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Measurement of small size loudspeaker units by new acoustical loads

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ABSTRACT

This paper describes a new measuring method for small size loudspeakers by using a tube load. The acoustical loads defined in IEC standards for loudspeaker measurement, both of closed boxes and a baffle, are too larger in size than the practical acoustical loads for small loudspeakers, for example, mobile telephone bodies. This paper proposes a tube load for measurement, and examines practical methods without any effect by tube resonance.

1. INTRODUCTION

Recent mobile telephones include a function of ringing by a musical signal. A small loudspeaker is used for the ringing signal radiation. However, measuring method for thus small loudspeakers is not still developed. IEC standard 60268-5 "Loudspeakers" defines three acoustical loads for measurement of loudspeaker units, a baffle board and two sorts of closed boxes. Figure 1 shows one of the boxes defined as an example. The dimension of this box, 1240940640, is extremely larger than ordinary mobile telephone housing. All of the acoustical loads defined in IEC 60268-5 are too large to simulate the mobile telephone use. Moreover, the standard measuring distance of 1 m, defined in IEC 60268-5, is too far for small loudspeaker use.

The Working Group for Acoustical Transducers in Japan Electronics and Information Technology Industries Association (JEITA) started discussion of measuring methods for extremely small loudspeakers. Three sorts of acoustical loads, a small closed box, a mid size baffle board and a tube, are being examined in the WG, now. We, The Shibaura Institute of Technology, are assigned for examination of the tube load which requires a study about effect of the tube resonance.

This paper reports an interim stage of this work.

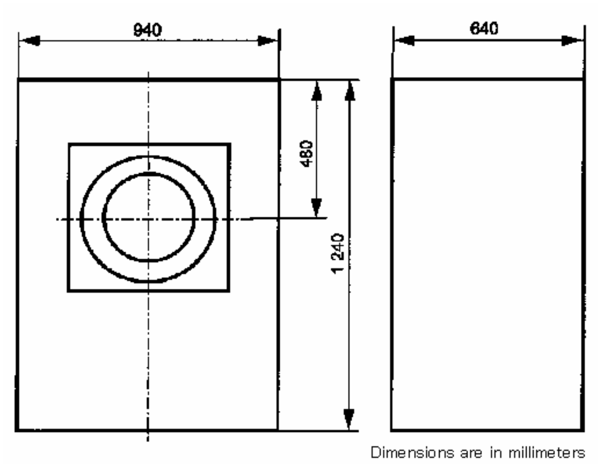

Figure 1 : IEC closed box

2. TUBE ACOUSTIC LOAD DESIGN

2.1. Minimum tube length

At first, the absolute minimum length of the tube as an acoustical load of the loudspeakers to be measured is examined. Dimensions of a typical extremely small electro-dynamic loudspeaker unit with a practically lowest resonant frequency are as follows:

The diameter of a diaphragm: 1.5 cm

The mass of a vibrating part: 0.2 g

The lowest resonance frequency 318 Hz

We estimate stiffness of the diaphragm as:

$$s = \omega_0^2 m = 0.8 \times 10^3 \text{ N/m} \quad (1)$$

We assume:

V_e = The equivalent volume of an vibrating part

P_0 = Atmospheric pressure $= 10^5$ N/m^2

γ = The specific heat ratio of air = 1.41

Then, formula of the stiffness is given as:

$$s = S_e^2 \frac{\gamma P_0}{V_e} \quad (2)$$

$$V_e = 1.76 \times 10^6 \text{ m}^3 = 1.76 \text{ cm}^3 \quad (3)$$

Therefore, if we use a length of several cm or more at least, the equivalent volume of a vibrating part will be sufficiently large.

2.2. Parameters for measurement

Maximum diameter of loudspeaker units for mobile equipment use in about 50 mm (2 inches). We used a PVC (Polyvinylchloride) tube of 56 mm in inner diameter with 2 mm in thickness. Parameters to be examined are the tube length, open or closed end and conditions of absorber included in the tube. Measurement conditions are shown in Table 1. 10 cm and 30 cm of distance between loudspeaker and microphone ware compared.

Table 1 Tube parameters

The length of tube	30 cm	100 cm
Inner conditions	With sound absorber	nothing
Terminus conditions	Open	Close

3. MEASUREMENT

Measurements were carried out by the system shown in Fig. 2. The tube with a loudspeaker was set in n anechoic room.

We assumed the maximum input power to the loudspeaker to be 0.1 W. The loudspeaker unit with following parameters is used for measurement:

The diameter of diaphragm: 36 mm

The material of diaphragm: PET

The lowest resonance frequency: 500Hz

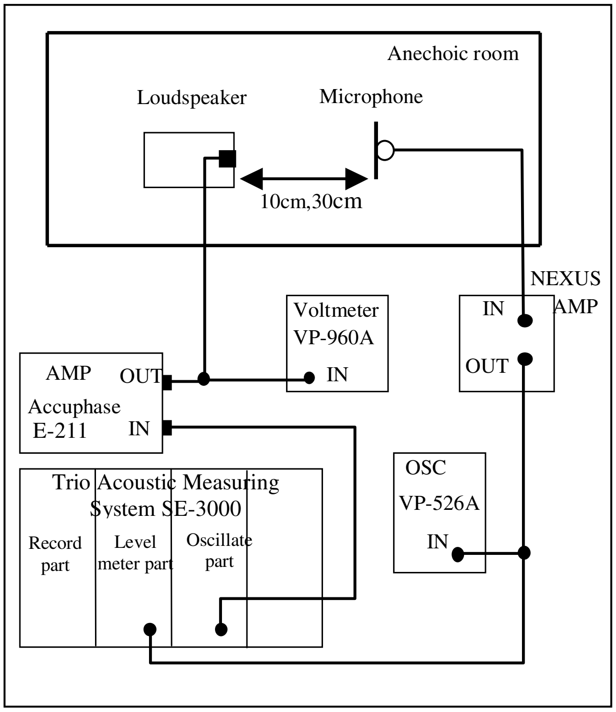

Figure 2 : Measuring system

4. EXPERIMENTAL RESULT

A few examples of measuring results are given in this chapter. The lower limiting frequency of this loudspeaker unit seems about 200 Hz. The components in less than 200 Hz are due to noise. In addition, a vertical axis shows sound pressure level and a horizontal axis shows frequency (Hz).

Figure 3 and Figure 4 show the experimental results, comparing the open and closed ends. Input voltage was 0.9 volt. Figure 4 shows the results by a tube with the absorber which is a glass wool block packed in the tube except 10 cm behind the loudspeaker unit.

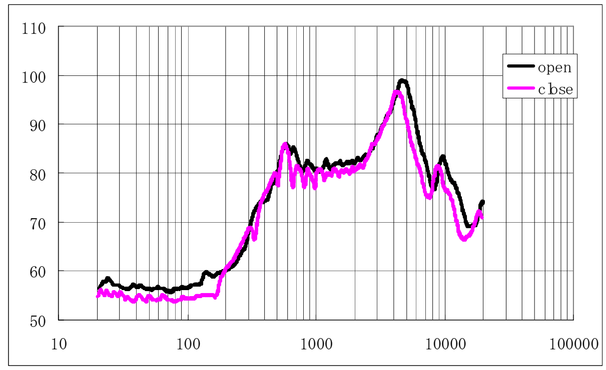

Figure 3 : Without sound absorber (100 cm tube)

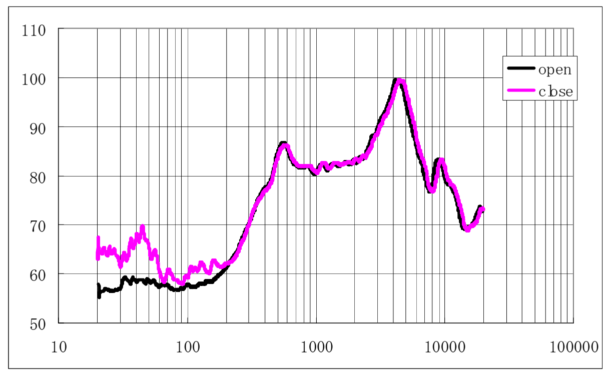

Figure 4 : With sound absorber (100 cm tube)

Figure 5 compares the tube (100 cm) and the IEC closed box shown in Fig. A with input of 0.09 volt.

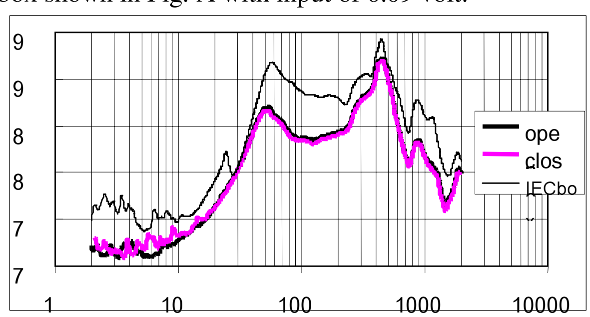

Figure 5 : Comparing the tube and the IEC closed box

Figure 6 and figure 7 show the directional response curves by both the tube and the IEC closed box.

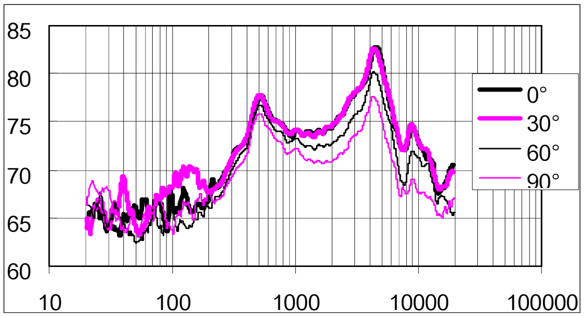

Figure 6 : Directional response by the tube (100 cm)

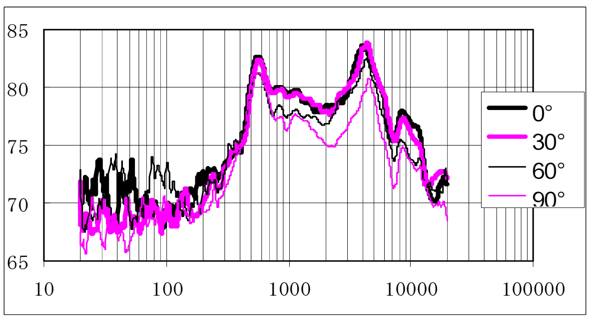

Figure 7 : Directional response by IEC closed box

5. CONSIDERATION

Table 2 describes calculated resonant frequency for both the open and closed tube of 100 cm in length. Measured resonant frequencies were similar to these values.

Effect of the resonance was not remarkable for the tube of 100 cm in length with the absorber. The tube of 30 cm shows a remarkable resonant effect even with the absorber.

Table 2 100 cm tube resonance frequency (calculated value)

Opened tube	170	340	510	680	850	1020
Closed tube	85	255	425	595	765	935

6. CONCLUSION

The measurement of small size loudspeaker units by tube is suitable for evaluation of performance of units.

The longer tube, 100 cm, for example, is recommended for practical use.

The following items should be the future work

Effect of the quantity of the sound absorbing material packed to tube

Effect of the density of the sound absorbing material packed to tube

Influence of diameter

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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