

ODEON APPLICATION NOTE – ISO 3382-3 Open plan offices – Part 2 Measurements

JHR, Revised September 2021

Scope

This is a guide how to measure the room acoustical parameters specially developed for open plan offices according to the second edition of international standard ISO 3382-3:2021 Acoustics – Measurement of room acoustic parameters – Part 3: Open plan offices [1].

The method is intended for furnished rooms, i.e. the room model must include tables, bookshelves, screening elements etc., but with no people present. The results can be used to evaluate room acoustical properties in open plan offices and it may be used for comparison of alternative solutions in design or acoustical treatment.

This application note refers to ODEON version 17, all editions.

Method

The principle is to measure the sound propagation from a sound source to a number of receivers that are located in different distances from the source, which must be omnidirectional, and have a standardised sound power spectrum of normal speech. Both the A-weighted sound pressure level (SPL) and the speech transmission index (STI) are measured, and a number of acoustical parameters are derived from the results. The positions of sources and receivers must correspond to actual work stations in the furnishing plan.

In order to define the relative distances between sources and receivers, it is necessary to create a dummy-room with sources and receivers. Of course, it is also possible to create a more accurate model of the office in questions, but it is not necessary for doing the measurements.

The results using this method are influenced by the volume, the amount of sound absorption, the use of screens and level of background noise. Examples of variation of these parameters are found in ref. [2].

Terms and definitions

Background noise level

sound pressure level in octave bands during working hours, but not including noise caused by people, spatially averaged over the work stations.

Sound power spectrum of normal speech

sound power level in octave bands emitted by a human speaker at normal vocal effort, as defined in ANSI 3.5 [3] and assuming a directivity as in [4].

Spatial decay rate of speech

$$D_{2,S}$$

rate of spatial decay of A-weighted sound pressure level of speech per distance doubling.

A-weighted sound pressure level of speech at a distance of 4 m

$$L_{p,A,S,4\text{ m}}$$

nominal A-weighted sound pressure level in a distance of 4 m, when an omnidirectional sound source emits a sound power spectrum of normal speech, obtained using a linear regression line through a series of measurement positions.

Comfort distance

$$r_C$$

distance from speaker where the A-weighted sound pressure level of speech falls below 45 dB. This parameter is new in the second edition.

Distraction distance

$$r_D$$

distance from speaker where the STI falls below 0,50.

Privacy distance

$$r_P$$

distance from speaker where the STI falls below 0,20. This parameter is not included in the second edition.

Room conditions

According to the standard, the test report shall include a sketch of the room plan with indication of scale and, if relevant a section of the room. A drawing/floor plan showing source and receiver position is required. In ODEON this can be accomplished by making a simple model of the room e.g. in the 3D extrusion modeller.

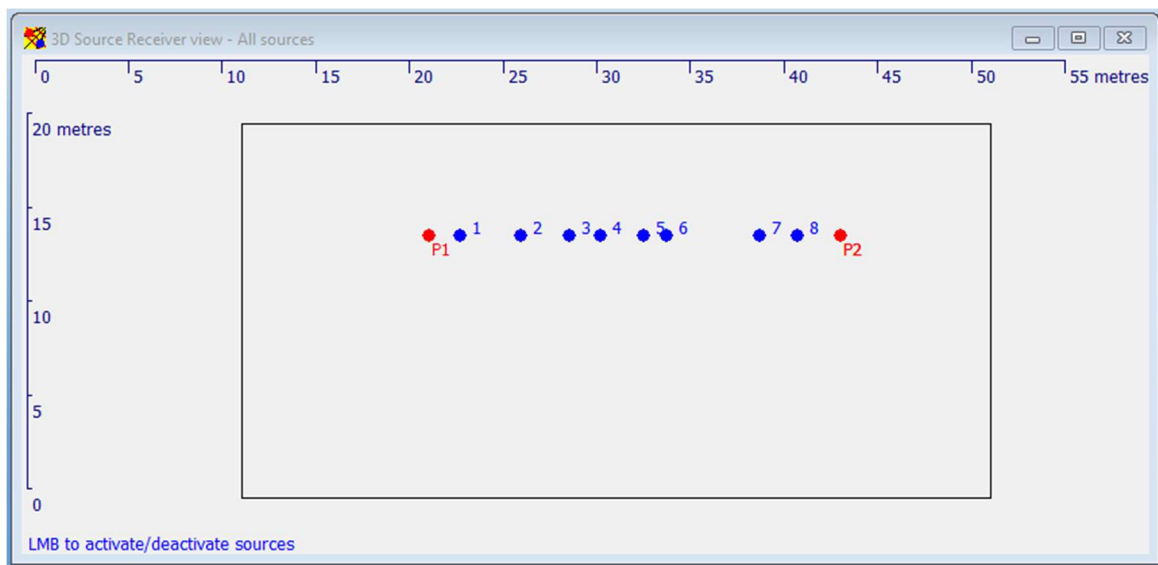


Figure 1. Example of simple room model used only to define relative position of sources and receivers.

The room model can be a simple box, big enough to contain the sources and receivers. The model needs not to include materials or furniture. It is suggested to assign material no 20 to all surfaces, or any other material; the absorption coefficients are not being used. An example is shown in Fig. 1.

Background noise

The background noise level is one of the important parameters in these measurements. It is applied for the STI calculations, and thus the background noise level has a direct influence on the distraction distance and the privacy distance. According to ISO 3382-3 the background noise shall represent the HVAC devices and other noise sources operating as during typical working hours. If the office is equipped with a sound-masking system, this shall be applied for the background noise. If the background noise varies with position, the average over all receiver positions shall be applied. Background noise in octave bands must either be measured with an ordinary sound level meter, or the data must be taken from the room specifications. The data shall be entered in the measurement setup, see the example in Fig. 2. It is not necessary to give data for the 63 Hz octave band, as this frequency band is not used for the simulations.

Background noise from people talking and other activities (the dynamic background noise) shall not be applied for the measurements in accordance with the standard, but it may be used for a supplementary calculation using the same measured impulse responses.

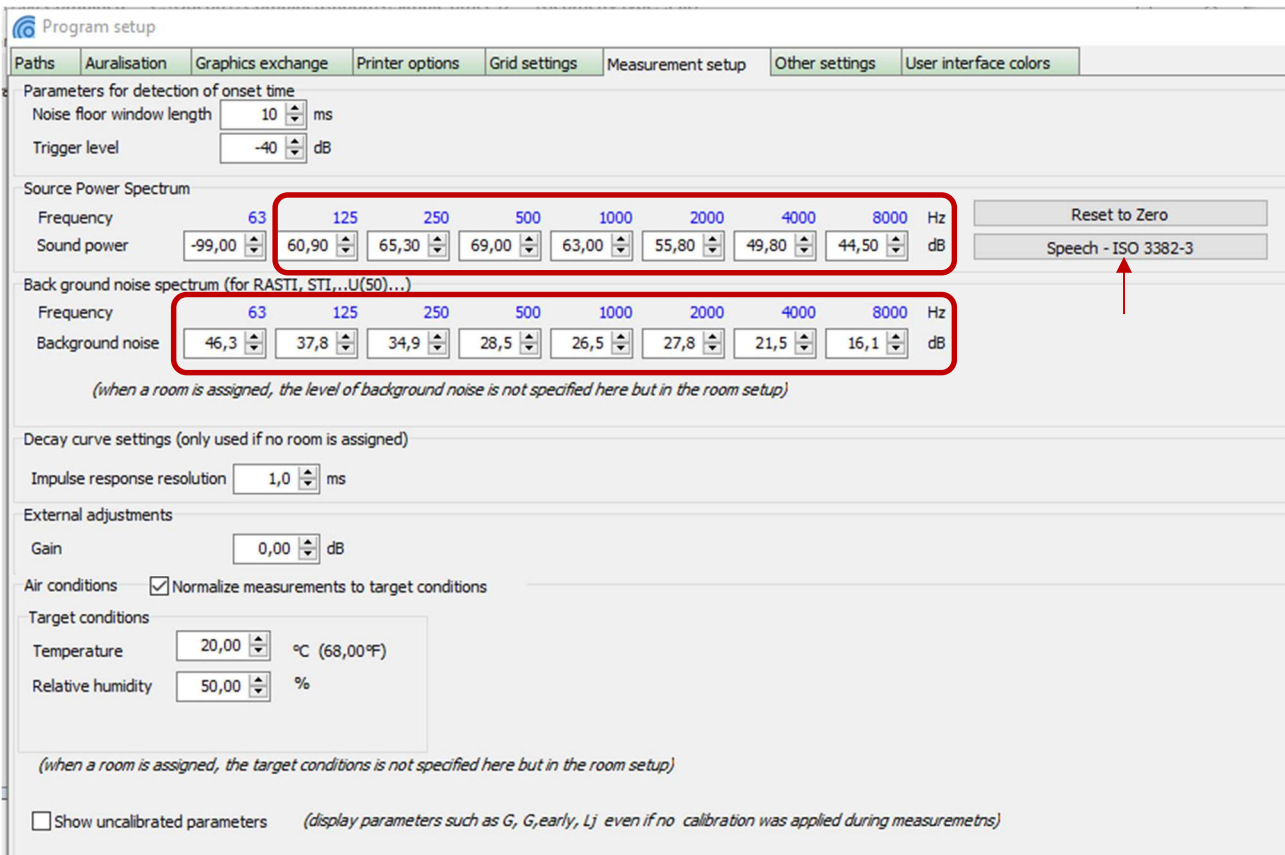


Figure 2. Measurement setup. The sound source with speech spectrum is selected, and the background noise entered in octave bands.

Sound sources

An omnidirectional sound source is used, and the spectrum and sound power is defined in order to represent speech at normal vocal effort. The spectrum is based on ANSI 3.5 [3].

The sound power is specified in octave bands from 125 Hz to 8 kHz. This is done in the Program setup/Measurement setup, see Figure 2.

At least two sound source positions shall be used. Each sound source shall be at the end of a group or line of receivers. The same line of receivers may be used twice with a sound source in each end of the line.

Sound sources are placed in typical workstations, and the height shall be 1.20 m above the floor, representing seated persons.

Receivers

The receivers are also located in typical workstations at a height of 1.20 m above the floor. The receivers shall be arranged in such a way that each group of receivers are related to one source position. Each group must consist of minimum 4 receivers, and preferably between 6 and 10 receivers approximately on a line. The workstation on the line that is nearest to the source shall be used for the first measurement position. The distance to the most remote receiver position depends of the size of the room; however, only positions within the range 2 m to 16 m are used for the determination of the spatial decay rate of speech. This is automatically managed by ODEON. NB: At least 4 receivers must be within the range 2 m to 16 m.

The groups of receivers are set up in the Job list/Multi point response parameters/3D sources and Receivers. NB: There must be one job for each sound source.

Calibration of sound source

The measurement equipment is put together, and a calibration of the sound source with the correct settings of volume controls and whatever has an influence on the emitted sound power. The reverberation room method is recommended; see the ODEON Application Note [4].

If a real reverberation chamber is not available, any empty room without sound absorbing materials may be sufficient. The volume of the room must be known. The procedure is very simple; just choose two loudspeaker positions and three microphone positions (none of them too close to walls or to the loudspeaker) and use ODEON to create a sine-sweep in each of the six combinations of positions. Keep these six impulse response files in a separate folder for easy access later on.

The calibration file to be used for the measurements is derived by clicking on Tools/Measurement calibration/Diffuse field. The one-step method is sufficient if the measurement chain is kept unchanged during all measurements. First **the volume of the reverberant room** must be entered, and then ODEON asks for the impulse response files to be used for the calibration, see Fig. 3.

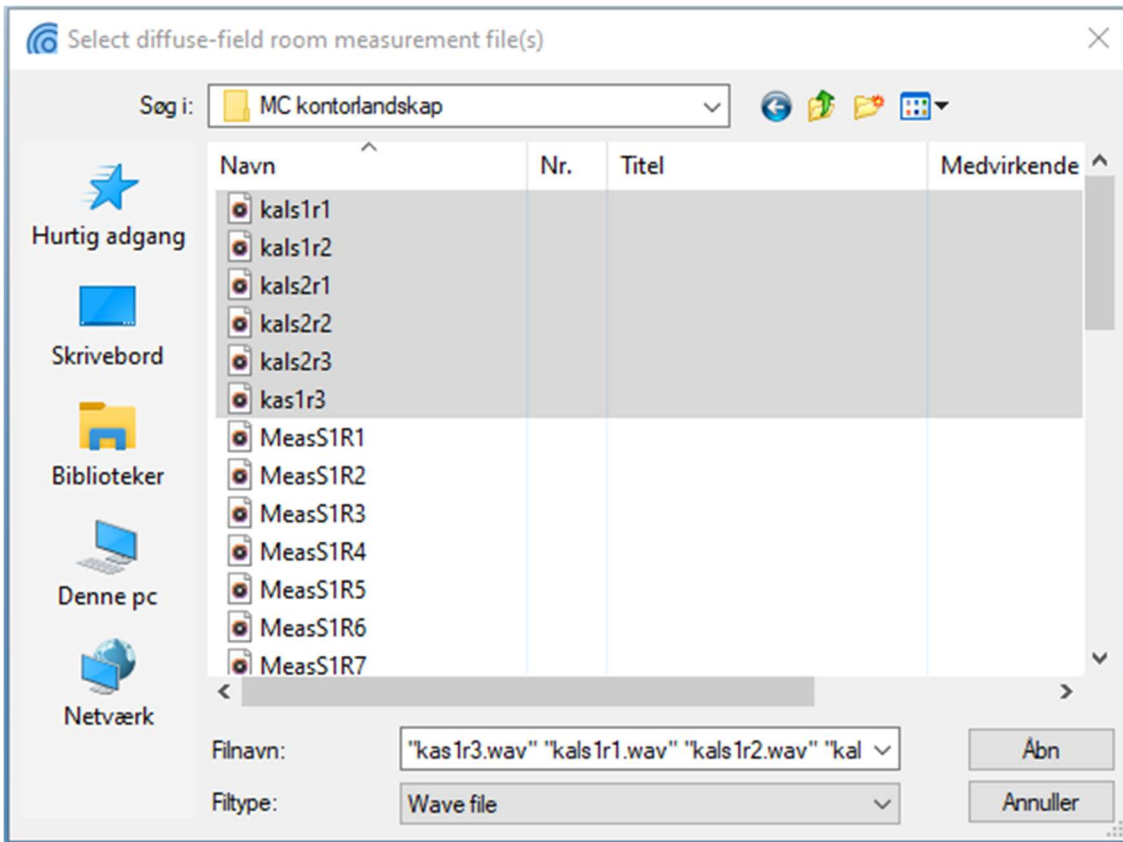


Figure 3. The wave files to be used for the calibration are selected (using Shift + left mouse key or arrow up/down to select subsequent files or Ctrl + left mouse key to select multiple individual files).

The selected impulse responses are loaded as a bunch and the SPL and reverberation times are automatically derived in order to create the calibration file, see Fig. 4. Finally, you are prompted to give the calibration file a name, so you can easily identify the file later on. (The calibration file is saved in the Application data folder, which is accessible from Options/Explore Application data folder/Calibrations).

You can make the calibration active from now on, or you can activate it later. If you want to apply the calibration after having performed the measurements in the office, this is done from Tools/Measurement calibration/Assign calibration to existing measurements.

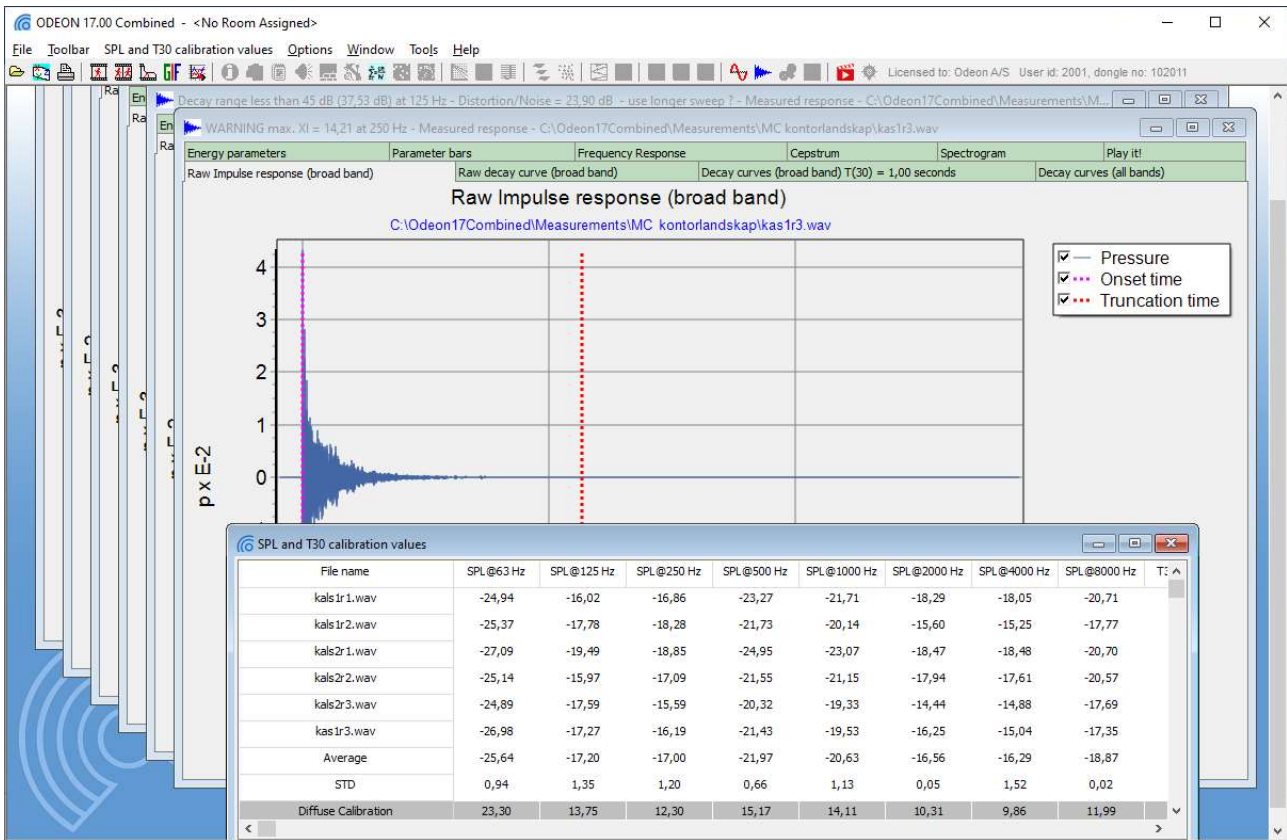


Figure 4. The bunch of wave files to be used for the calibration have been loaded and the calibration values have been calculated.

Measure impulse responses

When the equipment is ready in the open-plan office, put the sound source and the microphone in the previously selected positions and perform a sine sweep measurement in each position. It is recommended to name the wave files so that the source-receiver combination is clear, e.g. S1R1, S1R2, etc.

Import impulse responses to ODEON

When the measurements in the office are finished, the impulse responses are imported into ODEON as described in the following.

Open the Job list, select one of the jobs. Make sure the proper source is selected for that job (only one source in each job). Tick mark for Multi point response, and click on “View Multi point response”. See the example in Fig. 5.

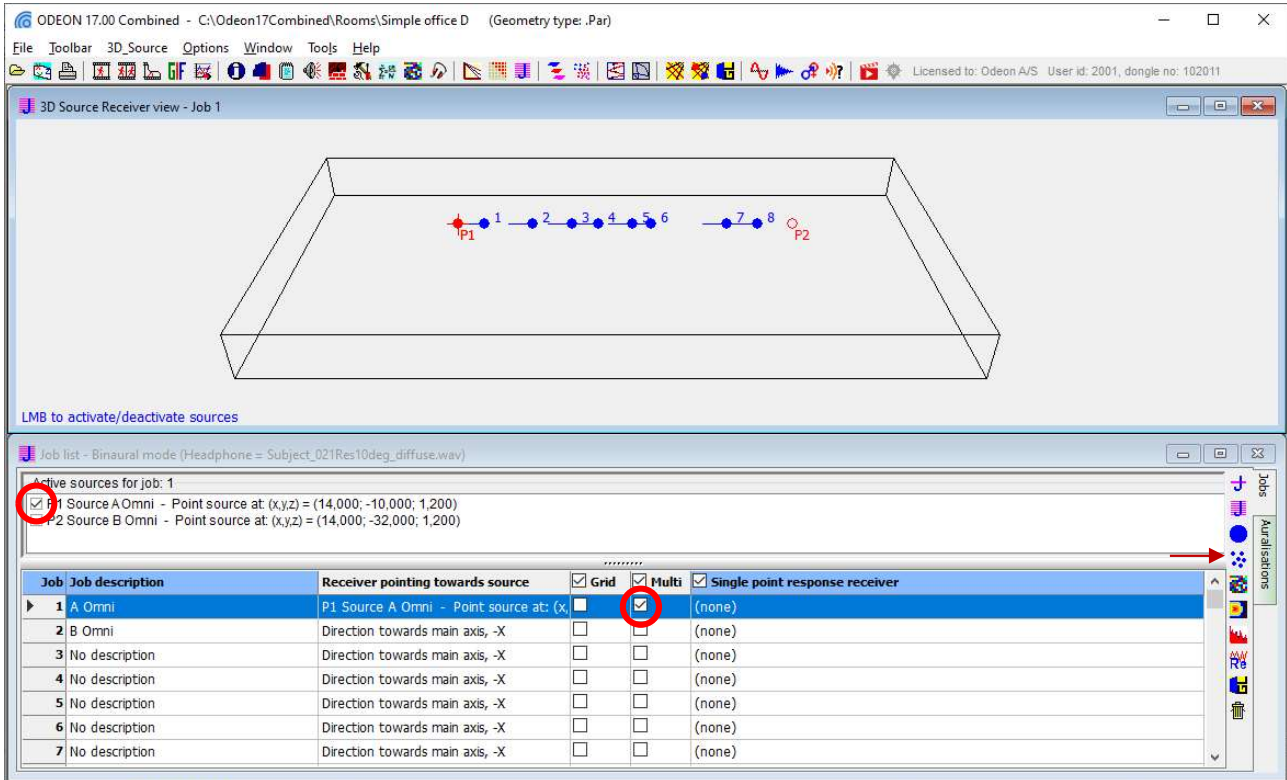


Figure 5. The simplified room model with source no 1 assigned to job no 1 and Multi point response activated.

Open the “Load impulse response” (Ctrl+Shift+L) and select the bunch of impulse responses measured with the source in the first job, see Fig. 6. Multiple files can be selected in the open dialog using Ctrl or Shift and Arrow key or Mouse.

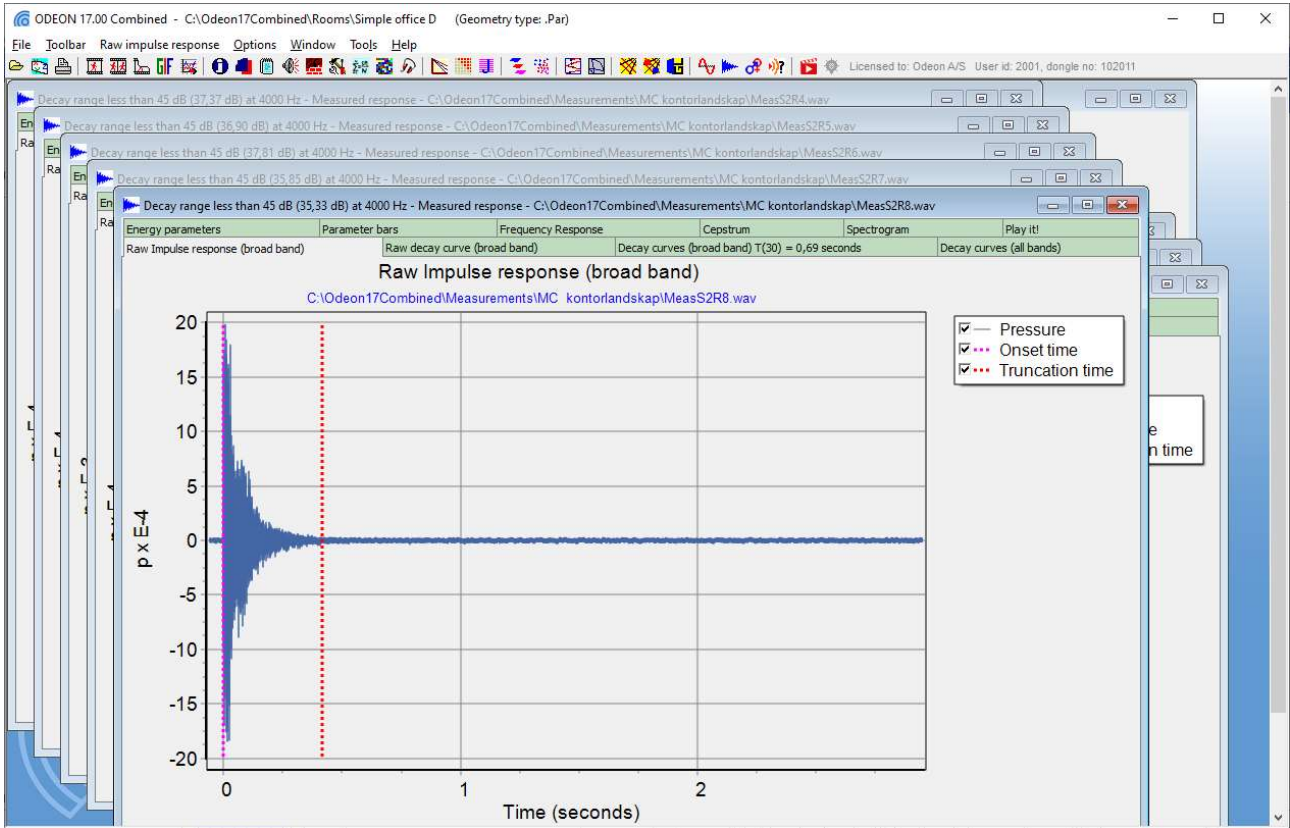


Figure 6. A bunch of impulse responses have been opened.

Now press Insert (or Ctrl+Insert) to assign each impulse response to a certain source-receiver combination, see Fig. 7. It is very important that each impulse response is assigned to the correct source-receiver.

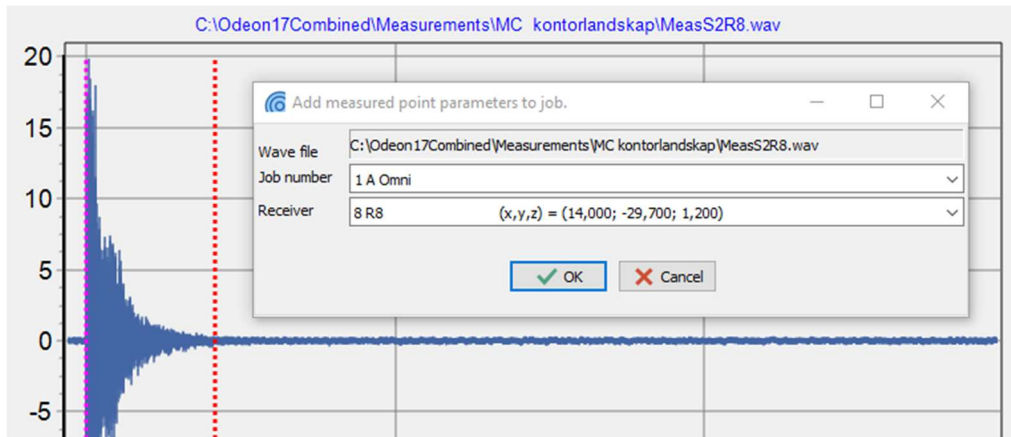


Figure 7. Make sure that the impulse response is assigned to the right job number (source position) and receiver position before clicking OK.

Results

From the Job list, the Multi point response is opened, see Fig. 5. Since no calculations have been made, the results shown are all related to the measurements.

In the Multi Point Response there are three windows with results that are relevant for the open plan office: Spatial Decay curves, STI versus distance, Energy parameters (see Fig. 8).

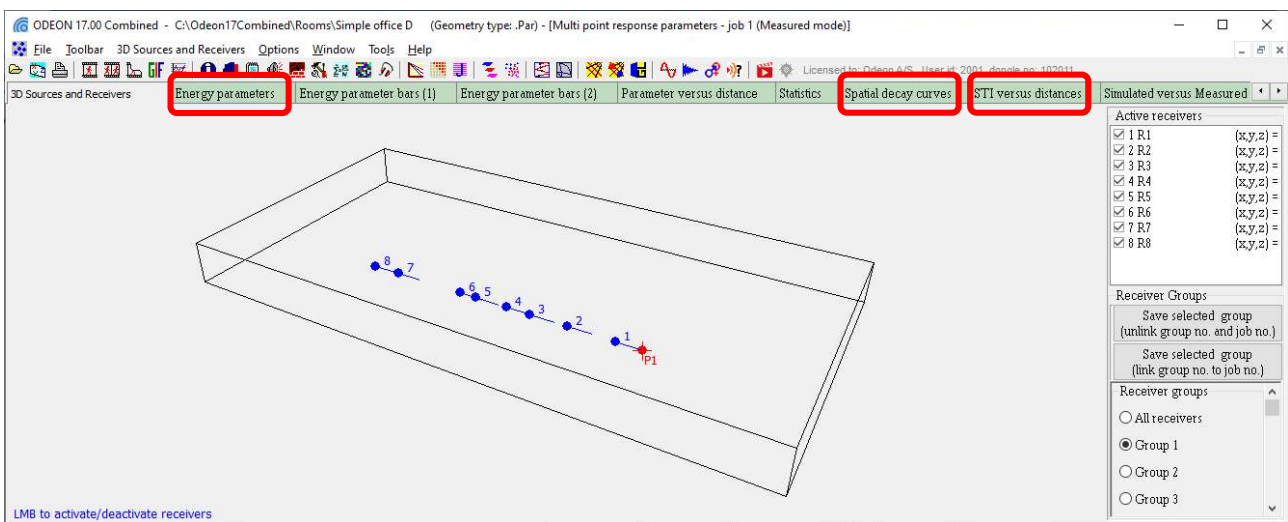


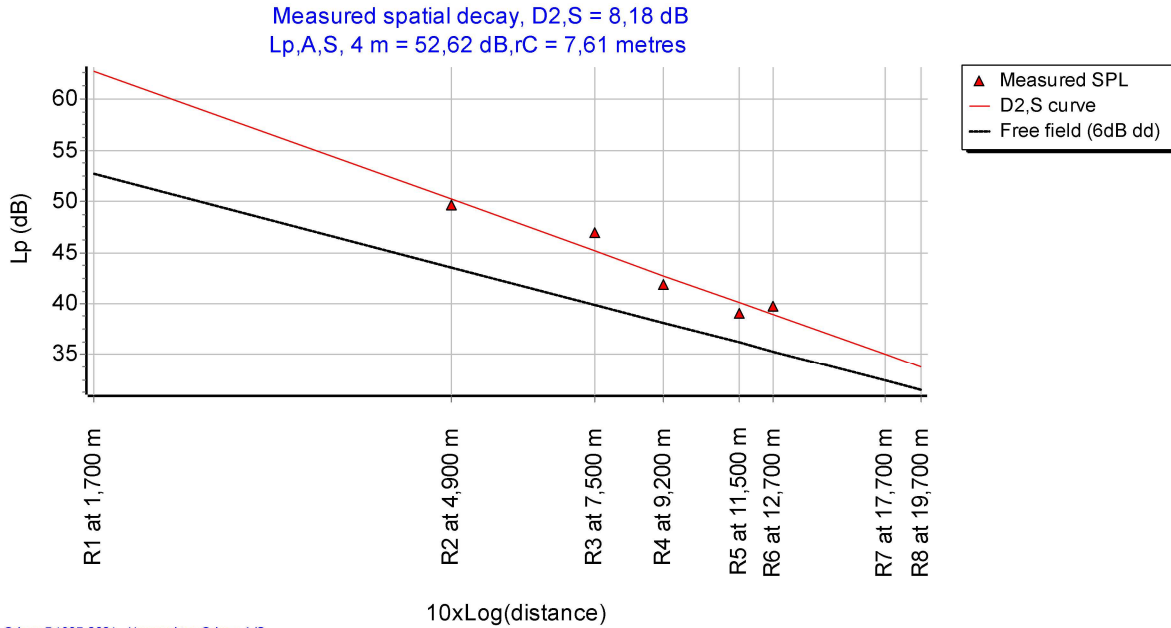
Figure 8. Multi Point Response. The results are displayed in the three windows marked in red.

Having selected the appropriate group of receivers (see above), the page with Spatial decay curves displays the spatial decay rate of speech and the two parameters derived from that curve, $D_{2,S}$ and $L_{p,A,S,4m}$. NB:

There are several spatial decay graphs on this page; use the up/down arrows to select the right graph for the $D_{2,S}$ parameter. An example is shown in Fig. 9.

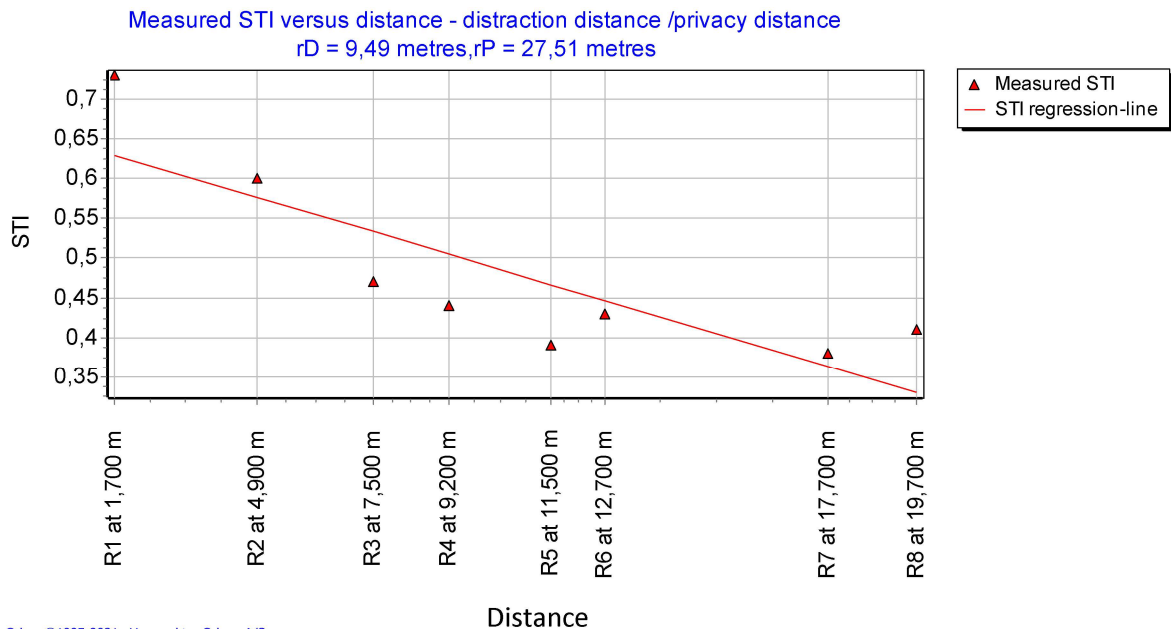
NB: Results will only show when one and only one point source is turned on in the job. In addition, none of the receivers in the selected group of receivers may coincide with the source position.

On the next page is a graph showing the spatial sound distribution of the STI parameter, and the regression line used to calculate the distraction distance and the privacy distance, see the example in Fig. 10. It is noted that the privacy distance can exceed the largest dimension of the room, typically in cases with no screens and low background noise. In cases with efficient screens and high background noise, it may occur that the distraction distance cannot be derived, simply because the STI values are below 0,5 in all distances from the source.



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Figure 9. The spatial decay rate of speech: Note that only receivers within the range from 2 m to 16 m are used for the calculation of the regression line. Receivers 1, 7 and 8 are outside this range. NB: There are several different frequency ranges available in this window; click arrow up/down to get this graph.



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Figure 10. The spatial sound distribution of STI and the regression line used to calculate r_D and r_P .

The page with energy parameters displays the results in each position and the statistics from the selected group of receivers. At the bottom is found the ISO 3382-3 parameters, see the example in Fig. 11. Use Ctrl + A to export the results to a text file, which can be further copied into a spreadsheet or a table in a document.

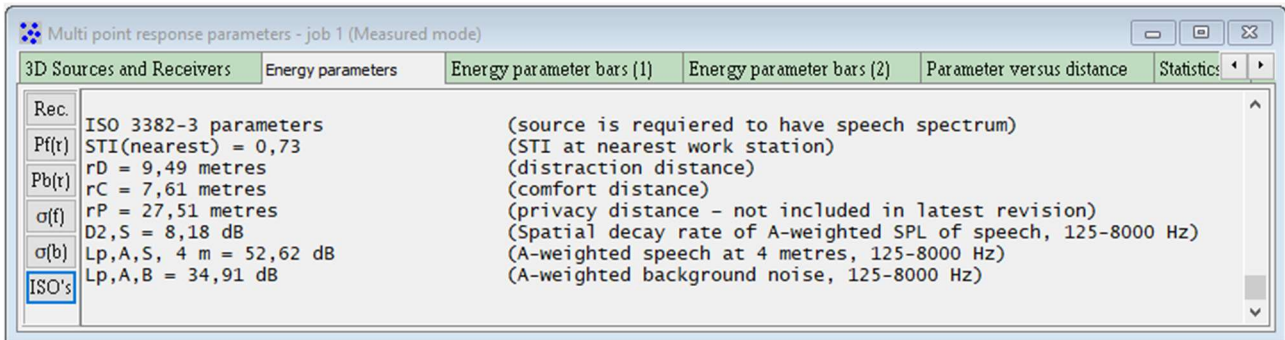


Figure 11. The results as they appear in the bottom of the page with energy parameters.

For the evaluation of results, Annex C of ISO 3382-3 provides some examples of target values, see Table 1. There is evidence from research that some of the parameters correlate well with the probability of being highly disturbed by noise in open-plan offices. The acoustical challenge is, that the design is an optimization problem with many dimensions. It is not a simple noise problem [5].

Table 1. Typical values of parameters in poor or good rooms.

Parameter		Poor	Good	Related to disturbance
Spatial decay rate	$D_{2,S}$	< 5 dB	> 8 dB	-
SPL(A) at 4 m	$L_{p,A,S, 4 m}$	> 52 dB	< 48 dB	Yes
Distraction distance	r_D	> 11 m	< 5 m	Yes
Comfort distance	r_C	> 11 m	< 5 m	-
Background noise	$L_{p,A,B}$	< 35 or > 48 dB	40 to 45 dB	Yes

References

1. ISO/DIS 3382-3:2021 Acoustics – Measurement of room acoustic parameters – Part 3: Open plan offices, Draft Second Edition. International Organization for Standardization, Geneva, Switzerland (2021).
2. J.H. Rindel and C.L. Christensen: Acoustical simulation of open-plan offices according to ISO 3382-3. *Proceedings of Euronoise 2012*, 10-13 June 2012, Prague, Czech Republic (2012).
3. ANSI 3.5-1997. *American National Standard – Methods for Calculation of the Speech Intelligibility Index*, (1997).
4. ODEON Application Note. Impulse Response Measurement Calibrations (2020).
5. J.H. Rindel: Open plan office acoustics – a multidimensional optimization problem. *Proceedings of DAGA 2018*, 19-22 March 2018, Munich (2018).