



# EVALUATION OF DIESEL POWERTRAIN NOISE -Difference between Professional and Non-professional-

Takeo HASHIMOTO<sup>1</sup>; Shigeko HATANO<sup>2</sup>; Sung-Hwan SHIN<sup>3</sup>

<sup>1,2</sup> Seikei University, Japan

<sup>3</sup> Kookmin University, Korea

## ABSTRACT

The evaluation of Diesel powertrain noise on unpleasantness for good sound quality is different between professional and non-professional due to the difference of the key sounds to evaluate. The professional pays more on the frequency component related to the sensation of annoyance caused by the Diesel knocking. To compare the professional evaluation, the one obtained by the non-professional is based on the overall impression of test sound. In order to match the evaluation between the professional and non-professional, training session for correct evaluation is required for non-professional subject. If non-professional subject experiences the training session to know the point of evaluation, the evaluation obtained after the training is well match with the professional subject.

Keywords: Diesel powertrain noise, Unpleasantness, Sound quality, Professional, Non-professional  
I-INCE Classification of Subjects Number(s):63.2.63.7

## 1. INTRODUCTION

If we would like to conduct subjective test for better impression of car interior noise at the university laboratory, it is required that the result is matched with the professional evaluation at the car manufacturer. But in general the evaluation on sound quality of car interior noise is different from the one obtained by professional and by non-professional due to the difference of the point of attention on sound.

This paper deals with such a case, in that the subjects composed of university students are asked to evaluate unpleasantness of various Diesel powertrain noises at the sound proof room at the university. At the first trial without any training, the evaluation obtained by the amateur is different from the one obtained by the professional for some sounds. After the close examination of the sound character, a training session to be familiar with the point of attention is conducted. After this session, subjective evaluation of Diesel powertrain noise is again conducted.

The result obtained after the training is well coincided with the one obtained by the professional subject.

## 2. EVALUATION OF UNPLEASANTNESS

28 kinds of Diesel powertrain noise are used to evaluate unpleasantness of the sound. The loudness (1) of the test sounds are ranged from 10 to 30 sones, namely, softer to louder sounds. The sound presentation is conducted using an equalized headphone set inside the sound proof room.

### 2.1 Test method

Magnitude estimation using a digit scale from 1 to 100 by a slide scale on PC screen was used to evaluate the subjective impression on unpleasantness. Subjects are familiar with this method for sound evaluation so they do not feel difficult to evaluate the sound impression. When a subject hear the sound to evaluate, then the subject begin to move the slide scale on the PC screen to the left of to

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<sup>1</sup> hashimot@st.seikei.ac.jp

<sup>2</sup> hatano@st.seikei.ac.jp

<sup>3</sup> soulshin@kookmin.ac.kr

the right to match with his/her impression of unpleasantness. Originally, the slide scale is rested at the middle position of the full scale, namely, 50 score.

### 2.2 Subject

The numbers of subject participated at Seikei University are 24 and they are mainly university students aged from 22 to 24 years old. They are familiar with the sound evaluation but not familiar with the Diesel powertrain noise. On the other hand, the numbers of subject participated at the car manufacturer are 5 aged 50 to 55 years old and they are all professional in that they are engaged with the sound evaluation for long years.

### 2.3 Test result without training

Test result without training with the university students is compared with the one for professional juries from car manufacturer. The result is shown in Figure 1. As can be seen from this figure, some sounds are different in unpleasantness between professional and amateur. The prominent difference can be seen for sound numbers 18, 22 to 25.

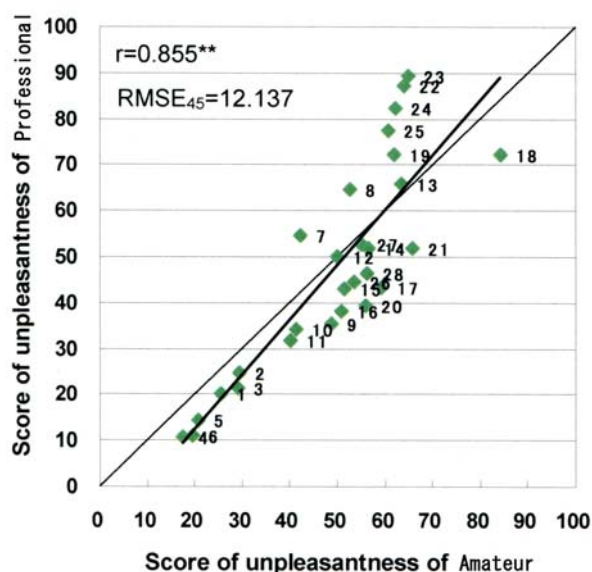


Figure 1 – Relation between the professional and amateur in unpleasantness before training

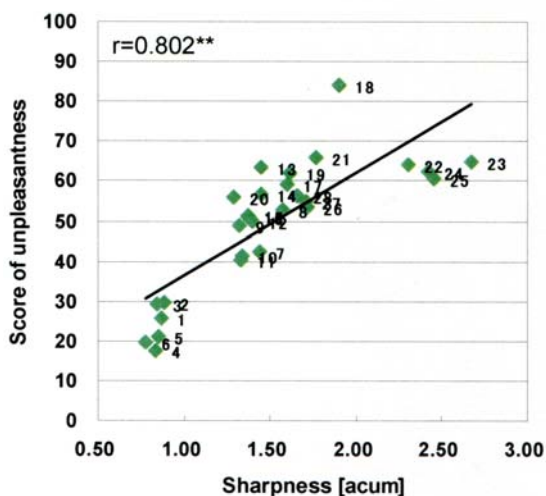


Figure 2 – Amateur without training (sharpness)

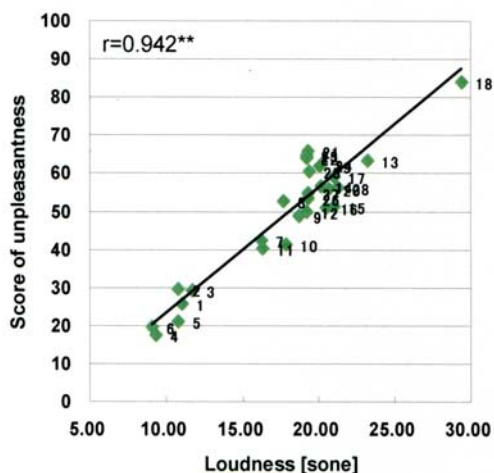


Figure3 – Amateur without training (loudness)

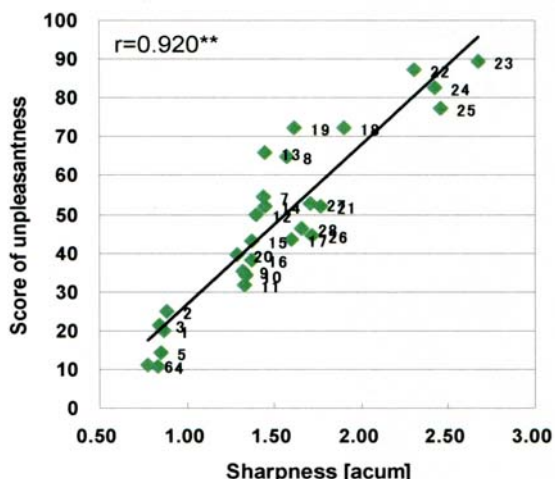


Figure 4— professional (sharpness)

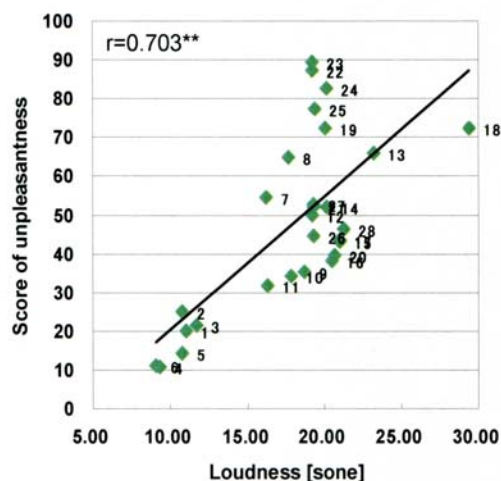


Figure 5— professional (loudness)

Figures 2 and 3 are the evaluation of amateur without training with respect to sharpness and loudness. As can be seen from these figures, amateur without training pay more attention with loudness of the test sound when they judge their impression on unpleasantness compared with sharpness of the sound.

To compare this result, professional pay more attention on sharpness when they judge the impression on unpleasantness and this can be seen from figures 4 and 5.

### 2.4 The cause of difference in unpleasantness

Figure 6 shows the percentage of the sound energy in low and high frequency ranges with respect to each test sounds. Here, low frequency range is the range below 7.5 Bark and high frequency range is the range above 8.5 Bark.

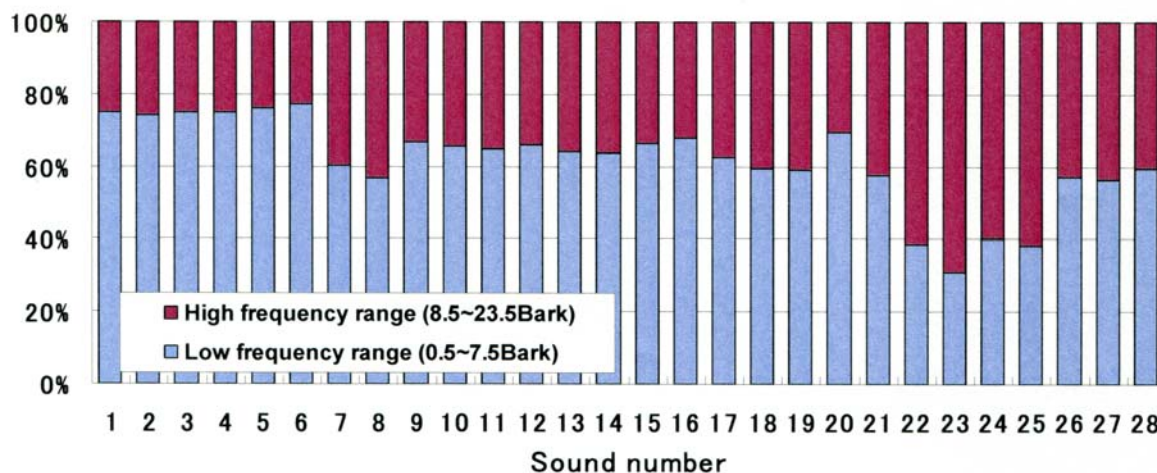


Figure 7— Sound energy percentage between low and high frequency ranges (below 7.5 and above 8.5 Barks)

With respect to test sounds 18 and 22 to 25, the percentage of sound energy is more in high frequency range. This is typical character of Diesel engine knocking noise around 8.5 Bark and combustion noise around 8.5 to 17.5 Barks (2).

The professionals pay more attention with respect to high frequency range above 8.5 Bark when evaluate the Diesel powertrain noise for improvement of unpleasantness of the sound. So, in order to

match the evaluation between the professional and non-professional, the training of amateur to be more familiar with the sound impression above 8.5 Bark is required.

### 2.5 Sound Training

As we have suggested that sound training of amateur is required to match their impression on unpleasantness with the professional, the digital high pass filter with its low limiting frequency at 8 Bark (920 Hz) is constructed by the FIR filter technique. The training processes are as in the following.

- Step 1: test sounds through high pass filter above 8 Bark are repeatedly presented to the amateur subjects to be familiar with the character of Diesel engine noise.
- Step 2: the original test sound and its filtered test sound are alternately presented to the amateur subject for them to differentiate the Diesel powertrain noise under the real original condition.
- Step 3: with the less numbers of the total test sounds, the amateur subject is asked to evaluate unpleasantness of the test sounds and the result is compared with the that of professional. IF the result is still different from the one obtained by the professional, then the steps 1 and 2 are again repeated for training.

### 2.6 Result obtained after training by amateur

Test result by amateur subjects after sound training was compared with the one obtained by the professional. The result is shown in Figures 8 to 10.

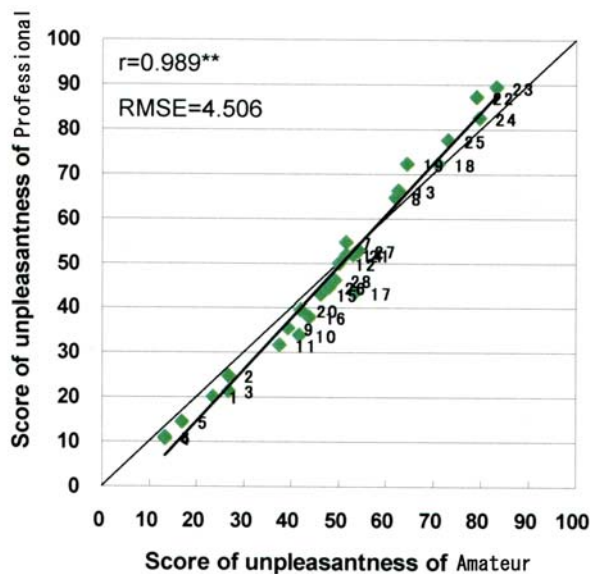


Figure 8— Relation between professional and amateur after training

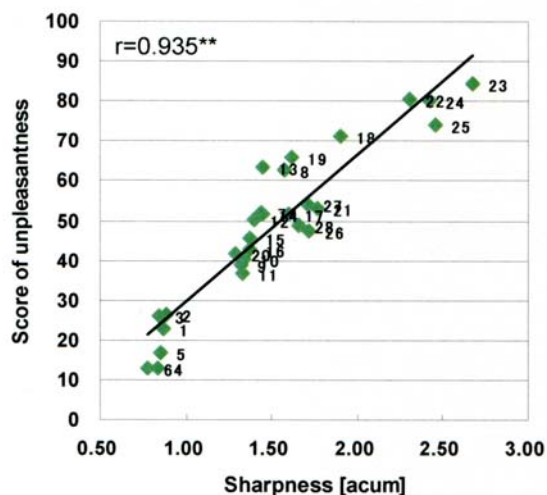


Figure 9—result of amateur after training (sharpness)

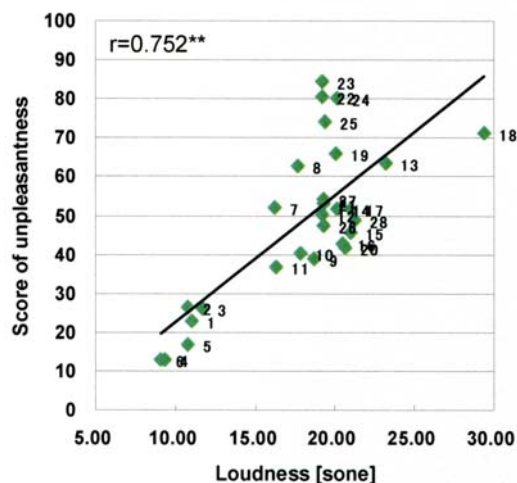


Figure10—result of amateur after training (loudness)

As is seen from Figure 8, the evaluation on unpleasantness by the amateur after training is improved and we could get good coincidence with the result obtained by professional.

The relation between the test result and sharpness (Figure 9) and loudness (Figure 10) are also similar with the results shown in Figures 4 and 5 for professional. This can confirm that amateur judge the character of the Diesel powertrain noise correctly after sound training.

### 3. CONCLUSIONS

The Diesel powertrain noises were evaluated for unpleasantness by the professional and by the amateur and the following conclusions are obtained.

1. Even for trained subjects for usual test sounds apart from Diesel powertrain noise, amateur subjects are difficult to evaluate the sound impression if they are not trained.
2. The character of Diesel powertrain noise is located in high frequency range above 8.5 Bark.
3. In order to be familiar with this character, training must be required for amateur subject.
4. After suitable training, amateur subject evaluate the Diesel powertrain noise the same as the professional subject.

### REFERENCES

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