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Restructuring the ISO 140 series for the future
– Background and approach

Birgit Rasmussen\textsuperscript{a}, Eddy Gerretsen\textsuperscript{b}

\textsuperscript{a} VELUX A/S, W-Product Quality, Ådalsvej 99, DK-2970 Hørsholm, Denmark
\textsuperscript{b} TNO Science and Industry, IS Acoustics, PB 155, NL-2600 AD Delft, The Netherlands

\textsuperscript{a}birgit.rasmussen@VELUX.com; \textsuperscript{b}eddy.gerretsen@tno.nl

Abstract

ISO 140 is the basic series of standards in Building Acoustics and consists of several parts relating to laboratory and field measurements. The standards were originally prepared by ISO/TC43/SC2 WGs in the early sixties and since then updated and implemented as European standards through CEN/TC126. The ISO 140 series now consists of more than 10 parts, and new parts are under preparation.

The ISO 140 laboratory standards cover a variety of building elements such as walls, windows, glazing, floors, floor coverings and air intakes. However, round robin tests have shown that the reproducibility is highly unsatisfactory for some product types due to insufficient or lacking instructions about mounting and boundary conditions, cf eg the European round robin on light-weight walls, which has led to preparation of Amendments to ISO 140-1 & 140-3.

In order to improve the structure of the standards for easier updating, ISO/TC43/SC2 has decided to re-arrange the ISO 140 series. As a first step, the restructuring is restricted to the parts for laboratory measurements of the acoustic performance of products, i.e. ISO 140-1, -3, -6, -8, -10, -11, -16. The aim is to re-arrange the contents of these parts into a more logical structure in a new series, ISO 10140, without changing the contents for the time being. The existing product related instructions about mounting and boundary conditions are collected in one of the 6 parts in the new series. The new structure will also allow easier updating in other aspects, eg new measurement techniques. ISO/CDs were circulated for enquiry in Feb. 2005.

The paper describes the shortcomings of the present ISO series, the advantages of the new structure, the approach to the restructuring process and the long-term implications and perspectives for laboratory as well as field standards.

1. INTRODUCTION

International discussions in ISO more than fifty years ago resulted in the first measurement standard for airborne and impact sound transmission in the field and in the laboratory: ISO Recommendation 140 [1], a document of just 11 pages. Based on growing experience and other needs, this recommendation evolved into the eight parts of the ISO 140 standard in
In the eighties an increased need to improve the accuracy of measurements – round robin results for glazing, interest in low frequencies – and the need for additional types of measurements – small building elements, suspended ceilings – resulted in revised versions of the existing 8 parts and in new parts of the ISO 140 series. Today ISO 140 consists of 16 parts and draft parts [3]. At the same time related activities have led to standards on characterising flanking transmission (ISO 10848 [4]), on different measurement techniques like intensity measurements (ISO 15186 [5]), on new measurement techniques for reverberation time measurements (ISO 3382 [6]) and on advanced digital signal analysis techniques (ISO/DIS 18233 [7]). The necessity to create new standards to determine the acoustic performance of building elements is largely caused by the need to design the sound insulation in buildings, e.g. as given in the standard series EN 12354 [8].

Due to this long history and the growing need to add to and adjust the ISO 140 series, its structure has become quite complex, making it difficult to implement changes in a logical and easy way. Even if only one subject needed to be adjusted it made changes necessary at several places or the opportunity was taken to start discussion on other items. As a consequence, there was a hesitation to implement newer measurement methods or specify mounting conditions for specific products. Thus, for some types of building products, instructions about size, boundary and mounting conditions are given precisely, for several others they are lacking in the ISO 140 series. Furthermore, specifying mounting conditions adequately requires specific product experience from acoustic tests as well as the product knowledge of manufacturers of those products. Due to the European Construction Products Directive, CPD 89/116/EEC [9] and the related CEN product standards and test standards being prepared in Europe, detailed descriptions are needed – quite urgently for some products. An example of a product standard is prEN 14351-1 [10] for windows and doors.

For these reasons CEN/TC126 established AHG 1 in 1999 “to investigate the feasibility and implications of rationalising the specifications of boundary and mounting conditions vis-à-vis the ISO 140 series and the product standards to which they apply”. The task of AHG1 was to find possible ways of including descriptions of boundary and mounting conditions in standards for laboratory measurements (direct transmission) and to propose the needed actions, bearing in mind that those steps will concern ISO/TC43/SC2 as well as CEN/TC126. The considerations do not concern the field parts of the ISO 140 series or the flanking transmission parts of ISO 140 (Parts 9 and 12), which will be replaced by ISO 10848.

2. THE PRESENT ISO STANDARDS FOR SOUND INSULATION MEASUREMENTS AND PROPOSAL FOR RESTRUCTURING ISO 140

The methods for laboratory measurement of sound insulation are given in ISO 140-1, -3, -6, -8, -10, -11, -16, cf [3], specifying the measurement facilities, instrumentation and test methods. During the last decades it has been realized that a satisfactory reproducibility of sound insulation measurements is not something that comes automatically, just because test rooms and test procedure fulfill the requirements of ISO 140. Boundary and mounting conditions are just as important. Several years ago a round robin test on glazing, see [11], led to precise prescriptions of dimensions and mounting of glazing. A few years ago a round robin test on lightweight walls showed far too high discrepancies, and several investigations were carried out in different laboratories. As a consequence of insufficient reproducibility for lightweight walls, see [12], a draft document on boundary and mounting conditions was prepared for this type of constructions, and it was decided to prepare amendments to ISO 140-1 & 140-3, although it was originally planned to prepare a separate standard, see [3].
Similar problems might become evident for various other products, making other additions necessary. This clearly implies that the present structure of ISO 140 is inappropriate on a long-term basis. This has also become evident for the introduction of newer measurement techniques and evaluation methods.

Existing standards can be divided into laboratory tests, field tests and various tests. In principle it would be beneficial in all cases to distinguish clearly between the basic measurement setup, measurement method and product related mounting and conditioning. In some standards this is already largely done, as for instance with the ISO 3822 standards on water supply systems, see [13], where Part 1 has the function of a basic measurement standard, while Parts 2, 3 and 4 are a sort of test codes for specific applications. As regards test codes, a similar approach has been used by ISO/TC43/SC1 & CEN/TC211 concerning noise from machinery, cf ISO 12001 [14]. A third example is the EN 352 series [15], a part of which has been editorially revised without technical changes. A fourth example is ISO 354 [16] for absorption with a separate annex on mounting.

Since most difficulties encountered with the ISO 140 standards are due to the structure, it was thought to be a solution to split the series into standards of two types:

1) Standards describing how to perform the basic building acoustic measurements including the general definitions, the description of test facilities, the measurement equipment, the test procedure and evaluation. This type of standards will be called “basic standards”.

2) Standards related to a category of products, and describing the specific boundary and mounting conditions. This type of standards will be called “test codes”.

Besides ISO 140, various other standards are involved in building acoustic measurements. Table 1 presents an overview of these standards (incl. drafts) and actions to be taken in relation to the restructuring of the ISO 140 parts on laboratory measurements. An indication of the way in which the existing parts on laboratory insulation measurements could be split up and re-arranged in the new parts is presented in Table 2.

### Table 1: Grouping of building acoustic standards, ISO 140 etc.

<table>
<thead>
<tr>
<th>Laboratory standards - sound insulation</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission, direct</td>
<td></td>
</tr>
<tr>
<td>ISO 140-1, -3, -6, -8, -10, -11</td>
<td>[3] To be replaced as group, when new series is complete.</td>
</tr>
<tr>
<td>Linings, DIS 140-16</td>
<td>[3] Proceed normally, could be incorporated in new standards when ready.</td>
</tr>
<tr>
<td>Loss factor, WI 140-17</td>
<td>[3]</td>
</tr>
<tr>
<td>Rain fall sound, DIS 140-18</td>
<td>[3]</td>
</tr>
<tr>
<td>ISO 15186-1, -3</td>
<td>[5]</td>
</tr>
<tr>
<td>Flanking transmission</td>
<td></td>
</tr>
<tr>
<td>ISO 140-9, -12</td>
<td>[3] Agreed procedure; 140-9 &amp; 12 will be replaced by ISO 10848 when ready.</td>
</tr>
<tr>
<td>ISO 10848-1, -2, -3, -4</td>
<td>[4]</td>
</tr>
<tr>
<td>Precision</td>
<td></td>
</tr>
</tbody>
</table>

### Field standards - sound insulation and equipment noise

<table>
<thead>
<tr>
<th>Field</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 140-4, -5, -7, -14</td>
<td>[3] No action; future changes could use new M&amp;Q standards; in the meantime only references might have to be changed.</td>
</tr>
<tr>
<td>ISO 15186-2</td>
<td>[5]</td>
</tr>
<tr>
<td>ISO 10052</td>
<td>[17] No action; future changes could use new M&amp;Q standards; in the meantime only references might have to be changed.</td>
</tr>
<tr>
<td>ISO 16032</td>
<td>[18]</td>
</tr>
</tbody>
</table>

| Precision                              |        |

### Other standards

<table>
<thead>
<tr>
<th>Various</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 354, ISO 3382</td>
<td>[16], [6] No action</td>
</tr>
</tbody>
</table>


The main changes proposed by CEN/TC126/AHG1 in 2002 are thus:

- To reorganize the ISO 140 laboratory standards into the following basic standards: L (“Laboratory”), A (“Airborne sound”), I (“Impact sound”), M (“Measurement”) and Q (“Qualification”), cf Tables 2 and 3. The first edition will essentially be an editorial revision of ISO 140, i.e. no technical changes. The standards concerned are ISO 140-1, -3, -6, -8, 10, -11(DIS), -16(CD) and -17(CD).

- To prepare test codes as needed. The first edition will consist of existing clauses about boundary and mounting conditions in the relevant parts of ISO 140.

Table 2: Existing ISO 140 laboratory standards and proposed split-up into a new structure with parts “Laboratory”, “Airborne sound”, “Impact sound”, “Measurement”, “Qualification” and “Test codes”

<table>
<thead>
<tr>
<th>Existing standard</th>
<th>Transfer to new standards section on</th>
<th>Proposed new standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 140 laboratory standards and proposed split-up into a new structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing standard</td>
<td>Transfer to new standards section on</td>
<td>Proposed new standards</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>140-1 lab</td>
<td>lab construction, frame, losses, requirements</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• generals about filler walls and opening dimensions</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• qualification tests (losses, Rmax, flanking)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>140-3 airborne lab</td>
<td>measurement method and principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• measurement details</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• equipment</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• general mounting, installation &amp; conditioning principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>140-6 impact lab</td>
<td>measurement method and principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• measurement details</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• equipment</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• general mounting, installation &amp; conditioning principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>140-8 coverings heavy floors</td>
<td>reference floors &amp; curves</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• measurement method and principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• general mounting, installation &amp; conditioning principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>140-10 small elements</td>
<td>measurement method and principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• general mounting, installation &amp; conditioning principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>WI 140-11 coverings light weight floors</td>
<td>reference floors &amp; curves</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• measurement method and principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• general mounting, installation &amp; conditioning principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>WI 140-16 wall linings</td>
<td>reference walls / floors &amp; curves</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• measurement method and principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• general mounting, installation &amp; conditioning principles</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• (product) specific mounting, installation &amp; conditioning details</td>
<td>X</td>
</tr>
<tr>
<td>WI 140-17 loss factor</td>
<td>measurement method</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• evaluation and use</td>
<td>X</td>
</tr>
</tbody>
</table>

After preparing and presenting these possibilities for the restructuring, see report [19], and an example on how to split up an existing standard (ISO 140-3), see [20], the work item was approved by CEN/TC126 and by ISO/TC43/SC2 in 2002. The work became a task for ISO/TC43/SC2/WG18 who established AHG 3 to do the actual work.
3. NEW STRUCTURE AND CONTENTS OF STANDARDS FOR LABORATORY MEASUREMENTS OF DIRECT TRANSMISSION

The present task with restructuring the ISO 140 parts on laboratory measurements is to re-arrange the contents of these parts into a new structure without losing anything and without adding or changing anything. The new series, ISO/CD 10140 [21], consists of 6 parts, see Table 3 with indication of main contents.

The division is based on the reasoning that ISO 10140-1 shall contain all that is needed to design and construct the laboratory, ISO 10140-5 shall contain requirements for equipment to be used and procedures to check and qualify the equipment and the facilities, while ISO 10140-4 shall contain all needed basic measurement techniques and processes, as far as references to other standards are not already available.

ISO 10140-2 then shall contain the complete general procedure for airborne sound insulation measurements, referring to ISO 10140-1 and ISO 10140-4, where appropriate; it shall be sufficiently complete and general to perform measurements for products without a specific test code, but if available, specifics in ISO 10140-6 shall be used. The same applies to ISO 10140-3 for impact sound insulation measurements. Finally ISO 10140-6 contains additional and more detailed preparation, mounting and operating conditions for specific types of elements or products. ISO 10140-6 could then easily be extended in future in cooperation with the relevant product TCs.

During the restructuring process various items of a technical nature were of course identified where it was thought that an improvement would be important or desirable. Such changes are however outside the task of ISO/TC43/SC2/WG18/AHG3, but have been marked on the so-called “wish-list”. If at the end of the restructuring process agreement could be reached quickly on proposals for such items, they could be taken into account during the restructuring process. Otherwise actions will be postponed to the first revision of the new series.

In the future it will be possible in the new ISO 10140 series to include or refer to other measurement techniques and standards in preparation, as for instance the intensity techniques (ISO 15186) or the standard on rainfall sound (ISO/DIS 140-18). The revised version of ISO 140-2 on accuracy, introducing the GUM, could be incorporated in ISO 10140-5, while the ISO 140 field measurement methods could be rewritten also, making use of references to ISO 10140-4 and ISO 10140-5.

To implement the proposed changes of ISO 140 it is essential that a smooth transition is possible between the reference to existing standards and the future revised standards. This means that a group of existing standards can be withdrawn only, when the complete set of new standards is available; see Table 1. Other standards can be adjusted to the new standards as they become available at first revision (ISO 140 field standards, ISO 15186) or while being finalized (ISO 10848, ISO/DIS 18233). An editorial updating of references to the new ISO 10140 series will be needed in ISO 717 [22] and in some national standards and regulations.
### Table 3: Indication of main contents of the proposed L-, A-, I-, M-, Q- and T-standards

<table>
<thead>
<tr>
<th>ISO WI</th>
<th>Contents &amp; use</th>
<th>Subjects / examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;L-standard&quot; ISO WI 10140-1 Requirements for laboratory test facilities</td>
<td>All that is needed to design and construct the laboratory.</td>
<td>Rooms, design criteria, flanking transmission, standard test openings (walls, floors, windows, door, small elements), filler walls in general, reference constructions (basic for $\Delta L$, $\Delta R$)</td>
</tr>
<tr>
<td>&quot;Q-standard&quot; ISO WI 10140-5 Qualification procedures</td>
<td>Requirements for equipment to be used, and procedures to check and qualify the equipment and the facilities.</td>
<td>Test facilities: laboratory loss factor, flanking transmission, max. achievable sound reduction index, influence of lack of diffusivity in the lab, equipment: loudspeakers (incl. directivity), tapping machine, microphones, test procedures: min. number of source / micro positions, precision</td>
</tr>
<tr>
<td>&quot;M-standard&quot; ISO WI 10140-4 Measurement procedures and requirements</td>
<td>All needed basic measurement techniques and processes, referring to Q where needed. Much of the contents implemented in software.</td>
<td>Definitions, frequency range, low frequency measurements, correction for background noise, correction for equipment, source and microphone positions, measurement of reverberation time, averaging, space and time, data processing, incl. rounding, loss factor, measurement of radiated sound power by velocity measurements</td>
</tr>
<tr>
<td>&quot;A-standard&quot; ISO WI 10140-2 Laboratory measurement of airborne sound insulation</td>
<td>Complete method for airborne sound insulation measurements, referring to the L-, M- and Q-documents. It shall be sufficiently complete and general to perform measurements for products without a specific test code, but specifics in T should be applied, if available.</td>
<td>Definitions of quantities to be measured, general mounting &amp; boundary conditions, general measurement procedure, data-processing, test report (general points)</td>
</tr>
<tr>
<td>&quot;I-standard&quot; ISO WI 10140-3 Laboratory measurement of impact sound insulation</td>
<td>Complete method for impact sound insulation measurements, referring to the L-, M- and Q-documents. It shall be sufficiently complete and general to perform measurements for products without a specific test code, but specifics in T should be applied, if available.</td>
<td>Definitions of quantities to be measured, general mounting &amp; boundary conditions, general measurement procedure, data-processing, test report (general points)</td>
</tr>
<tr>
<td>&quot;T-standard&quot; ISO WI 10140-6 Test codes</td>
<td>For specific types of elements / products, the standard may contain additional and more specific instructions about quantities and test specimen size and about preparation, mounting and operating conditions. Where no specific details are included, the general guidelines in the A- and I-standard should be followed.</td>
<td>Product related, specific, addit. instructions: quantities to be measured, size of test specimen, conditioning and mounting conditions, conditioning, test and operating conditions, test report</td>
</tr>
</tbody>
</table>
4. PRODUCT TEST CODES FOR LABORATORY MEASUREMENTS OF SOUND INSULATION

The purpose of a test code is to describe product specific test conditions to ensure reliable, comparable and reproducible test results. As described in Section 2, Round Robins on glazing and light-weight walls revealed far too high differences between laboratories, and stricter requirements on boundary and mounting conditions were introduced in ISO 140. A test code shall describe not only product specific boundary and mounting conditions and other test conditions that influence the test results, but shall also inform about the intended applications of test results and preferably warn against inappropriate uses. Inspired by ISO 12001 [14] about test codes on noise from machinery, CEN/TC126 has drafted a detailed document with definitions and guidelines related to several acoustic properties for building products, see [23]. Concerning laboratory test of airborne and impact sound insulation of building elements, ISO/TC43/SC2/WG18/AHG3 has proposed test code contents as indicated in the below table.

Table 4: Proposed contents of test codes

<table>
<thead>
<tr>
<th>Proposed contents of test codes linked to restructuring of ISO 140 laboratory standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
</tr>
<tr>
<td>- Definition of the product it applies to</td>
</tr>
<tr>
<td>- Quantities to be measured (if needed)</td>
</tr>
<tr>
<td>- Reference to test method(s)</td>
</tr>
<tr>
<td>Test specimen</td>
</tr>
<tr>
<td>- Size of the test opening and the test object</td>
</tr>
<tr>
<td>- Number of test objects</td>
</tr>
<tr>
<td>Boundary and mounting conditions (to be applied before installation)</td>
</tr>
<tr>
<td>- Boundary conditions, e.g. filler wall / element</td>
</tr>
<tr>
<td>- Mounting positions</td>
</tr>
<tr>
<td>Test and operating conditions (to be applied after installation):</td>
</tr>
<tr>
<td>- Fixation of the test specimen in the test opening</td>
</tr>
<tr>
<td>- Operating conditions, e.g. open/close before test</td>
</tr>
<tr>
<td>- Conditioning/curing/drying</td>
</tr>
<tr>
<td>- Loading</td>
</tr>
<tr>
<td>- Climate</td>
</tr>
<tr>
<td>Test report</td>
</tr>
<tr>
<td>Additional information, if necessary, to the information required in basic standards</td>
</tr>
</tbody>
</table>

In ISO/CD 10140-6 are found examples of preliminary test codes consisting of “test code parts” in the existing ISO 140 series. ISO/CD 10140-6 consists of a general part, including a list of proposed test code contents as in the above Table 4, and annexes for different types of products and measurements:

- Annex A  Walls - Airborne sound insulation
- Annex B  Doors - Airborne sound insulation
- Annex C  Windows - Airborne sound insulation
- Annex D  Glazing - Airborne sound insulation
5. ACTIONS AND LONG-TERM PERSPECTIVES RELATED TO ISO STANDARDS FOR MEASUREMENTS OF SOUND INSULATION

The first draft of the restructured series ISO/CD 10140 (6 parts) has been circulated for comments in ISO in February 2005. This draft has - in agreement with the WIs - no essential changes of contents, but a completely new structure, which is optimized for “easy” revision and updating. The results of the enquiry will be discussed during the ISO/TC43/SC2-meetings in Toronto in June 2005. So a very actual picture of the situation can be presented at the InterNoise 2005 congress. At that moment it might also be possible to see, whether elements of the so-called “wish-list” (see explanation in Section 3) could be incorporated without losing time in the process - accept from ISO/TC43/SC2 is also required.

In the near future, the attention will be focused on the following activities:

- decisions on items to be included from the “wish-list”;
- reference to new measurement standards, eg ISO/DIS 3382-2 on reverberation time;
- incorporation of measurement techniques from ISO 15186 and ISO/DIS 18233;
- incorporation of ISO/DIS140-18 on rainfall sound;
- revision of the ISO 140 field standards with appropriate references to the new series;
- revision of ISO 10848 flanking transmission standards with references to the new series;
- drafting test codes for various types of products;
- update of references to the laboratory measurement standards in other documents, eg in ISO 717 and national documents.

In order to improve the reproducibility of the test results to be applied as a basis for declaration of product performance data, drafting test codes will be an important issue within the EU, when applying the new ISO laboratory standards in a more strict way for products.
6. ACKNOWLEDGEMENTS

The authors acknowledge the fruitful discussions and cooperation in CEN/TC126/AHG1, who made the initial feasibility study, and in ISO/TC43/SC2/WG18/AHG3, who subsequently prepared the ISO/CD 10140 series.

7. REFERENCES


   – Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavy weight standard floor, 1997.
   – Part 11: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on lightweight framed standard floor, FDIS 2004.
   – Part 12: Laboratory measurements of room-to-room airborne and impact sound insulation of an access floor, 2000.
   – Part 15: WI cancelled. Instead AMDs to Parts 1 and 3 were developed.
   – Part 16: Laboratory measurement of sound reduction index improvement by additional lining, ISO/DIS 2004.
   – Part 17: Evaluation of the total loss factor (suspended, partly incorporated in ISO 10848).

[4] ISO 10848, Acoustics – Laboratory measurement of the flanking transmission of airborne and impact noise between adjoining rooms
   – Part 2: Application to light elements when the junction has a small influence, 2005.
   – Part 3: Application to light elements when the junction has a substantial influence, 2005.


ISO 3822, Acoustics - Laboratory tests on noise emission from appliances and equipment used in water supply installations


EN 352, Hearing protectors - Safety requirements and testing, 7 parts.


ISO 717, Acoustics - Rating of sound insulation in buildings and of buildings elements

