

# **Assessment and Regulation of Low Frequency Noise**

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# **Low Frequency Noise**

**Frequency range:**

**about 10Hz to 200Hz**

**Which is:**

**the HVAC rumble region**

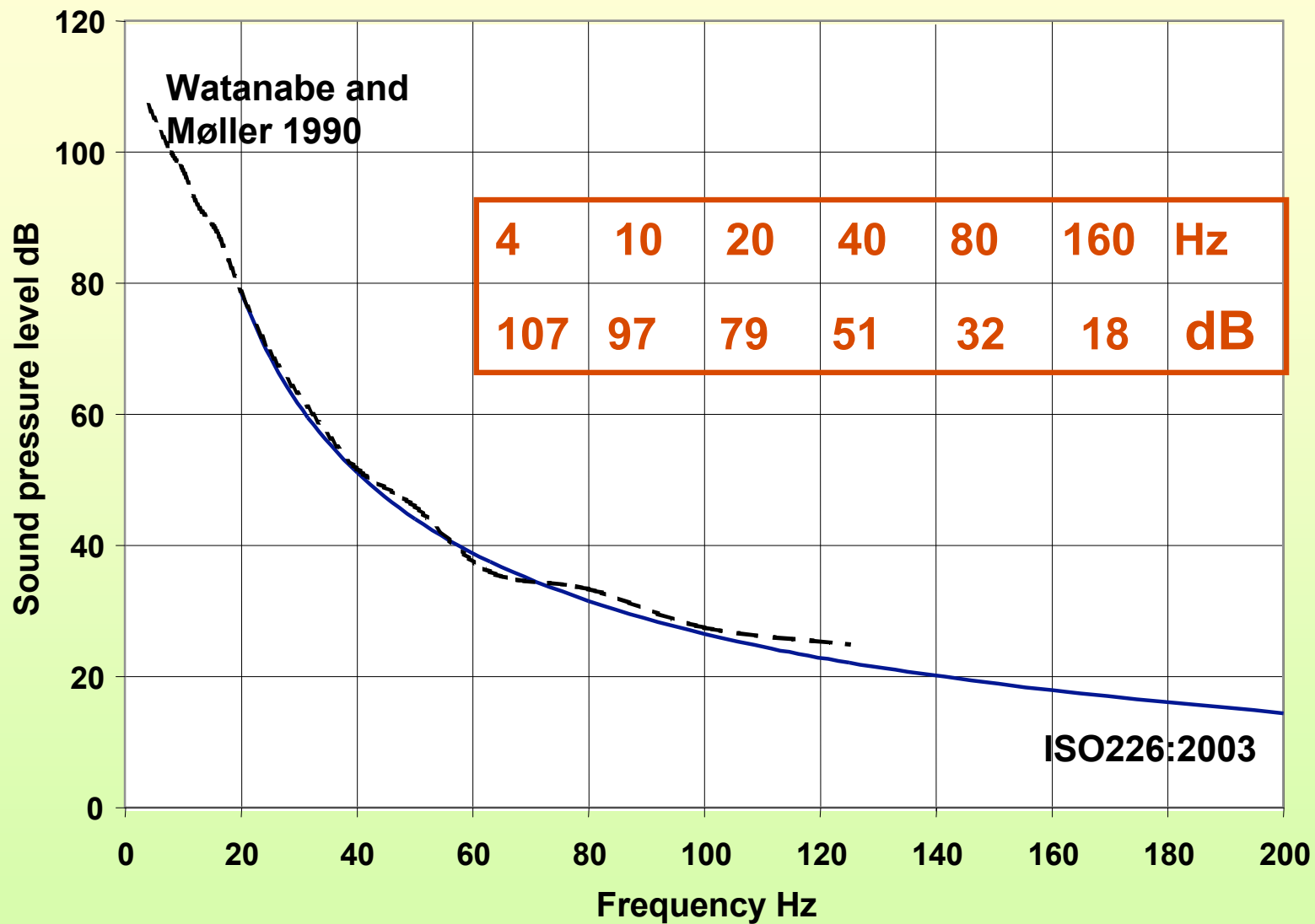
# **Starting point**

**Will the noise be audible?**

**Too much reliance is placed on  
“the threshold”.**

**Will the noise be annoying?**

**Very variable subjective  
responses.**



# LF Median Hearing threshold

# Statistics of the Threshold

“The Threshold” is the 50% (median) of young people 18~25 years

One standard deviation approx 6dB

68% within +/- one standard deviation

- About 16% are  $> 6\text{dB}$  more sensitive than threshold.
- About 2% are  $> 12\text{dB}$  more sensitive than threshold

# **ISO 7029:2000**

## **Statistical distribution of hearing thresholds as a function of age**

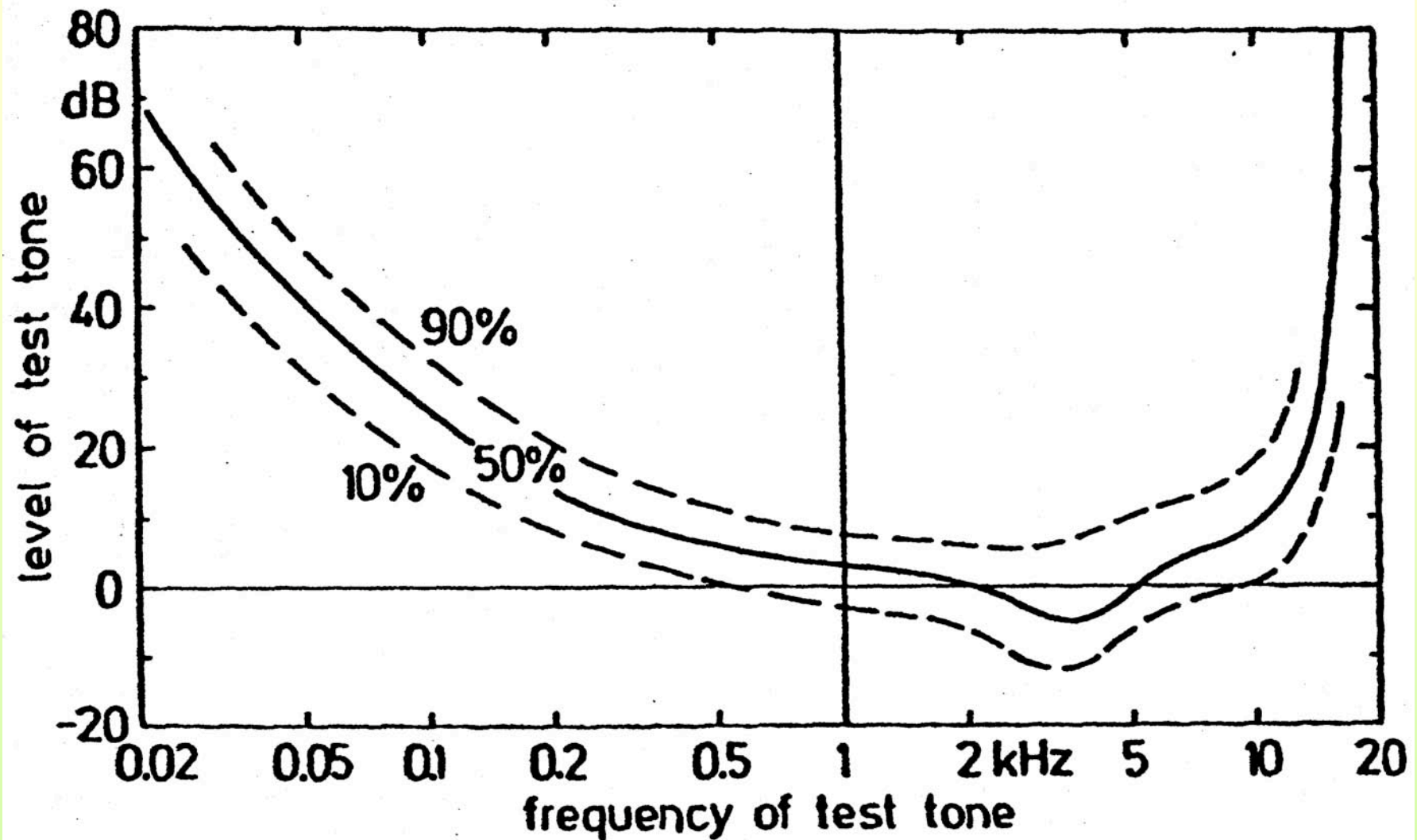
**Covers 125Hz to 8000Hz.**

**At 125 Hz: 10% of 60 year old males have a threshold of  $-4\text{dB}$  or lower.**

**Which means at least  $4\text{dB}$  better hearing sensitivity than the median 18 year old.**

**(Hearing loss occur at higher frequencies.**

**8000Hz: 10% of 60 year old thresholds  $+ 10\text{dB}$ )**



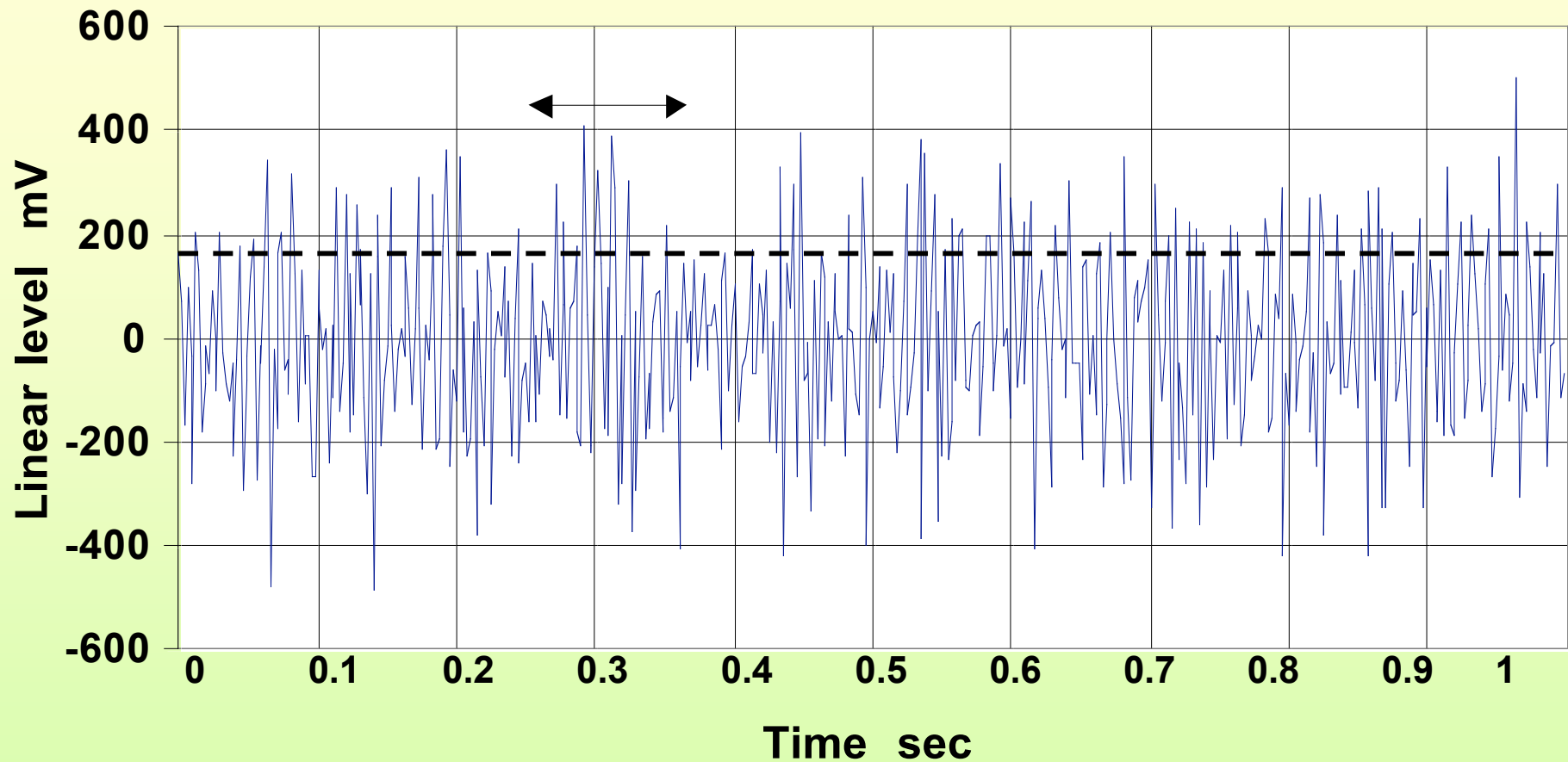
## 10%, 50% and 90% hearing thresholds

Zwicker and Fastl

# Characteristics of LF HVAC Noise

**Fluctuations - say up to  $\pm 10$ dB**  
**Measurement gives the average level**

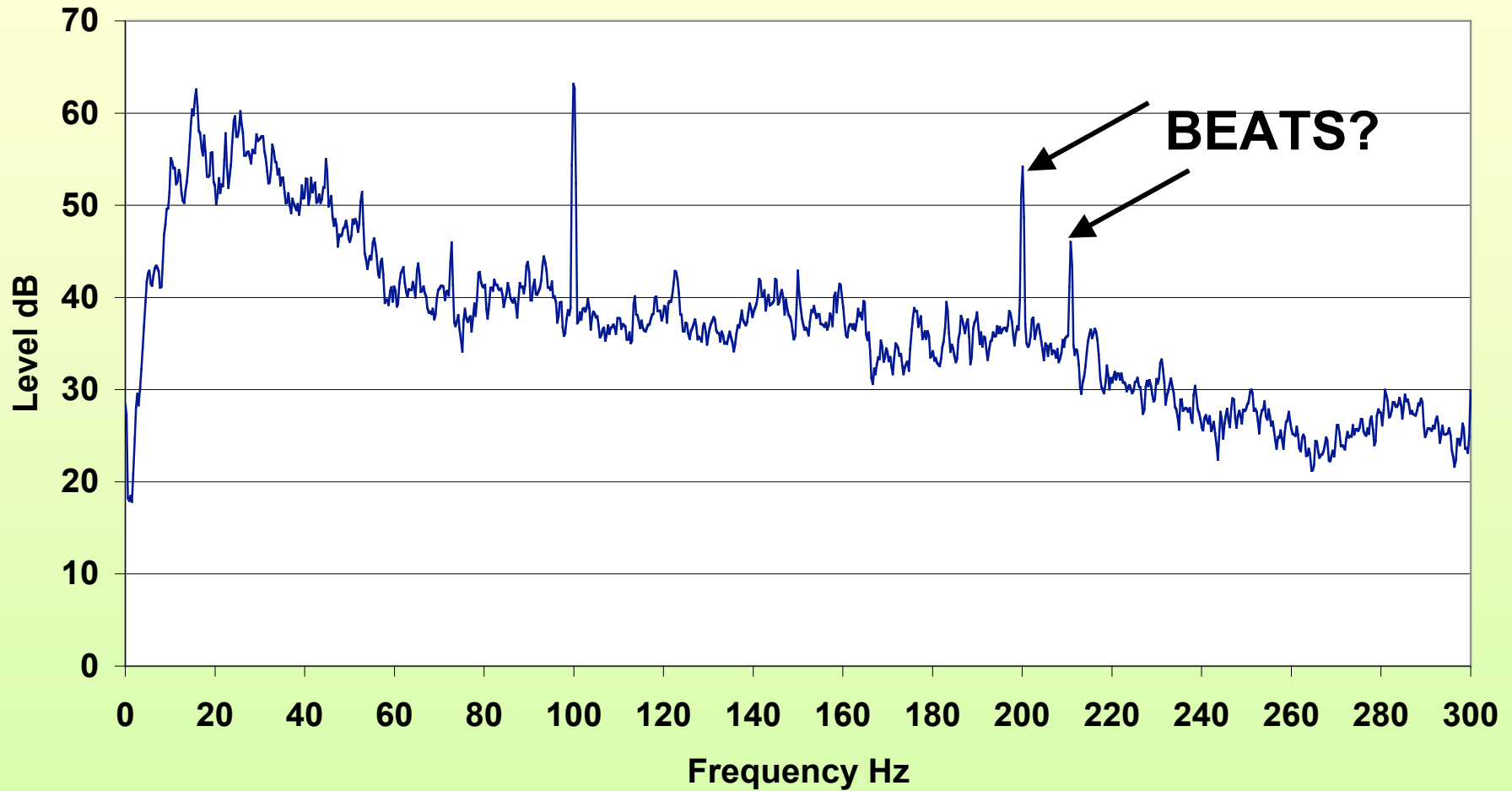
**A Criterion should take fluctuations into account e.g. levelling of RC2**



**Waveform of HVAC throbbing noise**

**RMS 175mv    Level variation +7dB, -12dB**

Analysis HVAC Throb Noise (0.3 Hz)



**Analysis HVAC throbbing noise** 10

# Measurement problems

A criterion requires measurement.

Problems at low frequency of:

- Temporal

- Spatial

variations

# **Temporal variations**

## **Short term**

- **Waveform fluctuation**

## **Long term**

- **Full load to system off**

# **Spatial Variations**

**Room modes at low frequencies**

**Effect of distance from source**

# **The “Dimensions” of Noise**

- 1. Frequency or level**
- 2. Average Level v. Frequency  
(Spectrum)**
- 3. Fluctuations with time**
- 4. Subjective response**

# **Subjective response**

**Noise is only one of the factors which combine to give our total subjective response.**

**Noise sensitivity is important, depending on the individual, the situation etc etc**

**What percent do we protect?**

# **Determination of limits**

- **Percent to protect?**

**Greater than 50%?**

- **Does an audible noise annoy?**

**Depends on the listener**

# Criteria

- **Denmark**
- **Poland**
- **Sweden**
- **Netherlands**
- **Germany**



# Types of Criteria

## Weighting curve

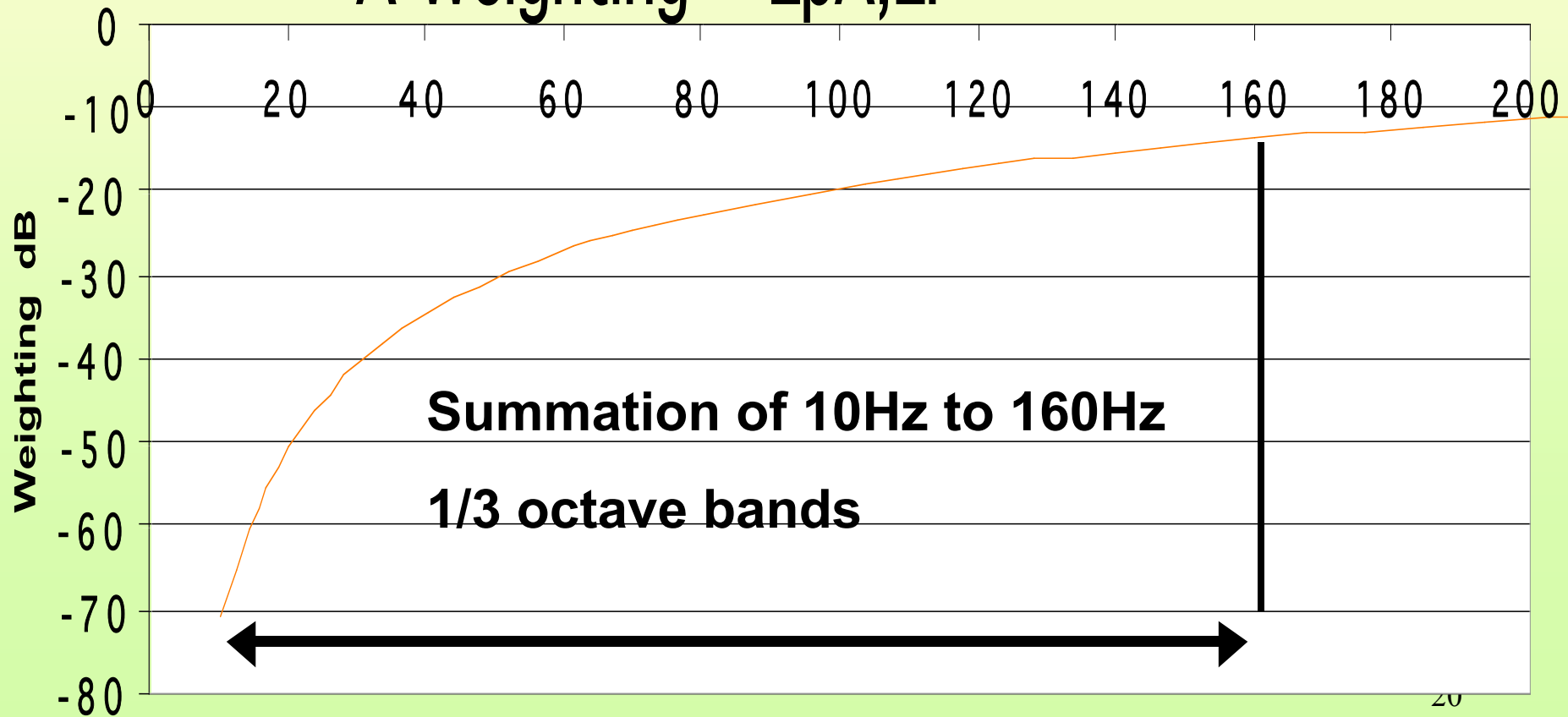
Summation over frequency range

## Limit curve

1/3 octave frequency analysis  
related to a criterion limit

# Denmark

## Low Frequency A-Weighting LpA,LF

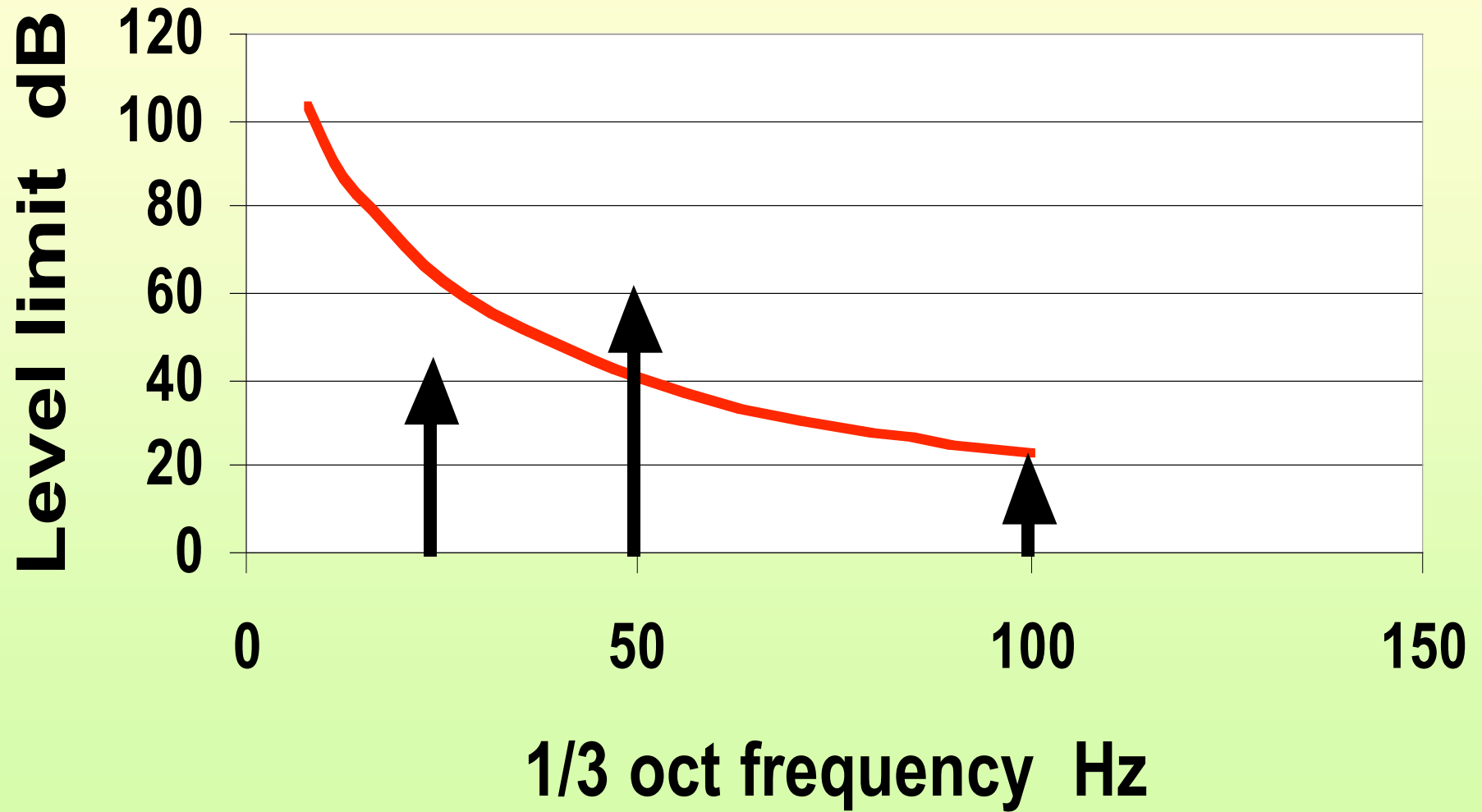


# Denmark - Weighting Curve

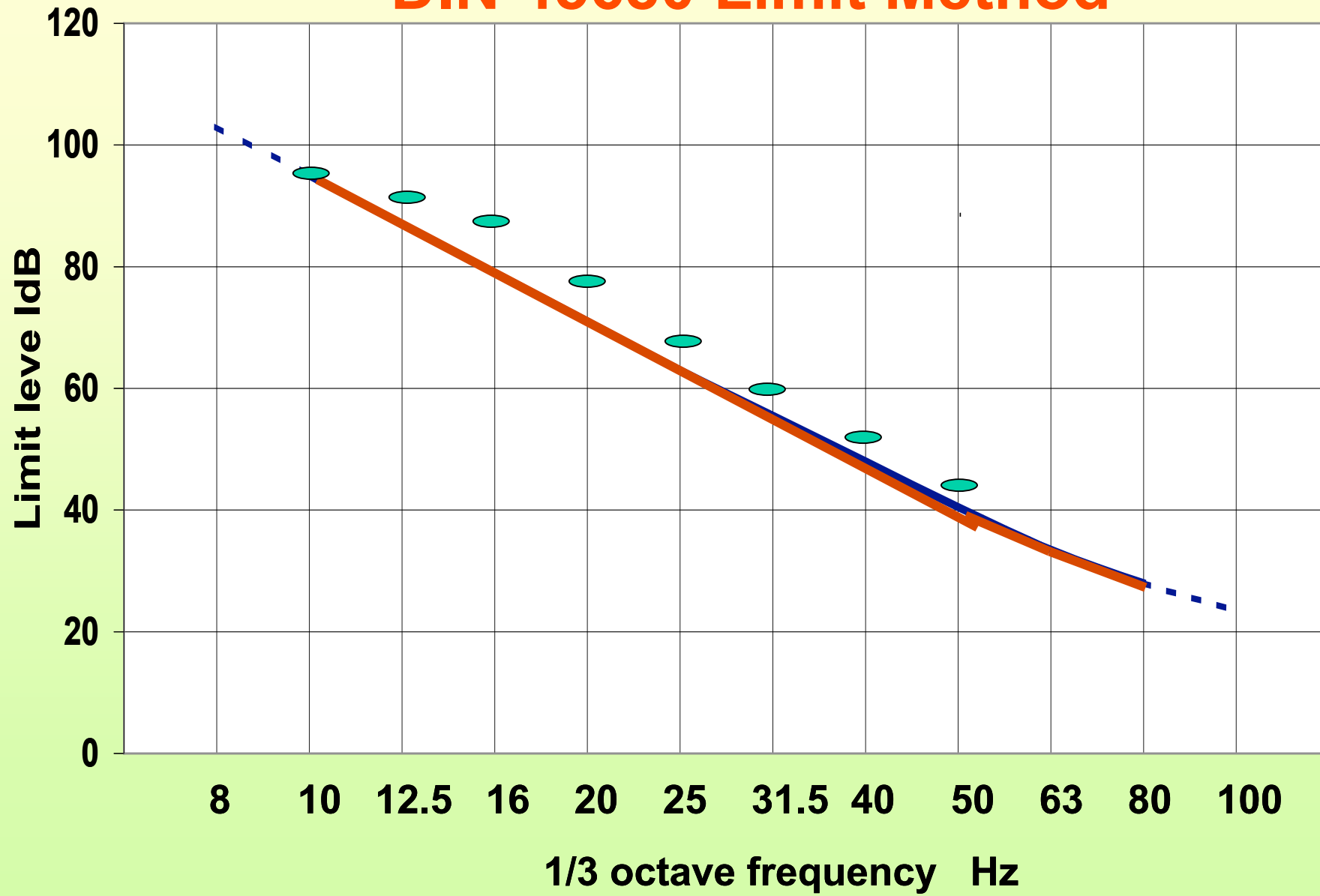
	Infrasound $L_{pG}$	Low frequency noise $L_{pA,LF}$ <b>10 –160Hz</b>	Normal noise limit $L_{pA}$
Dwelling, evening and night	85dB	20dB	30dB / 25dB
Dwelling, day	85dB	25dB	30dB – day and evening
Classroom, office etc	85dB	30dB	40dB
Other rooms in enterprises	90dB	35dB	50dB

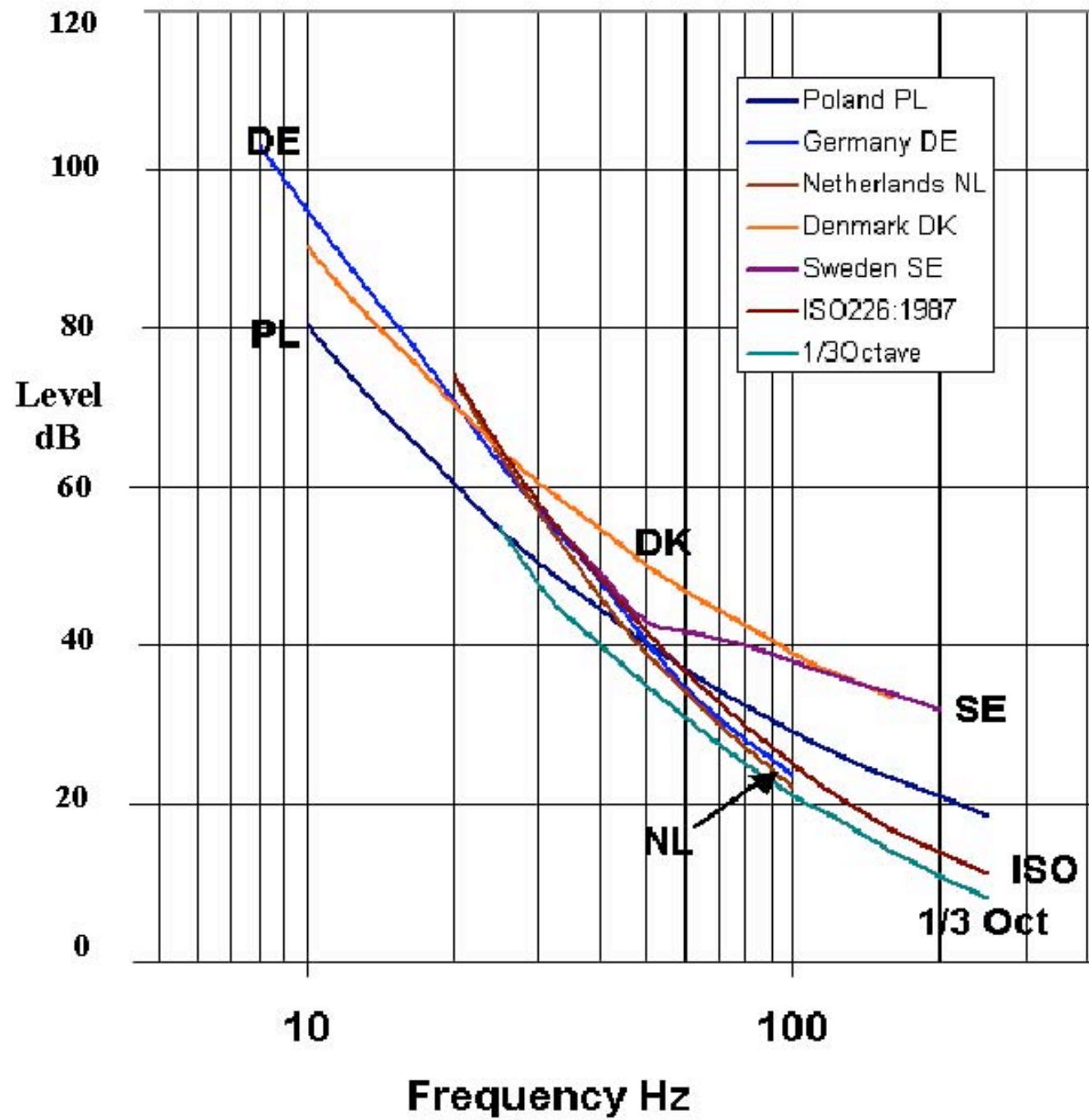
**Plus 5dB penalty for impulsiveness**

# LF Limit Curve

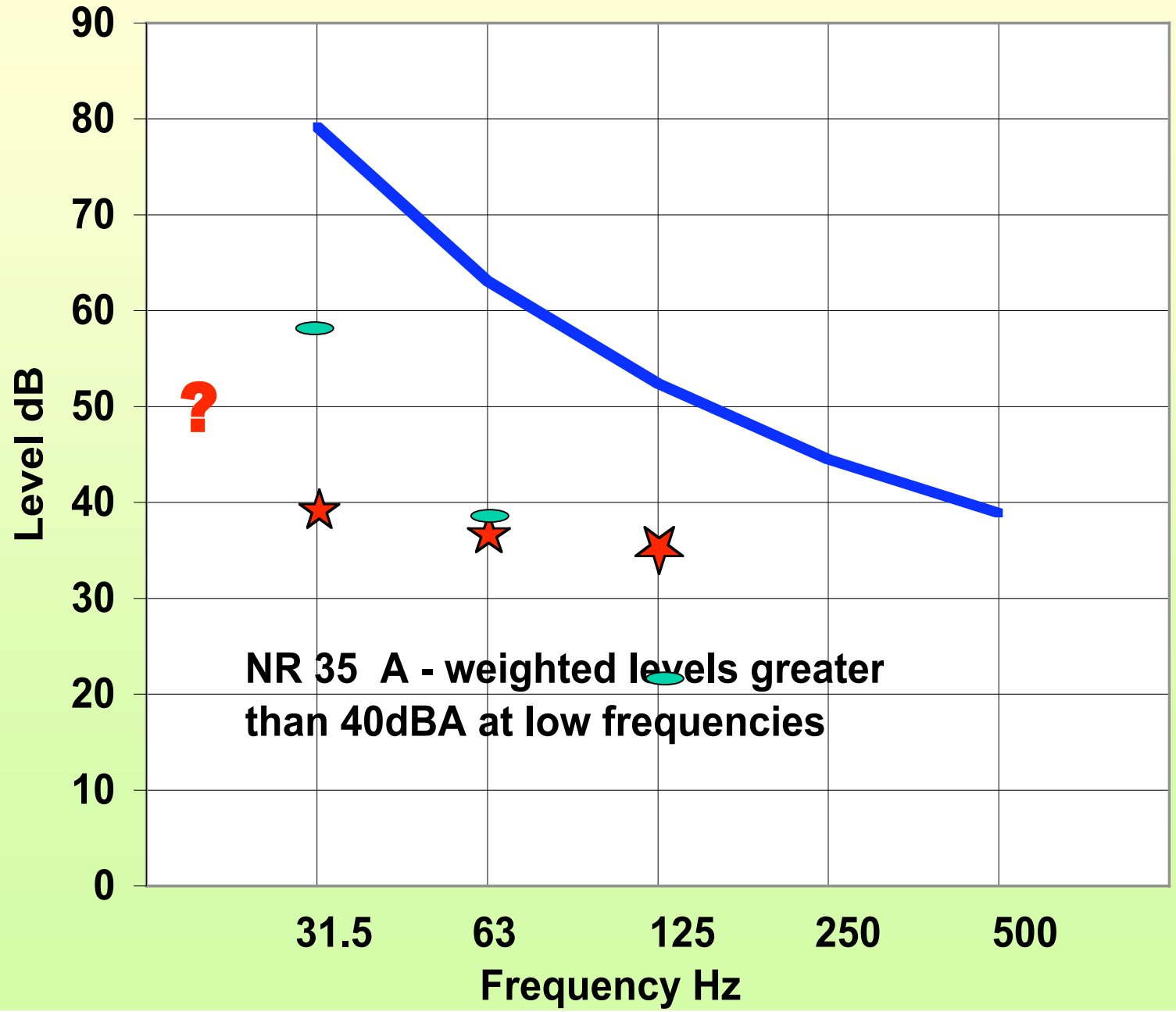


# DIN 45680 Limit Method





# NR35 up to 500Hz



# Conclusions

- **The fixed “hearing threshold” is a fiction**
- **Low frequency noise at low levels annoys some listeners**
- **Use of average levels hides annoying characteristics**

# **We need to**

- **Place less reliance on “the threshold” when making decisions**
- **Get rid of NR (ASHRAE RC OK)**
- **Assess fluctuations in the noise**