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Møller, Henrik; Lydolf, Morten

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A questionnaire survey of complaints of infrasound and low-frequency noise

Henrik Møller and Morten Lydolf*

Department of Acoustics, Aalborg University, Fredrik Bajers Vej 7-B4, 9220 Aalborg Ø, Denmark. hm@acoustics.aau.dk

**now at Bang and Olufsen, Struer, Denmark. mlf@bang-olufsen.dk*

ABSTRACT

A survey of complaints about infrasound and low frequency noise has been carried out. 198 persons reported about their troubles in a questionnaire. Their verbal reports often describe a *"deep and humming or rumbling sound, like coming from a distant idling engine of a truck or pump"*. Nearly all respondents report of a sensory perception of a sound. In general they report that they perceive the sound with their ears, but many mention also a perception of vibrations, either in their body or of external objects. The sound disturbs and irritates during most activities, and many consider its mere presence as a torment to them. Many of the respondents report on secondary effects, such as insomnia, headache and palpitation, which they associate with the sound mainly because it occurs at the same place. In a majority of the cases, only a single or few persons can hear the sound, but there are also examples, where it is claimed to be audible to everybody. Typically, measurements have shown that existing limits (and hearing thresholds) are not exceeded. The investigation leaves the key question: Are the troubles induced by an external sound or not, and if they are, which frequencies and levels are involved? The feasibility of a study of this is supported by the results.

INTRODUCTION

For many years there have occasionally been cases where people complain about infrasound or low-frequency noise. This is the case in Denmark, and the situation seems to be comparable in many other countries. Most descriptions mention a deep humming sound in the home of the complainant, which annoys and disturbs sleep, rest and concentration. In addition, the sound is often claimed to cause an impaired quality of life due to headache, pain, stress, and other kinds of trouble, including severe worries of being exposed to a 'mysterious sound'.

Typically, the sound is only perceived by a single person and not the entire household. For this reason, it is often taken for granted that the trouble cannot be induced by an external, physical sound. As a consequence, in most cases no action is taken, and the complainant is left alone with his or her problem. Many of the annoyed persons find this

situation unacceptable, and in Denmark some of these have organized themselves in a society, "Infralydens Fjender" ("Enemies of Infrasound"). The society puts a constant pressure on the authorities by repeatedly bringing up their problem, e.g., in the daily press.

A disturbing issue is the widespread misunderstanding that infrasound is inaudible for humans, because the frequency components are placed below the claimed '*audible frequency range*' from 20 Hz to 20 kHz. Although it was shown at least as early as in the 1930's that infrasound can be perceived, when only the sound pressure level is sufficiently high ([1], [2], [3]), this misunderstanding still exists, even among professionals. As a consequence, the mere mentioning of the word *infrasound* brings up associations to 'inaudible sound' that can hardly be taken seriously.

Official initiatives in Denmark

In 1995 the Danish Environmental Protection Agency arranged noise measurements in some selected cases. The measurements usually showed sound pressure levels well below or, at the highest, around the normal hearing threshold for low and infrasonic frequencies, a fact that added to the skepticism toward the complainants. The hypothesis was put forward that they might suffer from a special low frequency tinnitus, but this was never tested, thus neither confirmed.

In 1997 the Environmental Protection Agency issued an information report on low frequency noise, infrasound and vibrations [4]. The report recommends that the indoor noise in dwellings should not exceed 85 dB(G) for the infrasound and 20 dB(A) for the low frequency noise (10-160 Hz).

In Figure 1 the recommended limits are shown together with the hearing threshold standardized in ISO 389-7 [5], and for the lowest frequencies as measured by Watanabe and Møller [6]. For frequencies below 20 Hz the limits ensure a sound pressure level approximately 10 dB lower than the average hearing threshold. Going toward higher frequencies, the limit passes the average threshold around 30 Hz, and a level 10 dB above the average threshold is reached around 70 Hz.¹

These limits appear quite reasonable, provided that they are used with measurements that truly represent the human exposure. On the other hand, it seems that in most of those cases that initiated the information report, measured levels are below the limits, and the report apparently stopped further examination of these cases.

¹The information report [4] states that the limit is 10 dB below the average hearing threshold up to 40 Hz. As seen in the figure, this is not correct. The reason for the disagreement is that the report uses an 'average hearing threshold', which deviates significantly from the standardized hearing threshold in the 25-50 Hz frequency range

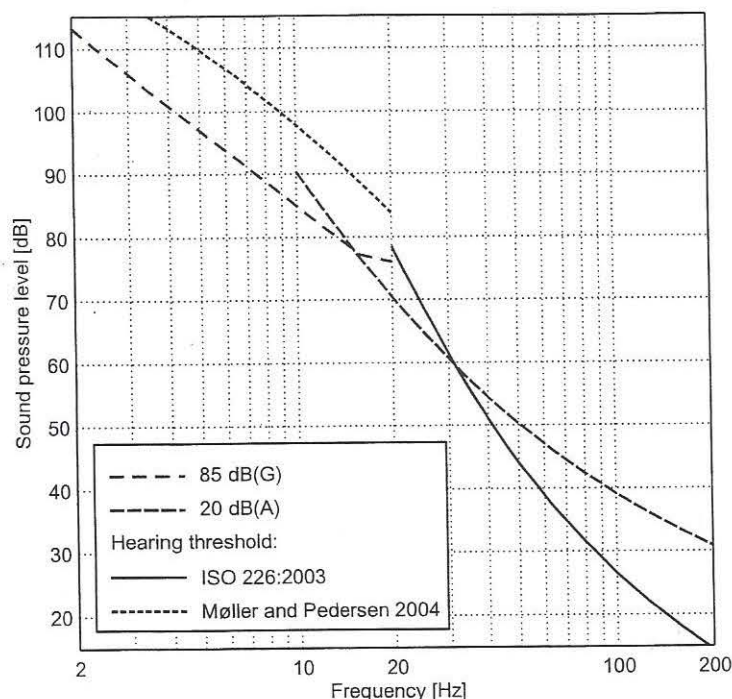


Figure 1. Limits of 85 dB(G) (up to 20 Hz) and 20 dB(A) (10-160 Hz) and the hearing threshold (as standardized in ISO 389-7 [5] and as proposed by Møller and Pedersen [6])

Present study

The survey presented in this chapter was meant to give a better understanding of the trouble experienced by individual complainants. In addition, and – depending on the results – it was thought to possibly serve as background material for planning and seeking of funds for a more thorough investigation of a group of complainants. It was the intention to collect in a systematical way information from a number of cases, and in this way to clarify, 1) whether the troubles experienced by different people are similar and 2) what they are, 3) whether there are reasons to believe that the troubles are induced by physical noise or not, 4) where and when the troubles occur, 5) whether there are problems all over the country, and 6) what has been done to solve the problems. It was not the intention to investigate systematically the extent of claimed low frequency noise problems – except that the survey would reveal, if there were only few isolated cases in Denmark. The present chapter summarizes some important results of the survey. Results have been updated with data from questionnaires received after the initial conference publication [7]. A full report is available in Danish [8].

DESIGN AND DISTRIBUTION OF THE QUESTIONNAIRE

The questionnaire was printed on nine sheets of A4 paper and included an instruction and 45 numbered questions. It was prepared in such a way that the annoyed person could fill it out directly, or a family member or case officer could do it, e.g., via an interview. The cover letter recommended that the annoyed person did it personally. In all cases, name and address of the annoyed person were registered. Most of the questions were structured in a multiple-choice form. A few questions required text to be entered.

Instructions

The respondents were encouraged to add comments in the large margins of the sheets, if the multiple-choice possibilities did not offer the relevant answer. It was pointed out that they were allowed to abstain from answering some of the questions, and that it was legal to give more than one answer in a question if appropriate. For these reasons the percentages of answers in a multiple-choice list will not necessarily sum up to 100%.

Depending on the situation and the answers given, some of the 45 questions would be irrelevant for some people. For this reason the respondents were sometimes told to skip questions and go to a subsequent question, depending on the answers already given. Some people were obviously too eager in answering the questions and did not make the correct jumps. These were kindly asked to fill out a new questionnaire, unless the error could be rectified in the data processing without any risk of misinterpretation.

Distribution

Questionnaires were sent to civic and regional environmental administrations throughout the country, to the secretariat of "InfraLydens Fjender" and to a number of acoustic consultants in Denmark. It was furthermore available in PDF-format from the internet homepage of the Department of Acoustics, Aalborg University. People were encouraged to copy and distribute it freely.

Because of the distribution form, it is not known how many copies that were actually distributed, and the responses cannot be used to estimate the number of annoyed persons, the geographical distribution of the problems, or any similar statistics. The responses must simply be taken as examples of cases where a person experiences some kind of trouble, which he or she believes is caused by low frequency noise or infrasound.

202 questionnaires were returned, most of these within the first months following the launch of the campaign in August 1998. 4 persons did not respond to a request of clarification in connection with incorrect jumps, thus leaving 198 responses for analysis.

RESULTS AND DISCUSSION

Nearly all questionnaires were filled out by the annoyed person and only a few by a family member or a case officer. The respondents were between 14 and 86 years of age with a mean of 55.7 years.

About two thirds of the respondents were female and one third were male. The only well established evidence of women having a better hearing than men, is at high frequencies, where the impairment of hearing with age differs between genders (ISO 7029 [9]). Even though the similarity of hearing between genders has not been fully confirmed at very low frequencies, the difference in number of respondents is more likely caused by social or psychosocial reasons.

Questionnaires were received from all over the country. Large and small cities as well as the countryside were represented. The density of responses was clearly higher in the region close to the secretariat of "InfraLydens Fjender" than in other regions, since 31.3% of the responses were from that county, and the county covers only 6.8% of the population in Denmark. This might indicate more problems in this region, but more likely it demonstrates the society's success in using the press to make people aware of the survey (and of the problem).

Individuals' description of the sound

In the first question about the noise, the persons were asked to describe the sound in their own words, and eight blank lines were left for this purpose. Most of the respondents tried eagerly to give a detailed description of the sound. Naturally, there is a large variety in the answers but some expressions are frequently used, such as *"the sound...."*

"...is a deep humming/rumbling sound",

"...is constant and unpleasant",

"...creates a pressure in the ears",

"...affects the whole body",

"...sounds like coming from a large (idle running) engine of a truck, pump, ferry or aircraft",

"...is coming from somewhere far away, outdoor, and may be transmitted through the ground".

Many persons are apparently not able to localize the sound source directly. Therefore they make a number of speculations as to what the source may be. The impression of the source being far away and outside the house might be caused by lack of midrange and high frequencies. Then our common experience from sound transmission through walls and over long distances could create the illusion of a distant source, even if the sound is actually generated nearby.

Where and when?

In one question the persons were asked where they experience trouble from the sound. The responses in terms of statistical frequencies are shown in Figure 2. It is seen that nearly all of the persons indicate indoors in their home, either all over the home (81.8%) or at particular places (16.7%). Furthermore it is seen that troubles are experienced not only inside buildings, but also sometimes outside. Only few problems are seen at the job. Many people added margin comments on extra details, such as where in the home the sound is most intense, what their experience is at other places etc.

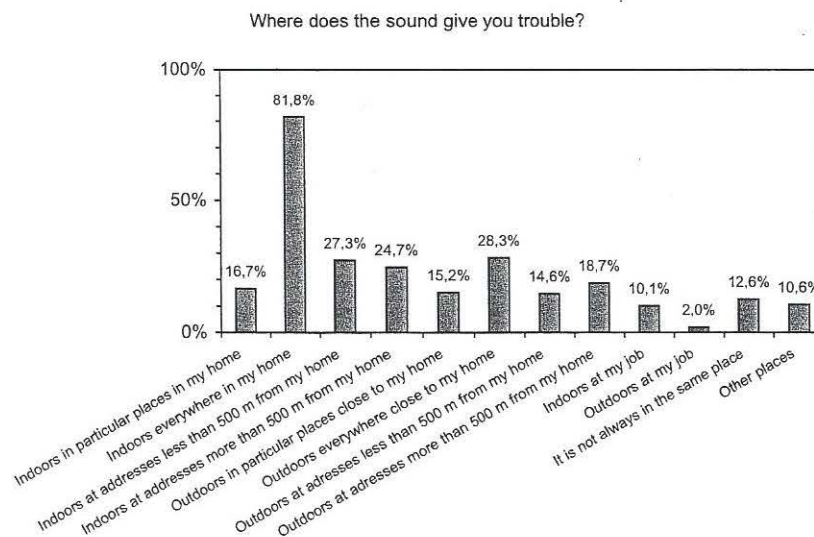


Figure 2. Question 6, places where the sound gives trouble. Rates of answers given in percentage of all respondents.

In another question the persons were asked which time of the day the trouble occurs. The answers were almost equally distributed between day, evening and night, however with a small preponderance in the nighttime (22:00-7:00). A vast majority marked two or three of the three given intervals.

Is there a sensory perception?

As mentioned, it has often been argued that some of the complainants might not actually *hear a sound*, but rather feel some general unpleasantness and put the blame on sound, only because of rumors about strange effects of infrasound and low frequency noise. In one question the persons were asked, whether they perceive the sound directly with their senses. In order not to bias the persons toward

reporting of a false sensory perception, the wording of the question and the possible answers were carefully selected in order to make it perfectly 'legal' and not in any way doubtful to admit that the sound was not directly perceived.

The results of this question are given in Figure 3. It is seen that nearly all persons (92.9%) report that they hear a sound with their ears. Some persons (16.2%) report of a sensation in the ears but not as that of a sound. 98.0% answered one or both of the two first categories. Thus, nearly all respondents have a sensory perception related to the ears. Many have a sensation of vibrations, either in their body (43.9%) or of objects around them (28.8%).

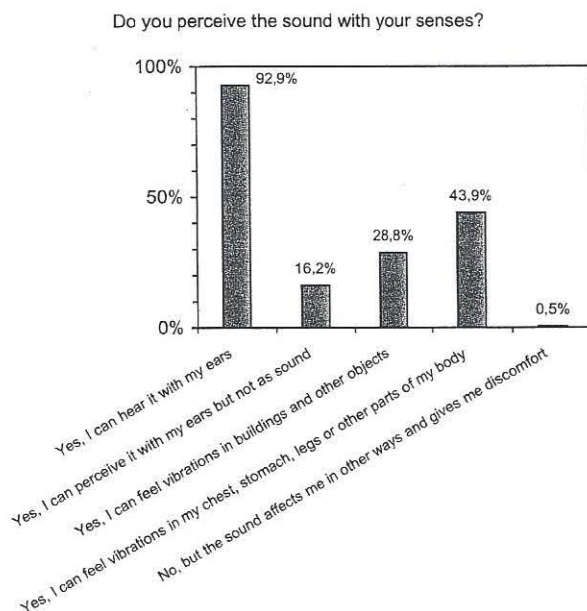


Figure 3. Question 7, sensory perception. Rates of answers given in percentage of all respondents.

Only 0.5% (a single person) did not report of a direct sensory perception. This person reported insomnia and headache, and as a reason for blaming infrasound or low frequency sound, the person reported that he or she had heard or read that it might be the reason.

In one question the persons were asked how long time they have to be in the sound before the trouble starts. Results from this question are given in Figure 4. Obviously, the trouble starts very soon for most of the persons, as 62.6% indicate "immediately" and 24.2% state "within a few minutes" (a few persons reported both of these answers, 83.3% answered at least one of them). The immediate occurrence of the trouble

corresponds well with the fact that many of the troubles are connected directly to the sensory perception.

How long do you have to be in the sound before the trouble starts?

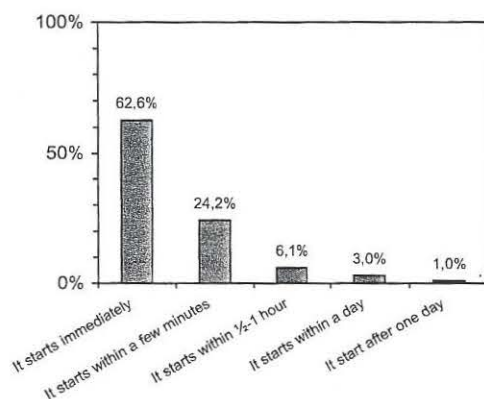


Figure 4. Question 28, time before trouble starts. Rates of answers given in percentage of all respondents.

Do other people hear the sound?

The persons with a reported sensory perception (i.e. all persons except one) were asked whether other people are able to perceive the sound as well. The results from this question are shown in Figure 5. A group of 38.1% reported that he or she is the only person who can hear it, while 28.9% indicated that a few persons can hear it. Only 14.2% indicated that the sound is audible to everybody.

Who can hear, feel or in other ways perceive the sound?

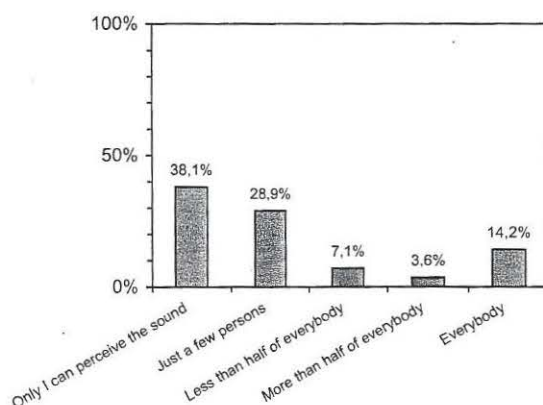


Figure 5. Question 14, number of persons who can perceive the sound. Rates of answers given in percentage of respondents with claimed sensory perception.

Some persons added extra information about exactly who can hear the sound, or mentioned that he or she lives alone and does not have visitors very often. In such cases there may be a bias in the answers, since more persons than indicated might be able to hear the sound, if only other people were being exposed to it.

In another question the persons were asked, whether other people had mentioned the sound without being made aware of it. This had happened in 34.5% of the cases.

Type of effects

The persons with a sensory perception were asked which kinds of trouble that are related to the sound. The question was split up into troubles directly related to the perception, and secondary effects, i.e., other kinds of trouble, which they believe are induced by the noise.

The answers from the question on troubles that are directly related to the perception are seen in Figure 6. A majority of the persons reported on problems like being disturbed when falling asleep or when reading, frequently paying attention to or being irritated by the sound, and being awakened from sleep. 76.1% consider the mere presence of the sound as a torment to them. An example from the "Others" category is "*pressure in the ears*".

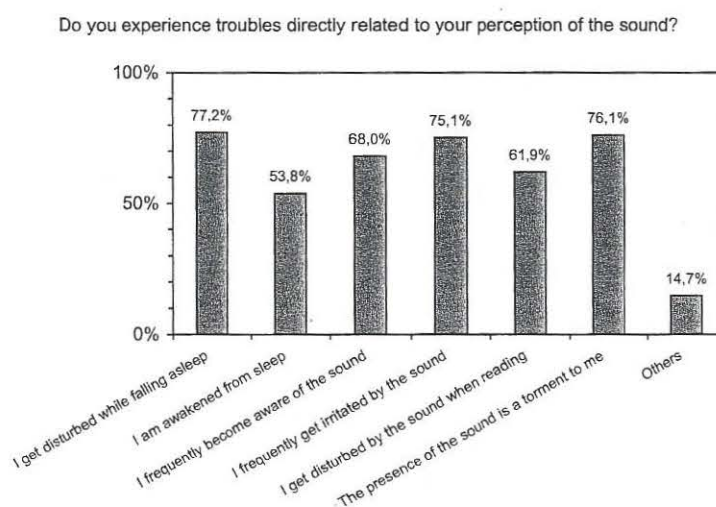


Figure 6. Question 16, troubles directly related to the perception. Rates given in percentage of respondents with a claimed sensory perception.

The answers concerning secondary effects are seen in Figure 7. The highest rates (close to 70%) occur for insomnia and lack of concentration, problems that are nearly directly related to the

perception, and which were more or less reported already in response to the question on this. As examples of truly 'secondary' effects, many reported dizziness, headaches and palpitation. Examples from the "Others" category are stress, aggression, restlessness, nausea, fatigue, increased tension in muscles, and weak nerves.

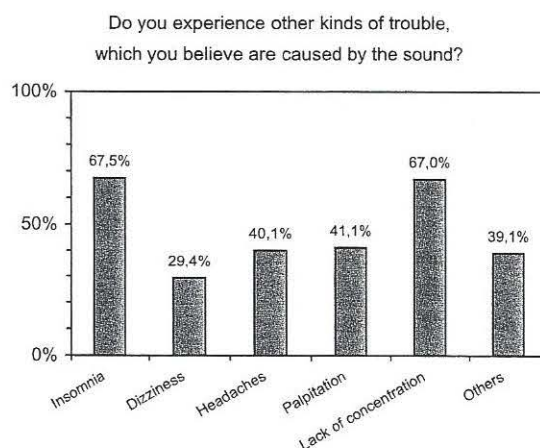


Figure 7. Question 17, troubles that are not directly related to the sensory perception. Rates of answers given in percentage of respondents with a claimed sensory perception.

Those persons who indicated secondary effects were asked, why they believe that infrasound or low frequency noise is responsible. 72.9% of them relate the secondary effects to the sound because it appears at the same place. Quite a few (36.2%) indicate that they have heard or read that the trouble they experience may be induced by sound.

Attempts to improve the situation

In one question the persons were asked what they have done in order to solve or relieve the trouble. Many have tried to use earplugs at night (62.9%) or during the day (34.0%), most often without any effect. 8.1% have moved to another house, and 48.7% consider doing it. 40.6% have consulted their general practitioner or a specialist, and 17.3% take medicine.

Complaints to authorities

64.6% of the responding persons have complained to the authorities about the noise. In 14.8% of these cases the complaint was rejected immediately. In 60.1% an official person has visited the complainant or an address in the neighborhood in order to evaluate the situation.

Noise measurements have been made in 48.4% of the cases in which an official complaint was filed, vibration measurements in 15.6%.

Typically, measurements did not reveal anything that was expected to give rise to problems (or be audible), and existing limits were usually not exceeded. (This refers to the explanations given by the annoyed persons; the authors have not had the opportunity to study the original measurement reports). Measurement difficulties are frequently reported, e.g., because of background noise or insufficient equipment. Some of the persons have expressed their distrust in the measurements and the limits.

Only 7.8% of those, who have complained to the authorities, indicate that their problem has been solved or partly solved. However, in an investigation like the present, there will be a natural bias toward a low number of persons for whom the problems have been solved, since these persons will be less motivated for filling out a questionnaire than those who still have a problem.

Are the troubles caused by a physical sound?

As mentioned, when measurements are made, only very low levels of low frequency and infrasonic noise are usually seen. The levels suggest that the sound would be inaudible or at least so soft that no complaints could be expected. It is a fact, though, that our knowledge of low frequency hearing is based on a few investigations with a limited number of subjects, and it cannot be excluded that there are individuals with a much better hearing at these frequencies, or an otherwise deviating hearing function, e.g., an unusually steep rise of loudness above the threshold. Møller and Pedersen [6] gathered a few cases of especially sensitive persons from the literature. If such extraordinary individual sensitivity is the reason for the troubles, it may not justify a lowering of the general limits, but a better understanding might lead to tools and solutions that could solve or relieve the trouble in specific cases. It is characteristic for many cases that the annoyed person, or even an alleged 'noise polluter', is willing to pay for a solution, if he or she only knew what to do.

The crucial question is, whether the trouble is induced by an external sound field or not, and if it is, which frequencies and levels are responsible. The authors have often been tempted to investigate in detail a few selected cases, e.g., with blind tests in the laboratory using recordings from the complainant's homes. However, we have refrained from doing this, since we imagine that there may be a variety of reasons for the complaints, and there would be a high risk of making wrong conclusions from a very limited and insufficient investigation.

The authors give a high priority to a detailed examination of a larger number of cases, and as seen below, a such investigation will follow. We are well aware that the investigation might show that external sound is responsible only in few or even none of the cases. Even that would be a valuable result, though, since it would pave the way for a constructive search for other possible reasons for the complaints. The uncertainty

which is still connected to the matter has irrational consequences, e.g., power plants and factories being accused of 'polluting' entire regions with noise, worries about effects of sound based on pure speculation, worries that house prices will go down in 'polluted' areas etc. There are even examples of local authorities who have abstained from investigating straightforward cases of noise complaints – with rather loud noise that would be annoying for everybody – by referring to the difficulty in handling of low frequency noise problems!

SUMMARY AND CONCLUSION

The 198 respondents experience troubles mainly in and around their homes. Their verbal reports often describe *"a deep and humming or rumbling sound, like coming from a distant idling engine of a truck or pump"*. Nearly all respondents report of a sensory perception from the sound. In general they perceive it with their ears, but many have also a perception of vibrations, either in their body or of external objects. The sound disturbs and irritates during most activities, and many consider its mere presence as a torment to them. Many of the respondents report on troubles that are not directly related to the perception of the sound, e.g., insomnia, headache and palpitation, but which they associate with the sound, because they occur at the same place as the sound. In a majority of the cases, only a single or few persons can hear the sound, but there are also examples where it is claimed to be audible to everybody.

There are respondents from all over the country, however with a preponderance in the area where "Infralydens Fjender" has been particularly active. There are more women than men among the respondents. Many of the respondents have complained to the authorities, but most often this has not led to a solution. Typically, measurements have shown that existing limits are not exceeded. Sometimes authorities have rejected cases immediately without any investigation. The study is most likely biased toward having unsolved cases, since people with solved problems are less motivated for submitting a questionnaire.

Because of the simple distribution form of the questionnaire, the result of the investigation cannot be used to estimate the extent of infrasound and low frequency noise problems in the country, but the cases must be regarded as examples only. However, it can safely be concluded that there are more than just a few people in a small region, who experience various kinds of trouble, which they believe are caused by infrasound or low frequency sound.

The investigation has not proven that the troubles are due to external sound, but the fact that most of the respondents report that they perceive the sound with their senses motivates a further investigation, and it facilitates the design of blind tests.

FUTURE INVESTIGATION

On this background a continuation of the project was planned and initiated. 22 cases have been randomly selected for a detailed investigation. Sound measurements and calibrated recordings have been made at the places of the claimed exposure. Each recording will be played back in the laboratory to the actual complainant, using a pattern of blind tests to see whether the sound can be heard and recognized. Also, playback of filtered recordings is planned in order to encircle the frequencies responsible for the troubles. The playback will take place in a newly updated laboratory at Aalborg University [10], thus taking advantage of exposure facilities, which cover both the infrasonic and the low frequency range. Furthermore, all complainants will undergo a general medical check and detailed audiological and vestibular examinations, including examinations at low and infrasonic frequencies. The investigation matches well an investigation, which was planned in 1995 by a National Board of Health group of general physicians, epidemiologists, audiologists and engineers, but which was never carried out. Results are expected in 2006.

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