inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 13

# COUNTERMEASURE FOR NOISE AND VIBRATION REDUCTION OF HIGH-SPEED VEHICLE EQUIPPED WITH RESILIENT WHEELS

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## 1. INTRODUCTION

Reduction of rolling noise as well as aerodynamic noise still calls for serious attention on controlling Shinkansen noise even if the speed of the train comes close to 300 km/h.

This paper presents results of on-line tests with resilient wheels which were adopted tentatively in order to lessen the rail vibration, considered to be a major cause of wheel/rail noise in Japan.

## 2. TEST OUTLINE

On-line tests with resilient wheels were executed in June and July 1994 on the Tohoku line of the Shinkansen in co-operation between JR-East and RTRI. Sound pressure data measured in the on-line tests included noise levels at some rail-side points and at a point right above the bogie which has been equipped alternately with resilient wheels and solid wheels (Fig. 1). In addition, vibration data on rail flange have been collected as references for noise data. An outline of measurement of wayside noise and vibration is depicted in Fig. 2.

Though resilient wheels were tentatively provided for only one bogie which has been at the end position in the 9-car test train named "STAR21", the effect of the resilient wheels on noise levels can be estimated successfully, because almost the same conditions of measuring locations and the velocity of the test trainset were maintained except for the provision of resilient or solid wheels.

## 3. RESULTS AND DISCUSSIONS

### INTERIOR NOISE

Sound power average data on the test train for long time spans are expected to be easily calculated, so that near-bogie noise could be used to estimate the effect of resilient wheels compared with solid wheels. The results of such a comparison in the 1/3 octave band spectra of sound are shown in Fig. 3. One effect of resilient wheels is to raise high frequency components in a frequency range from 1.25 kHz to 3 kHz. Conversely a decreasing effect can be recognized for some frequency components that are not so high. The all-pass level of resilient wheels is not lower than that of solid wheels as shown in Fig. 3. However, it may be reasoned that in-car noise is usually caused by under-car noise and can be lowered when using resilient wheels, since higher frequency components of sounds transmitted through a floor of the test car are expected to be greatly decreased. In reality the in-car noise was found to be decreased by 1-2 dB at many locations.

## RAIL-SIDE NOISE

In the case of rail vicinity sound, frequency components of a range from 1.6 kHz to 5 kHz are recognized to increase as depicted in Fig. 4. However, many of the frequency components lower than 1.25 kHz are found to be decreased. Such an effect of decreasing components of low and middle frequencies should be derived from the resiliency of the test wheels. In fact, it is verified that rail vibration velocity levels are lessened especially in a middle frequency range by adopting resilient wheels instead of solid ones (Fig. 5). On the other hand, the effect of increasing frequency components in a higher frequency range may be derived from the increased vibration of isolated tyres of resilient wheels. As a result, the all-pass level of the rail-side noise is thought to be almost totally unchanged.

## FAR FIELD NOISE

A standard point of a far field for evaluating the wayside noise of the Shinkansen has been determined to be the point at a distance of 25m from the center of the track in Japan. The track is usually shielded by sound barriers, which have a high decreasing effect especially on higher frequency components of diffracted sounds. Thus a rolling noise component of 25m point noise may be considered a weighted rail-side noise in the frequency domain. We estimated such weighting characteristics in the frequency domain simply by attenuation laws for diffracted and propagated sound waves and named them "S-weight".

Estimated levels for rolling noise components of 25m point noise using S-weighted levels are depicted in Fig. 6. Since S-weight, which simulates the diffraction, has an effect of decreasing the higher frequency components in particular, an all-pass level of estimated rolling noise at 25m point becomes lower when using the resilient wheels. Such a tendency was proved at other 25m points. Noise levels shown in Fig. 7 come from data measured at another 25m point by a set of directional microphone arrays. Major frequency components of that data can be regarded as measured sounds diffracted by a sound barrier.

The all-pass level of resilient wheels is proved to be lower than that of solid wheels by 1-2 dB. The result of this far field measurement allows validation of the method using S-weight.

STRUCTURE NOISE

From the fact that rail vibration velocity can be greatly decreased especially in a middle frequency range by adopting resilient wheels (Fig.5), structure noise, which is considered to be influenced greatly by rail vibration, is also expected to be lowered significantly by adopting resilient wheels. In fact, based on comparisons in sound levels measured just under a viaduct for both wheels (Fig.8), the decreasing effect of resilient wheels on structure noise is validated to be at least 3 dB.

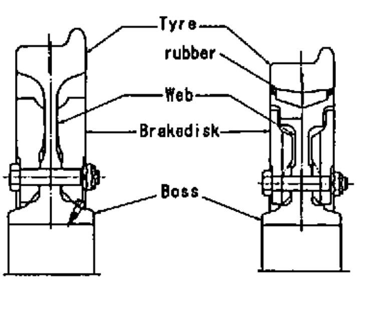
## 4. CONCLUSIONS

(1) In the cases of under-car noise and rail-side noise, the all-pass levels of resilient wheels are not lower than those of solid wheels.
(2) As a result of attenuation by transmission or diffraction in higher frequencies, in-car noise and 25m point noise can be lowered by 1-2 dB when using resilient wheels.
(3) The decreasing effect of resilient wheels on structure noise was proved to be at least 3 dB.

### References


[1] Y. SUNAGA, M. KANAO, "A Study on Rail Grinding and Rail Vibration for Reduction of Rolling Noise", RTRI Report, Vol.8, No.6, June 1994, 31-36

[2] H. Arai, "Characteristics of Noise and Vibration for Resilient Wheel (first Report)", Transaction of the Japan Society of Mechanical Engineers, Vol.49, No.440, April 1983, 543-552


(a) Solid wheel (b) Resilient wheel

Fig.1 Cross section of test wheel

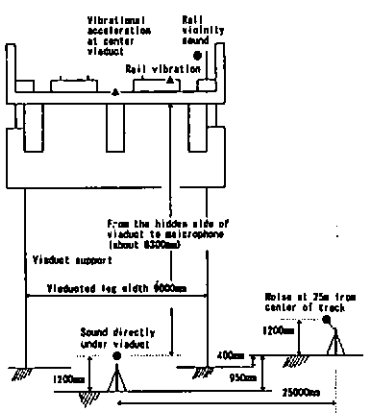



Fig.2 Outline of noise-vibration measurement

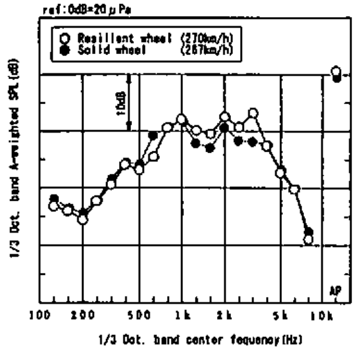



Fig. 3 Estimation of bogie vicinity noise for each wheel

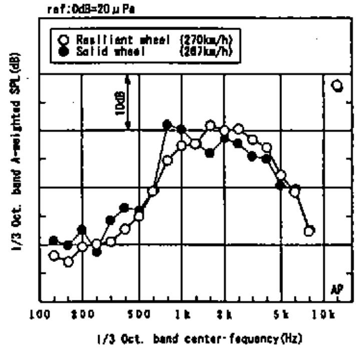



Fig. 4 Rail vicinity sound level

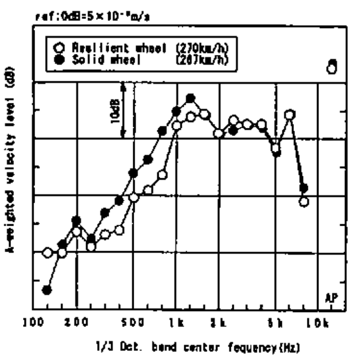



Fig. 5 Rail vibration velocity level

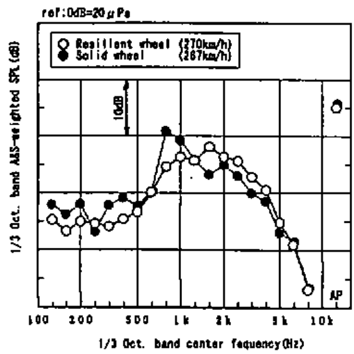



Fig. 6 Estimation of rolling noise component in 25m point noise

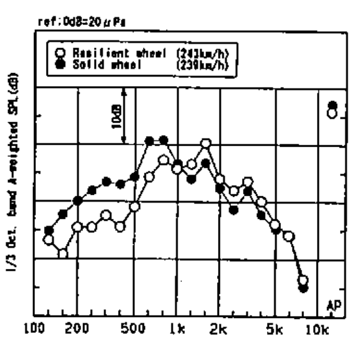



Fig. 7 25m point noise for each wheel by directional microphone array

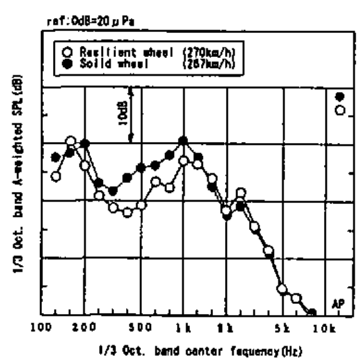



Fig. 8 Sound level measured directly under viaduct for each wheel