MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

STUDY ON THE CONTROL OF NOISE REDUCTION IN LOW FREQUENCY RANGE FOR SPLITTER TYPE SILENCERS

Yoshihito KOBAYASHI [1)]
1) Asahi Building-wall co., ltd.
1-3-5 Matsugaya, Taito-ku, Tokyo, 111-0036, Japan

Yoshinari, HAYASHI [1)]
Chihiro, AKUTSU [1)]
Toshiya, KITAMURA [2)]
Hiroyuki TSUNODA [2)]
Shinji, YAMADA [2)]
2) Faculty of Engineering, Yamanashi University
Takeda 4, Kofu-shi, Yamanashi-ken, 8511 Japan

ABSTRACT

A general splitter silencer has mainly noise reduction performance in middle frequency range. Thus, the noise reduction in low frequency range is not enough, even if the silencer has long length. On the other hand, some large fan in a power plant has peak sound power level in low frequency range according to the number of the blades and the rotating speed.
We studied low frequency noise reduction of a splitter silencer embedded resonator units by controlling the hole diameter and the pitch of the resonator, air space behind and the resonator position in the silencer.
As the results of 800mm length resonator unit, the maximum noise reduction of 15.2 dB at 160 Hz was achieved by controlling the specification of perforated plates. And we applied it to an actual silencer and confirmed the performance.

Keywords: Silencer, Plant Noise, Resonator

I-INCE Classification of Subject Number: 34

1. INTRODUCTION

Important functions of a silencer are noise reduction, pressure loss, self-generated noise. A splitter type silencer has mainly the noise reduction in the mid frequency range. For this reason, special silencers for low frequency ranges are often added in power plants, for noise reduction treatment of blowers of plants with noise power levels in the low frequency ranges. In such a case, the structure of silencers becomes complicated, pressure loss increases, and self-generated noise also tends to increase. In this paper, we have studied about “Composite silencers embedded resonator units in a part of splitter” (hereafter, “Composite Splitter Silencer”), having a simple structure and adding noise reduction in the low frequency range. Also, as this silencer was applied to an actual power plant, we investigated the effect.

[1] yoshi-kobayashi@agb.co.jp
[2] shinji-yamada@ae.auone-net.jp

2. HOW TO ENBED RESONATORS TO SPLITTER SILENCER

As shown in Figure 1, a general splitter silencer has the specification that fills a sound absorption material in a structure composed of a frame and protects the surface with a glass cloth and perforated plates. The sound absorbing material and the surface protective material in the part of the frame are removed, the partition plate is installed in the center position, and designed the resonator plates having the hole with the resonance frequency calculated on both sides of the surface are attached, instead of perforated plates. The continuous resonators are constituted by the frame, the partition plate, and the resonator plate. In this paper, the silencer with a splitter thickness of 300 mm and a “Gas-flow Passage” between splitters of 280 mm is studied.

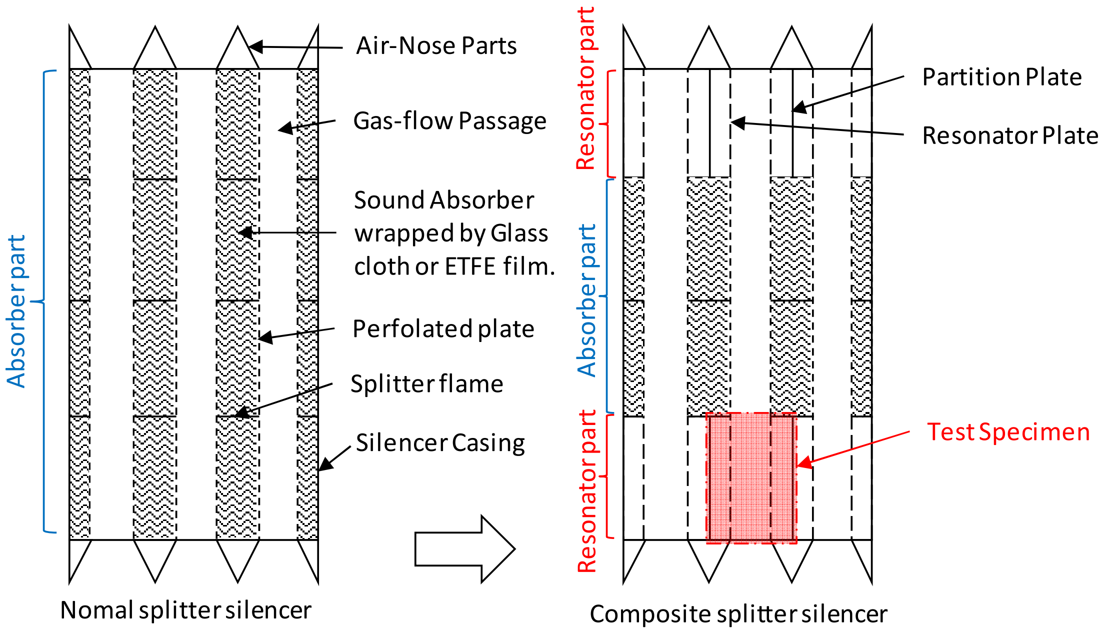


Figure 1 Outline of Composite Splitter Silencer

3. STUDY OF RESONATOR SPECICATION

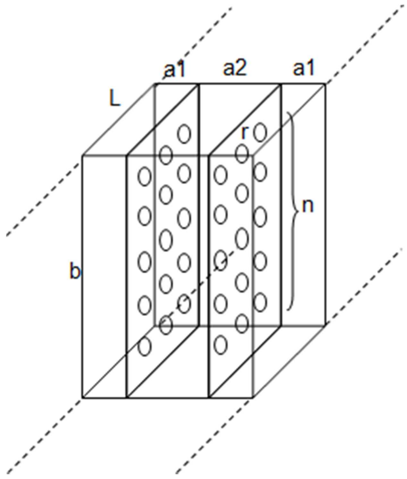
3.1 Resonance frequency

The resonance frequency of the resonator unit is calculated by Equation 1 [1]. A test specimen of a resonator unit having the width of 580 mm, the height of 1000 mm, and the length of 1200 mm shown in Figure 2 was fabricated. The holes were basically 10 mm in diameter and the pitch was 50 mm x 50 mm, the test conditions were that the hole was 100% open, 75% open, 50% open. As shown in Table 1, the theoretically calculated values are 257 Hz at 100% openings, 223 Hz at 75% openings and 182 Hz at 50% openings. A sound source box with a loud-speaker was connected to the inlet side of the silencer, and an elongated duct was connected to the outlet side. 1/3 octave band sound pressure levels of 3 points on each of the inlet area and the outlet area was measured, and the average values of difference between inlet and outlet were taken as the noise reduction level. The measurement results are shown in Figure 2. The peak frequency was 315 Hz band at 100% openings, between 250 Hz band and 315 Hz band at 75% openings, and 250 Hz band at 50% openings. The measured resonance frequencies were 20 to 35% larger than the theoretical values. This is presumably due to that the shape of the cavity constituting the resonator is flat and that the resonators face each other in a narrow space.

Table 1 Calculation results of resonance frequency of the resonator units

Description		Hole Dia.10mm, Pitch 50 x 50mm			
		100%	75%	50%	25%
Behind Air Space [m]	a1 :	0.15			
Wide of Gas Way [m]	a2 :	0.28			
Height [m]	b :	1.00			
Effective Length [m]	L :	1.20			
Tichness of Perforated Sheet [m]	t :	0.0016			
Radios of Holes [m]	r :	0.0050			
Area of each Hole [m²]	S :	7.85398E-05			
Number of Holes [pcs]	n :	960	720	480	240
Opening Ratio [%]	p :	3.14%	2.36%	1.57%	0.79%
Templeture [°C]	T :	20.0			
Volume of Behind Air Space [m3]	V :	0.360			
Sound Velocity [m/S]	c :	343.7			
Resonance Frequency [Hz]	f_r :	**257**	**223**	**182**	**129**

$$fr = \frac{c}{2\pi}\sqrt{\frac{Sn}{V(t+\frac{\pi}{2}r)}} \quad [Hz] \text{ --- 1)}$$



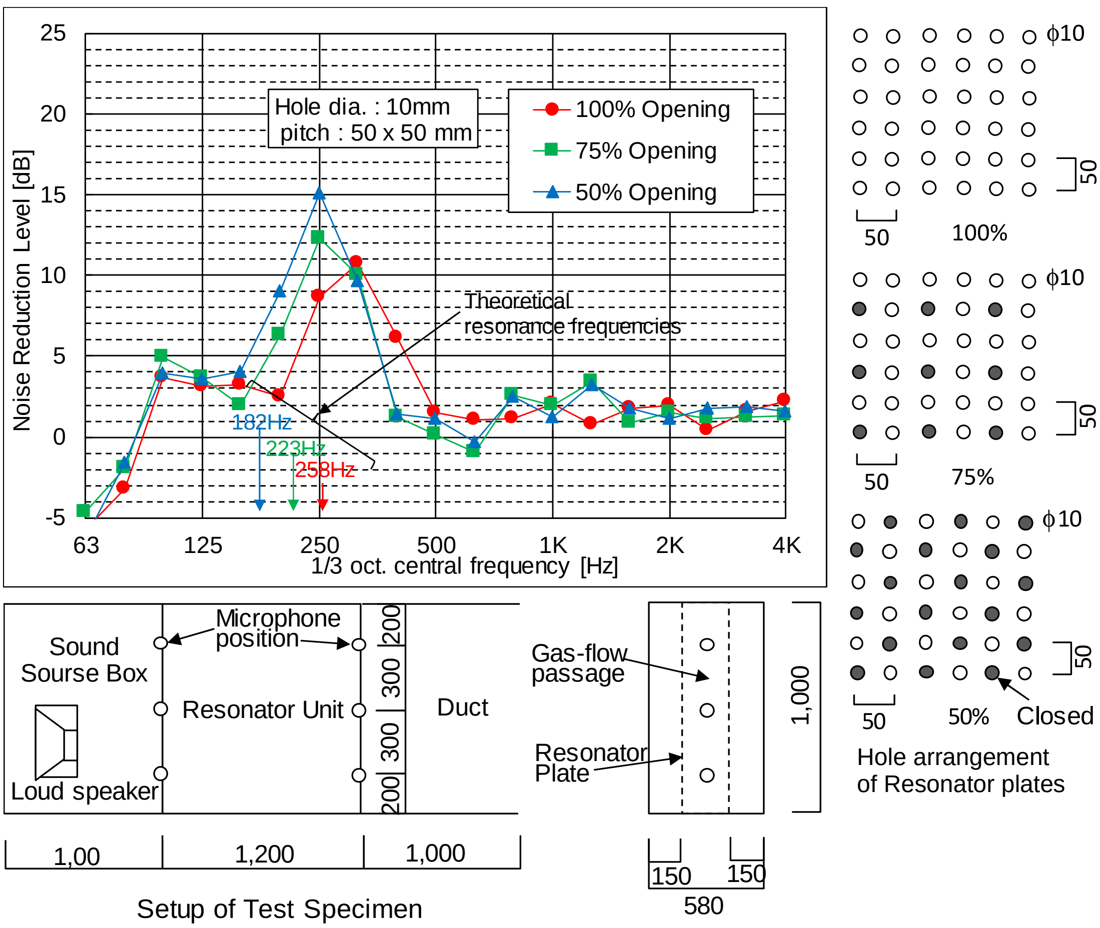


Figure 2 Measurement results of resonance frequency and the reduction level of the resonator units by hole opening ratio

3.2 Length of resonator unit and noise reduction level

In order to investigate the relationship between the length of the resonator unit and the noise reduction level, a resonator unit of 3.9 m length as shown in Figure 3 was prepared. And the noise reduction level by the distance from the inlet of resonator unit was measured. The holes in the resonator unit are 50% openings.

This resonator unit has main noise reduction in the 200 Hz band and the 250 Hz band, and the noise reduction level increases almost in proportion to the length up to 2.7 m.

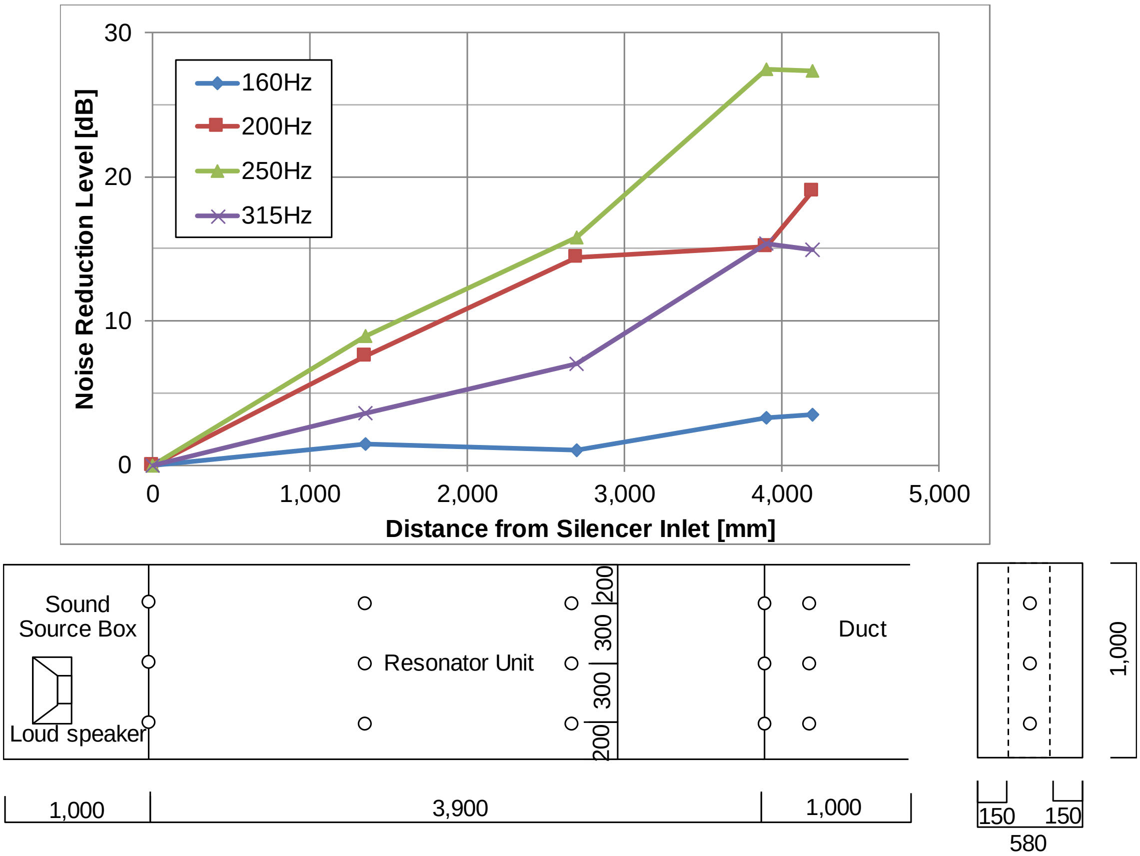


Figure 3 Measurement results of resonance frequency and the reduction level of the resonator units by hole opening ratio

3.3 Influence of resonator unit height

In order to investigate the influence of the height of the resonator unit on the performance of the resonator, resonator units with heights of 1.2 m, 1.5 m, and 2 m shown in Figure 4 were prepared. And noise reduction level of each resonator unit was measured. The holes in the resonator are 50% openings.

The hole opening ratio and the length of the resonator unit was the same for the three specimens, and both the peak frequency and the sound reduction amount were expected to be equal in the three specimens. However, there was difference of 1/3 octave at the peak frequency, and also difference of maximum 3 dB of noise reduction level. The reason is unknown, and it seems that the study to ensure stable performance is necessary in the future.

3.4 Performance of composite splitter silencer”

The interaction with the sound absorber part when the resonator unit is embedded to the splitter silencer, was studied. As the testing method, resonator units are connected to the sound source side (inlet side), outlet side, and both sides of a splitter silencer, as shown in Figure 5. And the value as resonance efficiency of this "Composite Splitter Silencer" was obtained by subtracting the noise reduction of the splitter silencer. By this method the resonance efficiency in " Composite Splitter Silencer " was obtained.

The resonance efficiency is compared with the noise reduction of the resonator unit alone. The hole of the resonator unit was tested with 100% opening.

Figure 6 shows the comparison results. In case of setting the resonator to the inlet side, the resonance efficiency was 4.5 dB (500 Hz band) and greatly reduced comparing to the noise reduction level 10.7 dB (315 Hz band) of the resonator unit alone, and the peak frequency shifted to the high frequency range. In case of setting the resonator to the outlet side, the resonance efficiency is 10.9 dB (250 Hz band) and almost equal to the noise reduction level of the resonator unit alone, but the frequency shifted to low frequency range. In case of setting the resonator to both sides, the resonance efficiency is 13.5 dB (250 Hz band) and rises by about 3 dB compared with the noise reduction level of the resonator unit alone, also the peak frequency shifts to the low frequency range. However, in the band expected to be effective in the resonator part, it was possible to obtain an effect greater than the noise reduction level in the resonator alone. From these results it seems that stable performance will be ensured by installing on both sides even if the length is shortened.

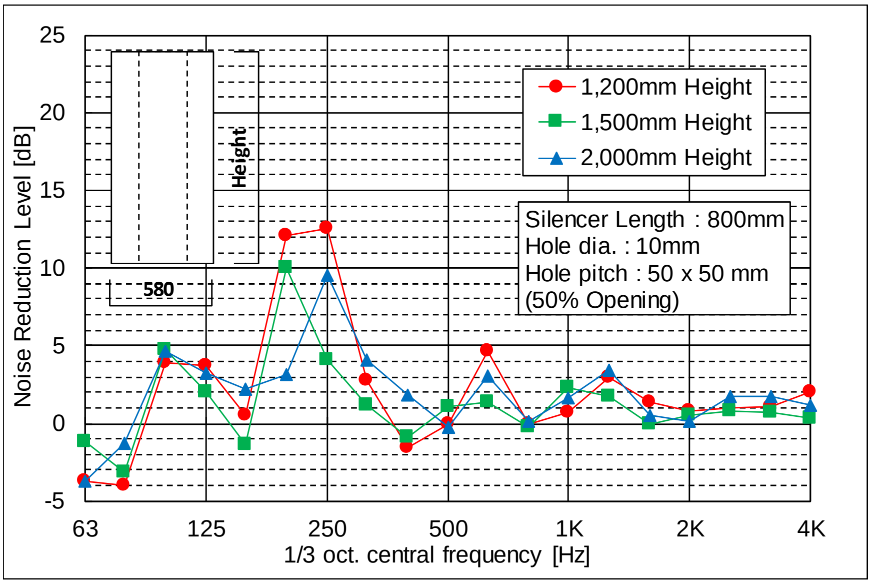


Figure 4 Measurement results of resonance frequency and the reduction level by height of the resonator units

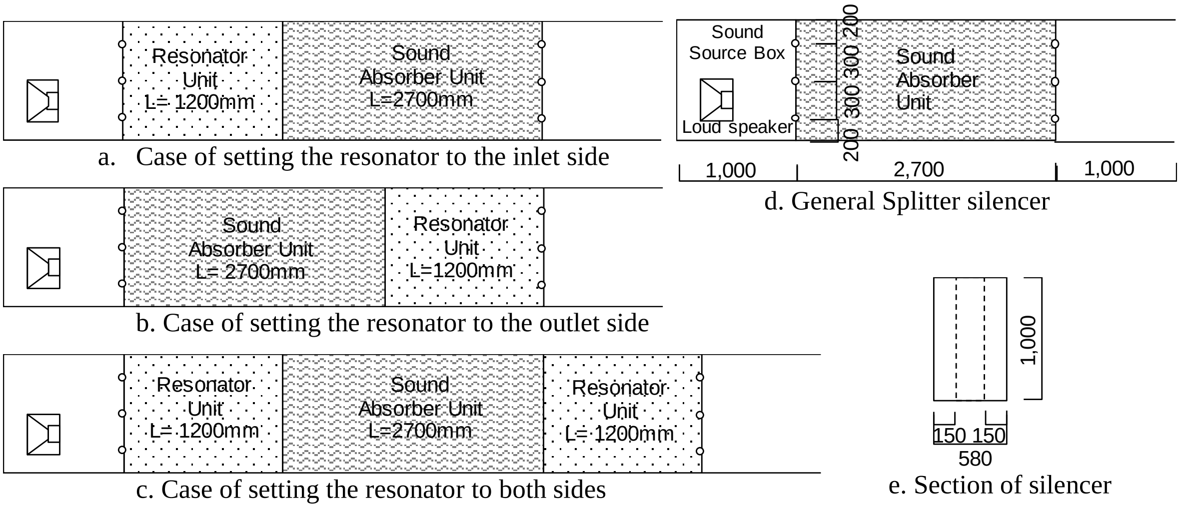


Figure 5 Setup of test specimens of "Composite Splitter Silencer" embedded the resonator units

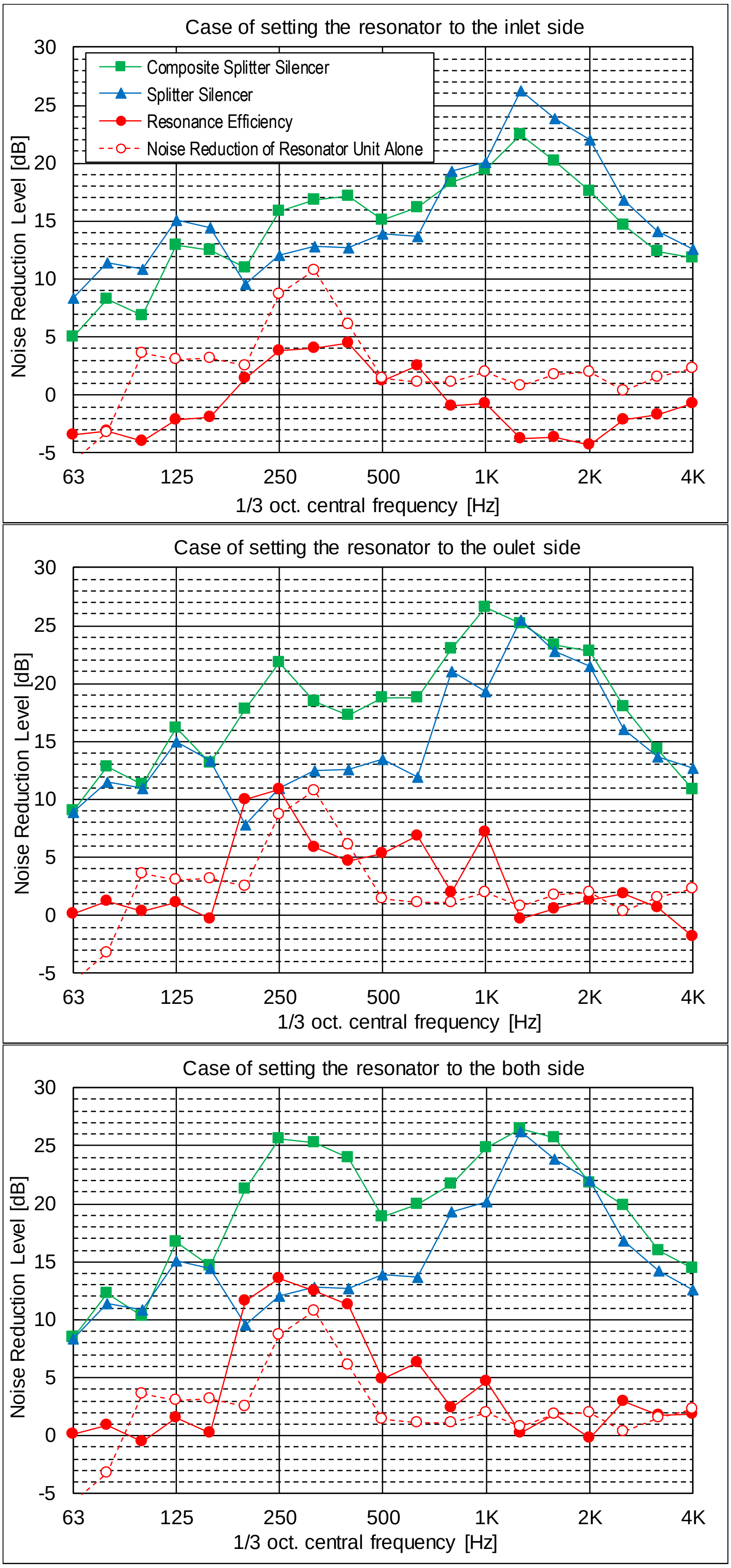


Figure 6 Resonance Efficiency of "Composite Splitter Silencer"

4. PERFORMANCE OF RESONATOR UNIT IN OPTIMIZED DESIGN

Based on the results of above studies, the specification of the resonator unit to be embedded to “Composite Splitter Silencer" was decided.

1) Hole size and pitch: diameter 10 mm, pitch 100 mm x 100 mm for the target of 160 Hz and 200 Hz bands,
2) The length 800 mm in order that the resonators are installed on both sides of the silencer,
3) The height 1500 mm to ensure maintainability.

Based on the above specifications, the resonator unit shown in Figure 7 was fabricated. And noise reduction level was measured. As the measurement result, noise reduction level 15.8 dB was obtained in the 160 Hz band, so we decided to embed the resonator unit of this specification into the "Composite Splitter Silencer".

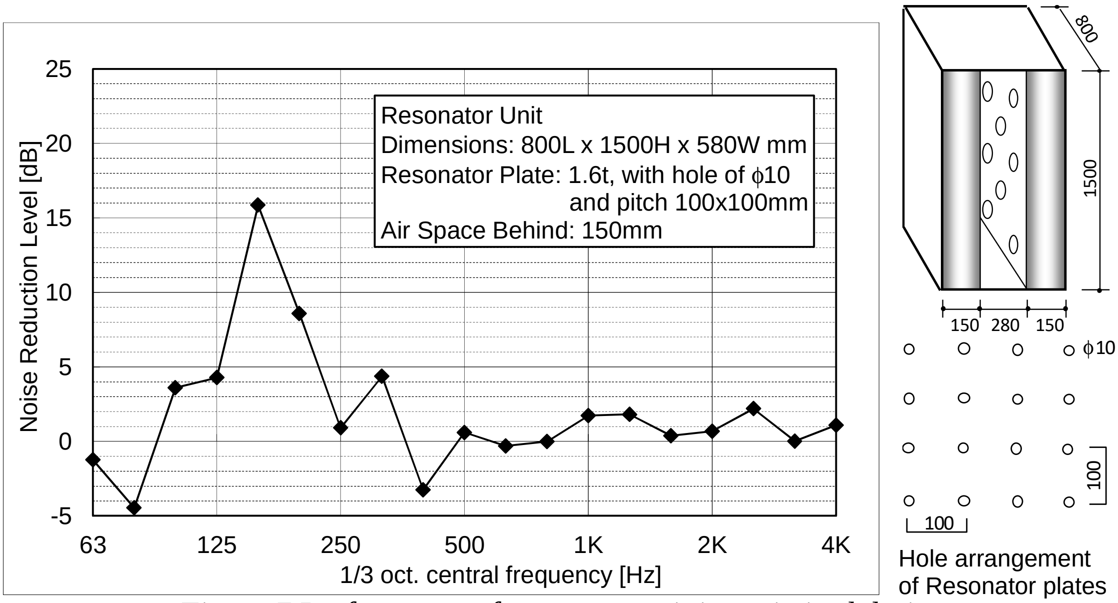


Figure 7 Performance of resonator unit in optimized design

5. THE APPLICATION TO THE ACTUAL POWER PLANT

This “Resonator type Silencer” was applied to noise reduction treatment for a blower in the exhaust gas duct of an actual power plant. As shown in Figure 8, the exhaust duct has a cross section with a width of 7900 mm and a height of 6700 mm and has a silencer installation space of 5000 mm in length. A blower having a blade pass frequency of 180 Hz is installed in the exhaust duct, and the exhaust gas temperature in operation is 100 degrees Celsius. For this reason, we designed “Resonator type Silencer” with a resonance frequency in the 160 Hz band at room temperature. The design target is 18 dB in the 180 Hz band and the sound reduction 15 dB or more in over-all.

The splitter had a resonator part of 800 mm in length on both sides, an absorber part of 1800 mm in length at the center, and an air-nose part of 300 mm at both ends, and the total length was 4000 mm. The Composite Splitter Silencer consists of 2 types of total 20 modules. One has a width of 1770 mm, a height of 1650 mm and a length of 4000 mm, with 3 gas-flow passages. The other has a width of 1180 mm, a height of 1650 mm and a length of 4000 mm, with 2 gas-flow passages.

Figure 8 shows the speaker test result per 1 module at a factory and the speaker test results of 2 silencers installed in the actual site. The noise reduction frequency characteristics at the factory has a peak reduction level of 21.1 dB in the 160 Hz band and reduction level of around 20 dB in the middle frequency ranges. Although the noise reduction frequency characteristic of the two silencers in the site was a little lower than the value at the factory test as a whole, the peak reduction level of 19.8 dB and 19.3 dB in the 160 Hz band and 15 to 20 dB in the middle frequency ranges was obtained. Then, the design target was achieved.

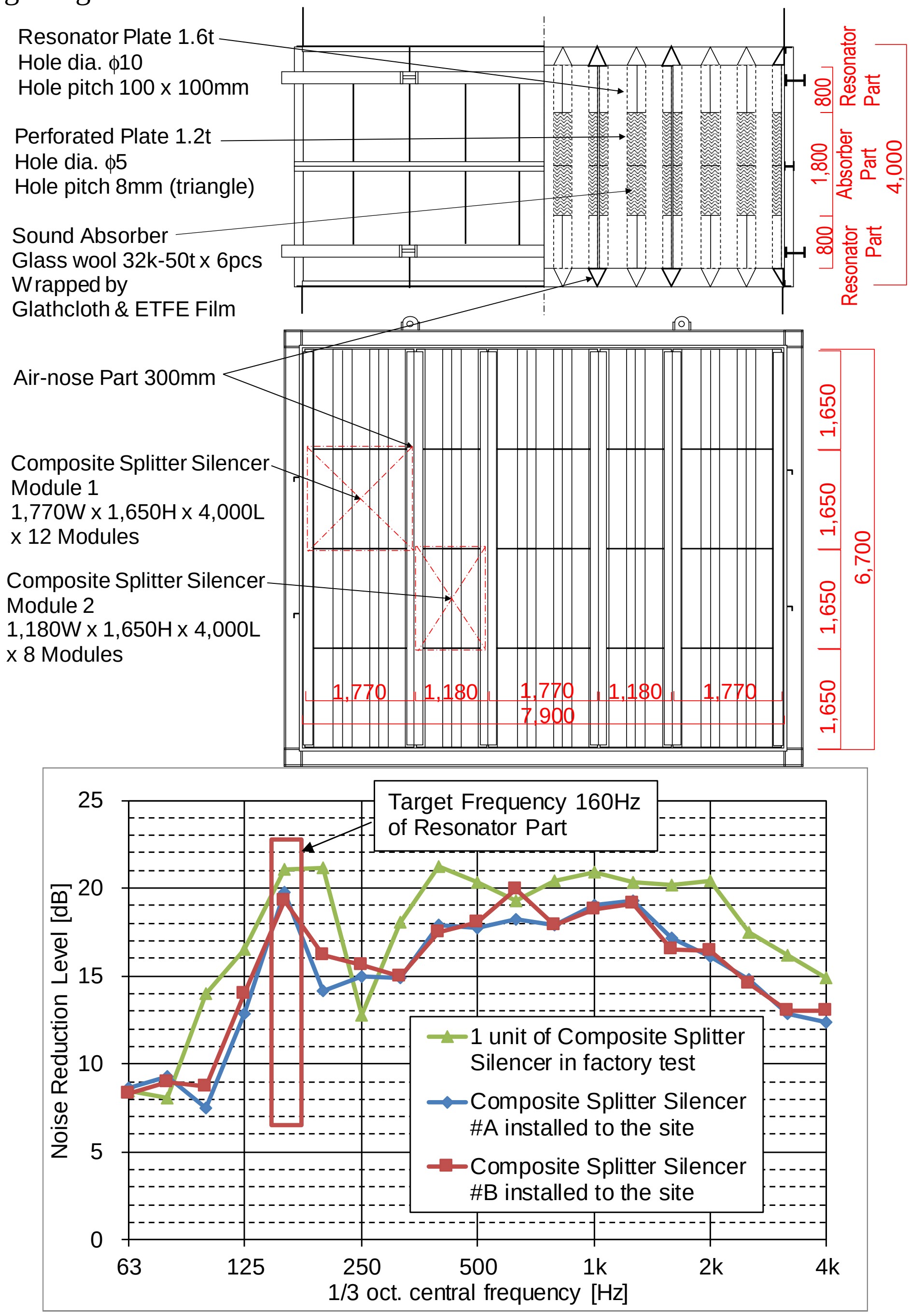


Figure 8 The Application Results to the Actual Power Plant

6. CONCLUSIONS

The effectiveness of “Composite Splitter Silencer” could be confirmed by the examination for the test samples and the application to the actual power plant. In the future, we would like to study about characteristics of resonance frequency and the noise reduction, by various parameters of the resonator, including numerical analysis.

7. REFERENCES

1. INCE Japan, “*Noise and Vibration Control Engineering – Principles and Applications*”, P829, Gihodo(2001) (in Japanese)