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# A DETAILED INVESTIGATION OF LOW-FREQUENCY-NOISE COMPLAINTS

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## ABSTRACT

From a group of 203 cases of low-frequency-noise complaints a random selection of twenty-one cases were investigated. The main aim of the investigation was to answer the question whether the annoyance is caused by an external physical sound or by a low-frequency tinnitus. Noise recordings were made in the homes of the complainants, and the complainants were exposed to these recordings from their own home in blind test listening experiments. Furthermore, the low-frequency hearing function of the complainants was investigated, and characteristics of the annoying sound was matched. The results showed that some of the complainants are annoyed by a physical sound (20-180 Hz), while others suffer from low-frequency tinnitus (perceived frequency 40-100 Hz). Physical sound at frequencies below 20 Hz (infrasound) is not responsible for the annoyance – or at all audible – in any of the investigated cases, and none of the complainants has extraordinary hearing sensitivity at low frequencies. For comparable cases of low-frequency noise complaints in general, it is anticipated that physical sound is responsible in a substantial part of the cases, while low-frequency tinnitus is responsible in another substantial part of the cases.

## 1. INTRODUCTION

Many cases of noise annoyance deal with noise that has a significant content of low frequencies and the complainants typically describe the noise as "rumbling". The cases are often solved, either by use of traditional noise limits and measurement methods, or by use of special low-frequency procedures as introduced by some countries: Austria [1], Denmark [2] (explained in [3]), Germany [4], Poland [5] (explained in [6]), The Netherlands [7], Japan [8] (explained in [9]), Sweden [10] (criteria) and [11] (measurement procedure, translated and explained in [12]).

However, there is a group of cases where persons claim to be annoyed by rumbling noise, but where they are not helped in a way that they find satisfactory. This often leads to repeated complaints, anger at authorities, feeling of helplessness, and reports in the daily press. To a certain extent, these cases have some common characteristics. There is often no obvious noise source, and often only one or a few persons are annoyed. Many of the cases are in areas that are generally quiet, and, if measurements are made, they often show low values.

From 203 cases of low-frequency-noise complaints a random selection of twenty-one cases were investigated. The main aim of the investigation was to answer the question whether the annoyance is caused by an external physical sound or by a physically non-existing sound, i.e. low-frequency tinnitus.

This paper contains only a brief overview of the investigation. For more details see the published article [13].

## 2. METHODS

Noise recordings were carefully made in the homes of the 21 complainants, taking into account the possible problems caused by standing waves. The complainants were exposed to these recordings from their own home in blind test listening experiments carried out in a special low-frequency test facility [14]. Furthermore, the

low-frequency hearing function of the complainants was investigated, and characteristics of the annoying sound was matched. Based on the outcomes of these tests, complainants can be divided into the following three categories:

1. The complainant could hear the recorded sound and reported that it resembled the annoying sound.
2. The complainant could hear the recorded sound but reported that it did not resemble the annoying sound.
3. The complainant could not hear the recorded sound.

For the first and last categories, natural conclusions are that the annoyance felt at home is caused, respectively not caused, by a physical sound. For complainants who fall into the second category, there is no obvious and straightforward conclusion, and it may not be possible to make a final conclusion.

For the sounds that were heard, blind tests and recognition tests were made for the sounds divided into four frequency sub-bands in order to reveal, which frequencies are audible and possibly responsible for the annoyance.

## 3. RESULTS AND DISCUSSION

From the results of the blind test listening experiments with the recordings from the subjects homes it was possible to categorize the subjects as seen in table 1. Seven subjects could hear the sound recorded in the home and recognize it as the annoying sound, which shows that these subjects are annoyed from a physical sound. Five subjects could not hear the sound recorded in their home, which means that they are not annoyed by a physical sound, but rather a type of tinnitus. The remaining subjects could hear the sound, but did not think that it resembles the annoying sound, which makes it difficult to conclude on these subjects. The focus in this section will be on the cases with annoyance from physical sound. For more results see the published article [13].

| Category | Description | Subjects |
|---|---|---|
| 1 | **Heard. Resembles annoying sound** | B, E, H, I, P, Q, R |
| 2 | **Heard. Does not resemble annoying sound** | D, F, G, K, L, M, N, O, S |
| 3 | **Not heard** | A, C, J, T, U |

Table 1. *Division of subjects into categories based on the results from the blind and recognition tests with original recordings x.*

A more detailed analysis of the results for the subjects who are annoyed from a physical sound (category 1) can be seen in figure 1, where third-octave spectra of the sound, individual hearing threshold, equal-loudness and matching results are shown for each subject. It is obvious from these results that the subjects are annoyed by a low-frequency sound with frequencies below 180 Hz.

A narrow band frequency analysis of the sound found in the home of the seven subjects annoyed by a physical low-frequency sound is shown in figure 2. It was not within the scope of the investigation to find the noise source, however, in general the sound in all seven cases contains combination of low-frequency tones. This indicates that the source(s) in each case has rotationary parts or pistons running at fixed (revolution) frequencies (e.g. pumps/compressors, engines, fans and ventilation systems).

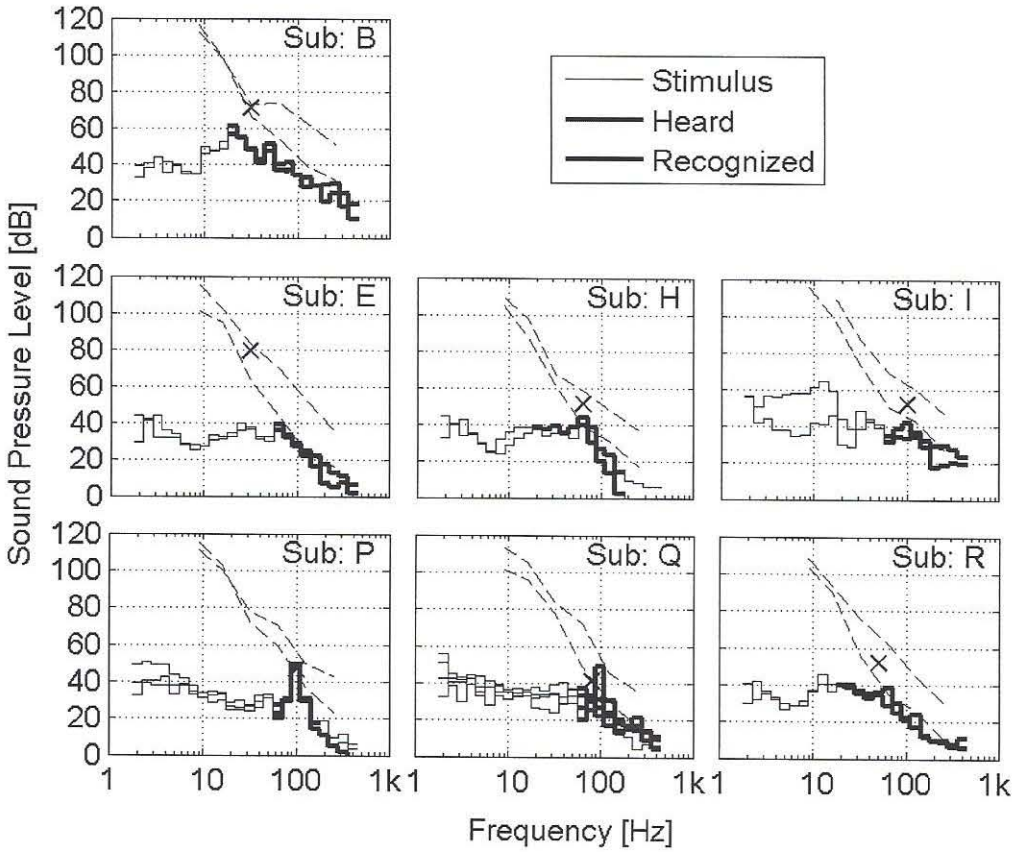


Figure 1. *Individual data for seven subjects annoyed by a physical sound: Third-octave analysis of the stimuli, where the thick lines in blue and black represent a frequency range audible to the subject at natural level (from blind tests with filtered sounds) and black is the most resembling frequency range (from recognition tests with filtered sounds). Dashed lines show individual hearing thresholds and equal-loudness contours. Results from the matching experiment are shown as an x.*

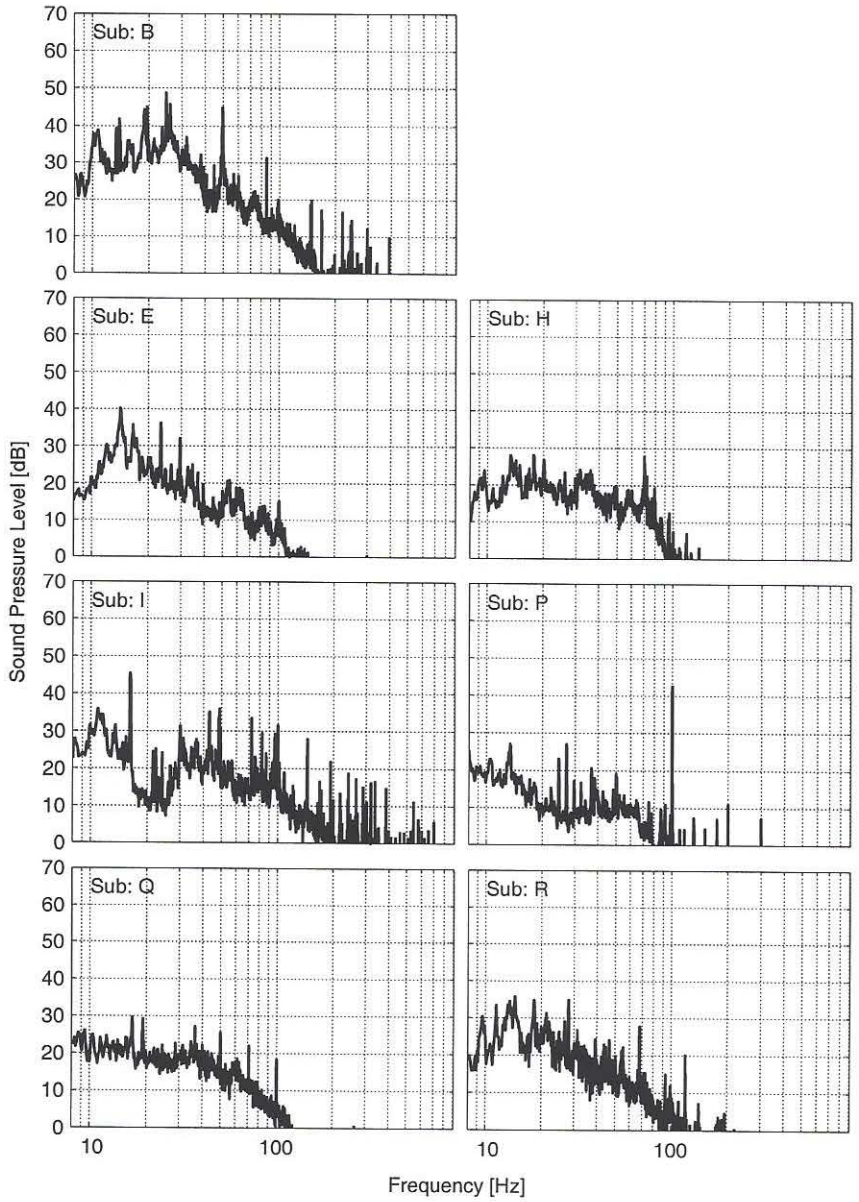


Figure 2. *Power-average of FFT spectra with 0.1 Hz frequency resolution (50% overlap Hanning window) from the eight corner positions for each of the clear low-frequency noise cases.*

## 4. CONCLUSIONS

The results showed that some of the complainants are annoyed by a physical sound (20-180 Hz), while others suffer from low-frequency tinnitus (perceived frequency 40-100 Hz). Physical sound at frequencies below 20 Hz (infrasound) is not responsible for the annoyance – or at all audible – in any of the investigated cases. None of the complainants has extraordinary hearing sensitivity at low frequencies. For comparable cases of low-

frequency-noise complaints in general, it is anticipated that physical sound is responsible in a substantial part of the cases, while low-frequency tinnitus is responsible in another substantial part of the cases.

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