ACOUSTIC SOLUTIONS FOR TEXTILE ARCHITECTURE

FERRARI

Contents

I/ INTRODUCTION

- The aim of this Notice

The aim of this Notice is to set out some general principles of acoustics and to provide some elements that highlight the advantages of solutions using textiles.

Demands for acoustic comfort are greater than ever and yet this high-tech specialty is still very poorly understood in the building industry.

At the same time a number of sites have been completed in recent years that prove the efficiency of solutions using composite membranes.

When it comes to absorption, the most commonly used concept today consists of trapping sounds in absorbent materials placed behind a grid.
Graded openings in the textile enable the filtering of sound waves that are then captured behind the textile.

A Roundup of the results of the various trials carried out with **BATYLINE® HM, PRECONTRAINT 392, PRECONTRAINT FT 371, SOLTIS 99 et SKY 300**, 300 is given in this Notice.

Other solutions that consist of using the intrinsic qualities of textiles can be envisioned by working on the shape and the layout of the panels. These solutions cannot currently be studied in mockup form and require the services of a specialist study bureau.

The field studied in this Notice is that of acoustic correction.

The target market is that of textile architecture for mural applications, stretched ceilings and fitting out.

It is thus imperative that the materials used meet currently applicable fire safety norms for establishments open to the public.

This brochure shows the insulation and absorption characteristics of the various composite membranes.

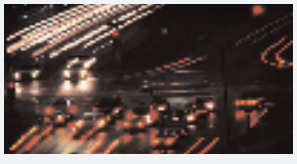
II/ BASIC PRINCIPLES

- Noise measuring units

a) Noise is measured in decibels (dB).

Hearing sensitivity is such that a linear sound measuring scale would not be appropriate. This is why noise is measured in dB, on a logarithmic scale. The noise scale shows levels in terms of source or sound ambience.

NOISE - INDICATOR
LEVEL - NOISE SCALE

	Air hammer	120 dB
	Aircraft engine	110 dB
	Milling, weaving, forge	90 dB
	Machining	80 dB
	Heavy traffic	70 dB
	Heavy traffic	60 dB
	Peacefull countryside	< 30 dB

NOISE - INDICATOR
LEVEL - HEARING APPRECIATION

Conversation possibilities	Hearing appreciation	Number of dB	Noises
Impossible	Pain threshold	140	Jet engine on a test bench
		130	Drop hammer
		120	Engine test bench, aircraft engine a few meters away
Necessary to shout to be heard	Very difficult to put up with	110	Boilermaking workshop, riveting 10 m away, TGV (high speed train) in a station
		105	Planing machine
		100	Bandsaw, punching press, pneumatic drill 5 meters away
Difficult	Very unpleasant	95	Forge, dense street traffic, propeller plane not far away
		85	Very loud radio, turning and dressing workshop; dense traffic one meter away
Fairly loud	Noisy but bearable	75	Typing pool, ventilation of a non-working factory
		70	Noisy restaurant, music, heavy traffic
		65	Noisy apartment, saloon car on the road
	Everyday noises	60	Department stores, normal conversation, residential street, motor boat
		50	Peaceful restaurant, very peaceful street, quiet car

Noises expressed in dB are added up in a special way.

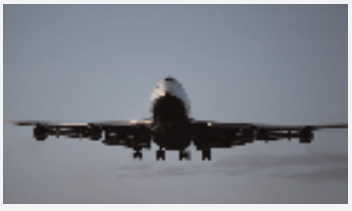
NOISE - INDICATOR
LEVEL - ADDITION

110 dB

+

110 dB

= 110



110 dB

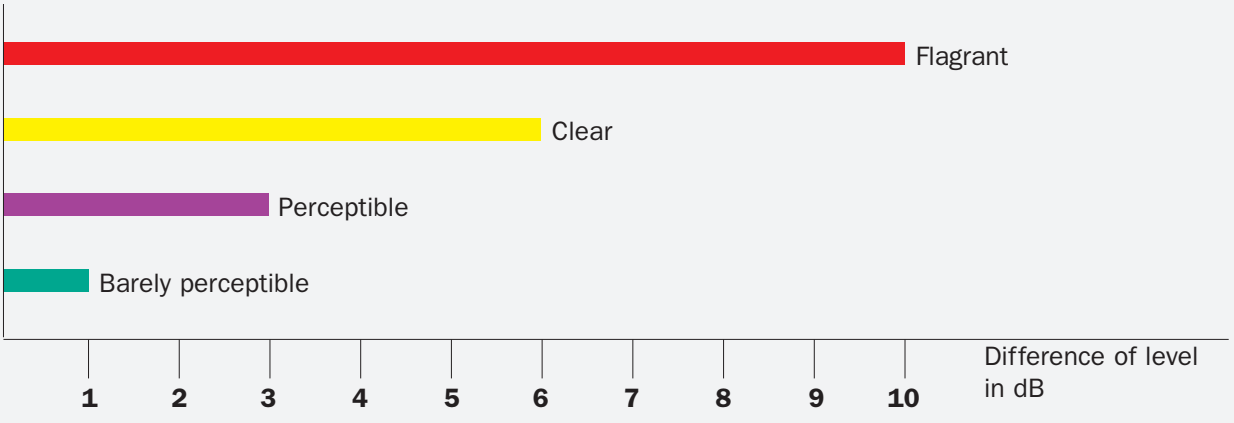
X

x x 110 dB

= 120

NOISE - INDICATOR
LEVEL - SOUND PERCEPTION

. Audible sounds are between 0 dB (hearing threshold) and 130 dB (pain threshold).
. An increase of 3 dB means the acoustic energy is doubled.
. An increase of at least 8 to 10 dB will be perceived as a noticeable increase of the sound level.



Noise is a spectrum of frequencies.

NOISE - INDICATOR
FREQUENCIES - FREQUENCY BANDS

. The sensation the ear has of frequencies is not linear but logarithmic.
. In fact, if we vary the frequency of a quality Δf, the variation of the corresponding sensation is not proportional to Δf but to $\Delta f/f$.
. The higher the frequency, the more a large variation of this frequency is needed to maintain a constant impression of frequency variation.

Therefore: $\Delta f/f$ = constant

E.g. 60/50 same impression of frequency variation as 600/500 and not 600/590.

NOISE - INDICATOR
FREQUENCIES - OCTAVE BANDS

The frequency spectrum is made up of frequency bands.
The central frequency of the band gives its name to the octave.

The standard values of these central frequencies are:

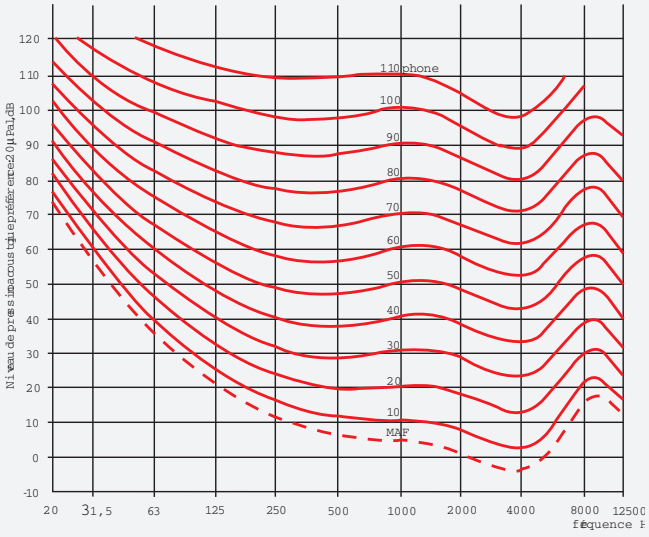
63 - 125 - 250	500 - 1000	2000 - 4000 - 8000Hz
Low frequencies	Medium	High frequencies

We are speaking here of octaves in musical terms as each central frequency is double the previous one and twice the following one.

The sensitivity of the ear to noise.

NOISE - INDICATOR dB(A)

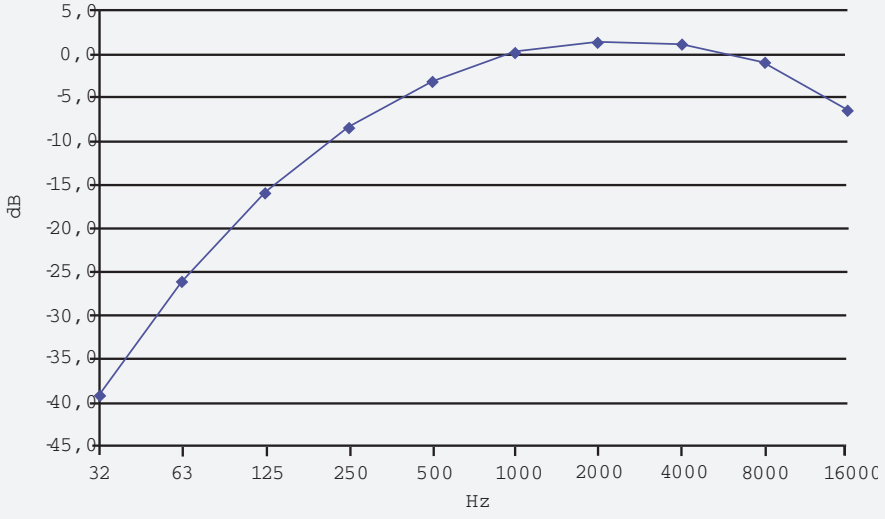
The ear is not sensitive to all frequencies in the same way.



NOISE - INDICATOR FREQUENCY WEIGHTING dB(A)

To take account of this sensitivity, a weighting scale has been drawn up:

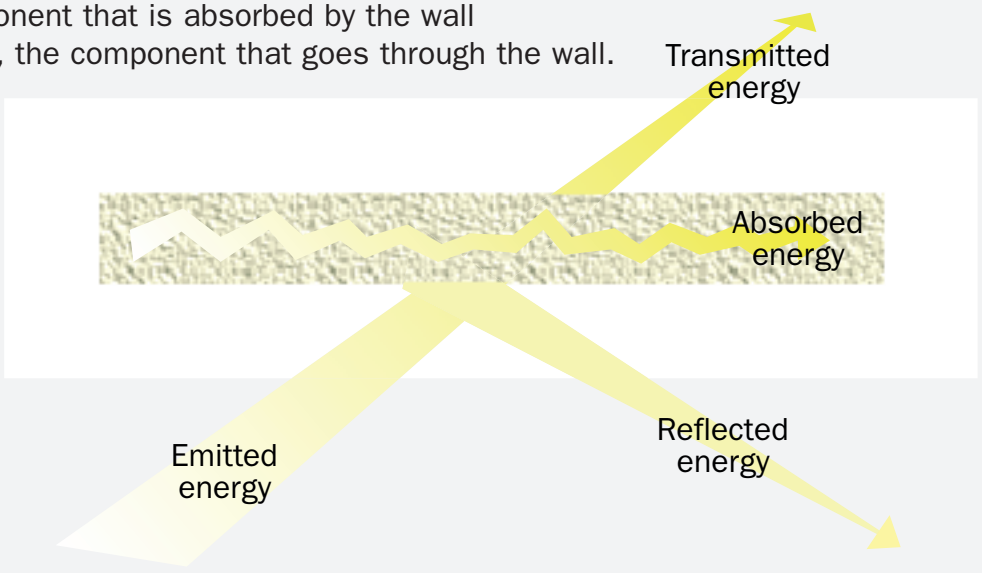
Weighting A.



- Acoustic absorption

Sound waves spread out in all physical environments, whether gases, solids or liquids. When a wave that is traveling through the air meets a solid object, a wall for instance, the wave divides into three main components:

- the component that is reflected by the wall,
- the component that is absorbed by the wall
- and lastly, the component that goes through the wall.



Depending on the frequencies making up the sound wave emitted and depending on the characteristics of the wall, the various components (reflected, absorbed, transmitted) take on variable proportions but their energy sum is always equal to that of the original wave:

$$\text{total incident} = \text{transmitted} + \text{absorbed} + \text{reflected}$$

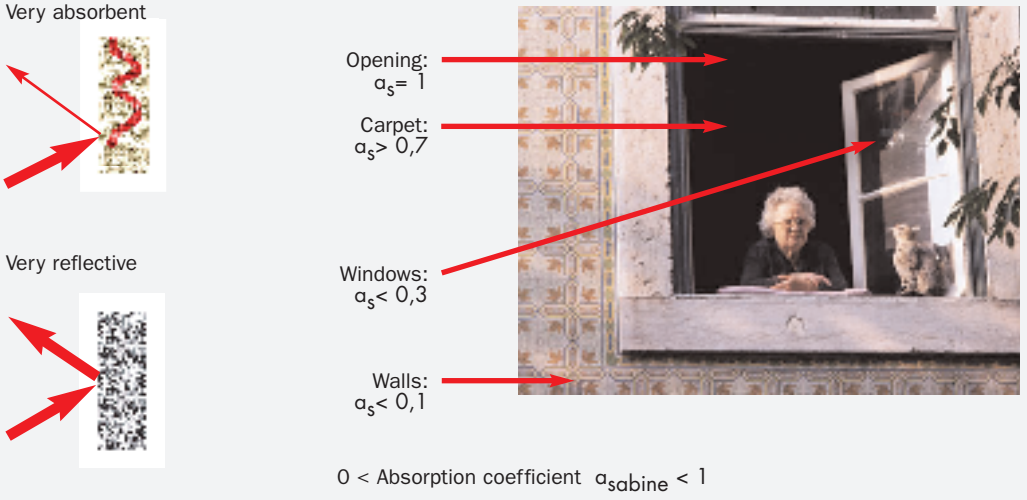
The coefficient of acoustic absorption "alpha Sabine" (aS) gives for each frequency the ratio between the energy transmitted plus that absorbed and the energy total incident.

$$\alpha s = \frac{\sum \text{transmitted} + \text{absorbed}}{\text{total incident}}$$

αs varies from 0 when all the energy is reflected to 1, when all the energy is absorbed or transmitted.

ACOUSTIC NOTIONS - ABSORPTION
a_{sabine} ABSORPTION COEFFICIENT

a_{sabine} coefficient



0 < Absorption coefficient a_{sabine} < 1

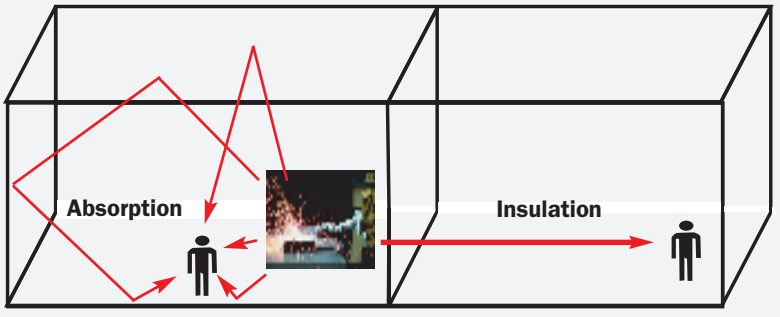
Two methods enable this coefficient to be assessed:
- a reverberant room, as per the EN ISO 354 norm
- a Kundt's tube

FERRARI® expresses its measuring results in a Kundt's tube.

- Acoustic insulation

The ability of a wall to prevent the transmission of sound waves is known as acoustic insulation.

ACOUSTIC NOTIONS
ABSORPTION ≠ INSULATION



- Reverberation time

A sound emitted by a source inside a space continues to be heard for a short while after the source has ceased to emit. During a speech for instance if the reverberation time is too long the first words of a sentence will be heard at the same time as the following ones; this blurs understanding.

Reverberation time T is defined as the time during which the sound reduces in intensity by 60 dB after the source has stopped emitting. It can be measured or calculated by the following formula:

$$T = 0{,}16. \frac{V}{\text{Sum } (S. \alpha s)} = S$$

where

V = volume of the premises
S = surface of the walls
αs = absorption coefficient of the walls S

III/ INSULATION

SINGLE SKIN INSULATION

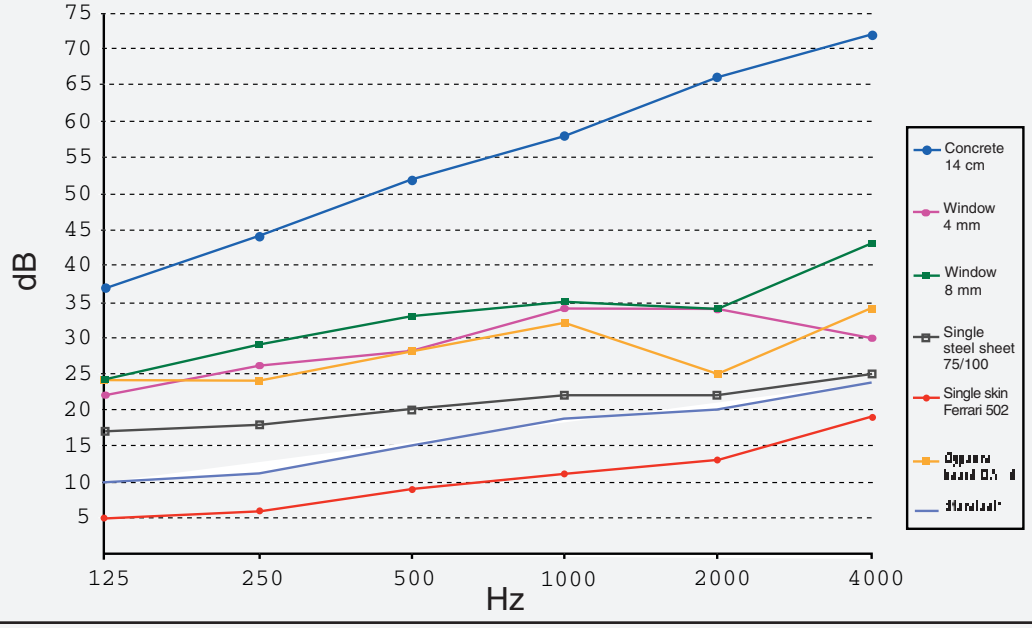
FREQUENCIES	125	250	500	1000	2000	4000	Rw*
Concrete 14 cm	37	44	52	58	66	72	54
Window 4mm	22	26	28	34	34	30	30
Window 8mm	24	29	33	35	34	43	32
Single thickness steel cladding 75/100	17	18	20	22	22	25	23
Gypsum board BA 18	24	24	28	32	25	34	29
Single skin Précontraint® 502**	**5**	**6**	**9**	**11**	**13**	**19**	**13**
Stamisol FR Foam 1550g/m²	**10**	**11**	**15**	**18**	**19**	**24**	**19**

* R : Index of acoustic weakening.
It characterizes the ability of a wall to weaken the direct aerial field of a sound wave. This value is measured in standardized laboratory conditions by octave bands or one-third octave bands. R is expressed in dB.
The weakening index Rw corresponds to the value at 500 Hz of a reference curve moved in steps of 1 dB until it covers as much as possible the curve of the material being tested: the index “w” references the ISO 717 norm.

** For outdoor architectural textiles the Rw values are as follows (ISO 717):

Précontraint® 702 : 14 dBA
Précontraint® 1002 : 15 dBA
Précontraint® 1202 : 15 dBA
Précontraint® 1302 : 16 dBA
Précontraint® 1502 : 17 dBA

NOISE WEAKENING OF THE VARIOUS MATERIALS



DOUBLE SKIN INSULATION

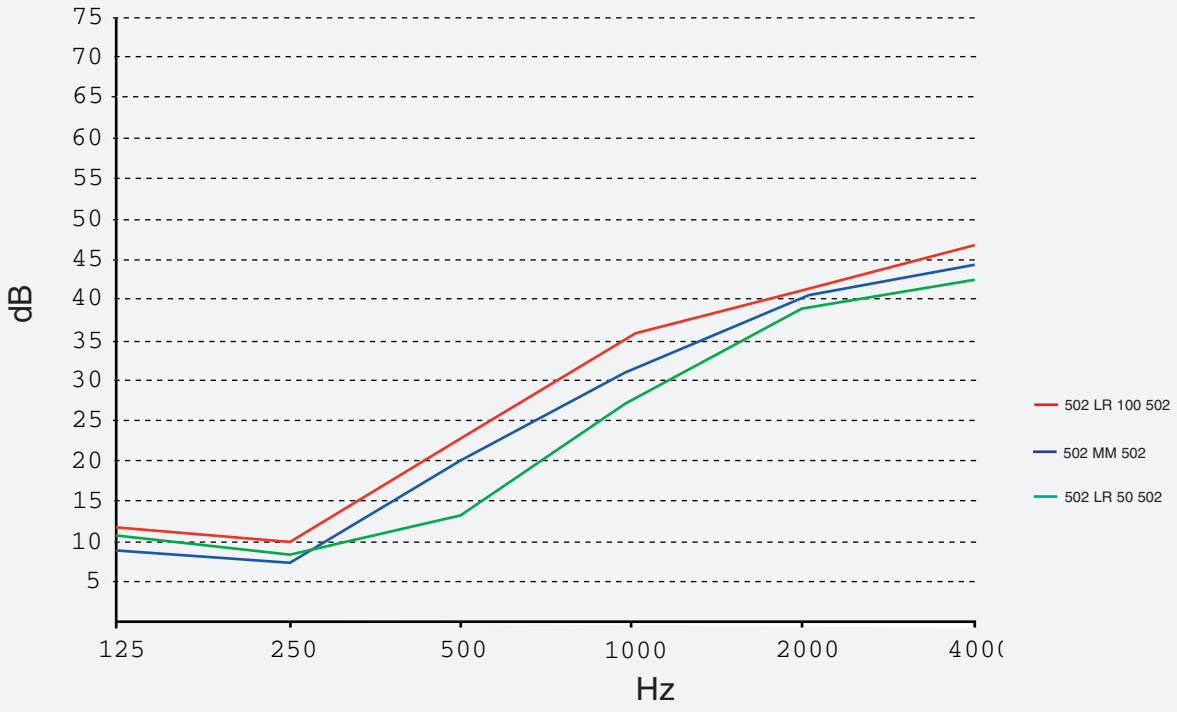
FREQUENCIES	125	250	500	1000	2000	4000	L en dBA
502 LR100 502	13	10	23	36	41	47	25
502 MM100 502	9	7	20	31	40	44	21
502 LR50 502	11	8	13	27	38	42	20

LR: mineral wool
MM: laminated foam

100 = 100mm
50 = 50mm

Reminder: If these tests had been carried out using architectural textile (1002/1202, etc) fabrics the insulation results would be of about the same scale.

NOISE WEAKENING OF THE VARIOUS MATERIALS

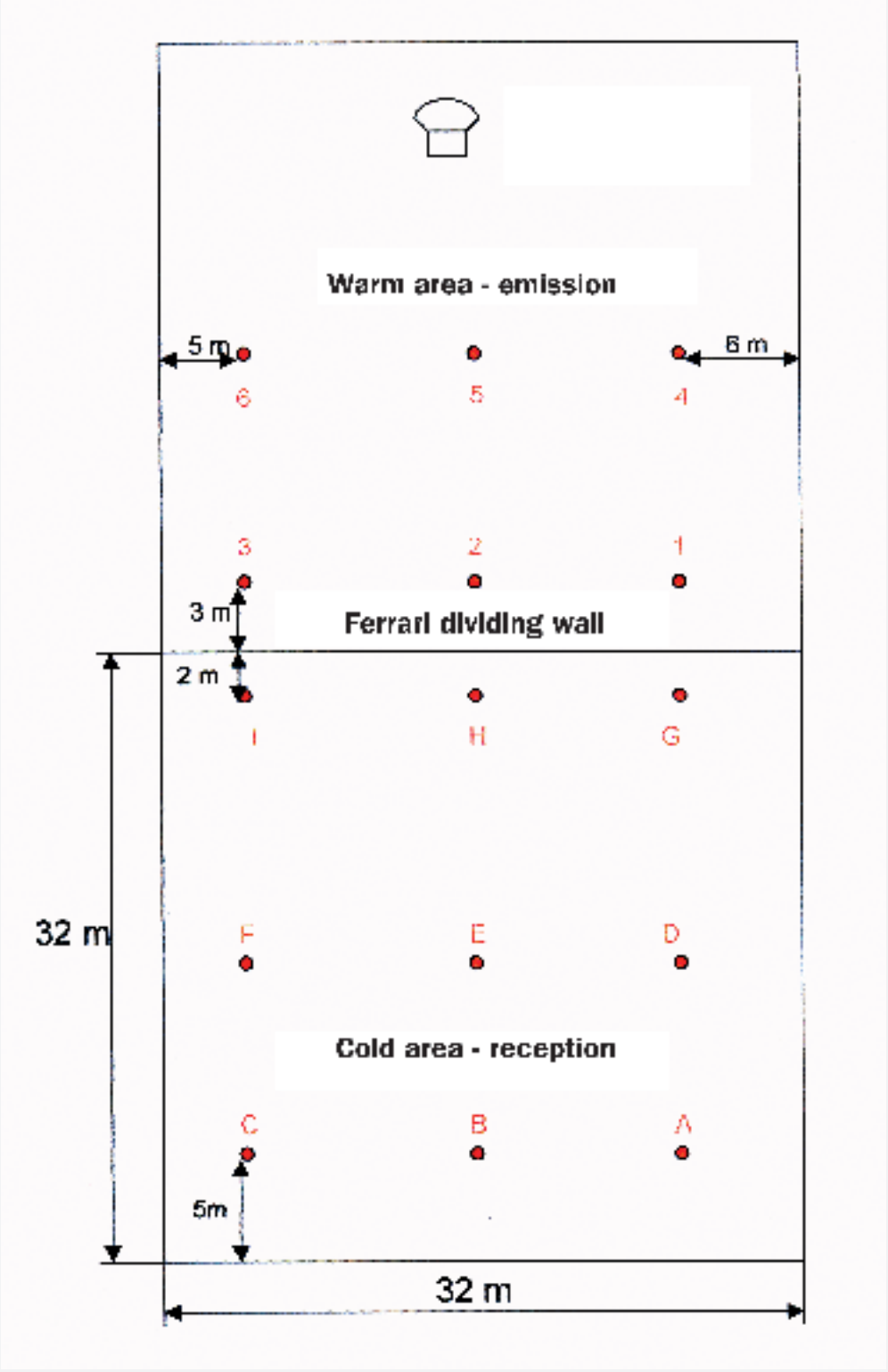


AN EXAMPLE: THE EMMENBRUCKE SITE, SWITZERLAND

Textile partition wall in a spinning plant.
Composite partition: Précontraint® 502 + LR 2 X 50mm + 502

Partition wall

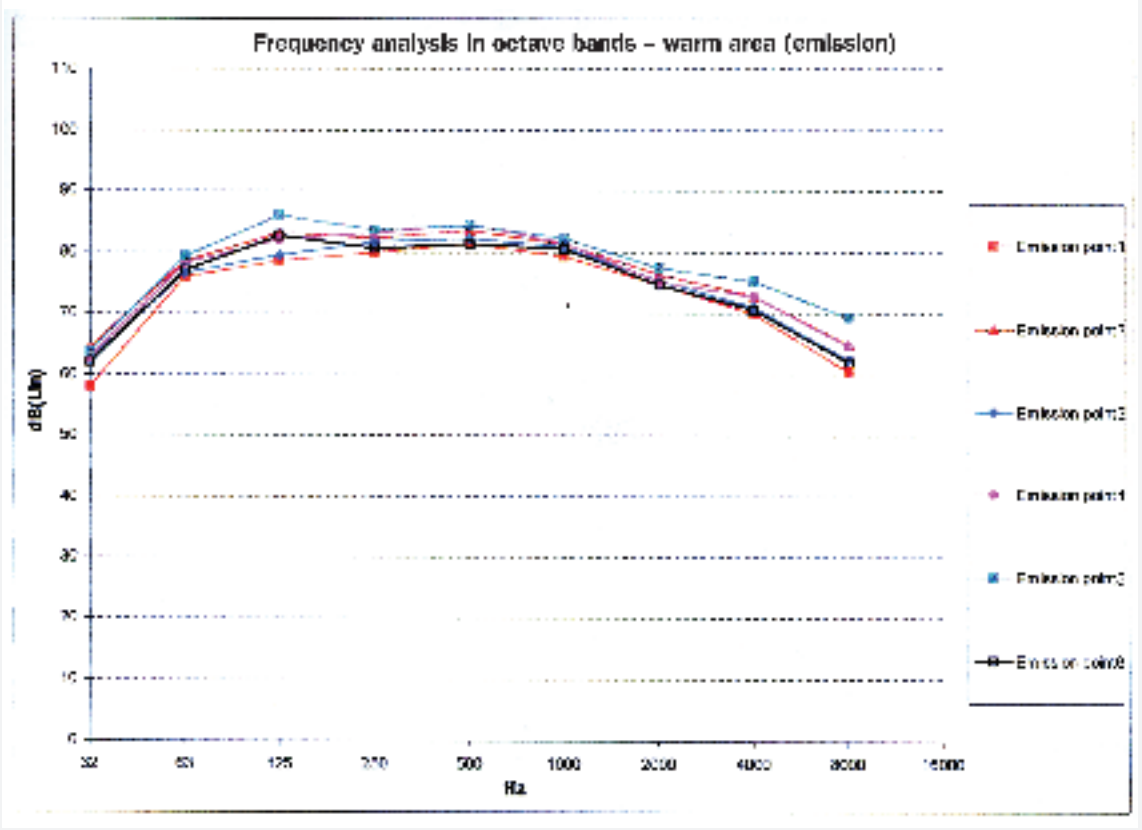
THE EMMENBRUCKE SITE in SWITZERLAND (cont.)



THE EMMENBRUCKE SITE in SWITZERLAND (cont.)

Building: warm area
Activity: ADI source operating

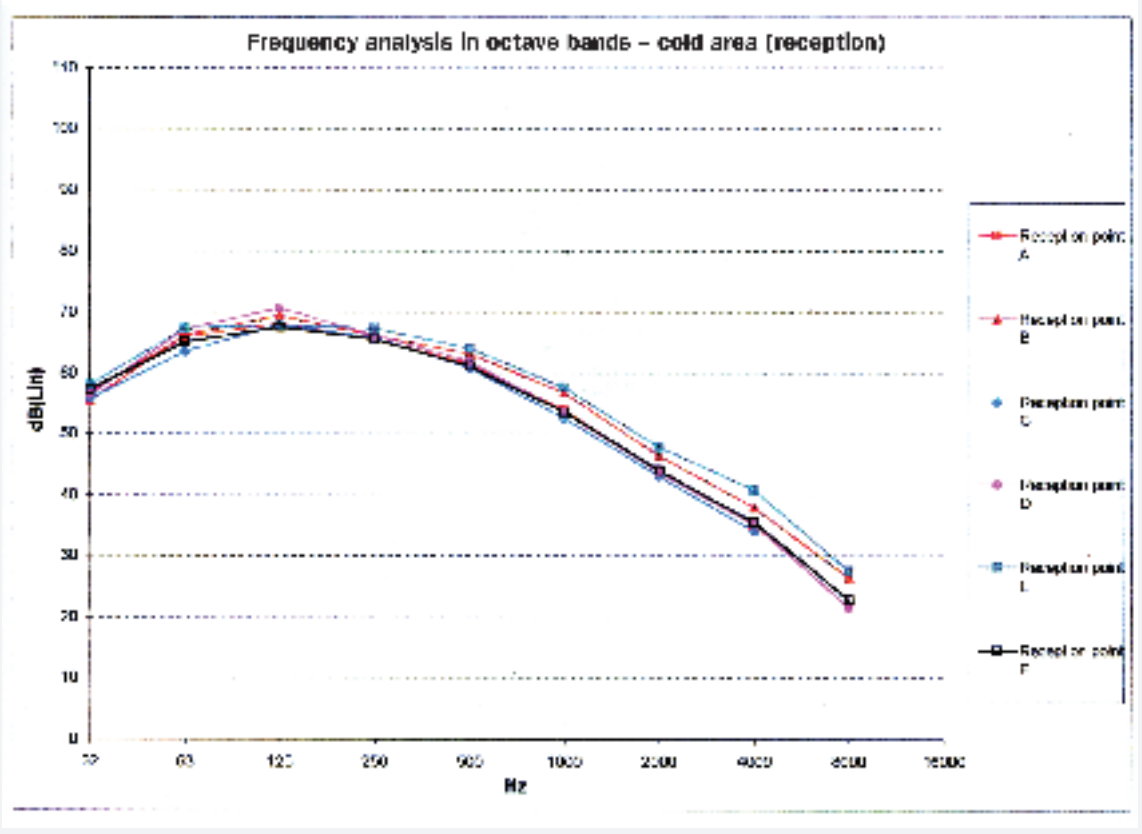
Frequencies	32	63	125	250	500	1000	2000	4000	8000	16000	Lin dB
Emission point 1	58	76	79	80	81	79	75	70	60		83
Emission point 2	64	79	83	82	84	81	78	73	66		85
Emission point 3	63	77	79	82	82	81	75	71	62		85
Emission point 4	63	79	82	83	86	82	75	73	66		86
Emission point 5	64	79	86	84	84	82	77	75	69		87
Emission point 6	62	77	83	81	81	81	75	71	62		84
Moyenne points 1 à 3	62	77	81	81	82	81	76	71	63		85



THE EMMENBRUCKE SITE in SWITZERLAND (cont.)

Building: cold area
Activity: ADI source operating

Frequencies	32	63	125	250	500	1000	2000	4000	8000	16000	L'eq dB(A)
Reception point A	57	65	68	65	62	56	46	35	22		67
Reception point B	55	66	66	65	63	57	46	38	26		64
Reception point C	56	63	60	66	61	53	43	34			62
Reception point D	56	57	71	66	62	54	44	35	22		63
Reception point E	58	67	68	67	64	58	48	41	28		64
Reception point F	57	65	63	63	61	54	44	36	23		62
Reception point G	61	69	70	67	62	53	42	34			63
Reception point H porte fen	59	71	74	72	71	64	54	48	39		70
Reception point I	56	67	71	68	60	53	43	35			63
Moyenne points G et I	58	68	70	67	61	53	42	34			63



Conclusion:
On average we go from 85 dB emitted to 63 dB received, a reduction of 22 dB.

The main interest of the textile partition wall solution is its adaptable fitting qualities. By faithfully following the contours and geometry of the site leakages are minimized and acoustic bridges are avoided.

IV/ ABSORPTION

ABSORPTION: coefficient aS OF COMPLEX TEXTILES ASSOCIATED WITH 50 MM AND 100 MM MINERAL WOOL

Mineral wool thickness = 50mm

OCTAVE BAND	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Batyline HM + LR50	0,10	0,30	0,76	0,98	0,98	0,98
Précontraint 371 + LR 50	0,12	0,44	0,88	0,85	0,86	0,99
Soltis 99 + LR 50	0,10	0,38	0,88	0,88	0,88	0,97
Précontraint 392 + LR 50	0,13	0,35	0,81	0,85	0,85	0,98
Sky 300 + LR 50	0,17	0,49	0,88	0,70	0,71	0,69
Précontraint 501 + LR 50	0,16	0,49	0,29	0,11	0,08	0,06
LR seule 50	0,1	0,3	0,8	0,9	1,0	1,0

Mineral wool thickness = 100mm

OCTAVE BAND	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Batyline HM + LR100	0,37	0,68	0,86	0,92	0,97	0,98
Précontraint 371 + LR 100	0,38	0,50	0,70	0,83	0,89	0,99
Soltis 99 + LR 100	0,40	0,51	0,69	0,81	0,94	0,96
Précontraint 392 + LR 100	0,39	0,50	0,71	0,83	0,89	1,00
Sky 300 + LR 100	0,40	0,53	0,69	0,74	0,81	0,73
Précontraint 501 + LR 100	0,65	0,50	0,28	0,10	0,08	0,06
LR seule 100	0,4	0,7	0,9	0,9	1,0	1,0

Conclusion:
By covering the mineral wool with an open-weave textile the performances of the absorbent material are maintained. A tight-weave textile would reduce the performance of the complex.

ABSORPTION: coefficient aS OF FERRARI® TEXTILES USING AN AIR LAYER OF 50 MM

Air layer thickness = 50mm

OCTAVE BAND	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Sky 300	0,10	0,32	0,66	0,82	0,79	0,65

Reminder: Coefficient aS for a mineral wool thickness of 50 mm

LR 50 mm	0,10	0,30	0,80	0,90	1,0	1,0

Conclusion:
In single skin cases and for very low and medium frequencies, Sky® 300 has a very similar absorption capacity to that of 50 mm thick mineral wool.

IV/ PRINCIPLES OF INSTALLING INTERIOR ACOUSTIC SOLUTIONS

- Fixing the absorbent material:

Whether fitted vertically or horizontally, we recommend fixing absorbent material to the support (plaster, concrete, wood, steel unit, etc.) before fitting the FERRARI® membrane.
The textile is then placed in front of the absorbent and is thus independent - this facilitates fitting, or re-fitting if necessary, later.
This way of working avoids overloading stretched ceilings, and achieves good flatness without increasing peripheral tension levels.
Lastly, when an air layer is included between the textile and the absorbent material acoustic performance levels are increased.

- Optimizing material consumption:

For horizontal applications the absorbent material is positioned beneath the slab, and the fabric panes are stretched after having been made to measure by high frequency assembly of the widths.

For vertical applications the membrane is fixed without any covering using mural rods or by traditional upholstery installation techniques. In this case, the size of the absorbent must not exceed the width of the textile roll, minus 10 cm.

- Color of the absorbent material:

So as not to spoil the color effect of the textile chosen, the color of the absorbent should be dark, preferably black.
If this is not possible, the absorbent can be covered with a film of black glass.

- For use in humid places: BATYLINE® is recommended

BATYLINE® is designed to be impervious to humid, hot and chlorinated atmospherics:
- its built-in antifungal treatment gives it exceptional qualities of resistance to the development of mold and micro-organisms,
- BATYLINE® maintains all the initial acoustic performances.

It is important to check with the supplier of the acoustic absorbent material that the chosen material is also compatible with installation in humid conditions.

V/ SUMMARY

This notice has set out the general principles of acoustics and illustrates the interest of FERRARI® textile solutions that ensure:

- protection of the absorbent without altering its acoustic performances,
- the required fire safety level,
- good-looking finish.

This information is provided to the best of our present knowledge and may evolve over time.

Both changing statutory conditions and research and development carried out by the FERRARI® laboratory may in fact lead us to adjust our acoustic solution offers.

Please don't hesitate to let us know about new situations that may arise on your sites so that we can study new solutions for you.

VI/ SOME INTERIOR PROJECTS

Church in Chater, France

University sports center, Saint Martin d'Hères, Grenoble, France.

The exclusive, patented Précontraint Ferrari@ technology involves the application of pre-tension during coating. This gives the fabric considerable dimensional stability.

Texyloop™: the recycling procedure for Précontraint® composite textiles. The Ferrari R&D department, in collaboration with the Solvay company, developed the Texyloop™ process, a unique recycling technology for composite Polyester/PVC textiles. The Texyloop™ process generates ready-to-use polyester fibers and supple PVC. The high quality of these materials means they can be reused in many industrial processes. With Texyloop™, Ferrari is responding to major preoccupations in our modern societies: recycling waste and worn out products, saving raw materials and respecting the environment.

The SKY® 300 (silicone/glass) range that is not in the TEXYLOOP™ recycling program is dealt with by an energy recovery program (to produce steam, gas, electricity, etc.)

Oko-Tex: an international ecological research and testing association for textiles. Ferrari textiles meet the Oko-Tex group 4 standard 100 for household decoration and equipping materials.

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