

Headphone Noise: Occupational Noise Exposure Assessment for Communication Personnel

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Background



- Headphone-sound risk rarely taken into account
- Large number of workers subjected to this risk
- Many of them do complain about the problem
- The risk of hearing loss appears to be directly connected with the occupational profile of these workers, and consequently the employee is responsible of it

Details :

- Risk assessment by advanced measurements techniques based on the usage of a mannequin (dummy head with binaural microphones)
- Proper post-processing ensures that the noise exposure of the workers is evaluated with the same rating as other “normal” types of occupational noise, which are measured far from the body of the worker.

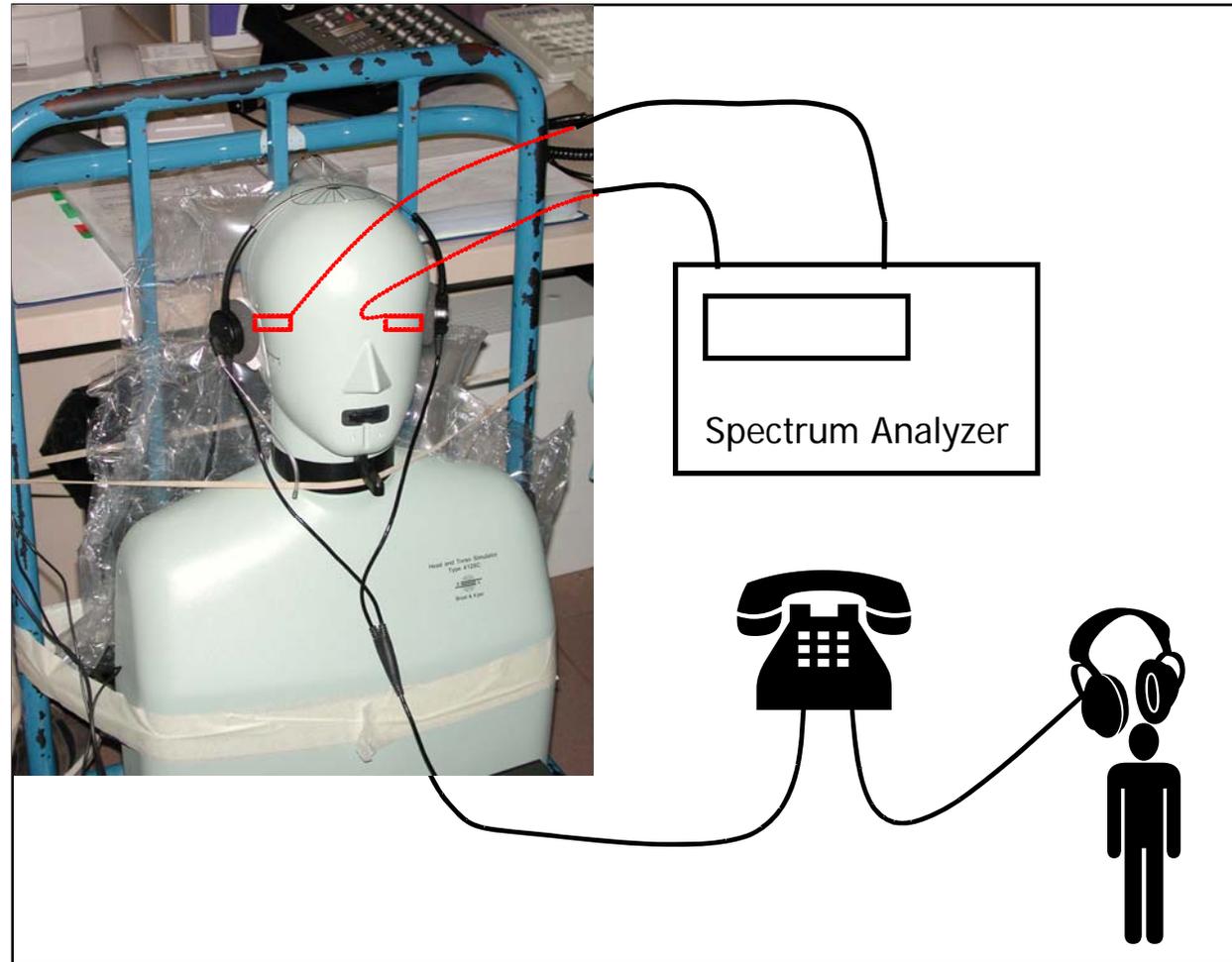
Law and technical standards



- In Italy the law which rules the occupational noise control is D.L. n° 277 (1991)
- This law specifies to make measurement far from the body of the worker, for avoiding modification of the sound field, but in the same position where the ears of the worker happen to be during the normal exposure.
- This of course is completely unapplicable to the case of sound produced by external or in-the-ear headphones
- This topic is covered by two preliminary standards:
 - ISO/DIS 11904-1 (2000). "Acoustics - Determination of sound immissions from sound sources placed close to the ears - Part 1: Technique using microphones in real ears (MIRE-technique)"
 - ISO/DIS 11904-2 (2000). "Acoustics - Determination of sound immissions from sound sources placed close to the ears - Part 2: Technique using a manikin (manikin-technique)"

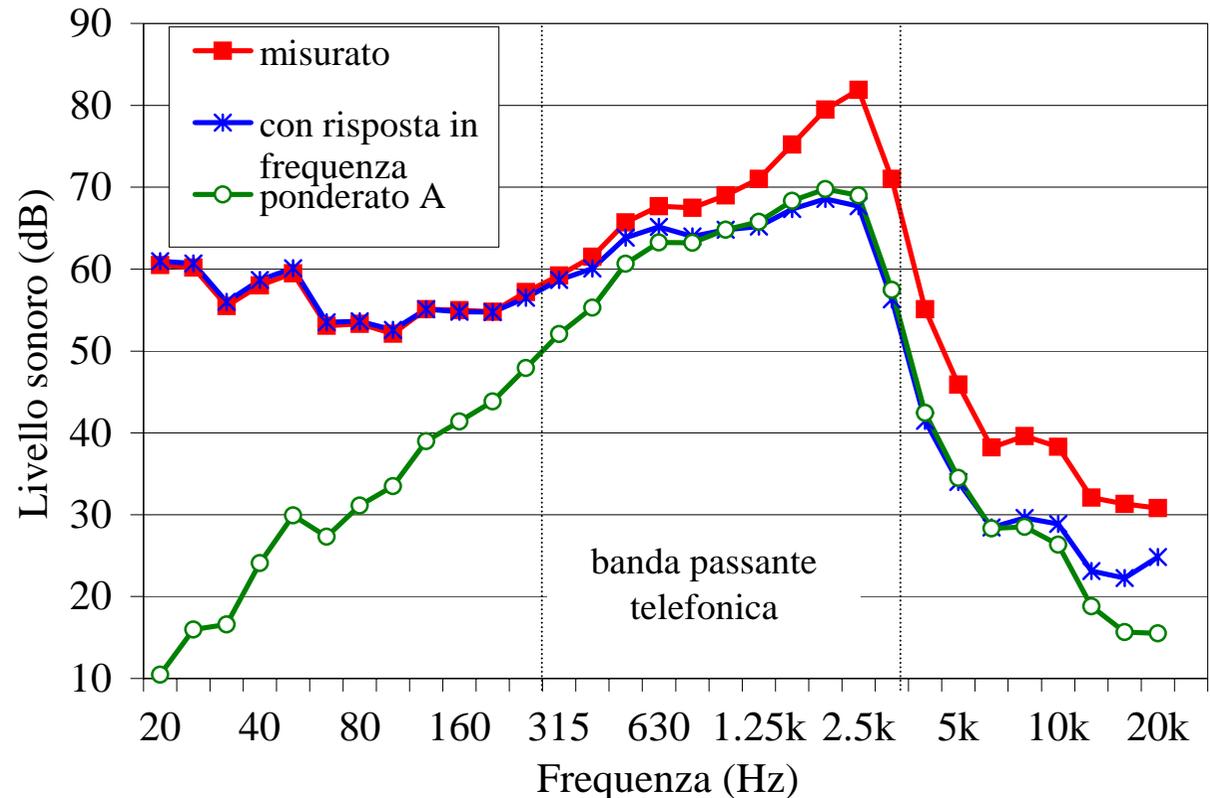
Outline of the method

- Measurement through the microphones of a dummy head
- The headphone is connected in parallel with a second unit, being weared by the operator
- An 1/3 octave spectrum of the equivalent level is measured at each ear for the whole exposure period
- From the measured spectrum it is possible to derive a correspondent far-field noise spectrum, which would create the same spectrum at the ear of the mannequin.
- This means to remove the head-related transfer function



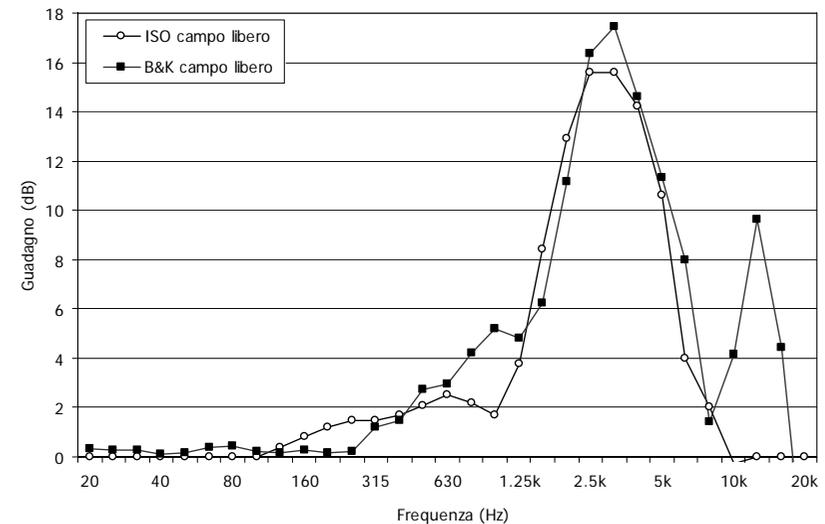
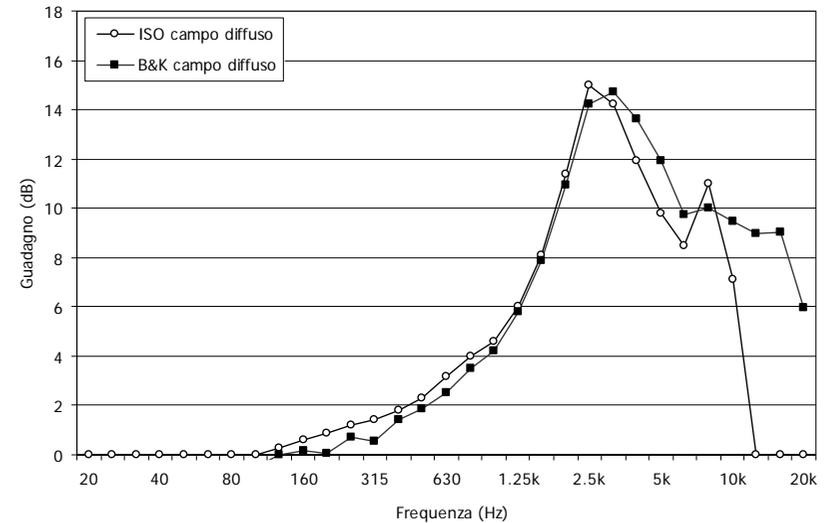
Spectral correction

- 1/3 octave spectrum measured through a dummy head
- Subtraction of the head-related transfer function
- The A-weighted total value is computed from the modified spectrum
- This A-weighted total value represents the “normal” noise exposure of subject immersed in a soundfield capable of creating the same effects inside the ears as the sound generated by the headphones



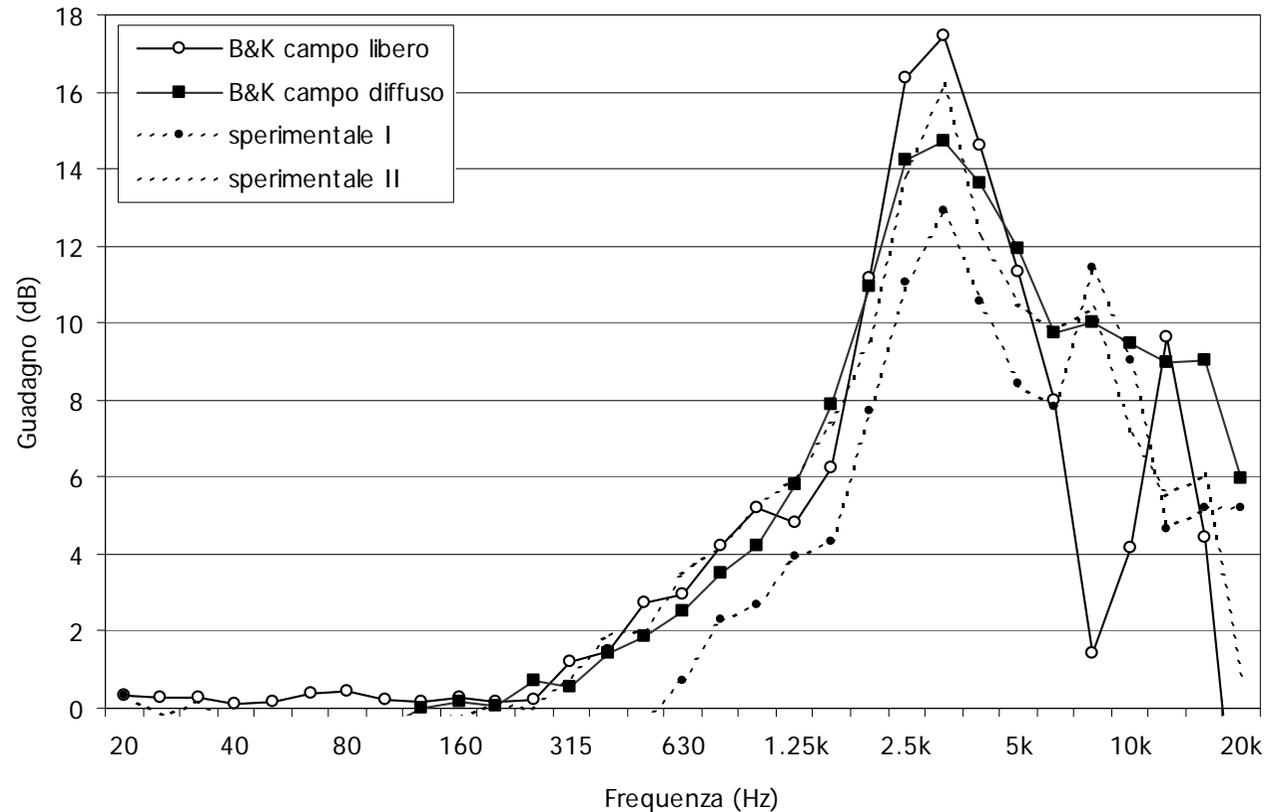
The head-related transfer function

- Diffuse field and free field
- Values suggested by the ISO 11904-II standard
- Values declared by the manufacturer (B&K type 4128)
- The manufacturer's data where verified in anechoic chamber



What HRTF is better?

- The experimental verification has shown differences even greater than those between the declared data and the ISO values
- But in practice, applying any of these 6 different curves to the measured spectra, cause limited variations of the estimated far-field equivalent A-weighted noise level
- These variations were always less than 1 dB(A) for the worst cases, meaning that in practice the usage of any of these HRTF spectra is acceptable.



Instruments employed

- Bruel & Kjaer type 4128 head and torso simulator (equipped with 2 ear simulators)
- Larson Davis LD-2900 dual-channel, real-time, 1/3 octave spectrum analyzer
- B&K type 4230 reference sound source
- Outline ET-1 electronic turntable
- PC equipped with an Echo Layla sound card and employing the software tools Cool Edit Pro and Aurora.

Experimental results

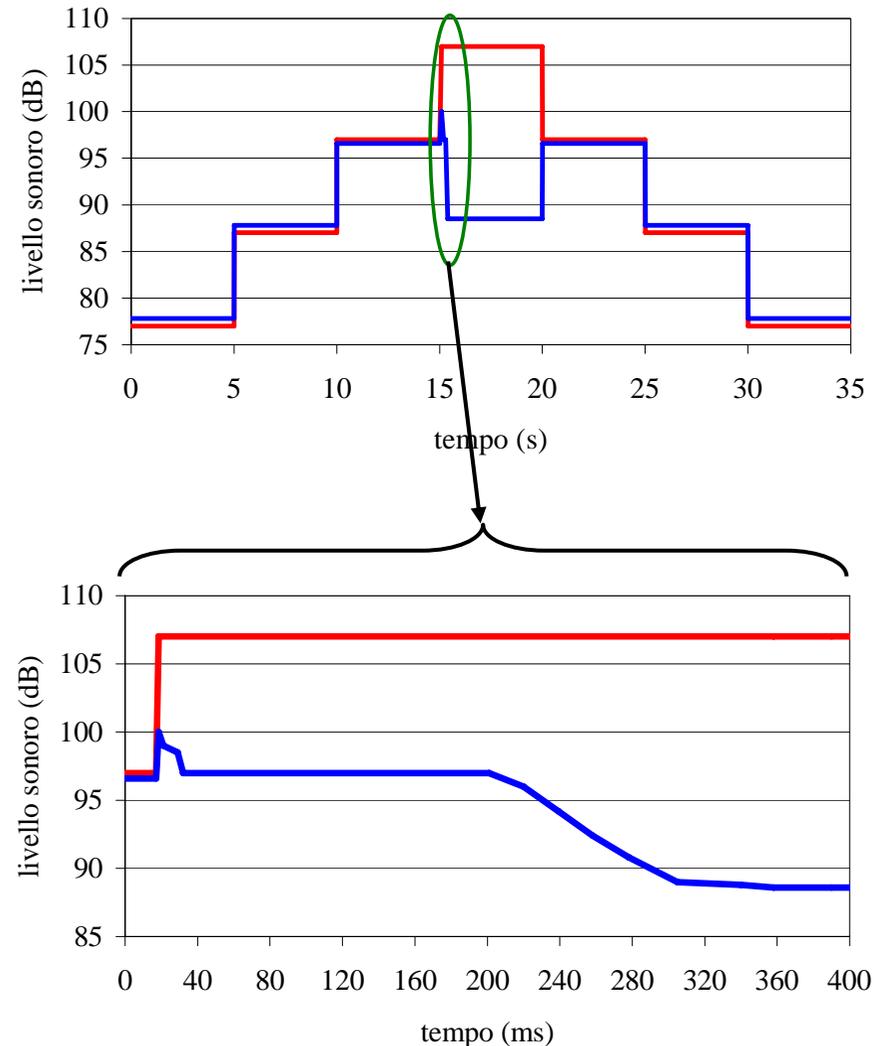
- 49 workplaces, 96 measurements, total averaging time : 17 h

Far-field equivalent Sound Pressure Level (dBA)

<i>Workplace</i>	<i>Dispositivo</i>	<i>Volume</i>	<i>Min.</i>	<i>Avg.</i>	<i>Max.</i>
Newspaper	Hand headset	fisso	58	67	80
	Siemens headset	fisso	62	67	76
	Headphones	regolato	50	63	73
Call center	Hand headset	fisso	74	77	79
	Headphones	volume I	70	72	74
		volume II	76	78	81
		volume III	80	82	84
	In-ear	volume I	76	77	79
		volume II	77	80	83
		volume III	82	84	87
Call center	Headphones with limiter	volume I	68	70	73
		volume II	74	75	76
		volume III	75	76	77
Phone bank	Headphones with limiter	regulated	68	73	77

Headphones with limiter

- The electronic circuit automatically reduces the gain when the sound exceeds a predefined value
- The response time is less than 10ms
- After 200ms, a further gain reduction is applied



Conclusions



- Literature does not report cases of deafness due to exposition to headphone sound.
- Nevertheless, the experimental values reported here show that in some cases the workers are subjected to potentially risky sound pressure levels ($L_{Aeq} > 80$ dBA).
- Consequently, some risk-reductive actions are to be taken:
 - Employment of headphones equipped with active electronic limiter
 - Reduction of the background noise (this makes it possible to select a lower listening volume, still ensuring good intelligibility)
 - Instructing the personnel to proper usage of these electronic devices and to adopt a proper behavior, aimed to the reduction of the exposure to harmful sound levels
- The methodology developed allows for the periodic evaluation of the risk and for the assessment of the exposure reduction obtained.