On the Experimental Evaluation of the Performances of Noise Barrier Diffracting Devices

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Summary
In the last decades the performances of diffracting devices to be installed on top of noise barriers have been usually estimated through numerical simulations or laboratory measurements on scale models. The recently issued European Technical Specification CEN/TS 1793-4 is the first standard that gives a methodology to measure the diffracting performances of full scale samples (in laboratory or directly at the installation site). This in situ method allows the qualification of such devices by means of a Maximum Length Sequence (MLS) technique in terms of two purposely defined indexes: $DI$ (Diffraction Index) and $\Delta DI$ (Diffraction Index Difference). A free field test facility was realized for this purpose at the Acoustic Laboratory of the University of Perugia. Several tests on different caps were carried out to set up the measurement methodology and to assess its accuracy. Results show that the experimental facilities and the measuring methodology are both efficient and reliable, though particular attention has to be paid to geometrical correction and to time windowing. Furthermore, the installation of this kind of devices can sometimes worsen the noise reduction performances in comparison with the simple noise barrier, due to the choice of materials of the cap and to the geometry of the element itself. The paper is completed by a review of the results obtained by other authors through numerical simulations and experimental measurements on diffracting devices.

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1. Introduction

Noise barriers are the most widely spread road traffic noise reducing devices, as they represent in most cases the only economically-feasible solution. Among the various non-acoustical criteria guiding the choice of a noise barrier (e.g. cost, safety, durability, structural strength, weight, fire-resistance etc.), the visual intrusion of such devices has progressively gained more and more importance, both for road users and for receivers. Provided that sound attenuation is not worsened, a reduction in the barrier height is therefore always welcomed, not just from an economical point of view.

The use of diffracting devices to be installed on the top of noise barriers is therefore becoming more and more widespread, since such devices allow to limit barrier height and at the same time to decrease the diffracted sound in the shadow zone. The design of these devices is however not supported enough by experimental results and theoretical analyses. A European technical specification (CEN/TS 1793-4) was recently issued to evaluate the intrinsic characteristics of diffracting devices; the standard describes a measurement method based on the Maximum Length Sequence technique. This method allows the qualification of a device in terms of two purposely defined indexes: $DI$ (Diffraction Index) and $\Delta DI$ (Diffraction Index Difference).

The paper illustrates the measurement procedures and the related problems for diffracting devices. An experimental test facility has been recently designed and employed for intrinsic characterisations of noise barriers samples [1] at the Acoustics Lab of the University of Perugia. Data analysis has been performed in order to evaluate the acoustical performance of different caps.

2. Literature review

Great effort has been dedicated in the last decades to improve the attenuation performance of noise barriers, without increasing the height but just modifying the top barrier profiles. In 1980, May and Osman [2] investigated new barrier shapes by means of full-scale and scale model insertion loss testing: in particular, they observed the highest attenuation for T-profile, relatively wide, absorptive top barriers.

In the same year, Sezneec [3] suggested to use the boundary element method (BEM) for numerical predictions of
the diffracted sound field behind a barrier. The BEM approach allows to make comparative studies in a relatively short time: for these reasons, it has been extensively employed to predict the performance of different barrier shapes almost always in terms of Insertion Loss variations.

Some examples are now briefly reported. The simulation results obtained by Alfredson and Du [4] show that T-shaped and Y-shaped elements give the highest Insertion Loss increases (on average an increase of 4 dB over the reference configuration of a barrier of the same height without added device).

Furthermore, the installation of absorptive material (rock wool) on the samples surfaces also improves the global efficiency, because it reduces the sound pressure on the edge, causing a decrease in the diffracted field behind the barrier. For the same design, the absorptive surface produces approximately a 2.5 dB increase in IL over the rigid surface.

The cylindrical design has the worst overall performance: when the surface is reflective, this configuration is even worse than the reference configuration without added device.

Analogous results can be found in [5]. Ishizuka and Fujisawa used a 2-D BEM model to test several typologies of diffracting caps with three surface conditions:

- rigid surface: the normalized surface admittance was set to 0;
- absorptive surface: the surface pressure is equal to the incident pressure; the normalized surface admittance was set to 1;
- soft surface: the normalized surface admittance was set to 1×10E6.

Once again the soft and the absorptive elements give the best results, particularly with a T or in a double-cylindrical configuration. The cylindrical cap appears to be the least performing, especially when a rigid surface is present: this configuration provides a 0.5 dB decrease in IL over the reference 3 m high plain barrier.

Other noteworthy discussions on this argument can also be found in [6, 7, 8, 9, 10, 11, 12, 13]; by means of BEM simulations, all these studies have demonstrated that the T-profile and Y-profile top barriers provide the highest insertion loss improvement. Cylindrical, pear-shape and curved top barriers have shown lower benefits, unless an absorptive treatment was incorporated into the barrier tops.

More recently, attempts have been made to determine, both numerically and experimentally through full scale measurements, the intrinsic efficiency of noise barrier caps or, that is equivalent, the achievable improvement in sound attenuation due to the added device.

Watts and Morgan tested three diffracting devices (T-shape, multiple edge and rounded hollow caps) by means of a cross-correlation technique using a MLS signal [14]. In this case the Insertion Loss is given by

\[ IL(f) = -10 \log \left( \frac{\left| H_b(f) \right|}{H(f)} \right)^2, \]  

where \( H_b \) is the frequency response of the diffracted component impulse response, \( H \) is the frequency response of the free-field impulse response, and \( d_b \) and \( d_f \) are the lengths of the shortest direct path through the barrier and the path length used for the free-field measurements, respectively (see Figure 1); moreover the single number rating of diffraction efficiency SNRD is given by

\[ SNRD = -10 \log \left( \frac{\sum t_{fL} 10^{L_i/10} 10^{-1L_f/10}}{\sum t_{fL} 10^{L_i/10}} \right). \]  

where \( L_i \) is the normalised A-weighted sound pressure level of traffic noise in third-octave frequency bands. The results in terms of SNRD for the tested samples are reported in Table I.

It can be seen that the order of overall performance reflects the results given by the previous numerical simulations i.e., the absorptive T-shape and multiple-edge options show relatively good performance while the rounded cap and plane barriers have poor performance. The reflective T-shape shows an intermediate performance. At last, Demirizous et al. employed the measurement procedures prescribed by the European Technical Specification CEN/TS 1793-4 on a T-shaped diffracting device, with and without an absorptive top surface [15]. In the case of the reflecting T-shaped added device the single number rating \( DL_{ADT} \) is 3.5 dB, while the absorptive top brings an increase of \( DL_{ADT} \) of 1 dB.

3. Measurement procedure

An impulse-response method was chosen to evaluate the diffracted sound attenuation performed by the barrier caps. It essentially consists in determining the system impulse response \( h \) by means of a cross-correlation technique, employing a maximum-length signal with and without the test specimen mounted over the barrier.

The method, recently prescribed by the European Technical Specification CEN/TS 1793-4 [16], defines a diffraction index \( DI \) to quantify in dB the top-edge attenuation.
Table 1. Single number rating of diffraction efficiency of added devices tested by Watts et al. [14].

<table>
<thead>
<tr>
<th>Geometry</th>
<th>Single number rating of Insertion Loss [dB(A)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Speaker pos.</td>
</tr>
<tr>
<td>0.11</td>
<td>0.00</td>
</tr>
<tr>
<td>0.11</td>
<td>0.05</td>
</tr>
<tr>
<td>0.11</td>
<td>0.15</td>
</tr>
<tr>
<td>0.11</td>
<td>0.30</td>
</tr>
<tr>
<td>0.36</td>
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</tr>
<tr>
<td>0.36</td>
<td>0.05</td>
</tr>
<tr>
<td>0.36</td>
<td>0.15</td>
</tr>
<tr>
<td>0.36</td>
<td>0.30</td>
</tr>
<tr>
<td>Average</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Source and microphone positions required by [16] (1 – reference plane; 2 – added device).

The performance in terms of the ratio of diffracted and incident sound intensities \( I \), in the third-octave bands between 100 and 5000 Hz:

\[
Df = -10 \log \left( \frac{\sum_{k=1}^{n} \int_{\Delta f} F(h_{dk}(i)w_{dk}(i)) \frac{d(f/dk)^2}{n \int_{\Delta f} F(h_{i}(i)w_{i}(i)) \frac{d(f/dk)^2}} \right),
\]

where the suffixes \( d \) and \( i \) stand respectively for the diffracted and incident components, \( F \) indicates the Fourier transform and \( \Delta f \) is the bandwidth. System impulse responses \( h_{dk} \) and \( h_i \) have to be respectively recorded, according to [16], in several source-microphone positions around the noise reducing device (at least \( n = 8 \), see Figure 2) and in a reference free-field position (being the ground the only reflective surface in the surroundings).

Measurements have to be performed at two angles of incidence: one at normal (\( \theta = 90^\circ \), free-field reference positions: S1-M2) and another at oblique (\( \theta = 45^\circ \), free-field reference positions: S4-M8) incidence with respect to the barrier surface.

The time windowing procedure in equation (3) (through a purposely defined “Adrienne” window \( w \) [16], see Figure 3) is needed to isolate the “useful” components from the “parasitic” ones (e.g. the top-edge diffracted response from the side-edge one). A geometrical wave spreading correction (through the factors \( d \), based on a spherical spreading assumption [17]) has to be performed in order...
to take into account the different path lengths from the source to the measurement points. Indeed, the impulse response amplitude is inevitably dependent on the source-microphone distance.

Measurements of the diffraction index have to be carried out in sequence with and without the test specimen installed upon the barrier and positioning the source and the microphone in order to keep unchanged their relative height with respect to the top edge. These two sessions lead respectively to evaluate the indexes $D_{Irad}$ and $D_{I0}$; their difference, which is called Diffraction Index Difference, indicates the improvement of performance achieved by installing the added device under test,

$$\Delta DI = D_{Irad} - D_{I0}. \quad (4)$$

The overall performance of the device under test with respect to road traffic noise can finally be evaluated (in dB) by a single-number rating, weighting the diffraction index calculated in third-octave bands with the normalized traffic noise spectrum $L_i$ defined in EN 1793-3 [18],

$$DL_{\Delta DI} = -10 \log \left[ \frac{\sum_{j=1}^{18} 10^{0.1L_i} 10^{-0.1\Delta DI_j}}{\sum_{j=1}^{18} 10^{0.1L_i}} \right]. \quad (5)$$

The European Technical Specification CEN/TS 1793-4, as well as CEN/TS 1793-5 [19] (a detailed analysis can be found in [17]), has several bright sides. It simulates the actual operating conditions of traffic noise barriers (slightly oblique incident sound fields) and has an excellent background noise immunity (measurement can be performed in the presence of vehicular traffic). It can also be used to verify the long-term performance of added devices by repeating the measurements in different time intervals. On the other hand, some drawbacks should be considered.

One main problem is that executing this kind of measurement is not easy, especially because of the need of positioning the source and the microphone near to the top edge of the samples under test (see Figure 4); indeed placing the equipment (in particular the source, because of its weight) at such heights is difficult and can even be dangerous for the persons in charge of the measurement.

Other problems of this technique are due to the complex signal analysis post-processing procedures and to the fact that the measured diffracting performance highly depends on the characteristics of the noise barrier on which the sample is placed (test construction), as can be seen from equation (4). As an example, the same added device has different measured performances if installed on different test construction: indeed, it shows worse performances if the test construction has a thick top edge (because it has itself intrinsic diffracting properties), while better results are obtained when it is installed on a thin screen. For this reason the so measured value of $\Delta DI$ is called $\Delta DI_{situ}$, since it can be applied only for that specific configuration.

The Technical Specification CEN/TS 1793-4 prescribes two normalized reference test constructions to obtain absolute results: a reflective wall and an absorptive one. Each wall must have a minimum length of 10 m and a minimum height of 4 m. It is easy to understand that the construction of these reference walls requires a lot of available free ground and also a fairly high expense of money.

Finally, some correction has to be made to the CEN/TS 1793-4 specification in order to make it more simple and comprehensive.

4. Measurement set-up and post-processing

4.1. Test field and test construction

In the framework of an agreement between the University of Perugia and the Italian Ministry for the Environment, an experimental outdoor test facility has been built at the Acoustics Laboratory of the University of Perugia to determine the in-situ intrinsic acoustic performance (reflection, insulation, diffraction) of prototypes and samples of noise barriers and additional devices [1].

A reinforced concrete basement has been designed to sustain a 4 m-high barrier with a bending stress equal to 1100 Pa; it is possible to install 6 m-long samples. The test facility has been built in an open place, in order to avoid any parasitic reflection apart from that of the ground.

As test construction, a thick lightweight concrete barrier (6 m in length and 4.1 m in height) has been mounted in the mentioned test field, having a caskets absorptive surface (thickness range: 110–210 mm) at the source side and a plane reflective one at the receiver side (see Figure 5). The absorptive elements have been coated by fibrous layers (thickness: 80 mm) and covered by profiled perforated steel sheets.

Different solutions were employed to install the added devices under test on the top edge of the noise barrier.

4.2. Measurement instrumentation

A two-channel PC card front-end (01dB-Metrawatt model Symphonie) has been used to generate the MLS signal (clock frequency: 51200 Hz, order 16, 32 averages),
drive the source (two-way coaxial speaker, Bouyer model CP2050), record the microphone signal (sampling frequency: 51200 Hz, passband: 20000 Hz, 1/6" free-field condenser microphone G.R.A.S. model 40AR) and finally perform the input-output cross-correlation procedure in order to determine the system impulse response.

Post-processing of the responses has been carried out by means of a code and a graphical user interface (GUI), developed on purpose (Mathworks Matlab release 13) to control all the numerical operations needed to get the final results: construction and positioning of the time windows, power spectra calculation, wave spreading corrections, graphical output.

5. Measurement accuracy

A flow chart of the CEN/TS 1793-4 procedure is reported in Figure 6. As for CEN/TS 1793-5, this in situ method uses a pseudo-random deterministic signal, called Maximum Length Sequences (MLS), to reconstruct the impulse response of a system with high background noise immunity.

Three different impulse responses have to be recorded:
- impulse response of the "measurement chain + barrier + diffusing device" system in different points,
- impulse response of the "measurement chain + barrier" system in different points,
- impulse response of the "measurement chain" system.
The first two are called "overall" responses, while the latter "free-field" response. The so called "free-field" measurement has to be carried out placing the loudspeaker and the microphone without any obstacle, including the test construction with or without added device, between them. The overall impulse responses provide information on diffracted responses, while the free-field ones allow the extraction of the incident responses. The Diffraction Indexes $D_{I0}$ and $D_{IA}$ are calculated as ratios of power spectra for the two configurations (with and without added device, see equation 3); finally the diffraction index difference $\Delta D_I$ and the single number rating $D_{IA}$ can be obtained (see equations 4 and 5).

The procedures that mainly influence the results provided by the in situ methods are the correction for sound wave spreading and the time windowing [17]. Nonetheless, as stated in section 3, the major source of error can be found not in the calculation procedures but in the equipment positioning. Indeed, the microphone and the source have to be placed close to the top edge of the sample under test (usually 3-4 m high): for this reason the required uncertainties for measuring the distances between the measurement positions and the sample (not greater than 1% of their nominal value [16]) can hardly ever be achieved. Therefore a good repeatability can only be achieved if a stable bearing for the instrumentation is used.

A correction for wave spreading has to be performed, as the sound intensity decreases with the distance $d_{SM}$ of the receiver from the source. According to the definitions given in CEN/TS 1793 parts 4 and 5, sound wave propagation from the source is assumed to be spherical. Two different wave spreading correction methods are adopted: for Reflection Index RI [19] in the time domain through multiplication of the impulse responses by the time, while for $SI$ [19] and $DI$ [16] in the frequency domain by means of a multiplication of the power spectra by the squared path lengths ("geometrical" correction). In order to analyze the relevance of the spherical propagation assumption in the time domain, free-field impulse responses have been recorded at several distances between source and microphone (sampling frequency: 51200 Hz, MLS order: 16, averages: 8). In Figure 7a the absolute amplitudes of the first peaks are correlated to their corresponding arrival times: $t_{Sample}$ stands here for the time instant calculated multiplying the first peak sample number by the sampling frequency. This "recorded" time does not coincide with the "physical" one estimated from the sound speed and the measured distance, as evident from Figure 7b.

Indeed, the measurement chain, as noticed in [20], introduces a delay corresponding to a characteristic distance, that can be evaluated by correlating the measured distance $d_{SM}$ and the one equivalent $(d_{peak})$ to the first peak arrival time. Such distance is called "source characteristic distance" (SCD) [20] and it can be estimated $(R_2 = 0.999975)$ around 0.175 m for the chosen measurement chain (see y-intercept in Figure 7b). The recorded time $t_{Sample}$ can then be corrected by means of the linear function:

$$t_{corr} = t_{Sample} - \frac{SCD \cdot c}{p}$$

(6)

where $p$ indicates the regression slope and $c$ the sound speed. This way the first peak amplitude becomes inversely proportional to the corrected time $(R_2 = 0.9977)$. 

Figure 5. Concrete noise barrier employed as the test construction. View of the absorptive panels from the source side.

Figure 7. Effect of the source-microphone distance on the free-field impulse responses: a) first peak amplitude vs. arrival time, b) first peak equivalent distance vs. measured distance.
Unlike Reflection Index and, above all, Sound Insulation Index [17], Diffraction Index calculation is not strongly influenced by this operation. Moreover, by means of the purposely developed software (see section 4), the length and the start position of the time window has been calculated individually for each impulse response taking into account the geometrical paths of the sound waves: in this way it is possible to correctly isolate the useful components (see Figure 3) and to improve the quality of the results. However, time window length directly influences the low-frequency limit of the results (shorter time window means higher low-frequency limit): for this reason too short windows have to be avoided.

Finally the method appears to be very reliable, but great attention must be paid to the instrumentation positioning in order to achieve a good repeatability of the results.

6. Experimental results

Three prototypes of barrier caps (see Figure 9) have been placed upon the barrier and tested according to the measurement procedure detailed in section 3, based upon CEN/TS 1793-4 [16]:

1. A half arch profile cap, made of steel sheet and coated by a 40 mm layer of polyurethane foam on its bottom surface (test code R). This sample was tested twice, modifying its surface impedance by covering also the upper surface with the abovementioned layer of foam (test code A) (see also [1]);
2. A fork-like profile cap, made of three rows of perforated metallic panels (the angle between them is 45°) filled with rock wool layers (thickness 60 mm, density 90 kg/m3) (test code F);
3. An octagonal profile cap, made of an exterior perforated sheet steel with octagonal section and a inner sheet steel with circular section; the gap is filled with rock wool (thickness 90 mm, density 90 kg/m3) (test code O).

The constructive schemes of the caps can be seen in Figures 10–12.

Figure 13 shows the diffraction index difference data obtained through the measurement procedure prescribed by [16] for the four tested samples.

It is worth noting that, considering the length of the employed test construction and, consequently, of the specimen under test (6 m), the time window width has inevitably to be shorter than that prescribed in [16] (6.5 ms vs. 10.5 ms), in order to get rid of the parasitic reflections; a low-frequency band limit of 250 Hz has then been estimated for the following results.

It is apparent that the half arch profile cap with the reflecting top surface (test R) shows a rather poor intrinsic diffraction performance, at least with respect to that of a relatively thick noise barrier: negative values of the Diffraction Index Difference mean indeed that the barrier without added devices shows better performances than the one with the added devices (see equation 4). Furthermore it can be supposed that its shape, and generally all curved rigid surfaces, may have the effect of “guiding” the sound.
waves in the so-called shadow zone. Such results for a curved shape added device are not totally surprising, be

Figure 9. Tested barrier caps.

Figure 10. Section views of the test sample R.

Figure 11. Section views of the test sample F.

Figure 12. Section views of the test sample C.

Figure 13. Difference of Diffraction Index DDI and single number rating DLDDI of the tested samples.

The effect of modifying the top surface impedance of the barrier cap can even be investigated from a "local" point of view: indeed, the diffraction index difference and the corresponding single-number rating can be evaluated for each measurement point, through equations (4) and (5). In Table III and Figure 14, results obtained at normal (S1M1 - S1M4) and at oblique incidence (S4M7 - S4M10) are reported for tests R and A. It can be seen that,
Table III. Diffraction Index Difference of the single measurement points for test samples R and A.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>S1</th>
<th>M1</th>
<th>S1 M2</th>
<th>S1 M3</th>
<th>S1 M4</th>
<th>S1 M5</th>
<th>S1 M6</th>
<th>S1 M7</th>
<th>S1 M8</th>
<th>S1 M9</th>
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<td>0.08</td>
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<td>6.17</td>
<td>6.50</td>
<td></td>
</tr>
</tbody>
</table>

Table II. Mandatory source and microphone positions and relative heights with respect to the top edge reference height [16] (see Figure 3).

<table>
<thead>
<tr>
<th>Code (source)</th>
<th>Height [m]</th>
<th>Code (microphone)</th>
<th>Height [m]</th>
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<tbody>
<tr>
<td>S1 (source)</td>
<td>0.50</td>
<td>S4 (source)</td>
<td>0.50</td>
</tr>
<tr>
<td>M1 (micro.)</td>
<td>0.75</td>
<td>M7 (micro.)</td>
<td>0.75</td>
</tr>
<tr>
<td>M2 (micro.)</td>
<td>0.50</td>
<td>M8 (micro.)</td>
<td>0.50</td>
</tr>
<tr>
<td>M3 (micro.)</td>
<td>0.00</td>
<td>M9 (micro.)</td>
<td>0.00</td>
</tr>
<tr>
<td>M4 (micro.)</td>
<td>0.25</td>
<td>M10 (micro.)</td>
<td>0.25</td>
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</table>

Figure 14. Effect of an absorptive surface on the single-number ratings for single source-microphone positions.

both for normal and oblique incidence, the attenuation performances of caps with the profile under test decrease going from the transition to the shadow zone of the noise barrier with respect to a relatively thick plane top-edge. The addition of an absorptive layer does not change the observed trend, while it is able to provide significant improvements, in particular at oblique incidence (mean difference between test A and R: 2.5 dB), exceeding the performance of the reference test construction, at least above the top-edge level.

The octagonal added device (test O) shows fluctuating values of ΔDI: the best performances are achieved between 800 and 2000 Hz and above 2500 Hz. Such low values are mainly due to the dimensions of the sample: the maximum width of sample H is close to the width of the test construction, while normally this kind of devices are much wider than the barrier they are installed on.

The fork-like sample (test F) has the highest intrinsic diffracting performances, showing positive values of ΔDI in the whole investigated frequency range. This result was expected, because of the large dimensions (see Figure 11) and of the complex shape of the sample: in this way the incident sound waves pass several times through the cap structure and can be absorbed by the absorptive material. Nonetheless better performances could have been achieved if the panels were not perforated on the receiver side; moreover, the diffracting performances of this sample have been reduced by the presence of gaps between the cap and the top-edge of the concrete noise barrier due to non-perfect mounting conditions (see Figure 15).

The single number index DL-ΔDI is negative for test R, is equal to 0 dB for test A and O, although they present a satisfying performance in mid-high frequencies, and is only 2 dB for test F (see Figure 13). It is clear that such index is of scarce significance, since diffraction measurements are highly influenced by the spatial configuration and the range of frequencies considered.

Furthermore the measured value of Diffraction Index of an added device highly depends on the characteristics of the top edge of the test construction, as stated in section 3. In this case the noise barrier has a remarkable thickness that leads to lower values of ΔDI than those achievable if the same added device were installed on thinner screens.

7. Conclusions

The study and optimization of the diffracting performances of caps and devices to be installed at the top of noise barriers is a topic of increasing scientific and technical interest. These devices are becoming more and more common even though their design is not supported enough by experimental results and theoretical analyses.
The recently issued European Technical Specification CEN/TS 1793-4 is the first standard that gives a methodology to measure the diffracting performances of full scale samples (in laboratory or directly at the installation site); to this extent, an experimental free-field test facility was realized at the Acoustics Laboratory of the University of Perugia, within an agreement with the Italian Ministry for the Environment. Measurements were carried out on four different diffracting caps samples.

The single number index $DL_{API}$ is negative for sample R, is equal to 0 dB for sample A and O, (although these samples show satisfying performances in mid-high frequencies), and is only 2 dB for sample F.

The results show that the methodology is accurate and reliable, even though the characterization of diffracting caps can not leave out of consideration a spatial analysis of the sound field; a detailed frequency analysis is also important, especially considering that the values of the single number index suggested by the CEN/TS (Diffraction Index $DI$) can be misleading.

The geometry and the absorbing properties of the caps appear to be the fundamental parameters influencing the phenomenon, since it can even happen that the installation of this kind of devices worsens the noise reduction performances in comparison with the simple noise barrier.

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References


On the Source Terms in Lilley’s Equation

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Unfortunately, the right hand side of equation (46) has been omitted. The corrected equation should read

$$\frac{\partial}{\partial x} \left( \frac{\rho^{1/\gamma}}{\rho} \right) = 0. \quad (46)$$

There are three further corrections:

1. On page 266, two lines above equation (12), the formula could be misunderstood and should read:

$$\rho_f = \rho + (y - 1)\rho w^2/2.$$  

2. On page 267, two lines before equation (21), it should read “in equation (7) with” instead of “in equation (6), with”.

3. On page 272, in the fifth and sixth line after equation (54), the text should read “... two main terms, one identified by Landahl...” instead of “... two main terms identified by Landahl...”

We kindly ask our readers to take note of this. S. Hirzel Verlag

Congress Reports and Announcements

10th School on Acousto-Optics and Applications in Sopot, 
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Following nearly 30-year tradition of Springs Schools, it is our great pleasure to invite you to participate in the 10th School on Acousto-Optics and Applications which will be held in Sopot, Poland, from 12th of May till 15th of May, 2008.

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- acousto-optic devices and their applications in light modulation and deflection, signal processing, ultrasonic imaging and tomography
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Registration starts: June 1, 2007
Deadline for abstract submission: January 31, 2008

Prof. Dr. hab. Bogumil B. J. Linde,
The Head of the Institute, University of Gdansk, Institute of Experimental Physics, ul. Wita Stwosza 57, 80-952 Gdansk, Poland


Leba which is a place of great resort, belongs to the most beautiful spots at the Baltic Sea. It is situated on the edges of the Slowinski National Park which boasts wide and sandy beaches as well as lakes in the vicinity of forests and unique shifting dunes. It is situated 80 km away from Gdansk. Leba and its environs offer many interesting places: remnants of Old Leba destroyed by elements of nature, meteorological station examining stratosphere, fishery harbour, stud, lighthouse in Stilo.

Symposium Organizers:
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Under the auspices of the European Acoustics Association, the Acoustics Committee of the Polish Academy of Sciences and the Polish Acoustical Society.

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26 papers were delivered and there were 5 keynote lectures:
- Carlos Ranz Guerra - Very shallow waters; a brief review of some acoustic based methods to explore the environment. Instituto de Acustica – CSIC, Spain
- Eddy Lund - Modern hydro acoustic implementation and use of wide band-width technology. Kongsberg Maritime AS, Norway
- M. Taroudakis - Inversion techniques for ocean acoustic tomography and bottom classification based on normal mode theory. University of Crete, Greece
- A. Orłowski - Acoustic transects as classification units of the bentic habitat. Sea Fisheries Institute, Poland
- M. Moszyński - On statistical linear inverse problems in fishery acoustics. Gdansk University of Technology, Poland

All accepted papers had been published in the periodical “Hydroacoustics” Vol. 10. The abstracts will be available on the web site http://www.hydro.eti.pg.gda.pl/pl/pta.