Informal document No. GRB-42-12
(42nd GRB, 5-7 September 2005,
agenda item 4.1.)

Low frequency noise

A short introduction for GRB

Definition of Low Frequency Noise

- No ‘global’ definition
- Definitions in D, DK, S, PL, NL, ISO

- Lower boarder: 8-20 Hz
- Higher boarder: 100-250 Hz

Examples:

- ISO: 20-250 Hz
- Ger: 8-100 Hz

Relevance for vehicle regulation

- LFN related to Health and Nuisance
- Vehicles are a source of LFN

LFN in the Netherlands

In the Netherlands many complaints about traffic bound Low Frequency Noise

- If specific conditions are mentioned
  - Accelerating conditions
  - Stationary conditions
- If specific sources are mentioned
  - Exhaust systems
  - City busses
  - Motorcycles
  - Heavy traffic

Example city bus

Bus company got a lot of complaints about a new type of bus: therefore an investigation was started:

- Investigation of complaints: residents at bus stops and traffic lights complain about LFN
- Measurements on two different types (old and new)
- Both were (correctly) approved according to R51
- New type emits more low frequency noise
  - Slightly during R51 acceleration and stand still
  - Significantly during pulling away from stand still (50-70 Hz)

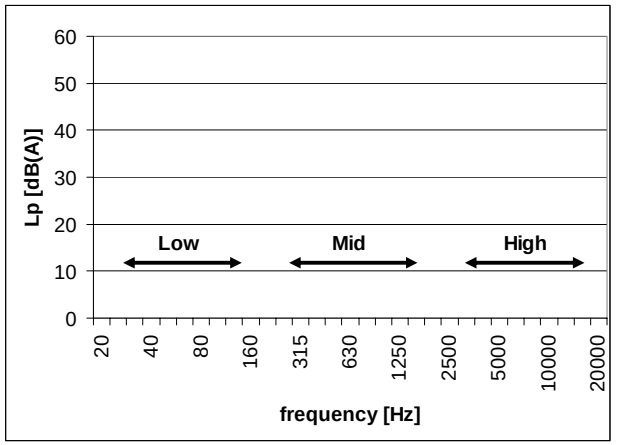
Example city bus (cont)

- Exhaust emits normally the firing frequency and higher harmonics
- Example: 6 cylinder 4 stroke line engine 500 rpm:
  - Firing frequency = 500/60 * 6 / 2 = 25 Hz
  - Higher Harmonics: 50 Hz, 75 Hz etc
- Exhaust was identified as source of LFN
- Manufacturer was asked to optimize exhaust system
- Bus company introduces ‘bus stop’ noise criteria for all new to buy busses

Acoustical Background information

What is so special about Low frequency noise?

Frequency regions



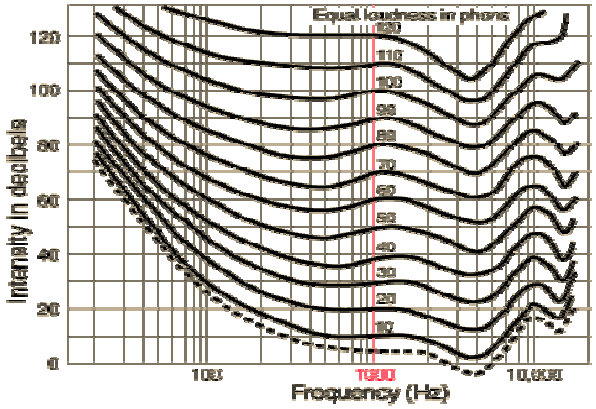
Examples of low frequency noise

Source	Low frequency noise	High frequency noise
Voice	Bass, male	Soprano, female
Nature	Earthquake, thunder, volcano	Snake, mosquito
Music	Contrabass, kettledrum, pipe organ	Piccolo, triangle
Household	Transformer, fan, washer	whistling kettle
Industry	compressor, pump	Steam release valve
Ships	exhaust, radiating hull	Whistle
Road traffic	wheel/road (structure borne on bumps) exhaust (airborne)	Valve train, tyres

Quantities for loudness

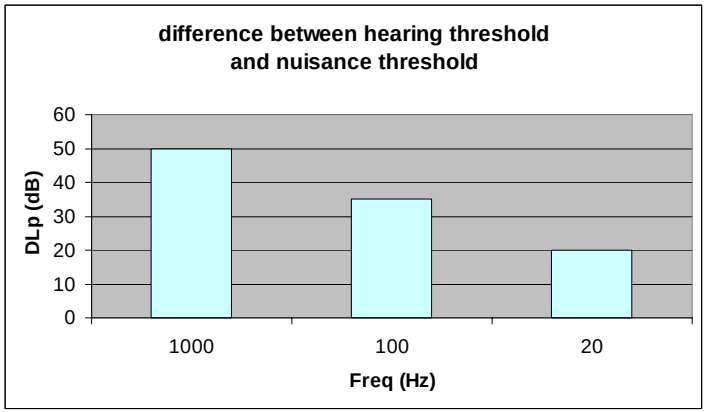
- Sound level meter measures physical quantity (sound pressure level or intensity level) in Decibels
- Human ear experiences Loudness level:
- Transition between human ear and sound level meter: ISO equal loudness curves in phons

ISO equal loudness curves
The human ear: non-linear sensitivity



The ear is more sensitive to high frequencies than to low frequencies
This discrimination becomes steeper for softer sounds

The human ear: non-linear sensitivity



LFN: hearing = annoyance

How to measure sound

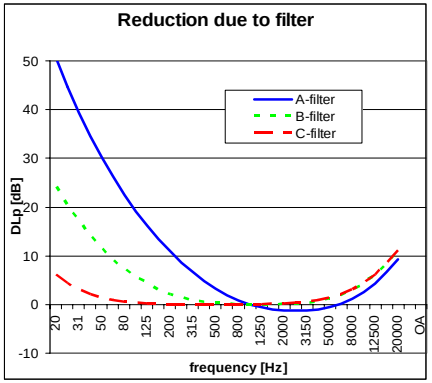
Filters: dB(A), dB(B) and dB(C)

- to compensate non-linear sensitivity of the human ear
- Different filter for different situations

Properties of filters

A-filter
- Made for noise levels of 40 phon
- Not made for noise levels of 70 phon and higher
- In practice used for 95% of measurements independent of level

- B-filter
  - Made for noise levels of 70 phon
  - used for vehicle interior noise measurements
- C-filter
  - Made for noise levels of 100 phon
  - used for low frequency noise measurements



Filters and vehicle regulations

- If the dB(A) is used for noise levels of 70-80 phon, the influence of low frequencies is underestimated. (too much filtered away)
- Vehicle test results are in the range of 70-80 phon and measured in dB(A)
- What is the justification?

From test result to traffic situations

- In real traffic situations noise propagates from 7,5 meter to citizens
  - On bigger distance
  - Behind barriers
  - Inside dwellings

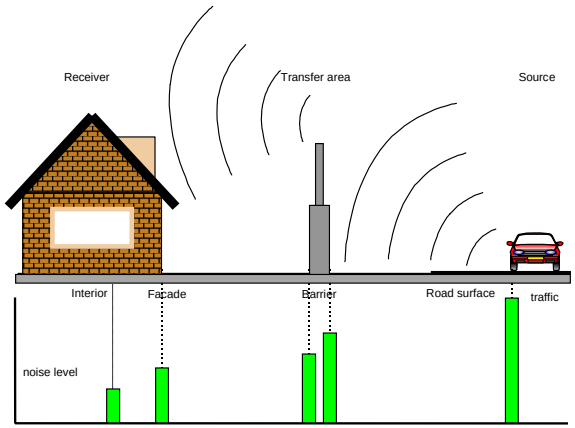
  Therefore Noise levels will decrease.

  At lower levels the A-filter could be justified

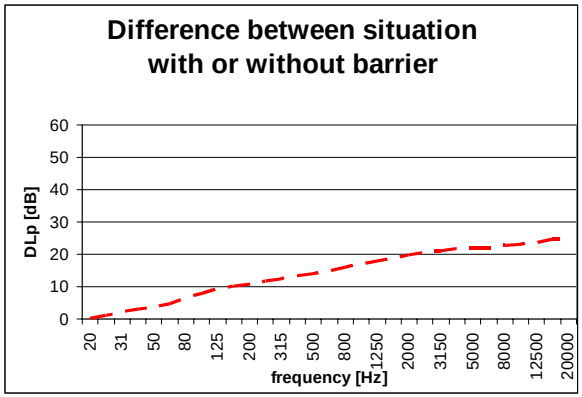
The noise reduction between source and receiver

Focus in on:

- Barrier
- Facade

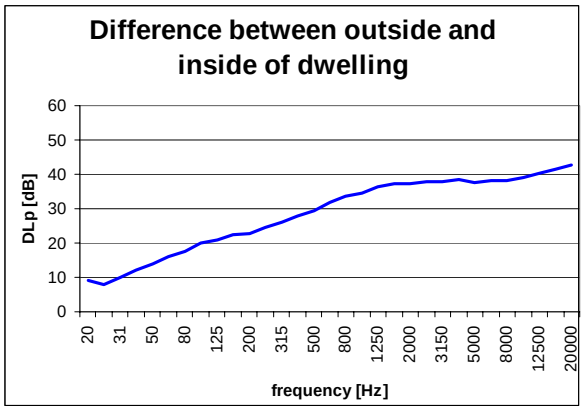


Influence of barrier



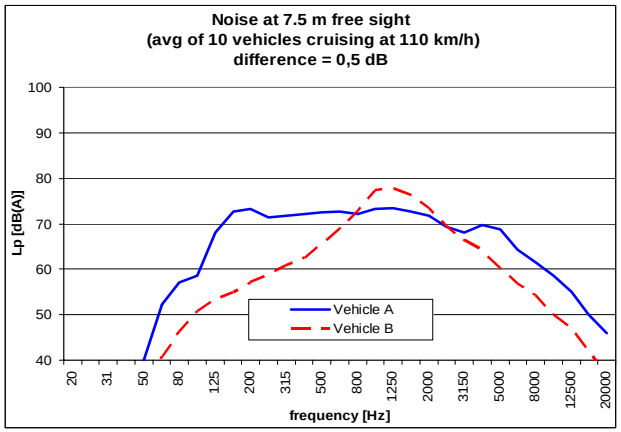
At low frequencies hardly any reduction from barrier

Influence of facade

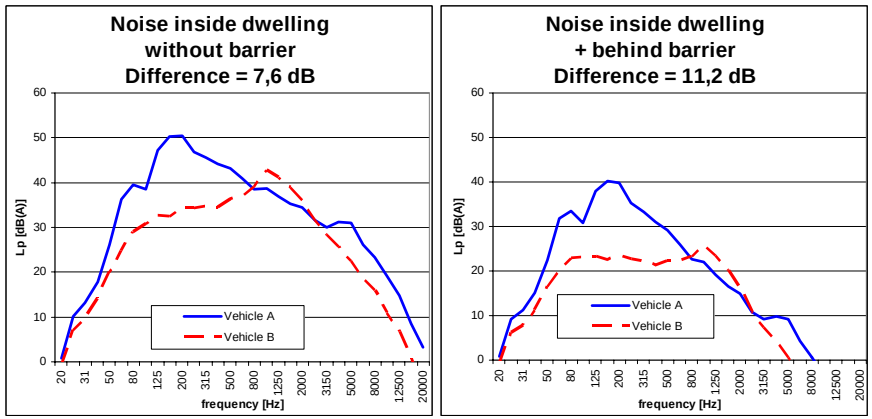


At low frequencies hardly any reduction from facade

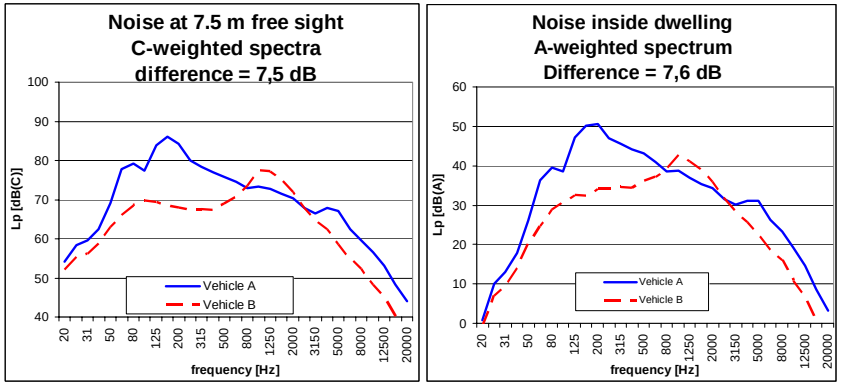
Example of two sources with same noise level, but different frequency content



Resulting noise at reception point



Influence of using C-filter



C-weighted spectrum on 7.5 meter is a good predictor for

A-weighted spectrum inside dwelling

Summary

- LFN is relevant for health and nuisance
- LFN is relevant for vehicle regulation
- For measurements on 7.5 m ,

  the dB(C) or dB(B) is a better predictor than the dB(A) for
  - the loudness on 7.5 m
  - the loudness inside dwellings

Thank you

For your attention !