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RAILWAY: WEAR AND NOISE

Gunnar Rasmussen

G.R.A.S. Sound & Vibration aps, Skelstedet 10B, DK2950 Vedbaek

1. INTRODUCTION

Transportation noise is a major problem. The traffic density is growing and the transportation by road, air and rail-ways calls for bigger and faster machines.

Acoustic noise is caused by vibrating surfaces and radiation into the air. The vibrating surfaces are excited by energy flowing in the structures and caused by losses in the energy transfer system. Noise is therefore associated with imperfections in the kinetic energy flow used for the drive system. Noise is an unwanted quality. By measuring the noise radiated from surfaces, we can monitor the condition of the system.

The energy and thus the noise originates from the many moving components involved in the rail-wheel-drive and brake system, where energy is being applied and wasted. A typical vehicle-track system is shown in Fig.1.

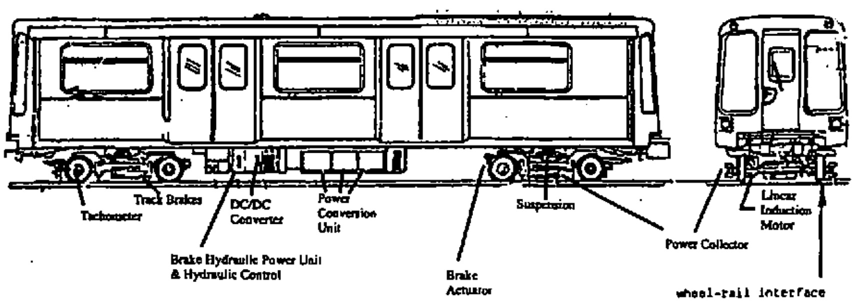

Fig.1: Vehicle-track system with possible noisy components.

The use of acoustic measurement technique and intensity technique offers very good diagnostic and monitoring possibilities.

The Intensity I, is the power per unit area. It is measured by multiplying pressure, p, and the vector quantitiy velocity, v, or by measuring two pressures, p_1 and p_2 over a known space Δr. If the density of air is ϱ, then

$$I = \rho \cdot v = \frac{p_1 + p_2}{2} \int \frac{p_2 - p_1}{\rho \Delta r}$$

Intensity is used for diagnostic purposes and noise control.

2. VEHICLE NOISE MONITORING

The use of permanent mounted microphones along the rails enable one to monitor the condition of the rolling stock in a pass-by situation. Fig.2. By measuring close to the wheels, noisy wheels with flats or corrugated surfaces can be identified and corrected before they cause further damage on the rail system and when the emitted noise increase above preset values Fig.3.

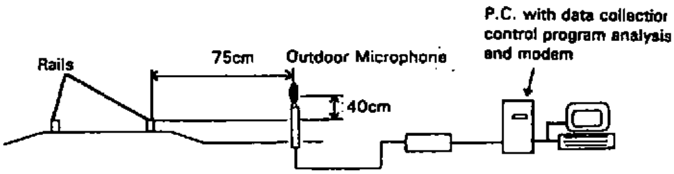

Fig.2: Data collection

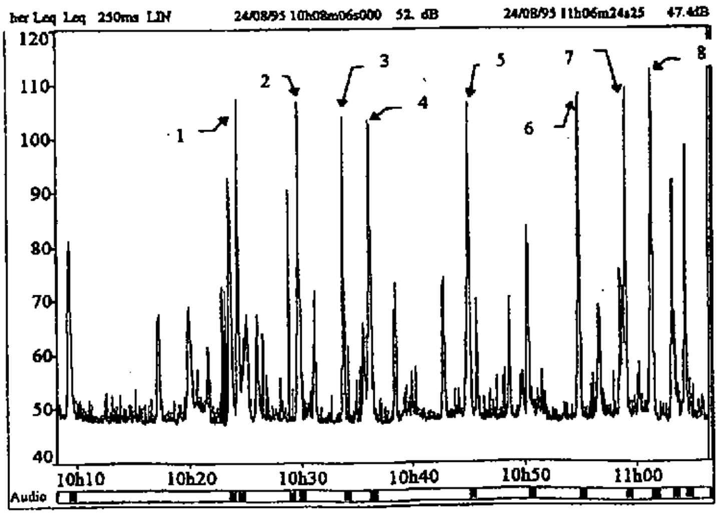

Fig.3: Trains passing exceeding the threshold and recorded for later analysis

Each event shown in Fig.2 may be analyzed in the time and frequency domain e.g. at a time of max. level during the pass of a certain wheel set.

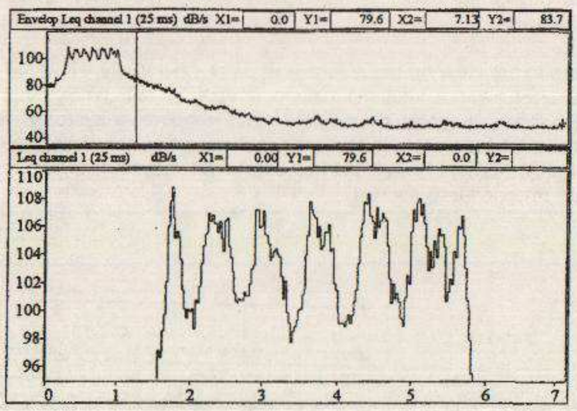

Fig.4: 40 sec by-pass and time record of the first 4.5 sec shown below. Note the pressure pulse from the first car.

Fig.4 shows the max. by-pass noise of a train consisting of control car, passenger cars and EA-engine. The upper curve is the total recorded when exceeding 80dB and 40sec record length. The train passage last 4.5 sec. An averaging time of 25ms is used as the best compromise between time resolution and statistical accuracy. The lower curve shows the actual by-pass over 4.5 sec. Each boogie can be identified on the lower record and analyzed in 1/3 octaves as shown in Fig.5.

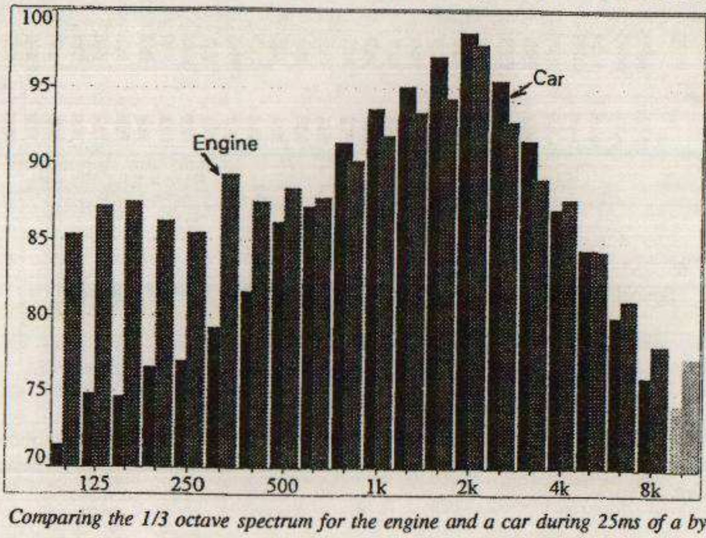

Fig.5: Comparing the 1/3 octave spectrum for the engine and a car during 25ms of a by-pass.

The environmental noise in the nearby community is proportional to the emitted sound power and to some extend on the power spectrum. Higher frequencies are more annoying than low frequencies.

The noise is closely related to the wear on the mechanical parts - especially wheel rail noise. Wheel conditions are best evaluated over a well maintained stretch of rail, while rail conditions are evaluated in a car with wheels in good conditions. This requires a systematic maintenance programme which could also lead to lower maintenance costs. Fig.6. Each train is measured during the pass of a fixed monitoring station. When the noise exceeds a level of 74dBA the train is sent for maintenance and then returned into service.

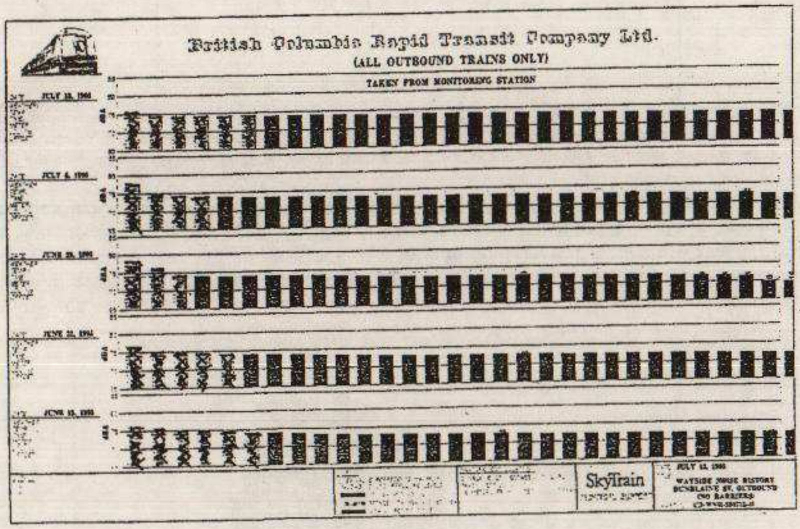

Fig.6: Typical data from a systematic wayside noise monitoring programme.

For diagnostics and research purposes the use of sound intensity is clearly an advantageous as one will be more clearly independent of other noise sources and the environment in general. An example is shown in Fig.7.

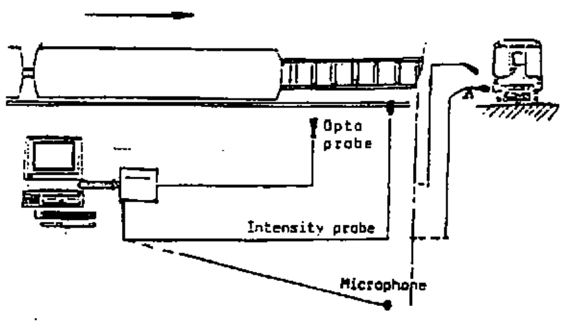

Fig. 7: Measurement set-up for pass-by noise.

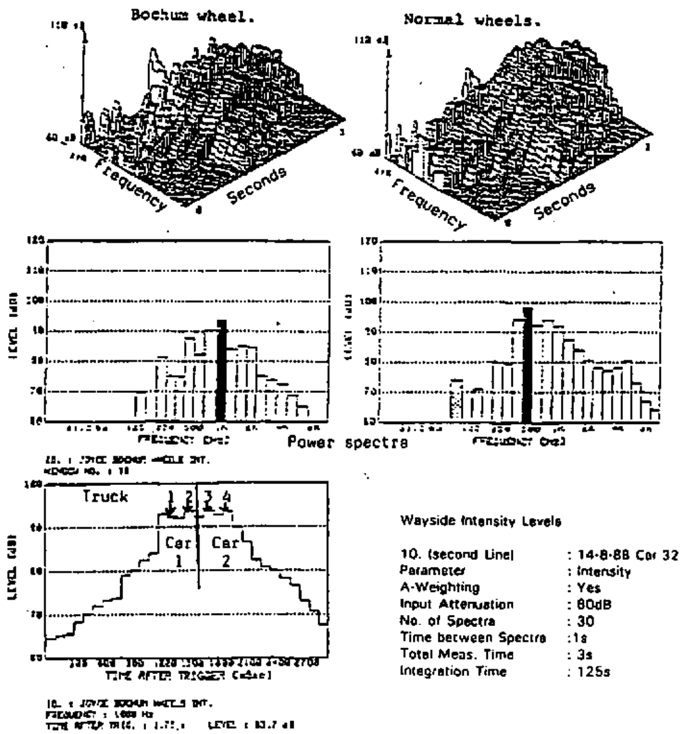

Fig. 7: Wayside intensity indicating the difference in emitted sound power from two different types of wheels on the same rails and same train. The time history identifies the wheel web as the main radiating surfaces at 1000Hz. The "normal" wheel radiates mainly at 500-600Hz.

Wayside noise may be used for evaluating the quality of single components like the influence of the traction system or the wheels on the noise. In Fig.7 is shown a comparison between solid wheels - Bochum wheels - and SAB wheels on the by-pass noise level as overall impression and for the three type of wheels at the max. level in the frequency domain. Using intensity the actual radiated sound power is measured in 1/3 octaves as a function of time. Fig.8.

The ride comfort is a function of the internal noise and the motion of the car. It is a very subjective quantity. On short trips one is much more tolerant to the ride comfort than on long trips. In general the noise is evaluated as an important factor. Also the motion in the vertical direction is important and should not exceed 1 m/sec^2 very often. The change of speed especially braking is another factor evaluated as very disturbing. A typical monitoring Microphone capable of functioning in the rough environment along railbeds.

A low noise level a smooth drive at high speed is the goal for the future.

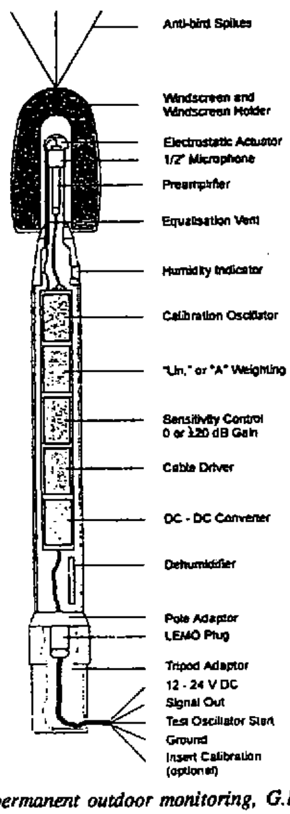

Fig.9: Microphone built for permanent outdoor monitoring, G.R.A.S. 41CM.