Field noise measurement in the huge industrial plants for accurate prediction

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ABSTRACT

Proper noise controls of the industrial plants based on accurate noise prediction are important since noise from these plants will affect wide area both inside and outside of the plants. Also, occupational noise exposure is serious problem for workers of the plants. However, it is not easy to predict the noise propagation from the industrial plants such as refineries, petrochemical and gas treatment plants because of their huge amount of noise sources and complicated structures as obstacles and reflectors.

At the inter-noise conferences in the last two years, we have presented our field data of noise propagation from industrial plants over the desert and sea with prediction results followed by ISO method. In this paper we focus on sound propagation in the near filed of the industrial plants. From our new field measurements, the effect of the noise sources, obstacles, and various field circumstances is discussed. We also try to improve the usage of the ISO calculation methods for each plant condition at design phase based on our measurement experience.

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1. INTRODUCTION

For industrial plants, noise control is required for the purposes of protecting the hearing of personnel, reducing interference with speech and work and preventing annoyance to the neighboring communities. JGC has executed over 20,000 projects of industrial plants including oil and gas, petrochemical and general industrial fields. The plants usually contain many sources of noise, such as compressors, pumps, piping systems, flare stacks and fin fan coolers. Moreover, in recent years, plants have been becoming larger and noise emission has increased in power accordingly.

Effective noise control for industrial plants depends upon proper noise prediction in design phase. ISO 9613 “Acoustics -Attenuation of sound during propagation outdoors-” [1] is most-used calculation method for the noise prediction of industrial plants. In this method, we have to decide several conditions such as, obstacles, temperature, relative humidity and ground factor for calculation models. Some of the factors are, however, not easy to determine because they are vary by each site. Therefore we need to estimate the factors supported by plentiful noise measurements. At last two inter-noise [2][3], we introduced our measurement experience of plant noise attenuation over the desert and sea where there are no obstacles, and we clarified the practical ground factors of each condition.

In this paper we will introduce our measurement results of plant noise attenuation across the areas including the fields with some obstacles. Noise attenuations on fields of no obstacles and of some obstacles are compared with calculation by ISO 9613-2 where the field conditions are coordinated with the conditions of measurement as far as possible.

We will also present measurement result of piling noise on construction phase and evaluate their attenuation in residential area where there are trees and houses. The piling noise is clear impact sound and we can identify their noise in residential area even though background noise exists.

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2. PARAMETERS REQUIRED FOR NOISE PREDICTION BY ISO 9613-2

Noise Prediction of industrial plants is often calculated using ISO 9613-2. The ISO 9613-2 requires many parameters for calculation, see equation (1). Some of the parameters are, however, difficult to obtain without field measurement on certain site.

$$L_p = L_w + D_C - A \tag{1}$$

$$A = Adiv + Aatm + Agr + Abar + Amisc \tag{2}$$

Where,

Lp: the sound presser level (SPL)at receiver point ,
Lw: the sound power level (PWL) of noise source,
Dc: the directivity correction,
A: the attenuation,
Adiv: the attenuation due to geometrical divergence,
Aatm: the attenuation due to atmospheric absorption,
Agr: the attenuation due to the ground effect,
Abar: the attenuation due to a barrier,
Amisc: the attenuation due to miscellaneous other effects.

Sound Pressure Level (SPL) at receiver location is calculated adopting Sound Power Level (PWL) of noise sources, their directivity and attenuation during propagation. PWL and directivity are obtained from equipment suppliers or estimated from past experience of similar equipment.

Attenuation should be defined taking the field conditions into account. As shown in equation (2) the attenuation *A* has some elements, geometrical divergence, atmospheric absorption, ground effect, screening by obstacle and miscellaneous other effects. The attenuation due to atmospheric absorption is given by plant design condition. Ground abruption and screening of obstacles should be chosen carefully depending on the site situation. Also, ISO 9613-2 considers downwind condition, so we have no choice.

Therefore, when noise sources information is obtained and design air temperature / humidity are given, models of ground and screening obstacles are key to accurate prediction in design phase.

Such conditions for modeling must be estimated by noise measurements on similar plants to our target. We have measured many plants we constructed to improve our prediction calculation.

3. PLANT NOISE ATTENUATION OBSERVED ON THE SEVERAL FIELDS

We would like to describe some overview of several measurement results to know the trend of the attenuation on several field conditions. In this section, three examples of noise attenuation from industrial plants are shown. Two no obstacles fields during propagation and the other is tank area adjacent to noisy plant units.

3.1 No Obstacle Conditions During Propagation

Noise attenuation can be calculated in practicable level of accuracy by using ISO 9613-2 at no obstacle fields if the adequate parameters are obtained by measurement at similar condition site. The attenuation is prone to be large at the measurement depending on the conditions such as wind.

As we presented at previous inter noise conferences, we measured attenuation of noise over the desert and the sea generated by industrial plants. Then we considered that the attenuation observed on the measurement can be replicated by using adequate ground factor on the calculation.

Figure 1 shows the noise attenuation on the desert from boundary to 1500m outside of the gas treatment plant and calculated noise attenuation. The measurement was conducted in the morning, temperature was about 15 ^{o}C, relative humidity was about 20% and there was no wind to be considered. We could find that when the ground factor is 1, the attenuation could be well replicated.

The attenuation obtained by measurement looks larger than calculation on the figure 1. One of the reasons is wind condition, there were no wind on the measurement but ISO considering downwind condition.

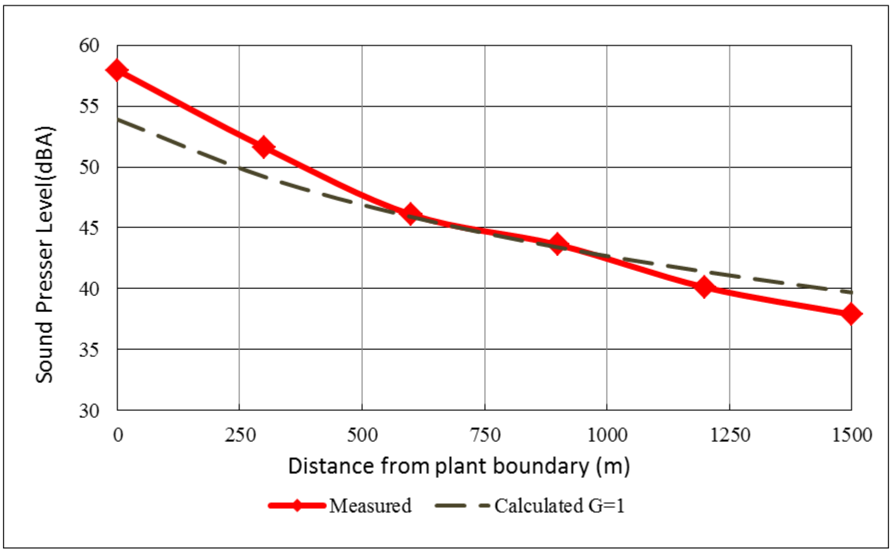

Figure 1 – Noise Attenuation on the desert by measurement and calculation

Figure 2 shows the noise attenuation on the sea from boundary to 1000m outside of a petrochemical plant and calculated noise attenuation. The measurement was conducted in the morning, temperature was about 10 ^{o}C, relative humidity was about 70% and wind speed was 4m/s downwind. Contribution of traffic noise running parallel to measuring points was subtracted from the measurement data. We found that when the ground factor is 0.4, the attenuation was well replicated.

In this case, the attenuation of measurement and calculation are almost same. It may be because the measurement condition and calculation condition including downwind presumption in ISO 9613-2 are similar; there were downwind condition on measurement and no obstacles in measurement. Slightly large attenuation is, however, observed on measurement compared with calculation.

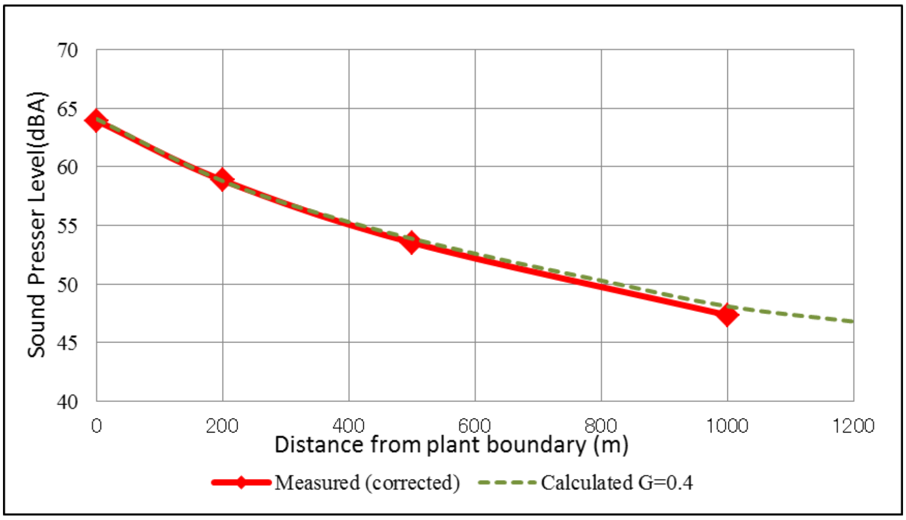

Figure 2 – Noise Attenuation on the desert by measurement and calculation

From above two examples, we may assume that if there are no obstacles, the attenuation is calculated in reliable level of accuracy by the ISO method. Also we found that large attenuation was observed on measurement compared with calculation in the case of no wind, and even downwind condition there was slight deference.

3.2 Tanks During Propagation

In our experience, the noise attenuation through some obstacles seems to be larger than calculated based on ISO 9613-2.

We conducted the measurement in the refinery plant and their adjacent tank area. The measurement was conducted in the afternoon, temperature of 35 ^{o}C, relative humidity of 50% and 2m/s downwind was observed. There are four small tanks and two lager tanks. The height of the small tanks is 12m and they located at 70m to 180m from noise generating plant units. The height of the large tanks is 20m and they located at 250m to 400m from the plant units.

Figure 3 shows the measurement result and calculation based on ISO 9613-2. The PWL of plant used in the calculation was assumed by the measurement of equipment in the plant. Tanks are modeled as obstacles. Modeling and calculation were conducted by SoundPLAN the noise propagation software.

The attenuation on measurement is obviously larger than on calculation at the small tanks area. At the back of large tanks noise levels become almost same level between measurement and calculation; the levels are influenced by background noise from other units. Therefore, unfortunately no idea can be derived from large tanks area.

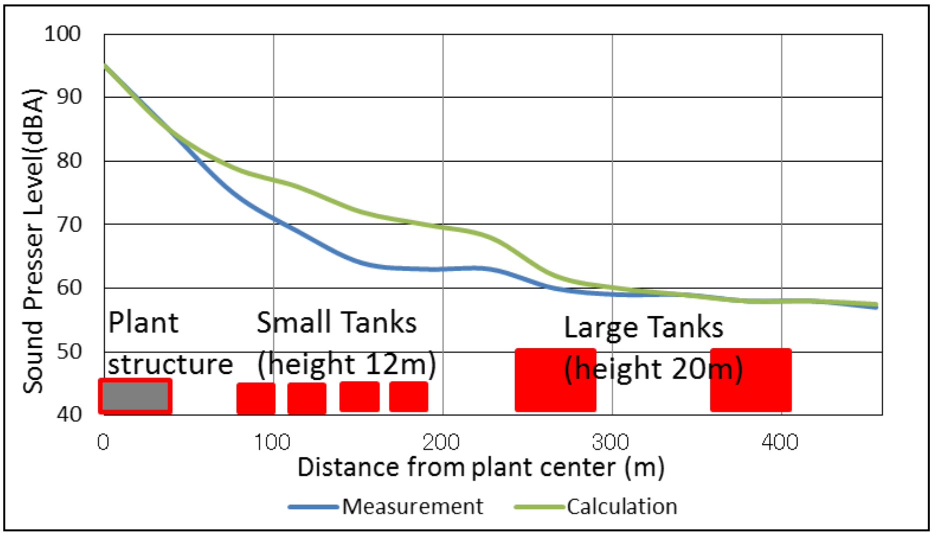

Figure 3 – Noise Attenuation on Tanks

We can find that it is difficult to predict accurate attenuation around obstacles. In this case, wind condition was downwind as ISO supposed and parameters are selected to consistent between calculation and measurement conditions. There was, however, obvious large attenuation at the obstacles area.

Therefore, accumulating an adequate amount of measurement experience is important to accurate prediction.

4. PILING NOISE ATTENUATION MEASUREMENT ON RESIDENTIAL AREA

In section 3, we presented the attenuation of plant noise on several sound propagation conditions. We can use these data for next plant which has similar condition.

On the other hand, we have noise measurement for the target site before detail design is fixed when the nearby residential area noise was supposed to be sensitive.

In this section, we introduce one of our measurement results during early construction phase. We measured noise levels of piling at around the piling machine and at adjacent residential area in order to know the propagation property from plant site to neighbor residential area. There are trees or rice field between the plant site and the village, so we observed different type of attenuation properties.

Piling noise is impact sound and it is clear to distinguish its noise levels at each location.

Table 1 shows measured noise levels around the piling machine to obtain its PWL.

The PWL of piling noise was estimated by measured at 15m, 50m and 100m from the machine. The impact high of piling hammer was at around 10m, thus we used directivity factor Q = 1 for measurement point at 15m from the machine and Q = 2 for measurement points at 50m and 100m from the machine in calculation of PWL from SPL and distances. As a result, we obtained PWL of this machine as135dBA by averaging out of three points.

Table 1 – Measured noise level of piling machine on construction site to estimate its PWL

Distance from Piling machine	Measured SPL	Directivity factor	Calculated PWL
[m]	[dBA]	Q	[dBA]
15	101	1	136
50	93	2	135
100	86	2	134

Table 2 shows the measurement results of each location of residential area. The measurement was conducted in the morning, temperature was about 35 ^{o}C, relative humidity was about 60% and wind speed was 2m/s downwind. Visibility of each location to piling machines are tentatively classfied as 0 to 4, 0 is completely clear view and 4 is completely blind, example images are shown in figure 4.

Calculation was conducted based on ISO 9613-2 in accordance with the site condition but not including any obstacles. We use 135dBA as PWL from piling machine measurement mentioned above.

We can find clear relation between visibility and differences of calculation and measurement. When the visibility is 1, difference is 0 – 1.5 dB. When the visibility is 2, difference is 7 – 8.5 dB. When the visibility is 4, difference is 11.5dB.

By using this information, we can consider the attenuation of each pass depending upon their visibility at each point. Also we can incorporate the obstacles in an appropriate way into calculation modeling for plant noise prediction at design phase.

Table 2 – Measured and calculated piling noise at various points in residential area

No.	Distance from Piling machine	Measured SPL	Calculated SPL not including any obstacles	Difference of Measured and Calc.	Visibility 0: completely clear ~ 4: completely blind
	[m]	[dBA]	[dBA]	[dBA]	
1	715	52	60.5	8.5	2
2	800	58	59.3	1.3	1
3	920	50	57.3	7.3	2
4	950	57	56.9	-0.1	1
5	1140	54	54.7	0.7	1
6	1150	43	54.5	11.5	4

Visibility:1 Visibility:2 Visibility:4

Figure 4 – Examples of visibility indicators

Modeling of residential area is difficult because the obstacles are varied at each location, but if the plant is near the residential area, accurate prediction is required. Therefore, this kind of measurements before detail design of the plants is effectual.

5. CONCLUSIONS AND FUTURE WORKS

Two plant noise measurement results of no obstacle sites, on the desert and sea, were introduced and the attenuation properties were compared with calculation based on ISO 9613-2. It was found that we can obtain good estimation from calculation by using appropriate ground factor. ISO 9613-2 presupposes downwind condition, so the measurement at downwind condition was good with calculation but there was slightly large attenuation. Also a plant noise measurement result of the site where there are obstacles was introduced and we found that the attenuation on the measurement was larger than calculated one.

We also introduced the measurement of piling noise at residential area. We obtained attenuation level of each pass of this site by comparing with visibility due to trees and houses. These attenuation levels obtained by measurement improve our noise model in designing the plant on this site.

For piling noise measurement, we measured many location and same location at some days. We would like to analyze these measurement results by each octave band, meteorological conditions and land use to understand detail effects of such factors.

REFERENCES

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