# Insul

version 6

## Sound Insulation Prediction Program

# Users Manual

Marshall Day Acoustics

2011

## Contact Details

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# Contents

## Limitations

Users should be aware of its limitations, like any prediction tool it is not a substitute for test data.  Comparisons with test data show that it is generally within 3 STC points for most constructions.

## Getting Started

### Installation Instructions for Single User Version

Before installing INSUL you should close any open applications and log on as a user with sufficient access rights to install programs.  This normally means having Administrator rights.

**Install INSUL**

1. **When you purchased INSUL you will have received a USB key .** Plug this into a spare usb port on your computer.  In most systems that are connected to the Internet Windows will automatically locate and install the correct drivers for the Safenet key.  This will take perhaps 30 seconds to a minute, after which you will get a message that the drivers are installed and then the small LED in the tip of the key will light up.

Your device is ready to use

| | |
|---|---|
| SafeNet Inc. HASP Key | ✓ Ready to use |
| SafeNet Inc. Sentinel HASP Key | ✓ Ready to use |

2. If this does not happen then run the file HASPUserSetup.exe from the INSUL CD.  This will install the drivers for the USB key.  Now plug the USB key into a spare USB port.  The small LED in the tip of the key will light up.

3. You should install INSUl from the CD by double clicking on the file “Steup.exe”.

4. Read the instructions on the Welcome page and click the next button.

**Welcome to the InstallShield Wizard for Insul6.4**

The InstallShield(R) Wizard will install Insul6.4 on your computer. To continue, click Next.

WARNING: This program is protected by copyright law and international treaties.

5. Read the Software license Agreement and if you accept the terms of the licence, click the Yes button.

6. If you wish to read the INSUL release notes you may scroll down the Readme Information then click the Next button.

7. Type your name and the company name in the appropriate fields and click the Next button.

8. To choose a particular destination directory for INSUL's files click the Browse button. To accept the default destination directory click the Next button.

9. To change the Program folder where program icons will be stored enter a new folder name in the Program Folder field, otherwise leave the default folder name. Click the Next button.

10. If you are satisfied with the settings click Next to begin copying the necessary files.

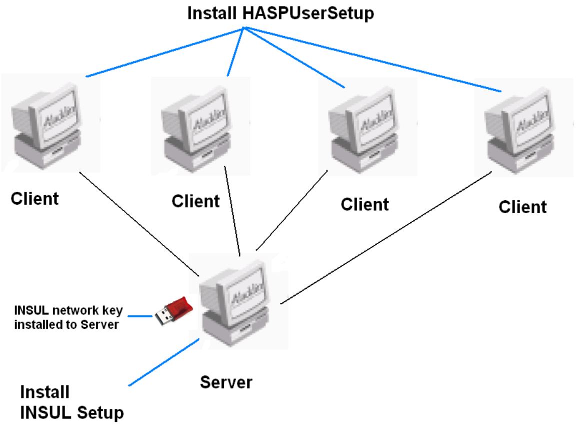
11. You can now run the program from the normal Windows “Start “, “All Programs” menu. The About form should display. INSUL is now ready to use.

Licenced to
key version = Insul6.4
Serial No. 1023
Copyright Marshall Day Acoustics 2010

## Installation Instructions for Network INSUL

INSUL can be run over a Local Area Network (LAN). It is not necessary to install INSUL on every client computer as it can be run from one network location. INSUL should be installed on one computer on the network, usually this would be the network file server. The network Hasp key should be plugged into the computer which has INSUL installed on it. Each user will need access rights to the folder where INSUL has been installed.

On each other client computer on the network you must install the Hasp drivers using the HASPUsersetup.exe file on the CD. This file can also be downloaded from the INSUL website (www.insul.co.nz) Once these Hasp drivers have been installed the client computer will be able to communicate with the network key to determine if any licenses are available



## Install INSUL Setup

### File Server

1. Insert the INSUL CD into the CD-ROM drive. Start the INSUL installation program by running the program setup.exe in the folder INSUL.

2. Read the instructions on the Welcome page and click the next button.

3. Read the Software license Agreement and if you accept the terms of the licence, click the Yes button.

4. If you wish to read the INSUL release notes you may scroll down the Readme Information then click the Next button.

5. Type your name and the company name in the appropriate fields and click the Next button.

6. To choose a particular destination directory for INSUL's files click the Browse button. To accept the default destination directory click the Next button. Note that this folder must be accessible by all users on the network.

7. To change the Program folder where program icons will be stored enter a new folder name in the Program Folder field, otherwise leave the default folder name. Click the Next button.

8. Once the installation process has finished you can start INSUL on that computer (this is the computer labelled Server in the diagram above).

9. INSUL should start and display the About screen. This should have the version no. of INSUL, the version no. of the key and the serial no.

**Client Computers**

10. On each other networked computer that you want to run INSUL from you will need to install the Hasp key drivers. Run the file HASPUsersetup.exe on each computer (These are the computers labelled Client in the diagram above).

11. You should now be able to run INSUL from each computer by running the application file Insul64.exe from the network folder where you have installed it.

12. The operation of the key software can be monitored by starting an internet browser such as Internet Explorer or Firefox and typing into the address bar localhost:1947. This shows the Hasp keys connected to the system and allows one to change and monitor various settings.

## First Look

Start with a very simple example of predicting the transmission loss of a sheet of gypsum plasterboard. In the bottom left hand quarter of the window you will see what looks like a notebook with tabs sticking up. These tabs are labelled panel 1, panel 2, wall, ceiling, double-glazing, etc. Initially **panel 1** is selected and the Material is Gypsum plasterboard. Note that the materials database is customised for different countries and may have different material names to what is shown in this manual.

**Material** 10 Standard Gib Board

**Thickness** 10 (mm) **Number of Linings** 1

Surface Mass 6.4 kg/m2 Critical Freq 4165 Hz

One may see what other materials are available by clicking on the little triangle at the right hand side of the **materials** box, a drop down list will appear and any of the available materials can be selected by clicking on the list. In this case click on Gypsum plasterboard.

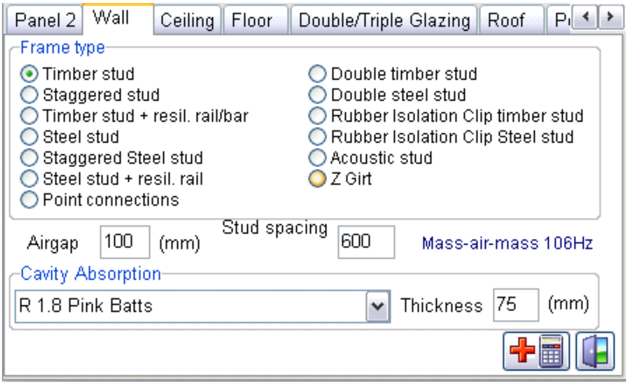
Enter the thickness of the material by either clicking in the **thickness** box or by pressing the **tab** key and deleting the previous value and entering the new one. Entering a thickness of zero will cause an arithmetic error.

One can force a calculation by either clicking on the little picture of a lightning bolt

in the top left-hand corner on the toolbar or by clicking on the **Panel 1** tab or by pressing F9 or enter. The graph on the right hand side will then display the 1/3 octave band transmission loss as a function of frequency and the STC or Rw will be displayed in the area just above the graph together with the calculated octave bank transmission loss spectrum.

For European countries the index Rw can be displayed instead of STC (click the box showing STC to toggle between STC and Rw). It is easy to add multiple layers by clicking on the up and down arrows to the right of the **No. Linings** box. For the outer layer you can not have less than one lining, but for the inner layer you can have zero linings.

To predict the performance of a wall consisting of a single row of timber studs with a layer of 12.5mm Gypsum plaster board either side click on the tab labelled **panel 2.** As before select the material, thickness and number of layers (eg Gypsum, 12.5mm and 1 respectively). Now that you have specified the linings on each side click on the tab labelled wall. This will give you the display shown below.



Frame type

- ● Timber stud
- ○ Staggered stud
- ○ Timber stud + resil. rail/bar
- ○ Steel stud
- ○ Staggered Steel stud
- ○ Steel stud + resil. rail
- ○ Point connections
- ○ Double timber stud
- ○ Double steel stud
- ○ Rubber Isolation Clip timber stud
- ○ Rubber Isolation Clip Steel stud
- ○ Acoustic stud
- ○ Z Girt

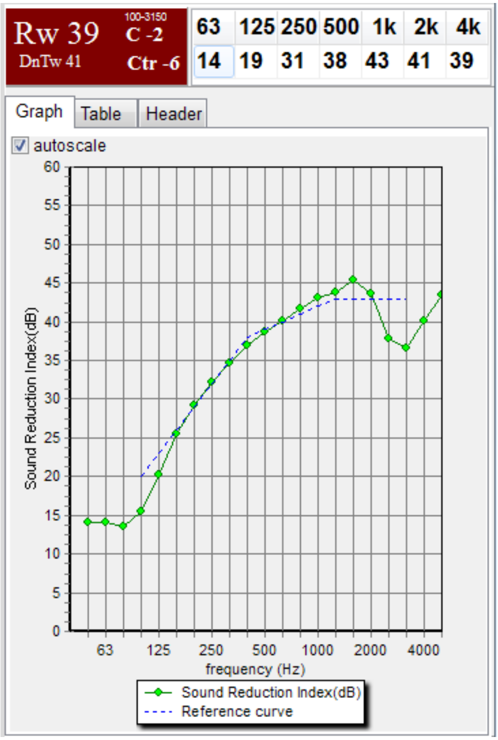
Airgap 100 (mm) Stud spacing 600 Mass-air-mass 106Hz

Cavity Absorption

R 1.8 Pink Batts Thickness 75 (mm)

Choose timber stud, enter the width of the airgap (in this case the thickness of the studs eg 100mm) and the spacing of the studs (eg 600mm) and then either click the tab labelled **wall**, or press F9 or click the calculate button on the toolbar. As before the STC is displayed in the box in the top of the screen, the graph shows the 1/3 octave band sound transmission losses (together with STC curve) and the octave band values are given in the table to the right of the STC value.

It is now easy to check the effect of changing to steel studs by clicking on the option for steel studs. You can use the comparison tool for highlighting the change on the graph.


Rw 39
DnTw 41
100-3150 C -2
Ctr -6

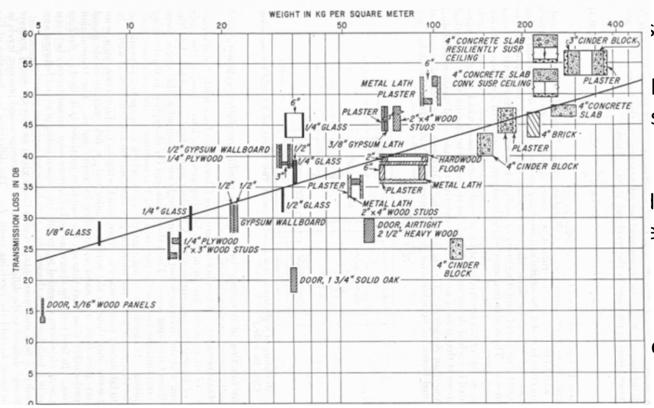
| 63 | 125 | 250 | 500 | 1k | 2k | 4k |
|---|---|---|---|---|---|---|
| 14 | 19 | 31 | 38 | 43 | 41 | 39 |

☑ autoscale

# Theory

## Mass Law

The mass law can model walls consisting of a single homogeneous panel quite well up to about half the critical frequency. The mass law predicts the transmission loss (TL) from the surface mass (mass of $1m^2$ of the panel) and the frequency. If the surface mass is in $kg/m^2$ and the frequency is in $H_2$ then TL = 20 . Log10 (f.m) - 48. The TL increases by 6 dB for each doubling of the surface mass or frequency.



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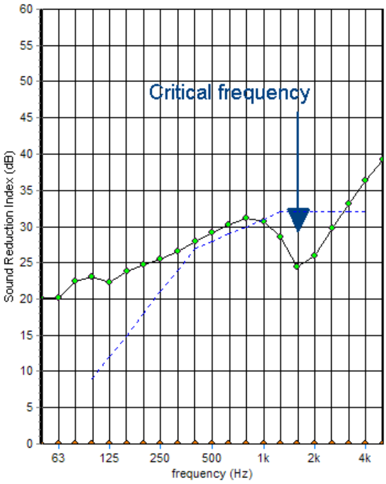
INSUL models this effect and the influence of shear waves can be seen at high frequencies where the TL increase at only 6 dB per octave again.

The mass law predicts the Transmission Loss of most materials up to the critical frequency. Above this frequency Cremer's theory is used to predict the Transmission Loss.

The critical frequency is high for thin limp materials, such as lead, steal, plastics. For thick stiff materials the critical frequency can be low (brick, plywood).

## Critical Frequency

At low frequencies most materials behave as simple limp masses and the mass law can predict the Transmission Loss. At higher frequencies the bending stiffness of materials becomes important and at a certain frequency known as the critical frequency, the transmission loss dips well below the mass law.



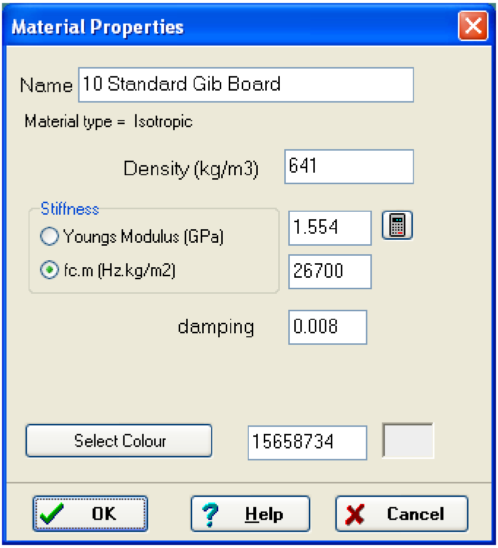
Above the critical frequency the TL increases at 12 dB/octave (doubling at frequency) so that as the frequency increases the TL can increase to above the mass law.

At the critical frequency the wavelength of bending waves in the panel equals the wavelength of airborne sound.

For homogeneous materials the product of surface mass and critical frequency is a constant, thus doubling the surface mass (by doubling the thickness of the panel) will halve the critical frequency. This constant can be calculated if the elastic modulus (also known as Youngs Modulus) of the material is known. Alternatively it can be inferred from a Transmission Loss test by examining the curve of TL versus frequency to determine the critical frequency. (Knowing the surface mass for that test).

## Modulus of Elasticity

The critical frequency of a panel is determined by the Modulus of Elasticity (sometimes known as Young's modulus) and the thickness of the panel. For most normal materials the product of the surface mass (kg/m$^2$ ) and the critical frequency is a constant and this simple relationship can be used to quickly determine the coincidence frequency of any given thickness. This constant is called fcm in INSUL for want of any recognised term. For most building materials this constant falls in the range 10,000 to 1000,000 Hz kg/m$^2$ , with gypsum plasterboard being about 30,000 Hz kg/m$^2$ . These constants have been determined for a range of building materials and are built into INSUL, but it is easy to adjust these by opening the materials properties dialog box and entering ones own values.



Name 10 Standard Gib Board

Material type = Isotropic

Density (kg/m3) 641

Stiffness

○ Youngs Modulus (GPa) 1.554

● fc.m (Hz.kg/m2) 26700

damping 0.008

15658734

If the fcm is not known it can be calculated from the modulus of elasticity. Enter the value in the box opposite the Youngs dialog box and click the radio button beside the title to tell the program that you want to use this value to determine the coincidence frequency rather than using the value of fcm.

## Damping

The internal damping affects the transmission at and above the critical frequency. Generally it is found that a damping factor of 0.01 is a reasonable starting point for most building materials, but you can play around with this to get the best match with experimental data.

## New Materials

To model a new material 3 parameters are needed, the density of the material, the product of critical frequency and surface mass (fcm), and the internal damping of the panel.

The density is usually easy to determine either by direct measurement or from manufacturers data. The constant fcm can be determined either from a TL test on one particular thickness of the material, or it can be calculated from the elastic modulus of the material. Manufacturers can often provide data on the elastic modulus since it is usually needed for strength and deflection calculations for building materials.

The damping constant can be determined from measurement or from TL test data. If no data is available it is reasonable to use a value of 0.01 which is very typical of many building materials.

In general it is best if you have manufacturers test data on some thickness of a single panel of the material. If you do have the TL for new material, then the recommended procedure is as follows:

Enter the data as a ref spectrum. in the table page. You then choose a similar material if possible from the menu. Set the thickness to the correct thickness and alter its properties using the "materials constants" button on the Panel 1 page to open up the "material properties" dialog box. You either enter the density of the material if you know it or adjust the density in the "material properties" dialog box until you get the low frequencies as correct as possible. Then you alter the "fcm" constant until you get the critical frequency dip as close as possible to the correct frequency, then you alter the damping until the high frequencies match as well as possible.

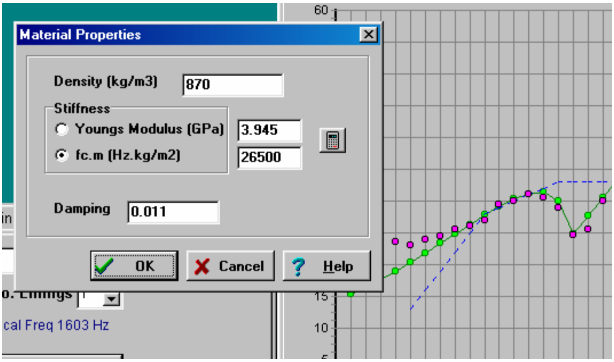
Once you have worked out the best combination of density, fcm and damping, then you can open up the text file "materials.txt" and enter these parameters as a new material.  Then in future you can select the new material from the menu.

An example with 19mm thick gypsum plaster board is shown below. The material constants have been altered to get good agreement with the manufacturers test data. These parameters can then be stored as "19mm Gypsum plaster board" for use in future.

The data for each material is contained in the text file "materials.txt". The first line contains the description of the material, and the second line contains the density of the material in kg/m$^3$, the product of surface mass and critical frequency (a constant for any homogeneous material), the damping coefficient, and the standard thickness of the material.

For the example shown below the entry in the materials.txt file would look like this:

19 Gib Fyreline
870 26500 0.011 19



Material Properties

Density (kg/m3) 870

Stiffness
○ Youngs Modulus (GPa) 3.945
● fc.m (Hz.kg/m2) 26500

Damping 0.011

If you do not have any test data on the material then you need to know the density of the material, the Modulus of Elasticity and if possible the internal damping of the material (if damping is not known set it to 0.01). Enter this data in the "material properties" dialog box with the radio button "Youngs Modulus" selected. Then click on the calculator icon to have INSUL calculate fcm for you. This data (density, fcm and damping) can now be entered into the file "materials.txt" which should be in the sub-directory from which INSUL is run.

## Ribbed and Corrugated Panels

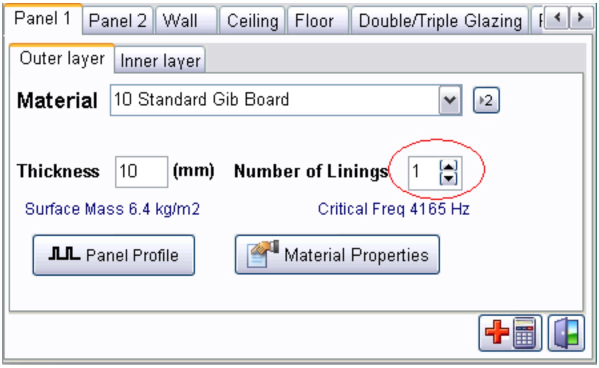
Thin materials are often corrugated or ribbed to increase their stiffness and hence ability to span larger distances between supports. This can dramatically lower their TL by lowering the critical frequency (in the direction of the corrugations). The bending stiffness is different in the direction of the corrugations compared to the direction at right angles to the corrugations. Panels which have differing stiffness in each direction are known as orthotropic. Their sound transmission properties are well predicted by simple theories developed by Heckl and more recently by Windle and Lam.

To model a corrugated or ribbed panel click the Panel Profile button on the input page to open the Profile Form dialog. At the top of this form is a drop down menu of various standard profiles. The profile dimensions are stored in an external text file "profile.txt" and additional profiles can be added to this list.

If the panel profile you are interested in is not in this list then you can define your own custom profile. Click on the type of profile (i.e. flat, corrugated, or trapezoidal) and input data on the depth and pitch of the corrugations, or the various dimensions of a trapezoidal shaped panel in the spaces shown on the drawings . Clicking on the button will display the two coincidence frequencies for the orthotropic panel. The Lc/Lw parameter that is shown is the ratio of the width of the crown of the profile to the length of the web of the profile. This parameter is from Windle and Lam (Proceedings of the Institute of Acoustics Vol 16 part 2 (1994) "A Simple Empirical Methiod for Predicting the Sound Reduction of Single Skin Cladding") and for values between 0.5 - 3 the algorithms of Windle and Lam are used. Closing the dialog Box by clicking on OK will calculate the STC and TL of the panel.

## Multiple Layers

When two or more layers of a material are fixed together they generally do not behave the same as a single layer of increase thickness. For instance two layers of 12.5 mm plasterboard do not give the same performance as one layer of 25 mm plasterboard. At low frequencies the TL of both is the same as their combined mass, but the coincidence frequency of the 2 layers of 12.5 mm plasterboard are the same as each individual layer, whereas the 25 mm thick plasterboard has a coincidence frequency half that of the 12.5 mm thick panel. INSUL takes account of this and additional layers can be modelled accurately by entering the number of layers in the number of layers field.



**Material** 10 Standard Gib Board

**Thickness** 10 **(mm)** **Number of Linings** 1

Surface Mass 6.4 kg/m2

Critical Freq 4165 Hz

By using the inner and outer layer pages you can for instance have 3 layers of 16 mm plasterboard and 2 layers of 6 mm plywood.

This model assumes that the multiple layers are only lightly fixed together. Most normal fixing methods would fulfil this assumption, for instance screws, spot gluing, nailing etc. However, if the layers are intimately bonded together for instance by a full coverage of glue (particularly a rigidly setting glue), then it would be more accurate to model the panel as a single panel of total thickness equal to the combined thickness of the multiple layers.

## Elastic Core Materials

INSUL can now predict the performance of panel materials that have a compressible or elastic core (also inelastic cores). Such materials are often made with thin steel sheets as exterior facings (typically 0.5mm thick) with an expanded polystyrene core 70 - 250 mm thick. A typical product is the Kingspan KS1000 panel which is widely used for instance in the UK.

These types of panel have many useful construction properties such as good thermal insulation, ability to span long distances, and a pre-finished surface which speeds construction times. They are commonly used in industrial and commercial buildings. However they have a very significant dip in their sound insulation performance in the middle of the frequency range (commonly around 1kHz) which combined with their light weight means that they have only modest sound reduction properties.

INSUL can accurately predict their performance (including this dip) and also more importantly can predict the sound insulation performance when combined with other materials, either with additional linings to increase the surface mass, or as part of a cavity wall or roof/ceiling construction.

There are a variety of standard elastic cored materials in INSUL's standard materials file and more can be added either by requesting the developers to add specific materials or by modifying or extending the materials database file. The properties that define an elastic core material are the skins (density, thickness, damping and stiffness) and the core (density, thickness, Modulus of elasticity, damping and "plateau"). A typical entry in the materials database is as follows:

Kingspan KS1000 RW 80mm

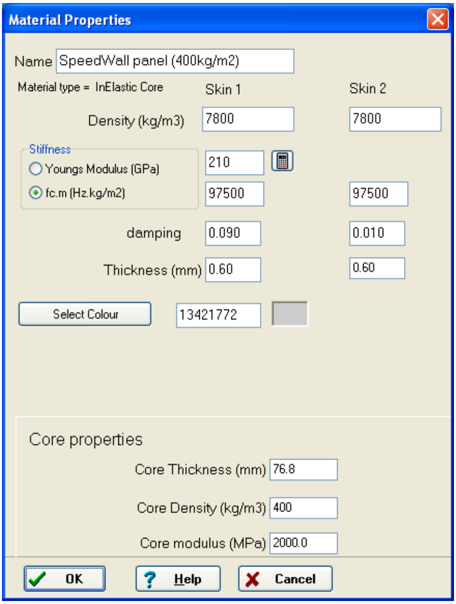
7800 97500 0.01 0.53 14215676 2 40 14000000 0.15 78.94 0 14215676
7800 97500 0.01 0.53 14215676

See the help file for more information on the meaning of each value.

## Inelastic Core Materials

INSUL can predict the sound insulation of panels with a stiff core and external skins.  A typical example is Speedwall which has lightweight concrete core inside a thin steel casing.

Because the core is very stiff inelastic core materials behave quite differently to  elastic core materials but the data entered into the materials file is identical except that the material type used in the file to denote an inelastic core is 3.  For inelastic core materials the internal damping and plateau are not used and are not displayed in the materials properties form.



Material Properties

Name SpeedWall panel (400kg/m2)

Material type = InElastic Core

| | Skin 1 | Skin 2 |
|---|---|---|
| Density (kg/m3) | 7800 | 7800 |
| Stiffness ○ Youngs Modulus (GPa) | 210 | |
| ● fc.m (Hz.kg/m2) | 97500 | 97500 |
| damping | 0.090 | 0.010 |
| Thickness (mm) | 0.60 | 0.60 |

Select Colour 13421772

Core properties

Core Thickness (mm) 76.8

Core Density (kg/m3) 400

Core modulus (MPa) 2000.0

## Orthotropic Materials

An orthotropic material is one that has pronounced differences in two or more directions at right angles to each other.

From version 6.4 INSUL can model orthotropic materials that have different stiffness in the plane of the panel. Previously INSUL could model corrugated or ribbed materials and this facility continues, but now a material that is not profiled but has different stiffness in the X and Y directions can be entered into the software by specifying the ratio of stiffness in the x and y direction. The material is entered into the materials file (material.txt) as with a normal isotropic material, but then three extra parameters are added at the end of the line. The first parameter is the colour (see this topic for description of how to enter a colour), the second is an integer value that signifies the type of material, in this case 1 tells INSUL the material is orthotropic. The third parameter is the ratio of the elastic modulii in the x and y directions.

## Porous Materials

A porous material such as fibreglass or mineral wool can be used as a sound attenuating layer, either by itself, or as a facing to a solid barrier.  The porous layer attenuates sound partly by reflecting sound (due to the impedance change between air and the material), and partly by converting sound energy into heat as the sound waves travel through the material.

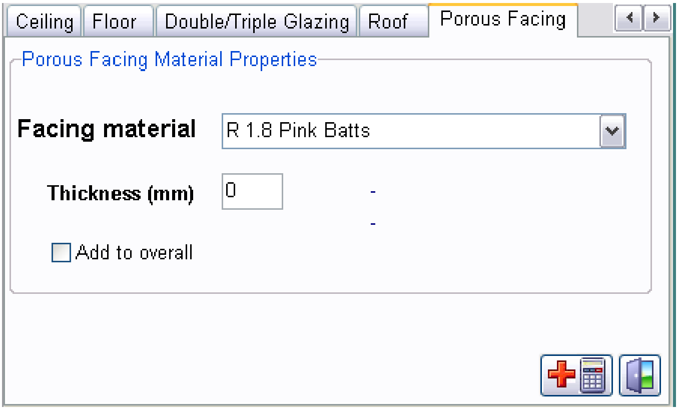
From Version 6.4, INSUL can now predict the sound reduction index of  a layer of porous absorber and also the effect of a porous absorber used as a facing on a partition.  Click on thePorous Facing tab and select one of the absorptive materials from the drop down box.

The materials defined in the absorption.txt file are used in this drop down box, and new materials can be added to this list by editing the text file absorption.txt.  The meaning of the entries in the file are as follows:

- The first line is a description of the material
- The second line contains the thickness of the material (in millimetres), the flow resistivity of the material (Rayls/m), the density of the material (kg/m3) and the colour of the material (see New Materials for explanation of how to get the integer value corresponding to the colour you want).

Note that you can adjust the thickness of the material by entering a new value into the box marked "thickness".  If you want to adjust the density or flow resistivity you must edit the absorption.txt file.

Tick the *Add to overall* check box to add the transmission loss of the porous facing to the transmission loss from the Panel 1, Panel 2, Wall or Ceiling tabs. The drawing should correctly display the thickness and colour of the material you have chosen.



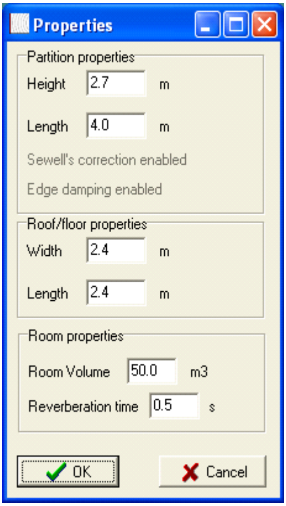
**Facing material** R 1.8 Pink Batts

**Thickness (mm)** 0

☐ Add to overall

## Panel Size

The size of the panel can have an effect on the measured sound transmission loss. Small panels have a low radiation efficiency at low frequencies and so appear to have a higher TL than larger panels of the same material. INSUL predicts this effect using an expression developed by Sewell. In INSUL the adjustment is called as Sewells correction. This correction is normally turned on and the panel size is set to 2.7 x 4.0 m. You can turn this correction off or set a different panel size in the panel dimensions dialog box which is accessed via the button on the toolbar.



Partition properties

Height 2.7 m

Length 4.0 m

Sewell's correction enabled

Edge damping enabled

Roof/floor properties

Width 2.4 m

Length 2.4 m

Room properties

Room Volume 50.0 m3

Reverberation time 0.5 s

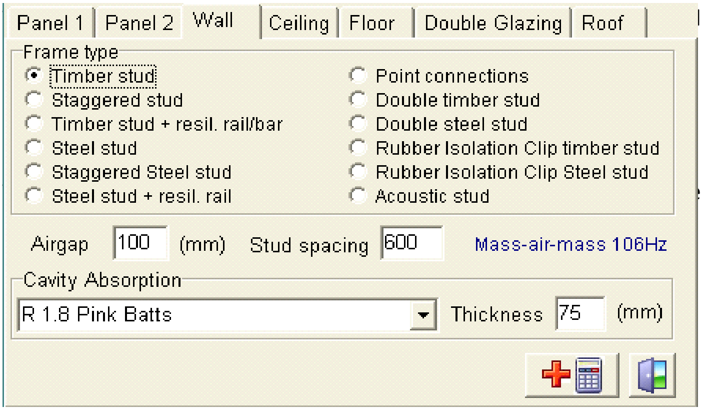
In this dialog box you can also turn off edge damping. The edge damping factor models the energy loss that occurs at the edge of a normal surrounding structure. This is significant for very heavy partitions in normal constructions. In some laboratory tests and some unusual situations the partition may not be solidly connected to the surrounding structure and so the energy loss is much less, in these situations the edge damping can be turned off.

## Double Panels

While it is rather simple and accurate to predict the TL of single panels, it is more difficult to predict walls that have two panels separated by a space. However, since this is such a common type of construction and since it can improve performance considerably various techniques have been developed. Indeed this is the main reason for using INSUL since it makes a complicated task quick and easy.

The easiest situation to understand and explain is two panels separated by an airspace with an absorptive blanket in the space between the panels. There is assumed to be no connection between the panels. At low frequencies the stiffness of the air between is so high relative to the inertia of the panels that the two panels are effectively locked together and move as one. The TL is simply predicted from the mass law using the combined mass of the two panels. As the excitation frequency increases the inertia of the panels increases, at the mass-air-mass resonance frequency the inertia of the panel is cancelled by the stiffness of the air and the two panels move out of phase with each other.

As the frequency increases further the TL increases at a much greater rate than the mass law (up to 24 dB/octave). At even higher frequencies the separation of the panel becomes less than ½ a wavelength and the TL increases at 12 dB/octave.



Frame type

● Timber stud
○ Staggered stud
○ Timber stud + resil. rail/bar
○ Steel stud
○ Staggered Steel stud
○ Steel stud + resil. rail
○ Point connections
○ Double timber stud
○ Double steel stud
○ Rubber Isolation Clip timber stud
○ Rubber Isolation Clip Steel stud
○ Acoustic stud

Airgap 100 (mm) Stud spacing 600 Mass-air-mass 106Hz

Cavity Absorption

R 1.8 Pink Batts Thickness 75 (mm)

Enter the spacing between the inner faces of the two linings and the spacing between studs.

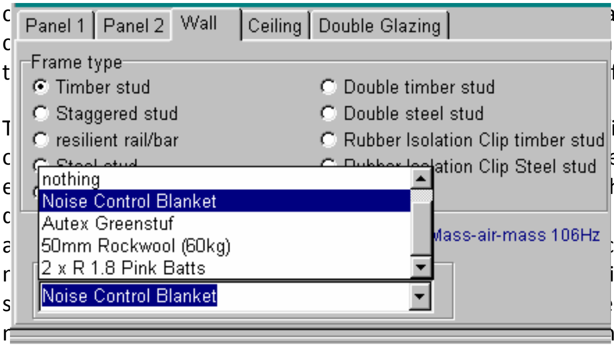
## Cavity Infill

### Effect of Absorptive Material

INSUL can predict the performance of double panel walls if there is an absorptive blanket in the cavity between the panels or if the cavity is empty. The type of absorptive blanket can be selected from the drop down list.

The absorptive blanket has several related effects, it dampens the mass-air-mass resonance, it dampens cavity modes which otherwise provide
c ation in the
c ight say
t fect).

T ibre, wool,
c ed into the
e he
c density,
a ause the
r ical it
s r than 25
r 500 Rayls/
m or more than 60,000 Rayls/m.



A special case is double glazing for which INSUL has a special empirical routine.

## Impact Noise

Impact noise is most often created by footfall, as well as from closing cupboards and scraping chairs, in adjacent apartments. By their nature, impact events transmit vibration energy straight into the structure of a building. These vibrations can then radiate as acoustic energy in adjacent spaces. Impact noise is a common issue in apartment buildings and terraced houses. In the past, impact insulation performance has only been considered for vertically adjacent spaces (such as apartments that are vertically stacked, one on top of the other). This is reflected in the established theory for impact noise which has generally addressed only vertical transmission.

However, impact noise is transmitted in all directions once it enters the building structure, thus consideration of horizontal and diagonal impact

## Timber Studs

A common form of construction is to use timber studs to make a framework and line either side with plasterboard or similar panel materials. Timber studs are usually 100 x 50mm in cross section but can be smaller or ljarger depending on structural requirements. Timber studs act as very stiff, light connections between panels and can be modelled to acceptable accuracy as line connections between panels.

Thus the option on the wall page labelled timber studs uses line connections between panel 1 and 2 to calculate TL.

Should you need to model other forms of construction that rigidly connect between two panels along lines, then you can use this option.

From this discussion it is apparent that this option is only valid where the panels are rigidly connected and the panels make connection along with whole length of the stud. If a resilient element is placed between the stud and the panel then the TL will in general be increased above what is predicted from line connections.

## Resilient Rails

Resilient rails are used in partition walls to increase the TL. They are normally fixed to timber studs, with the wall or ceiling linings fixed to the resilient rail rather than directly to the stud. The function of the rail is to prevent direct vibration transmission via the stud by acting as a soft spring between linings and stud. Resilient rails are usually steel channels folded in such a way as to be quite springy. They are normally fixed in horizontal lines at 600 mm centres. They are very easy to install wrongly however and with inexperienced workmen the chances are that the wall will not achieve the predicted or lab performance.

## Rubber Isolation Clips

An improved performance can be achieved with a metal bracket incorporating a rubber or neoprene isolation element. Al good example is the RSIC-1 clip from Sound Isolation system

This fixes to the stud or joist and holds a metal channel to which the wall lining is screwed. The rubber or neoprene ensures a high degree of isolation from the wall frame and sound insulation can approach a double frame wall performance. It is also much more reliable than resilient rail.

## Ceiling Supports

In the case of a ceiling it is also possible to introduce a resilient element. Normal practice is different in different countries. In North America it is common to use a 13 mm resilient metal channel. In Australia it is common to use resilient clips (eg Rondo or Gyprock or RSIC) while in New Zealand the Gib Ceiling batten can be used to provide isolation. The RSIC clips can also be used in a ceiling and as in a wall they provide a high degree of isolation.

## Steel Studs

Steel studs are used to construct framed partition walls. In some countries they are used extensively almost to the exclusion of timber studs. They generally provide much higher sound transmission loss performance than timber studs because they are far less rigid than timber studs. Typically steel studs would be C or Z shaped in cross section, made of 0.55 mm thick steel and come in various cross sectional widths (51, 63, 92 mm wide). From the test data that is available steel studs seem to work about as well as a resilient rail. However, be wary about steel studs that are thicken than 0.55 mm or are of a different profile to a C or a Z as INSUL may over predict their

## Double Studs

Double studs provide the ultimate in performance for framed partition walls. They are constructed by erecting two separate frames, usually 25mm apart, and lining the outside of each frame typically mean the chances are that the wall will not achieve the predicted or lab performance with 1 or 2 layers of plasterboard.

Because there is no physical contact between each side of the wall, the only transmission path is via the air cavity, and provided this has an absorbent blanket very high TL's can be achieved. In practice flanking transmission would often prevent the very high TLs predicted at high frequencies, but in extreme cases where measures have been taken to prevent flanking TL's of 60—70 dB at 1 kHz and above can be achieved (e.g. adjacent rooms on concrete floating floors).

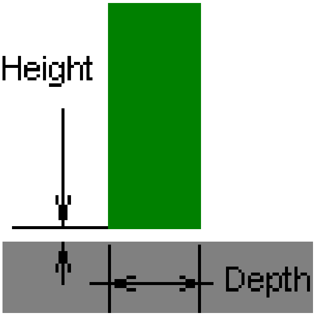
### Double and Triple Glazing

A special empirical routine is built into INSUL to predict the performance of double-and triple glazing. This is more accurate than selecting glass as panel 1 and glass aspanel 2 and then selecting no infill in the wall section.

In version 5 and later there is an optin to have different glazing materials such as laminated glass, or clear plastic. This goes under different trade names such as Perspex, Lucite, Lexan, etc.

## Leakage

Leaks can be modelled by entering the height, depth and length of the leak (see diagram below).



**Doors** (assume leak is full perimeter).

No seals: leak height = 1.2mm
Weather stripping: leak height = 0.5mm
Magnetic seals: leak height = 0.2mm

**Timber framed walls**

No acoustic seal around the perimeter of the wall:
leak height = 0.6mm (assume leak is full perimeter and
leak length = perimeter of wall).

(Note: if part of the perimeter is sealed then reduce the length of the leak accordingly).

noise can also be required in many situations. In particular, as footfall noise is efficiently radiated through concrete floor structures, horizontal impact noise radiation (that is, between horizontally adjacent spaces, on the same floor level) can often be a problem in large, concrete apartment buildings. INSUL's impact insulation procedure is based on Cremer's theory of point force excitation, and so can be used to evaluate vertical impact noise radiation for massive, rigid homogeneous constructions (typically concrete constructions). The model depends on the mass, bending stiffness and the damping of the floor, as well as its impedance (the floor impedance can be thought of as the resistance of the floor to excitation by the point source). INSUL 6.0 does not calculate impact noise radiation in the horizontal ordiagonal directions nor for light weight timber-joist floor constructions.

There are several standardised devises used for assessing the impact insulation performance of a floor construction. The most common devise is a standardised tapping machine. A tapping machine comprises five metal hammers, each weighing 500 grams, which are dropped onto the test floor from a height of 40 mm. Each hammer hits the test floor twice a second meaning that the tapping machine generates 10 impacts onto the floor every second.

The noise generated from the continuous impacting of the tapping machine hammers on the floor is measured in the room underneath the test floor. These Impact Sound Pressure Levels are then normalised and used to determine the impact insulation (IIC and Ln,w) ratings.

Resilient floor coverings such as carpet and cork can act as an elastic layer between the noise source and the floor structure and thus reduce the amount of impact energy that is transferred into the floor.

Because floor coverings are relatively thin, improvements in impact noise radiation are generally achieved at high frequencies. Typically, a floor covering will not be able to significantly reduce impact noise at frequencies any less than 500 Hz - 1 kHz. For homogeneous floor covers with known material constants, theoretical models can be used to predict the reduction in impact noise achieved by the floor cover.

However, in practice the majority of floor covers are not homogeneous. For example, where hard floor surfaces are installed, such as tiles and timber (parquet) floors, a proprietary resilient (acoustic) underlay can be installed between the finished floor surface and the floor construction, to provide extra damping. Thus the 'floor cover' may consist of, say, a tiled floor surface and a resilient underlay, and so is not homogeneous.

To account for this, the effects of resilient floor coverings are commonly derived from laboratory and field measurements. Two sets of impact insulation tests are conducted: one set on the bare floor construction; the other on the same floor construction but with the addition of the floor cover. The difference in the two sets of measured impact sound pressure levels gives the effective improvement in impact insulation. This measured improvement can be applied to similar bare construction types (in the case of concrete floor structures, this means the measured improvement can be applied to concrete floors of varying thicknesses) to model floor cover's effect on impact insulation for different constructions. INSUL uses this method (rather than a theoretical model) to calculate the effect of floor coverings

Like floor covers, ceilings can be used to improve impact insulation performance. Typically, a plasterboard or similar light weight ceiling is installed beneath a floor construction. The ceiling is generally installed on joists or hangers which are mounted to the underside of the floor and insulation (fibre glass, polyester or similar) can be installed in the resulting air cavity. Also, the ceiling linings can be fixed into place on resilient elements (such as resilient clips of steel suspension grid systems).

When considering the effect of a ceiling on impact noise, there are two transmission paths to consider:

1. Airborne transmission of noise through the ceiling cavity: Noise radiated from the underside of the floor structure can travel through the air in the ceiling cavity, then through the ceiling linings and into the receiving room. This noise path is effected by the inclusion of insulation in the cavity, insulation will reduce the amount of noise transmitted through the ceiling.
2. The second noise path is through the support structure for the ceiling: energy from the floor structure can transfer directly through the joists or hangers that are used to mount the ceiling linings, and into the ceiling linings themselves. This path is quite distinct from the airborne transmission path. Noise connection to mount the ceiling lining (such as steel hangers, or rubber mounts). transmitted along thispath can be reduced by using resilient

IIC (Impact Insulation Class) is a single number rating for floors. It is calculated or derived from 1/3 octave band Normalised Impact Sound Pressure Level data by a method described in American Society for Testing Materials (ASTM E989). This method was evolved to predict performance for footfall and other impact type sounds.

To determine the IIC rating, a standard shaped curve (the blue curve on the graph) is slid down from above until the sum of the deviations of the green test curve above the blue curve add up to just less than 32, (provided that no single deviation at any frequency is more than 8). By looking at where the green curve (the Normalised Impact Sound Pressure Level) is above the blue curve (the IIC curve) you can tell what frequencies are determining the IIC rating.

The IIC rating can be applied to any type of floor construction (including concrete and timber floor constructions), however care should be taking when comparing IIC ratings for different constructions. For example, concrete and timber floor constructions sharing a common IIC value can, subjectively, sound quite different from each other.

Ln,w is an alternative single number rating for floors. Like the IIC rating, Ln,w uses 1/3 octave band Normalised Impact Sound Pressure Level data, but derives its rating in accordance with ISO standard (ISO 717/2).

The higher the Ln,w value for a floor construction, the worse its impact insulation performance. (Note that this is the converse of the IIC rating system).

To determine the Ln,w rating, a standard shaped curve (the blue curve on the graph) is slid down from above until the sum of the deviations of the green test curve above the blue curve add up to just less than 32, (there is no restriction on the size of a deviation at a single as there is with the IIC method).

Both the IIC and Ln,w ratings are evaluated from the frequency range 100 -3150 Hz. IIC and Ln,w ratings for a given floor construction vary from each other considerably and must not be compared directly to each other to evaluate performance.

## Joists

### Joist spacing and floor modal response

Joist spacing or, for walls, stud spacing has traditionally been used in Insul when modelling the performance of cavity constructions. The spacing of the joists is used to determine the total length of line connections which join the two sides of a cavity construction as required by Sharp's classic theory.

Observations from measured data suggest that the modal response of a section of the floor/roof effects measured sound levels. From Version 6.4, Insul's calculations for impact sound and rain noise include effects from the influence of modal response of a section of the floor/ roof layers which is bounded by the length of the floor and its joists. Therefore the joist spacing becomes significant.

The frequencies of the primary and secondary modes of the floor section are calculated based on theory described in Warburton. At these frequencies, the predicted sound level in the receive room increases moderately above the average response of the floor. Modal effects tend to occur in the mid-frequency region. Insul does not allow for modal effects above the critical frequency of the floor layers.

### Joist properties

From Version 6.4, Insul impact sound and rain noise prediction routines include consideration of the joists which form part of the floor/roof construction. Theory from Gibbs et al (2008) is used to estimate the influence of joists on the impedance of the floor/roof construction in the low frequency region.

The density, bending stiffness and damping of the joists may be specified, as can the cross-sectional depth and width of the joists. These parameters are used to determine the impedance/admittance of the joists, which is relevant for light weight floors and roofs. In particular, in the low frequency region the impedance of the joists can be greater than that of the floor/roof layers and, given the large wavelengths of the sound in this frequency region, can control the performance of the overall construction.

The low frequency region where the joist impedance can be influential is dependent on the joist spacing as well as the bending wave speed of the floor/roof layers which in turn depends on the critical frequency of the roof/floor layers.

Joists properties are not significant for massive floor structures such as concrete floors.

### Setting joist properties

Joist depth and spacing may be set on the Floor tab.

Joist density, bending stiffness, damping and width can be set by clicking on the Joist properties button on the Floor tab, which opens a new window.

From the Joist Properties window the type of joists may be selected.

When the joist type is set to *Automatic* Insul will model either:

Timber joists with a density of 490 kg/m3, bending stiffness of 4.95 GPa and damping of 0.035. Timber joists are assumed to have a rectangular cross-section.

ZGirts, when a ZGirt ceiling is selected, with a density of 7800 kg/m3, bending stiffness of 210 GPa and damping of 0.01.

When the joist type is set to *Custom Joists* the Custom Joists box will become active and the joist density, bending stiffness and damping may be adjusted. Custom joists are assumed homogeneous with a rectangular cross section. Composite style joists cannot be modelled.

The joist depth and width can also be adjusted from the Joist Properties window.

The joist length is automatically set to equal the floor length.

## Impact Sound Limitations

### Agreement with measured data

Users should be aware of the limitations of the Insul predictions, like any prediction tool it is not a substitute for test data. Comparisons with test data show that Insul is generally:

- +/- 3-5 Ln,w/IIC points for most massive constructions which include a concrete floor.
- +/- 3-6 Ln,w/IIC points for most light weight floor constructions where the combined thickness of the floor layers is less than approximately 25-35mm.

The transition between thin, light weight floor constructions of less than 25-35mm and massive floor constructions such as concrete which are 75mm or thicker involves a transition from the force function for light weight floors according to Brunskog & Hammer to the classical impact force theory of Cremer. Accordingly, impact sound insulation predictions in the intermediate region can be less accurate. Based on available test data, which is somewhat limited, Insul is generally +/-5-10 Ln,w/IIC points for relatively thick, light weight floor constructions where the combined thickness of the floor layers is approximately 35-75mm.

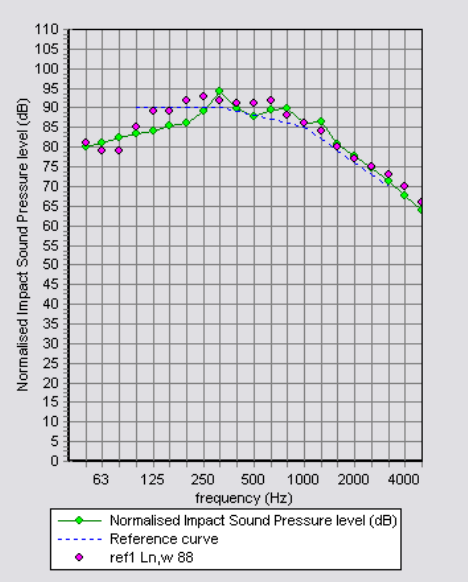
## Agreement with measured data at low frequencies

Variability of both measured and predicted sound levels at low frequencies, below about 100Hz, is much greater than at higher frequencies.  The variability may be caused by many factors including the larger wavelengths of sound in the low frequency region, the relatively small size of test samples and natural modes of vibration of the test panel, its supporting structures such as joists and the receiving room.

Insul impact sound insulation predictions may vary from measured data in individual one-third octave bands in the low frequency region by 10 Ln,w/IIC points or more.  Care must be taken when low frequency impact sound insulation methods are being designed.

## Examples

- Insul comparison with measured impact sound pressure levels for a thin, light-weight floor construction: 2 layers of 15 mm plywood (NRC test IIF-96-062).  The Insul predicted level is Ln,w 88dB.



# Rain Noise Theory

## Introduction

An international standard for the measurement of rain noise in laboratories was released in 2006—ISO 140-18 *Acoustics—Measurement of sound insulation in buildings and of building elements—Part 18: Laboratory measurement of sound generated by rainfall on building elements.*

From Version 6.3, INSUL can predict levels of rain noise measured according to ISO 140-18. INSUL can also predict levels of rain noise that occur naturally, based on a statistical model of natural rainfall distribution.

The predictions are based on simple point force excitation theory as described by a number of reference texts, in particular Cremer & Heckl. The theory is also generally consistent with the methods used in EN12354-2:2000 Building Acoustics—Estimation of acoustic performance in buildings from the performance of elements. Impact sound insulation between rooms.

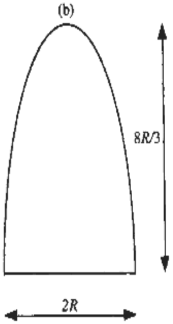
Users should be aware of the limitations, like any prediction tool INSUL is not a substitute for test data. Comparisons with test data show that it is generally within 3 – 5 dBA points for most constructions. However, as ISO 140-18 is relatively new, there is only a limited amount of test data available for comparison.

## Drop Theory

The accuracy of the rain noise predictions depends critically on the input of a suitable impact force, in this case being a rain drop.

Three different drop shapes have been considered for rain noise predictions:

- Cylindrical drop as proposed by Ballagh
- Cylindrical-hemispherical drop as proposed by Petersson
- Paraboloidal drop as proposed by Petersson.



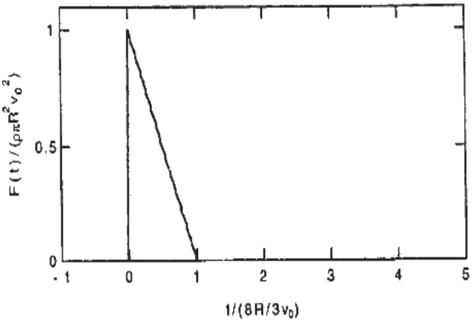


**Figure 4.** Calculated. normalised force versus non-dimensional time for a paraboloidal drop model at constant drop speed.

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(1) Petersson, B.A.T. 'The liquid drop impact as a source of sound and vibration' *Building Acoustics, 2(4), 585-623.*

INSUL predictions calculate the impact force of each individual rain drop falling on the roof. These individual impacts are summed per unit time to determine the vibration velocity of the roof, which is then used to calculate the sound radiated from the panel.

## Laboratory Rainfall (ISO 140-18)

ISO 140-18 was released in 2006 to provide a standardised method for the laboratory measurement of rain noise. The ambition of the standard is to provide a means of testing a range of roofing materials in a way that provides a robust comparison across materials, of the rain noise attenuation characteristics of the materials.

Rainfall used in the test standard uses drops of constant size, with a constant rainfall rate.

Four different rainfall rates are available:

| | |
|---|---|
| Moderate | up to 4mm/hr |
| Intense | up to 15mm/hr |
| Heavy | up to 40mm/hr |
| Cloudburst | greater than 100mm/hr |

The drop velocity is also specified in the standard and varies with rainfall rate.

Standard rain noise measurements use Heavy rainfall.

Rainfall is generated from an elevated water tank with a perforated base. The tank size can be fixed and may not cover the entire roof panel being tested. For example, this can mean that doubling the size of a test panel may not double the measured sound pressure level as the amount of rain fall remains fixed rather than doubling.

Measurements can be made as sound pressure level of sound intensity level. Results should be expressed as sound intensity levels.

## Natural Rainfall

Natural rainfall predictions are based on a similar approach to that used for ISO 140-18 predictions. However, rather than modelling artificial rainfall from a tank of fixed size, rainfall rates are calculated based on a natural rainfall distribution model as described by Marshall and Palmer.(2)

For a given rainfall rate, the Marshall and Palmer distribution provides the number of raindrops in a particular size range, that are likely to fall in 'typical' natural rain. With natural rain it is assumed that the drops hit the roof at terminal velocity. Further details of this method can be found in a paper by Ballagh (3).

An important difference between ISO 140-18 and Natural rain fall prediction is that the area of rainfall according to ISO140-18 is fixed independently of panel size. In contrast, with Natural rainfall, an increase in panel increases the effective area upon which rain fall is incident and, in turn, the predicted level of sound will increase.

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(2)Marshall, J.S. & Palmer, W. McK (1948). The distribution of raindrops with size, *Journal of Meteorology, 5, 165-166.*

(3) Ballagh, K (1990). Noise of simulated rainfall on roofs, *Applied Acoustics, 31, 245-264*

## Using INSUL

### Insul Tabs

The Insul tabs are the primary control point for predicting sound levels.

- Version 6.4 of Insul includes 8 tabs:
- Panel1
- Panel 2
- Wall
- Ceiling
- Floor
- Double/Triple Glazing
- Roof
- Porous Facing

By selecting a different tab, Insul will calculate predicted sound levels under various circumstances.

- Panel 1 & Panel 2 will calculate transmission loss or sound reduction levels for a panel or combination of panels.
- Wall & Ceiling will calculate transmission loss or sound reduction levels for various wall and ceiling cavity constructions, using the elements of Panel 1 and Panel 2 as the linings on each side of the cavity construction.
- Double/Triple Glazing will calculate transmission loss or sound reduction levels for various double and triple glazing constructions, with glazing types and thicknesses selected directly on the Double/ Triple Glazing tab.
- Porous Facing will calculate transmission loss or sound reduction levels for a porous blanket.
- Floor will calculate impact sound insulation levels for various floor constructions with and without a ceiling.
- Roof will calculate rain generated noise levels for various roof constructions with and without a ceiling.

### Scrolling through tabs

Depending on the size of screen that is being used, it may be that not all the tabs are displayed on the Insul page control. If this is the case, the hidden tabs can be scrolled through using the scroll buttons at the top right-hand corner of the page control as shown below.

**Material** 10 Standard Gib Board

**Thickness** 10 (mm) **Number of Linings** 1

Surface Mass 6.4 kg/m2

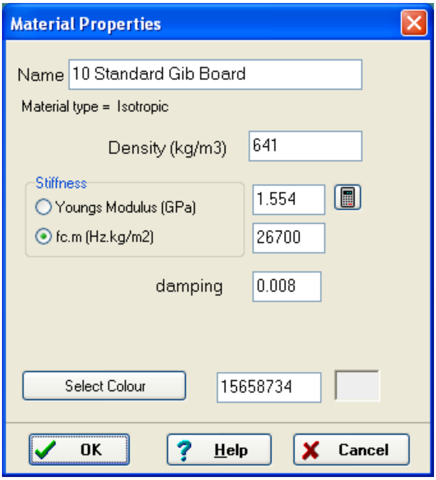
Critical Freq 4165 Hz

layers” field or by using the spin edit button to the right of the field. Note setting the number of layers to zero and initiating a calculation will cause an arithmetic error. To initiate a calculation, either click the left mouse button in one of the button on the left hand side of the tool bar (showing a symbol of gear wheels) or press control c.

Note you can have 2 different materials or 2 different thicknesses of the same material by using the inner and outer layer tabs at the bottom

To model a new material 3 parameters are needed, the density of the material, the product of critical frequency and surface mass (fcm), and the internal damping of the panel. The density is usually easy to determine either by direct measurement or from manufacturers data. The constant fcm can be determined either from a TL test on one particular thickness of the material, or it can be calculated from the elastic modulus of the material. Manufacturers can often provide data on the elastic modulus since it is usually needed for strength and deflection calculations for building materials. The damping constant can be determined from measurement or from TL test data. If no data is available it is reasonable to use a value of 0.01 which is very typical of many building materials.

If the material is not available in the drop down material list Box then the characteristics of the material must be input in the material constants dialog input Box.



Name 10 Standard Gib Board

Material type = Isotropic

Density (kg/m3) 641

○ Youngs Modulus (GPa) 1.554

● fc.m (Hz.kg/m2) 26700

damping 0.008

15658734

Clicking on the materials constants button on the input page accesses this. This has input fields for the material density, the fcm constant and the material dumping. Alternatively, if fcm is not known but the elastic modulus is known then this can be input, but the radio button to the left of the input field for elastic modulus must be clicked. Once all material characteristics are input the dialog Box is closed by clicking on the OK button.

New materials can be permanently entered into the materials.txt file. This is a simple ASCII text file. See the section **New Materials** for details of how to enter new materials. If desired you can send Marshall Day Acoustics the details and we will customise the materials file for you.

## Double Panels

While it is rather simple and accurate to predict the TL of single panels, it is more difficult to predict walls that have two panels separated by a space. However, since this is such a common type of construction and since it can improve performance considerably various
techniques have been developed. Indeed this is the main reason for using INSUL since it makes a complicated task quick and easy.

The easiest situation to understand and explain is two panels separated by an airspace with an absorptive blanket in the space between the panels. There is assumed to be no connection between the panels. At low frequencies the stiffness of the air between is so high relative to the inertia of the panels that the two panels are effectively locked together and more as one. The TL is simply predicted from the mass law using the combined mass of the two panels. As the excitation frequency increases the inertia of the panels increases, at the mass-air-mass resonance frequency the inertia of the panel is cancelled by the stiffness of the air and the two panels move out of phase with each other.

As the frequency increases further the TL increases at a much greater rate than the mass law (up t 12 dB/octave). At even higher frequencies the separation of the panel becomes less than ½ a wavelength and the cavity can now be modelled as a room with a single panel wall on each side.

To model a double panel or cavity wall click on the tab labelled wall and select the type of frame that best describes the connections between the two sides of the wall. Note that a drawing of a cross section of the wall appears in the panel above the input page showing the type of wall you have selected.

Single stud walls are walls in which the linings on both sides of the frame are rigidly fixed to each other; this is the most common type of wall.

Steel studs are a common type of wall framing in non-load bearing situations (eg office walls) which can be modelled by INSUL.

Double stud walls are modelled reasonably well as double panels without connections.

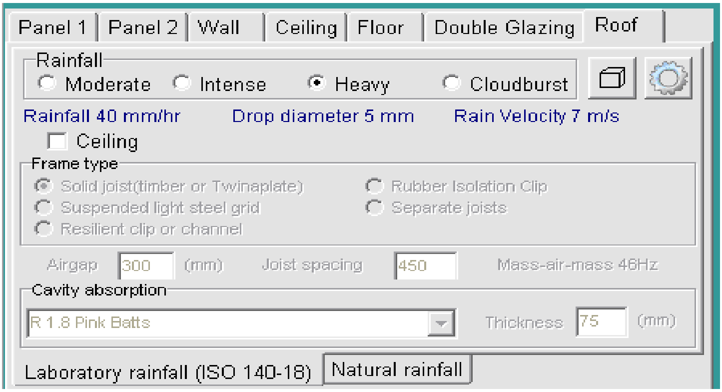
Enter the spacing between the inner faces of the two linings and the spacing between studs.

## Roof

### *Rain noise calculations*

The roof materials you would like to model can be set on the Panel 1 tab, as is done when modeling a wall, ceiling or floor.

To predict the level of rain noise for a construction, click on the Roof tab.



Rainfall
○ Moderate ○ Intense ● Heavy ○ Cloudburst

Rainfall 40 mm/hr Drop diameter 5 mm Rain Velocity 7 m/s

☐ Ceiling

Frame type
● Solid joist(timber or Twinaplate)
○ Suspended light steel grid
○ Resilient clip or channel
○ Rubber Isolation Clip
○ Separate joists

Airgap 300 (mm) Joist spacing 450 Mass-air-mass 46Hz

Cavity absorption
R 1.8 Pink Batts Thickness 75 (mm)

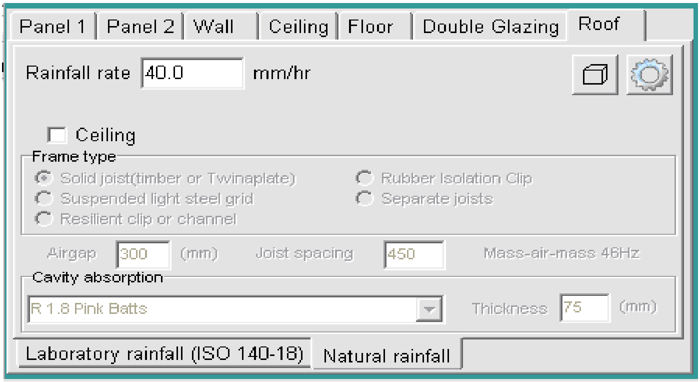
### *Laboratory rainfall (ISO 140-18)*

Select the Laboratory rainfall (ISO 140-18) page on the Roof tab.

Four different rainfall rates are available, Moderate, Intense, Heavy and Cloudburst.

### *Natural Rain*

Select the Natural rainfall page on the Roof tab. Enter the rainfall rate you would like to use in the edit box at the top right hand corner of the Roof page.



Rainfall rate 40.0 mm/hr

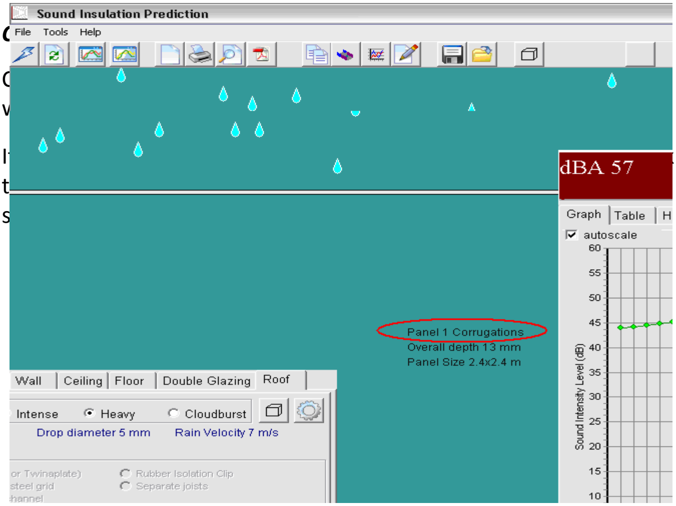
☐ Ceiling

Frame type
- ● Solid joist(timber or Twinaplate)
- ○ Suspended light steel grid
- ○ Resilient clip or channel
- ○ Rubber Isolation Clip
- ○ Separate joists

Airgap 300 (mm) Joist spacing 450 Mass-air-mass 46Hz

Cavity absorption

R 1.8 Pink Batts Thickness 75 (mm)



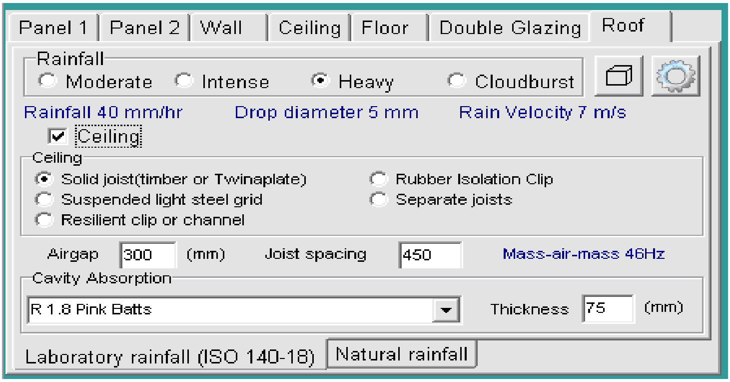
dBA 57

Panel 1 Corrugations
Overall depth 13 mm
Panel Size 2.4x2.4 m

○ Intense ● Heavy ○ Cloudburst

Drop diameter 5 mm Rain Velocity 7 m/s

or Twinaplate) ○ Rubber Isolation Clip
steel grid ○ Separate joists
hannel



Rainfall
○ Moderate ○ Intense ● Heavy ○ Cloudburst

Rainfall 40 mm/hr Drop diameter 5 mm Rain Velocity 7 m/s

☑ Ceiling

Ceiling
● Solid joist(timber or Twinaplate) ○ Rubber Isolation Clip
○ Suspended light steel grid ○ Separate joists
○ Resilient clip or channel

Airgap 300 (mm) Joist spacing 450 Mass-air-mass 46Hz

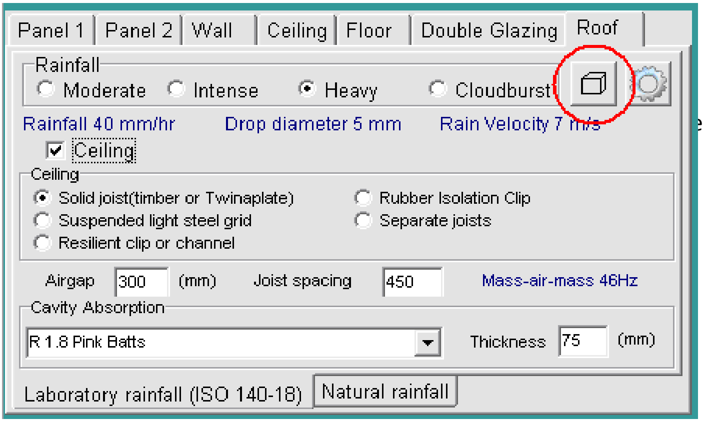
Cavity Absorption
R 1.8 Pink Batts Thickness 75 (mm)

You can use these ceiling properties to select the ceiling arrangement you want. You can specify different ceiling connections, the air-gap and joist spacing and the type and thickness of any insulation used in the cavity. The controls on the roof tab page are the same as those shown on the Ceiling tab.

The ceiling controls are linked across the Ceiling, Floor and Roof tabs. If you make a change to the ceiling arrangement shown on, for example, the Floor tab, these changes will be carried across to the Ceiling tab and the Roof tab.ii

***Panel size***

The roof panel size can be set by clicking on the Room properties button on the Roof page.



Rainfall

○ Moderate ○ Intense ● Heavy ○ Cloudburst

Rainfall 40 mm/hr Drop diameter 5 mm Rain Velocity 7 m/s

☑ Ceiling

Ceiling

● Solid joist(timber or Twinaplate)
○ Suspended light steel grid
○ Resilient clip or channel
○ Rubber Isolation Clip
○ Separate joists

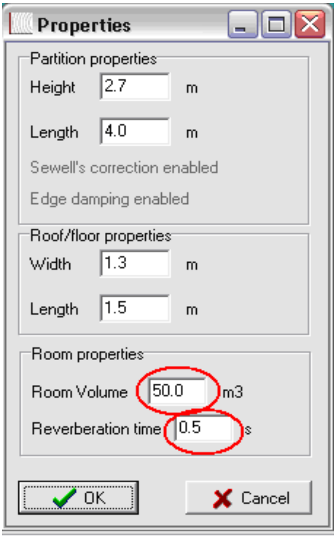
Airgap 300 (mm) Joist spacing 450 Mass-air-mass 46Hz

Cavity Absorption

R 1.8 Pink Batts Thickness 75 (mm)

### *Reverberation time and room volume*

To set the reverberation time and room volume, open the Room properties window, by clicking on the Room properties button on the Roof page



Partition properties

Height 2.7 m

Length 4.0 m

Sewell's correction enabled

Edge damping enabled

Roof/floor properties

Width 1.3 m

Length 1.5 m

Room properties

Room Volume 50.0 m3

Reverberation time 0.5 s

The reverberation time and room volume can be changed using the edit boxes.

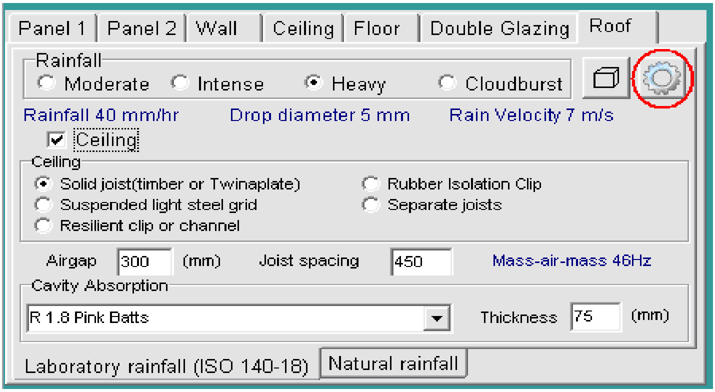
Changing the reverberation time and room volume is important when predicting rain sound pressure levels.

### *Outputs*

Insul can predict rain sound levels as:

- sound power levels
- sound pressure levels
- sound intensity levels.

To set the type of output, click on the settings button on the Roof page.



Rainfall
○ Moderate ○ Intense ● Heavy ○ Cloudburst

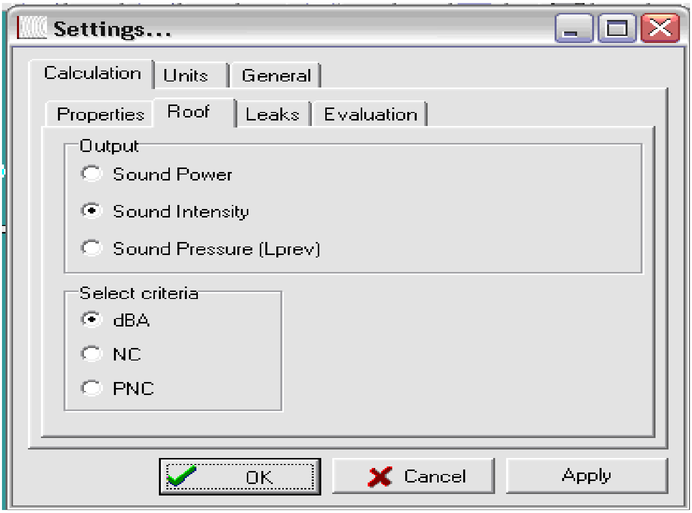
Rainfall 40 mm/hr Drop diameter 5 mm Rain Velocity 7 m/s

☑ Ceiling

Ceiling
● Solid joist(timber or Twinaplate) ○ Rubber Isolation Clip
○ Suspended light steel grid ○ Separate joists
○ Resilient clip or channel

Airgap 300 (mm) Joist spacing 450 Mass-air-mass 46Hz

Cavity Absorption
R 1.8 Pink Batts Thickness 75 (mm)



Output
○ Sound Power
● Sound Intensity
○ Sound Pressure (Lprev)

Select criteria
● dBA
○ NC
○ PNC

When sound pressure is the selected output, the reverberation time and room volume become important. These can be set from the Room properties window.

The single figure index for the predictions can also be set from this menu. dBA, NR and NC are available.

## Saving and retrieving files

It is possible to save the details of a construction for future reference. Click the button on the top tool bar that has a picture of a diskette. This will bring up a file dialog Box. Click in the filename Box and enter the file name that you want it saved as. If you want to save in a different directory you can use the standard windows file directory tree to navigate to the desired directory. If you don't type in a file extension it will automatically give the file and extension of ins. You may recall a file at a later stage by clicking on the button on the top tool bar that has a picture of a folder. This will bring up a file dialog Box. This works similarly to other windows programs, for instance you can double click on the file you wish to recall, or type its name into the edit Box.

## Comparison

INSUL includes a feature to allow immediate comparison of the TL of different constructions. The buttons with a graph with 2 lines on it when clicked will memorise the graph of the current construction. The TL of the previous construction will be shown in red or yellow so that you can see immediately how your changes have affected the TL at different frequencies. You can also use CTRL-S to set this comparison. The red or yellow comparison curve remains until you either set a new comparison or reset it (which sets it to zero). (Use the option under the File Menu).

## Reference

Sometimes you may have an existing partition with test data available and you want to use INSUL to predict changes. In this case you can enter the test data onto the graph so that you can see how closely INSUL models the existing partition and if necessary you can adjust the model for best agreement before modelling the changes. You can do this by clicking on the tab labelled Table and entering the data into the grid in the column headed **Ref.** You must then click the checkbox marked **Display ref spectrum** just next to the table, where upon the test data will appear in pink on the graph for easy comparison. You can turn off the display by un-checking the box. Another reference spectrum can be displayed in the Ref 2 column again using the checkbox marked **display ref2 spectrum** to turn on or off the display of this data. Data may also be pasted from the clipboard using the two buttons to avoid having to manually enter the data

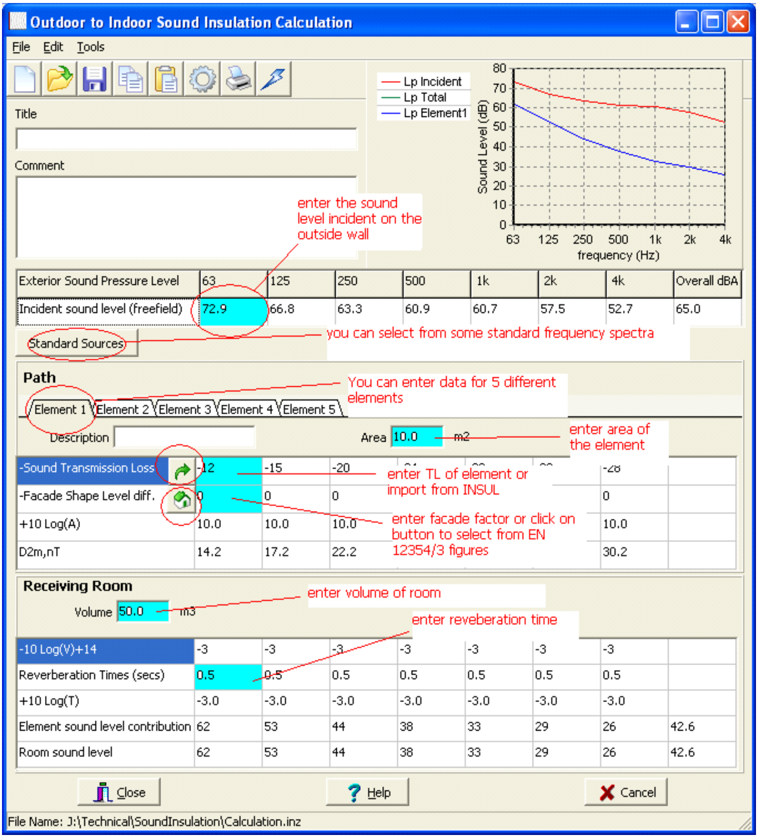
## Outdoor to Indoor Transmission

INSUL is primarily a tool for predicting the sound transmission loss of a wall or floor. However a simple calculation tool has been added for working out the overall transmission of noise from outside to inside. For instance with aircraft or road traffic noise incident on a house or the facade of an apartment, what will be the noise level inside a particular room. INSUL can now be used to complete this calculation

## Calculation Form

Open up the calculation form by clicking on the button on the toolbar

You will see a form like that below with places to enter the relevant data. The light blue indicates the cells where you should enter data. Note that in general you need to enter data at every frequency.



Title

Comment

enter the sound level incident on the outside wall

| Exterior Sound Pressure Level | 63 | 125 | 250 | 500 | 1k | 2k | 4k | Overall dBA |
|---|---|---|---|---|---|---|---|---|
| Incident sound level (freefield) | 72.9 | 66.8 | 63.3 | 60.9 | 60.7 | 57.5 | 52.7 | 65.0 |

you can select from some standard frequency spectra

**Path**

You can enter data for 5 different elements

Element 1 Element 2 Element 3 Element 4 Element 5

Description

Area 10.0 m2

enter area of the element

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -Sound Transmission Loss | -12 | -15 | -20 | [illegible] | [illegible] | [illegible] | -28 | |
| -Facade Shape Level diff. | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | 0 | |
| +10 Log(A) | 10.0 | 10.0 | 10.0 | [illegible] | [illegible] | [illegible] | 10.0 | |
| D2m,nT | 14.2 | 17.2 | 22.2 | [illegible] | [illegible] | [illegible] | 30.2 | |

enter TL of element or import from INSUL

enter facade factor or click on button to select from EN 12354/3 figures

**Receiving Room**

Volume 50.0 m3

enter volume of room

enter reveberation time

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -10 Log(V)+14 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | |
| Reverberation Times (secs) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| +10 Log(T) | -3.0 | -3.0 | -3.0 | -3.0 | -3.0 | -3.0 | -3.0 | |
| Element sound level contribution | 62 | 53 | 44 | 38 | 33 | 29 | 26 | 42.6 |
| Room sound level | 62 | 53 | 44 | 38 | 33 | 29 | 26 | 42.6 |

File Name: J:\Technical\SoundInsulation\Calculation.inz

## Extra data required

In addition to the sound transmission loss of the wall (predicted by INSUL) we also need to know the outdoor noise level incident on the wall, the area of the wall, and the volume and reverberation time of the room. There may be several elements to the facade, such as the main external wall construction, a window and an additional transmission path through a side wall. The sound transmission loss and area of each path must be known or estimated.

### *Outdoor noise level*

The sound transmission loss is a function of frequency and in general the outdoor noise will consist of a mixture of different frequencies. Thus the calculation must be made over the normal audible frequency range . INSUL can be set to do this in either octave or 1/3 octave frequency bands. The choice of frequency bandwidth will generally be determined by whether the data is available in octave or 1/3 octave bands. There is a handy calculator which you can use to calculate the frequency spectrum for different noise sources if you know the A weighted noise level (dBA).

### *Reverberation Time and Room Volume*

The reverberation time can often be estimated with reasonable accuracy from a knowledge of the room and its furnishings. It is a convenient phenomenon that for general living spaces such as bedrooms and living rooms the reverberation time of most rooms turns out to be close to 0.5 seconds and reasonably flat across the frequency range. Thus for domestic rooms in the range 20 $m^3$ to 200 $m^3$ you can use 0.5 seconds at all frequencies as a reasonable estimate. For different rooms that are either much larger or more sparsely furnished the reverberation time should be either calculated or measured.

### *Façade Shape Level Difference*

As noted in EN12354 the facade of the building can affect the sound transmission by either shielding or reflective effects. The afore mentioned standard contains a table of corrections to be applied to the calculations depending on the facade arrangement. In INSUL you can click on the button that has a picture of a house. This brings up a form that shows the vertical cross sections of some different arrangements. Click on the picture most closely describing your situation. The effect of reflection from an over hanging balcony above, and whether this balcony has absorptive surface, and the shielding effect of ones own balcony front can be allowed for.

For other situations one can enter you own value in this row. Based on consultants experience our current practice is to use - 6 dB factor for the shielding of a side wall which is not directly visible by the source, -3 dB for a roof, and -10 dB for a rear wall. These values are for guidance only and may be updated as more current research and experience becomes available.

## Angle of incidence (you don't need to read this if you don't want to)

An often overlooked factor with outdoor to indoor calculations is that all sound transmission loss data that is commonly provided is measured (or calculated) for a random incidence field on both the source and receiver side of the partition. Yet as acoustic text books point out, the sound transmission loss of a partition will vary with angle of incidence, reducing as the angle of incidence approaches grazing incidence. Thus you would expect that the transmission loss of the facade and hence the internal noise level in the room should vary with the angle of incidence of the external noise. However research undertaken by Rindel (Transmission of Traffic Noise through Windows. Influence of Incident Angle on Sound Insulation in Theory and Experiment, report no 9, DTU Denmark 1975) shows that for finite sized partitions (i.e. not infinite sized partitions) and for low and mid frequencies there is little actual influence of angle of incidence on the "External" transmission loss.

To explain this in a different way, in classical acoustics the sound transmission loss (defined in terms of incident intensity) tends towards zero at grazing incidence. However the incident sound power will also tend towards zero because the projected area the sound wave is incident on tends to zero. Thus it is not clear what wins, the incident level tends to zero but the transmission loss tends to zero also. What will the internal level be? Rindel avoided the confusion by defining the "External Transmission Loss" as the ratio of the energy densities of the sound fields on the source and receiver sides.

The external energy density does not go to zero and the External transmission Loss can be estimated from the traditionally measured random incidence transmission loss. These effects are included in the outdoor to indoor calculations carried out by INSUL. The same effects are included in EN 12354/3 in section 4 when it describes the general principles of the calculation model. The apparent sound reduction index of the facade is given as equal to the random incidence sound transmission loss.

Thus trying to reach a simple conclusion, the answers calculated by INSUL are a good prediction for noise that is incident from a range of different angles of incidence (e.g. traffic noise) and furthermore is a reasonable approximation for most building facades for any angle of incidence. The answers for specific angles of incidence could be in error at frequencies above 1 kHz. For either normal incident sound or for grazing incidence sound, the maximum expected error at say 4 kHz would be +/- 3dB, and for most noise sources these frequencies would not determine the overall loudness of the internal noise.

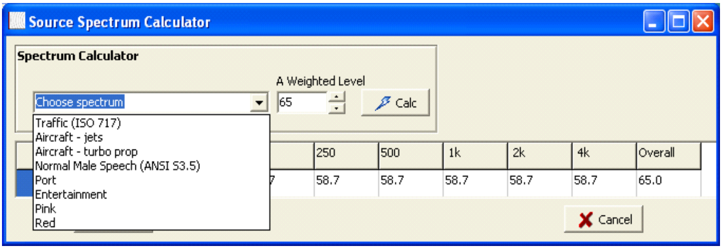
## Sound Source

### Very Important Note

The source sound level to be entered into the calculation sheet is the sound level incident on the building facade, but measured or assessed with the building not there. It is the free field level. If you have a noise level measured in the presence of the building then this measured level will include some reflection from the facade. In general if you measure 1 to 2 metres from the facade the noise level will be about 3 dBA higher than the free field level (i.e. with the building not there).

## Frequency Spectrum

The noise level inside the room will depend on the frequency spectrum of the noise source. For instance noise from nightclubs or bars will often contain a lot of low frequency sound energy and light weight building elements like windows will provide only a small amount of attenuation of that noise. Therefore it is important that the frequency spectrum of the noise is either known or can be estimated with reasonable accuracy. INSUL contains a small calculator which can estimate the frequency spectrum if the overall A-weighted noise level is known. For instance traffic noise can be estimated reasonably well in free flowing conditions from a standard spectrum given in ISO 717, or male speech spectrum can be estimated from ANSI S3.5. Click on the button labelled "Standard Sources" and the following form will appear.



A Weighted Level: 65

| 250 | 500 | 1k | 2k | 4k | Overall |
|---|---|---|---|---|---|
| 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 65.0 |

### Octaves versus 1/3 Octaves

Acoustic calculations are generally required to be carried out at a range of different frequencies. The Outdoor to Indoor Calculation in INSUL can be carried out either in Octave or 1/3 Octave bands. The choice is primarily dependent on the information available and the degree of accuracy required. Traditionally octave bands have been used for engineering calculations, probably because historically this sped up calculations by a factor of 3 without much loss of accuracy for most purposes. For many noise sources which are broad band in nature (e.g. traffic noise) the change in precision between use of octave or 1/3 octave bands would be minute. If you have all the data available in 1/3 octave bands then there is little point in not using it. If however some of your data is only in octave bands then use octave bands.

INSUL can be set to use either octave band data or 1/3 octave band data. Go to the settings page and choose the bandwidth.

## Standards

INSUL calculates in accordance with

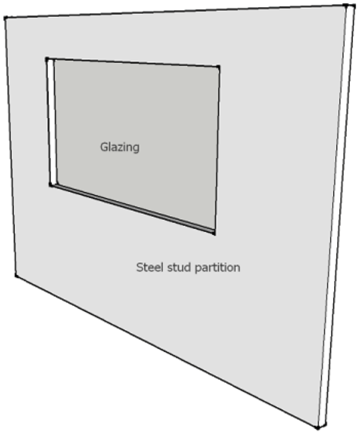
- EN 12354-3:2000 "Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 3: Airborne sound insulation against outdoor sound”.

## D2m,nT

INSUL displays this quantity on the calculation form. If you are not familiar with ISO standards then this needs some explanation. This quantity is a standardised measure of facade performance. It is the difference between the outdoor sound level measured 2 metres from the facade (thus including the effects of reflection from the facade) and the spatial average sound level inside the receiving room, when the receiving room has a reverberation time of 0.5 seconds (at all frequency bands). This quantity will vary somewhat depending on the volume of the room and the area of facade exposed so it is not a unique quantity of the partition.

## What is Composite Transmission Loss?

If a partition comprises, say, 75% steel stud wall and 25% glazing, the sound reduction or transmission loss through the steel stud wall will be different from the transmission loss of the glazing.



So what will be the transmission loss of the overall partition?

The theoretical transmission loss of the overall partition is called the *Composite transmission loss* or *Composite TL.*

### Composite Transmission Loss Equations

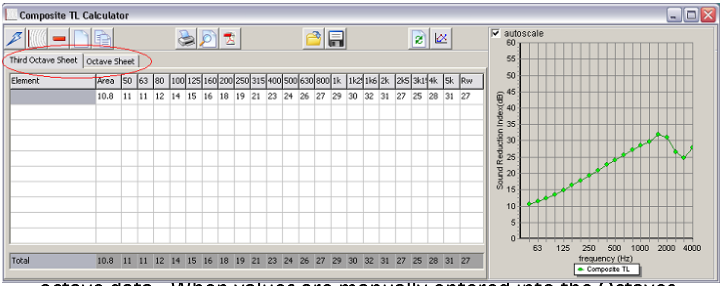
The composite transmission loss can be calculated as the average of the transmission coefficients (      ) of the individual elements that make up the partition. The average is weighted, according to the surface area (S) of each of the elements.

$$R_{Total} = -10log_{10}\left(\frac{1}{\sum_{n=1}^{N} S_n}\sum_{n=1}^{N} S_n \tau_n\right)$$

## Composite TL Calculator functions

### Octaves versus 1/3 Octaves

Octave and Third Octave sheets are available in the Composite TL Calculator.

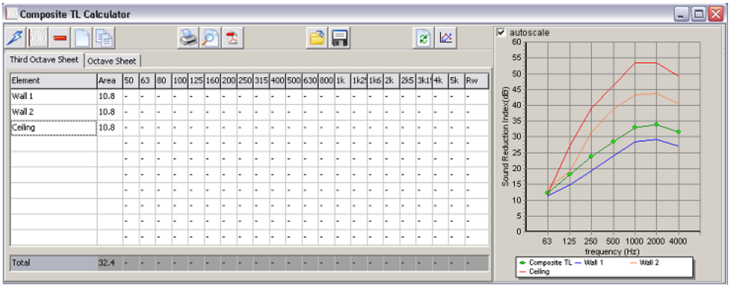


Composite TL Calculator

Third Octave Sheet | Octave Sheet

| Element | Area | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1k2 | 1k6 | 2k | 2k5 | 3k1 | 4k | 5k | Rw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 10.8 | 11 | 11 | 12 | 14 | 15 | 16 | 18 | 19 | 21 | 23 | 24 | 26 | 27 | 29 | 30 | 32 | 31 | 27 | 25 | 28 | 31 | 27 |
| Total | 10.8 | 11 | 11 | 12 | 14 | 15 | 16 | 18 | 19 | 21 | 23 | 24 | 26 | 27 | 29 | 30 | 32 | 31 | 27 | 25 | 28 | 31 | 27 |

octave data. When values are manually entered into the Octaves Sheet the Third Octaves Sheet will be zeroed and will appear as follows:



Composite TL Calculator

Third Octave Sheet | Octave Sheet

| Element | Area | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1k2 | 1k6 | 2k | 2k5 | 3k1 | 4k | 5k | Rw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall 1 | 10.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Wall 2 | 10.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ceiling | 10.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total | 32.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Delete data**

Click to delete a row of data. The row which contains the selected cell will be deleted and all values in that row will be set to zero.

**Reset calculator**

Click to reset the Composite TL Calculator and clear all data.

**Printing**

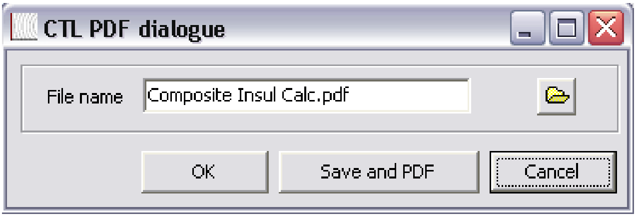
A sheet can be printed which records each set of transmission loss data in the Composite TL Calculator including the composite transmission loss. There are 3 buttons associated with printing.

The first button, ,w icked will display a print dialog box which enables the user t e usual selection of printer properties etc before sending the page to the printer.

The second button, displays a preview of what will be printed. Due to the generally p resolution of screens compared to printers this will not look exactly the same as the printout).

The third button, , v nerate an Adobe Acrobat file of the printout. This is a fairly universal format that enables, for instance, the user to email printouts to others. The receiver will require the Acrobat reader which is free to download from the Adobe site (http://www.adobe.com/products/acrobat/readstep2.html

Clicking there is also an option to generate a pdf printout and save the file simultaneously. On the dialog window that appears:



File name: Composite Insul Calc.pdf

Click the *Save and PDF* button.

**Save**

It is possible to save composite transmission loss data for future reference.

Click the button c e Insul Toolbar.

This will open a Windows file dialog Box. Click in the filename Box and enter the name the file is to be saved as. To change to a different directory use the standard windows file directory tree to navigate to the desired directory. If a file extension is not included in the filename, the file will be saved as a *.cns* Insul file.

**Open**

You may open/recall/load a file at a later stage by clicking on the button . This will bring up a file dialog Box. This works similarly to other windows programs, for instance you can double click on the file you wish to recall, or type its name into the edit Box.

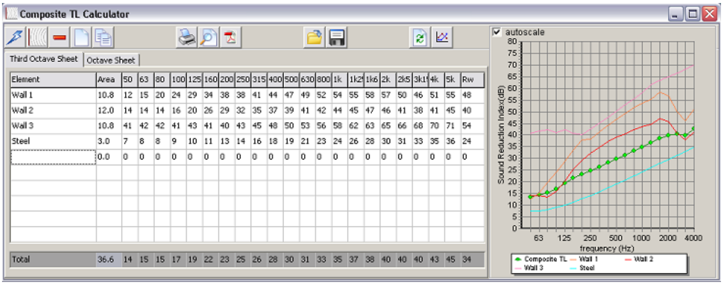
## Toggle STC/Rw

Click the n to toggle between STC and Rw single figure indices.

## Show/Hide plots.

Click the b to show/hide element plots.
When the ent plots are hidden, the chart displays only the Composite TL data plotted as a green curve.

When the element plots are shown, the chart displays a plot for each set of transmission loss data that is entered into the Composite TL Calculator. A different line colour is used for each set of data. An example composite transmission loss calculation with element plots shown is provided in the image below.



| Element | Area | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1k2 | 1k6 | 2k | 2k5 | 3k1 | 4k | 5k | Rw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall 1 | 10.8 | 12 | 15 | 20 | 24 | 29 | 34 | 38 | 38 | 41 | 44 | 47 | 49 | 52 | 54 | 55 | 58 | 57 | 50 | 46 | 51 | 55 | 48 |
| Wall 2 | 12.0 | 14 | 14 | 14 | 16 | 20 | 26 | 29 | 32 | 35 | 37 | 39 | 41 | 42 | 44 | 45 | 47 | 46 | 41 | 38 | 41 | 45 | 40 |
| Wall 3 | 10.8 | 41 | 42 | 42 | 41 | 43 | 41 | 40 | 43 | 45 | 48 | 50 | 53 | 56 | 58 | 62 | 63 | 65 | 66 | 68 | 70 | 71 | 54 |
| Steel | 3.0 | 7 | 8 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 19 | 21 | 23 | 24 | 26 | 28 | 30 | 31 | 33 | 35 | 36 | 24 |
|  | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 36.6 | 14 | 15 | 15 | 17 | 19 | 22 | 23 | 25 | 26 | 28 | 30 | 31 | 33 | 35 | 37 | 38 | 40 | 40 | 40 | 43 | 45 | 34 |

## Remote Update of Insul USB Key

The Hasp key which is required to run INSUL has the version number which the customer has purchased stored in it. When an update is purchased the key must be updated before it will allow the new version to run. This can be done without returning the key to the Distributors or the Developers.

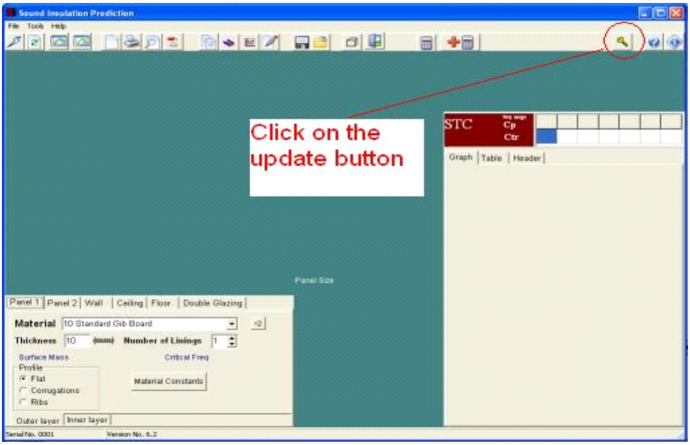
## Upgrading Insul Keys

Starting with Insul version 6.2 , the usb keys can be upgraded without needing to be returned to the developer or distributor. The process is for the user to generate a file from their key using Insul , this file is sent to the developer who generates an update file. This update file is sent back to the client who then uses Insul to update their key. The key can be upgraded to a new version or other software can be added to the key.

1. Start Insul and then click on the remote update button on the tool bar (see below).

2. Click on the "Save Key Information to file" and save the file (*.c2v) this produces to a convenient location and then email it to the Distributor or the Developer (insul@insul.co.nz).

3. An update file will be emailed to you that can be used with Insul to update the key to the new version using the "update Key from file" button. Browse to the update file sent to you by the developer or the distributor. This will be named something like "0101key1300.v2c". Open this, Insul will then update the key and display a message that the key has been updated successfully. The key should now have the new information loaded and should unlock the new version of Insul.



Click on the update button

Material 10 Standard Gib Board
Thickness 10 (mm) Number of Linings 1
Serial No. 0001 Version No. 6.2

key version = 6.2

Serial No. 0001

## Clipboard

The transmission loss data can be copied to the Windows clipboard by clicking on the left-hand button shown above. The data can then be transferred to a spreadsheet or similar. The format is given blow. The graph may also be transferred to the clipboard by clicking on the right-hand button shown above.

| | |
|---|---|
| 50 | 13.4 |
| 63 | 14.3 |
| 80 | 15.5 |
| 100 | 16.8 |
| 125 | 16.7 |
| 160 | 21.7 |
| 200 | 25.9 |
| 250 | 29.7 |
| 315 | 33 |
| 400 | 35.7 |
| 500 | 37.8 |
| 630 | 39.3 |
| 800 | 41.2 |
| 1000 | 42.8 |
| 1250 | 44.3 |
| 1600 | 45.7 |
| 2000 | 46.6 |
| 2500 | 47.8 |
| 3150 | 45.9 |
| 4000 | 40.2 |
| 5000 | 42.1 |
| STC | 39 |

### Settings

To open the Settings windows either:

- Click the button
- From the Tools menu select: Tools>Settings...
- Pressing *Ctrl+,* from the Insul main page.

### Calculation Settings

Click the *Calculation* tab in the Settings window to adjust various calculation parameters.

- Sewell's Correction and Edge Damping can be turned on and off from the *Properties* tab.
- Roof (rain noise) output and single figure index can be selected from the *Roof* tab.
- The calculation algorithm for Slits and Apertures can be selected from the *Leaks* tab.

The evaluation method (ISO or ASTM) can be selected from the *Evaluation* tab, as can the frequency range for assessment of the C correction when using the ISO 717 evaluation method.

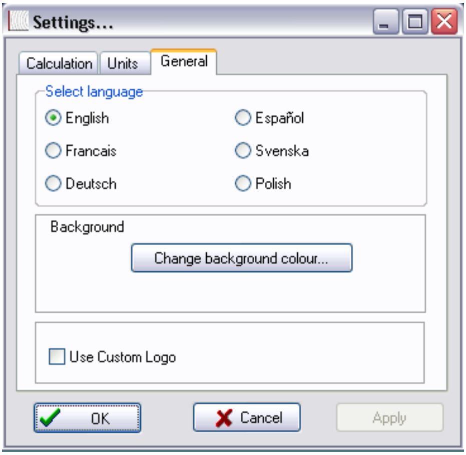
### Units

Click the *Units* tab in the Settings window to change units between Metric and English.

**Important**: Insul must be restarted after changing the units for the changes to be made correctly.

### General

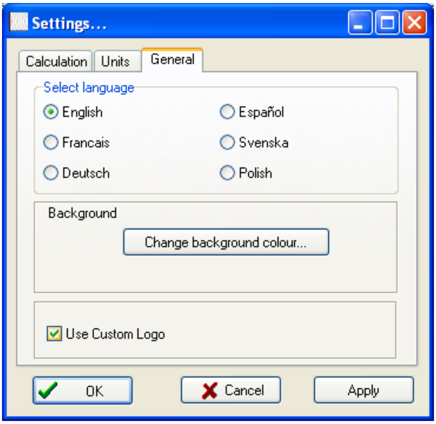
Click on the *General* tab to change the language for Insul and also to change the colour of the background panel and activate a Custom Logo.



## Custom Logo

Users can insert their own logo into the printout. The logo should be in the form of a bitmap file, named logo.bmp and stored in the Insul folder (this is usually C:\program files\marshall day acoustics\Insul64)

To activate the custom logo, open the Settings window, select the *General* tab and check on the box marked *Use Custom Logo*.



## Limitations

Users should be aware of its limitations, like any prediction tool it is not a substitute for test data.  Comparisons with test data show that it is generally within 3 STC points for most.

## Contact Details

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