Low Frequency Noise and Wind Turbines

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Hayes McKenzie Partnership

BWEA 26 8th July 2004

What is Low Frequency Noise?

- Normal Hearing Range : 20 - 20 kHz
- Low Frequency Range : 20 - 160 (250) Hz
- Infrasound Range : < 20 Hz

Why are Wind Farms and Low Frequency Noise an Issue?

- Complaints received from neighbours to three operational wind farms;
- Complainants claim that low frequency noise is leading to health effects.

Advice and Guidance

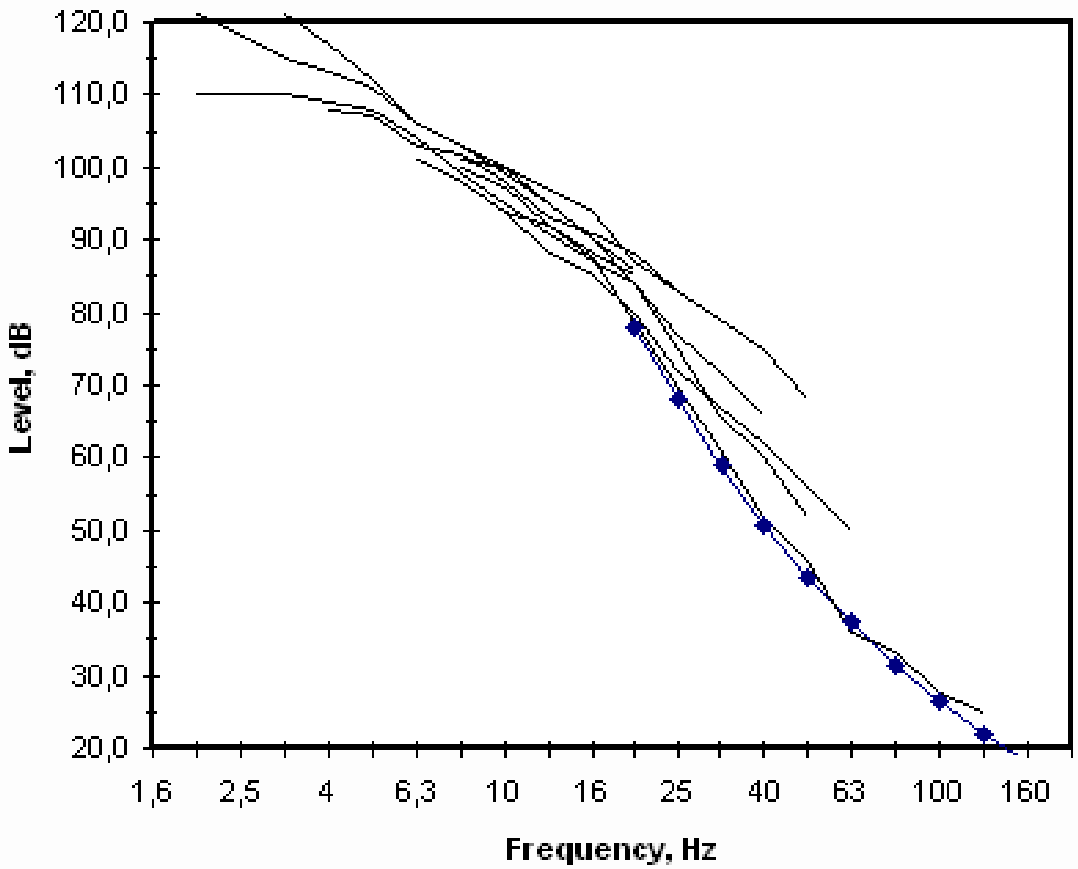
- DEFRA Reports
- Casella Stanger Report : Low Frequency Noise : Technical Research Support for DEFRA Noise Programme : 2000
- A Review of Published Research on Low Frequency Noise and its Effects : May 2003
- No British Standard dealing with LFN

Casella Stanger Report
Low Frequency Noise

From about 10 Hz to 200 Hz
covers low frequency noise.

All the low frequency noise range is audible, although high levels are required to exceed the hearing thresholds at the lower frequencies

Low Frequency Hearing Threshold



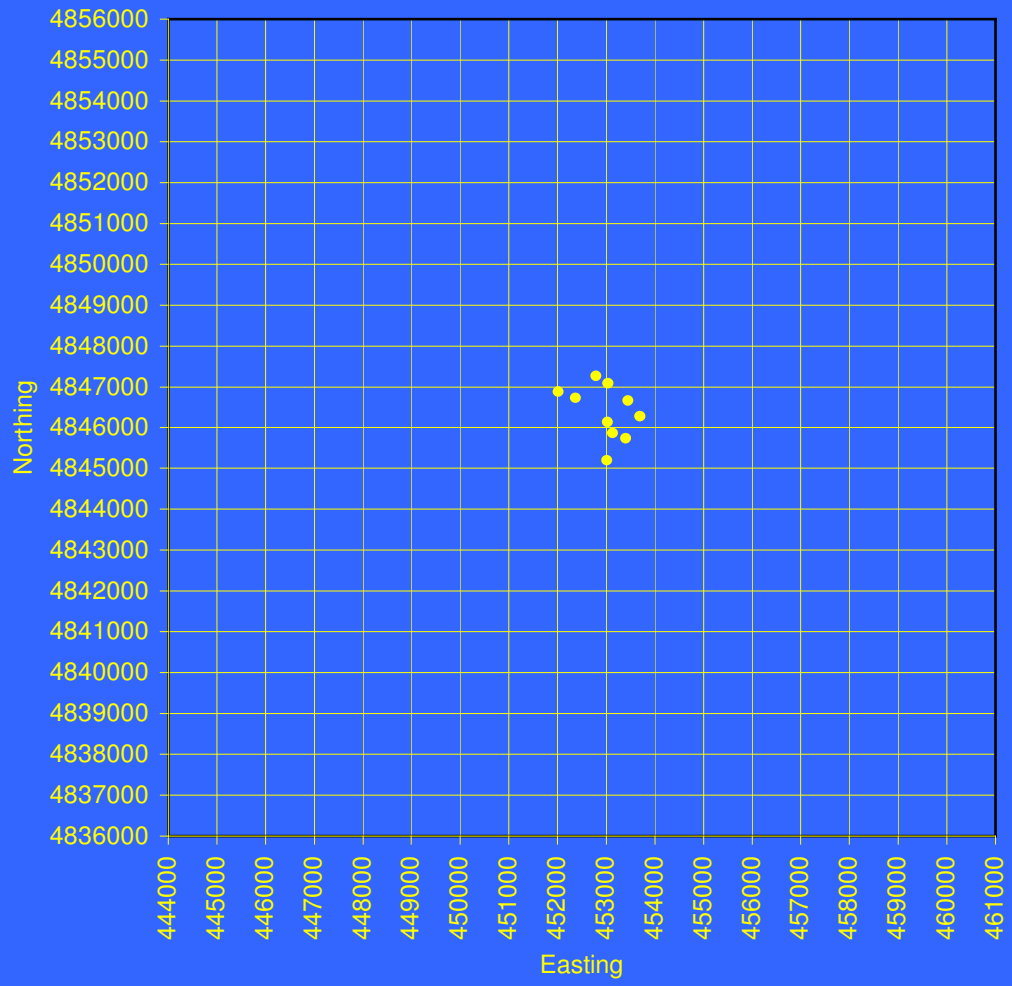
Factors relevant to LFN Propagation and Perception

- Effects of atmospheric attenuation;
- Effects of sound attenuating properties of buildings;
- Resonance within rooms;
- Deterioration of hearing with increasing age;
- Possible “sensitive” persons

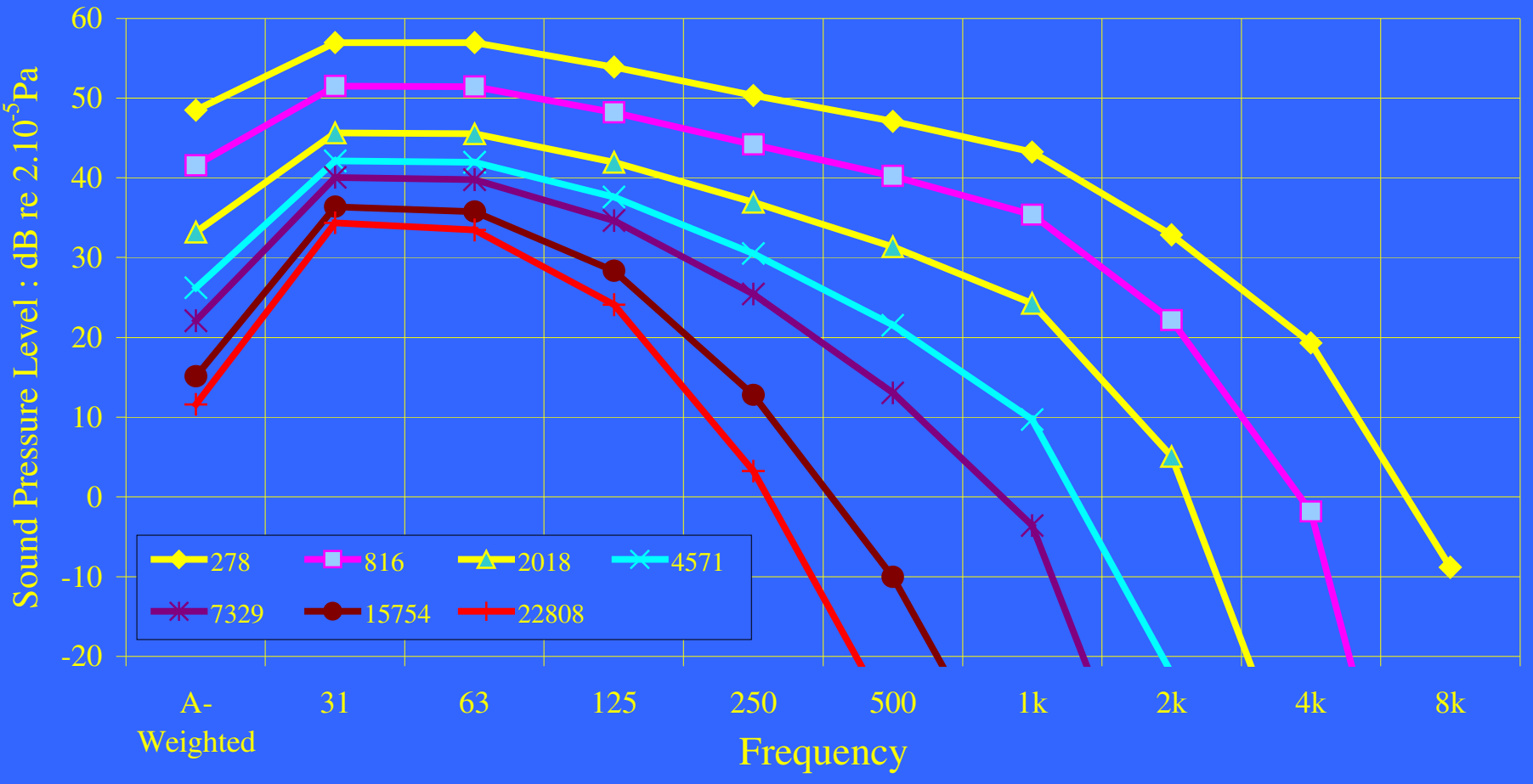
Effect of Atmospheric Absorption

- Mid and High Frequencies more readily absorbed
- Low frequencies less affected by atmospheric absorption
- Further from a wind farm, increased bias towards low frequencies.

Turbine Locations



The Effect of Atmospheric Absorption upon Spectrum Shape : 10 Turbines



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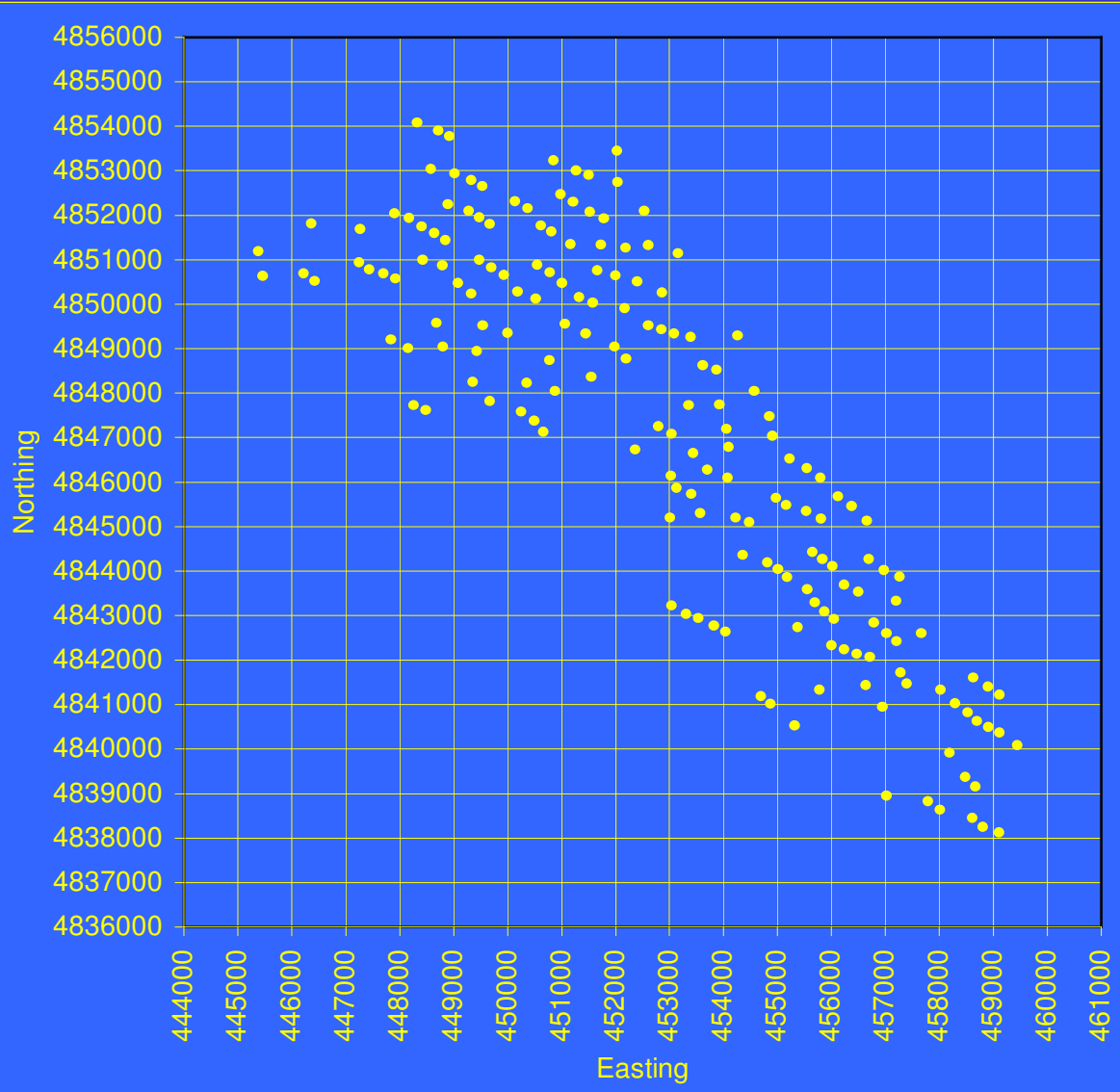

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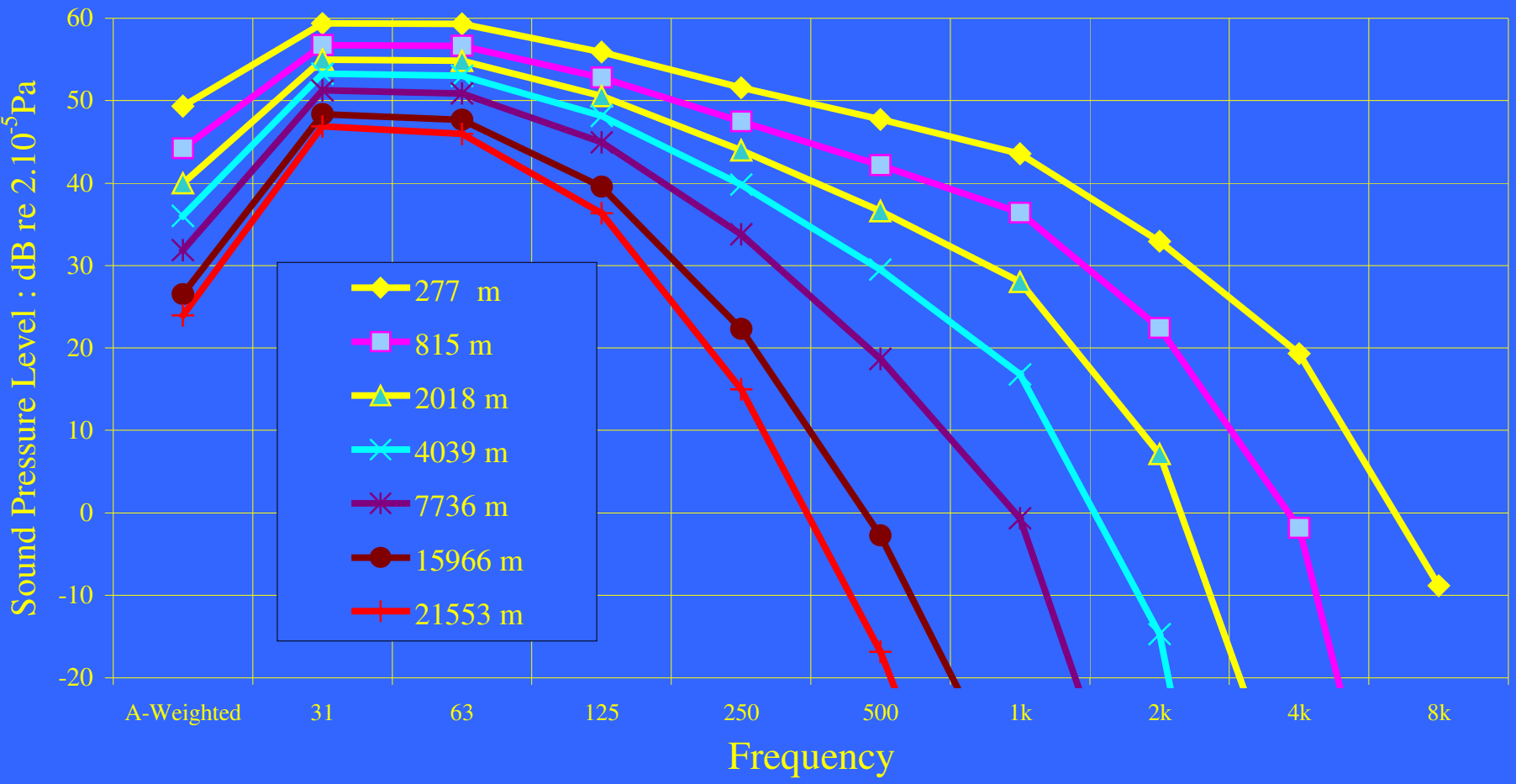
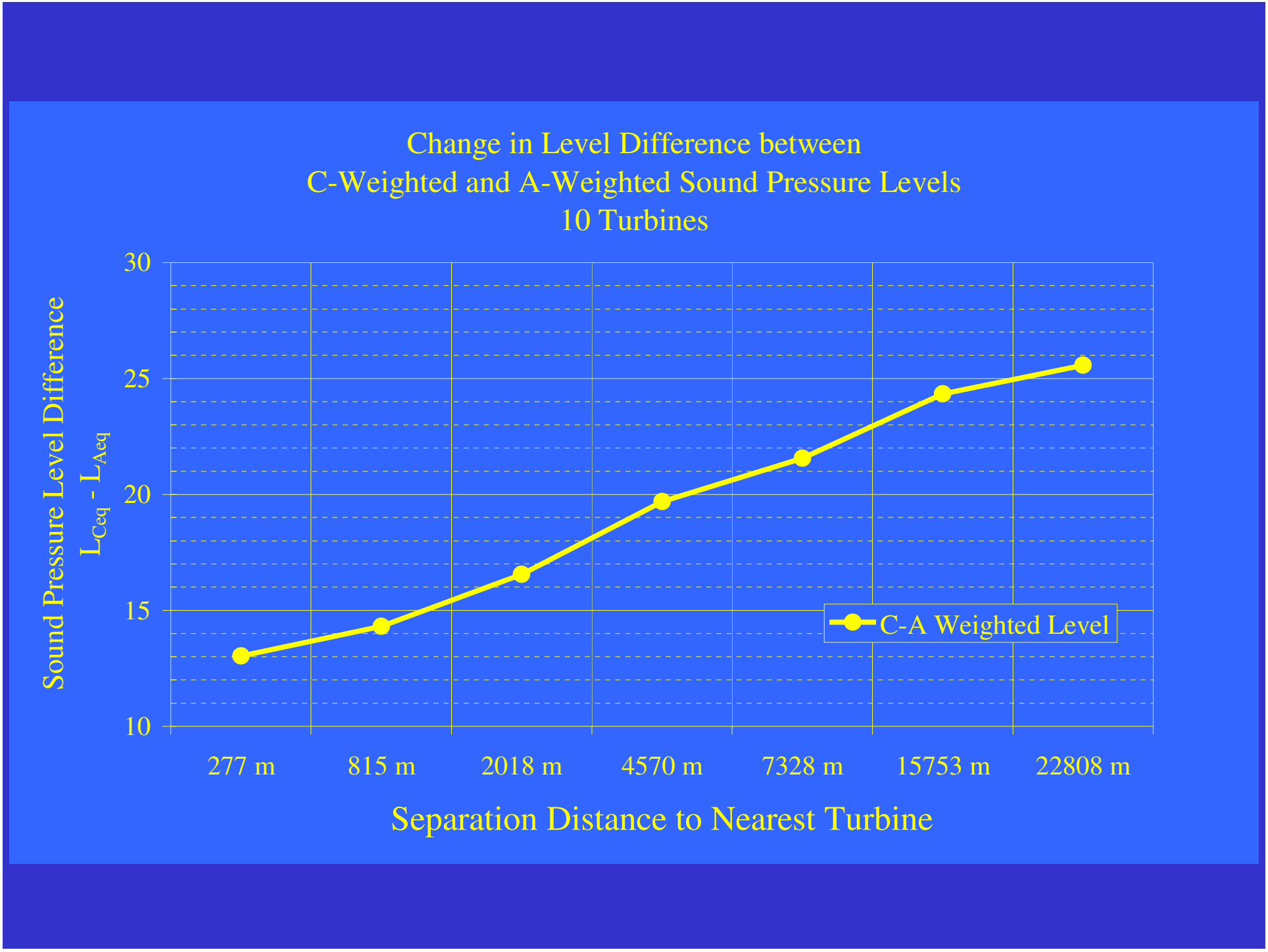
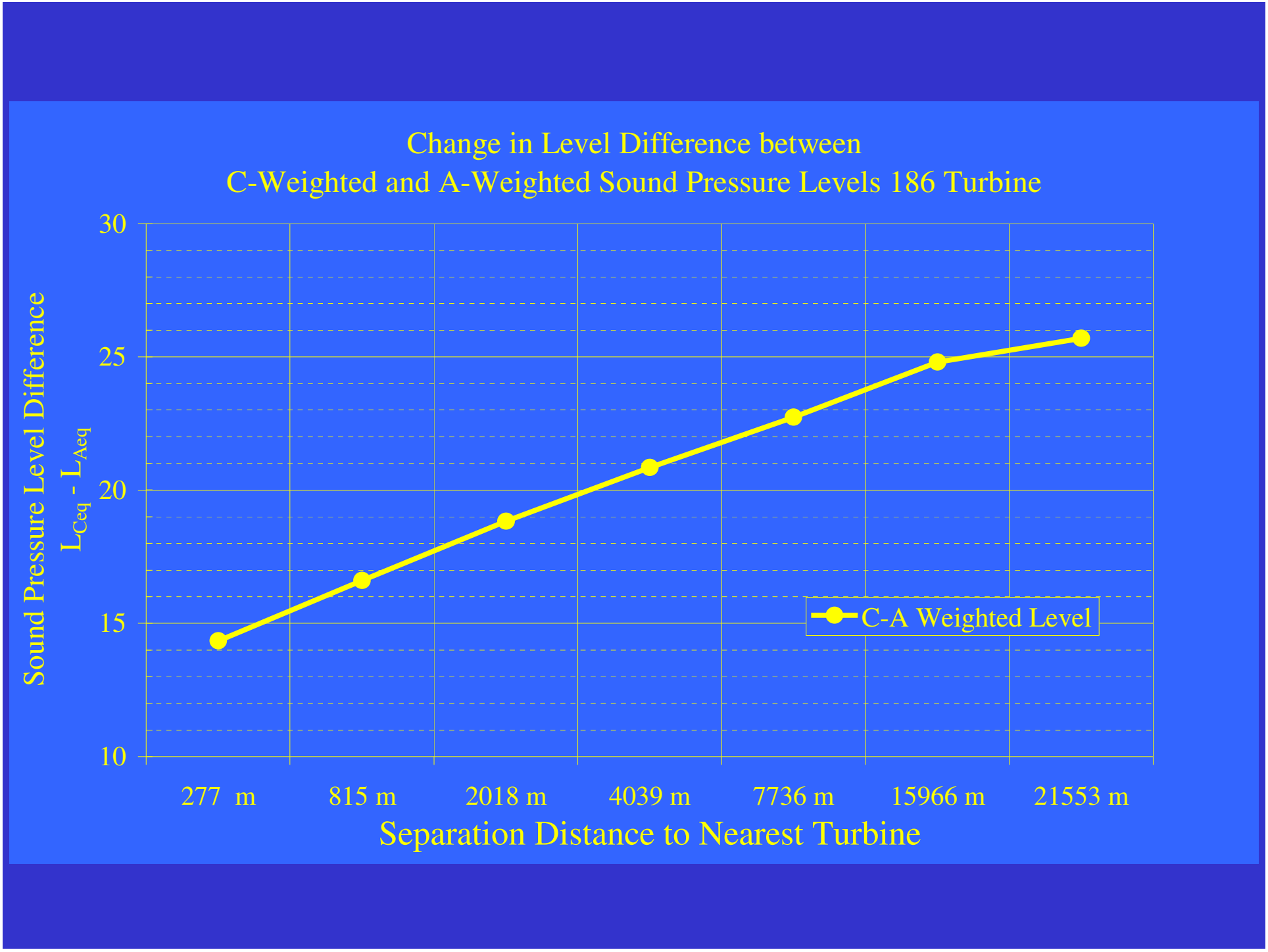


DIN 45680 : 1997

Measurement of Low-Frequency Sound : Environmental Law

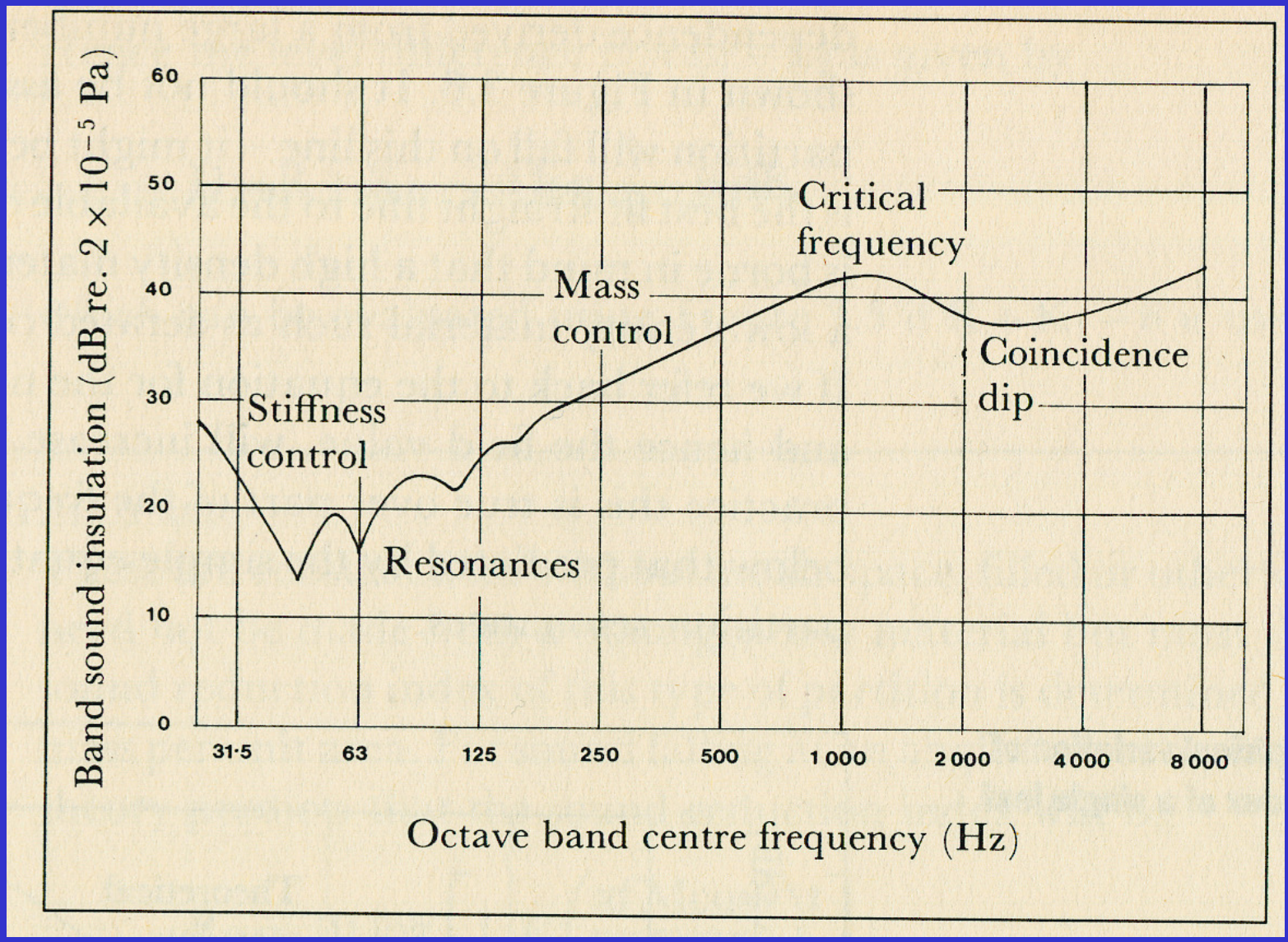
- Suggests as a preliminary investigation of incident noise a comparison of level difference between C and A Weighted Sound Pressure Levels;
- Values greater than 20 dB, then low frequency noise problem should be suspected;
- Noise Review Working Party : 30 dB


Change in Level Difference between
C-Weighted and A-Weighted Sound Pressure Levels
10 Turbines
Sound Pressure Level Difference
$L_{Ceq} - L_{Aeq}$
30
25
20
15
10
277 m
815 m
2018 m
4570 m
7328 m
15753 m
22808 m
C-A Weighted Level
Separation Distance to Nearest Turbine


Change in Level Difference between
C-Weighted and A-Weighted Sound Pressure Levels 186 Turbine
Sound Pressure Level Difference
$L_{Ceq} - L_{Aeq}$
30
25
20
15
10
C-A Weighted Level
277 m
815 m
2018 m
4039 m
7736 m
15966 m
21553 m
Separation Distance to Nearest Turbine

Attenuating properties of buildings

- Sound attenuation better at Mid-High Frequencies than Low Frequencies
- Resonant effects of building structure : windows / walls

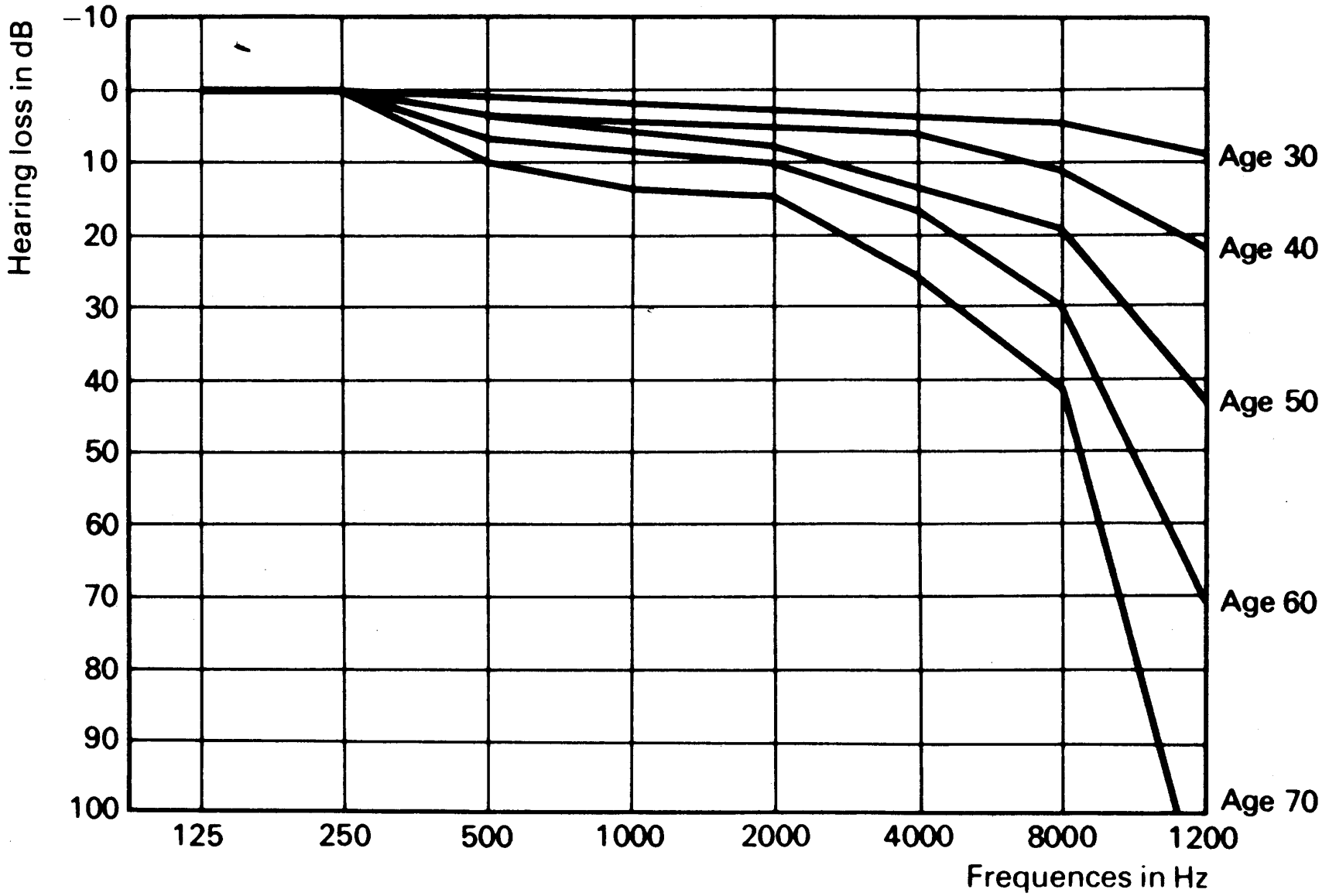

Band sound insulation (dB re. 2 × 10⁻⁵ Pa)
60
50
40
30
20
10
0
Stiffness control
Resonances
Mass control
Critical frequency
Coincidence dip
31·5
63
125
250
500
1 000
2 000
4 000
8 000
Octave band centre frequency (Hz)

Resonance within Buildings

- Caused by room dimensions;
- Nodes (quiet points) and Anti-nodes (loud points) located within rooms depending upon room dimensions and frequency of noise
- Elevate levels by as much as 9 dB in some circumstances

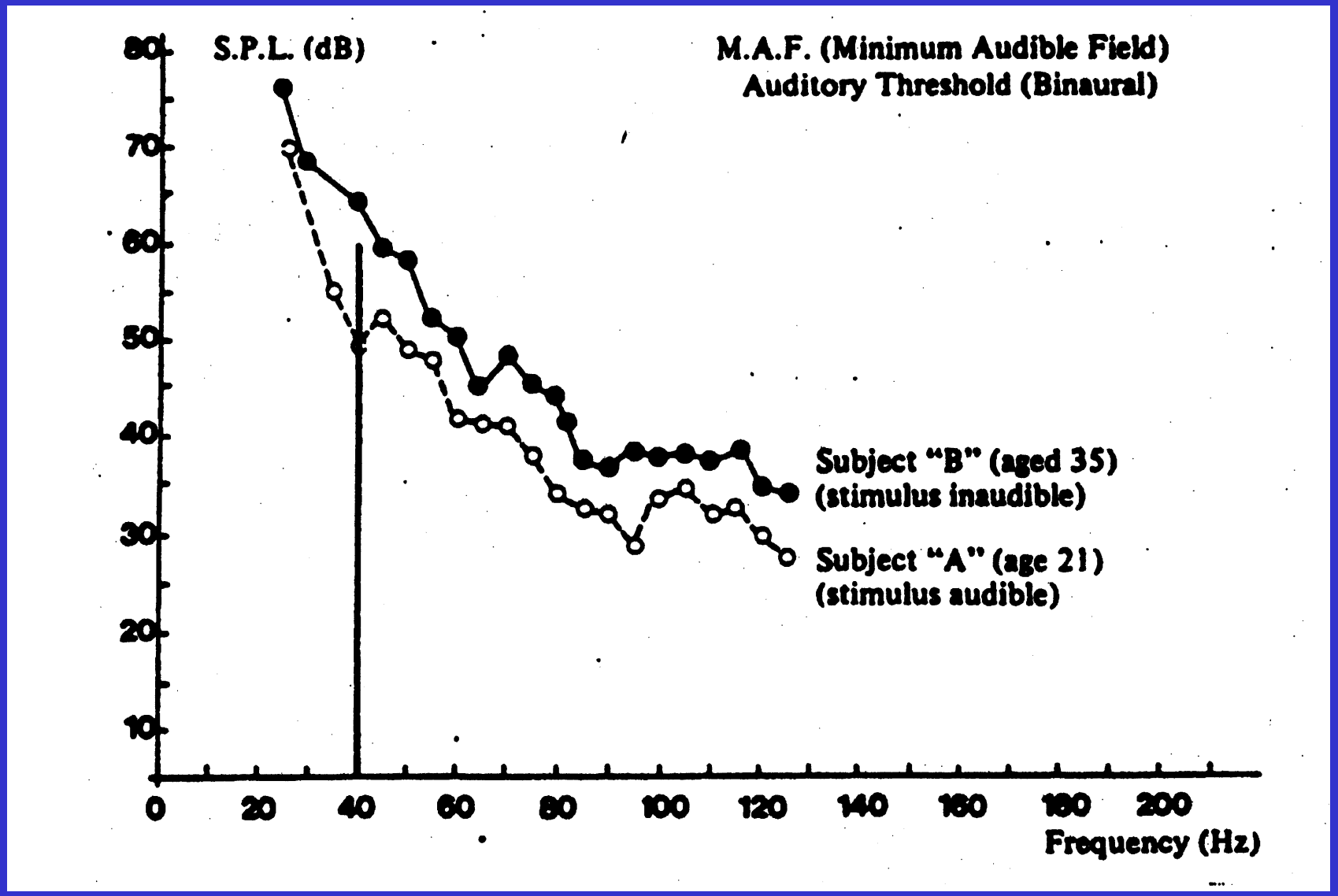
Effects of ageing on hearing

- Hearing tends to deteriorate with increasing age;
- Not equal across the spectrum;
- Mid - High Frequencies deteriorate more rapidly than low frequencies;
- Older listener tends to be proportionately more acute at low frequencies

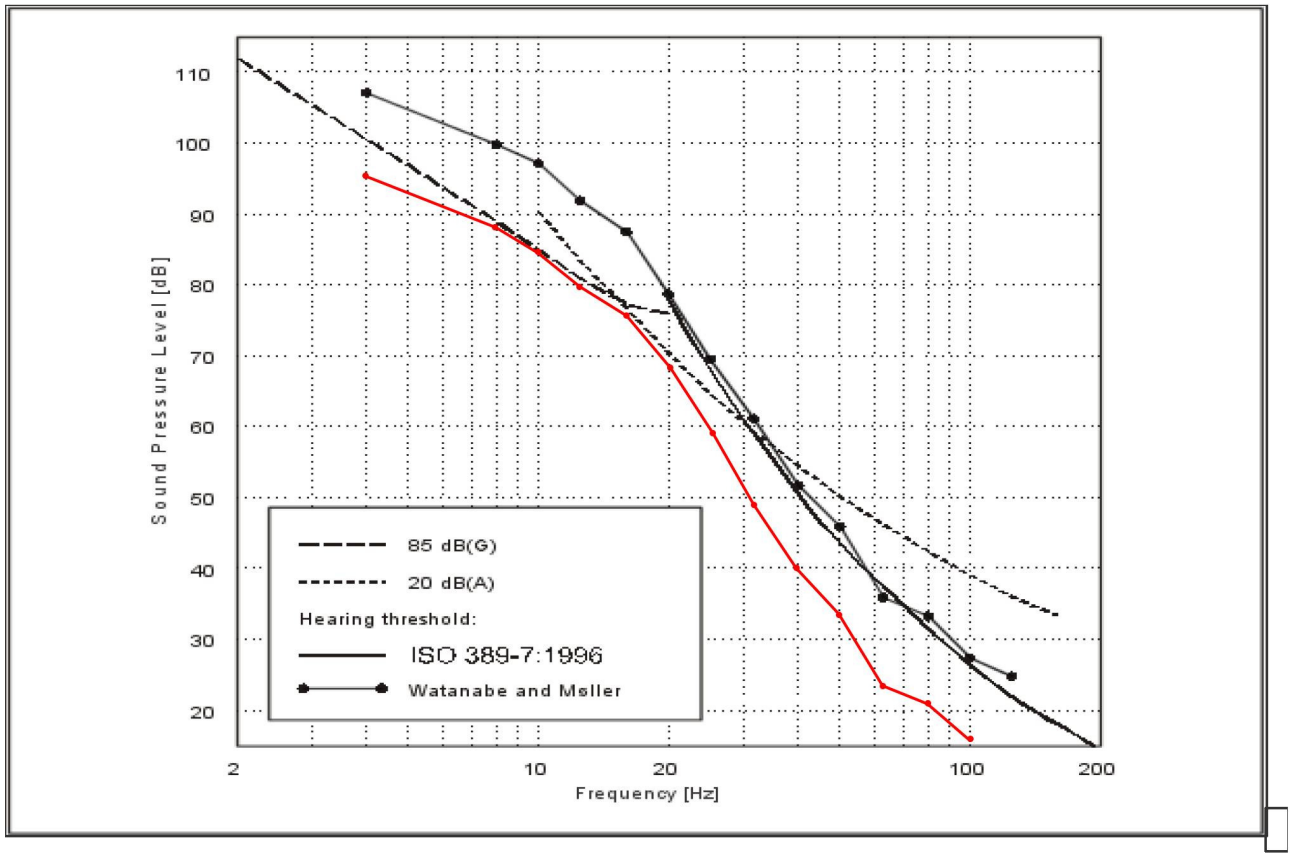

Hearing loss in dB
−10
0
10
20
30
40
50
60
70
80
90
100
125
250
500
1000
2000
4000
8000
1200
Frequences in Hz
Age 30
Age 40
Age 50
Age 60
Age 70

Potential for Sensitive Persons

- Individual thresholds of hearing may differ significantly at specific frequencies;
- What may be audible to one person may be inaudible to another

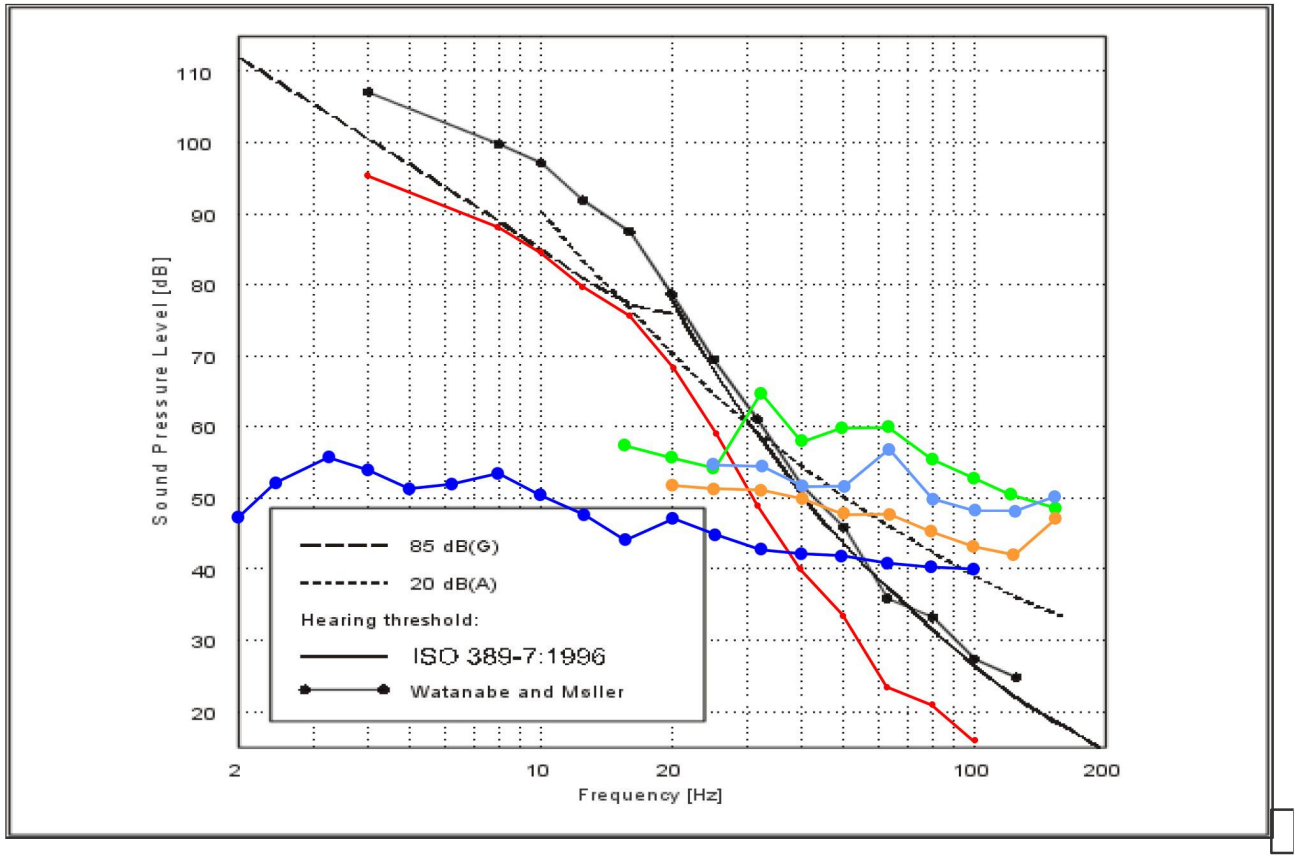

S.P.L. (dB)
M.A.F. (Minimum Audible Field)
Auditory Threshold (Binaural)
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
160
180
200
Frequency (Hz)
Subject "B" (aged 35)
(stimulus inaudible)
Subject "A" (age 21)
(stimulus audible)

Low Frequency Hearing Threshold



Threshold levels after Watanabe and Møller (1990b).

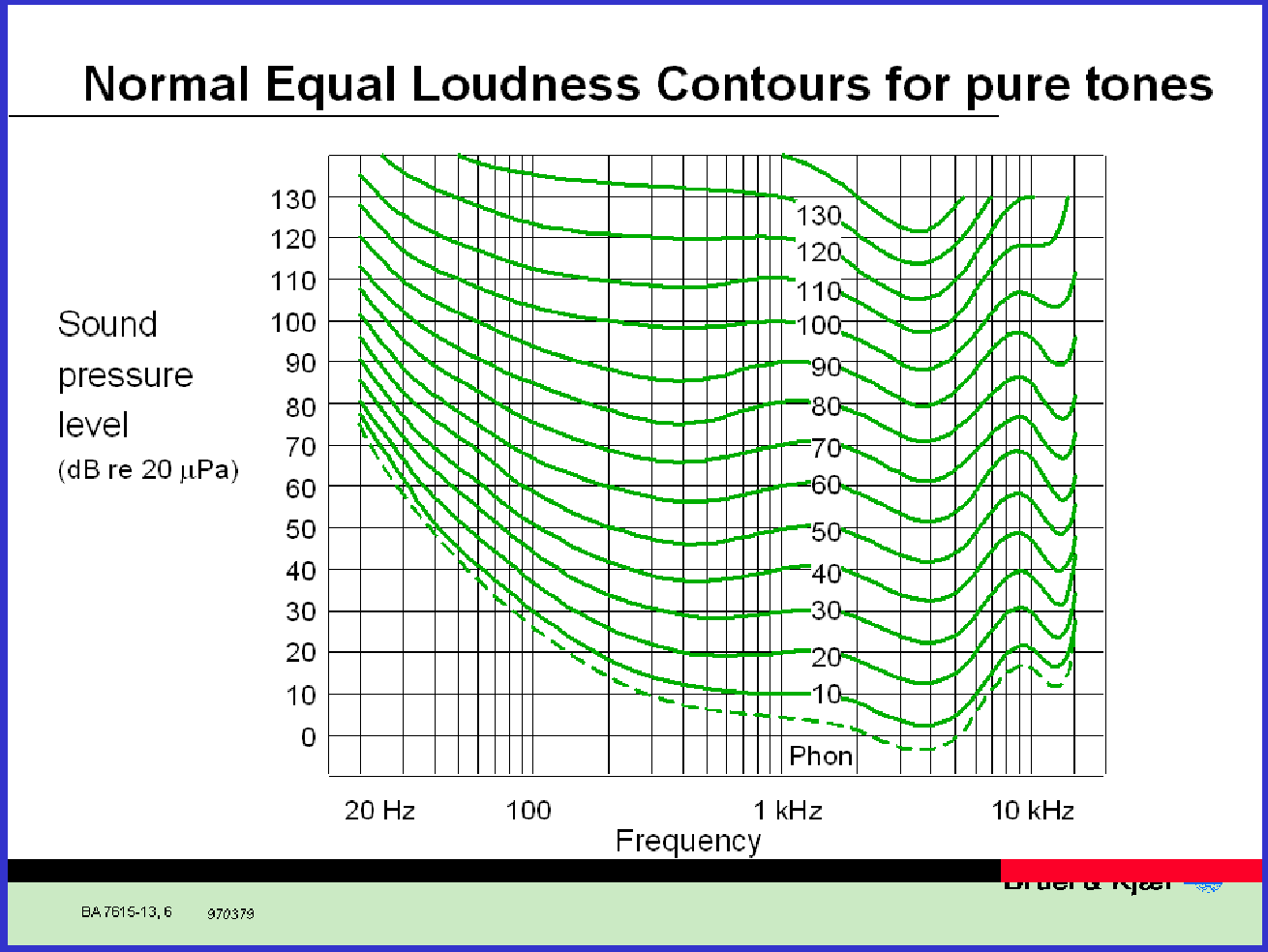
Low Frequency Hearing Threshold



Threshold levels after Watanabe and Møller (1990b).

Nordex N-80 : messung der Infraschall-Abstrahlung einer Windenergieanlage des Typs Nordex N-80 : 13th May 2003

Potential Change in Perceived Noise Level



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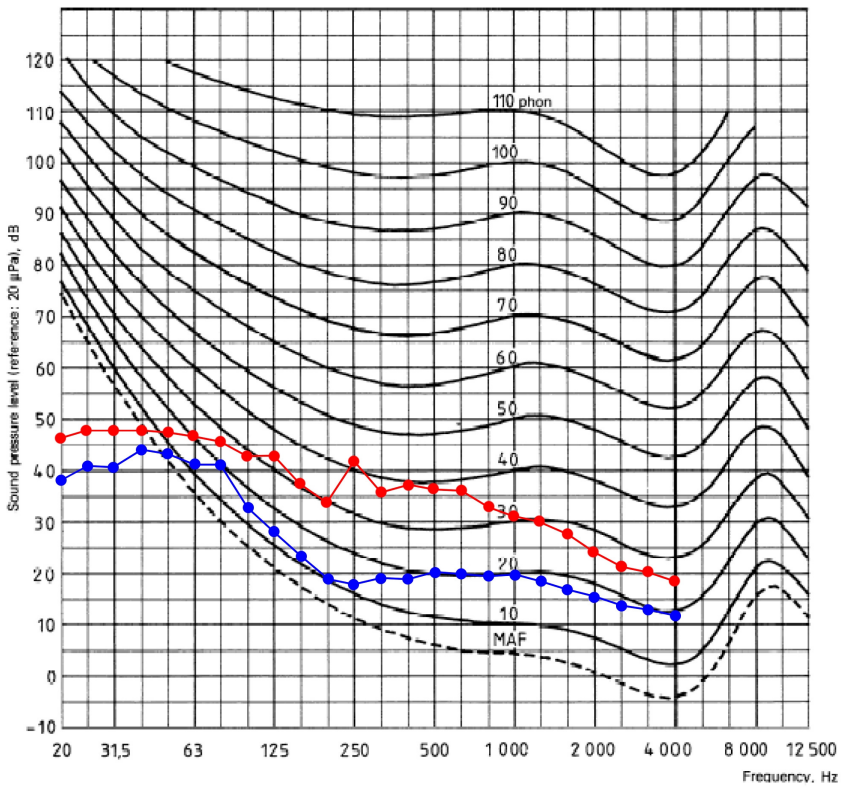

Figure 8. Equal loudness contours (ISO 226).

Potential Change in Perceived Noise Level

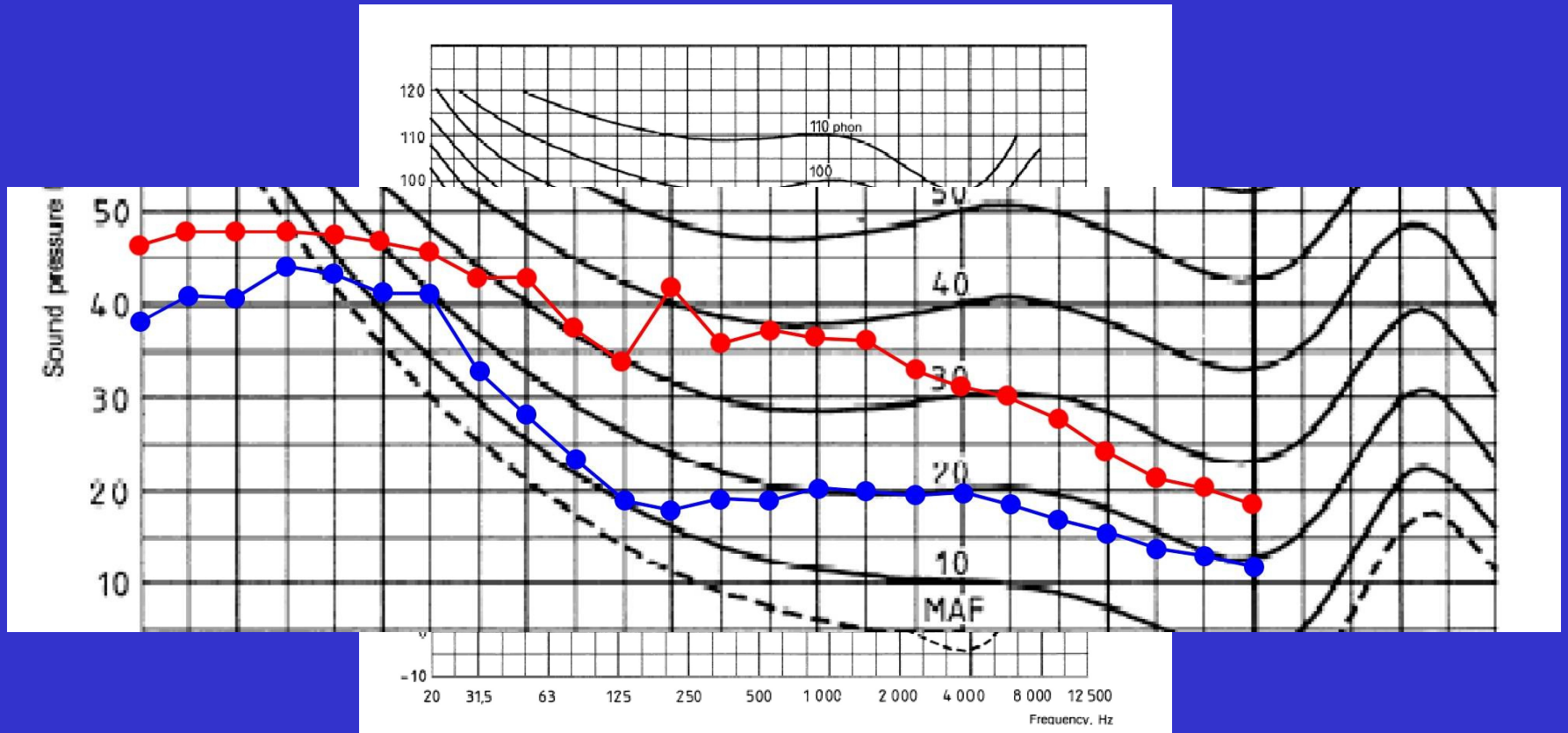

Figure 8. Equal loudness contours (ISO 226).

Summary

- Infra-sound below recognised thresholds of perception even when measured close to wind turbines
- Energy in the 30 - 200 Hz band has the potential to be audible within dwellings;
- Audibility likely to be dependent upon a number of factors including : building construction, room dimensions, sensitivity of occupants

- Measured levels below recognised onset levels for health effects;
- An issue of audibility and acceptability.
- A small change of level in this frequency region may be perceived as an apparent larger increase of loudness;

- Sites of 10 - 20 turbines unlikely to result in Low Frequency Noise Issues unless caused by site specific effects
- Large Sites (50 +) i.e. future offshore L_{Ceq} - L_{Aeq} level differences greater than 20 dB with separation distances of 5 - 7 km and greater.