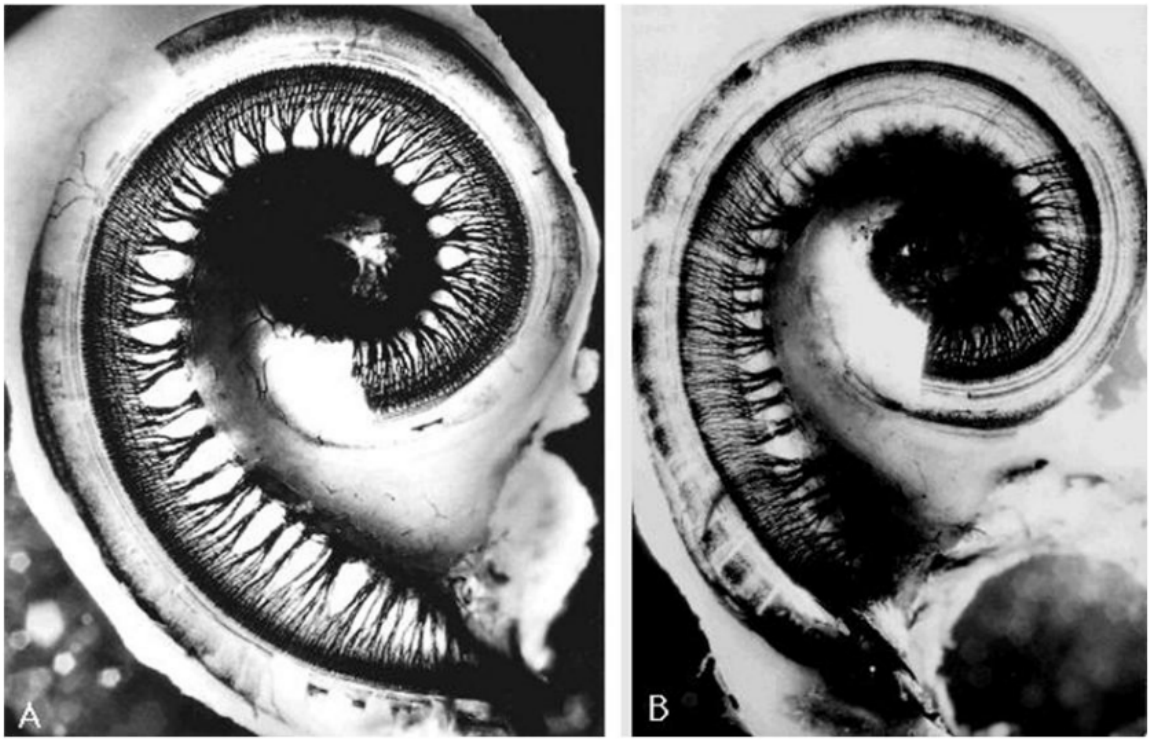


Detection by ear



Damage to the inner ear

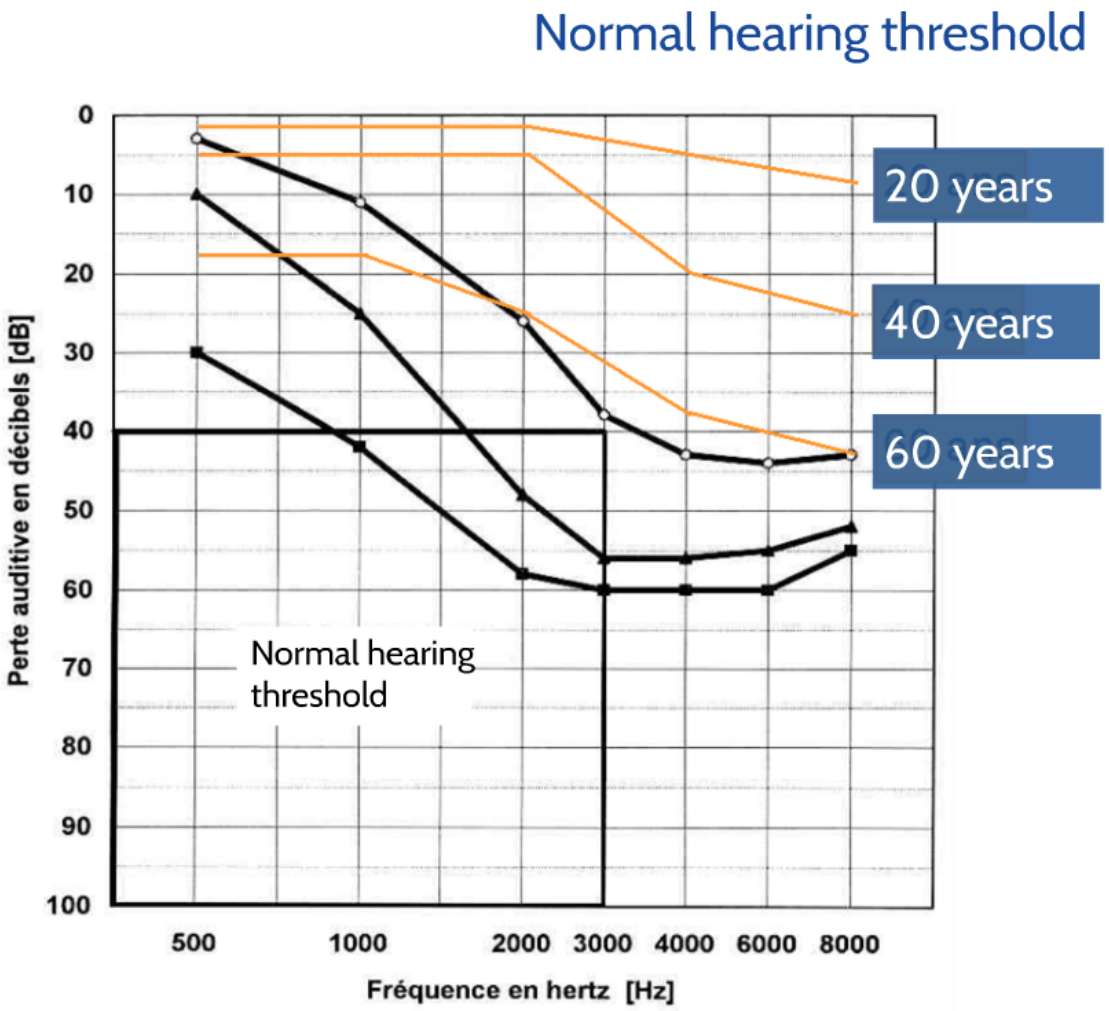
Progressive destruction of the cilia lining the cochlea (loss of hearing in certain frequency ranges)



Audiogram

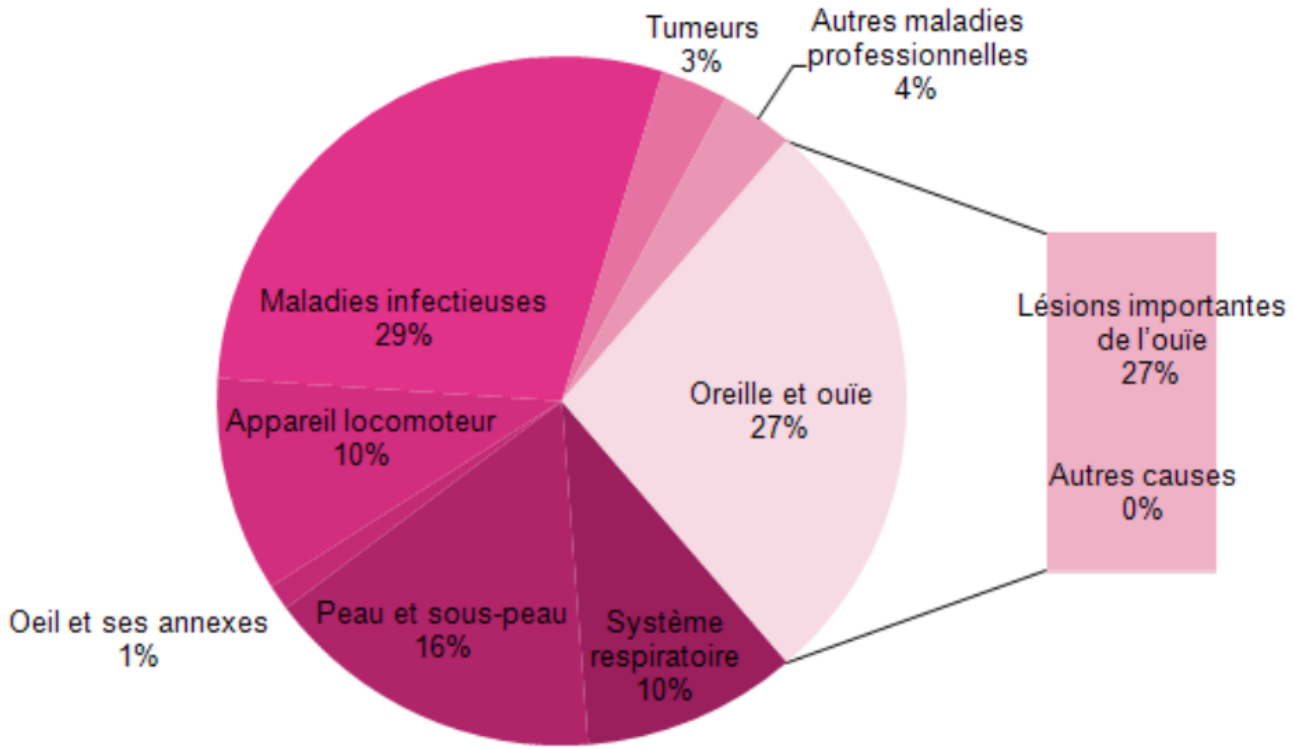
Hearing acuity decreases with age (presbiacusis)

Regular exposure to noise › 80 dB(A) also causes a decrease in hearing acuity



Noise, an occupational risk factor

Recognized occupational diseases (2010)



Ototoxiciy

Agents that are toxic to the sensory organ of hearing or potentiate the effects of noise exposure.

Effects

- Poisoning of the outer hair cells
- Symptoms identical to noise exposure, no specific tests

Evidence

- Epidemiological, animal

Substances

Aromatics:

Toluene, styrene, ethylbenzene

Carbon monoxide, hydrocyanic acid [P]

Antibiotics

Diuretics, salycilates, anti-tumor agents [R]

[P] potentiating
[R] reversible

Noise, permissible limits

Noise disturbance (Suva requirements and OLTr 3 recommendations)

Activities	normal requirement Leq [dB(A)]	increased requirement Leq [dB(A)]
industrial activities, arts and crafts	< 85	< 75
office work and similar activities	< 65	< 55
intellectual activities requiring great concentration or creativity	< 50	< 40

Immediate and temporary effects

- cardiovascular disorders, decreased attention, decreased memory capacity, agitation, reduced visual field, gastrointestinal disorders

Long-term effects

- physical and nervous fatigue, insomnia, bulimia, chronic high blood pressure, anxiety, depressive and aggressive behavior...

Noise measurement

Sound level meters
- average sound level (Lm)

Integrating
- equivalent sound level (Lequ)

Dosimeters
- noise dose (%)

Frequency analyzers
- spectral analysis

Average and equivalent level

Average level

$$L_m = 10 \cdot \log\left(\frac{1}{t_m} \cdot \int_0^{tm} \frac{p^2(t)}{p_0^2} dt \right) [dB]$$

Integrated time measurement

If we compare it to a reference time (often 8 hours), we call it the equivalent level (Leq)

Equivalent level

$$L_{éq} = 10 \log_{10}\left(\frac{1}{100} \cdot \sum f_i \cdot 10^{\frac{Li}{10}} \right)$$

L_{eq} : equivalent sound level in dB(A)
F_i : time interval expressed in % of the reference period
L_i : sound level in dB(A)

Dose of noise

Percentage of acoustic energy relative to the tolerated energy in the workplaces (corresponding to 85 dB(A) during 8h).

A dose greater than 100% indicates that the permissible limit has been exceeded.

$$ND = 100 \int_0^{T/8} \left| \frac{P(t)}{0.355} \right|^n dt$$

P(t) : sound pressure [Pa] weighted at time t
T : duration of exposure [hours]
0.355: pressure [Pa] corresponding to 85 dB(A)
N: 2 (ISO) or 1.2 (USA)

Noise control

Reduce the emission

machines, quieter processes

Reduce transmission

insulation against vibrations, damping

Eliminate the hazard

Noise control

Reduce transmission

- hooding

Limit exposed areas

- subdivide the premises
- concentrate sources
- Limit the propagation on the building ceilings and walls

Noise control

Work organization
- limit the duration of exposure
- job rotation

Individual protection
- information, marking
- protective equipment
- medical prophylaxis

Isolate the Source

Vibrations


Vibrations, exposure of the active population
Vibrations, limit values
Pathologies related to hand-arm (mano-brachial) vibration
Effects on target organs
Exposure situations
Vibrations
Vibrations, definitions

Vibrations, definitions

Three possibilities to express a vibration

- displacement [m]
- velocity [m/s]
- acceleration [m/s2]

$$A_{rms} = \sqrt{\frac{1}{T}\int_0^T A^2(t)dt}$$

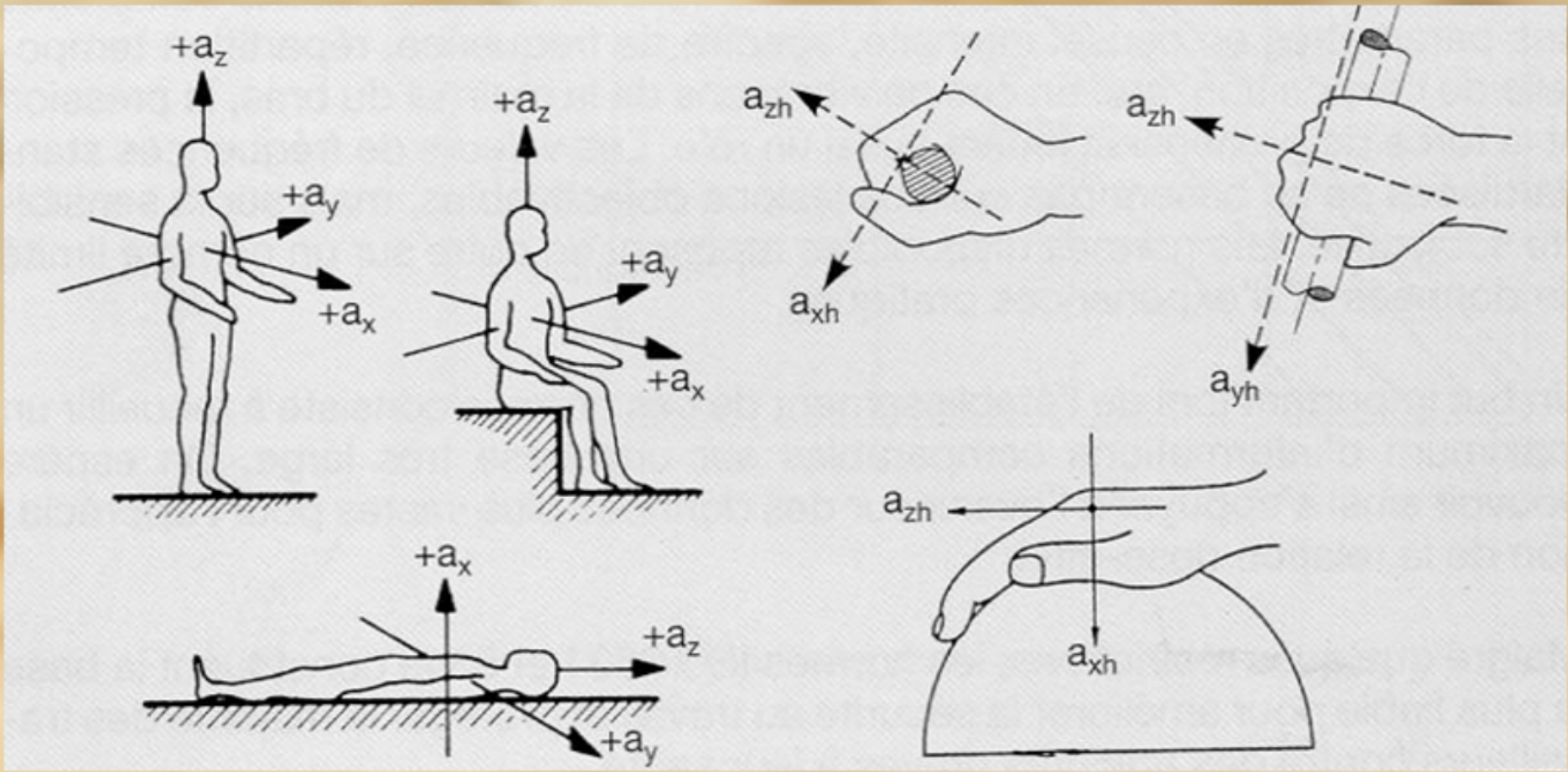
$$A = (2\pi f)^2 D$$

Vibrations are measured with accelerometers along the three conventional axes

- x: horizontal ”front - back
- y: horizontal ”left - right
- z: vertical

Vibrations

Measurement axis conventions for body and hand



Exposure situations

Whole body vibration: logging tractor

- 2-8 Hz, 0.4-2 m/s2 occasionally (tolerated 0.8 m/s2)

Hand-arm vibration: handheld machines (sander, router, jigsaw, grinder, etc.)

- 4-800 Hz, 1-15 m/s2 occasionally

Effects on target organs

Frequency	Effect
Low: 0.5-16 Hz	motion sickness, spinal injuries, neurovegetative disorders
Medium: 10-80 Hz	osteoarticular lesions of the upper limbs
High: 80-1000 Hz	peripheral vascular lesions (Raynaud's syndrome or dead fingers), neuromuscular lesions

Pathologies related to hand-arm (manubrachial) vibration

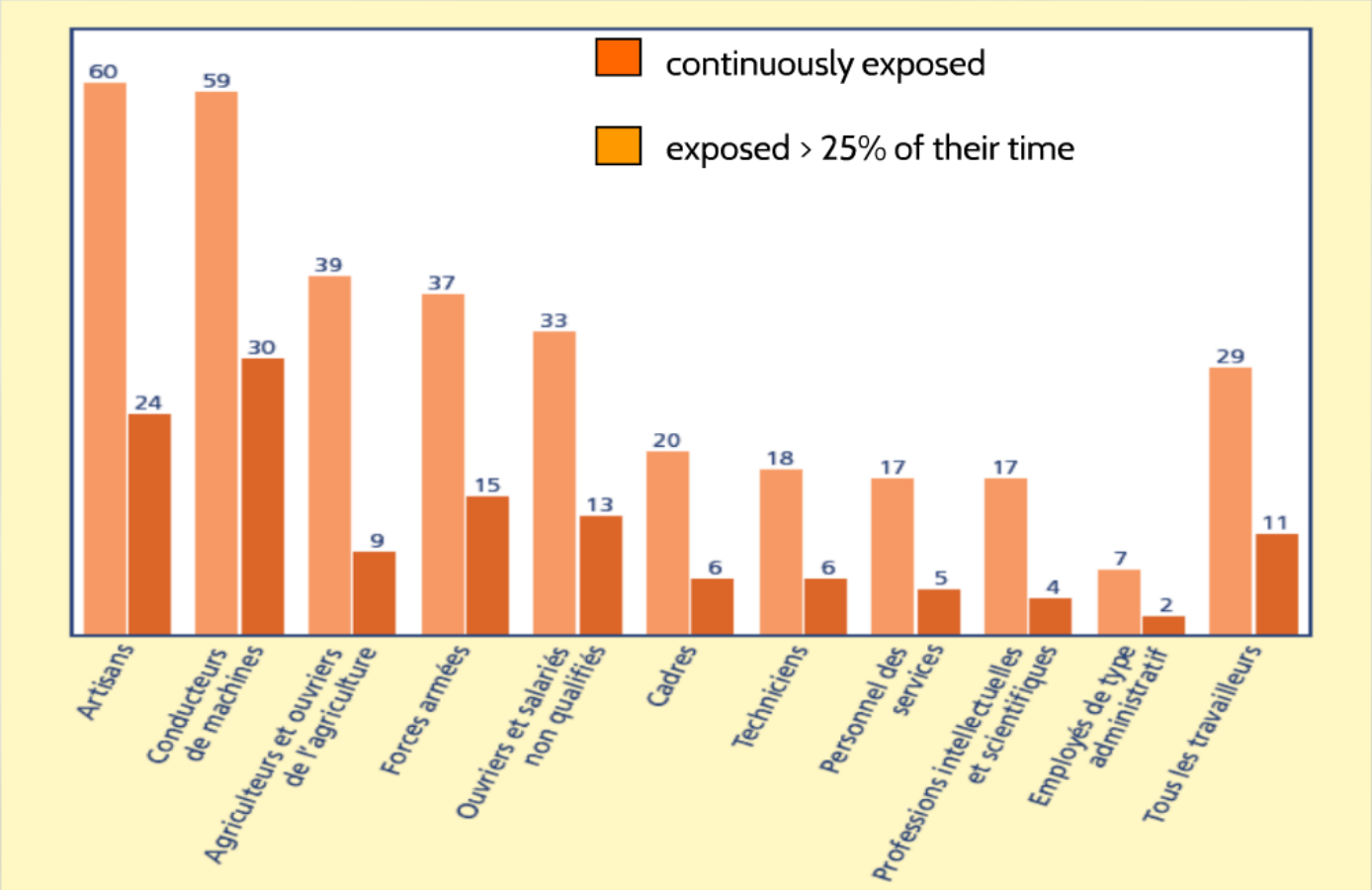
Vascular diseases
- Vibration syndrome (Raynaud's disease), vascular damage

Neurological disorders
- vibration neuropathy, loss of sensitivity

Osteoarticular disorders
- joint pain, loss of mobility

Vibrations, exposure of the active population

Percentage of EU workers exposed to noise, by category of workers (2000)



Vibrations, limit values

European Directive 2002/44/EC of 25.06.02
Hands - arms and whole body
Occupational exposure : 8 h/d and 5 d/wk

	action values	exposure limit values
manubrachial	2.5 m s^{-2}	5.0 m s^{-2}
total body	0.5 m s^{-2}	0.8 m s^{-2}