“Interpretation of Evaluation Guide” to Solve Low Frequency Noise Problems

1. Scope

Local government frequently receive complaints about low frequency noise from stationary sources at plants, workshops, stores and facilities installed in residential areas. These sources emit low frequency noise in a relatively stationary sound pressure level. Test labs have accumulated data through experiments using almost steady and constant low frequency sound. They have not yet obtained enough research data of low frequency noise which occurs singly or for a short period.

This Evaluation Guide is not applicable to low frequency noise from sources on highways which do not always emit the noise but where the noise from these sources is irregular and varies widely depending on the time and situation, or the noise from transient and intermittent sources such as airplanes and railways, and explosive noise from such sources as blasting, explosion and high-speed trains entering a tunnel. The Evaluation Guide will be limited at the moment to being applicable to those sources which are stationary or temporarily not moving, and which emit low frequency noise consistently for a certain period.

2. Reference Values to Counter Complaints about Low frequency Noise

The Guide provides reference values to identify whether complaints are ascribable to low frequency noise or not, because of differences in response to the low frequency noise between fittings and persons. These reference values are categorized into those for complaints of rattling and those for complaints of mental and physical discomfort.

2.1 Reference Values for Complaints of Rattling

(1) Thresholds of Low Frequency Noise to Rattle Fittings

The threshold of low frequency noise for rattle in fittings is the minimum sound pressure level at which fittings start rattling. The result of steady low frequency noise testing of fittings indicates that the minimum sound pressure to initiate rattling varies with the type of fittings and ranges between 30 and 40 dB (see Figure.4.3.2 in “Examination of Low frequency Noise Countermeasures (interim report)” issued in July 2003[1]: following Figure.3[2]). The “mean value - standard deviation” of the minimum sound pressure level to initiate rattling in fittings generally coincides with the previously obtained “threshold of rattle in fittings” (see Figure. d-5 in “the Measurement Manual for Low Frequency Noise”[3]: following Figure.4[4]).

There are differences in characteristics between low frequency noise thresholds at which fittings start rattling and at which persons sense the noise. People can sense low frequency noise at a higher sound pressure level, while fittings tend to start rattling at a lower sound pressure level than people sense at a frequency below 20 Hz.

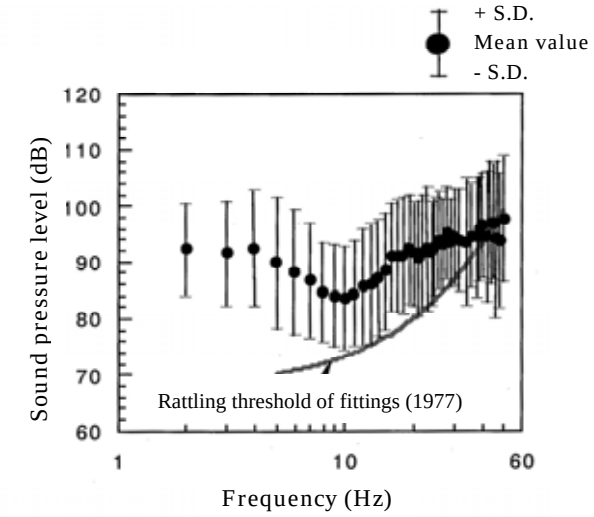

Fig.3 Minimun sound pressure level of rattling. (63samples; 2002[2])

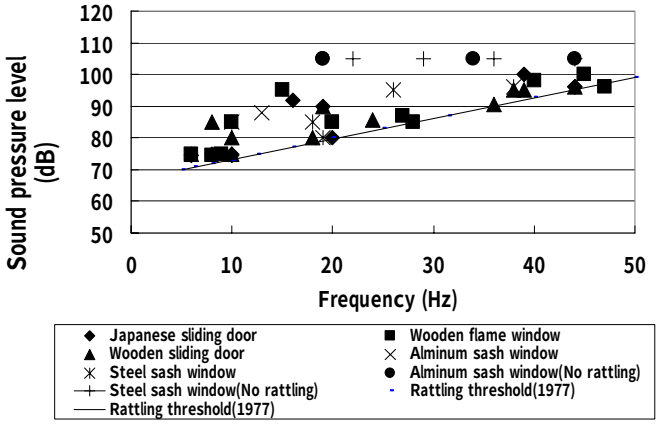

Fig.4 Minimun sound pressure level of rattling. (15samples; 1977[4])

(2) Interpretation of Reference Values for Complaints of Rattling

There are complaints of rattling such as quivering and rattling of fittings caused by low frequency noise. Each fitting has its own characteristic frequency. When the frequency of low frequency noise from outside and the characteristic frequency synchronize, the fittings tend to rattle at a low sound pressure level. This means the “mean value - standard deviation” correspond to complaints better than mean values of low frequency ranges.

The results of the national survey of low frequency noise problems since 2000 also indicate complaints of rattling at the sound pressure level of around the “threshold of rattle in fittings” as calculated through experiments in a test lab. It is generally concluded that complaints of rattling can be reasonably assessed by these values.

Taking data accumulated so far into consideration in addition to the above, the “thresholds of rattles” were employed as reference values for complaints of rattling from low frequency noise.

2.2 Reference Values for Complaints of Mental and Physical Discomfort

(1) Results of Evaluation of Threshold and Mental and Physical Complaints

It is said that the complainants are sensitive. To confirm this belief, the Ministry tested the minimum sensing threshold (hearing threshold) by comparing complainants with an adult control group as test subjects in 2003. The test results did not indicate that complainants are sensitive. Although it was probably partly the cause that there were rather aged complainants who participated in the test to obtain data; the average values of their hearing threshold were higher than those of the average adults (in short, the complainants were not sensitive)(following Figure.5).

In 2003, the Ministry also examined the tolerable level (acceptable limit) when the test complainants and average adults control group were exposed to low frequency noise in a room (a low frequency pressure

chamber assumed as in living room or bedroom). The test was based on the assumption that test subjects would prefer a calm and peaceful living environment. According to the test results, many average adults felt the noise at a higher tolerable sound pressure level than the hearing threshold by a few decibels to a dozen decibels. In contrast, many complainants felt the level approximate to the hearing threshold tolerable. The result demonstrated the tendency for the frequency characteristics of the tolerable level for the complainants to be at around the reference values for mental and physical discomfort which were obtained from ten percentile curve of the tolerable level of average adults control groups in the bedroom (following Figure.6).

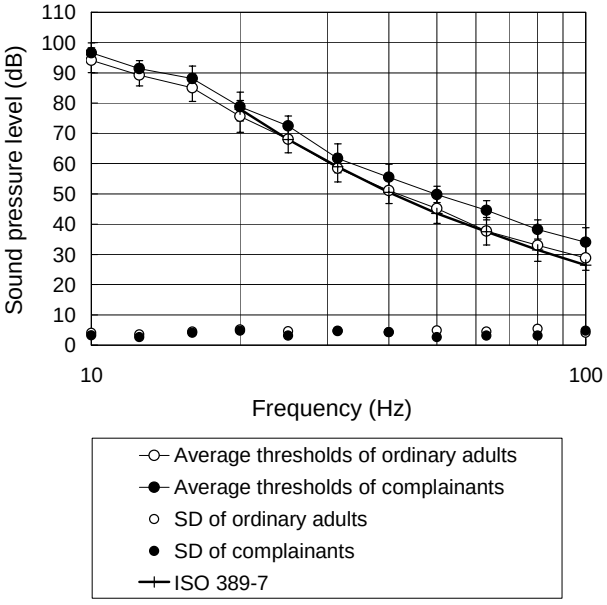

Figure.5 Average hearing thresholds of ordinary adults and complainants[5]

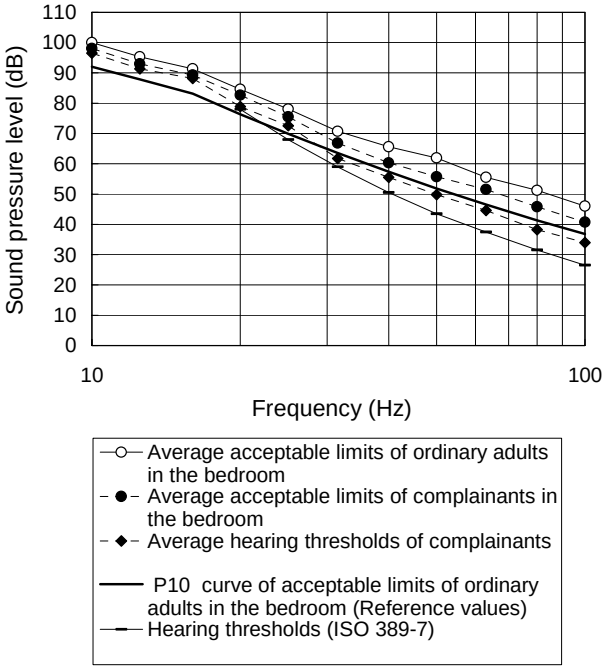

Figure.6 Tolerable levels (acceptable limits) of ordinary adults and complainants in the bedroom[6,7]

(2) Interpretation of Reference Values for Complaints of Mental and Physical Discomfort

Most complainants felt low frequency noise in a room. Taking this fact into consideration, the measurement values obtained in the room were employed as reference values. In addition, considering significant individual differences in sensing the low frequency noise, the sound pressure level which the large proportion of the test subjects felt tolerable was defined as a reference value.

The past field measurement data were compared with the reference values. In the case where complaints corresponded to the period of operation of a source, most data indicated that the sound pressure level exceeded the reference values at some frequencies. In the case where there was no source but complaints, and there could be causes other than the low frequency noise, most data about complaints were lower than the reference values at every frequency. In short, it was concluded that the reference values reasonably correlated with most complaints corresponding to operation of the source. Incidentally, there is a slight possibility that complainants would complain about the noise at a lower sound pressure level.

According to the results of the past surveys, tremendously significant infrasound seldom occurred in

ordinary living environments. Focusing on mental and physical discomfort caused by infrasound, the Ministry added the evaluation using the G-weighted sound pressure level. The reference values at the G-weighted sound pressure level were calculated based on the tolerable level in the bedroom. Incidentally, low frequency noise is assessed basically at the 1/3 octave band sound pressure level. It is not recommended to evaluate low frequency noise only by the G-weighted sound pressure level.

3. Measurement

3.1 Measurement Methods

As a rule, measurement methods for low frequency noise were carried out in accordance with the "Measurement Manual for Low frequency Noise (October 2000)"(in Japanese) and "Guidance" to counter low frequency noise problems.

3.2 Measurement Position

(1) Measurement Position for Complaints of Rattling

The test results of low frequency noise to rattle fittings are sorted by the incident sound pressure level to the fittings; therefore, the measurement was performed outside of the building. A desirable outdoor measurement position is 3.5 meters or more away from complainant's building, considering any influence from reflection from the surrounding buildings to measure low frequency noise in general living conditions. In cases of complaints of rattling, the low frequency noise would be measured one or two meters away from complainant's building such as residences, etc.

(2) Measurement Position for Complaints of Mental and Physical Discomfort

This measurement is designed to identify the characteristics of low frequencies which are the subject of complaints by measuring the noise at the position in the room where complainants most frequently feel low frequency noise and discomfort. The measurement position was defined as the position where people feel the noise most, because standing waves occur at a certain frequency in a room and the sound pressure level of noise varies according to the location of the room.

In addition, it is generally effective if the above measurement data are compared with measurements taken at the position in the room where the complainant does not feel low frequency noise or discomfort.

3.3 Measurement Value

With regard to the measurement value of low frequency noise, test results as a base for reference values are already classified by frequency. Thus, the sound pressure level is measured in the 1/3 octave band. In addition, the G-weighted sound pressure level is employed for the evaluation of mental and physical discomfort caused by infrasound, as specified with respect to the weighting for the evaluation of infrasound below 20 Hz in ISO-7196.

3.4 Frequency Range for Measurement

The frequency range for measurement is the center frequency of 1 Hz to 80 Hz in the one-third octave

band according to the “Measurement Manual for Low frequency Noise”(in Japanese).

3.5 Calculation Method for Measurement Results

This Guide covers low frequency noise with a narrow fluctuation range of the sound pressure near sources. In spite of there being little fluctuation in the sound pressure level at the source, the fluctuation range might increase due to several factors in process of transmission. In this sense, the Guide provides how to calculate the results with an unstable sound pressure level of low frequency noise.

In the case where the sound pressure level of the low frequency noise fluctuates with wind, the noise will be measured at positions with less influence from wind where, in other words, the sound pressure level seldom fluctuates. Then, the sound pressure level of power average is used.

The fluctuation range of the sound pressure level is determined by reading indications of a low frequency sound level meter or a level recorder. In this measurement, with regard to the weighing characteristic of the low frequency level meter, the flat-weighting is used for frequency analysis and the G-weighting for calculating the G-weighted sound pressure level (If the low frequency meter does not have a G-weighting function, flat-weighing may be used).

4. Evaluation Methods

4.1 Evaluation Methods for Complaints of Rattling

In the case of a rattle in fittings, the causes are different from the case where every fitting in a house or in a room rattles to the case where only a specific fitting rattles. In the latter case, low frequency noise is a possibility.

If the sound pressure level of measurements in the 1/3 octave band is higher than or equal to the reference values shown in Table 1 at either of frequencies, it is concluded that low frequency noise may cause such rattle.

If the sound pressure level of measurements in the 1/3 octave band is below the reference values at any frequencies, and if there is no correlation between operation of the source and the rattle in fittings, a cause of the rattle could be factors other than low frequency noise, such as ground vibration. If every fitting in a house or a room quivers, ground vibration is likely.

Incidentally, the G-weighted sound pressure level is not used for the evaluation of complaints of rattling.

4.2 Evaluation Methods for Complaints of Mental and Physical Discomfort

In past evaluation of complaints of mental and physical discomfort caused by low frequency noise, only the G-weighted sound pressure level used to be measured and the result of 100 dB or less used to be determined as no problem. The G-weighted sound pressure level is an evaluation index used to evaluate the influence of infrasound of 20 Hz or less, so it cannot evaluate low frequency noise in the audible range up to 80 Hz. For the evaluation of complaints of mental and physical discomfort due to low frequency noise, it is crucial to both the G-weighted sound pressure level and the 1/3 octave band sound pressure level.

If the G-weighted sound pressure level is higher than or equal to the reference values, people may sense a infrasound and may make a complaint. The G-weighted sound pressure level, however, seldom increases

to the reference values or higher in general living conditions. Next, if the sound pressure level of measurements in the 1/3 octave band is higher than or equal to the reference values as shown in Table 2 at either of frequencies, people may perceive low frequency noise and may make a complaint. If the G-weighted sound pressure level is less than the reference values, and the sound pressure level of measurements in the 1/3 octave band is smaller than the reference values at any or all frequencies, the low frequency noise is seldom problematic. In the latter case, a noise of 100 Hz or more or other factors such as ground vibration, rather than low frequency noise, may cause complaints.

If there is no relation between changes in low frequency noise and the response of complainants, it is concluded that complaints of mental and physical discomfort may be caused by the noise from 100 Hz to 200 Hz outside of the frequency range initially measured, ground vibration or factors other than low frequency noise (factors directly related to the complainant, such as tinnitus, etc.)

References

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[4] Yasuo Tokita and Kazuo Shimizu, “Proposal on the low frequency noise meter”, Proceedings on low frequency noise and hearing, 227-234(1980).

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[6] Kamigawara, K., Yue, J., Saito, T. and Hirano, T. “Publication of Handbook to Deal with Low Frequency Noise (2004)”, Proceedings of Low Frequency 2004, Maastricht, The Netherlands, 157-161 (2004).

[7] Yukio Inukai, Shinji Yamada, Hiroaki Ochiai and Yasuo Tokita, “Acceptable limits and their percentiles for low frequency noise in ordinary adults and complainants”, Proceedings of Low Frequency 2004, Maastricht, The Netherlands, 117-127(2004).