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IMMI

VDI 3760

Workplace Noise Module 2009

Calculation of Sound Propagation Indoors

Wölfel

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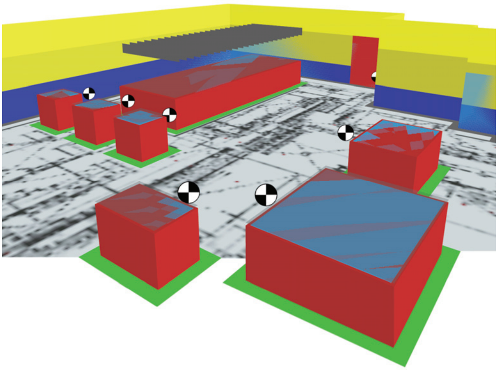

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1 Introduction & Preliminaries

IMMI is best known for its outdoors noise mapping and air-pollution modelling features. However, IMMI can as well be used to calculate indoor noise propagation. In fact, several features of the software have been developed with indoor noise propagation in mind. Indoor noise propagation is closely linked to industrial noise prediction. Both share the same calculation methods (with some additions for the indoor calculations) and many of IMMI's advanced features such as higher order reflections.

IMMI's indoor noise mapping is suitable for calculations in large industrial halls, factories and workshops. It is not suited for room acoustics applications in theatres, conference centres or business environments.

The present manual explains the use of IMMI's features for indoor noise mapping. Basically, the manual will focus on the following topics:

- Sabine's equations, the internal noise emission database and calculation of sound emitted outdoors from inside the building
- Designing industrial halls and using higher-order reflections
- Sound Decay Curves /SDC) according to VDI 3760

Calculation of sound propagation indoors requires the availability of the following features in IMMI:

- Industrial noise libraries such as ISO 9613-2, Handleiding Industrielawaai 1999, ÖNORM or MSZ….
- Frequency-dependent calculations
- Higher-order reflections
- External and internal databases
- VDI 3760 for sound decay curves
- The present manual has been first written for IMMI 2009. The user should at least have a license of IMMI Plus to use the features described in this text.

2 Empiric calculation of indoor sound pressure levels in large industrial halls: IMMI’s calculator for Sabine’s equation

2.1 Sabine Equation

Sabine's (empiric) reverberation equation establishes a relationship between the reverberation time of a room RT_{60}, its volume, and its total absorption:

$$RT_{60} = \frac{c \bullet V}{S \bullet a}.$$

where

- c is the speed of sound in the room (roughly 0.161 s/m),
- V is the volume of the room in m³,
- S total surface area of room in m²,
- a is the average absorption coefficient of room surfaces.
- The denominator of the fraction can also be written Sa. It is effectively the product of S * a giving the total absorption in sabins – a somewhat artificial unit that you do not have to care about as an IMMI user.

For a given room surface and volume, both reverberation time and total absorption are frequency-dependent. Neither the geometric shape of the room nor attenuation due to atmospheric absorption and distance are taken into account.

A major characteristic of room acoustics is the time reflected sound needs to decay by 60 dB below the level of the initial direct sound. This time is called the reverberation time RT_{60}. It is frequency- dependent. Given the above equation, Sa is linked to RT_{60} and thus the total absorption of a room is frequency-dependent. Most rooms absorb less in the lower frequency range, which results in longer decay times. A limitation of Sabine’s equation is that it does not take into account neither geometric shape of the room nor attenuation due to atmospheric absorption and distance traveled.

2.2 Sabine calculations in IMMI

Sabine calculations are part of the internal database. They are found in the menu “Projects | Internal database | Indoor level”. Here, in typical IMMI fashion, a list of indoor levels can be managed as shown below:

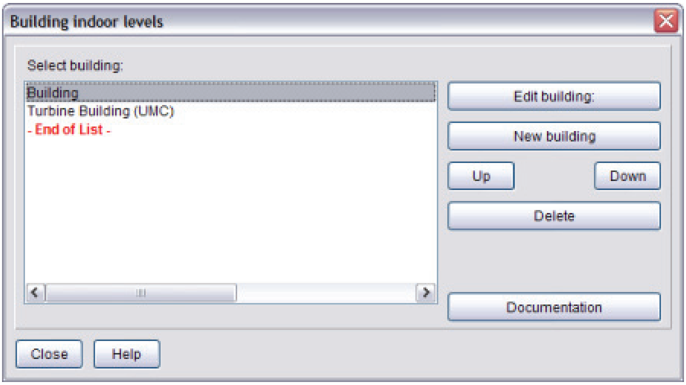
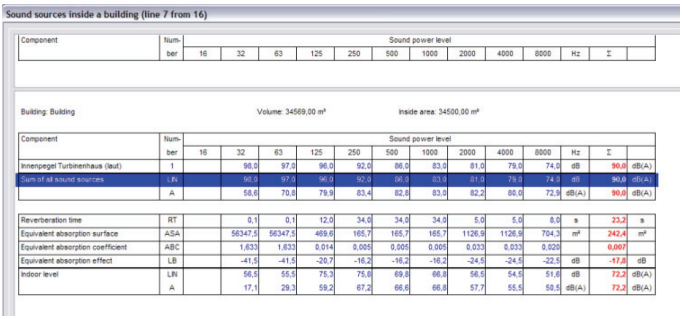


Figure 1 – List of indoor levels in the internal database

Creating a new building, an empty spread-sheet like table is opened. To edit data in the table, use the buttons at the bottom of the window.

- Use the button: “Insert from internal DB” to add sources to the room. The sources (with their respective sound power levels in octave bands) will be shown at the top of the table.
- Use the button: “Edit parameter” to modify the room data such as volume, surface, reverberation time or total absorption.



Sound sources inside a building (line 7 from 16)

Component	Num-ber	16	32	63	125	250	500	1000	2000	4000	8000	Hz	Σ	

Building: Building   Volume: 34569,00 m³   Inside area: 34500,00 m²

Component	Num-ber	16	32	63	125	250	500	1000	2000	4000	8000	Hz	Σ	
Innenpegel Turbinenhaus (laut)	1		98,0	97,0	96,0	92,0	86,0	83,0	81,0	79,0	74,0	dB	90,0	dB(A)
Sum of all sound sources	LIN		98,0	97,0	96,0	92,0	86,0	83,0	81,0	79,0	74,0	dB	90,0	dB(A)
	A		58,6	70,8	79,9	83,4	82,8	83,0	82,2	80,0	72,9	dB(A)	90,0	dB(A)
Reverberation time	RT		0,1	0,1	12,0	34,0	34,0	34,0	5,0	5,0	8,0	s	23,2	s
Equivalent absorption surface	ASA		56347,5	56347,5	469,6	165,7	165,7	165,7	1126,9	1126,9	704,3	m²	242,4	m²
Equivalent absorption coefficient	ABC		1,633	1,633	0,014	0,005	0,005	0,005	0,033	0,033	0,020		0,007	
Equivalent absorption effect	LB		-41,5	-41,5	-20,7	-16,2	-16,2	-16,2	-24,5	-24,5	-22,5	dB	-17,8	dB
Indoor level	LIN		56,5	55,5	75,3	75,8	69,8	66,8	56,5	54,5	51,6	dB	72,2	dB(A)
	A		17,1	29,3	59,2	67,2	66,6	66,8	57,7	55,5	50,5	dB(A)	72,2	dB(A)

Figure 2 – Frequency-dependent sound power levels of one source and calculated results

The following figure shows a more realistic situation of the noise situation inside a Turbine Building. The individual sound power levels of a total of twenty distinct sound sources have been entered. The room characteristics are shown in the small dialogue on the right-hand side (this is the dialogue that opens when one clicks “Edit parameters”). The lower part of the table shows all calculated results. Note that the calculated "*Indoor level*" on the last line of the table is a sound pressure level in dB with either linear- or A-weighting.

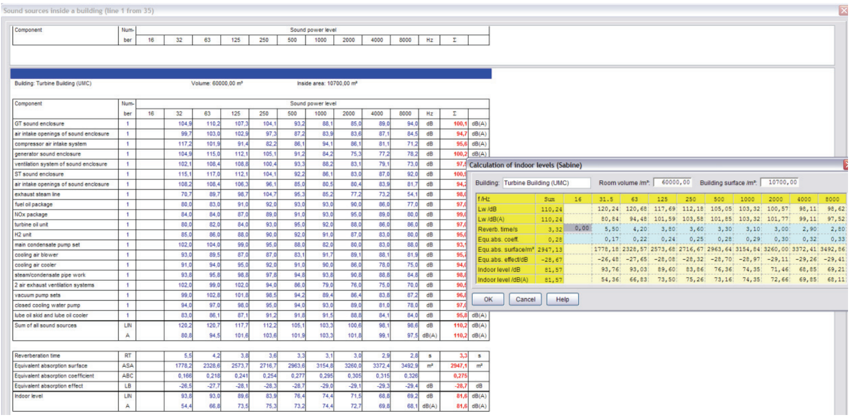


Figure 3 – Indoor sound calculation in a Turbine Building using Sabine's equation

The result is stored under the name of the building in the internal "indoor sound" database. The calculated indoor sound level can be used as an input value for the outdoors sound propagation of emitting buildings.

2.3 Indoor-outdoor transmission of sound

To enter data from the internal or reference database, you need to right click on the spectrum display window in the expanded input mask of the sound sources. From the pop-up select either "*Indoor level from internal database*" or "*Emission spectra from internal database*". Note that an indoor level always is a sound pressure level measured or calculated at 1 m inside from the external wall.

<u>**Note:**</u> In the case of sound power levels determined by means of sound intensity measurements <u>*outside*</u> the building the proper selection for "*Input data (emission) are …*" would be either "Sound power lev. per unit area" or simply "Sound power level" depending on how the sound power level was determined from the measurements. In the latter case, IMMI will apply a correction 10 log (wall area) to transform it into sound power level per unit area.

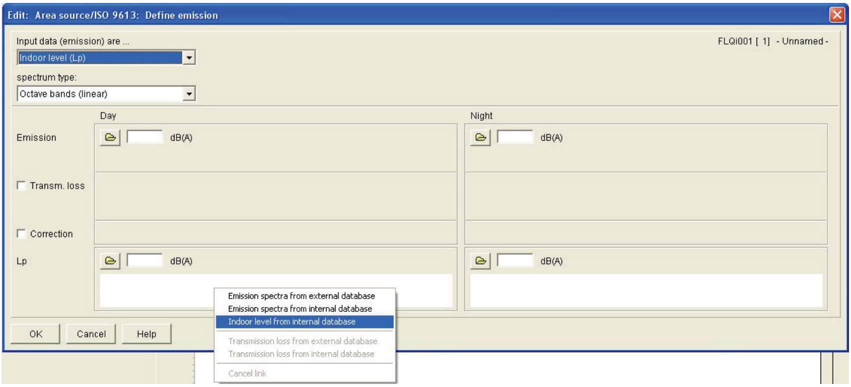


Figure 4 – Assigning an indoor spectrum to a sound source

The following text describes individual steps to model a sound emitting building.

For octave-band calculation, you need to activate octave band calculation in "Calculate | Calculation parameters | Calculation model" as shown below

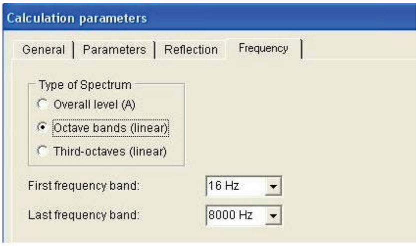


Figure 5 – Choosing the frequency range

Use a HLIN to draw the footprint of the building on the ground and close it (use IMMI functions to close the polygon, don't do it manually).

Open the element dialogue of the HLIN: on the lower left-hand side a button reads "*Erect building*". Click the button.

In the dialogue fill in all required data: bottom and top height of the cuboid, whether a height contour should be drawn at the bottom height to make the building stand upright, whether you want to model a roof, whether you want to close the selected footprint polygone, etc.

In the dialogue select ISO 9613-2 from the list of source types

Hit "OK", read and (if everything is fine) confirm the next message

Go to the element list and select ISO 9613-2 library; there go to the area elements.

If you have ticked the "*Generate area sound source 'roof'*" previously (see above), there should be one area element for the roof (DACH).

Double click the element to open the dialogue

Go to the noise emission input mask; make sure "*Level input:* " is set to "*expanded*"; observe the settings below, especially "*Indoor level*" and spectrum type. Tick "*Transm.loss*" as shown below. Then click the folder-icon next to it.

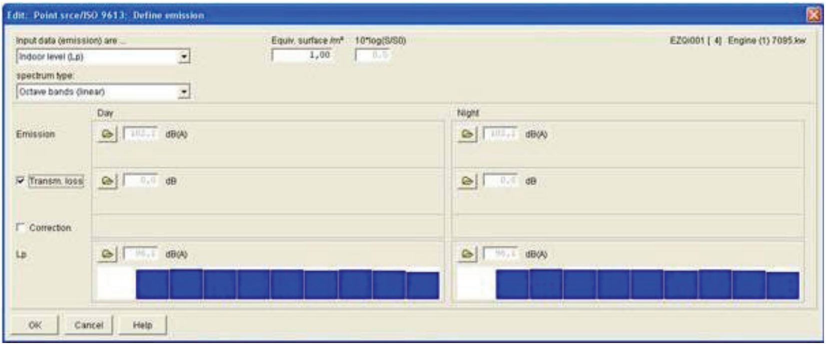


Figure 6 – Transmission loss

The input dialogue for the transmission loss spectrum opens. Fill in your data as shown below (here only part of the spectrum have been entered). Click OK.

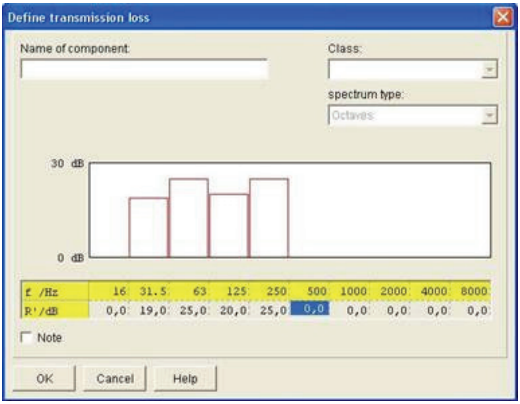


Figure 7 – Entering a transmission loss spectrum manually

Click the folder icon next to "Emission". A mask similar to the previous one opens. Enter here the frequency spectrum of the indoor sound pressure level measured at 1m from the roof (idem later for all other walls).

Repeat the above for all external walls.

<u>What does IMMI actually do?</u> Using the footprint (i.e. a closed polygone drawn with a help line HLIN) and the user specified building height, a building element (HAUS) is erected. For each external wall and - if desired by the user - for the flat top roof of the building individual area sources are generated at a very small distance outside the HAUS-element. These elements are the active sources. Their emission characteristics depend on data entered by the user for both sound emission levels and transmission losses. Furthermore, source directivity can be defined for each active source individually by the user. To simplify the task, IMMI offers a pre-defined directivity for radiating building walls. If desired by the user, an additional reflecting element is generated for the roof (this makes sense only if at least one receiver can be found at a position where it is likely to have a contribution by reflection of the sound beam emitted by a different sound source on the roof of the building; i.e. only in very special cases).

3 Propagation calculation inside large industrial halls

In addition to using the empiric Sabine's equation, one can use IMMI standard sound propagation methods such as ISO 9613-2, Handleiding Industrie 1999, etc. to calculate the actual propagation inside a confined space.

Note: Due to their inherent limitations, the current calculation methods (ISO 9613-2, …) are not suitable for room acoustics or calculations in small rooms. Neither may they be used to optimise the sound ambiance of a theatre or of a conference room. Nevertheless, if properly used, these methods can be used to great effect inside large industrial halls, factory floors and workshops. To determine whether a hall or room is large enough, a general rule of thumb might be that all dimensions of the room must be larger than 2 times the wavelength of the lowest frequency of interest.

Further to using sound source elements from an industrial noise calculation method, elements of the library "Standard" are used to model the building walls, roof and floor. Reflection must be activated on all of these elements. Absorption coefficient of the wall, roof and floor elements must be known and specified.

Higher-order reflections will be used. Here no fixed rule can be given. Anything below 3rd order reflections is unreasonable. Good guesses would be between 5th and 10th order reflections, even though IMMI would allow for the most demanding cases to go up to reflections of 25th order.

3.1 Erect industrial halls

For IMMI, an industrial hall is a confined space. It is enclosed by wall or reflecting elements in all spatial directions. A macro function enables the user to easily generate these elements and to set their respective reflection attributes. The same macro function helps generating baffle ceilings composed of vertically suspended reflecting elements.

You can find the macro function at the following two locations:

- Extras |VDI3760 | Erect industrial hall, and
- in the input dialogue of the helpline (HLIN) element: button *Erect industrial hall.*

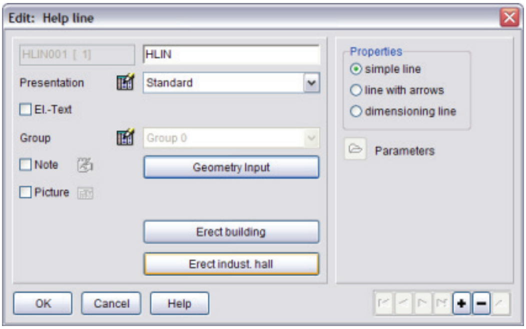


Figure 8 – Input dialogue of a helpline with the button „*Erect indust. hall*"

To use the macro function, first the footprint of the hall must be drawn using a closed help line. Basically this is juts a closed polygon drawn using a help line. The footprint may be complex, but simplification by means of approximation by rectangular elements is recommended. The shape of the building may be of more complex nature if actual sound source elements are used (such as ISO 9613-2 point sources). However, modelling of the building shape should keep the actual characteristics of the calculation methods in mind. A first good indicator for sensible simplifications is that walls will act as reflectors only if their horizontal dimension is not smaller than wavelength. For the purpose of sound decay curve calculations according to VDI 3760, the shape of the building should be approximated by means of rectangular forms. If the macro function is called from within the input dialogue of the help line element, this particular help line is used as the building footprint. If the macro function is called from within the menu *Extras*, a help line must be chosen using the button "*Select footprint*".

Name	Reflection	DRefl. inside / dB	DRefl. outside / dB
Hall ceiling	Yes	1.00	1.00
Floor	Yes	1.00	1.00
Wall 1	Yes	1.00	1.00
Wall 2	Yes	1.00	1.00
Wall 3	Yes	1.00	1.00
Wall 4	Yes	1.00	1.00
Baffel area 1	Yes	1.00	1.00

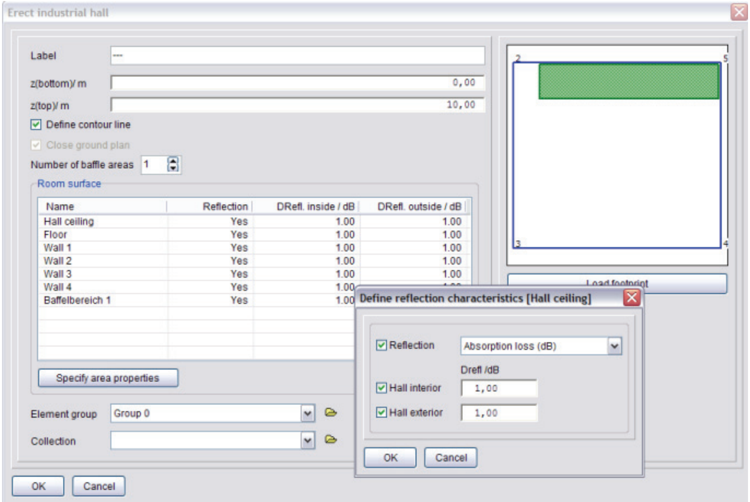


Figure 9 – The dialogue to erect an industrial hall

Label:

This free text will be used to generate the names of the different elements.

z(bottom) /m and z(top) /m:

These two parameters define the lower and upper edge of the wall elements. The roof element will be put at z(top) and the floor element at z(bottom).

Define contour line:

Uses the geometry of the footprint to generate a height contour. The z-coordinate will be set to z(bottom). In case of uneven terrain, this will make sure all side walls will be perpendicular to the terrain altitude z(bottom).

Close ground plan:

Closes the polygon delimiting the building footprint.

Number of baffle areas:

In an industrial hall sound control can be locally achieved (i.e. in several separate areas) by means of one or several areas where sound baffles are suspended from the ceiling. Sound baffles are vertically suspended highly absorptive reflective elements with equidistant spacing parallel to a room direction. In a first step, the user simply defines how many areas are equipped with baffles.

Surfaces:

Here you find a list of both the hall's confining surfaces (walls, roof and floor) and the areas equipped with baffles. The reflection characteristics assigned to each surface are shown. At this point, these elements do not yet exist: they will be generated in a subsequent step.

Double-click an element to edit its reflection characteristics. The following dialogue opens:

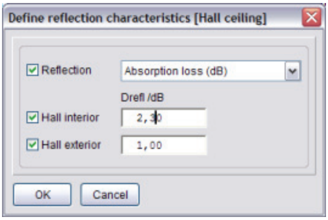


Figure 10 – Defining the reflection characteristics of an element of the industrial hall

Defining a baffle:

A double-click on an area equipped with baffles opens the dialogue to define the set if baffles installed in that particular area. The user can define both: the position and the size of the baffles.

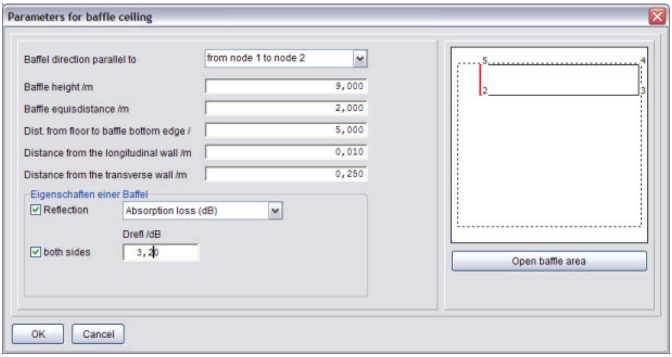


Figure 11 – Dialogue to edit the parameters of baffles

Basically, sound baffles are modelled in three steps:

1. Select the area where the baffles are installed.

Use the button “Open baffled area” to make a selection. This selects a help line that delimits the area for the baffles.

2. Define the position and the size of the baffles

Baffle direction parallel to:

Baffles will be positioned parallel to a reference section of the polygone.

Baffle height:

Height of the baffles in z direction.

Baffle distance:

The horizontal distance between two baffles.

Distance between the hall floor and the lower edge of the baffle:

Horizontal position of the baffle

Distance to the longitudinal wall:

Distance to the baffle that is closest to the reference section.

Distance to the transverse wall:

Distance ***between*** the baffles and the wall that is perpendicular to the reference section.

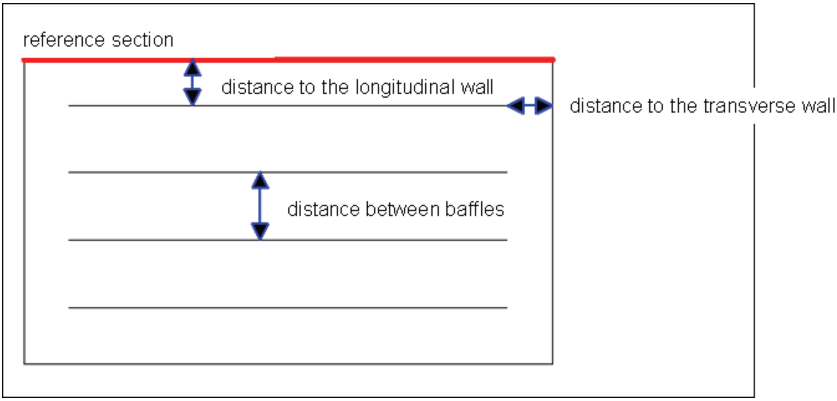


Figure 12 – Illustration of the different distances

3. Reflection/absorption characteristics

Define the reflection characteristics of the baffles here.

All baffles occupying the same area have identical reflection/absorption characteristics.

Both sides of a baffle have identical reflection/absorption characteristics.

Define characteristics of the area:

This button has the same effect as double-clicking on any of the entries in the list of surfaces and areas equipped with baffles.

Element groups and collections:

Select an element and/or a collection and all elements generated will be assigned to this element group and/or collection.

3.2 Calculation of noise levels inside industrial halls

Once an industrial hall has been modelled using the above function *Erect industrial hall*, the user must add sound sources and obstacles inside the building. This can be done using elements from calculation method libraries such as ISO 9613-2 and from the *Standard* library.

Finally, a grid or one or several receiver points must be defined. The calculations can then be started from the *Calculation Control Centre*.

3.2.1 Adding sources

Point, line and area sources can be used inside buildings. The use of octave or third-octave band data is recommended. Note that the acoustics features of a room of any size will vary over the frequency range.

The sound power levels of sources can be taken from the external database. IMMI's external databases contain numerous sound power levels. Many of the sound power levels are encoded in octave bands. Two ways of using sound power levels from the external databases:

- They can be copied to the internal database. Entries in the internal database can be linked to individual sources: this comes in handy when several sources share the same sound power level and frequency distribution. Linked spectra may not be altered in the input dialogue of the source element. They can be altered centrally in the internal database only.

- They can be copied into the input dialogue of sources. You can choose to use them "as is" or to modify them locally in the source. Note that from within this source-related dialogue you'll just modify the copy of the sound power spectrum in the source, not the entry in the database.

- If you have your own sound power spectra, you may want to add them to either the external database where they are available for all subsequent projects or into the internal database if you wish to restrict their use to one specific project. To import your data to the external database, you may use copy and paste operations from your spreadsheet software. Make sure the spectra are formatted the right way. Finally sound power spectra may be entered manually in the input dialogue of sound source elements.

3.2.2 Adding obstacles

Obstacles are machines (which may also be sources), walls, solid cubicles, and other hard solid objects with a surface density of at least 10 kg/m² and no gaps or fences and a horizontal dimension larger than the wavelength (the frequency dependency of this condition is checked by IMMI).

All obstacles should have "Reflection" activated and absorption characteristics properly specified.

Caution:

- Do not create source enclosures: current noise calculation methods do require free propagation conditions in the near field of the source. The enclosure will be inside the near field at least for the lower frequencies.

- Do not create multi-room situations! The idea is to have a single large hall including sources and obstacles.

3.2.3 Adding receivers and grids

Individual receivers are freely positioned by the user. Their position is given by a unique (x,y,z) coordinate inside the building. There is no limitation as to the number of individual receivers in a project.

Grids are defined as usual in the menu "*Calculate | Definition*". To ensure that grid points are calculated inside the building only,

- either make sure the grid fits inside the industrial hall,

- or design a *land-use area (NuGe)* of the size and shape of the footprint of the industrial hall and activate "*land-use only*" in the grid definition dialogue.

3.2.4 Calculating noise levels

All calculations – whether for grids or for single receiver points - are started as usual from the *Calculation Control Centre*. All of the usual functionality for grids and receiver points are available.

4 Sound Decay Curves (SDC) according to VDI 3760

4.1 VDI 3760

VDI 3760 is a German standard. It describes methods to calculate and measure sound propagation in workshops. It can be used to determine sound pressure levels in workrooms from sound power levels of machines and other noise equipment. It can be used in all rooms of roughly cubic form.

The central element to assess noise levels inside the workroom is the sound decay curve (SDC). VDI 3760 considers that the sound levels in any point of the curve are the result of direct sound propagation, sound reflected on the outer enclosures of the confined workroom space, and contribution from scattered noise. In VDI 3760 the scattering is taken into account using a statistical approach. Contributions from direct sound and reflected sound can be calculated. Image sources are used to model reflected sound.

VDI 3760 describes equations to calculate SDCs in octave band spectra. The sound power levels of the source must thus be specified in octave band spectra.

4.2 Calculation of sound power levels of indoor noise sources

This function calculates the sound power using the enveloping surfaces method. To access this function click ***Extras/VDI3760/Determine sound power levels.***

This method is based on EN ISO 3744. It uses the enveloping contour method to calculate sound power levels of point sources. For further details regarding the method please refer to EN/ISO 3744.

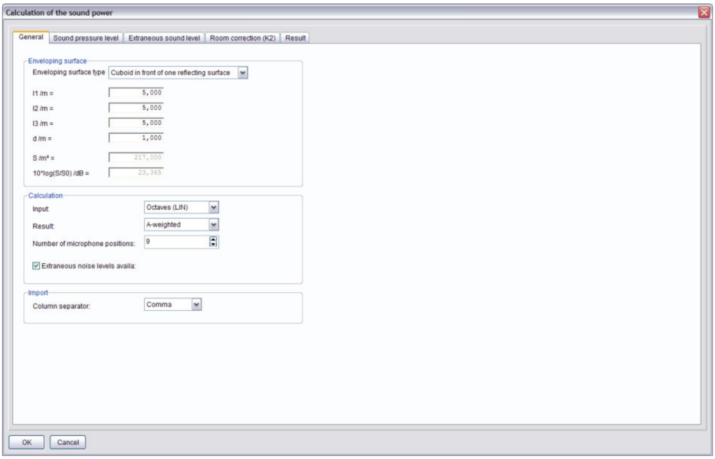


Figure 13 – General parameters to calculate sound power levels

The calculation of the sound power needs a set of general parameters first.

Enveloping surface:

The position of the sound emitting equipment under test relative to reflecting walls and the floor is specified.

- Cuboid in front of a reflecting surface
- Cuboid in front of two reflecting surfaces
- Cuboid in front of three reflecting surfaces
- Hemispheric measurement surface
- Enter measurement surface manually

Data to define the enveloping surface:

- Measurement surface is a cuboid: length (l1), width (l2) and height (l3) and the distance to the microphone (d) in meter.
- Measurement surface is a hemisphere: radius r.

In the two cases of cuboids and hemispheres the measurement surface is calculated from the user-specified data and cannot be altered.

The actual measurement surface can be entered directly if the selected type of enveloping surface is *Enter measurement surface manually*.

Calculation parameters:

Select the type and form of the following parameters: *sound pressure level, extraneous noise*, and *room corrections (K2)*.

Set the weighting to be applied: A-weighted levels, third-octaves linear, third-octaves A-weighted, octaves linear or A-weighted.

Calculated results

The calculated results can be *A-weighted* or *linear*.

The selection made for the *Calculation parameters* determines whether overall A-weighted, octave band or third-octave band will be calculated.

Number of measurement microphones

The number of measurement microphones is determined. The algorithm can work with a maximum of 25 microphone positions.

Presence of extraneous noise

The setting determines whether the calculation takes into account extraneous noise. Only when activated the user-specified extraneous noise will be taken into account (and it is mandatory to enter extraneous noise if the setting activated). If no information regarding extraneous noise is available, the setting can be deactivated.

Import column separator

Measured sound pressure levels and extraneous sound levels can be imported from text files. Select the column separator here.

Enter sound pressure and extraneous noise and room correction

Use the different tabs of the dialogue to enter all relevant data. For each microphone position either overall A-weighted levels, octave band levels or a third-octave band levels must be entered.

The input data can also be *imported* from a text file. Individual values must be separated by using the separator specified under *Import column separator*. The decimal separator is always a point.

The files must contain complete third-octave or full octave spectra. If a single (or several) band is not available, use -99 as the substitute.

Example of an octave level file (here for 5 microphone positions):

(In this example, the sound levels in the 16 Hz octave band are unknown and subsequently they are all set to -99.)

-99,56.3,73.4,61.0,55,66.8,69.2,71.22,53.02,52.8

-99,51.3,73.4,62.0,55,66.8,69.2,71.22,53.02,52.8

-99,52.3,73.4,63.0,55,66.8,69.2,71.22,53.02,52.8

-99,59.3,74.4,67.0,55,66.8,69.2,71.22,53.02,52.8

-99,58.3,72.4,64.0,55,66.8,69.2,71.22,53.02,52.8

Use this button to save the input data in a text file. The data are stored in a format compliant with the above specification of the import file.

All calculated sound power levels will be shown on the tab *Results*.

Use this button to import the calculated result into the external database of emission spectra. This database is shared by all projects and the saved spectrum will be available there for further use.

The identifier assigned to the input data will be used to identify the calculted sound power level in the external database.

Use this button to *save* the result in a text file. This file is compliant with the above specification of the import file.

4.3 Calculating Sound Decay Curves with IMMI

IMMI enables the user to calculate sound decay curves (SDC hereafter) according to VDI 3760. For further theoretical information regarding SDC, please refer to VDI 3760.

4.3.1 The element SDC

To calculate sound decay curves, at least a single SDC-element must be present in the project.

This is the button of the element SDC in the *Standard* library. Click this button to enable drawing of SDC-elements in *Design* mode.

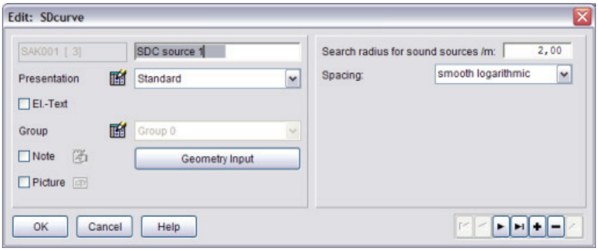


Figure 14 - Element dialogue of an SDC-element (sound decay curve)

An SDC-Element is a straight line element with just two nodes.

The SDC is calculated using the following equation:

$$SAK_k = L_{p,k} - L_W$$

where:

- SAK_k: the value of the sound decay curve at the plot-point k
- $L_{p,k}$: the sound pressure level at the plot-point k of the sound decay curve
- L_W: the sound power level of the point source at the first node of the sound decay curve

Each SDC-element needs a point sound source in close vicinity to its first node. This point source is the only source that will be taken into account to calculate the plot-points of the sound decay curve and this independently of the number of other sound sources available in the project. To determine the closest point source the *search radius for sound sources* is used. The first point sound source located inside the search radius centred on the first node of the SDC-element will be used for the SDC calculation.

The position of the plot-points k of the SDC is determined by means of the parameter *Spacing*:

Discrete constant

Distance of the plot-points from the first node in meter:

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 28, 32, 36, 40, 44, 48 etc.

Smooth logarithmic

Distance of the plot-points from the first node in meter:

1, 2, 3, 4, 5, 6.3, 8, 10, 20, 30, 40, 50, 63, 80, 100, 200 etc.

According to BGI 797

Distance of the plot-points from the first node in meter:

0.75, 1.5, 3, 6, 12, 24, 48 etc.

Hint

An SDC-calculation according to VDI 3769 should be done in octave bands and preferably for the frequency bands between 125 Hz and 4000 Hz.

4.3.2 SDC calculation

SDC calculations are fully implemented into IMMI's Calculation Control Centre (CCC). SDC calculations have been added as a further calculation mode.

The menu *Extras* of the CCC contains special functions to evaluate SDCs.

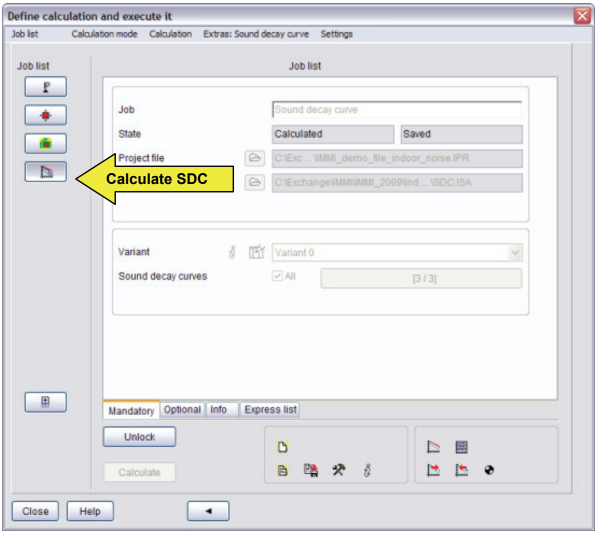


Figure 15 – The Calculation Control Center with the SDC button

Hint:

SDCs can only be evaluated and displayed from within the CCC. It is not possible to show map-like presentations in the site map.

4.3.3 Diagram view of SDCs

The calculated or imported (see below) SDCs can be viewed graphically in a diagram. To access this function use either

- the following menu from the Calculation Control Center dialogue: *Extras: Sound decay curve* | *Show*, or
- the button  from the lower right frame of the dialogue.

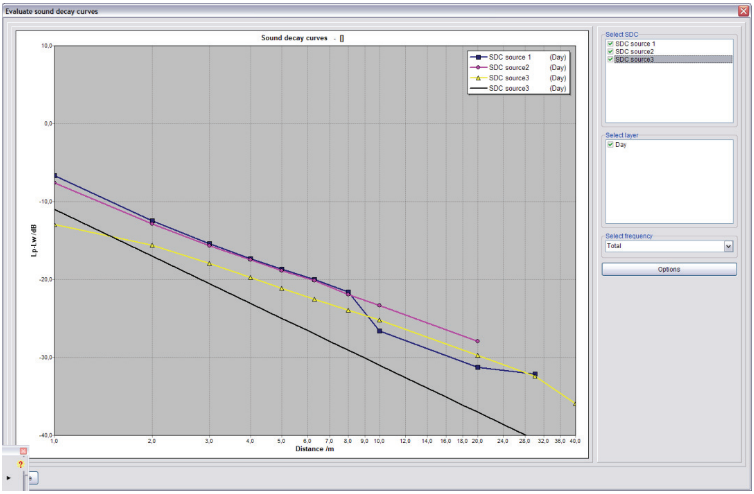


Figure 16 – Typical SDC diagram with several sound decay curves

All SDCs calculated within a task list can be displayed simultaneously. Furthermore, the SDCs of all layers (or rating periods) can be shown simultaneously. To do so, please mark the desired SDCs in the two selection lists *Select SDC* and *Select layer*.

For frequency-dependent curves, either a particular frequency band or the complete curve according to VDI 3760 equation 12 can be displayed. The same frequency bands are always shown for all curves.

The button *Options* gives access to a further set of diagram parameters.

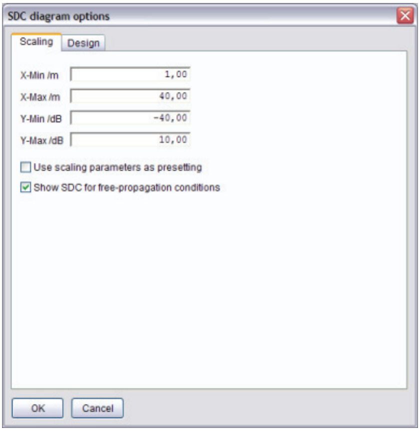


Figure 17 – optional parameters to display SDCs

The following selections and settings can be made on the tab “Scaling” (the tab shown in the above figure):

XMin, XMax, YMin, YMax

Determines the scaling of the diagram. These settings apply to the diagram currently shown only.

Use scaling parameters as pre-settings

If the chosen scaling parameters should be used for all following diagrams, then this setting must be activated.

Show SDC for free propagation conditions

Tick the checkbox to get an additional SDC displayed in the diagram: SDC in case of free propagation conditions. This is meant to provide a means of comparing the true SDC calculated for of a given room with an SDC for the same source in free propagation conditions, i.e. only the distance attenuation will be calculated ignoring reflection, absorption and screening effect.

The second tab of the options dialogue is called “Design”. It mainly gives access to colour settings and to the diagram editor:

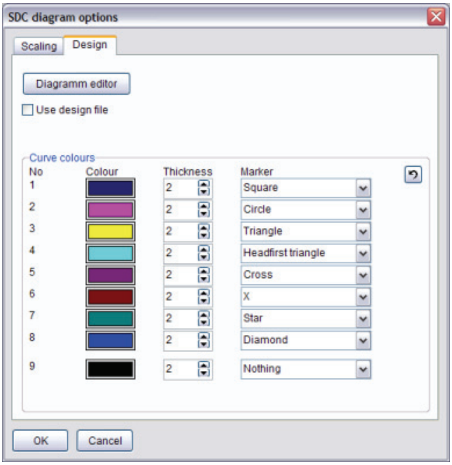


Figure 18 – The tab “Design” of the options dialogue

Diagram editor

Starts the diagram editor.

Use design file

The settings of the diagram editor can be saved to a file using the function *Save design* from the local menu. Tick "*Use design file*" if you wish to reuse the settings for subsequent diagrams. Make sure to enter the name of the proper design file in the line just below the setting.

Curve colour

Curve colour, lines thickness and marker types can be saved for eight distinct curves. This definition applies to all diagrams.

Colour, thickness and marker of curve nine are reserved for the SDC in free propagation conditions (only used if this curve is actually displayed).

Use this button to reset colour, thickness and markers for all nine curves to the default values.

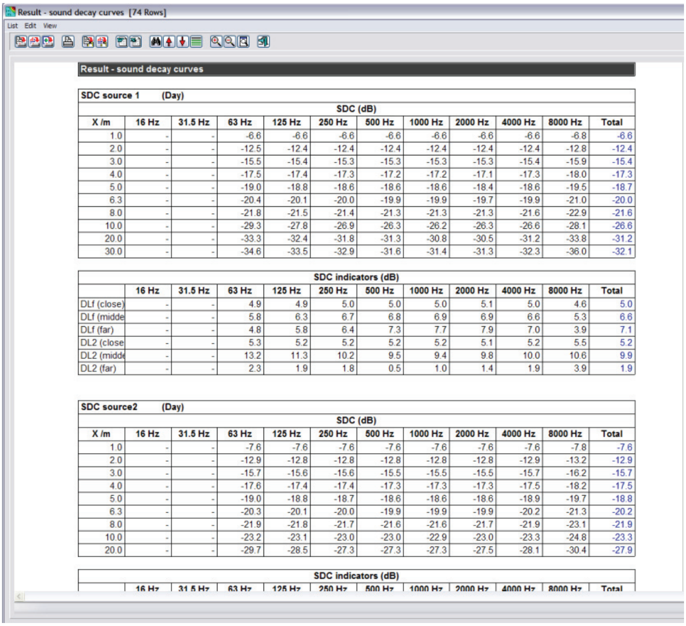
Hint:

Curves of distinct layers (i.e. rating periods) will all use the same colour but will differ in line style: straight, dotted, broken, etc.

These line styles cannot be chosen or altered by the user.

4.3.4 List/text view of SDCs

The numeric values calculated at the plot-points of the SDCs can be shown in a list. This list has the same features as any other IMMI list.



Result - sound decay curves

SDC source 1 (Day)											
					SDC (dB)						
X /m	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Total
1.0	-	-	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.8	-6.6
2.0	-	-	-12.5	-12.4	-12.4	-12.4	-12.4	-12.4	-12.4	-12.8	-12.4
3.0	-	-	-15.5	-15.4	-15.3	-15.3	-15.3	-15.3	-15.4	-15.9	-15.4
4.0	-	-	-17.5	-17.4	-17.3	-17.2	-17.2	-17.1	-17.3	-18.0	-17.3
5.0	-	-	-19.0	-18.8	-18.6	-18.6	-18.6	-18.4	-18.6	-19.5	-18.7
6.3	-	-	-20.4	-20.1	-20.0	-19.9	-19.9	-19.7	-19.9	-21.0	-20.0
8.0	-	-	-21.8	-21.5	-21.4	-21.3	-21.3	-21.3	-21.6	-22.9	-21.6
10.0	-	-	-29.3	-27.8	-26.9	-26.3	-26.2	-26.3	-26.6	-28.1	-26.6
20.0	-	-	-33.3	-32.4	-31.8	-31.3	-30.8	-30.5	-31.2	-33.8	-31.2
30.0	-	-	-34.6	-33.5	-32.9	-31.6	-31.4	-31.3	-32.3	-36.0	-32.1

					SDC indicators (dB)						
	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Total
DLf (close)	-	-	4.9	4.9	5.0	5.0	5.0	5.1	5.0	4.6	5.0
DLf (midde	-	-	5.8	6.3	6.7	6.8	6.9	6.9	6.6	5.3	6.6
DLf (far)	-	-	4.8	5.8	6.4	7.3	7.7	7.9	7.0	3.9	7.1
DL2 (close	-	-	5.3	5.2	5.2	5.2	5.2	5.1	5.2	5.5	5.2
DL2 (midde	-	-	13.2	11.3	10.2	9.5	9.4	9.8	10.0	10.6	9.9
DL2 (far)	-	-	2.3	1.9	1.8	0.5	1.0	1.4	1.9	3.9	1.9

SDC source2 (Day)											
					SDC (dB)						
X /m	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Total
1.0	-	-	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-7.8	-7.6
2.0	-	-	-12.9	-12.8	-12.8	-12.8	-12.8	-12.8	-12.9	-13.2	-12.9
3.0	-	-	-15.7	-15.6	-15.6	-15.5	-15.5	-15.5	-15.7	-16.2	-15.7
4.0	-	-	-17.6	-17.4	-17.4	-17.3	-17.3	-17.3	-17.5	-18.2	-17.5
5.0	-	-	-19.0	-18.8	-18.7	-18.6	-18.6	-18.6	-18.9	-19.7	-18.8
6.3	-	-	-20.3	-20.1	-20.0	-19.9	-19.9	-19.9	-20.2	-21.3	-20.2
8.0	-	-	-21.9	-21.8	-21.7	-21.6	-21.6	-21.7	-21.9	-23.1	-21.9
10.0	-	-	-23.2	-23.1	-23.0	-23.0	-22.9	-23.0	-23.3	-24.8	-23.3
20.0	-	-	-29.7	-28.5	-27.3	-27.3	-27.3	-27.5	-28.1	-30.4	-27.9

					SDC indicators (dB)						
	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Total

Figure 19 – List view of the calculated sound decay levels for all plot-points of each curve

Note that for each SDC both the numeric values at the plot-points of the curve and the overall evaluation of DLf and DL2 are shown. Plot-points and indicators are contained in separate list tables.

4.3.5 SDC import and export – general information

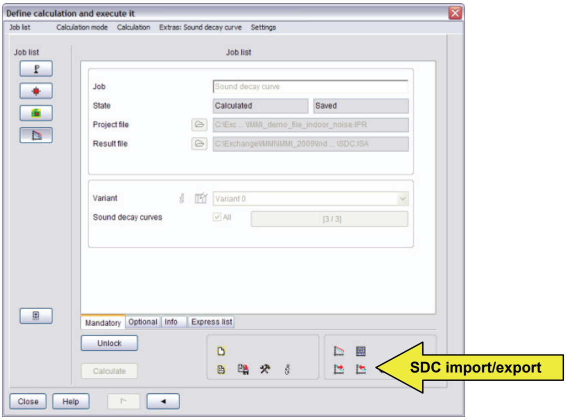


Figure 20 – SDC import/export functions

SDC export

This is a function to export SDCs.

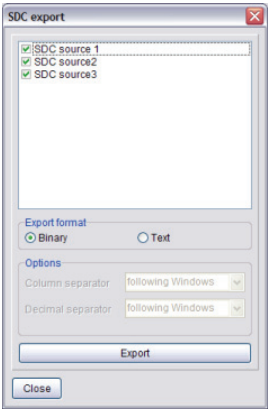


Figure 21 – SDC export dialogue

First tick all curves that shall be exported.

Export format

SDCs can be exported either in binary or in text format.

The binary format is useful to exchange SDC data between projects. This is a proprietary IMMI format and no documentation or description is provided.

Options

Both the column separator and the decimal separator can be chosen for text exports.

Export

This button starts the actual export.

SDC import

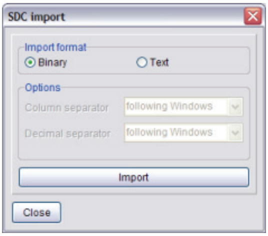


Figure 22 – SDC import dialogue

It is possible to import SDCs that were previously exported. Binary export files can be directly imported.

To be suitable for import, text files must closely follow the above description. Text files may be used to import measured SDCs.

Hint:

Text file import: the last column of the block(s) of the values of the function containing the overall value will be ignored during import and may even be omitted from the text file. Both DLf and DL2 will be re-calculated by IMMI from the values of the function.

4.3.6 SDC export: graphics formats

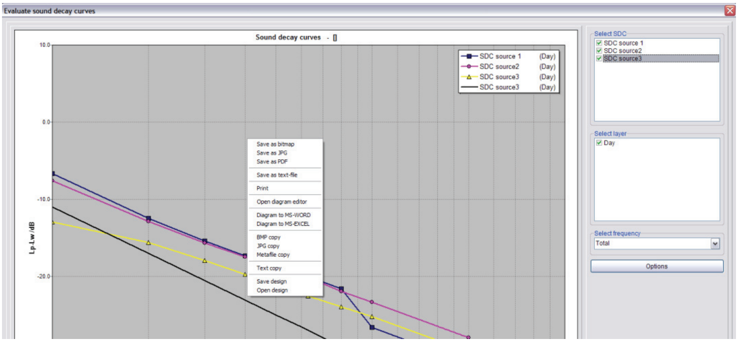


Figure 23 – SDC diagram local pop-up menu with export functions

The local menu of the diagram windows offers a range of export functions:

Export into a graphics file using one of several graphics formats (BMP, JPG, PDF).

Export of the numeric results in a text file format.

Print-out of the diagram.

Export of the diagram to MS-WORD and MS-EXCEL.
(please, make sure a current version of Microsoft® Office is installed on your PC)

Export into the clipboard using one of several graphics formats (BMP, JPG, PDF).

Use the diagram editor to edit a large selection of parameters. Caution: these settings will be lost once the diagram is closed.

All changes to diagram settings made in the diagram editor can be saved in a file: click *Save design*. To open a setting file use *Open design.* These settings will then be applied to the diagram currently shown.

4.3.7 SDC import and export - Description of the text export format

IMMIWIN---												Identification of an IMMI file
IMMISAK---												Identification for an SDC file
322												Version number
2												Number of SDCs in this file
3												Number of layers per SDC
SAK waagerecht												**Name** of the SDC
OktavLin												Frequency type (overall A-weighted, octave bands, third-octave bands)
16												First frequency band
8000												First frequency band
12												Number of plot-points of this particular SDC
1	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	**START values of the function**: X, Y1,Y2...,overall
2	-14	-14	-14	-14	-14	-14	-14	-14	-14.1	-14.1	-14	
3	-17.5	-17.5	-17.5	-17.5	-17.5	-17.5	-17.5	-17.6	-17.6	-17.7	-17.6	
4	-20	-20	-20	-20	-20	-20	-20	-20.1	-20.1	-20.2	-20.1	
5	-22	-22	-22	-22	-22	-22	-22	-22	-22.1	-22.2	-22.1	
6.3	-24	-24	-24	-24	-24	-24	-24	-24	-24.1	-24.3	-24.1	
8	-26.1	-26.1	-26.1	-26.1	-26.1	-26.1	-26.1	-26.1	-26.2	-26.5	-26.2	
10	-28	-28	-28	-28	-28	-28	-28	-28.1	-28.2	-28.5	-28.2	
20	-34	-34	-34	-34	-34	-34.1	-34.1	-34.2	-34.4	-35.1	-34.3	
30	-38.7	-38.7	-38.7	-38.8	-38.8	-38.8	-38.9	-39	-39.4	-40.3	-39.2	
40	-42.4	-42.4	-42.4	-42.4	-42.4	-42.5	-42.5	-42.7	-43.2	-44.5	-43	
50	-44.9	-44.9	-44.9	-45	-45	-45	-45.1	-45.3	-46	-47.5	-45.7	**STOP values of the function**
DLf (nah)	3	3	3	3	3	3	3	3	3	2.9	-99	Excess of sound pressure level (DLf) for the close zone
DLf (mitte)	3	3	3	3	3	3	3	2.9	2.8	2.6	-99	Excess of sound pressure level (DLf) for the middle zone
DLf (fern)	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.3	0.8	-0.2	-99	Excess of sound pressure level (DLf) for the far zone
DL2 (nah)	6	6	6	6	6	6	6	6	6	6.1	-99	Reduction of sound pressure level per distance doubling (DL2) for the close zone
DL2 (mitte)	6	6	6	6	6	6	6	6	6.1	6.3	-99	Reduction of sound pressure level per distance doubling (DL2) for the middle zone
DL2 (fern)	8.3	8.3	8.3	8.3	8.3	8.3	8.4	8.5	8.7	9.4	-99	Reduction of sound pressure level per distance doubling (DL2) for the far zone

If a SDC has more than a single layer the functional values of the following layers will be appended at the end of the first block. (The block START-values of the function to STOP-values of the functions will be stored once for each layer). If the file contains more than 1 SDC, then the data fort he next SDC will follow immediately the line for DL2 far zone starting with the name of the SDC, the frequency type, etc.

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