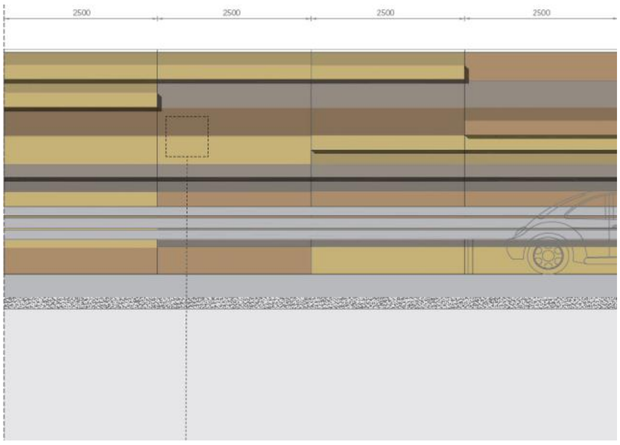
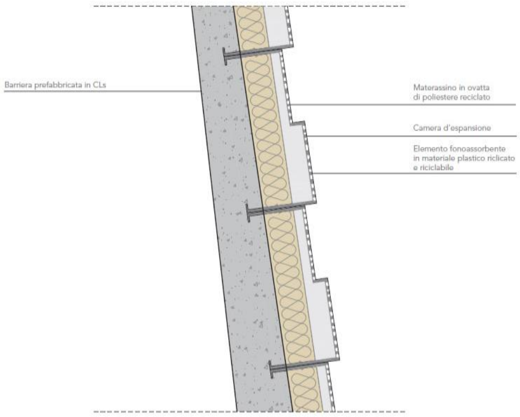
# SCS-9017 Adrienne

# Noise Barrier Acoustic Test

# 1 System features

Testing of noise barriers according to ISO EN 1793, minimum barrier extension 4 x 4 x 3(h) m

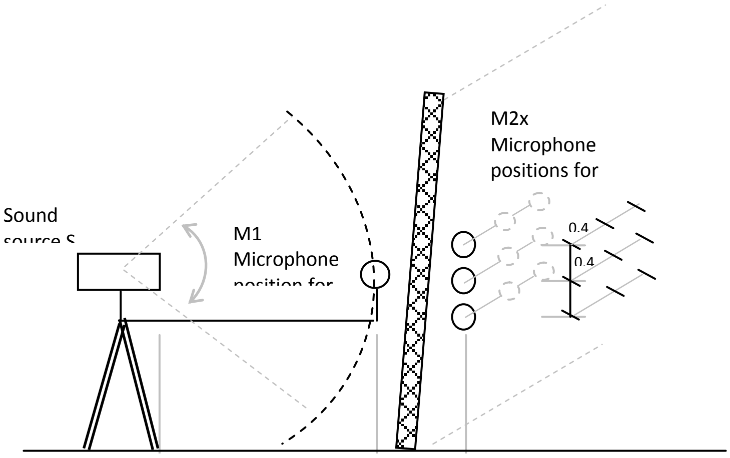



- Standard EN/TS 1793-1: Highway noise barriers acoustic performances
- Standard EN/TS 1793-2: Highway noise barriers acoustic performances
- Standard EN/TS 1793-3: Normalized road noise psectrum
- Standard EN/TS 1793-5: Intrinsical characteristics for in-situ airborne sound reflection and sound insulation
- Determination of Reflection Index $R_i$ in 1/3 octave bands
- Determination of evaluation index $D_{RI}$
- Determination of Sound insulation index $S_i$ in 1/3 octave bands
- Determination of evaluation index $D_{SI}$

# 2 System elements

- Data acquisition system SCDT4 – 4 channels 24 bit-51.2 kHz (max) with MLS generator, software SCS80BA with “Adrienne” weighting.
- ½” microphone cl. 1
- Sound calibrator IEC cl 1
- Sound diffuser *Adrienne* on suitable tripod and microphone holder as for EN/TS 1793-5




## SCS 9017


Software SCS90BA

DAQ SCDT4

Speaker Microphone system

# 3 Measurement setup

- The distance between source and microphone, and between them and the barrier are those indicated in EN/ TS 1793-5. for the reflection index and for the Sound Insulation Index.
- The sample of barrier in the test is normally extended on the horizontal plane, with or without slight curvature, with a typical 4m in height, therefore, it can be considered a lower limit frequency below 200 Hz and a validity of measures from 1/3 octave of 200 Hz.
- Placements and the lengths of the windows Adrienne are those indicated by the EN / TS 1793-5 for Reflection Index, while the Sound Insulation index follows the provisions of the EN / TS 1793-5.
- The sample of barrier in test can have any surface finishing of sound-absorbing surface with or without perforated sheet metal and in reliefs presented in some sections, as shown in the previous figures, the material shall be dry.
- The temperature can be between 0 and 40 degC and the wind speed below 5 m / s.

# 4 Procedures

### 4.1 Reflection Index $R_I$:

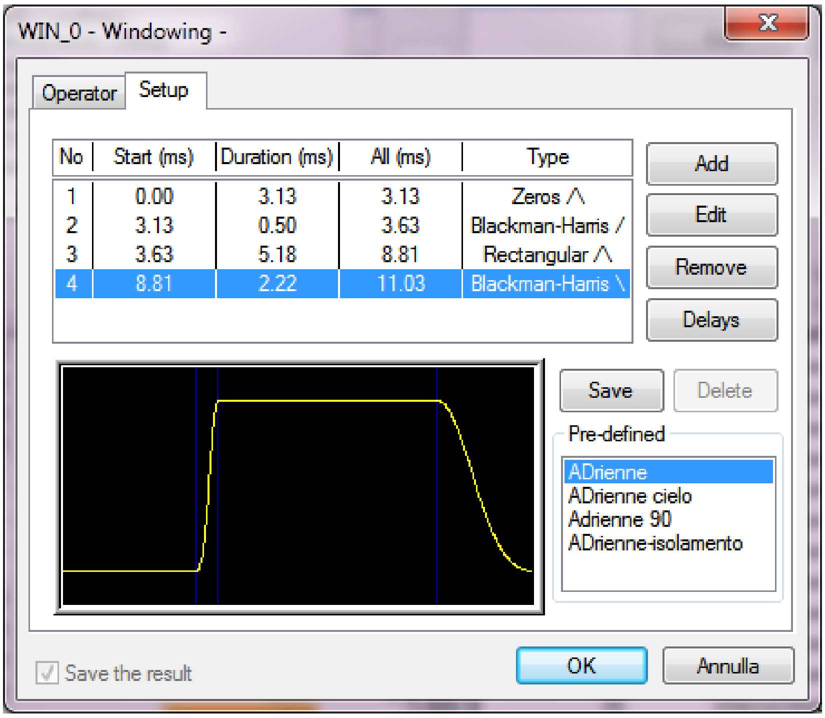
1. Generate a deterministic signal type MLS and acquisition with M1 microphone placed in front of the barrier from the side sound-absorbing, averaged over about 40 seconds - Total $S_{T,d}$ – signal, d=9 measurements taken in different positions corresponding to tilt between 50 and 130 degrees of the whole source-microphone, referred to 90 degrees is meant the horizontal position;
2. Generate a deterministic signal type MLS and acquisition with microphone M1 facing up signal, averaged over about 40 seconds - Signal free field $S_{CL}$;
3. Calculation of the equivalent function of the impulse response signals $S_{T,d}$, $S_{CL}$ acquired;
4. Application of the dialog Adrienne on signals $S_{T,d}$, and $S_{CL}$ parameterized so as to isolate the direct part and the reflected part of the signal transmitted and reflected by the barrier means subtraction method;
5. Determination of $R_I$ by calculating the average of the differences in dB spectra $S_{T,d}$, d in 1/3 octave spectrum than the $S_{CL}$;
6. Determination of evaluation $DL_{RI}$ considering the spectrum of the traffic normalized referred to EN/TS 1793-3

### 4.2 Sound Insulation Index $S_I$:

1. Generate a deterministic signal type MLS and acquisition with microphone M2 place across the barrier, averaged over about 180 seconds - Total $S_{T,t,p}$ signal, p = 9 measurements taken in different positions arranged at 0.4 m distance, a square of 0.8 x 0.8 m wide;
2. Generate a deterministic signal type MLS and acquisition with microphone M2 facing up signal, averaged over about 180 seconds - Signal free field $S_{CL,t}$;
3. Calculation of the equivalent function of the impulse response signals $S_{T,t,p}$ and $S_{CL,t}$ acquired;
4. Application of the dialog Adrienne on signals $S_{T,t,p}$ and $S_{CL,t}$ parameterized so as to isolate the direct part and the transmitted part of the signal transmitted through the body of the barrier, eliminating the phenomena of diffraction;
5. Determination of YES by calculating the average of the differences in dB spectra $S_{T,t,p}$ p in 1/3 octave spectrum compared to the $S_{CL,t}$;
6. Determination of evaluation DLSI considering the spectrum of the traffic normalized referred to EN/TS 1793-3

# 5 Calculation as for EN/TS 1793-5

## 5.1 Operational




- Registration of the detected signals with the microphone for the Reflection Index, placed in the respective angular positions , for a total of 9 angles
- Recording of the signals detected by the microphone oriented towards the free field
- Calculation Impulse Response
- Application of Adrienne window placed upon indications EN/TS 1793-5 , as an example of the figure to the side,for an arbitrary location .
- calculation of the spectra in 1/3 octave on the portions of the signal windowed, respectively: direct and reflected signal from the barrier
- Applying the formula EN/TS 1793-5 (Ref . 4.2) formula 1

$$RI_j = \frac{1}{n_j}\sum_{k=1}^{n_j} \frac{\frac{\int |F[t\cdot h_{r,k}(t)\cdot w_r(t)]|^2 df}{\Delta f_j}}{\frac{\int |F[t\cdot h_i(t)\cdot w_i(t)]|^2 df}{\Delta f_j}}$$

In which *F* represents the Fourier transform calculated for the frequencies of 1/3 octave index *j* ( between 100 Hz and 5 kHz ) of both the direct component $h_i$ weighted for the Adrienne $w_i$ both of the reflected $h_{r,k}$ (to various angles *k* ) weighted with window Adrienne $w_r$ .
The index t ( time ) is common for all variables , whose origin is at the beginning of the impulse response function .

## 5.2 Test signal and acquisition

- The test signal used meets the requirements of EN/TS 1793-5 and is sampled synchronously .
  - The generation of the test signal type MLS is deterministic and exactly repeatable ;
  - The impulses response is sampled accurately ( without distortion ) on the full range of frequencies;
- Frequency to analyse as third octave bands between 100 Hz and 5 kHz
  - Test method presents an immunity to background noise greater than 10 dB over the entire frequency range;

- The sampling frequency is sufficient to allow the accurate correction of possible displacements of the times between the measurements before the test sample and the free field measurement due to temperature variations.

### 5.3 Low Frequency limit due to sample dimensions

- The low frequency limit f*min* of the measurements of the " reflection index" depends on the shape and amplitude of the time window Adrienne that is related to the minimum dimension (height or length) of the acoustic barrier under test ;
- The sound barrier in the test sjal have a minimum size extended horizontally for 4m and 3-4 m in height , so the measurements are valid from the 1/3 octave band 200 Hz.
- The measures to be taken into account for the spatial average are those indicated by the EN/TS 1793 representing the values of the reflection coefficients for different angles of rotation , and that contribute to the calculation of index RI :

### 5.4 Measurement of Sound Insulation Index Si

- The procedure for the calculation for testing sound insulation is similar and still corresponds to the EN/TS 1793-5 , maintaining the same configuration on the side of the speaker - microphone acoustic barrier and placing the 2nd M2 microphone in the other 9 positions side, see figures above .
- The type of signal generated and the acquisition of the same are the same as previously described .
- The shape and positioning of the window of Adrienne as defined by the standard and are entirely similar to the procedure for the Reflection Index.
- The formula for calculating the Sound Insulation Index EN/TS 1793-5 section 5.2 Formula 7 - is as follows :

$$SI_j = -10\lg\left\{\frac{\sum_{k=1}^{n}\int_{\Delta f_j}|F[h_{tk}(t)w_{tk}(t)]|^2 df\left(\frac{d_k}{d_i}\right)^2}{n\cdot\int_{\Delta f_j}|F[h_i(t)w_i(t)]|^2 df}\right\}$$

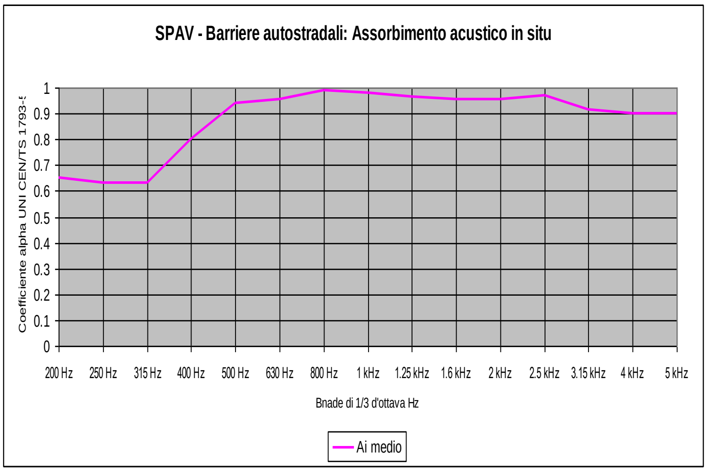
In which *F* represents the Fourier transform calculated for the frequencies of 1/3 octave index *j* ( between 100 Hz and 5 kHz ) of both the direct component *hi* weighted for the dialog Adrienne *wi* both of the transmitted $h_{t\,k}$ ( to various angles *k* ) weighted window Adrienne *wt* .
The index t ( time ) is common for all variables , whose origin is at the beginning of the impulse response function .
The parameters *dI* and *dk* are the correction factors of geometric divergence for the components and direct broadcast respectively

# 6 EN/TS 1793-5 “real case” Example Results

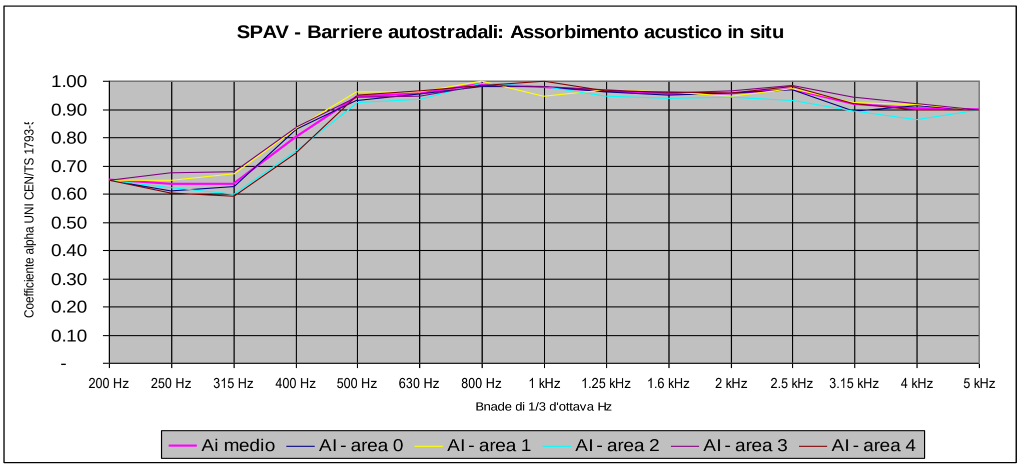
### 6.1 Reflection Index $R_I$:

The barrier had a variable geometry surface with pads about 7cm aiming to improve the aesthetic appearance . These measurements were made with the same sound-absorbing material and the same surface protection in perforated plate .
Whereas, the surface of the barrier, concerning the high sound-absorbing , presented these differences , and in particular were the other flat areas that presented instead from 1 to 4 reliefs , it was decided to carry out 5 independent measurements of many areas along the barrier, to obtain an averaged value of the coefficient of reflection *RI*, reported on the following table and the corresponding value of the absorption coefficient *Ai* on the graph.

| *Freq. Hz* | *Ri averaged on 5 measurements* | *Ai* |
|---|---|---|
| **200 Hz** | 0.35 | 0.65 |
| **250 Hz** | 0.37 | 0.63 |
| **315 Hz** | 0.37 | 0.63 |
| **400 Hz** | 0.20 | 0.80 |
| **500 Hz** | 0.06 | 0.94 |
| **630 Hz** | 0.05 | 0.95 |
| **800 Hz** | 0.01 | 0.99 |
| **1 kHz** | 0.02 | 0.98 |
| **1.25 kHz** | 0.04 | 0.96 |
| **1.6 kHz** | 0.05 | 0.95 |
| **2 kHz** | 0.05 | 0.95 |
| **2.5 kHz** | 0.03 | 0.97 |
| **3.15 kHz** | 0.08 | 0.92 |
| **4 kHz** | 0.10 | 0.90 |
| **5 kHz** | 0.10 | 0.90 |
| **DL Ri** | **11.1** | |




Graph at side reports the 5 Sound absorption measurement results



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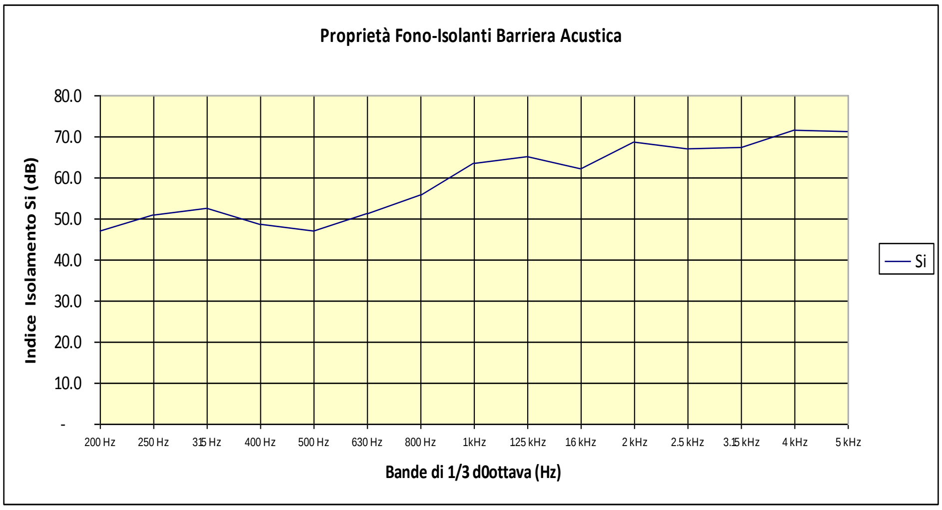
### 6.2 Sound Insulation Index $S_I$:

The barrier in question presented , on the opposite side to the sound absorption surface, a smooth and even surface, therefore was rated the transmission coefficient SI as mean value of two measures , one of them corresponding to which structures built between the joints of the panels of the barrier.
The results are shown in the following table and on the graph .

| *Freq. Hz* | *Si* |
|---|---|
| 200 Hz | 47.2 |
| 250 Hz | 51.0 |
| 315 Hz | 52.6 |
| 400 Hz | 48.8 |
| 500 Hz | 47.2 |
| 630 Hz | 51.2 |
| 800 Hz | 55.7 |
| 1 kHz | 63.7 |
| 1.25 kHz | 65.1 |
| 1.6 kHz | 62.3 |
| 2 kHz | 68.7 |
| 2.5 kHz | 67.2 |
| 3.15 kHz | 67.3 |
| 4 kHz | 71.6 |
| 5 kHz | 71.3 |
| **DL Si** | **58.0** |




# 7 Classification

The absorption characteristics and airborne acoustic insulation in external environment and in a directive sound field in accordance with EN/TS 1793-5, are identified by unique indexes evaluation: Sound Reflection Index $DL_{RI}$ and Sound insulation index, $DL_{SI}$ , calculated between the bands of 200 Hz and 5 kHz.

Unique indexes are calculated on the basis of assessment of the spectrum of noise from road traffic as reported in EN1793-3 and grouped by classes as defined by the EN 1793-2 . This classification is used to define categories of performance barriers according to the following tables .

| Index $DL_{RI}$ (dB) | Categories |
|---|---|
| Not defined | A0 |
| < 4 | A1 |
| From 4 to 7 | A2 |
| From 8 to 11 | A3 |
| > 11 | A4 |

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| Index $DL_{SI}$ (dB) | Categories |
|---|---|
| Not determined | B0 |
| < 15 | B1 |
| From 15 to 24 | B2 |
| > 24 | B3 |

**Tested barriers classification for Sound Absorption performance: CLASS A4**

**Tested barriers classification for Sound Insulation: CLASS B3**