EFFECTS OF MEASURES TO DECREASE THE REVERBERATION TIME IN SHIPBUILDING HALLS.

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In the Netherlands ships are nowadays often built in shipbuilding halls constructed from corrugated steel-plates. Unless special measures are taken, these halls have a long reverberation time (called R.T.) This has a number of negative effects on the people who have to work in these halls. It is possible to decrease the R.T. to an acceptable level by appropriate measures. We calculated the average R.T. of the frequencies 1/2K, 1K, 2K, 4K. Since these frequencies are predominantly present in the typical noise in these halls.

The shipbuilding halls.

<table>
<thead>
<tr>
<th>Hall nr.</th>
<th>Volume m$^3$</th>
<th>Surface m$^2$</th>
<th>R.T. in sec. non-absorbing</th>
<th>absorbing</th>
<th>decrease factor R.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50,000</td>
<td>2,100</td>
<td>6,4</td>
<td>2,3</td>
<td>2,8</td>
</tr>
<tr>
<td>2</td>
<td>16,500</td>
<td>1,100</td>
<td>4,2</td>
<td>2,3</td>
<td>1,8</td>
</tr>
<tr>
<td>3</td>
<td>140,000</td>
<td>5,000</td>
<td>.5,9</td>
<td>2,8</td>
<td>2,1</td>
</tr>
<tr>
<td>3</td>
<td>42,000</td>
<td>1,600</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hall 3 has an absorbing and a non-absorbing section in open connection with each other.

The measures.

Hall 1 was an existing hall. To decrease the R.T., rockwool baffles were installed at the ceiling of this hall. Two baffles per square meter were chosen, dimensions 1200x600 mm, thickness 30 mm into a dust-proof foil (picture).

The employees of the ship-yard carried out this job themselves. It was done outside the working-hours and a platform built on an overhead-crane was used. The costs were F 50,- per m$^2$, average absorption was 1,4 m$^2$ Sabine per m$^2$ surface, price level 1980.
For hall 2 and 3 was chosen for a different type of construction. Hall 2 was also an existing situation. The absorbing part of hall 3 was recently built. In these halls a heat-insulating and sound-absorbing corrugated steel-plate was put, in order to improve the heat insulation of the walls at the same time. It consisted of a perforated steel-plate; 40% perforation, a dust-proof foil and 55 mm of glasswool insulation (picture). In hall 2 this was attached to 50% of the surface of the walls, in hall 3, absorbing part this also was fixed on 50% of the surface of the walls and to the whole ceiling. The costs were f 100,— per m², average absorption 1 m² Sabine per m² surface, price-level 1982.

The sound measurements.

We did frequency analyses from the L-eq measurements of the noise in the halls. It was evident that in an absorbing hall the high frequencies - like 1K, 2K and 4K - appeared considerably less than in a non-absorbing one. This is in connection with aspects of well-being. (diagram).

We also studied the decrease of the sound level with increasing distance. In hall 3 - with sound-absorbing corrugated steel-plate - the curve of the absorbing hall is a few dB(A) below the curve of the non-absorbing hall. In hall 1 - with the baffle ceiling - the curve drops strongly. In hall 2 this effect was hardly measurable (diagram).

We also did measurements with dosemeters. We measured a decrease of the L-eq, sound-level of about 3 or 4 dB(A) in hall 1. In hall 3 this was 2 dB(A). In hall 2 a decrease was hardly measurable.

Social aspects.

The reasons for management to pay attention tot the improvement of working conditions were: complaints of the employees; communication problems on the workspot; workers mentioned the noise as one of the reasons when leaving the company; several workers had problems of medical nature with the hearing.

The reason for choosing the inside perforated corrugated steel-plateing was the combining of the improvement of the heat-insulation of the walls, the lowering of the R.T. and aesthetical aspects.
R.T. TIME IN SHIPBUILDING HALLS

The opinion of the employees was asked by means of a questionnaire.

<table>
<thead>
<tr>
<th>Improvement Noticeable</th>
<th>Hall 1</th>
<th>Hall 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No improvement noticeable</td>
<td>17 %</td>
<td>-</td>
</tr>
<tr>
<td>Hardly any improvement noticeable</td>
<td>21 %</td>
<td>60 %</td>
</tr>
<tr>
<td>Improvement noticeable</td>
<td>48 %</td>
<td>40 %</td>
</tr>
<tr>
<td>Considerable improvement</td>
<td>7 %</td>
<td>-</td>
</tr>
<tr>
<td>Significant improvement</td>
<td>7 %</td>
<td>-</td>
</tr>
<tr>
<td>Less annoyance</td>
<td>83 %</td>
<td>53 %</td>
</tr>
<tr>
<td>Better conversation</td>
<td>38 %</td>
<td>17 %</td>
</tr>
</tbody>
</table>

The measures taken give a positive result. The baffle ceiling has the best effects. A typical result is the decrease of the reverberation time of one third (average of the frequencies 2K, 1K, 2K, 4K). In spite of the high costs the management as well as the employees were satisfied with the measures taken.

The improvement of hall 1 and 2 were subsidized by the Dutch Government under supervision of the Dutch Labour Inspectorate all within the framework of a program to improve the working conditions. The ship-yards concerned are situated in the same area and knew each others problems with the reverberation in the halls. In a later stage in the same area more shipbuilding halls have been improved without subsidy of the Government.
LII. inn den Berg

SHIP

YARD

LABS

ORB

CH-J

CO

Leq IN dB

500 1K 2K 4K 8K

BAFFLE CEILING

1, ABSORB.

2, NON_ABSORB

DECREASE IN dB(A)

0 1 2 4 8 16 32 METERS

3, NON_ABSORB

PERFORATED WALL

3, ABSORB.

1, ABSORB.

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