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# Type approval and COP tests for low noise surfaces

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## Abstract

The development of low noise surfaces is going rapidly and several new types are being produced nowadays. Application of these surfaces in every day road building practice requires the availability of generally accepted test methods to establish the acoustic properties and the be able to control the performance after being produced and during its life time.

In this paper we will describe an assessment method for the type approval of acoustic quality of noise reducing road surfaces, closely connected to the noise immission calculation scheme, and we will we will discuss the statistical and methodological aspects and further work on a conformity of production testing and monitoring procedures. Data from seven surfaces will be used as illustration of the method.

## 1. Introduction

The severity of traffic noise requires the large scale introduction of low noise technology. In the Netherlands situation the need for low noise surfaces is very manifest due to the dense road network, the impossibility to plan separation of roads and living areas and the high car mobility of its inhabitants.

Of the several technologies available to road authorities, the application of low noise surfaces is not only the most cost-effective but also can be implemented on short notice without the long time path needed for the development of international type approval directives (as are needed for tyres and vehicles). These advantages has led to the development and application of several low noise surfacing types that, depending on the composition and speed of traffic give the required level reduction.

The broad introduction of low noise road technology however is not guaranteed by the availability of low noise surfaces alone. In too many situations positive results of demonstration projects were followed by disappointing results in practice due to the lack of a framework of guidelines, assessment methods, standardized test methods and quality assurance procedures.

A broad R&D program was set- up by the Environmental Ministry in co-ordination with the Transport Ministry, local road authorities, road building industry and acoustic experts to develop a framework incorporating all “rules” needed for reliable implementation of low noise road technology.

In this paper we will address the issue of the unambiguous assessment of the noise reducing property of the surface and the procedures to control the “conformity of production” (COP).

# 2. Noise reduction property

## 2.1 development of procedure

The road surface itself does not produce noise (as one can observe very quickly). The road surface affects the noise production of road vehicles driving on it. Its effect is therefore very dependent on the characteristics and driving states of the vehicles in the traffic flow and should be regarded relative to the noise production of that same traffic flow on a “normal” road. Although this approach leads to the theoretical best definition, it is also highly impractical since it requires the existence of reference surfaces next to each low noise surface.

In the Netherlands program the following steps were taken:

1. The definition of the noise reducing effect;
2. The definition of the reference surface;
3. The development of a standardized procedure to determine the typical noise reduction effect of the road surface type;
4. The development of a procedure to control and to monitor the conformity of production of a certain road surface to the properties that belong to that surface type.

## 2.2 requirements

In order for such a procedure to be effective in practice it must meet certain requirements:

1. The definition of the components in the procedure must be unambiguous;
2. The procedure must fit in the national noise assessment procedures but also in the national used road material specifications and related quality assurance and life time monitoring procedures;
3. The methods used must be based an generally accepted standards such as EN or ISO.
4. The procedure must be supported by all stakeholders

In a working group operating under the Netherlands Information and Technology Center for Transport and Infrastructure (C.R.O.W.) a working group was installed in which all relevant parties (road authorities, environmental ministry, road manufacturers and acoustical experts) were represented.

## 2.3 formula

The formal framework in which the noise produced by road traffic is determined is the Dutch Noise Act. Within this framework operates the official noise calculation scheme in which three types of vehicles are distinguished, the noise production of which is calculated:

$$L_{i,j}(v) = a_{i,j} + b_{i,j} \log\left(\frac{v}{vo_j}\right) \qquad (1)$$

with $L_{i,j}(v)$ : noise production level of vehicle type j in octave band i at speed v
$i$ (1…8) : octave band number ranging from 63 Hz to 8 kHz
$j$ (1..3) : vehicle type: 1: small cars, 2: medium trucks, 3: heavy trucks
$vo_j$ : reference speed, 80 km/h for cars, 70 km/h for trucks.

The reduction effect should therefor fit this scheme. After studying several alternatives [1] it was found that the optimal trade off between accuracy and practicability was:

$$\Delta L_{i,j,k}(v) = c_{i,j,k} + d_{j,k} \log\left(\frac{v}{vo_j}\right) \qquad (2)$$

with $\Delta L_{i,j,k}$ : octave band reduction [in dB] and $k$ (1…) : surface type index

The noise production of vehicle type *j* in frequency band *i* on a certain road surface type *k* is now given by:

$$L_{i,j,k}(v) = a_{i,j} + c_{i,j,k} + (b_{i,j} + d_{j,k})\log\left(\frac{v}{vo_j}\right) \quad (3)$$

## 2.4 reference surface

The reference surface is defined by its zero reduction effect, i.e. the surface type on which the standardised noise production is determined on. In the Netherlands this is a dense asphalt concrete surface with 16 mm maximal chipping size (DAC 0/16) and of average age. This last aspect introduces the ageing property of the surface. Although very relevant for the durability of the acoustic effect, the road usage may cause unwanted sources of variances. Therefor the age of both the surface under study and the reference surface is limited to 1 year and must bear no visible signs of wear. As a first approach ageing will work on all surfaces in the same way and therefor will not affect the difference between them.

## 2.5 vehicle categorization

The definition of vehicle categories influences both representativity and reproducibility. Incorporating a broad variety of road vehicles in the procedure, either by defining several sub categories or incorporating a broad range into a single category would of course improve the quality of the procedure in representing the real effect of the surface on the noise production of road vehicles. However the increased variances involved in extending the population will increase measurement errors or necessitates unpractical long measurement procedures. Each doubling of variance must be compensated by a fourfold increase of data points.

An optimal balance was found in reducing the number of vehicle categories to two: small cars and heavy trucks, and only select passenger cars for category 1 and three or more axle trucks for category 2 and 3. Two axle trucks, buses, vans, off-road vehicles etc. are discarded.

## 2.6 measurement methods

The trade-off between representativity, reproducibility and general acceptance has led to the choice for the ISO standardised method 11819-1, *Statistical Pass-by Method (SPB).* Although an LAeq based method would be preferable. The LAmax based SPB method does not necessarily represent LAeq levels, but gives large advantages in terms of practical application and general acceptance. The not yet solved problem of propagation effects is taken care off by standardising the microphone height to 5m, and using 1.2 m as supplementary one.

A further trade-off is needed for the COP and/or durability monitoring method. The in the frame work of ISO TC43/SC1/WG33 developed CPX method was found to be in principle adequate for that task.. Although the first experiences with respect to both representativity and reproducibility of the procedure were rather disappointing [2], the modifications made on base of that experience are promising and a final test done in the framework of the SILVIA project [3] will certainly exhibit better results.

The related standardised measurement methods based on texture and absorption measurements (ISO 13472 and 13473 series) are helpful in the understanding acoustical characteristics, their role in the functional specification of the noise reducing effect however is limited.

# 3. procedure C-road

## 3.1 lay-out

The procedure was named C-road since it provides the correction factor due to the road surface on the noise production of the road vehicle fleet. It consists of the following parts:

1. Determination of the acoustic property of the reference surface by the SPB method;
2. Development of the procedure for assessing $\Delta L$ of a specific road surface type;
3. Testing the procedure on 8 different road surface types;
4. Development of a COP procedure based on the CPX method;
5. Implementation of the system in formal schemes.

## 3.2 reference surface

We performed S.P.B. measurements on a set of 10 road surfaces of type DAC 0/16 on base of the mentioned protocol. (see figure1)

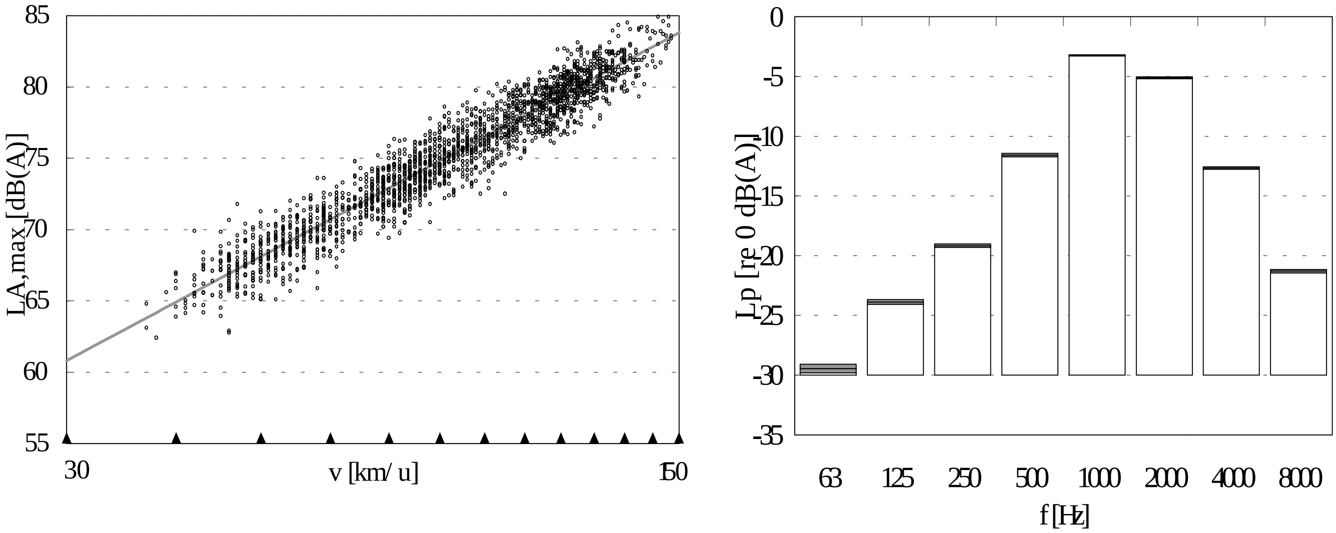


Figure 1: left: SPB data in LAmax as a function of speed for passenger cars composed of more than 2000 pass-by events on 10 different road surfaces, all of DAC 0/16 type. Right: Average octave band spectrum at the reference speed of 80 km/h.

## 3.3 data on 8 surface types

The S.P.B. procedure was repeated on 7 additional surface types, each one represented by about 10 surfaces (see table 1)

| Nr. | type | Grading [mm] |
|---|---|---|
| 1. | Single layer porous asphalt 40 mm thick | 6/16 |
| 2. | Double-layer porous asphalt 70- mm thick | 4/8-11/16 |
| 3. | Split mastic asphalt | 0/6 |
| 4. | Surface dressing on asphalt | 4/8; |
| 5. | Transversely brushed concrete | - |
| 6. | Exposed aggregate concrete | |
| 7. | Concrete with surface dressing | 2/3 |

Table 1: road surface types subjected to the C-road procedure.

De results were brought into relation with the reference surface in order to establish is noise reducing effect. The results are given in figure 2.

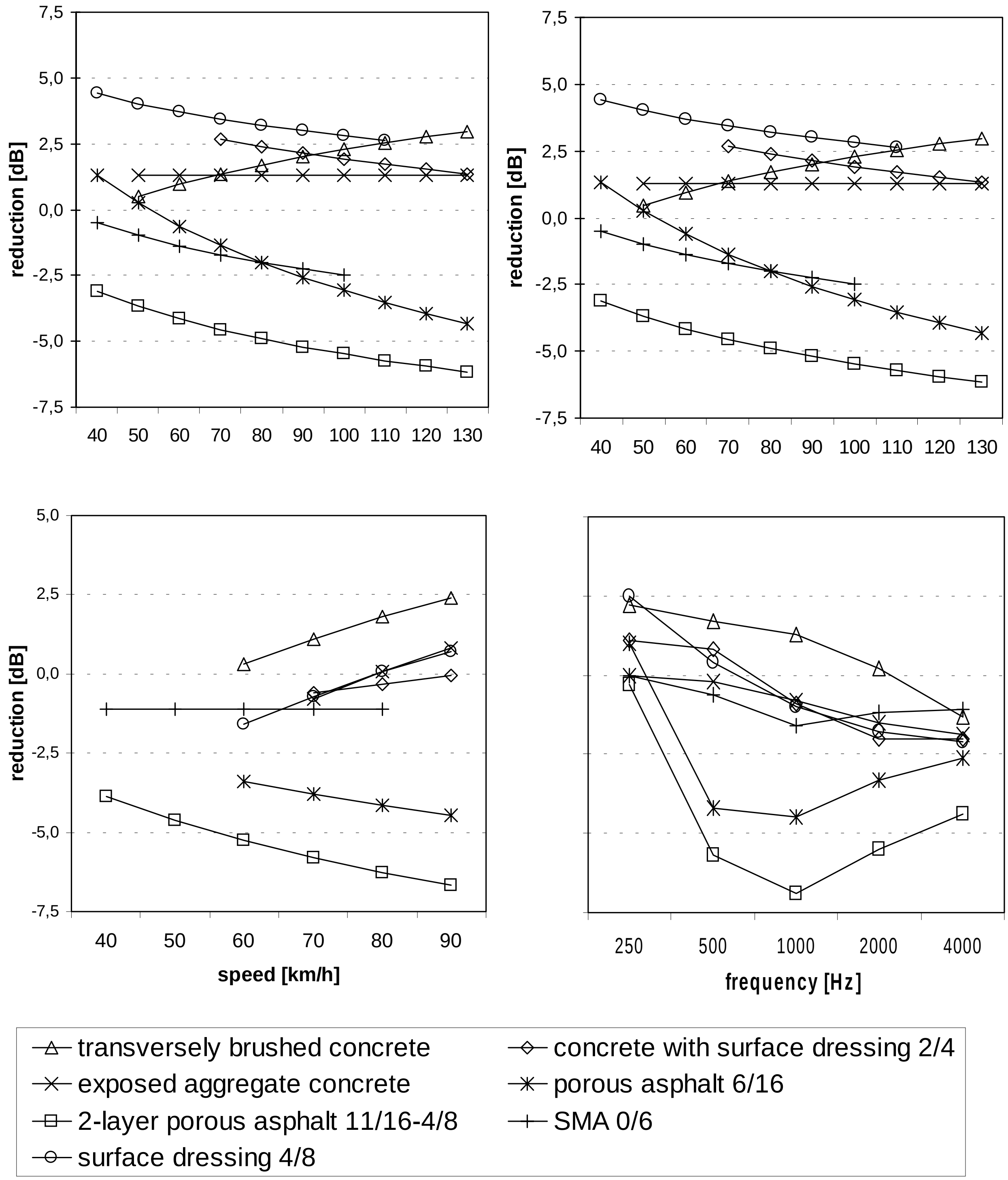


Figure 2: standard noise reduction effect of seven different surface types (minus is reduction, plus is increase relative to DAC 0/16) . Upper part: data for passenger cars, lower part: data for heavy vehicles.

## 3.4 speed range and surface variation

In order to be able to establish and accurate reduction factor, the input data must meet certain reliability criteria. We require a 95% confidence level of the regression line of equal or better than 0.3 dB for passenger cars and 0.5 dB for heavy vehicles. This is in general not a constraint at the center of the scatter diagram, however it limits the extrapolation to higher and lower speeds where data points get scares. The extrapolation of the regression curve is further limited to the average speed plus or mines 2 times the standard deviation.

The data points are to be acquired on 5 different road surfaces, all of the same type, manufactured at different locations, so that the reduction is not influenced too much by a single , very low noise outlier.

### 3.5 conformity of production

Quality assurance procedures, either by road builders or by road authorities require a continuous control product quality. Also the control of the acoustical surface characteristics must not be limited to the situation just after laying, but should be monitored over its technical lifetime. The SPB method does not satisfy this need. This type of measurements can only be done under certain conditions of traffic flow and requires a clear propagation area and reflection free vicinity. Furthermore, it delivers only the property at a specific location.

The CPX method is able to determine rolling noise properties of road surfaces over a certain distance under much less stringent environmental constraints. At the moment we study the technical aspects and possible application of a C.O.P. and monitoring procedure based on the CPX method. Since this procedure will be used for evaluating the acoustical quality of a road surface in relation to the required specifications, large financial consequences are involved, so not only an accurate determination is essential but even more important is a clear and generally accepted insight on the errors inherent are measuring noise.

## 4. Discussion and Conclusions

The method C-road presented here has been operational for about two years and extended experience was gathered with respect to its functioning in practice. The method as such was welcomed by both road authorities and road manufacturers not only as a great step forward in the unambiguous determination of the acoustical characteristics of a road surface but also the direct relation with the official noise calculation scheme has streamlined the assessment of the effect of low noise surfaces on meeting legislative noise limits in nearby living areas.

Traffic noise reducing characteristics are now one of the “selling point” of road surface types and this has resulted in the development of several new low noise surface types. The broad implementation of low noise road surfaces is not only a matter of availability of the technology but also of the availability of a reliable assessment procedure and a direct relation with the official noise calculation scheme. We recommend that the 5th framework project on low noise road surfaces SILVIA (3) develops a scheme along this same line.

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