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NOISE MONITORING OF TRAIN WHEELS

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ABSTRACT
A system for automatic recording and processing of the noise emission from train wheels is described. The system is part of a procedure for systematic condition-based wheel maintenance, whereby the maintenance cost can be reduced and the lifetime of the wheels can be extended. The noise monitoring system has been established on one of the main tracks towards Copenhagen central station, Denmark, and automatically records the noise emission from all inbound trains. Based on the distance between the wheels and the noise profile known train types can be identified and the noise contribution from each individual wheel can be isolated and normalized with respect to the train speed. The data can be transferred via modem to the central maintenance facility for recalling of train units for service. The system has proved a potential cost reduction in maintenance and a reduction in noise emission.

1 - INTRODUCTION
Train wheel wear is responsible for one of the dominating contributions to the overall maintenance cost of trains. A train wheel may be able to run for many weeks without need for service, but once a defect has started to develop, the wheel condition will rapidly deteriorate. While the wheel may be repaired by machining off 0.1mm of the surface at the onset of the defect, it may require machining off 1-5 mm of the wheel if the wheel defect is allowed to develop. As the total lifetime of the wheel to a large extent is determined by the amount of material machined from the wheel it is important to detect the defects at an early stage.

The wheel conditions of the Danish State Railways (DSB) passenger trains have been monitored by measuring the noise emission. A measurement site has been established on one of the main tracks leading into Copenhagen Central station so that all trains coming from the western part of Denmark are measured. The typical train speed at the measurement site is 120-180 km/hour. The measurements are performed automatically and the data are processed and stored. The data can be transferred to the central maintenance facility in Copenhagen so that trains with developing wheel defects can be recalled for service.

2 - SYSTEM DESCRIPTION
The noise monitoring system, fig. 1 consists of two outdoor microphone units, two wheel detectors, a PC with data acquisition board and software and a modem for data transfer. The outdoor microphones G.R.A.S. type 41CM are special rugged units specially designed for permanent outdoor use in harsh environments. The microphone units contains microphone, preamplifier, power supplies and signal conditioning and can drive cables of up to 1000m. They are placed one on each side of the track about 0.7 m from the wheel/rail interaction point, Fig. 2. The microphones have to be as close as possible to the wheel/rail interaction point in order to distinguish the individual noise sources, but must at the same time be in accordance with safety regulations. The two wheel detectors are placed 10 m and 20 m before microphone position and triggers the start of a measurement. The time between the trigger signal from the two sensors is used to determine the speed of the train.

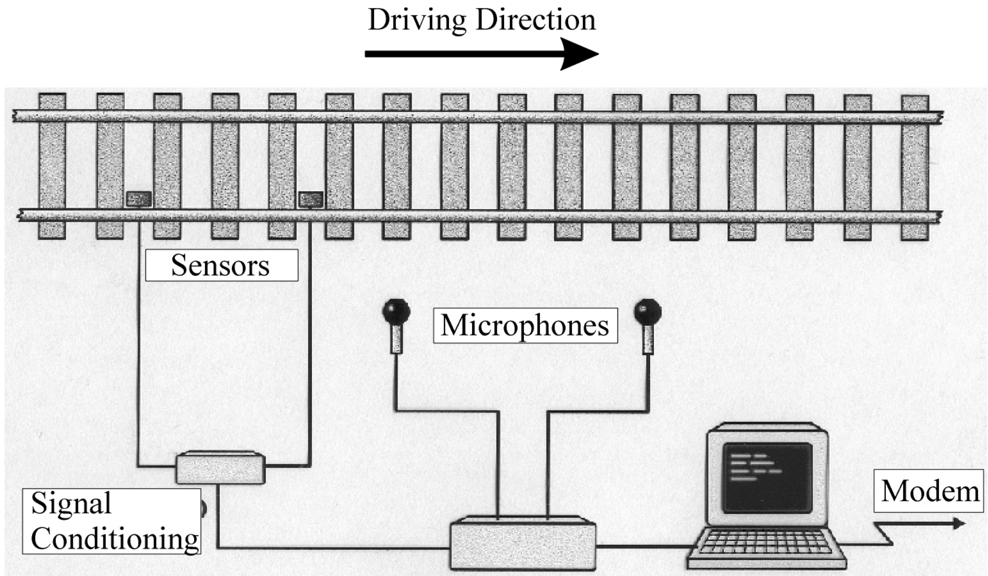

Figure 1: Train wheel noise monitoring system.

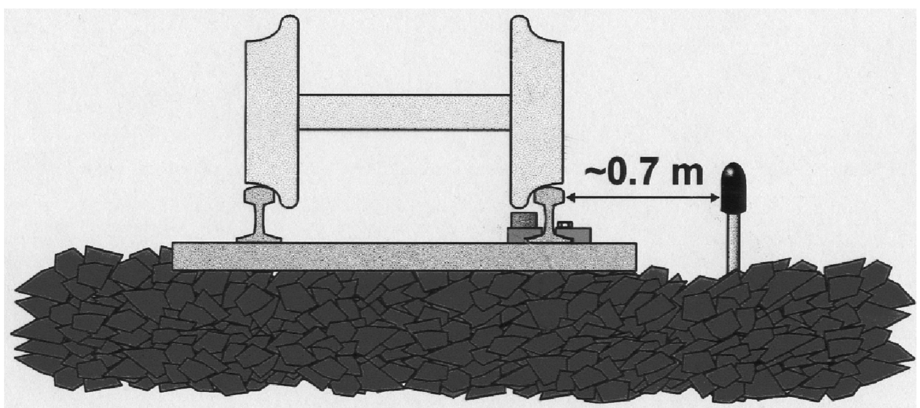

Figure 2: Microphone position.

3 - TEST RESULTS

The signals from the wheel sensors and outdoor microphones goes to a computer placed in a building about 100m from the track. Here the signals are digitized and digitally filtered to obtain the relevant wheel/track interaction noise. The filtering removes the low frequency pressure pulses at the front and back of the train caused by the air volume displacement. Fig. 3 shows a typical noise profile for an IC3 light weight train running at 120 km/hour. It can be seen that the noise contribution from each individual bogie can be identified and isolated. The IC3 in the example consists of two identical train sections, where each section consists of three wagons with two shared bogies. For each type of train the relationship between speed and noise level has been established based on a statistical analysis of the noise from approximately 1000 train passages. The noise from each individual train bogie is rated by correcting the measured noise level for the speed of the train. The noise data are stored in the computer together with speed information and time and date.

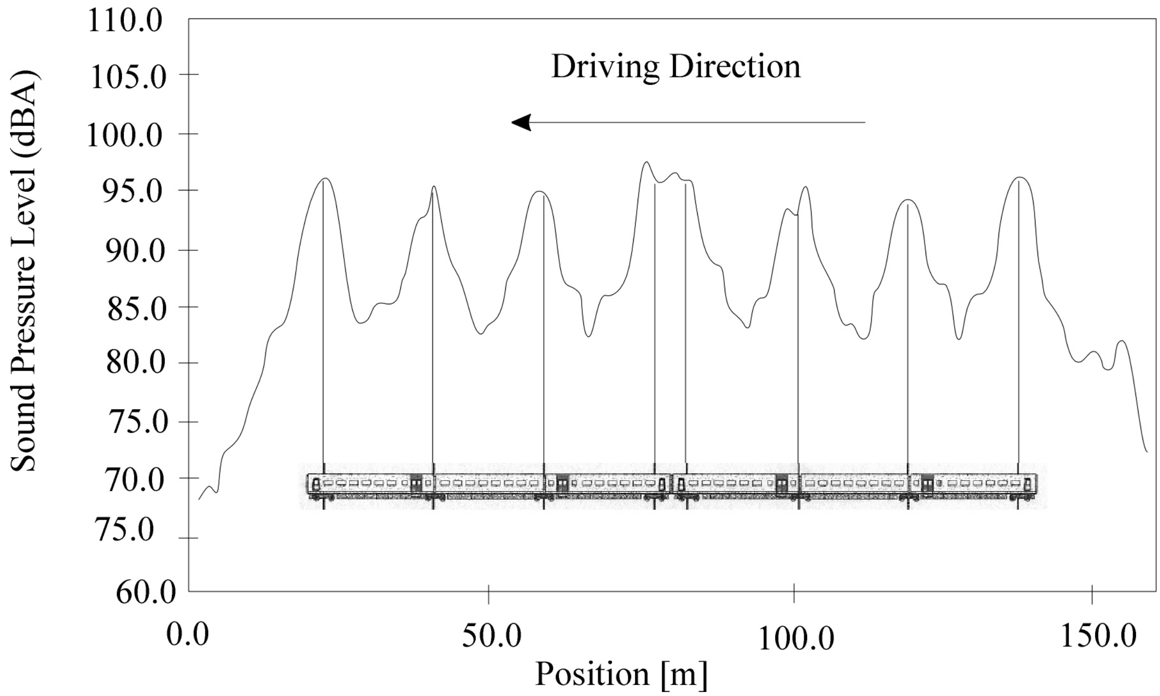

Figure 3: Typical noise profile for IC3 train.

No	File name	Date	Time	Speed	Train type	Bogie no.	Noise level	Noise Index
1	Au283	1-10	13.13	170.6	IC3	7	114.2	1.051
2	Au632	2-10	21.10	132.6	IC3	9	110.7	1.048
3	Au632	2-10	21.10	132.6	IC3	8	110.7	1.048
4	Au801	3-10	20.11	140.6	IC3	6	110.4	1.047
5	Au819	3-10	22.06	132.1	IC3	3	108.9	1.043
6	Au969	4-10	20.13	154.1	IC3	8	113.1	1.043
7	Au969	4-10	20.13	154.1	IC3	9	113.1	1.043
8	Au358	1-10	19.10	164.5	IC3	4	113.9	1.039
9	Au358	1-10	19.10	164.5	IC3	5	113.9	1.039
10	Au133	30-9	21.09	161.8	IC3	4	113.5	1.038

Table 1: The 10 most noisiest passages for a one week period.

All the measured data were stored in a database enabling search for particular train types and speed ranges. Table 1 shows a list of the 10 most noisiest type IC3 train passages within a 7 day period in August 1998. The total number of passing IC3 trains in this time period was 1341. The noise data for all bogies on all these train have been corrected for the train speed to obtain a noise index independent of the speed. A number of these train passages have not been identified either because the particular train type was not involved in the test program or because of missing identification. Of the remaining 7 highest passages out of a total 1341 passages, these were all caused by two particular trains. One of these were subsequently followed over a period of time and then taken out of service for maintenance.
Fig. 4 shows the noise index for a particular train followed over a period of time. The speed corrected noise index was 1.02 or higher until October 7 when the train was taken out of service for maintenance. The wheels were machined and the train was put back in service on October 9. Subsequent measurements shows a speed corrected noise index of less than 1.00.

4 - CONCLUSION

The train wheel noise monitoring system has been able to detect increased noise levels from individual train bogies on a number of train types. At the moment the system is being modified to include an automatic train identification system. This will use tags on the trains and a trackside antenna to read a train identification and direction number so that the noise data can be automatically stored with the train identification.

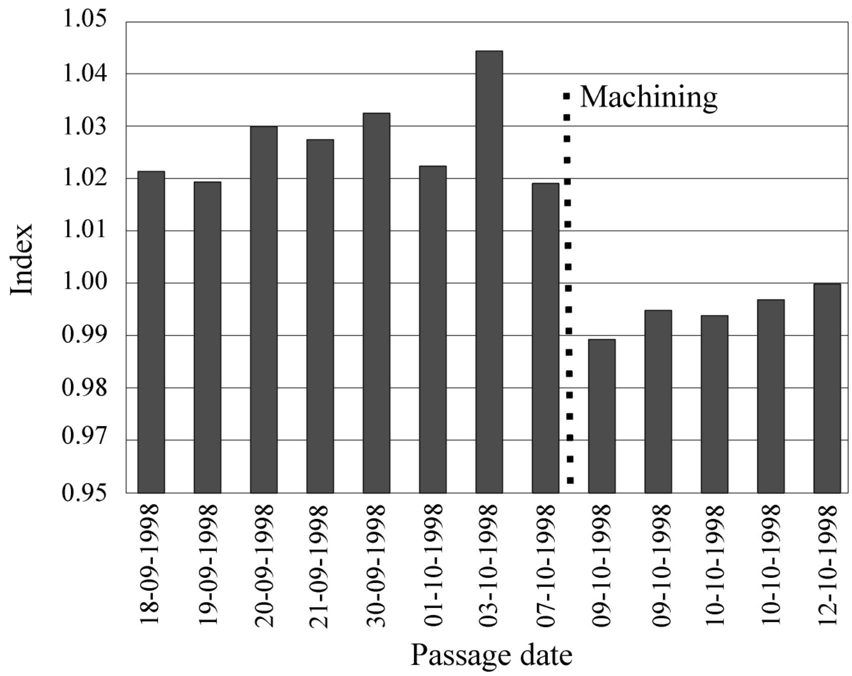

Figure 4: Speed corrected noise index before and after machining.