

“Guidance” to Counter Low Frequency Noise Problems

1. How to Counter Complaints about Low Frequency Noise

This Guidance is intended to give a direction to solve low frequency noise problems through analyzing and measuring complaints and evaluating such complaints according to the “Evaluation Guide” to counter low frequency noise problems from stationary sound sources*.

* Stationary sound source: the Guidance is applicable to a source which consistently emits low frequency noise for a certain period at a fixed position. The Guidance is not applicable to complaints about low frequency noise from moving sources of transportation facilities, blasting, explosion, etc.

2. Understanding Complaints

It is of an extreme importance to understand complaints by complainants apparently caused by low frequency noise. In particular, when receiving complaints on the phone, it is very important to have a careful telephone interview with the complainant.

○ Interview Check List

Receiving

- Contact:
- Received date:
- Interview by: Telephone/Face-to-face
- Complainant: Name, phone number, etc.
- Address:
- Number of complainants: One / More than two

Description of complaints

- Noise field:
- Place: outdoor / indoor (living room, bed room, etc.)
- Residence: Detached (two-storied, one-storied, etc.) /
Condominium (number of stories)
- Contents of complaints: Rattle in fittings, discomfort feelings including oppressive feeling, vibration and unpleasant sensation
Can the complainant hear (sense) the noise, or otherwise, is there ground vibration?
- In case of rattle in fittings: Only a certain fitting rattles, or every fitting in the residence rattles.
- In case of hearing noise: What type of noise?
- When opening windows: The complainant will feel better / worse.
The complainant can hear (sense) / can not hear (sense) the noise.
- When closing windows: the complainant will feel better / worse.
The complainant can hear (sense) / can not hear (sense) the noise.
- Difference in feeling by room in the residence: Are there rooms
where the complainant feels or does not feel the noise?
- Place where the complainant frequently feels the noise:
Near the wall, center of the room, near the floor and others (to confirm whether there is a standing wave or not).
- When it occurs?: Daytime (morning/afternoon/evening) / Nighttime / When sleeping/ All day long /
Others
Windy day, rainy day, etc.
- Time period: Consistent / short time / always changing (every _____ minutes)
- Time course: How long has the complainant felt or annoyed?
(____ years ago / ____ months ago / since the trigger ____)
- Source which the complainant assumes:
- Special instruction: other complaints

NOTES:

Individual differences in sensing the low frequency noise is significant. There is a case where only one household complains or where only one person of a family feels discomfort. Many complainants are often mentally isolated. Therefore, inspectors are required to have an interview caring such mental isolation.

Components of low frequency noise and other noise are examined by opening and closing windows. When windows are open, people do not hear (sense) low frequency noise because noise components entering from outdoor counteract the low frequency noise. In contrast, when the windows are closed, people often hear (sense) low frequency noise distinctively.

Depending on the wavelength of the low frequency noise and the dimensions of a room, standing waves* often occur; therefore, people feel the noise differently even in a same room. It is necessary to ask which position the complainant most strongly feels the noise.

* Standing wave: When the distance between walls and a half of the wave length accord in a room, the distribution of sounds in the room will be constant due to sound interference. Under the circumstance, the sound pressure near the wall gets larger, while it gets smaller at the center of the room. This phenomenon is defined as a standing wave. On the other hand, when the frequency is high and the wave length is short, the sound pressure on the wall and at the center of the room will get large.

3. Field Inspection

Since telephone interviewing has a limitation to counter complaints about low frequency noise, inspectors will visit to inspect the actual field to assess the situation and to investigate a source of the complained noise. To investigate the source, the inspector shall assess the current operation of a suspected source facility, comparing the operating time of the facility with the duration when the complainant complained the noise, and hearing or sensing the noise with his or her five senses. The inspector may perform prior provisional measurement at this phase.

When the source can be estimated or identified, it is helpful for the inspector to make a plan for measurement and to more precisely understand the complaint by the complainant.

○ Field Evaluation Check List

The inspector may ask the following to the complainant in the telephone interview; provided, however, field evaluation is still required.

- Residence conditions: floor plan of the residence, etc.
- Circumstances around the complainant's residence:
 - Positional correlation among the complainant's residence, neighboring factories, offices, stores and private residences , etc;
 - Facilities and equipment installed in the neighboring factories and offices, and their operation ; , etc
 - Other facilities and equipment around the complainant's residence (facilities and equipment installed in neighboring private residences, buildings and stores around the complainant's residence), etc.
 - Conditions of neighboring roads, railways, etc.
 - Use districts under the City Planning Law and designated areas under the Noise Control Law, etc.
 - Other special instructions, etc.

○ Check List to Locate Sources

- Name of facilities/equipment installed in a suspected source factory:
- Correlation between the suspected source facility and complaints:
 - Operation time, situation of operation and seasonal changes , etc; and
 - Complained time period and seasonal changes, etc.
- Grade of complaints by room of the complainant's residence:
- Relationship with neighbors: discussion about complaints, changing facilities and equipment without prior notice, etc.
- Past complaints in the neighboring area and if the source received any administrative directives or not:

○ Records of Inspector's Observations

- Records of comparison of the complaint with the observations of the inspector: if there is rattle in fittings or not, if any discomfort is sensed or not, if the inspector can hear (sense) any noise, conditions by room, and noise outside of the residence, etc .

○ When the source can be estimated or identified,

- Types, specifications, the number and operation of facilities, equipment, etc.:
- Overall layout of these facilities, equipment, etc. when they were installed, and if there was any change in the capacity and the numbers of them:
 - Were facilities, structures, equipment, etc. ever remodeled or repaired?
 - Past administrative actions:
 - Environmental efforts, :
 - With or without managers, etc. in charge of pollution control:

- Is the source able to voluntarily and technically counter the noise (measurements and countermeasures, etc.)?
- In the event where the source is not deduced nor identified,
 - Re-checking the complaint:

NOTES:

If large facilities such as factories are operating, low frequency noise is highly anticipated. The inspector is highly recommended not to obsess such preconceived idea. Even small facilities could be complained about noise, if they were to be in a small and quiet area.

If the inspector locate the source through interviewing and field evaluation, the inspector will require the source facilities to voluntarily counter the noise under the administrative direction. The inspector will be consulted about necessity of measurement and sincere response to neighborhood residences, and the inspector will also provide technical information over measurement and evaluation methods and countermeasures.

To implement the measurement as described in the next chapter, it is desirable to secure a power source for the measurement and to predetermine measurement positions.

4. Measurement

4.1 Making Measurement Plan

Before the measurement of low frequency noise, to clarify the correlation between the source and the complaint is crucial to make a proper measurement plan to solve noise problems. To be more precise, the inspector is required to study measurement items appropriate for complaints, selecting measurement positions and time, and selecting a structural plan for the measurement.

○ Check List for Measurement Plan

● Measurement items:

Low frequency noise analysis with frequencies in the 1/3 octave band, and G-weighted sound pressure level

Noise level, vibration level

Wind direction and velocity

● Measurement date:

All day long, a few days

Continuous measurement, measurement with a certain interval

● Measurement time:

Morning, daytime, evening, night, midnight and early morning

● Measurement positions:

Adjacent to the source, on the border line of lot, outside of the complainant's residence, indoor (closing and opening windows)

Positions where the complainant complained the noise, or where the complainant hears (feels) or does not hear (sense) the noise (for comparison)

● Structural plan for the measurement

Number of inspectors for measurement, personnel positioning, measurement systems and equipment, etc.

● Developing measurement plan:

Measurement objectives, methods, evaluation criteria, how to compile and present measurement results, etc.

● How to explain to complainants:

● How to instruct source: how to present specific countermeasures

● Request sources for cooperation

Cooperation for measurement (measurement positions, power source, etc.)

Request to provide information over types, capacity, the number and operation conditions of the facilities (compressor, pump, Electrical generator, etc.)

● Request complainants for cooperation

Cooperation for measurement (measurement positions, power source, etc.), jointly checking the correlation between the measured sound pressure level and the complaint

● Others: collecting data of similar cases

NOTES:

If the source (facilities) is identified, and if they can be stopped, the inspector will start or stop operation of the facilities without notifying the complainant of such operation to assess the correlation between the operation and the complainant's response. In this case, it is desirable for the inspector to check the operation of the facilities in the presence of the relative of the complainant at the source side.

If it is impossible to stop the source facilities or if the source is not identified, the inspector will ask the complainant about the time and the place in which he or she feels discomfort. The inspector may continue measurement, if necessary.

According to the complainant requests, the inspector may perform measurement on the complainant's side without notifying the source facilities if necessary. In this case, the inspector needs to know the operation status of the source facilities and equipment.

○ If the suspected source (facilities, etc.) can be stopped,

- Measurements at the suspected source side and the complainant's residence:

Simultaneous measurement at both sides is desirable; however, if measurement equipment is short, the inspector may move the measurement equipment among measurement positions.

If there might be more than one source, the inspector will measure noise under several conditions; operating the facilities/equipment one by one, or in the combination of them.

- Measurement duration:

Timing of start and stop operation of the facilities differs from measurement conditions. The measurement duration should be five to ten minutes as a target.

- Observations over changes in rattling complaints of rattle in fittings, etc. in operation and stop mode:

The inspector will ask the complainant about how to feel and changes in problematic conditions (it is desirable to have an interview without giving information over operation not to give preconceived ideas).

NOTE: If there are two or more measurement devices, the inspector should perform simultaneous measurement on both the source and the complainant's sides. This is an effective manner to clarify the correlation between the complaint and the source.

○ If the source (facilities, etc.) can not be started or stopped, or otherwise, if the source is unknown,

- Ask the complainant about the precise time and positions that the complainant complains the noise.

- Measurement at the complained time and the position:

The inspector measures the noise for a few times. In addition, the inspector will measure the noise at different times and positions to compare the results. The inspector check the correlation between the complaint and changes in the sound pressure level, and then determine the frequency of the low frequency noise considered as a possible cause. In the complained time period or before and after the time period, the inspector records low frequency noise on a level recorder, etc. to estimate the source through changes in the sound pressure level (if possible, it is desirable to recode the data on a data recorder).

- Re-inspection of the existence of a source appeared to emit the pertinent frequencies:

4.2 Implementing Measurement

The measurement shall be performed according to the “Measurement Manual for Low Frequency Noise (by the Atmosphere and Life Bureau of the Ministry of Environment issued on October 2000. It is uploaded at <http://www.env.go.jp/air/teishuha/manual/index.html>)” (in Japanese). In the measurement, the inspector will measure noise and vibrations, check operation of facilities and response of the complainant.

The following is the check list for the measurement.

○ Check List for Measurement

- Check measurement systems: check if the measurement equipment is well maintained or if spare parts are ready (battery cells, etc.)
- Staffing:
- Check the measurement positions: check if there is any background noise, etc.
- Check the settings:
- Check field check lists, etc.: record measurements
- Check conditions where the low frequency noise occurs, etc.:
- Check operation of factories, facilities, etc.
- Check measurement conditions:
- Weather conditions: wind velocity, etc.
- Others: if some photos of measurement are taken, these photos will be useful for post measurement review.

NOTES:

When assessing the noise at the time such as daytime when traffic is heavy, it is impossible to make an accurate measurement because the background noise and the complained low frequency noise are overlapped. In this case, the inspector shall measure the noise at the time when the traffic is light.

When assessing the noise in a windy day, the noise of wind is likely to get larger than the low frequency noise. In this case, the inspector shall measure the noise at the time when wind is moderate.

In either of the cases, it is necessary to measure the noise under the conditions to minimize these influences during the complained time period.

5. Evaluation Methods

Complaints about low frequency noise are generally categorized into two groups: one is rattle in fittings and discomfort in a room. The inspector shall perform evaluation matching the individual complaints. For the evaluation, the reference values are provided in the Evaluation Guide.

5.1 Complaints of Rattling

(1) Getting a Handle on Correlation of Operation Status of the Sound Sources and Complaints

Start and stop operation of the suspected source facilities and equipment to check if there is any correlation between the low frequency noise and rattle in the fittings. Check if the sound pressure level will drop and the rattling will stop or not when the suspected source facilities are stopped.

If there is any correlation between operating and stopping of the facilities and such rattling complaints as rattle in the fittings these facilities can be identified as the source. If such facilities can not start or stop operation, the correlation between the source and the complaint can be determined from the operating time period and changes in the low frequency noise.

If no correlation between operational status of the source facilities and rattling or the correlation between them is unknown, different sources should be considered carefully.

(2) Evaluation of Complaints of Rattling

Complaints of rattling will be determined through comparing the measurement results with the reference values provided in the Evaluation Guide.

If the measurement values are greater than or equal to the reference values at some frequencies when the sound pressure level measured in the 1/3 octave band and the reference values (Table 1 in the Evaluation Guide) are compared, the frequency is highly anticipated to cause the complaint.

If the source is unknown, check if there are facilities which emit frequencies exceeding the reference values.

Although the measurement value is less than the reference values, there is a rare occurrence of rattling. Thus, it is necessary to estimate the issued frequency using the reference values and to investigate the source again.

○ Examples for Determination of Rattle in Fittings

(A) Measurement values exceeded the reference values:
In the upper right chart, the measurements exceeded the reference values at 6.3 Hz and 8 Hz. The infrasound at 6.3 Hz and 8 Hz could be a cause.

(Upper-right chart: example where measurements exceed reference values)

(B) With two or more dominant frequencies:
With two or more peaks in the dominant frequencies, the complained frequencies will be estimated through comparing these peaks with the reference values. In the right-center chart, difference is only about 5 dB in the sound pressure level between 16 Hz and 50 Hz. It is concluded that the frequency of 16 Hz over the reference value could be a cause of complaints of rattling .

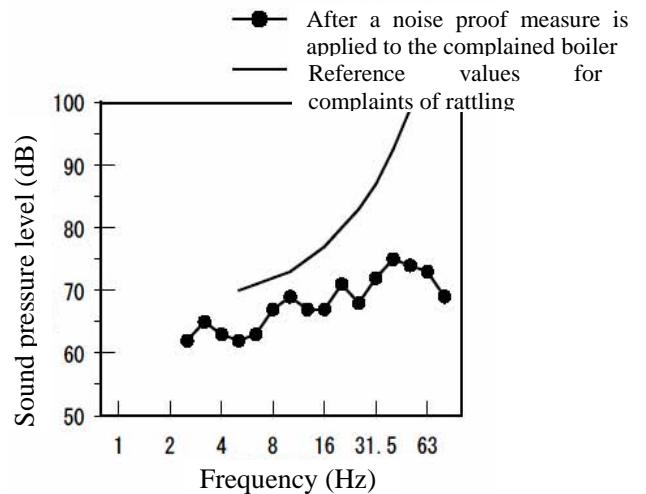
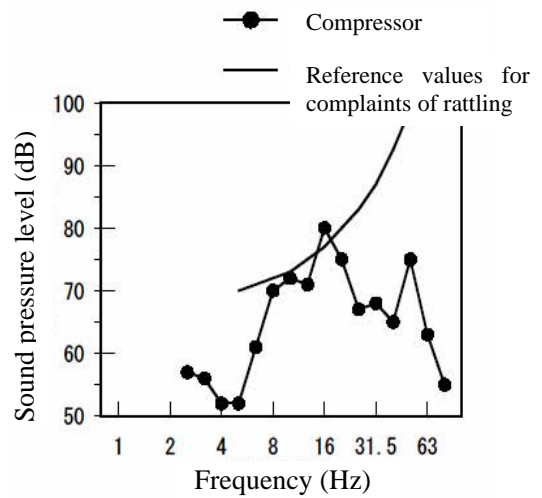
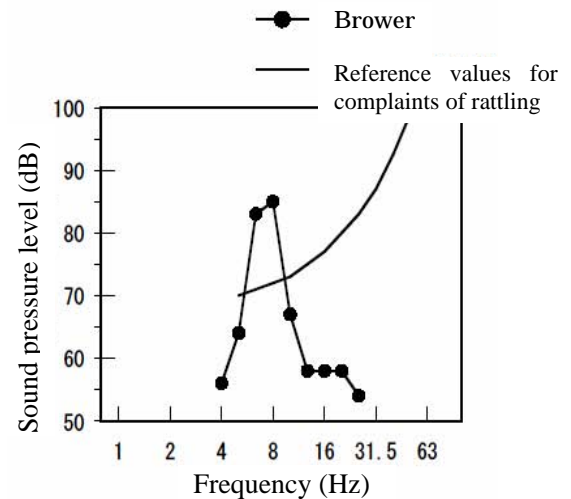
(Right-center chart: the case where there are two peaks)

(C) With measurement values below the reference values:

With measurement values below the reference values at every assessed frequency, there could be other factors including ground vibration, etc.

Although the measurement values are below the reference values at a lower sound pressure level by around 5 dB, these could occasionally cause some complaints of rattling. In this case, review the data by comparing the measurement values and the reference values.

(Lower-right chart: in the case of measurement values below reference values)



NOTES:

Where fittings rattles in spite of measurement values below the reference values at any frequencies, examine ground vibration with a vibration level meter on solid portions inside the house of rooms with a wooden floor, door sills, etc.

If the measurement values inside the house exceed the reference values in spite of those measured outside of the house below the reference values, the rattles may be caused by ground vibration.

5.2 Complaints of Mental and Physical Discomfort

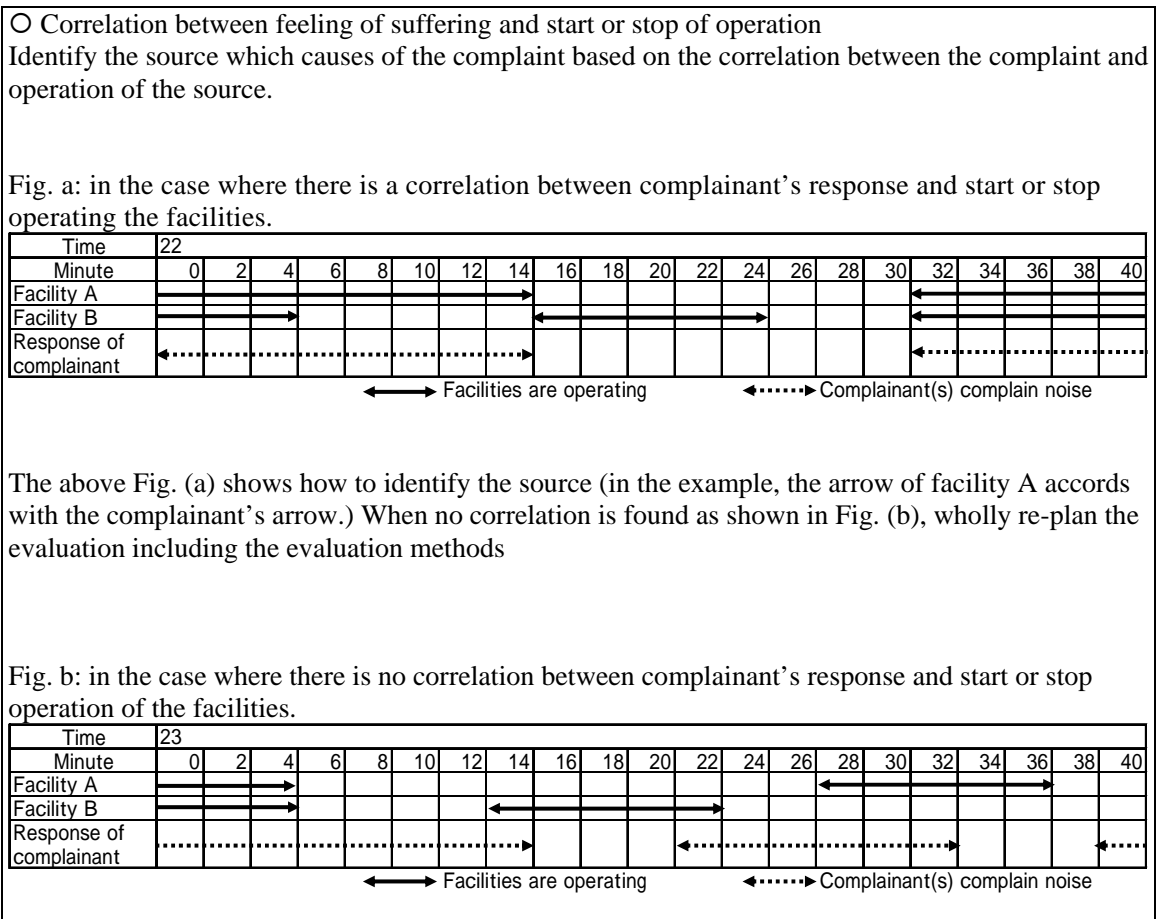
(1) Getting a Handle on Correlation of Operation status of the Sound Sources and Complaints

It is crucial to determine the correlation between operation of the source and complaints based on measurement results. The inspector shall confirm if the sound pressure level drops and the complainant does not complain the low frequency noise at all after stopping the suspected source facilities. If the complainant still complains after the facilities stop operation, any countermeasures taken on the facilities and reducing the sound pressure level are no more a solution for the complaint.

Check if the complainant can discriminate when the facilities start or stop operation every five or ten minutes, or the complainant changes his or her complaints in the room where the complainant feels the low frequency noise most. Where the sound pressure level of the low frequency noise is small, it may take a few seconds for the complainant to distinguish when the facilities start and stop operation. This is because it is hard for the complainant to hear (sense) the low frequency noise, the complainant might still feel discomfort a little, or otherwise, background noise from vehicles passing by can interfere the complainant's hearing or sensing.

If the facilities can not be started or stopped operation, assess the correlation between the complained time and the period when the facilities are in operation. To be more precise, observe changes in the correlation between the source and the complaint by time from daytime to nighttime, season, weekdays and holidays.

To identify the source corresponding to the complaint, measure the low frequency noise in the complainant's residence and at neighboring measurement positions to the suspected source facilities and then assess the noise, taking the correlation with dominant frequencies into consideration.

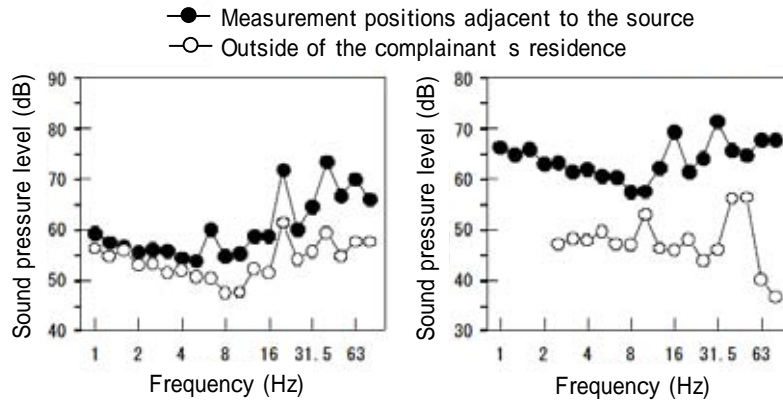


NOTE:

To determine the correlation between the operation of the source and the complaint, it is necessary to consider noise, vibration, etc. with the low frequency noise from the source.

○ Determination of Concerned Frequencies

Measure the noise at the source and the complainant's residence to check if any accord between the concerned frequency outside of the complainant's residence and at measurement positions adjacent to the source. If there is no agreement between measured frequencies, examine if there is any other sources.



In Fig. (a), where the measurement sound pressures at 20 Hz reach the complainant's residence, attenuating throughout the distance from the source, it is determined that there is a correlation between the complaint and the noise. In Fig. (b), there is no correlation between the complaint and the noise because the frequency is unlikely to shift as it transmits. In this case, review and re-plan the evaluation including subjects to be assessed.

If the sound pressure level at the concerned frequencies at the source side and outside of the complainant's residence is almost the same, there could be other sources or the effects of background noise. In addition, if the sound pressure level at the concerned frequencies is larger in the complainant's residence than the source side, review and re-plan the evaluation including influence from equipment, etc. used in the complainant's residence.

NOTE: If the source can not be located according to the above described procedures, if the operation of the source discord with the complaint, or otherwise, if the correlation between them is unknown, re-assess the noise according to the following procedures. Ask experts for cooperation for the evaluation if necessary.

○ Check List for Re-planning

- Did you measure the noise at the position and during the time period which the complainant complained?
- Was the measured room the room which was strongly affected by the low frequency noise from the source?
 The sound pressure level is usually large in room near the source. In contrast, the level is occasionally large in other rooms due to influence from reflection, etc.
- Were there any influence from opening and closing windows, doors, etc.?
- Did any equipment, etc. used by the complainant (e.g. the refrigerator, outdoor fan of the air conditioner, the boiler, etc.) emit the noise?
 Observe changes in the noise when these equipment and apparatus start or stop operation. For the information, when a wind blew a troubled TV antenna installed on the roof, it caused vibration. Its specific sound in the low frequency range caused the complaint.
- Others: complainant's problems – Does he or she have a tinnitus, etc.?

(2) Evaluation of Complaints of Mental and Physical Discomfort

Evaluate the noise and the complaint based on the measurement values and in accordance with the Evaluation Guide.

In the case where there is a correlation between the operation of the source and the complaint,

- Where the G-weighted sound pressure level is 92 dB or higher as prescribed in the Evaluation Guide, it is highly anticipated that the noise occurs in the frequency range of the infrasound.
- Where the measurement values exceed the reference values at some frequencies in comparison of the measured sound pressure level in the 1/3 octave band with the reference values (see Table 2), these frequencies are likely to cause the complaint about the low frequency noise.

If either of the values is higher than or equal to the reference values in the evaluation described in the above two paragraphs, there is a chance of low frequency noise problems (including infrasound).

Where the measurement values are higher than the reference values, the low frequency noise is likely to occur. But if there is no or not clear correlation between the operation conditions of the source and the complaint, there might be different sources than those first assumed. So, close evaluation is required, including background noise.

If the G-weighted sound pressure level is below 92 dB and if the measured sound pressure level in the 1/3 octave band is below the reference values at all frequency ranges, check if there are noise of 100 Hz or higher or other factors such as ground vibration. People infrequently feel mental and physical discomfort even with the sound pressure level lower than the reference values. Estimating the concerned frequency in comparing with the reference values, investigate any other sources to cause the problem.

○ Examples for Determination of Complaints of Mental and Physical Discomfort

(A) In the case where dominant frequencies exceeds the reference values

In the upper right chart, the measurement values exceed the reference values at 31.5 Hz and 50 Hz . These frequencies are concluded as the cause.

(Upper-right chart: there are extreme dominant frequencies)

(B) In the case there is no dominant frequency but measurement values exceed the reference values:

Complaints of mental and physical discomfort are often caused when people hear a certain frequency noise stronger than any other noise. In the right-center chart, noise at the frequencies in the range of 50 Hz or more, or those in the rage of 100 Hz or more can cause the noise problem.

(Right-center chart: the case where the level exceeds in the audible low frequency range)

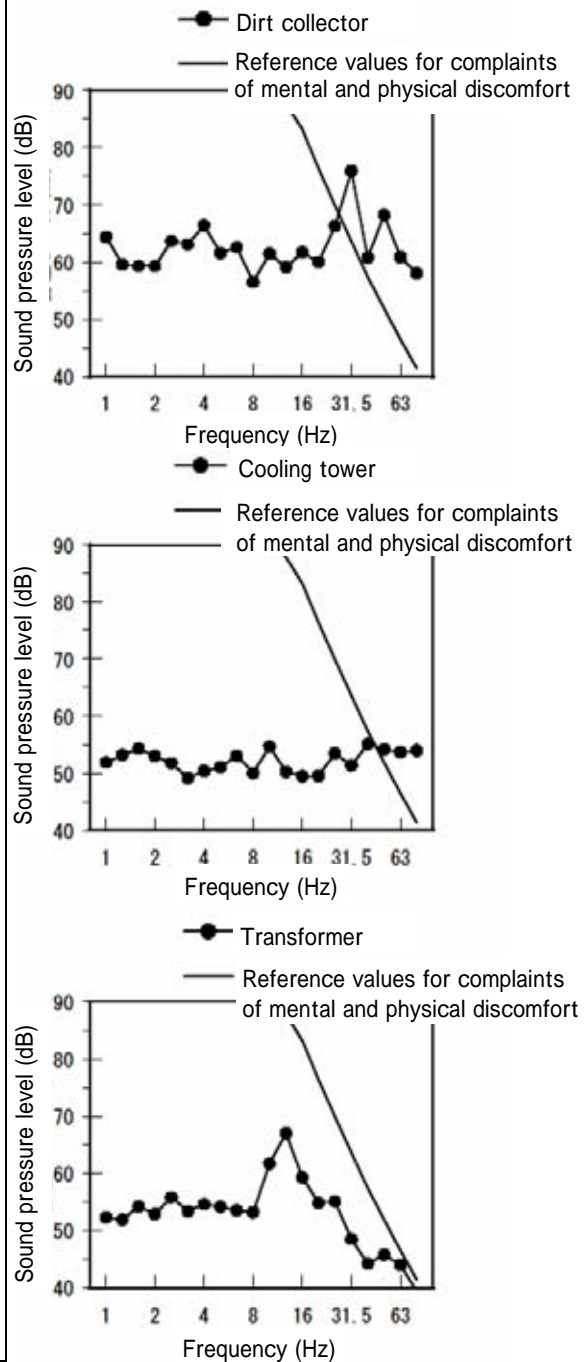
(C) In the case where measurement values are significantly below the reference values

In the right chart, the dominant frequencies are measured at 12.5 Hz, while the sound pressure level is significantly below the reference values by around 10 dB. In this case, it is necessary to check (1) if the complained noise were accurately measured, and check any possible sources from various perspectives including (2) noise in the range of 100 Hz or higher, (3) ground vibration, etc. and (4) others (tinnitus, etc.).

(Lower-right chart: in the case where there are dominant frequencies but the level significantly below the reference values)

(D) No dominant frequencies but similar to background noise

If the complained low frequency noise can not be detected because it is overlapped by the background noise, review and remake the measurement plan. Also check the items No. (1) to (4) as listed in paragraph (C)



NOTE: These reference values are defined based on the results of subjective experiments over tolerable limitations by stationary sound and taking individual differences among human subjects into consideration. Although the measurement values are below these reference values, there still infrequently is a chance that people would feel low frequency noise.

(3) Care and attention in cases of measurement values below reference values and/or of no correlation between operation of sources and feeling of suffering

Where the sound pressure level of measured low frequency noise is below the reference values in any evaluation, it is concluded that there is no low frequency noise problem.

In such case, also check the following points:

(a) Is the complained noise measured comparing with the operation of the source?

Make sure to check if the complainant feels suffering during measurement. Where the complainant does not allege the feeling of suffering during the measurement, ask the complainant about time and position at which the complainant feels, and plan a re-evaluation. If there is no evidence of noise in the measurement data, even though the complainant alleges the feeling of suffering, consider other factors.

(b) Is the complained noise in the noise range of 100 Hz or higher ?

Even if the complaint is in conjunction with the low frequency noise, a cause of the complained noise can be in the noise range of 100 Hz or higher. Thus, it is needed to analyze frequencies with the sound level meter, increasing the measurement frequency range to 100 Hz or higher. In addition, the inspector may ask experts for their cooperation.

(c) Is there any ground vibration?

Some complaints of rattling, mental and physical discomfort of vibration sensation and dizzy are ascribable to ground vibration. Consider any necessity to measure vibration on the ground or the floor of the complained place. If it is necessary, it is needed to examine the vibration not only in the perpendicular direction but also in the horizontal direction.

(d) Does the complainant have own problem (tinnitus, etc.)?

If the results of No. (a) to No. (c) checks indicate no correlation between the operation of the source and the complaints, the complainant is likely to have his or her own problem (tinnitus, etc.).

NOTE: It is difficult for complainant to be aware of tinnitus. The inspector is required to carefully listen to what the complainant's said to comprehensively assess the complaint including medical views. In light, final judgments by experts are crucial.

Incidentally, the reference values are the accumulated results of past experiments frequency weighting characteristics of low frequency noise. Considering individual differences is vital to the evaluation of the noise. It is desirable to understand each complainant's sensitivity to the low frequency noise. The inspector may ask experts for their cooperation to measure the individual sensitivity of each complainant.

The above mentioned judgment might not help solving noise problems. Even if so, the complaint would change as time goes by. Assess the noise again, if necessary, after carefully listening to the complainant and observing if any temporal changes in the complaint. The inspector may ask experts for their cooperation as the case may be.

6. Countermeasures

If the low frequency noise exceeds the reference values, and if there is a correlation between the operation of the source and the complaint, the inspector will develop countermeasures. Necessary reduction level will vary with background noise, circumstances by region, technical issues, situation of complaints, etc. so that they can not reduce the low frequency noise evenly. The reference values are not target values. To solve noise problems, it is necessary to discuss and develop comprehensive countermeasures.

The inspector is required to identify the source and clarify the mechanism to emit the low frequency noise from the source to establish effective countermeasures. Before implementing such countermeasures, the inspector shall estimate technical limitations and costs based on meticulous measurement. In light, the inspector is required to have broad experience in this field. It is desirable to ask experts for their cooperation.

Administrative personnel shall make sure to:

- Mediate between the source and the complainant to have sufficient discussion;
- Provide the source with data, etc. to develop effective countermeasures;
- Give counsel in a broad spectrum with the source over countermeasures including changing operating time of the facilities, and with the complainant over the countermeasures as the case may be; and
- Ask experts for their cooperation.

Prior to implementing the countermeasures, it is essential to obtain consent of the complainant to implement the countermeasures after providing the complainant with information over how to and how long the countermeasures be taken.

For examples for specific countermeasures, see the “Case Studies of Low Frequency Noise Countermeasures (issued in March 2002 by the Ministry of Environment, which is also available from <http://www.env.go.jp/air/teishuha/jirei/index.html>) (in Japanese).

7. Follow-up Measurement

The inspector shall implement follow-up measurement after the countermeasures are taken.

It is desirable that administrative personnel would witness the follow-up measurement after the source side voluntarily takes countermeasures. The competent authority may implement follow-up measurement, if necessary. For either of the cases, it is desirable to record measurement methods, evaluation methods, etc. established in process of developing countermeasures in a check list for the follow-up measurement.

The inspector is required to check and properly evaluate effects of the countermeasures, and to give them a complete picture of the measurement.