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# Railway applications - Noise emission - Road test of standard for rail roughness measurement EN 15610:2009

Applications ferroviaires - Emission de bruit - Essai de route relatif de norme pour la mesure de rugosité de rail EN 15610:2009

Bahnanwendungen - Geräuschemission - Feldversuch zu EN 15610:2006 über Messung der Schienenrauheit im Hinblick auf die Entstehung von Rollgeräusch

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## Foreword

This document (CEN/TR 15874:2009) has been prepared by Technical Committee CEN/TC 256 “Railway Applications”, the secretariat of which is held by DIN.

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# 1 Introduction

## 1.1 Background

It is well established that rolling noise originates in the combined 'roughnesses' of the wheel and rail running surfaces. Through the rolling interaction of the wheel and rail this roughness imposes a time history of relative displacement across the wheel-rail contact that leads to vibration of the wheel and of the track. This vibration, in turn, gives rise to the noise components radiated by the wheel, the rail and the sleeper. The fact that at low ('normal') levels, the roughness gives rise to noise radiation linearly and accounts for the noise fully, has been shown by the comparison of theoretical models and carefully controlled measurements [1]. It has furthermore entered the practice of a number of railways to control the roughness, even of uncorrugated, track as a measure to reduce noise.

In recent years, in line with the European Union's strategy for harmonisation of internationally running train services in Europe, new Technical Specifications for Interoperability (TSI) have been written for the acceptance testing of new rolling stock. The acoustic TSI reflects the understanding of the noise generation mechanisms [2, 3]. In order to ensure that the acceptance test, that may be made at different locations on different rolling stock, is a fair test of the rolling stock and depends as little as possible on the local track design, the TSI specifies conditions for a 'reference track' on which pass-by noise measurements are to be made. The reference track is controlled in terms of the noise produced per unit level of combined roughness and the roughness of the rail head running surface. The first condition is characterised by a minimum decay rate spectrum that must be obtained on the reference track (for how this relates to the noise performance of the track see [4] and to [5] for the method of measurement). The second condition is a limit to the spectral level of rail roughness that may exist on the reference track [6].

To ensure comparable and repeatable pass by noise measurements are made, the TSI calls upon ISO 3095. This standard also contains an Annex concerning the measurement of roughness.

A programme of measurements of noise from both high-speed and some conventional speed rolling stock was undertaken to test the practical applicability of the TSI method of measurements (NOEMIE project [7]). In most respects the tests were successful but it was shown, as previously realised, that the part of ISO 3095 concerning roughness measurements is too limited in the following respects:

a) the wavelength range specified is too short for use for high speed trains;

b) too little data sampling is demanded to give the required certainty in the measured spectrum of roughness over the wavelength required;

c) the standard is written on the assumption of a particular measurement technology; it is preferred that only a performance criterion be implied for the quality of measurements obtained;

d) ISO 3095 imposes a fixed pattern of sample records; this sometimes causes the measurement of rail-head defects that are not wanted in the signal and have a significant effect on the estimated spectrum;

e) the standard specified the averaging of the roughness across a number of lines at different distances across the rail head. Since the variation across the rail-head is significant, closer specification of where to measure is required and the data for separate lines should be presented separately.

For these reasons the TSI Committee requested CEN/TC 256, Working Group 3, to draft a new standard solely for the measurement of acoustic roughness. It is the intention that the TSI should, in future, refer to the new standard for this aspect.

### 1.2 Objectives of the road test

The purpose of the road test is to check that the standard can be interpreted consistently and leads to a consistent estimate of roughness spectrum when used by different measurers with different instruments. Many of the instructions of the new standard have not been practiced by measurers before and so these are also being tested for practicability and effectiveness. The exercise is not concerned with testing instruments or measurement technology. The standard specifies minimum performance criteria but otherwise is designed to be as inclusive as possible with regard to technology.

In order to gain a proper understanding of the practical difficulties and the outcome in terms of consistency of practice as well and results, it was seen as essential that the 'road test' should take place in an industrial context, i.e. making measurements with instruments used by the industry on running railway lines having normal constraints of access time and safety procedures, etc.



## 2 Brief review of the nature and requirements of the new standard

For the method of pass-by noise measurement, the current High Speed Rolling Stock TSI (2008) refers to EN ISO 3095: 2005 [8]. The current Conventional Rail TSI refers to ISO 3095:2001. Having said this, there is not a significant difference between the two versions.

The EN ISO 3095 standard itself already sets a limit spectrum for the track on which acceptance tests are made and prescribes a method for its measurement. The limit spectrum set in EN ISO 3095 is not used in the TSI's, rather a tighter limit is set from within the TSI's according to what was found possible by the associated NOEMIE project [7]. The project also found, for high speed trains (above 200 km/h), that a minimum wavelength range up to 0,25 m is required.

### 2.1 Longitudinal position of measurement records and sample length

EN ISO 3095 specifies a set of six positions for 1 or 2 m records of the rail-head profile. These are fixed with respect to 'the microphone position'. This leads occasionally to the measurement of rail-head defects, welds *etc.* Such large localised irregularities are not appropriate to include in the roughness spectrum since they create forces and noise that are not linear with their depth (the contact geometry, and therefore the contact stiffness, changes radically). They also strongly distort the mean of the six sample records leading to both an overestimate of the level and uncertainty in the true operational roughness level. This has been a problem many times in the past and specifically at one of the test sites in the NOEMIE project. In the new standard, the choice of location of the measurement records is made by the measurers and they are advised not to include such irregularities. Moreover, the new standard envisages that a certain track section is to be characterised rather than assuming a microphone position. (The placing of a microphone might be decided on the results or there may be no associated noise measurements at all.)

To keep the variance in the estimated spectrum at 0,25 m wavelength consistent with that at 0,1 m in EN ISO 3095, the new standard requires there to be a 15 m sample length in total.

### 2.2 Lateral position of the measurements on the rail head

EN ISO 3095 requires that the 'running band' on the rail head be identified (as 'clearly visible') and 1 or 3 lines of roughness measurement record be taken depending on its width. The new standard refers to a 'reference surface' that must be defined by the measurer. The relationship of noise measurements to the measured roughness will then be valid as long as the wheel-rail contact remains inside the reference surface. Its identification from the running band or otherwise is an important subject in the new standard. Three different criteria depending on the situation and the purpose of the measurements are offered:

a) the running band is visible and is known to be a product of the rolling stock for which the roughness measurement is to be used,

b) the contact position can be measured for the specific rolling stock at the time of roughness measurement,