Hans G. Jonasson

Acoustical Rating and Classification of Office Screens
Nordtest, project 809-89

SP
Swedish National Testing and Research Institute
Physics and Electrotechnics
SP REPORT 1991:33
Abstract

Acoustical rating and classification of office screens

The aim of this project has been to propose a Nordtest method, easily understandable for ordinary buyers of office equipment, to rate and classify the acoustical properties of screens to be used in open plan offices.

Different rating systems are discussed and examples are given. The final proposal is to rate and measure the screen sound attenuation according to the international standard ISO/DIS 10053. The sound absorption is proposed to be rated and classified according to the Swedish Standards SS 025259 and SS 025260 respectively.

As to the classification of the screen sound attenuation it is proposed to have 5 different classes: A+, A, B, C and D. The class is determined from measurements of the weighted screen sound attenuation. Typical screen heights of screens without significant sound transmission and leakage are for the 4 classes A+, A, B and C 2,2 m, 1,8 m, 1,5 m, and 1,2 m respectively. The different screen sound attenuation classes match the corresponding ceiling sound absorption classes. If the ceiling height is 3,0 m the screen sound attenuation will be 1-4 dB higher than the distance-absorption attenuation of the ceiling reflection.

Key words: Office screens, sound attenuation, sound absorption, rating, classification

SP
SP RAPPORT 1991:33
ISBN 91-7848-286-0
ISSN 0284-5172
Borås 1991

Swedish National Testing and Research Institute
SP REPORT 1991:33

Postal address:
Box 857, S-501 15 BORÅS, Sweden
Telephone +46 33 16 50 00
Telex 36252 Testing S
Telefax +46 33 13 35 02
Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>2</td>
</tr>
<tr>
<td>Contents</td>
<td>3</td>
</tr>
<tr>
<td>Preface</td>
<td>4</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>5</td>
</tr>
<tr>
<td>1.1 Background</td>
<td>5</td>
</tr>
<tr>
<td>1.2 Aim</td>
<td>6</td>
</tr>
<tr>
<td>1.3 Carrying out</td>
<td>6</td>
</tr>
<tr>
<td>2 Considerations</td>
<td>7</td>
</tr>
<tr>
<td>2.1 General</td>
<td>7</td>
</tr>
<tr>
<td>2.2 Arithmetic mean value</td>
<td>7</td>
</tr>
<tr>
<td>2.3 Weighted screen sound attenuation</td>
<td>7</td>
</tr>
<tr>
<td>2.4 A-weighted screen sound attenuation</td>
<td>8</td>
</tr>
<tr>
<td>2.5 Loudness screen sound attenuation</td>
<td>9</td>
</tr>
<tr>
<td>2.6 Ceiling related single number</td>
<td>9</td>
</tr>
<tr>
<td>3 Some calculated examples</td>
<td>10</td>
</tr>
<tr>
<td>3.1 Examples of screens</td>
<td>10</td>
</tr>
<tr>
<td>3.2 Calculated examples</td>
<td>12</td>
</tr>
<tr>
<td>3.3 Examples of ceilings</td>
<td>13</td>
</tr>
<tr>
<td>4 What to do with single numbers</td>
<td>14</td>
</tr>
<tr>
<td>4.1 Equivalent screen height</td>
<td>14</td>
</tr>
<tr>
<td>4.2 Sound absorption</td>
<td>15</td>
</tr>
<tr>
<td>4.3 Final considerations</td>
<td>16</td>
</tr>
<tr>
<td>5 References</td>
<td>17</td>
</tr>
<tr>
<td>6 Proposal for Nordtest method</td>
<td>19</td>
</tr>
</tbody>
</table>
Preface

This project has been financed by Nordtest, project 809-89. The project has been carried through by a project group consisting of

Hans G. Jonasson, project leader
Swedish National Testing and Research Institute, S-501 15 Borås, Sweden

Henrik Olesen
Danish Technological Institute, DK- 8000 Århus, Denmark

Asbjörn Ustad
DELAB, N-7034 Trondheim - NTH, Norway

Seppo Uosukainen
Technical Research Centre of Finland, SF-021 50 Esbo, Finland

Thank you for the support and the fruitful discussions!

Hans Jonasson
1 Introduction

1.1 Background

Screens to be used in open plan offices are acoustically characterized by their screen sound attenuation and sound absorption.

The screen sound attenuation is measured according to NT ACOU 036, [1], or ISO/DIS 10053, [2]. Technically the two methods are identical. The sound absorption is determined according to NT ACOU 032,[3], which can be regarded as a supplement to ISO 354,[4].

![Diagram](image)

Figure 1.1. Test set up according to ISO/DIS 10053.

The screen sound attenuation $\Delta L_{s}$ is measured with the set-up shown in Figure 1.1. It is evaluated from

$$\Delta L_{s} = L_{p0} - L_{p} - 20 \lg (R/r) \quad (1.1)$$

where

$L_{p}$ = sound pressure level at the standardized microphone position,
$L_{p0}$ = sound pressure level at the reference position with the screen absent,
$R$ = distance between source and standard position = 3.0 m + screen thickness
$r$ = distance between source and reference position.

NT ACOU 036 and ISO/DIS 10053 have different single number ratings. Both standards measure the screen sound attenuation $\Delta L_{s}$ in exactly the same way. The measurements are carried out in octave band within the range 125 Hz - 4000 Hz. The Nordtest method uses the arithmetic average of $\Delta L_{s}$ for its single number rating. ISO, on the other hand, uses the weighted screen sound attenuation $\Delta L_{s,w}$ which basically is calculated in the same way as the weighted sound reduction index $R_{w}$ according to ISO 717/1, [5], but adopted to the 6 octave bands in stead of the 16 third octave bands.

Neither of the above single number ratings have any solid base. They have both been more or less arbitrarily chosen.
1.2 Aim

The aim of this project has been to propose a Nordtest method, easily understandable for ordinary buyers of office equipment, to rate and classify the acoustical properties of screens to be used in open plan offices.

1.3 Carrying out

The project has been carried out by a Nordic project group with 4 members. The group has had two meetings to discuss the different proposals.
2 Considerations

2.1 General

A single number rating should be simple to understand and reflect the true efficiency of
the product concerned. Office screens are particularly difficult to rate as their effect is
closely coupled to the environment in which they are placed. Principally one could
consider several different ways to carry out the rating.

Alternative 1. If we want to rate the screen system alone disregarding the practical
performance in the field the standardized screen sound attenuation is evaluated to a single
number. This single number is then used for the rating. The disadvantage with this
alternative is that the published number very often will have little relevance to the true
performance in the field. Reflections from the ceiling and nearby obstacles will determine
the true performance.

Alternative 2. This is equivalent to alternative 1 but in stead of using the evaluated single
number directly it is translated to an equivalent screen height. This kind of rating can for
example rate a 1,8 m high screen with leakage or low sound reduction index as a 1,5 m
screen. The advantage of this alternative is that it does not promise any special
performance in the field. It just promises that the screen concerned in its acoustical
performance is equivalent to a "perfect" screen of specified height.

Alternative 3. It is also possible to couple the rating to the performance of the ceiling.
The screen can be given a class matching the sound absorption class, see the Swedish
standard SS 02 52 60([5]). The advantage with this alternative is that it draws the
attention to the importance of the ceiling. The disadvantage is, of course, that we then in
many cases will not rate the screen but the ceiling.

Whichever alternative we choose we first have to specify the basic method to get a single
number. The different single numbers will be described in 2.2 - 2.6.

2.2 Arithmetic mean value

The arithmetic mean value can be taken over different frequency ranges. In NT ACOU
036 and in an informative annex of ISO/DIS 10053 we have \( \Delta L_{s,av,125-4000} \), that is the
average over the whole frequency range covered by the measurement method. As
speech, which is the predominant source of noise in offices, has little energy of
importance at low frequencies it is also of interest to study more limited frequency
ranges. In the following we will also look at
\( \Delta L_{s,av,250-4000} \) and \( \Delta L_{s,av,500-4000} \).

2.3 Weighted screen sound attenuation

In addition to the arithmetic mean value ISO/DIS 10053 describes, in an informative
annex, a single number rating called \( \Delta L_{s,w} \). It is calculated from the reference curve in
Figure 2.1. The reference curve is shifted in steps of 1 dB towards the measured value
until the mean unfavourable deviation is less than 2 dB. An unfavourable deviation
occurs at a particular frequency when the measured value is less than the value of the
reference curve. Only deviations in the unfavourable direction are counted. The weighted
screen sound attenuation $\Delta L_{s,w}$ is defined as the value of the shifted reference curve at 500 Hz.

![Image of a graph showing dB Screen sound attenuation vs Frequency (125 to 4000 Hz)]

**Figure 2.1** Reference curve for the calculation of $\Delta L_{s,w}$.

### 2.4 A-weighted screen sound attenuation

In ASTM 1130, [6], the spectrum of a male human voice is given as shown in Figure 2.2

![Image of a graph showing dB Sound pressure level at 1 m vs Frequency (125 to 4000 Hz)]

**Figure 2.2** Spectrum of male voice at 1 m according to ASTM 1130.

By using this spectrum it is possible to calculate the A-weighted screen sound attenuation from

$$\Delta L_A = 10 \log \left(\frac{\Sigma 10^{(\text{Lpi} - \text{Ai})/10}}{10^{\Sigma 10^{(\text{Lpi} - \Delta Lsi - \text{Ai})/10}}}\right)$$  \hspace{1cm} (2.1)

where the summation is carried out over all octave bands i and where Lpi and Ai denote the speech spectrum band sound pressure levels of Figure 2.2 and the A-weighting band correction respectively.
2.5 **Loudness screen sound attenuation**

It is also possible to calculate the screen sound attenuation for the spectrum given in Figure 2.2 by using ISO 532, [7], method A to calculate the loudness level for the unattenuated and screen attenuated spectrum respectively. The difference will, in the following, be denoted \( \Delta L_{\text{Loud}} \).

2.6 **Ceiling related single number**

A sound ray hitting a ceiling with the sound absorption factor \( \alpha \) will be reflected with a \( \Delta L_T \) dB lower level determined by

\[
\Delta L_T = 10 \log \left( \frac{1}{1 - \alpha} \right)
\]  

(2.2)

In Figure 2.3 \( \alpha \) is given for different ceiling absorption classes.

![Graph showing sound absorption factor vs. frequency](image)

**Figure 2.3** Minimum sound absorption factor of different absorption classes(from [10]).

In addition there will be a distance attenuation due to the longer distance source - ceiling - receiver. In the standardized test setup this distance attenuation, compared to the direct sound wave, becomes

\[
\Delta L_d = 20 \log \left( \left( \frac{H - 1.2}{2} \right)^2 + 1.5^2 \right) + 0.5 + 20 \log (3)
\]  

(2.3)

where \( H \) is the height above the floor of the ceiling. With \( H = 3.0 \text{ m} \) we get

\[
\Delta L_d = 3.9 \text{ dB}
\]  

(2.4)

By adding eq. 2.2 and 2.4 we get the ceiling sound attenuation

\[
\Delta L_{\text{Ceiling}} = 3.9 + 10 \log \left( \frac{1}{1 - \alpha} \right)
\]  

(2.5)
3 Some calculated examples

3.1 Examples of screens

Examples of screens which will be dealt with in future examples are given in Figure 3.1, 3.2 and 3.3. The screens in Figure 3.1 are those to be exemplified in an informative annex in ISO 10053 as "perfect" screens without any leakage. The examples of Figure 3.2 have been taken from [8].

![Graph showing dB Screen sound attenuation vs. Frequency, Hz for different heights (2.5 m, 2.0 m, 1.8 m, 1.5 m).](image1)

**Figure 3.1** Ideal screens of different heights. Examples from ISO 10053.

![Graph showing dB Screen sound attenuation vs. Frequency, Hz for different types of screens (1.8 m, glasfiber, chipboard, etc.).](image2)

**Figure 3.2** Examples of different screens. From [8].
Figure 3.3  4 examples of screens with absorbing surfaces with and without sound transmission. The "no transmission" screens have probably some leakage between lower edge and floor.

From the top to the bottom of the figure legends above the different screens illustrated above are numbered as follows:

1. Thin rigid screen with h = 2,5 m, negligible sound transmission and leakage.
2. As 1 but with h = 2,0 m.
3. As 1 but with h = 1,8 m.
4. As 1 but with h = 1,5 m.
5. 1,8 m high screen made of glass wool only. Substantial transmission through the screen.
6. 1,8 m high screen made of 22 mm chipboard. Negligible sound transmission or leakage.
7. As 6 but h = 2,4 m.
8. As 6 but with 20 mm wide slits between the screen elements.
9. As 6 but with 5 cm mineral wool on both sides of the screen.
10. As 6 but with a 30 cm wide airgap between the lower part of the screen and the floor.
11. As 10 but with a 5 cm wide air gap.
12. 1,5 m high screen with absorbing surfaces and some sound transmission.
13. As 12 but 1,8 m high.
14. 1,5 m high screen with absorbing surfaces and no sound transmission.
15. As 14 but 1,8 m

Table 3.1  List of screens used for the calculations.
3.2 Calculated examples

The single numbers described in section 2 have been calculated for the different screens in Table 3.1. The results are given in Table 3.2. From top to bottom the screens have been rank ordered after their $\Delta L_{S, w}$.

<table>
<thead>
<tr>
<th>Screen no</th>
<th>$\Delta L_{S, w}$</th>
<th>$\Delta L_{S,125}$</th>
<th>$\Delta L_{S,250}$</th>
<th>$\Delta L_{S,500}$</th>
<th>$\Delta L_{A}$</th>
<th>$\Delta L_{\text{Aud}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21(1)</td>
<td>18.2(1)</td>
<td>19.6(1)</td>
<td>21.1(1)</td>
<td>17.6(1)</td>
<td>15.9(1)</td>
</tr>
<tr>
<td>7</td>
<td>19(2)</td>
<td>16.3(2)</td>
<td>17.9(3)</td>
<td>19.4(3)</td>
<td>15.7(2)</td>
<td>14.3(2)</td>
</tr>
<tr>
<td>9</td>
<td>18(3,4)</td>
<td>16.2(3)</td>
<td>18.2(2)</td>
<td>19.9(2)</td>
<td>14.4(3,4)</td>
<td>13.5(3)</td>
</tr>
<tr>
<td>2</td>
<td>18(3,4)</td>
<td>15.4(4)</td>
<td>16.8(4)</td>
<td>18.3(4)</td>
<td>14.4(3,4)</td>
<td>13.1(4)</td>
</tr>
<tr>
<td>15</td>
<td>17(5)</td>
<td>14.1(5)</td>
<td>15.4(6)</td>
<td>17.1(5)</td>
<td>12.4(6,7)</td>
<td>11.6(5)</td>
</tr>
<tr>
<td>6</td>
<td>16(6,7)</td>
<td>13.8(6)</td>
<td>15(3)</td>
<td>16.4(6)</td>
<td>12.6(5)</td>
<td>11.6(5)</td>
</tr>
<tr>
<td>3</td>
<td>16(6,7)</td>
<td>13.4(7)</td>
<td>14.6(7)</td>
<td>16.1(7)</td>
<td>12.4(6,7)</td>
<td>11.3(6)</td>
</tr>
<tr>
<td>13</td>
<td>13(8)</td>
<td>11.3(8)</td>
<td>12.7(8)</td>
<td>13.7(8)</td>
<td>10.5(8)</td>
<td>9.3(7)</td>
</tr>
<tr>
<td>8</td>
<td>12(9,10,11)</td>
<td>10.8(9)</td>
<td>11.2(11)</td>
<td>12.6(9)</td>
<td>10.4(9)</td>
<td>9.3(7)</td>
</tr>
<tr>
<td>4</td>
<td>12(9,10,11)</td>
<td>10.4(10)</td>
<td>11.3(10)</td>
<td>12.3(10)</td>
<td>9.7(10)</td>
<td>8.9(8)</td>
</tr>
<tr>
<td>11</td>
<td>12(9,10,11)</td>
<td>10.3(11)</td>
<td>11.5(9)</td>
<td>12(11)</td>
<td>9.1(11,12)</td>
<td>8.4(9)</td>
</tr>
<tr>
<td>14</td>
<td>12</td>
<td>9.5(12)</td>
<td>10.6(12)</td>
<td>11.5(12)</td>
<td>9.1(11,12)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>8(13)</td>
<td>7.3(13)</td>
<td>8.1(13)</td>
<td>8.6(13)</td>
<td>6.1(13)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6(14)</td>
<td>5.2(14)</td>
<td>5.8(14)</td>
<td>5.8(14)</td>
<td>5.3(15)</td>
<td>4.8(11)</td>
</tr>
<tr>
<td>10</td>
<td>5(15)</td>
<td>4.6(15)</td>
<td>5.4(15)</td>
<td>5.5(15)</td>
<td>6.1(14)</td>
<td>5.4(10)</td>
</tr>
</tbody>
</table>

Table 3.2 Single number evaluation of the different screens. Rank order within ( ). The ISO "reference" screens are typed with bold font.

Table 3.2 does not indicate any special problems. The rank order between the different screens is virtually the same for all the different single numbers. The very few differences which can be found are very small. However, one problem is that the resolution between different barrier heights is small. The difference is less than 1 dB/10 cm screen height. This is not much as the ISO standard stipulates that the $\Delta L_S$-values shall be rounded to the nearest whole dB. The missing values of the loudness values were not calculated.
3.3 Examples of ceilings

By applying the limit sound absorption factors in Figure 2.3 and calculating the ceiling sound attenuation \( \Delta L_{\text{ceiling}} \) according to eq. 2.5 we get Figure 3.4.

![Graph showing ceiling sound attenuation for different absorption classes.]

**Figure 3.4** The ceiling sound attenuation for different absorption classes.

In Table 3.3 the corresponding single number values can be found.

<table>
<thead>
<tr>
<th>Ceiling class</th>
<th>( \Delta L_{c,w} )</th>
<th>( \Delta L_{c,125} )</th>
<th>( \Delta L_{c,250} )</th>
<th>( \Delta L_{c,500} )</th>
<th>( \Delta L_{c,A} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14</td>
<td>10,8</td>
<td>12,9</td>
<td>13,9</td>
<td>13,2</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>8,6</td>
<td>10,3</td>
<td>10,9</td>
<td>10,5</td>
</tr>
<tr>
<td>C</td>
<td>8</td>
<td>6,3</td>
<td>7,5</td>
<td>7,9</td>
<td>7,7</td>
</tr>
<tr>
<td>D</td>
<td>5</td>
<td>4,3</td>
<td>5,2</td>
<td>5,4</td>
<td>5,3</td>
</tr>
</tbody>
</table>

**Table 3.3** Single number values for different ceilings.

Table 3.3 shows that also for ceilings there do not seem to be any problem with the different single numbers. They do all behave in the same way.
4 What to do with the single numbers?

In 2.1 3 different alternatives to deal with the single number was mentioned. The project group decided at its first meeting that alternative 1 should preferably not be used because of the fact that the single numbers had little meaning in normal field situations. In the following the other alternatives will be discussed in more detail.

4.1 Equivalent screen height

It has been shown that there is little difference between the different single number ratings. In the following it will be assumed that $\Delta L_{s,w}$ is the single number rating and the problem is then to convert its value to an equivalent screen height. In Table 4.1 a proposal is made to translate weighted screen sound attenuation to equivalent screen height. Because of the small resolution of $\Delta L_{s,w}$ it is proposed to use classes in steps of 0.3 m. This will probably guarantee that a good screen with its height equal to the class centre class always will get its proper class. The centre of the height classes have been selected to represent the most common commercially available screen heights, that is 1.5 m and 1.8 m. It has also been assumed that the best reference is a reflecting screen. By making the screen absorbing on both sides it will be possible to improve the rating, maybe one class, and such improvements should be encouraged. On the other hand it is also possible to do the reverse, that is punish reflecting screens by giving them a lower class than the corresponding absorptive screen.

<table>
<thead>
<tr>
<th>Screen height (m)</th>
<th>$\Delta L_{s,w}$ from 3.2</th>
<th>Proposal for rating, $\Delta L_{s,w}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.1 m</td>
<td>No rating</td>
<td></td>
</tr>
<tr>
<td>1.1 m</td>
<td></td>
<td>7 - 10 dB</td>
</tr>
<tr>
<td>1.2 m</td>
<td></td>
<td>11 - 14 dB</td>
</tr>
<tr>
<td>1.3 m</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>1.4 m</td>
<td></td>
<td>16, 16</td>
</tr>
<tr>
<td>1.5 m</td>
<td></td>
<td>15 - 17 dB</td>
</tr>
<tr>
<td>1.6 m</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>1.7 m</td>
<td></td>
<td>18 - 19 dB</td>
</tr>
<tr>
<td>1.8 m</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>1.9 m</td>
<td></td>
<td>20 - 21 dB</td>
</tr>
<tr>
<td>2.0 m</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>2.1 m</td>
<td></td>
<td>22 - 23 dB</td>
</tr>
<tr>
<td>2.2 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.8 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.9 m</td>
<td></td>
<td>&gt; 23 dB</td>
</tr>
<tr>
<td>&gt; 3.0 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1 Proposal for subdivision into different screen height classes.

Applying the classes in Table 4.1 to the screen examples in Table 3.2 and the suspended ceilings in Table 3.3 yields the result shown in Table 4.1.
<table>
<thead>
<tr>
<th>Screen or ceiling</th>
<th>Screen class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 2,5 m reflecting screen</td>
<td>2,4 m</td>
</tr>
<tr>
<td>7. 2,4 m reflecting screen</td>
<td>2,1 m</td>
</tr>
<tr>
<td>9. 1,8 m absorbing screen</td>
<td></td>
</tr>
<tr>
<td>2. 2,0 m reflecting screen</td>
<td></td>
</tr>
<tr>
<td>6. 1,8 m reflecting screen.</td>
<td>1,8 m</td>
</tr>
<tr>
<td>15. 1,8 m absorbing screen.</td>
<td></td>
</tr>
<tr>
<td>8. 1,8 m reflecting screen with 20 mm slits</td>
<td>1,5 m</td>
</tr>
<tr>
<td>4. 1,5 m reflecting screen</td>
<td></td>
</tr>
<tr>
<td>11. 1,8 m reflecting screen with 20 mm airgap</td>
<td></td>
</tr>
<tr>
<td>13. 1,8 m absorbing screen with transmission</td>
<td></td>
</tr>
<tr>
<td>14. 1,5 m absorbing screen</td>
<td></td>
</tr>
<tr>
<td>Ceiling class A and B</td>
<td></td>
</tr>
<tr>
<td>12. 1,5 m absorbing screen with transmission</td>
<td>1,2 m</td>
</tr>
<tr>
<td>Ceiling class C</td>
<td></td>
</tr>
<tr>
<td>5. 1,8 m absorbing screen with transmission.</td>
<td>No rating</td>
</tr>
<tr>
<td>10. 1,8 m reflecting screen with 30 mm airgap</td>
<td></td>
</tr>
<tr>
<td>Ceilings class C and D</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2  Result after rating of the examples in section 3.

Looking at the results of Table 4.2 we find that screen no 7 has got the wrong rating as it is 2,4 m high and has no leakages or sound transmission. Screen no 9 has been promoted to a higher equivalent height than its real height because of its good twosided absorption which increases the screen sound attenuation about 2 dB. All the other screens seem to have a reasonable rating.

### 4.2 Sound absorption

How to rate the sound absorption is not a big problem. The measurement method is given in NT ACOU 032, [3] and the rating system should be chosen from the Swedish standards SS 02 52 59 and SS 02 52 60. The different sound absorption classes are given in Figure 2.3. One problem is that ISO has a working group with the scope of making a system for single number rating of sound absorbing products. Although the ISO standard is likely to be very similar to the Swedish standards there may be some differences. Another problem is that the Nordtest method does not clearly specify if the frame of the screen shall be included in the area when calculating the sound absorption factor.

The sound absorption rating can easily be combined with the screen sound attenuation rating. The class could for example be 1,8A.
4.3 Final considerations

To use the equivalent screen height as described in 4.1 is a good starting point. However, it is probably risky to use the height itself as rating. People may get confused if they get a 1.8 m screen which is rated 1.5 m. A better alternative is to introduce a rating such as the one used for sound absorbers, that is A, B, C and D. If we couple this to the ceiling classes described in Table 3.3 we can get an efficient system which includes the effect of ceiling reflections.

A combined screen - ceiling rating system should have limits fitting well into both Table 3.3 and 4.1. The minimum requirement is, of course, that the screen does not transmit more sound than the ceiling. There are, however, reasons to have tougher requirements on the screen. The source may be closer to the screen than the measurement standard’s 1.5 m, the directivity may be larger in the direction of the screen than is the case in the direction of the ceiling, the ceiling may be further away than 1.8 m from the source. If we add a margin to the screen of 1 - 3 dB compared to that of the ceiling we get Table 4.3.

<table>
<thead>
<tr>
<th>Screen sound attenuation class</th>
<th>Requirement</th>
<th>Typical screen height</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>$\Delta L_{S,W} \leq 5$</td>
<td>No rating</td>
</tr>
<tr>
<td>C</td>
<td>$6 \leq \Delta L_{S,W} \leq 8$</td>
<td>1.2 m</td>
</tr>
<tr>
<td>B</td>
<td>$9 \leq \Delta L_{S,W} \leq 11$</td>
<td>1.5 m</td>
</tr>
<tr>
<td>A</td>
<td>$12 \leq \Delta L_{S,W} \leq 14$</td>
<td>1.8 m</td>
</tr>
<tr>
<td>A+</td>
<td>$\Delta L_{S,W} \geq 19$</td>
<td>2.2 m</td>
</tr>
</tbody>
</table>

Table 4.3 Final proposal

The proposal in Table 4.3 has the following advantages:

---- the best "normal" screen has the same class as the best "normal" ceiling
---- the second best "normal" screen has the same class as the second best "normal" ceiling
---- the classes are wide enough not to cause unnecessary problems with screens on the margin
---- there is an easily understandable link between the screen and the equally important ceiling
5 References

Acoustical screens: Screen sound attenuation

Acoustics - Measurement of office screen sound attenuation under specific laboratory conditions

Acoustical screens: Sound absorption

Acoustics - Measurement of sound absorption in a reverberation room

Acoustics - Rating of sound insulation in buildings and of building elements - Part1: Airborne sound insulation in buildings and of interior building elements


Acoustics - Method for calculating loudness level

Measurement of insertion loss of screens
SP Technical Report 1980:8

[9] Svensk standard SS 025259 - 1986
Byggakustik - Ljudabsorbenter - Värdering av mätresultat

Byggakustik - Ljudabsorbenter - Klassindelning
6 Proposal for Nordtest method

Acoustical screens:
Rating and classification
1 Scope and field of application

This Nordtest method gives methods for rating and classifying the sound attenuation and the sound absorption of screens intended for use in large rooms without partitions in order to increase speech privacy or noise insulation between working positions.

Rating and classification according to this method simplifies the comparison and the choice between different types of screens. In Annex A some guidelines on the practical applications of this Nordtest method are given.

The classification obtained according to this method is particularly valid in those practical situations where the screens are used to separate two nearby workstations with seated workers. In other cases the directivity of the actual sound source and the sound transmission properties of the screen may produce screen sound attenuation values not covered by the rating and classification of this Nordtest method.

2 References

ISO 354: 1985
Acoustics - Measurement of sound absorption in a reverberation room

ISO 717/1:1982
Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation in buildings and of interior building elements

ISO/DIS 10053: 1990
Acoustics - Measurement of office screen sound attenuation under specific laboratory conditions

NT ACOU 032: 1981
Acoustical screens: Sound absorption

NT ACOU 036: 1981
Acoustical screens: Screen sound attenuation

Svensk standard SS 025259: 1986
Byggakustik - Ljudabsorbenter - Värdering av mätsresultat

Svensk standard SS 025260: 1986
Byggakustik - Ljudabsorbenter - Klassindelning

3 Definitions

screen, screen element: partial height space divider that is intended for use in large rooms without partitions. A screen may consist of several screen elements coupled together.

screen sound attenuation, $\Delta L_s$, in decibels: screen sound attenuation measured according to ISO 10053. For a screen with no air gap at the floor, $\Delta L_s$ is an approximation of the insertion loss that would have been obtained in a free field with a corresponding finite width, semi-infinite screen.
weighted screen sound attenuation, $\Delta L_{s,w}$, in decibels: single number frequency independent value evaluated from the frequency dependent screen sound attenuation.

practical sound absorption factor, $\alpha_p$: octave band sound absorption factor evaluated from the measured third octave band values according to ISO 354 with supplements according to NT ACOU 032. It is evaluated as the arithmetic mean value of the three third octave band values within each octave and rounded to the nearest 0.05. If $\alpha_p > 1.00$ put $\alpha_p = 1.00$.

weighted absorption factor, $\alpha_{w}$, in decibels: single number frequency independent value evaluated from the frequency dependent screen sound absorption factor.

4 Procedures for evaluating single-number quantities and classes

4.1 Weighted screen sound attenuation

The screen sound attenuation, $\Delta L_s$, is measured according to ISO 10053. The measured values, rounded to the nearest whole dB, are then used to calculate the weighted screen sound attenuation, $\Delta L_{s,w}$, from the reference curve in Figure 1 and Table 1. The reference curve is shifted in steps of 1 dB towards the measured value until the mean unfavourable deviation for the 6 octave bands 125 - 4000 Hz is less than 2 dB. An unfavourable deviation occurs at a particular frequency when the measured value is less than the value of the reference curve. Only deviations in the unfavourable direction are counted. The weighted screen sound attenuation, $\Delta L_{s,w}$, is defined as the value of the shifted reference curve at 500 Hz. An example of a calculation of $\Delta L_{s,w}$ is given in Annex B.

![Reference curve for the calculation of $\Delta L_{s,w}$](image)
<table>
<thead>
<tr>
<th>Frequency Level</th>
<th>125 Hz</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 dB</td>
<td>25 dB</td>
<td>32 dB</td>
<td>35 dB</td>
<td>36 dB</td>
<td>36 dB</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Values of the reference curve in Figure 1

Note 1. The reference curve has been taken from ISO 717/1 after having converted the third octave band values to octave band values.

Note 2. The position of the reference curve has no meaning until it has been shifted.

4.2 Classification of screen sound attenuation

The single number value, $\Delta L_{s,w}$, is used to calculate the screen sound attenuation class according to Table 2.

<table>
<thead>
<tr>
<th>Screen sound attenuation class</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not classified</td>
<td>$\Delta L_{s,w} \leq 5$</td>
</tr>
<tr>
<td>D</td>
<td>$6 \leq \Delta L_{s,w} \leq 8$</td>
</tr>
<tr>
<td>C</td>
<td>$9 \leq \Delta L_{s,w} \leq 11$</td>
</tr>
<tr>
<td>B</td>
<td>$12 \leq \Delta L_{s,w} \leq 14$</td>
</tr>
<tr>
<td>A</td>
<td>$15 \leq \Delta L_{s,w} \leq 18$</td>
</tr>
<tr>
<td>A+</td>
<td>$\Delta L_{s,w} \geq 19$</td>
</tr>
</tbody>
</table>

Table 2: Classification of screen sound attenuation.

Note 1. Typical screen heights for well functioning screens complying with the classes in Table 2 are given in the table below:

<table>
<thead>
<tr>
<th>Screen sound attenuation class</th>
<th>Typical screen height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not classified</td>
<td>---</td>
</tr>
<tr>
<td>D</td>
<td>1,2 m</td>
</tr>
<tr>
<td>C</td>
<td>1,5 m</td>
</tr>
<tr>
<td>B</td>
<td>1,8 m</td>
</tr>
<tr>
<td>A</td>
<td>2,2 m</td>
</tr>
</tbody>
</table>

Note 2. The different screen sound attenuation classes match the corresponding ceiling sound absorption classes according to the Swedish Standard SS 025260. If the ceiling height is 3,0 m the screen sound attenuation will be 1-4 dB higher than the distance-absorption attenuation of the ceiling reflection.

4.3 Weighted sound absorption factor

The sound absorption measurements are carried out according to ISO 354 with supplements according to NT ACOU 032. From the measured third octave values the practical sound absorption factor $\alpha_p$ is evaluated. The $\alpha_p$ are then used to calculate the weighted sound absorption factor $\alpha_w$, from the reference curve in Figure 2 and Table 3.
The reference curve is shifted in steps of 0.1 towards the measured value until the mean unfavourable deviation for the 5 octave bands 250 - 4000 Hz is less than or equal to 0.1. An unfavourable deviation occurs at a particular frequency when the measured value is less than the value of the reference curve. Only deviations in the unfavourable direction are counted. The weighted sound absorption $\alpha_w$ is defined as the value of the shifted reference curve at 500 Hz. An example of a calculation of $\alpha_w$ is given in Annex C.

![Graph of $\alpha_p$, Practical sound absorption factor.](image)

**Figure 2** Reference curve for evaluation of weighted sound absorption factor.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>125 Hz</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_p$</td>
<td>0.8</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Table 3** Values of the reference curve in Figure 2.

Note. The values of the reference curve have been taken from the Swedish Standard SS 025259.

### 4.4 Classification of the sound absorption

The single number value, $\alpha_w$, is used to calculate the screen sound absorption class according to Table 4.

<table>
<thead>
<tr>
<th>Screen sound absorption class</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not classified</td>
<td>$\alpha_w &lt; 0.3$</td>
</tr>
<tr>
<td>D</td>
<td>$\alpha_w = 0.3$ ; 0.4 ; 0.5</td>
</tr>
<tr>
<td>C</td>
<td>$\alpha_w = 0.6$ ; 0.7</td>
</tr>
<tr>
<td>B</td>
<td>$\alpha_w = 0.8$</td>
</tr>
<tr>
<td>A</td>
<td>$\alpha_w = 0.9$ ; 1.0</td>
</tr>
</tbody>
</table>

**Table 4** Screen sound absorption classes.
Note 1. The sound absorption classes correspond to the ones given in the Swedish Standard SS 025260.

Note 2. Ceilings are often classed accordingly.

5 Statement of results

The weighted screen sound attenuation is given as an integer and the weighted sound absorption factor is given with one decimal.

The screen sound attenuation class is given as:
Screen sound attenuation class: A (optionally "screen sound" may be omitted).

The screen sound absorption class is given as:
Screen sound absorption class: C (Optionally "screen sound" may be omitted). If the one sided screen surface area is used when calculating the screen sound absorption coefficient, the screen sound absorption class shall have the label "(one side)", e.g. C(one side).

The combined screen sound attenuation and sound absorption class is given as:
Screen sound attenuation/screen sound absorption class : A/C (Optionally "screen sound" may be omitted).
ANNEX A  
(informative)

Guidelines on the practical applications of Nordtest's classification of screen sound attenuation

In practical field situations the acoustical effect of a screen will often be different from that of the laboratory situation. Other transmission paths than those through or around the screen will influence the efficient screening. In Figure A1 the most important transmission paths are shown:

- **Path 1:** reflection from the ceiling,
- **Path 2:** reflection from a wall or other nearby obstacles,
- **Path 3:** diffraction around the top of the screen,
- **Path 4:** diffraction around the edge of the screen,
- **Path 5:** direct transmission through the screen,
- **Path 6:** reflection from the floor.

![Diagram](image)

**Figure A1.** The most important transmission paths in a room with an office screen.

In the standardized screen sound attenuation test, on which the classification is based, prescribed source and receiver positions are used and the transmission paths 3, 5 and 6 are included. The transmission paths 2 and 4 must normally be taken care of by using a suitable screen arrangement which will screen these paths. However, transmission path 1 will always be present and in many cases determine the resulting field performance of the screen.

The screen sound attenuation classes have been chosen to match the corresponding ceiling sound absorption classes. This means that the minimum requirement is to chose a
ceiling with the same sound absorption class as the screen's sound attenuation class. The resulting screen sound attenuation from the paths 1, 3, 5 and 6 will then be as shown in Table A.1 assuming that the ceiling height is 3.0 m and that the source and receiving positions are the standardized positions. Higher ceilings will improve the resulting performance.

<table>
<thead>
<tr>
<th>Class</th>
<th>Screen</th>
<th>Ceiling</th>
<th>Resulting $\Delta L_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>$\Delta L_{s,w} \geq 19$</td>
<td>Not classified</td>
<td>12</td>
</tr>
<tr>
<td>A</td>
<td>$15 \leq \Delta L_{s,w} \leq 18$</td>
<td>$\Delta L_{c,w} \geq 14$</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>$12 \leq \Delta L_{s,w} \leq 14$</td>
<td>$\Delta L_{c,w} \geq 11$</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>$9 \leq \Delta L_{s,w} \leq 11$</td>
<td>$\Delta L_{c,w} \geq 8$</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>$6 \leq \Delta L_{s,w} \leq 8$</td>
<td>$\Delta L_{c,w} \geq 5$</td>
<td></td>
</tr>
</tbody>
</table>

Table A.1. Screen sound attenuation $\Delta L_{s,w}$, distance-absorption ceiling sound attenuation, $\Delta L_{c,w}$ and the resulting total sound attenuation, $\Delta L_w$, for the different screen and ceiling classes.

If one ceiling class better than the corresponding screen sound attenuation class is used 1 dB can be added to the resulting $\Delta L_w$. 
ANNEX B

Example of how to calculate $\Delta L_{s,w}$

Figure B1. Shifted reference curve and measured screen sound attenuation.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Reference curve</th>
<th>Screen attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>250</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>500</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>1000</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>2000</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>4000</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Table B1. Numerical values for the curves in Figure B1.

In the example above the reference curve has been moved in steps of 1 dB downwards to 16 dB at 500 Hz until the sum of the maximum unfavourable mean deviation between the reference curve and the measured screen sound attenuation for the six octave bands 125 - 4000 Hz is less than 2 dB yielding $\Delta L_{s,w} = 16$ dB.
ANNEX C

Example of how to calculate $\alpha_w$

Figure B1. Example of an $\alpha_w$-calculation.

Figure B1 shows an example of how to calculate $\alpha_w$. The reference curve is lowered in steps of 0.1 until the sum of the maximum unfavourable deviations $\leq$ 0.1. In the example the unfavourable deviations occur at 250 and 1000 Hz and the result is $\alpha_w = 0.6$. 