Hearing protection

ELEC-E5640 - Noise Control P

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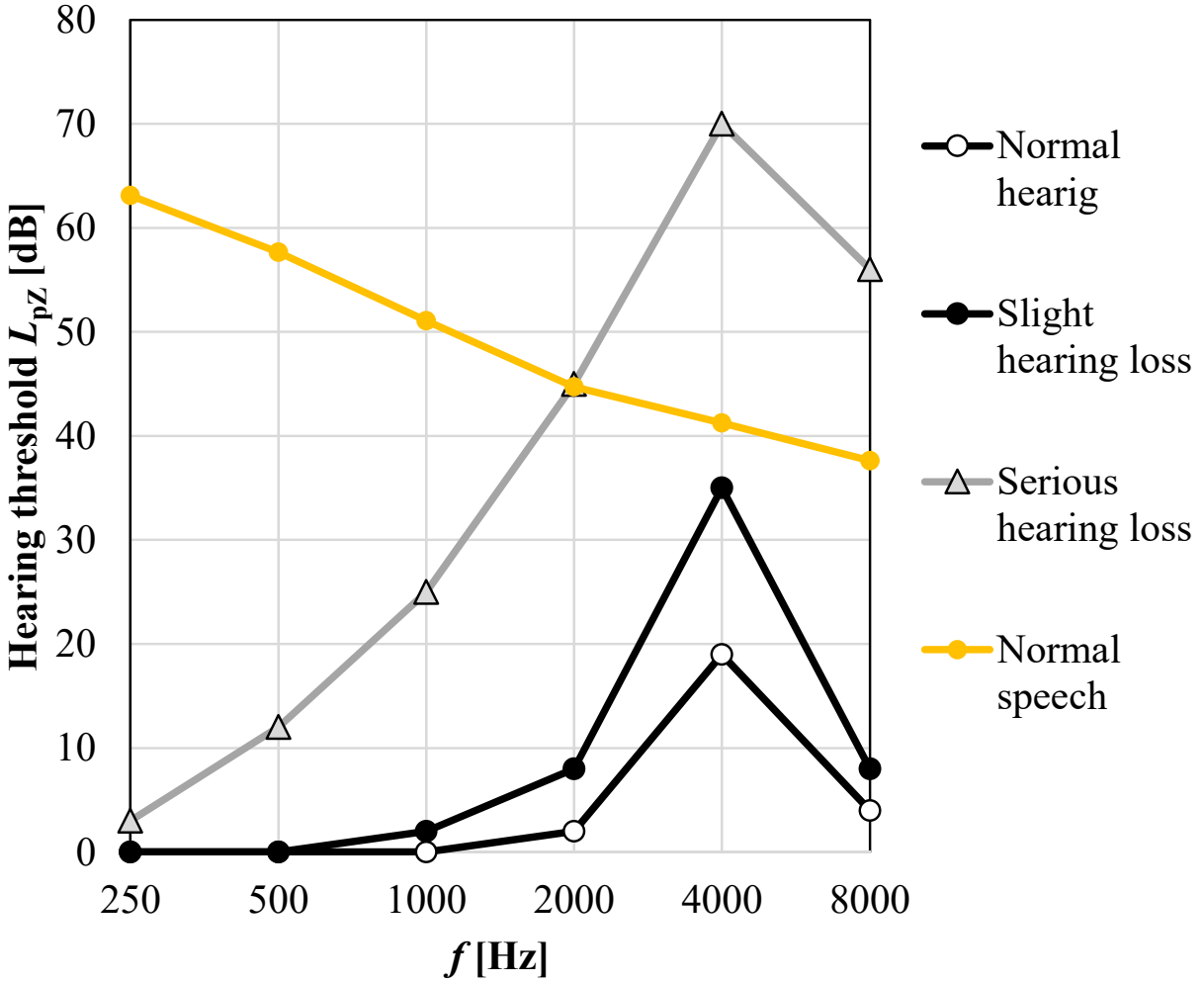
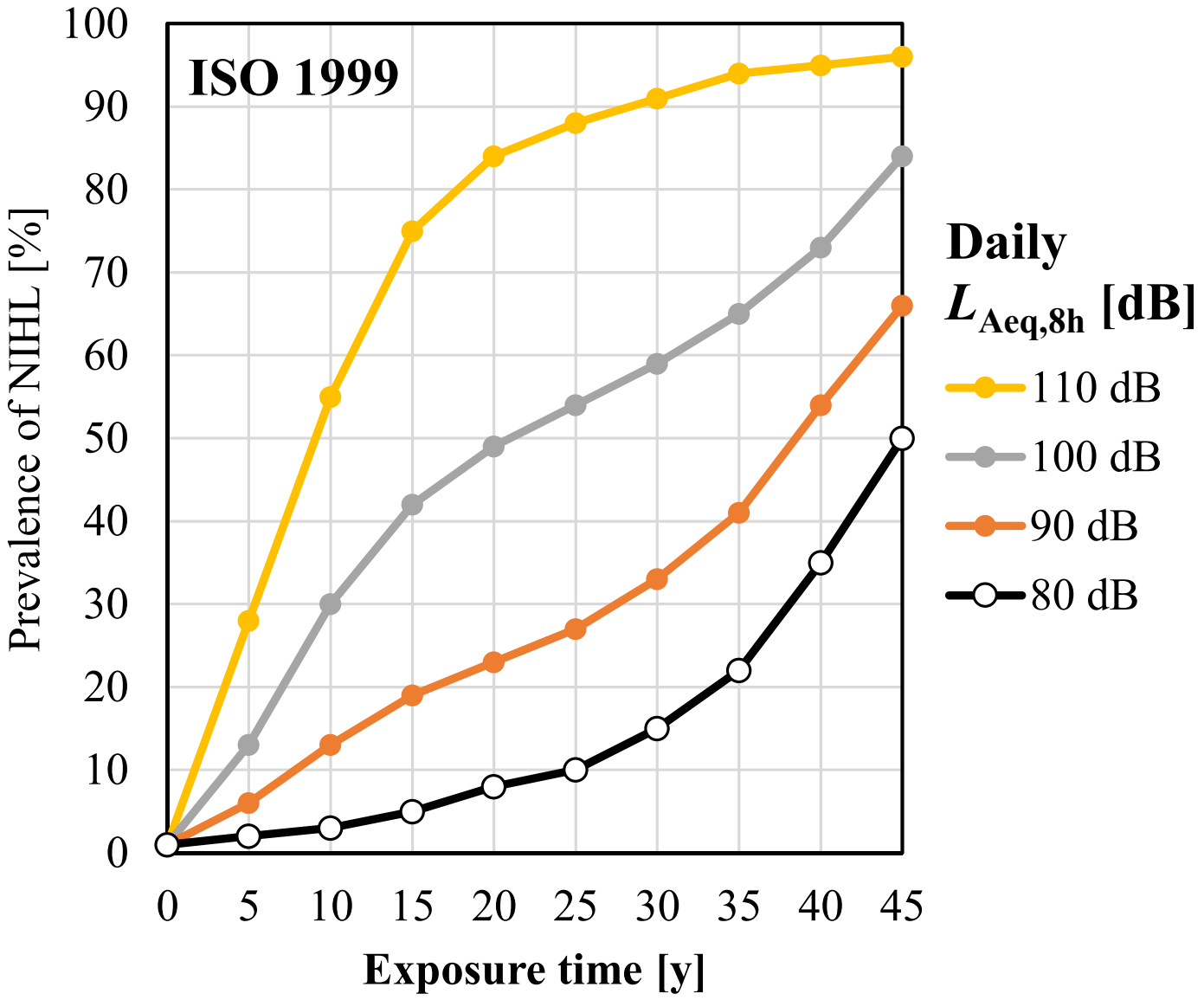
Noise-induced hearing loss - NIHL

- Hearing is normal if the hearing threshold is less than 20 dB within 250-8000 Hz.
- NIHL can be observed as a notch in hearing threshold at 4 kHz
- Serious hearing loss makes normal communication difficult due to reduced speech intelligibility.
- NIHL is usually preceded by temporary hearing loss
- NIHL is also associated with tinnitus



Risk of NIHL

- Present threshold level for launcing noise control measures in workplaces, 80 dB L_{Aeq8h}, is based on the lowest curve: less than half of the population should get NIHL after 45-year work exposure.



Regulated values of workplace noise exposure in Europe

	$L_{A,eq,8h}$ [dB]	$L_{A,eq,40h}$ [dB]	$p_{C,peak}$ [Pa]	$L_{C,peak}$ [dB]
Lower exposure action values	80	80	112	135
Upper exposure action values	85	85	140	137
Exposure limit values*	87	87	200	140

* Exposure is determined in ear channel.

The effect of hearing protector and utilization rate must be considered.

Valtioneuvoston asetus 85/2006 is based on 2003/10/EC.
English: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0010&from=EN.
Finnish: http://eur-lex.europa.eu/legal-content/FI/TXT/PDF/?uri=CELEX:32003L0010&from=EN

Regulated values of workplace noise exposure in Europe

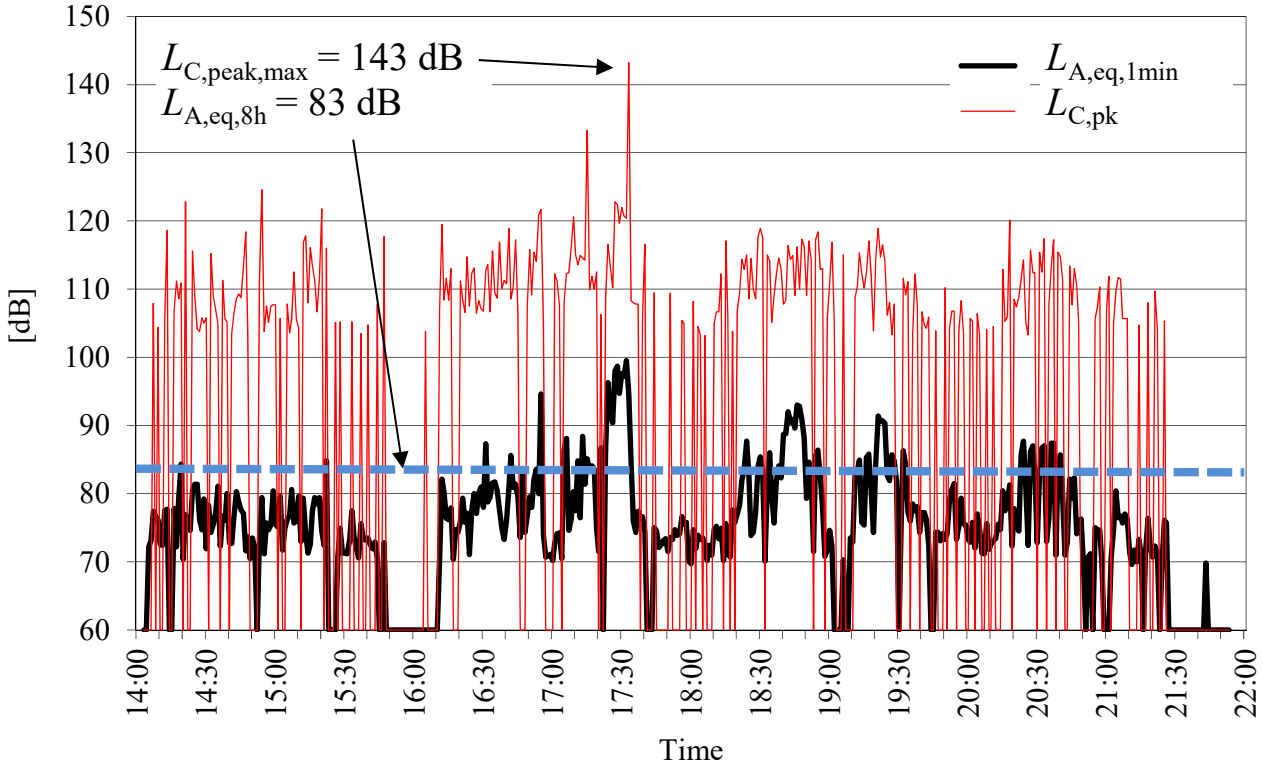
Noise exposure exceeds	Sanctions to the employer
Lower exposure action value	® Personal hearing protectors shall be available for employees. ® Information and education must be given to employees about noise protection.
Upper exposure action value	® Employees must wear hearing protectors. ® Noise areas shall be marked. ® Noise control program shall be developed to reduce noise exposure.
Exposure limit value	® Exceedance shall be prevented immediately. ® Preventive actions.*

* If NIHL is observed, the preventive actions must be reconsidered.

- **Noise control program**: use of low-noise methods and machinery, adequate hearing protectors, noise reducing materials, screens and enclosures, reduction of noise exposure time and training about noise control.

Measurement of noise exposure

- $L_{EX,8h}$=L_{Aeq8h} is the main quantity to be measured
- Continuous monitoring near to ear channel outside protectors
- Monitoring time depends on the variation within a day
- If the daily exposure varies, weekly exposure is estimated

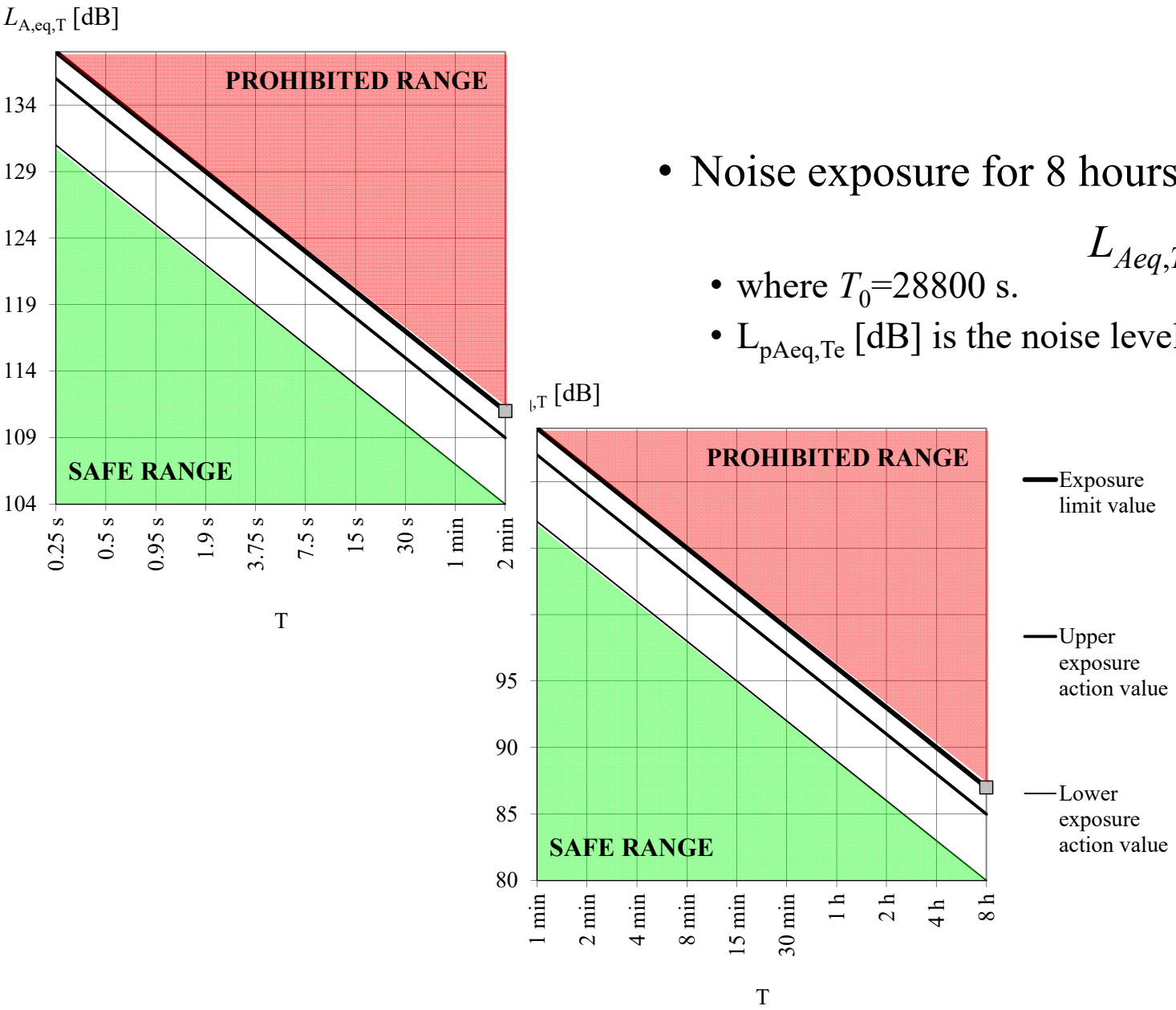


Safety limits

- Noise exposure for 8 hours is

$$L_{Aeq,T_0} = L_{Aeq,T_e} + 10\lg\left(\frac{T_e}{T_0}\right)\text{dB}$$

  - where T_0=28800 s.
  - $L_{pAeq,Te}$ [dB] is the noise level during time T_e [s]



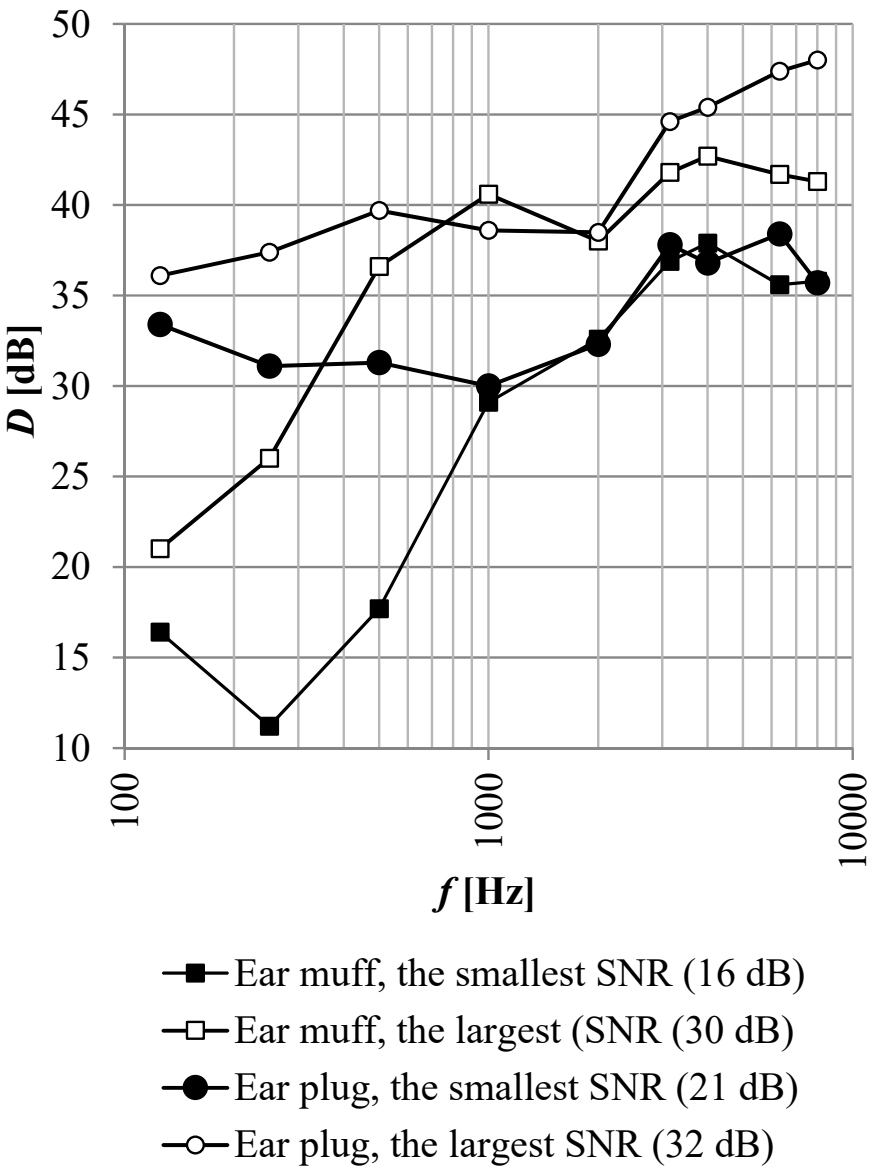
Basics of hearing protection

- Protectors are available between 10 and 40 dB noise reduction
- Too large noise reduction may reduce utilization rate due to discomfort
- Dimensioning: 70–80 dB L_{Aeq} inside the ear channel
- Nominal noise reduction of a protector is achieved with correct wearing and 100% utilization rate
- Inappropriate wearing of protectors can reduce noise reduction significantly:
  - ear muffs 3–6 dB
  - ear plugs 5–13 dB
- Training can improve the actual noise reduction of ear plugs by several decibels
  - proper mounting, 100% utilization rate

Some protector types

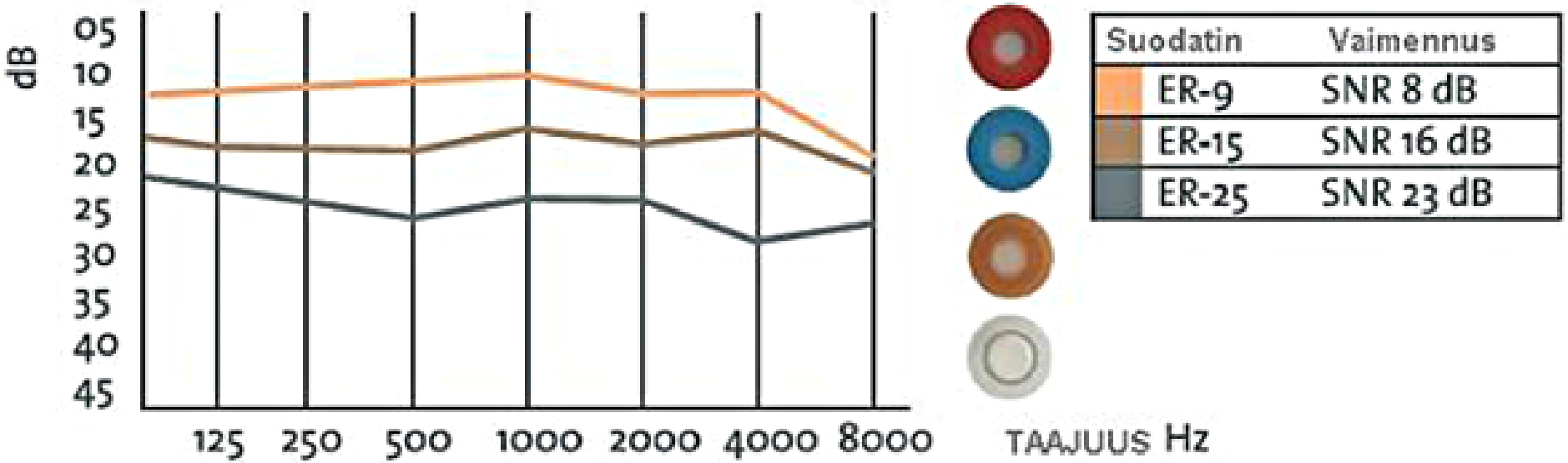
- Ear muffs
- Ear plugs
- Ear muffs with
  - radio, auxiliary input, Bluetooth
  - communication unit and peak sensor (hunters)
- Active noise control in
  - ear muffs
  - ear plugs
- Helmet
- Individually shaped ear plugs
  - Enable flat frequency responses
- Double protection
  - plug + helmet
  - plug & muff

Values declared by a single manufacturer



Individually shaped ear plugs

- DEMO http://www.elacin.fi/tuotteet/tarvikkeet/item/er-suodattimet



Dimensioning of protectors

- Desired level inside the protector is L'_A=75±5 dB.
- Dimensioning methods
  - Octave band method (accurate)
  - HML-method
  - SNR-method (simple) →

$$L'_A = L_C - SNR$$

STAR Kuulonsuojain
Hörselskydd

Suojain täyttää standardin EN 352-1 (SFS-EN-352-1) vaatimukset
Skyddet uppfyller fordringarna i standarden EN 352-1 (SFS-EN-352-1)

Taajuus Frekvens Hz	125	250	500	1000	2000	4000	8000
Keskiarvo Medelvärde dB	8,5	13,9	20,7	22,8	31,1	30,8	32,4
Sf/dB	2,9	2,1	1,9	2,0	4,0	1,7	2,3
APVf/dB	5,6	11,8	18,8	20,8	27,1	24,1	30,1

VIRTACO SAFE

E. VIRTA & CO Oy

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Karjalankatu 2 C, 00520 Helsinki, ☎ 90-148 5445, Telefax 90-148 2715

SNR: 23
H: 27 M: 20 L: 13

Paino/Vikt: 160 g

Sangan puristusvoima/Bygelns fjäderkraft: 11,5 N
Paine päätä vastaan/Tryck mot huvudet: 3,2 KPa

OCTAVE BAND METHOD

$$L'_A = 10\lg\sum_{i=1}^{7} 10^{(L_{Z,i}+A_i-APV_i)/10}$$

- $L_{Z,i}$ [dB] is the linear SPL in the room
- A_i [dB] is A-weighting
- i is the octave band index (125–8000 Hz)
- APV_i [dB] is the assumed protection value
- L_C [dB] is the C-weighted total SPL in the room

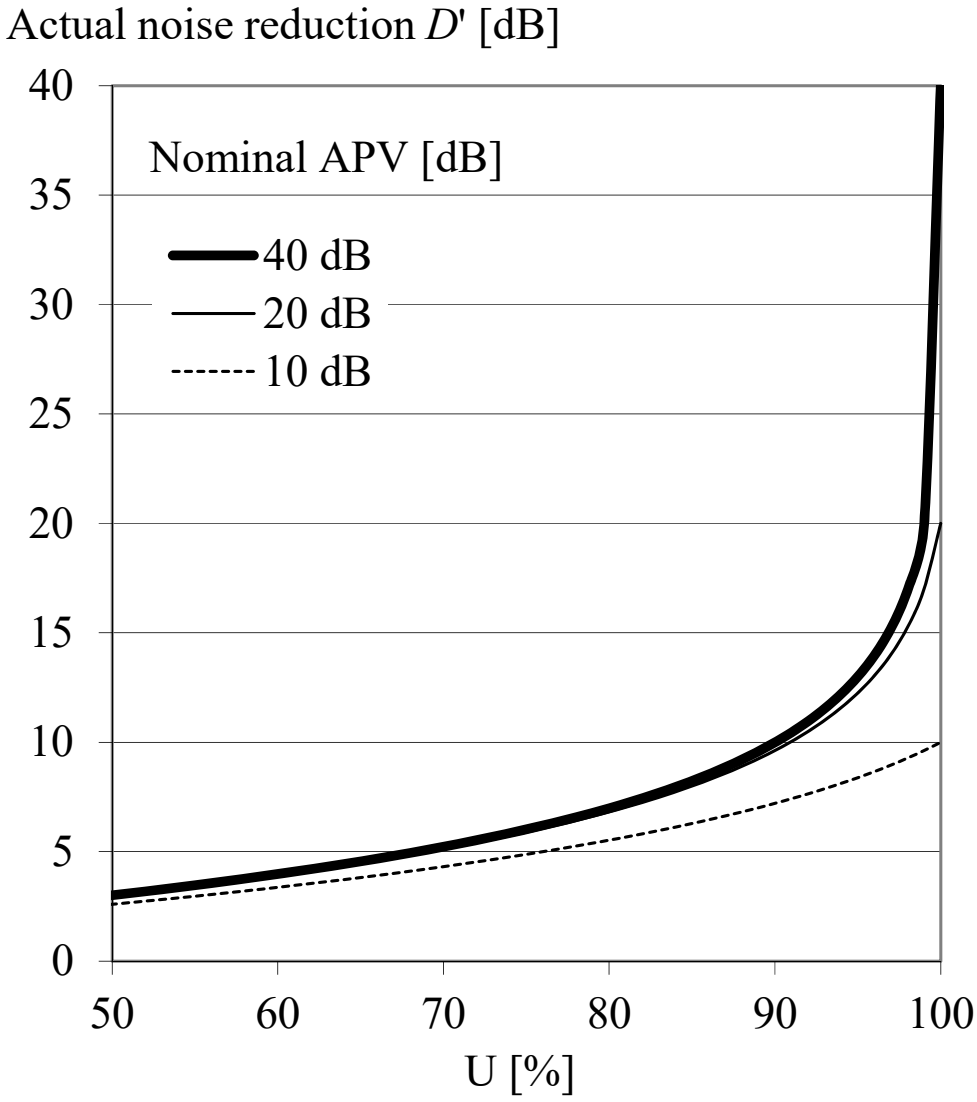
Utilization rate

- *D*’ [dB] is the actual noise reduction for a *T*=8 h working day when the protector’s utilization time is T_D

$$D' = 10\lg\left[\frac{1}{T}\left(T_D 10^{-D/10} + T - T_D\right)\right]$$

  - *D* [dB] is the nominal protection (APV)
- Increased user comfort and knowledge about NIHL increase utilization rate.
- Utilization rate *U* [%] is

$$U = 100\frac{T_D}{T}$$

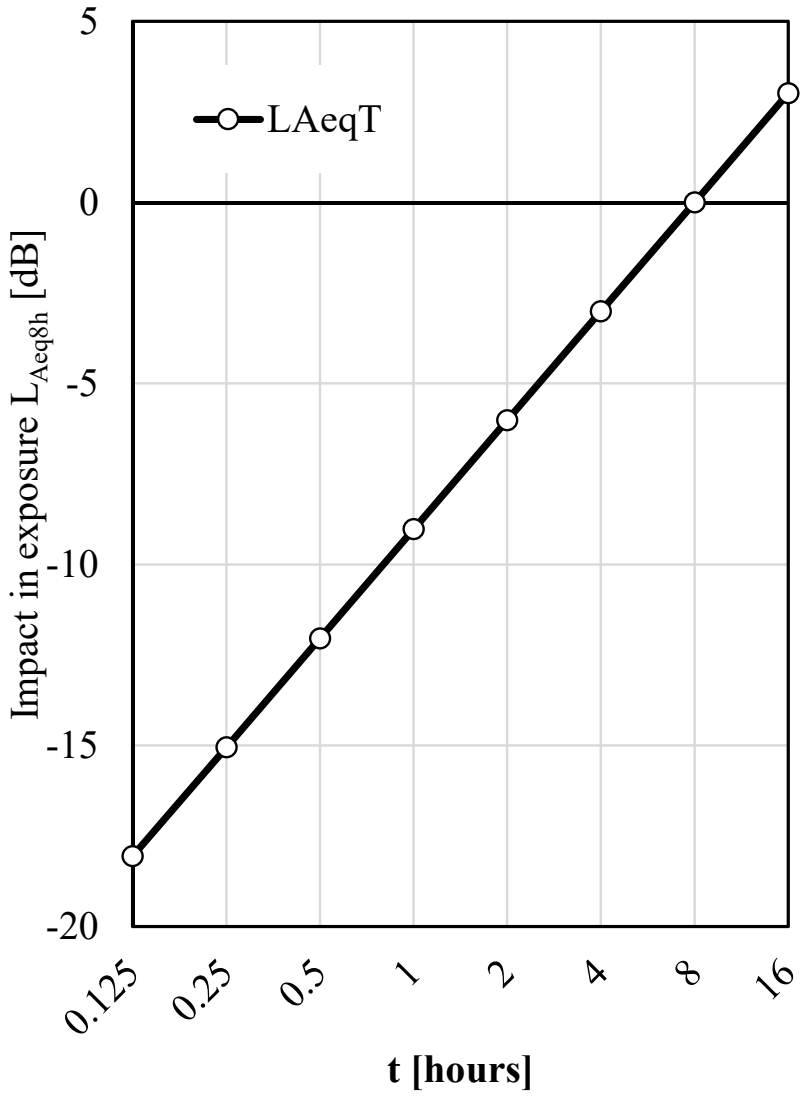


Limitation of noise exposure

- In some places, noise level is very high so that $L_{A,eq,8h}$=87 dB is exceeded even after wearing the best possible hearing protectors 100% of time.
- Limitation of noise exposure to time t is applied in such situations

$$L_{A,eq,T} = L_{A,eq,t} + 10\log_{10}\frac{t}{T}$$

  - T=8 h



Study on headphones with ANC

- Headphones with ANC are known to reduce noise up to 500 Hz. Most of speech is above 500 Hz. Are they efficient then in environments where speech is main noise source?
- Purpose was to determine how well closed headphones with active noise canceling reduce ambient speech. More specifically, does the STI reach 0.20 inside headphones which is the limit of confidential privacy and provides full concentration
- Speaker produced standard real speech to reach 50 dB L_{Aeq} in listener position outside headphones.
- Background noise level of the room was 40 dB L_{Aeq}
- Sound masking (brown noise) was produced in one condition from the headphones.

Conditions:

1 – Without headphones

2 – With Headphones, ANC off

3 – With headphones, ANC on

4 – With headphones, ANC on, masking on

Acoustic results

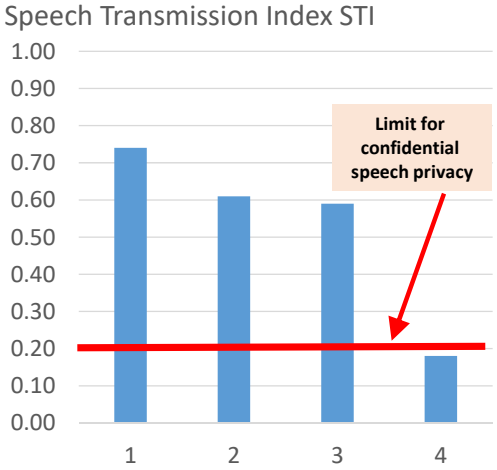
Conditions:

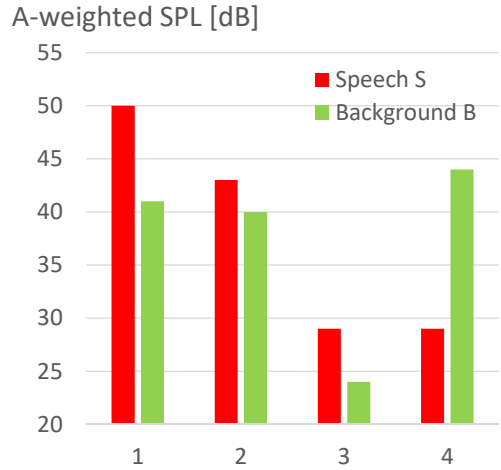
1 – Without headphones

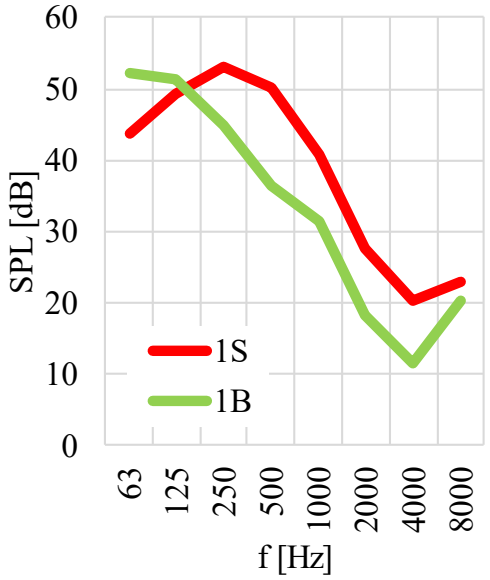
2 – With Headphones, ANC off

3 – With headphones, ANC on

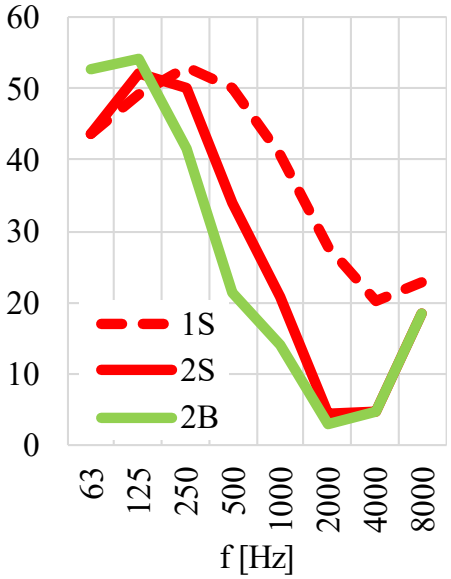
4 – With headphones, ANC on, masking on



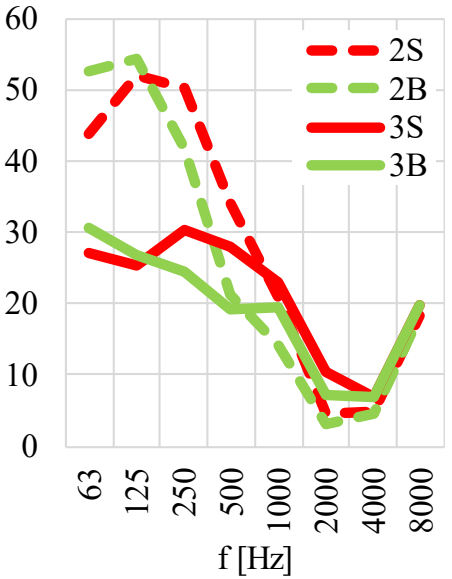




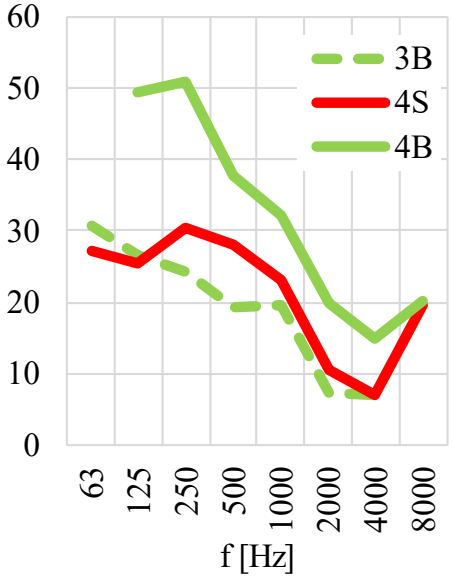
SNR is high.
Speech privacy low.



SNR is still positive.
Speech privacy low.



Levels below 1 kHz get down.
SNR is still positive.
Speech privacy low.



SNR is negative.
Overall noise level is 44 dB
while it was 50 dB with speech.