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SOUND CONTROL

PVB FILM FOR ACOUSTIC GLAZING

PRODUCT INFORMATION

TROSIFOL®

WHAT IS NOISE?

Noise is defined as any type of sound that is considered disturbing, annoying or painful. Ambient noise consists of a multitude of sounds of different frequencies and intensities.

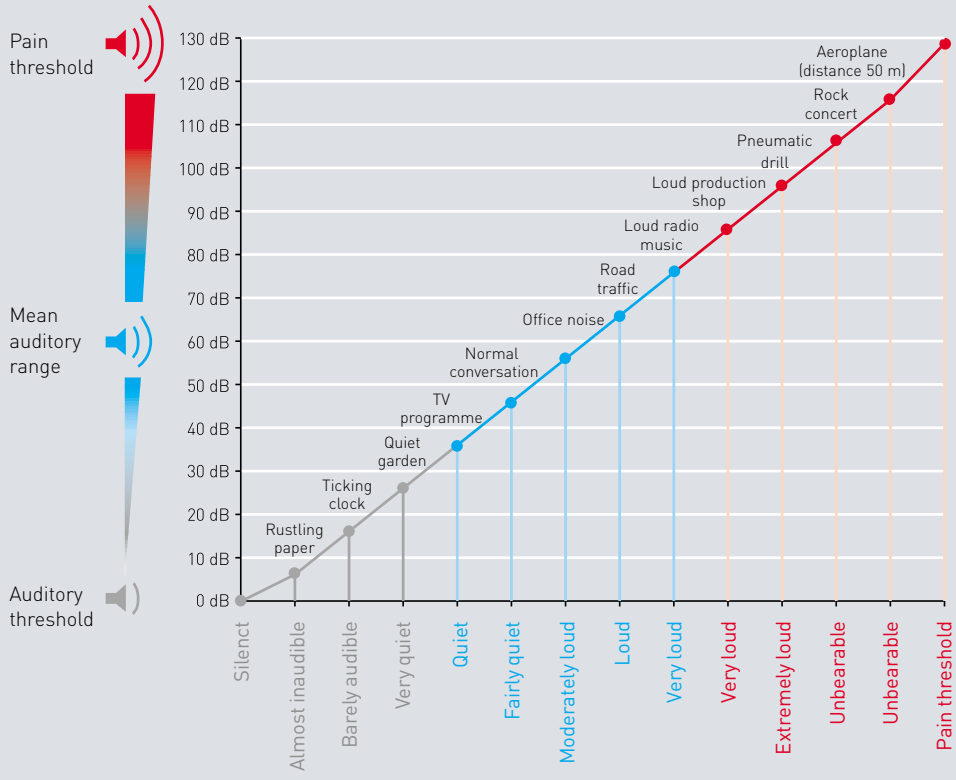
The measurement of noise intensity takes account of what is perceived by the human ear. Higher pitches are subjectively perceived as louder than lower pitches. The loudest sound that a human being can painlessly hear has ten trillion times the sound intensity of the quietest.

The sense of hearing organizes perception by converting the tenfold sound intensity into about twice the volume.

To represent the volume perceived by the human ear, a logarithmic scale has been chosen for acoustic measurements. The unit of measurement is the decibel (dB). The auditory threshold is assigned by definition the value of 0 dB, while the tenfold sound intensity has a value of 10 dB, the hundredfold sound intensity 20 dB etc. through to the pain threshold, which has a value of about 130 dB.

The following graph shows typical sounds with their volumes and subjectively perceived intensities.

NOISE SOURCES AND PERCEPTION



CAUSES AND CONSEQUENCES OF NOISE

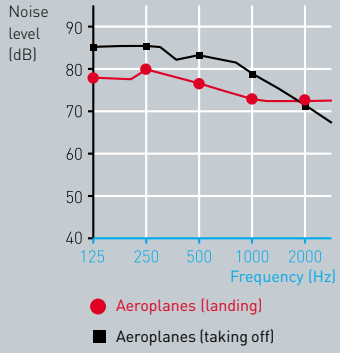
In the last two decades, the traffic density on the roads, in the air and on rails has almost doubled in the industrialized nations. At the same time, the noise nuisance for the population has increased sharply as a result of two decisive factors: Greater settlement density and the associated development and use of building land.

This means that the required noise control in buildings in noise-affected zones such as the landing paths of airports, areas close to motorways and railway tracks has grown considerably.

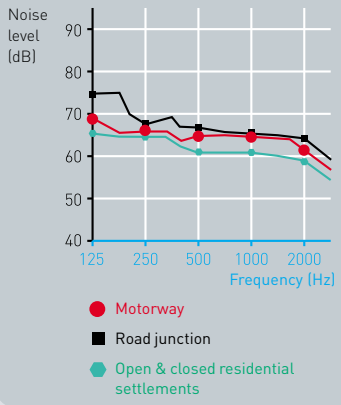
It is a proven fact that noise causes illness. People who are constantly exposed to unwanted, continuous noise nuisance suffer from such consequences as stress, nervousness, sleeplessness, poor concentration and cardiovascular ailments.
To keep the effects of such problems within acceptable bounds, planners and architects are increasingly required to incorporate noise control in building design.
It is particularly important in this connection that the glazed surfaces of buildings in zones burdened by noise are correctly designed.

FREQUENCY-DEPENDENT NOISE LEVELS OF DIFFERENT MEANS OF TRANSPORT

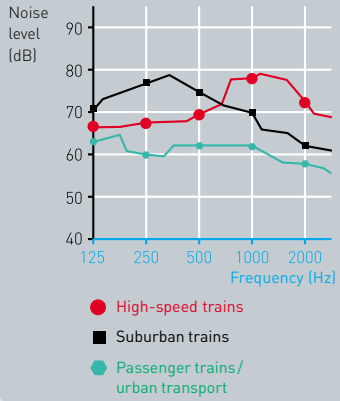
AIR TRAFFIC



ROAD TRAFFIC

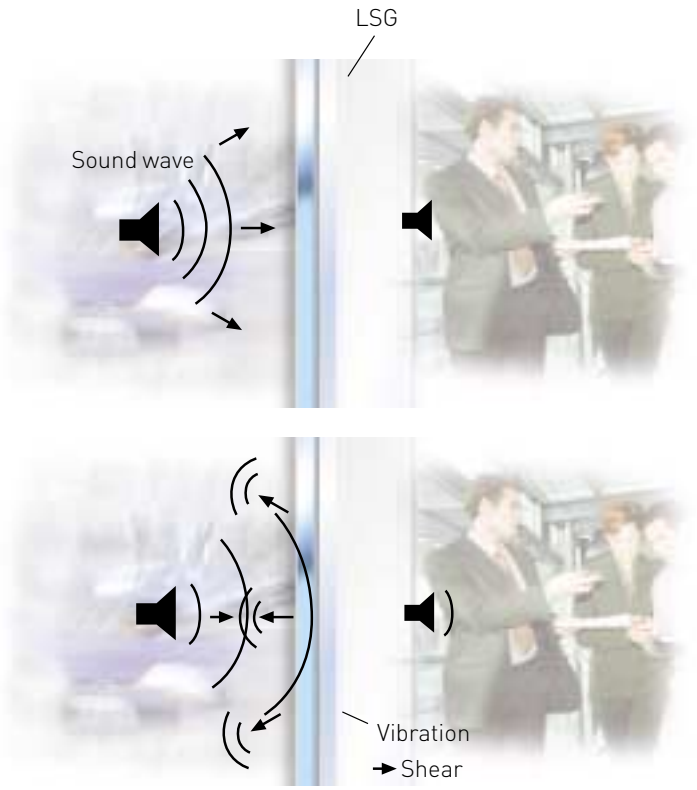


RAIL TRAFFIC

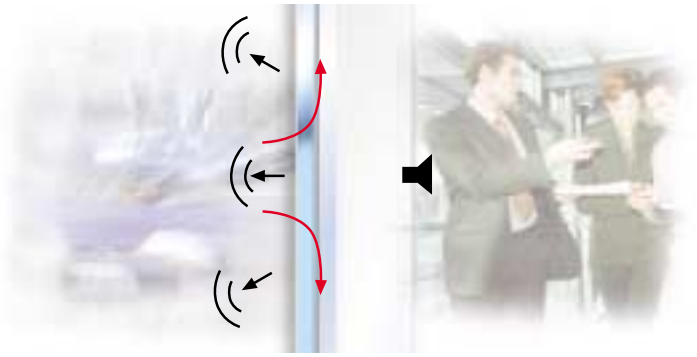


DEFINITION OF SOUND AND SOUND ABSORPTION/INSULATION

SOUND ABSORPTION (INSULATION) WITH LSG



Principle: Directional, mechanical energy is converted into non-directional energy (heat).



A distinction is made according to the noise source between airborne sound (e.g. outdoor and indoor noise in buildings, internal inherent noise), footsteps (internal noise) and structure-borne sound (equipment noise, building services). Effective sound insulation means screening off the interior of buildings from noise generated outside.

To scale down an existing noise nuisance perceived as loud, two fundamental physical effects of wave propagation can be exploited:

- **Noise insulation by reflection** (sound insulation)
- **Noise insulation by absorption** (sound absorption)

The terms „sound insulation" and „sound absorption" must be clearly distinguished. In the former case, the sound energy is not converted into a different energy form, but its direction of propagation is changed by reflection.

In the case of absorption, sound energy is essentially converted into heat (dissipation). In the adjacent figure, the latter is illustrated with the example of laminated safety glass (LSG).

ACOUSTIC GLAZING FOR ARCHITECTURAL APPLICATIONS

Much like solar control, thermal insulation and security glazing, the most effective way of minimizing the effects of noise entering a building from outside is by insulating the window.
The glass surface itself as well as the glass frames and the window's installation position in the façade are crucial for effective sound insulation.
For use in buildings, a large number of basic glass types and specially treated glass products are available.

FLOAT GLASS (MONOLITHIC)

Float glass is so called because it is produced in a floating process, e.g. flat glass. It serves as the initial material for a large number of functional glass types. The sound absorption properties of monolithic glass are, however, modest: Doubling the glass thickness improves absorption by about 5 dB. Because of the associated increase in weight, there are limits to increasing glass thickness. In addition, sound insulation does not improve linearly in relation to low-frequency resonance.

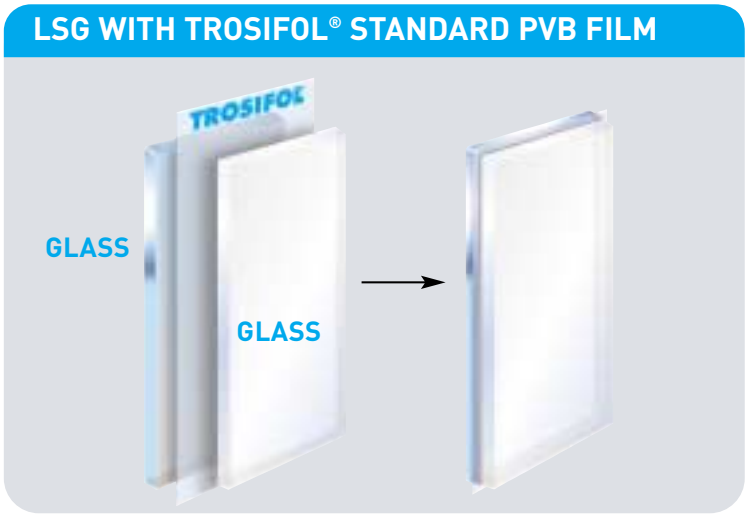
MULTIPLE GLAZING

By using a combination of two individual glass plies of the same thickness, only a slight improvement in the sound insulation values is usually achieved. This is because of the complex interactions between the two plies of glass and the cavity or air space between the two plies – similarly to the physical system of mass/spring/mass. To minimize this effect, the two glass plies must have an at least 30% difference in thickness. An improvement in the sound insulation performance is achieved by increasing the width of the cavity.
Sulphur hexafluoride (SF_6), which is familiar as a greenhouse gas, also significantly improves sound insulation but contributes to global warming.*
By using special laminated safety glass with TROSIFOL® SOUND CONTROL, on the other hand, it is possible to achieve SF_6-free sound insulation windows without impairment of the sound insulation values.

* SF_6 has been banned in Switzerland and, since 2007, in Germany as a filling gas and is no longer used. The use of SF_6 is being increasingly abandoned in EU member states on a voluntary basis.

LAMINATED SAFETY GLASS WITH TROSIFOL® SOUND CONTROL

LSG WITH TROSIFOL® STANDARD PVB FILM



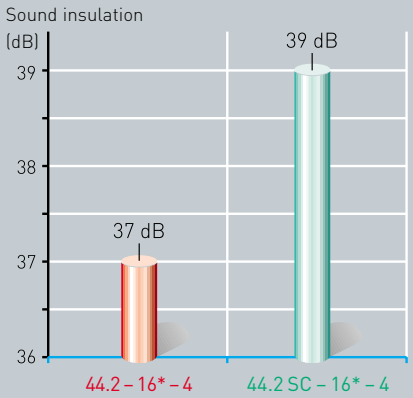
Laminated safety glass consists of two plies of glass and one or more layers of polyvinyl butyral film, which are laminated at high pressures and temperatures to create a permanent bond between the plies. Laminated safety glass produced with TROSIFOL® has outstanding security properties, as any glass fragments resulting from breakage remain stuck to the film and thus strongly reduce these fragments' capacity to cause injury. In terms of sound insulation values, laminated safety glass is up to 2 dB better than float glass of the same thickness.

With the development of TROSIFOL® SOUND CONTROL (TROSIFOL® SC), a novel and special PVB acoustic film, TROSIFOL® made a breakthrough in high-quality acoustic glazing. This product combines the outstanding sound insulation features of multiple glazing with all the advantages of a conventional TROSIFOL® PVB film.
Even in monolithic laminated safety glass, TROSIFOL® SOUND CONTROL reveals its outstanding sound insulation performance.

SOUND INSULATION WITH MONOLITHIC GLASS

Compared to float glass of the same thickness, an improvement of 5 dB in the sound insulation value is achieved in this example with TROSIFOL® SOUND CONTROL. By optimizing the film composition, a further-improved film product is now available that again significantly and measurably improves the sound insulation performance of insulation glazing consisting of one or two laminated safety glass elements.
Laminated safety glass with TROSIFOL® SOUND CONTROL complies with the requirements of the Construction Product List for laminated safety glass as well as the "Technical rules for linearly mounted glazing" of the German Institute of Construction Engineering. The product thus satisfies all the requirements of conventional laminated safety glass – even for overhead use and in glazing that prevents falls.

SOUND INSULATION BY MULTIPLE INSULATION GLAZING



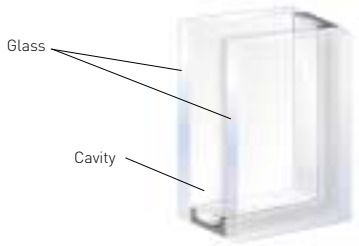
* Argon filling

LSG WITH TROSIFOL® STANDARD PVB FILM COMPARED TO TROSIFOL® SOUND CONTROL

LSG composition (glass/PVB/glass)	TROSIFOL® Standard PVB	TROSIFOL® SOUND CONTROL	
		R_w [dB]*	C ; C_{tr} [dB]
4/0.76 mm/4	34 dB	**37 dB**	**-1 ; -3**
5/0.76 mm/5	35 dB	**38 dB**	**0 ; -2**
6/0.76 mm/6	37 dB	**39 dB**	**0 ; -2**
8/0.76 mm/8	38 dB	**41 dB**	**-1 ; -3**
10/0.76 mm/10	39 dB	**42 dB**	**0 ; -3**
12/0.76 mm/12	40 dB	**43 dB**	**0 ; -3**

* Measurements at the IfT Rosenheim to DIN EN 20140-3/DIN EN ISO 140, test certificates available on request

STANDARD INSULATING GLASS



SCOPE FOR OPTIMIZING SOUND INSULATION

If one considers all the above statements on the possibilities of optimizing sound control glazing, we arrive at the following:

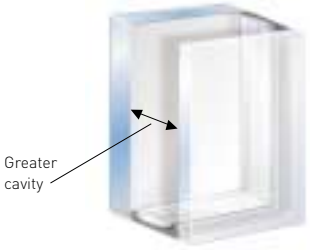
SOUND INSULATION STEP 1

ASYMMETRICAL CONSTRUCTION

Use of an asymmetrical glass construction in multiple insulation glazing for improved vibration behaviour (reducing the construction's capacity to transmit noise)

SOUND INSULATION STEP 2

ENLARGING THE CAVITY



Enlarging the cavity

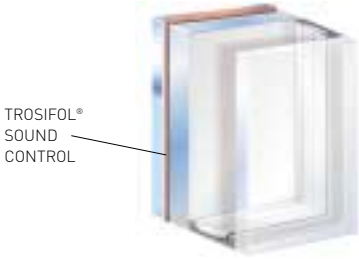
SOUND INSULATION STEP 3

USE OF LSG WITH TROSIFOL® STANDARD PVB

Use of laminated safety glass with TROSIFOL® Standard PVB film

SOUND INSULATION STEP 4

USE OF LSG WITH TROSIFOL® SOUND CONTROL



Use of laminated safety glass with TROSIFOL® SOUND CONTROL demonstrably achieves the highest sound insulation values Rw up to approx. 45 dB with one pane of laminated safety glass and 50 dB or more with two panes of laminated safety glass.

In invitations for tenders for building windows in Germany, the familiar tables of VDI Guideline 2719 are applied, supplemented by the standard DIN 4109 "Sound insulation in building construction".

SOUND INSULATION CLASSES IN ACCORDANCE WITH VDI GUIDELINE 2719

Sound insulation class [1]	R_w value (dB) measured on the building	Window's required R_w value (dB) measured on the test stand	Glazing's required R_w value (dB) measured on the test stand
1	25 - 29	≥ 27	≥ 27
2	30 - 34	≥ 32	≥ 32
3	35 - 39	≥ 37	≥ 37
4	40 - 44	≥ 42	≥ 45
5	45 - 49	≥ 47	[2]
6	≥ 50	≥ 52	[3]

[1] For single-glazed windows with insulating glass complying with VDI Guideline 2719, Tables 2+3.
[2] Single-glazed windows with insulating glass for Class 5 must undergo type testing on the test stand in accordance with DIN 52210.
[3] Sound insulation Class 6 has so far only been achieved by tested winter windows.

Important factors for the sound insulation of windows in addition to the sound insulation values of the glass include:

- **Acoustic quality of the frame and casement**
- **Seal between the casement and frame**
- **Seal of the frame against the brickwork, i.e. where the window frame is firmly connected to the building.**

SOUND TEST VALUES OF MULTIPLE INSULATION GLAZING WITH LSG USING TROSIFOL® SOUND CONTROL

Construction [mm]			Total thickness [mm]	Total weight [kg/m²]	R_{wp} [dB]	C;Ctr [dB]
Pane 1	Cavity*	Pane 2				
4	16	44.2 SC	29	30	**39**	**-1;-5**
6	16	44.2 SC	31	35	**41**	**-2;-6**
8	16	44.2 SC	33	40	**42**	**-3;-8**
8	16	66.2 SC	37	50	**43**	**-2;-6**
10	16	44.2 SC	35	45	**44**	**-2;-6**
10	16	66.3 SC	39	56	**45**	**-1;-4**
66.2 SC	16	44.2 SC	38	50	**47**	**-2;-6**
66.3 SC	16	44.2 SC	38	50	**48**	**-3;-8**
66.4 SC	16	44.3 SC	38	51	**48**	**-2;-7**
66.3 SC	16	44.3 SC	38	51	**49**	**-3;-7**
66.2 SC	20	44.2 SC	42	53	**49**	**-2;-7**
66.3 SC	20	44.3 SC	42	53	**50**	**-2;-7**

The above table contains the R_{wp} values obtained for selected ISO sound insulation constructions in accordance with DIN EN 20140-3 and DIN EN ISO 140**. They refer to the standardized test samples measuring 1230 mm x 1480 mm.

* All values with argon as the cavity gas
** Measured at the Fraunhofer Institute for Structural Physics (Fraunhofer Institut für Bauphysik) in Stuttgart

PRODUCT PROPERTIES OF TROSIFOL® SOUND CONTROL

TROSIFOL® SOUND CONTROL is available in roll widths up to 3210 mm. This means that all conventional sizes of laminated safety glass can be produced.

TROSIFOL® SOUND CONTROL is just as easy to process as our standard TROSIFOL® products for architectural glazing.

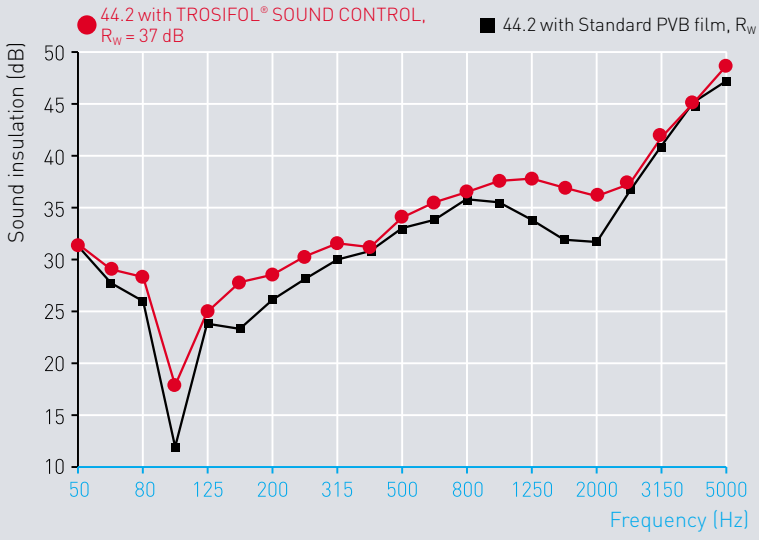
Laminated safety glass produced withTROSIFOL® SOUND CONTROL is distinguished by its outstanding clarity, transparency and light stability.

Laminated safety glass produced with TROSIFOL® SOUND CONTROL complies with Class P1A in construction 44.2 and Class P2A in construction 44.4 in accordance with EN 356.

Laminated safety glass produced with TROSIFOL® SOUND CONTROL meets the requirements of the quality standard EN ISO 12543-2. The constructions 33.2 and 44.2 tested in the pendulum test according to DIN EN 12600 show safe shattering behaviour at a maximum dropping height of 1200 mm (Class 1B).

Laminated safety glass produced with TROSIFOL® SOUND CONTROL complies with the requirements for laminated safety glass in the German List of Construction Rules and with the guidelines "Technical rules for linearly mounted glazing" and the "Technical rules for fall-prevention glazing".
It is thus a laminated safety glass with outstanding acoustical properties.

ACOUSTIC PERFORMANCE OF TROSIFOL® SOUND CONTROL



TECHNICAL DATA

FILM PROPERTIES

Property	Film thickness [mm]	
	0.76	1.14
Roll length	200 m	150 m
	450 m	330 m
Roll width	max. 3210 mm	max. 3210 mm
Water content	0.45 ± 0.07 %	0.45 ± 0.07 %
Visible light transmittance*	≥ 88 %	≥ 88 %
UV-transmittance	≤ 0.5 %	≤ 0.5 %
Glass adhesion (pummel test, -18°C)	≥ 7 visual	≥ 7 visual

* LSG with 2 x 2 mm clear glass

LSG SYSTEM PROPERTIES WITH TROSIFOL® SOUND CONTROL

LSG test	Result
P1A test to EN 356 on 44.2	Passed
P2A test to EN 356 on 44.4	Passed
Pendulum test to DIN EN 12600 on 33.2	OK up to 1200 mm
Pendulum test to DIN EN 12600 on 44.2	OK up to 1200 mm
Ball drop test to DIN 52338 on 33.2	Passed at > 4 m
Ball drop test to DIN 52338 on 44.2	Passed at > 4 m

LOGISTICS

TROSIFOL® SOUND CONTROL IS AVAILABLE:

in film thickness of 0.76 mm and 1.14 mm

PE interleaved

in rolls with a running length of 1500 mm – 4500 mm

in widths up to 3210 mm

Note: We advise storing TROSIFOL® SOUND CONTROL refrigerated.

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EUROPEAN TESTING INSTITUTES FOR SOUND REDUCTION GLAZINGS

D:	**Fraunhofer Institut für Bauphysik, Stuttgart Institut für Fenstertechnik (IfT), Rosenheim**
A:	**Versuchs- und Forschungsanstalt der Stadt Wien, MA 39-VFA, Wien**
CH:	**Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), Zürich**
NL:	**Technisch Physischer Dienst (TPD), Delft**
F:	**Centre Expérimental de Recherches et d'Études du Bâtiment et des Travaux Publics (CEBTB), Rouen**
GB:	**University of Salford, Department of applied acoustics, Salford U.K.**

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