Sound and Vibration

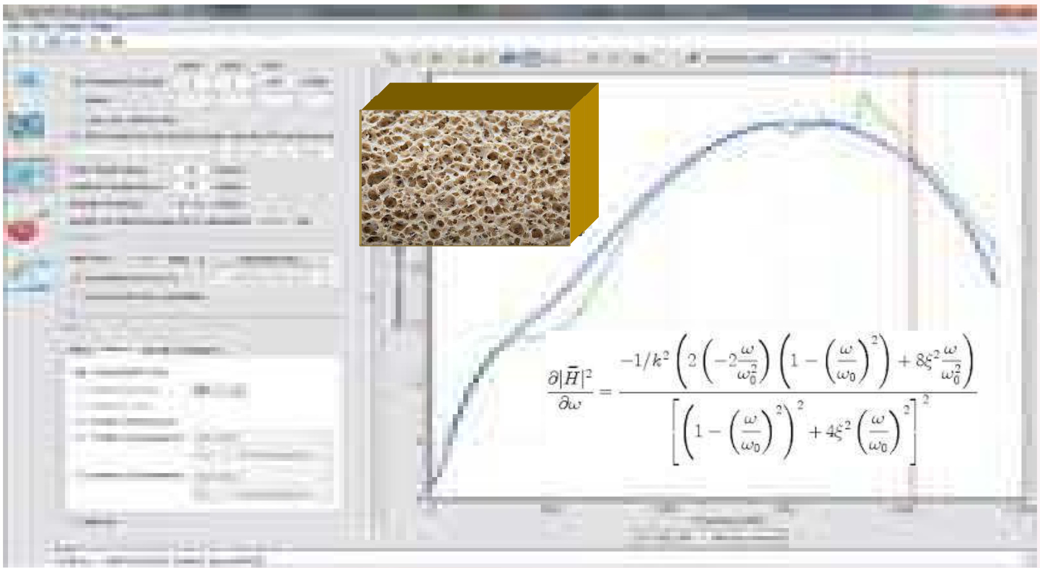
SCS 902A Suite

Vibro-Acoustic - Headquarter: ITALY - Via Antoniana, 278 - 35011 CAMPODARSEGO (PD) - VAT. n. IT04587160286 - info@scs-controlsys.com

Vibro-Acoustic Material Characteristics

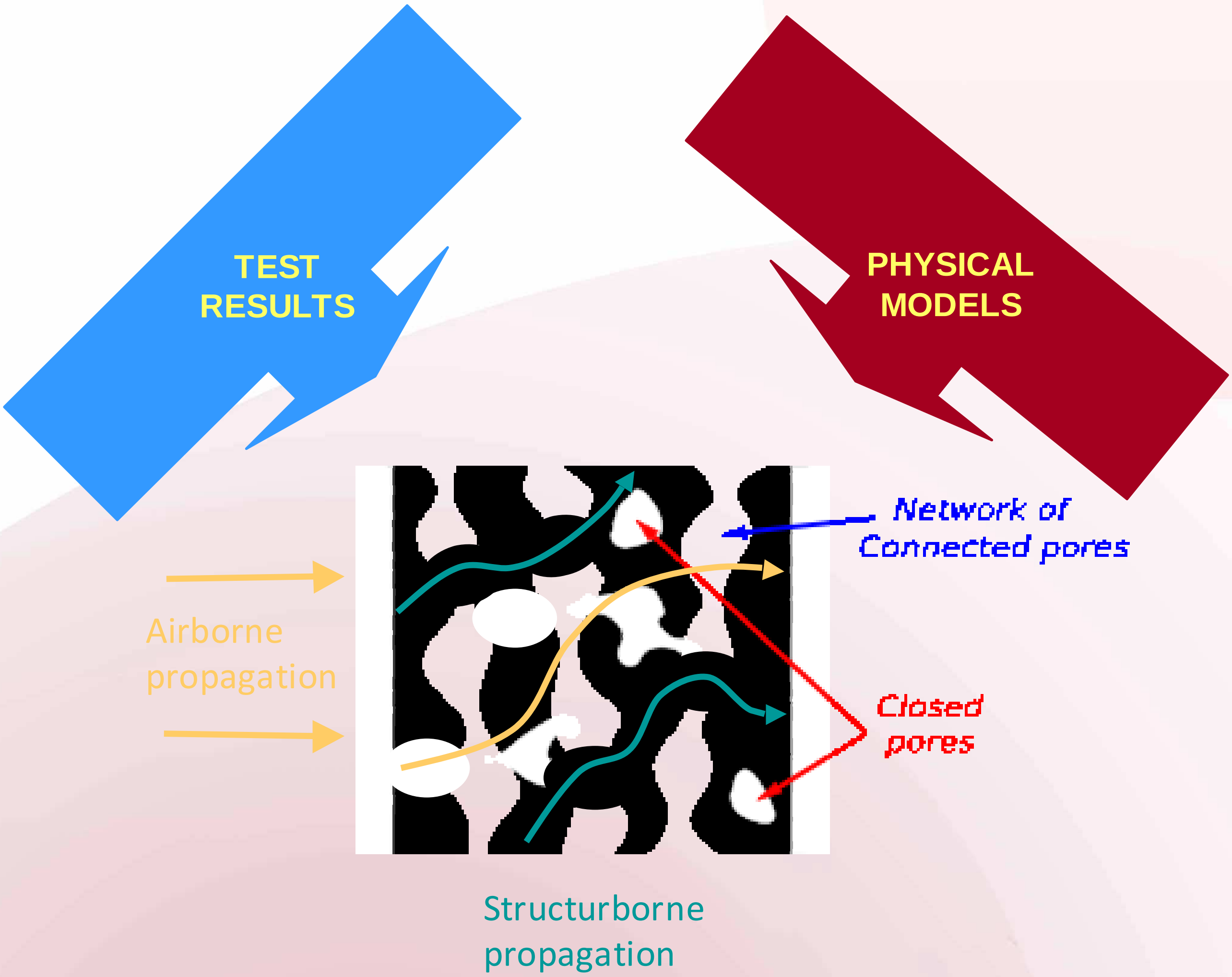
Consulting activities & application fields:
Vehicle, Automotive, Aeronautics, Railway, Ships, Construction, machines, Building construction, household appliances

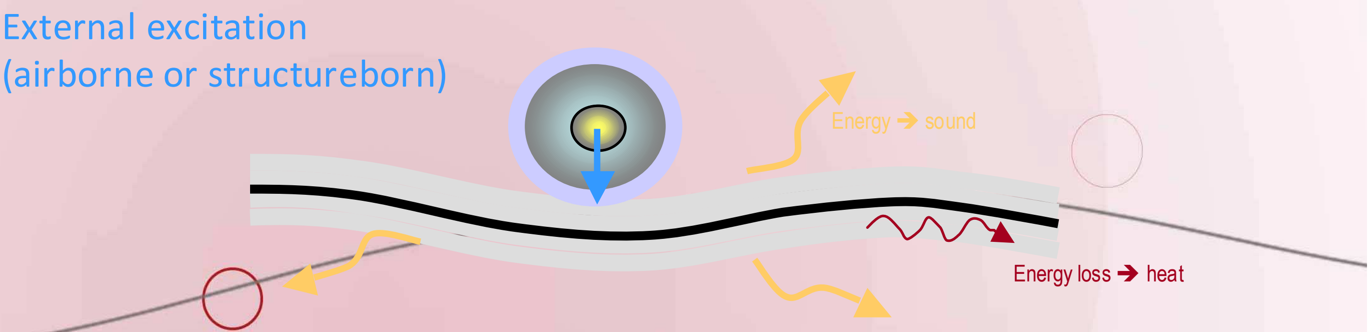
Vibro-Acoustic Material Characteristics



	Parameters:
Poro-acoustic	α_{ST}
Poro-elastic	α_{∞}
Physical	R
Foams	E
Fibers	η
Textile	σ
Mass	ϕ
Absorption	K
Insulation	TL
Damping	Δ'

Vibro-Acoustic Prediction & Material Characteristics





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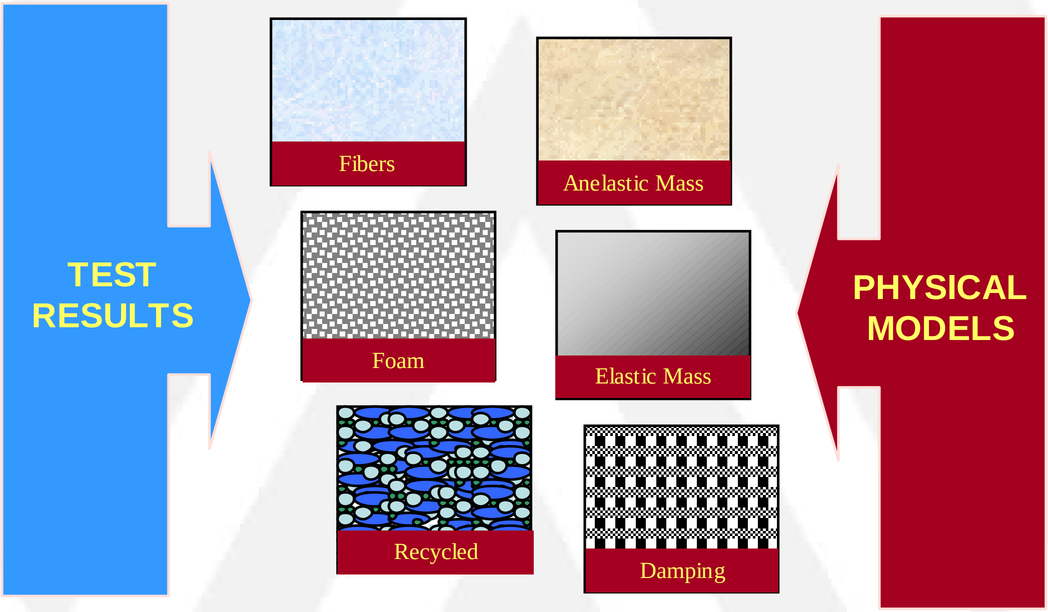
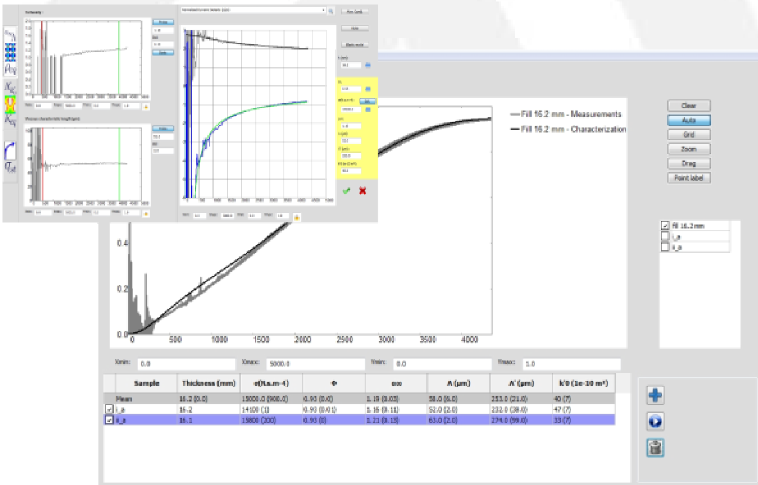
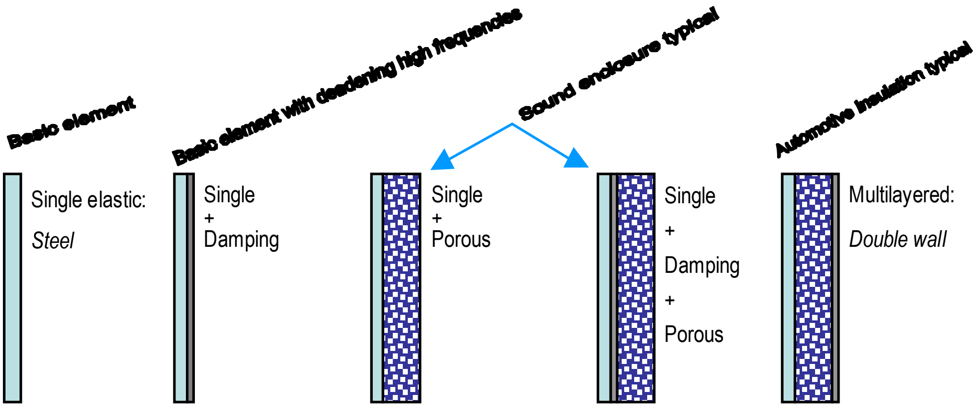
Poro-acoustic and poro-elastic data

Testing → Simulation → Prediction



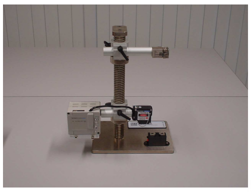


Poro-Elastic and Poro-Acoustic Parameters:
Density
Young's Modulus
Poisson's ratio
Viscous Length
Thermal Length
Damping Loss factor
Insertion Loss
Transmission Loss
Modal Density
Bulk Modulus
Acoustic Absorption
Impedance
Porosity
Flow Resistance
Tortuosity
Complex Modulus
3-d Bulk Modulus
Statistical alpha
Random incidence TL

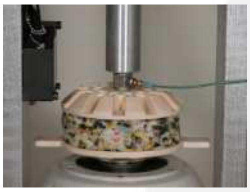


Sound and Vibration

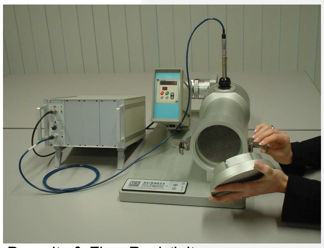
VibroAcoustic Materials



Damping Loss Factor



Bulk Modulus & Loss Factor



Porosity & Flow Resistivity

Physical parameters

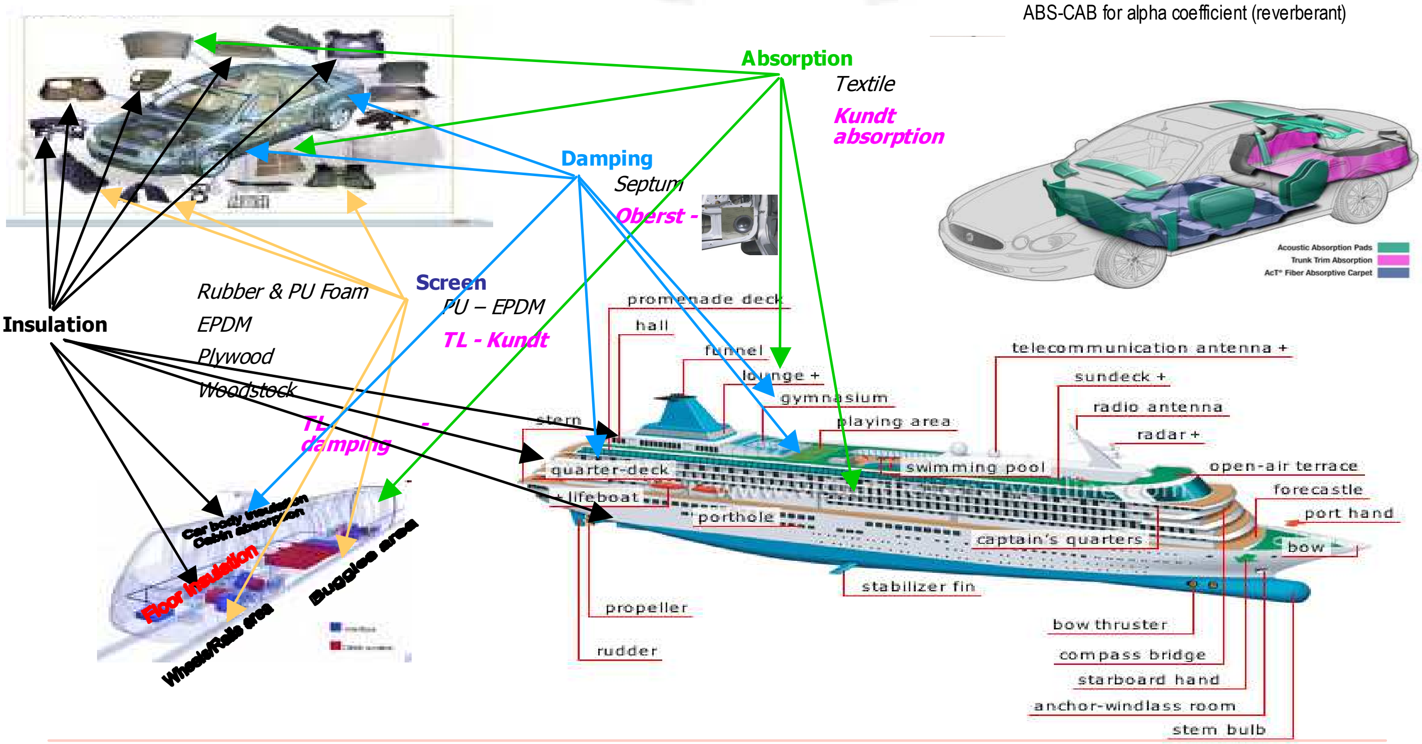
TEST RESULTS → ← **PHYSICAL MODELS**

- Density
- Young's Modulus E
- Poisson's ratio ν
- Damping Loss factor η
- Insertion Loss
- Transmission Loss
- Acoustic Absorption α
- Impedance Z
- (*) Open Porosity ϕ
- (*) Flow Resistivity r
- (*) Tortuosity α_{∞}
- (*) Complex Bulk Modulus K
- (*) Complex Mass density ρ
- (*) Viscous characteristic length Λ
- (*) Thermal characteristic length Λ'
- Bulk Loss Factor

Absorption & Transfer Impedance, TL, Bulk, etc.

Tortuosity

ABS-CAB for alpha coefficient (reverberant)



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BR_Kundt_2014-01

SCS

_SCS9020B

_Impedance tube (Kundt)

“Kundt tubes” configuration rapresents the basic, standard system set up for Acoustic absorpiton coefficient and Impedance measurements, according to ISO 10534-2 and ASTM E1050-98.

We can offer:

_ Three standard tube size:

_28 mm diameter

_45 mm diameter

_100 mm diameter

_custom size diamater

_Made your analysis from 80 Hz up to 6300Hz !!

_And more:

_ Samples length up more than 40 cm

_ Kund tubes pair upgradeable for TL measurement!

_Optional measuremente:

_Surface Impedance

_Bulk Modulus

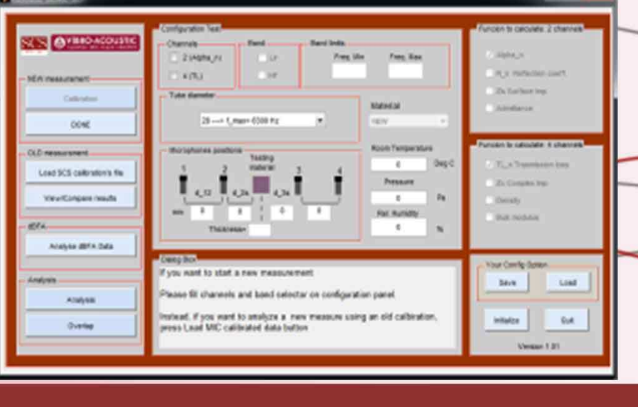
Measurement precision are exressed by individual hardware platforms, refer to specific Technical data sheet, and are in general much better than the minimum requirements of ISO 10534-2 which are:

- Dynamic range > 65 dB
- Amplitude error < 1 %
- Phase error < 0,6°
- Microphones sensitivity closer enough toh ave 0.3 dB level difference in Amplitude calibration. This statement is not mandatory as the precision improvement cannot be estimated

Software Analysis

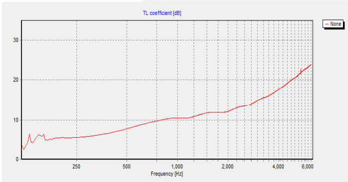
SCS-90 series, entirely developed with Matlab, software implemented for SCS9020B Kundt tube system works with external libraries (server mode) on several DAQ platforms.

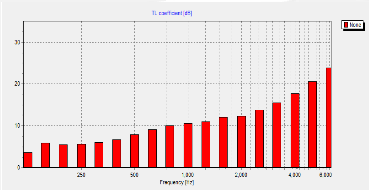
Measurements of Sound pressure of each microphone and Transfer Function are performer by the external libraries and data are transferred to the SCS-90 application, acting as a master, for calculating the absorption coefficient and other optional parameters.

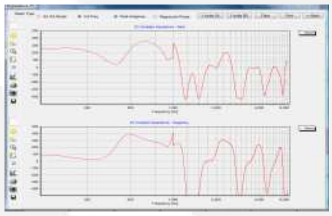


_Poro-acoustic and poro-elastic material characteristics

SCS9020: Impedance Tubes







(*) The **bulk modulus** *K* measures the material's resistance to uniform compression. It is defined as the ratio of the infinitesimal pressure increase *dP* to the resulting *relative* decrease of the volume *dV* (unit is Pascal), or using *r* as density and derivative of pressure to density *dP/dr*:

$$K = -V\frac{dP}{dV} = \rho\frac{\partial P}{\partial \rho}$$

The work of Song & Bolton describes the method for estimating r (dynamic mass density) and K (dynamic bulk modulus) which are given as:

$$\rho = \frac{Z_p K_p}{\omega} \quad [Zp = rc_p]$$

$$K = \frac{\omega Z_p}{K_p}$$

Schematic representation of the standing waves tube in the 3 and 4 microphone configuraiton to measure compelx impedance and the related complex parameters: r, K, L.

The standing waves tube is also used for the determination of absorption coefficeint, Surface impedance, admittance, Transmisiosn loss.

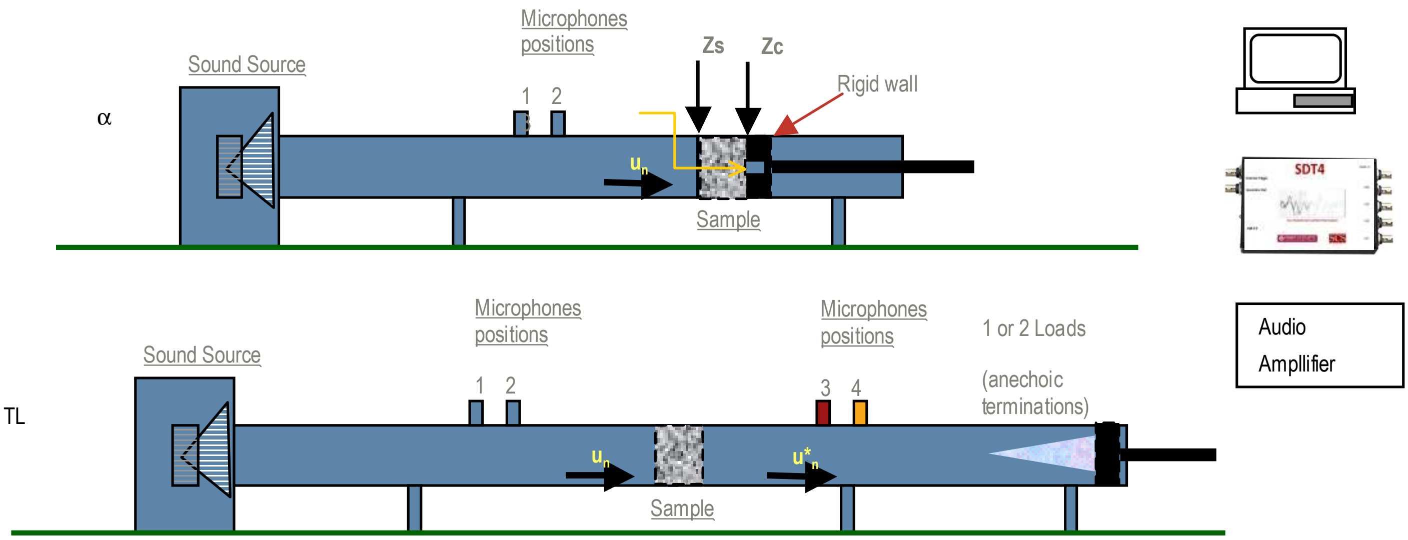
Measured Parameters:

- Acoustic Absorption α ⊥
- Reflection coefficient ⊥
- Admittance ⊥
- Surface Impedance Zs ⊥
- Transmission Loss TL⊥
- Complex Impedance Zc ⊥
- Propagation constant Γ
- (*) Complex Bulk Modulus K
- (*) Complex Mass density r

Standards conformity:

ISO 10534-2

ASTM E 1050



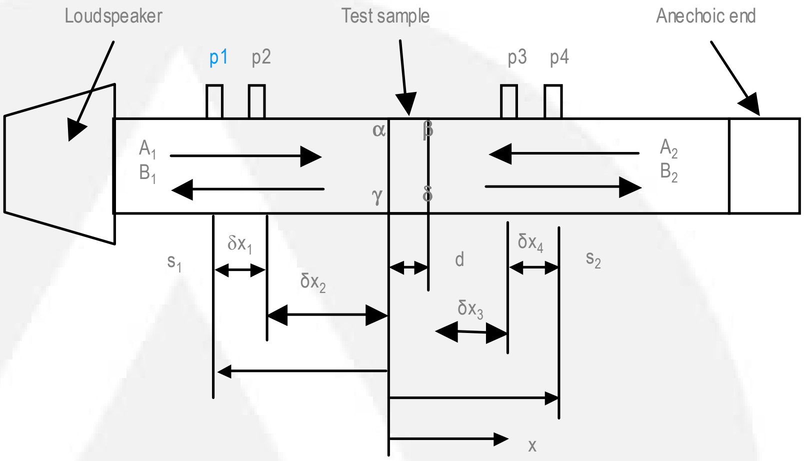
Plane waves Transmission Loss TL

From the general definition of TL in which:

$$TL = 10 \cdot \log_{10}\left(\frac{1}{\tau}\right) \quad dB$$

TL measurements in a tube is based on the "Transmission Loss Matrix" ➔ ***a unique parameter for each material.***

$$\begin{Bmatrix} A_1(f) \\ B_1(f) \end{Bmatrix} = \begin{bmatrix} \alpha(f) & \beta(f) \\ \gamma(f) & \delta(f) \end{bmatrix} \cdot \begin{Bmatrix} A_2(f) \\ B_2(f) \end{Bmatrix}$$



We are interested just in the 1st term of the Matrix $\alpha(f)$ which is the same as τ in the definition of TL

There are 4 waves to consider:

The "Forward travelling wave" is defined by its incident part A_1 and transmitted part B_2

The "Backward travelling wave" is defined by its incident part A_2 and transmitted part B_1

Notes:

Material sample with Symmetric thickness yeld to error in Cremer method for calculating the Matrix Determinant

TL results with Kundt method are very similar to 2 rooms method

And we can calculate the coefficient in terms of Sound Pressure **p** measured at each microphone positions at distance **δx**

$$A_1(f) = \frac{-j}{2}\frac{P_1(f) - P_2(f)e^{-jk\delta X_1}}{\sin(k\delta X_1)}e^{-jk\delta X_2} \qquad A_2(f) = \frac{j}{2}\frac{P_4(f) - P_3(f)e^{jk\delta X_4}}{\sin(k\delta X_4)}e^{jk\delta X_3}$$

$$B_1(f) = \frac{j}{2}\frac{P_1(f) - P_2(f)e^{jk\delta X_1}}{\sin(k\delta X_1)}e^{jk\delta X_2} \qquad B_2(f) = -\frac{j}{2}\frac{P_4(f) - P_3(f)e^{-jk\delta X_4}}{\sin(k\delta X_4)}e^{-jk\delta X_3}$$

$$A_1(f)G_1^*(f) = \frac{-j}{2}\frac{\overline{G_{11}(f)} - \overline{G_{12}(f)}e^{-jk\delta X_1}}{\sin(k\delta X_1)}e^{-jk\delta X_2}$$

$$A_2(f)G_1^*(f) = \frac{j}{2}\frac{\overline{G_{14}(f)} - \overline{G_{13}(f)}e^{jk\delta X_4}}{\sin(k\delta X_4)}e^{jk\delta X_3}$$

$$B_1(f)G_1^*(f) = \frac{j}{2}\frac{\overline{G_{11}(f)} - \overline{G_{12}(f)}e^{jk\delta X_1}}{\sin(k\delta X_1)}e^{jk\delta X_2}$$

$$B_2(f)G_1^*(f) = -\frac{j}{2}\frac{\overline{G_{14}(f)} - \overline{G_{13}(f)}e^{-jk\delta X_4}}{\sin(k\delta X_4)}e^{-jk\delta X_3}$$

System of equations in 4 unknowns α β γ δ can be reduced to a "two loads" case in which the Sound Pressure *(G_1 autospectrum)* **p1** is assumed as reference for cross-spectra taken for two measurements conditions (two loads), *using different anechoic ends*, indicated as pedix "*O*" and "*C*" (↓)

$$\alpha(\omega) = \frac{\left(A_{1O}(\omega)G_{1O}^*(f)\right)\left(B_{2C}(\omega)G_{1C}^*(f)\right) - \left(A_{1C}(\omega)G_{1C}^*(f)\right)\left(B_{2O}(\omega)G_{1O}^*(f)\right)}{\left(A_{2O}(\omega)G_{1O}^*(f)\right)\left(B_{2C}(\omega)G_{1C}^*(f)\right) - \left(A_{2C}(\omega)G_{1C}^*(f)\right)\left(B_{2O}(\omega)G_{1O}^*(f)\right)}$$

BR_Tortuosity_2014-01

_SCS9025

_Tortuosity Device

In order to discover and measure proprieties of materials for Noise and Vibration Control application, we present here a device to measure a fondamental parameter: Tortuosity

_Why I have to measure that?

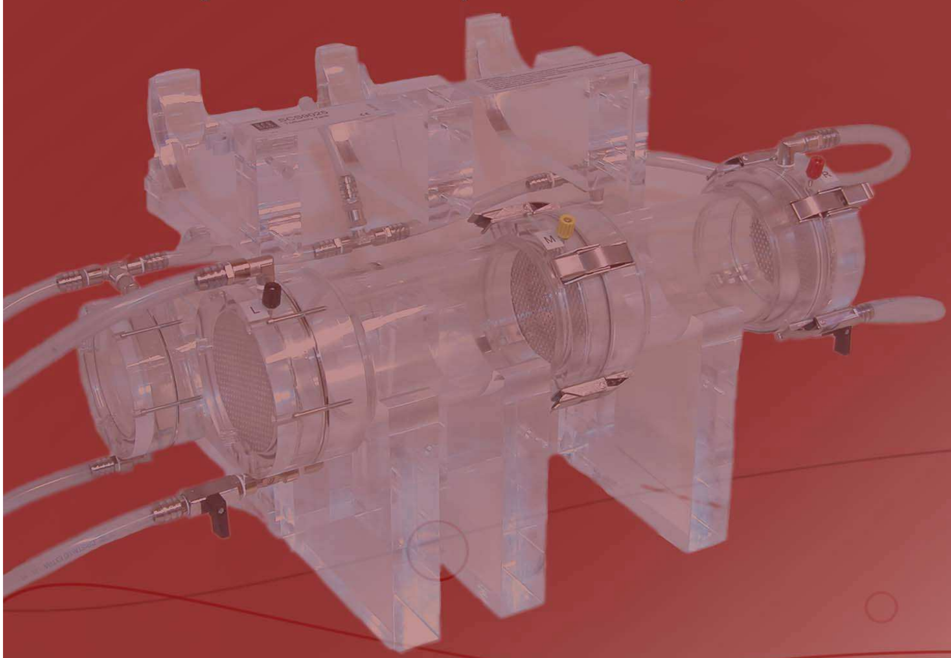
_Tortuosity keep into account the complexity (i.e. tortuosity) of the porous channel's pat through which the fluid phase (air indside t pores) flows.

_Tortuosity values are influenced by pore's path section variation along the path itself.

How it works:

_SCS-9025 Device for Measurement of tortuosity is based on electrical conductivity where a sample of material is posed in a cylindrical device (shown in t figure below) and is filled with fluid electrically conductive.

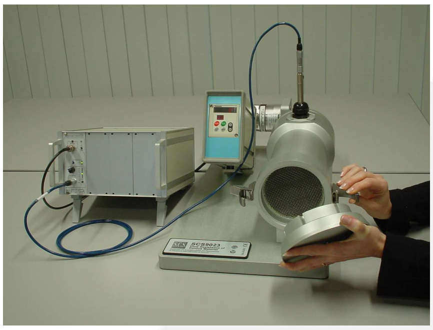
An high voltage alternate current passes through the fluid-filled sample. The knowledge of electrical conductivity both of the fluid and of the fluid filled sample and of the porosity allows wi a relationship to obtain finally the tortuosity value.

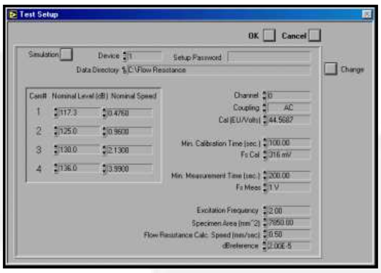


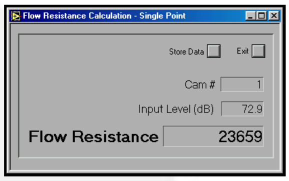
_Poro-acoustic material Tortuosity

SCS9023, 25, 28: Flow Resistivity, Tortuosity, Porosity

VIBRO-ACOUSTIC







Measured Parameters:

- Flow Resistance
- Flow Resistivity
- Tortuosity
- Porosity

Standards conformity:

ISO 29053-Part 2 (SCS9023)

Porosity: the density fraction of the porous material that is comprised of fluid. Defined as:

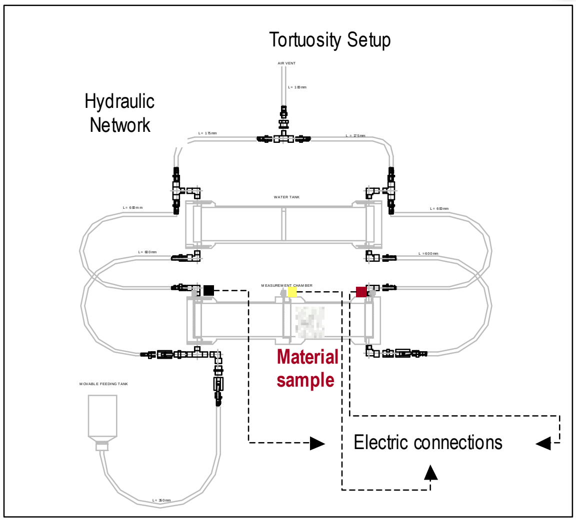
$$h = 1 - \frac{\rho_{solid}}{\rho_{porous}}$$

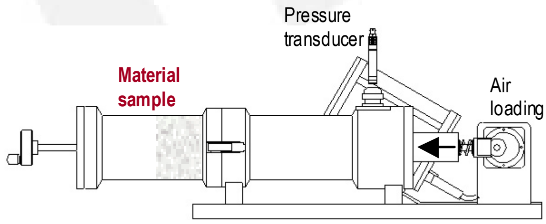
where ρ is the mass density.

Flow Resistivity: a measure of the resistance to fluid flowing through the porous material. Defined as:

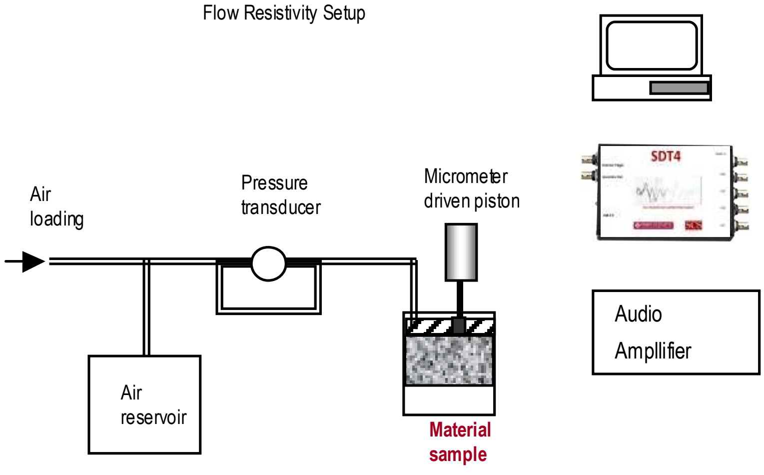
$$R = \frac{1}{v}\frac{\Delta_p}{\Delta_x}$$

where Δ_p is the static pressure differential across a layer of thickness Δ_x, and v is the velocity of airflow through the material.





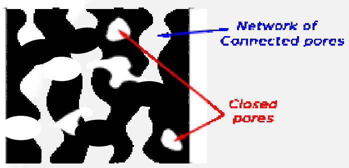
Flow Resistivity Setup



Schematic representation of the porosity device.

Porous materials basic parameters definition.

Open-**Porosity**, Static **Flow-Resistivity** and Hi-Freq. Limit of dynamic **Tortuosity** are the 3 parameters describing the visco-inertial and thermal behavior of acoustical porous materials, which are directly measurable.



Static Flow-Resistance

The static air flow resistance, or (specific) flow-reisitivity, and Porosity are key parameters to study visco-inertial effects at low frequencies.

Flow resistivity represent the difficulties for air to penetrate in porous materials pores, and since sound is a mechanical vibration of air particles, than Flow resistivity gives a measure on how is difficult for sound to propagates inside porous materials as well.

Static Flow-Resistivity measurement

Flow-resistance R is defined as the ratio of Pressure over air velocity:

[Pa.s.m-3 or Rayls] $$R = \Delta_p / u$$

Specific Flow-resistance or Flow-resistivity is a measure of the resistance per unit thickness Δx:

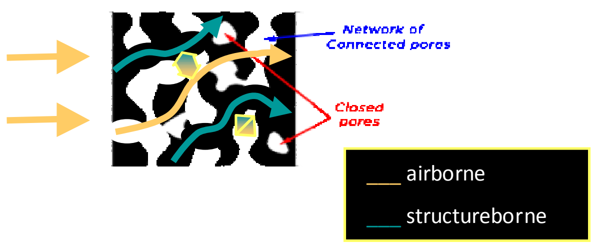
[Pa.s.m-2] $$Rs = R / \Delta x$$

Typical porous materials has a Flow-resistivity in the range of 10^3 - 10^6.

Measurement of Flow-resistivity is supported by ISO 29053 with 2 methods: Pressure drop across the sample using an air-reservoir and 2 pressure transducers, or a piston pumping air in a cavity (frequency at 2Hz), closed by the porous material, in which the pressure value is measured using a microphone.

Tortuosity

The tortuosity or the structural form factor of the material takes into account the actual form of the pores and the difference between the speed of sound in open-air and through a rigid porous material at very high frequencies.



Tortuosity measurement

Tortuosity is well approximated by considering electrical conductivity of a porous solid saturated with electrical conducting fluid. Measurement of Tortuosity can be performed by comparing electrical resistivity of a liquid saturated porous sample to the resistivity of the saturating fluid. Considering porosity (h) and form factor F_f, the Tortuosity $T_:$ becomes:

$$T_\infty = F_f / h$$

Form factor Ff is defined as:

$$F_f = \sigma_s / \sigma_f \quad \text{and} \quad \sigma = G \cdot L / A$$

G is the ratio current/voltage of the electrical signal applied across the sample in the liquid, L is the sample length, A is the sample area.

Open Porosity

Porosity is the the ratio of the fluid volume occupied by the continuous fluid phase to the total volume of porous material, typically in the range between 0.7 and 0.99 for an acosutical material (porous medium) in whihc we can consider the fluid phase (pores) and solid phase (skeleton)

Open porosity measurement

Few methods are available to mesaure the porosity and among them there are two approach widely used. The rather simple one is the **gravimetric measurement** in which it is necessary to weight a dry material of a known volume with a preliminary cleaning by a centrifuge process.

The bulk density ρB is the weigth/volume of the sample (dry), while the density ρA is assumed by knowing the fiber density. Porosity is than estimates as:

$$h = 1 - \rho_A / \rho_B$$

Alternatively, it is possible to saturate the sample with a liquid (water..) and estimate porosity from the ratio of weights of saturated and unsaturated samples.

The **dry method** to measure porosity - developed by Champoux et al. - is based on a precise measurements of pressure change versus volume change within a sample container. The volume change is driven by a piston coupled with a precise micrometer, while the pressure inside the chamber is monitored by a pressure transducer; a suggested air reservoir connected to the container through a valve will void the fluctuations of ambient pressure.

The main difference between the gravimetric and dry methods is that the dry method takes in account the porosity of connected air-filled pores.

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BR_ABSCAB_2014-01

SCS

_SCS9031

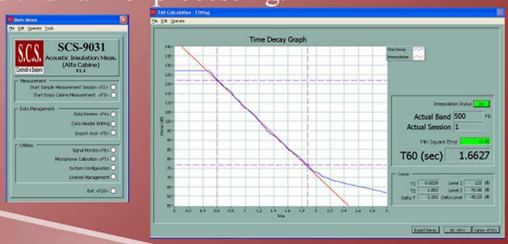
_AlphaBS CABine

_The SCS9031 -ABS Alpha Cabin has been specifically designed for the measurement of acoustic absorption characteristics of materials

Why to use it

_ the right system to use during the development of optimized sound packages
_worldwide standard used by most OEMs and suppliers
_fast and easy measurement procedure thanks to user-friendly software interfaces
_also ideal as a quality control system
_an R&T tool for the development of new materials and parts
_easy transportation.

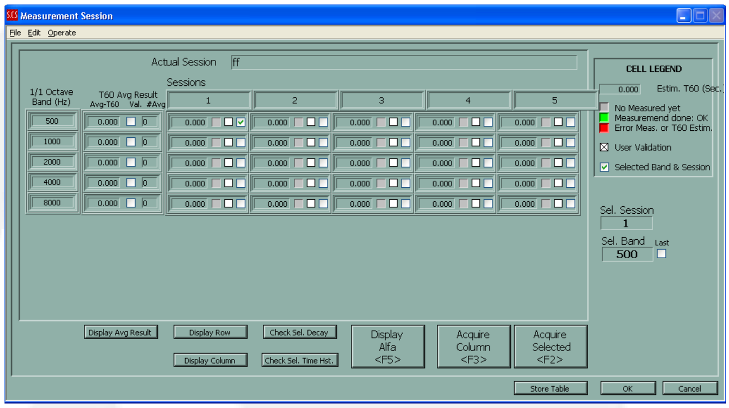
SCS software is menu driven and it would automatically perform all measurement steps.
Results displayed both in numeric format and as graphic and are stored in the internal HD; they can also be exported in most common format for user convenience and further processing.

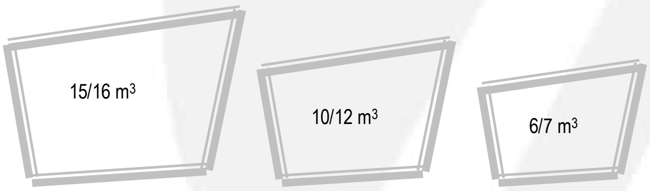


_From 6 Mc to 15 Mc!!!

_Acoustic absorption in reverberation room

SCS9031: ABS-CAB α_{stat} Absorption Coefficient





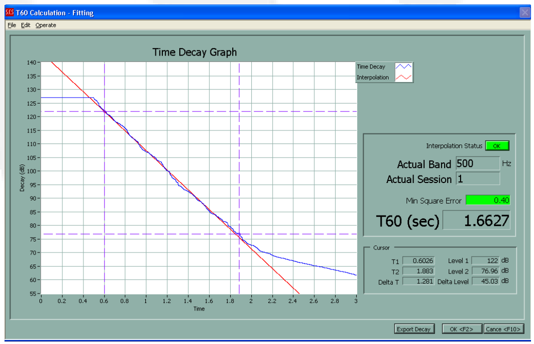
Measured Parameters:

- Random Incidence Sound absorption coefficient

Standards conformity:

ISO 354 to scale

Reverberationtime measurment using Impulse Response method and Schroeder theory for decay estimation



ABS-CAB α_{stat} **Random alpha**: the random incidence absorption coefficient is (statistic alpha) measured on a scaled ISO 354 room (200 mc ➔ 6 to 15 mc).

ABS-CAB is available in 3 size with lower frequency limits (315 Hz ➔ 200 Hz – 1/3 octave bands). The theory applied as follows:

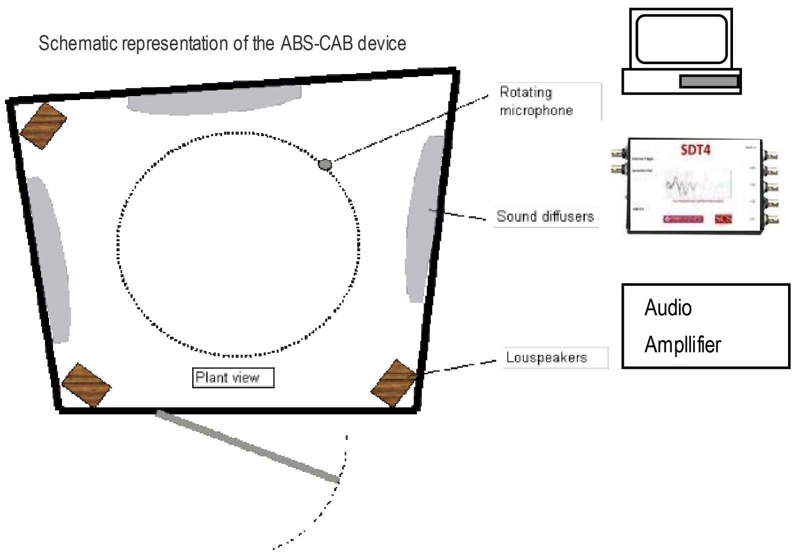
$$\overline{A}_{(f)} = 55.3 \times V \times \left(\frac{1}{T_{60,empty} \times c} - \frac{1}{T_{60,material} \times c} \right) - 4 \times V_m$$

About ABS-CAB Frequency Range

Small reverberant room like ABS-CAB are normally used below Schroeder frequency fc granting diffuse field:

$$f_c = 2000 \cdot \sqrt{T/V}$$

If the T_{60} is about 2.5s and the Volume is 6.5m^3, than fc=1240Hz, but neverless the small reverberant room is used from 400Hz (about 1/3 of fc) up to 10kHz. The proposed 15m^3 version of ABS-CAB can be considered to start at about 250Hz.



_SCS9021

_Oberst device

SCS9021 Damping Measurement", is a complete set of hardware and software tools, for measuring acoustic material properties such as Damping Loss Factor.

The Oberst method allows the determination of vibration losses for simple materials and the effects of various coating layers following ASTM standard: E756-98.

_Description

Stiff base plate, provides high stability to the entire system, reducing spurious and unwanted vibration modes.

The vertical rod allows highly accurate and independent vertical positioning for the two adjustable arms,which in turn hold the sample and the vibration sensor.

Screw the knurled rings to shift the arms, clockwise or counter-clockwise, while a driver pole prevents arms turning. The black levers, in the rear side of the system, are used to lock the vertical movement.

The arms, moving in horizontal direction, allow adjusting both the sample position between the electro-dynamic exciter polar expansions and vibration sensor position with respect to the sample. The upper arm is used for sample locking.

The black levers, in the front side of the system, are used for arms blocking. The clamping vice, fixed to one end of the upper arm, ensures the rigid bond to one side of the sample stripe. The electro-dynamic exciter is located onto the frame plate and is provided of two metallic ends in the upper side: these are the polar expansions of the electro-dynamic magnet.

_Software

Damping calculation is performed using 1 out of 3 methods available:

_Exponential decay:

This method allows the damping loss factor determination calculating the angular coefficient of the line, in logarithmic scale.

The user shall manually select one of the vibration mode using 2 cursors on the Transfer Function interactive graph.

_ Circle fit:

A circle fitting standard method is applied on the vibration mode selected as above.

_3 dB method:

In the vibration mode selected identified using the 2 cursors, are identified the peak frequency and the 2 other frequencies values at -3dB from the peak value.

Each files can be edited in the header information stored together with the results, which are stored in a binary format: the software allows the user to export data in an ASCII format.

_The vibration sensor

You can choose:

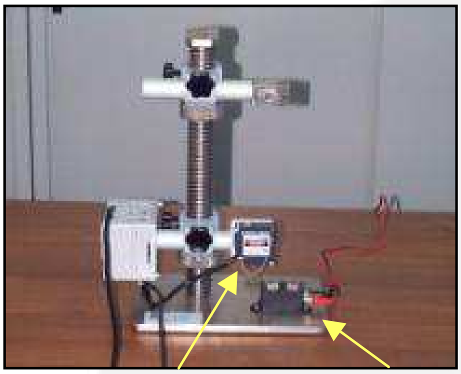
_a non-contact, inductive, high resolution, dynamic position sens for material measurements, and for testing at high temperature;

_a contact, ultra light weight accelero meter for high frequency measuremen snd for high ambient temperature.

_Damping measurement

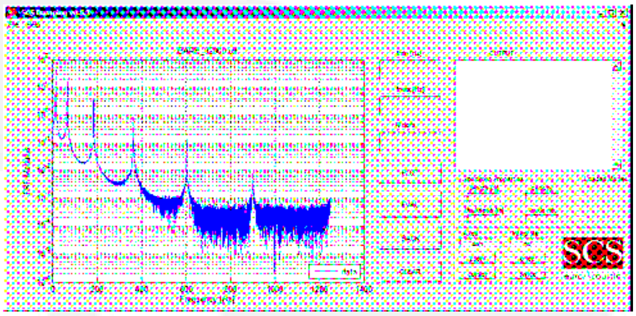
SCS9021, 22: Damping Loss Factor

Oberst device SCS9021

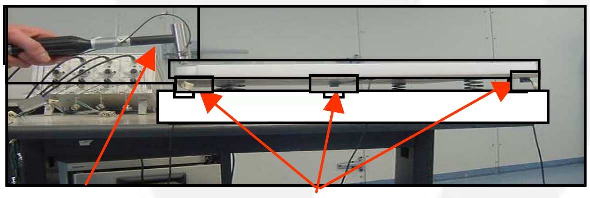


Response transducer: Proximitor, Laser, Accelerometer

Electrodynamic non-contact exciter



SAE device SCS9022



Instrumented hammer

Accelerometers

Measured Parameters:

- Damping Loss Factor
- Young Modulus (SCS9021)

Standards conformity:

SAE J1637 (SCS9021)

ASTM E-756 (SCS9021)

SAE J671 (SCS9022)

ASTM E-756 (SCS9022)

Resonance peaks of the beam plate are analysed with FFT analysis and damping coefficient can be derived from the Frequency Response Function FRF with 3 methods:

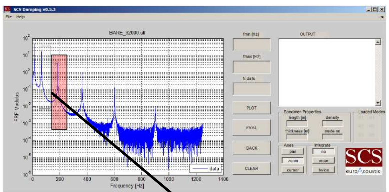
- Half power frequency band at –3dB points
- Circle fitting of resonance peaks (see figure at side)
- Exponential decay of synthesized SDOF

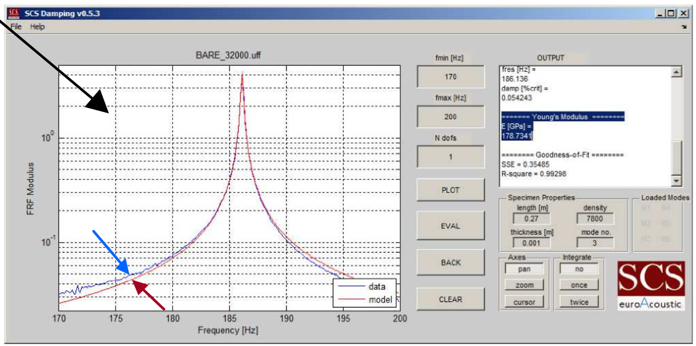
Alternatively, it is also implemented a most advanced method based on Rational Fractional Polynomial Synthesys.

Curve fitting FRF function using RFP method

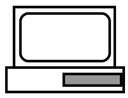
Frequency Response Function (FRF) is a complex valued function, defined over a given frequency range which need to be curve-fitted to identify parameters (estimation) obtaining a mathh-model as close as possible to the measurement.

Rational Fraction Polynomial method (RFP method) perform curve fitting on FRFs to identify parameters as: natural frequencies, damping ratios, mode shape for main modes of vibration of the structure.





Extremely good correspondance between experiment and mathematical fitting alghoritm



Audio Amplifier

_SCS9026

_Bulk Modulus Device

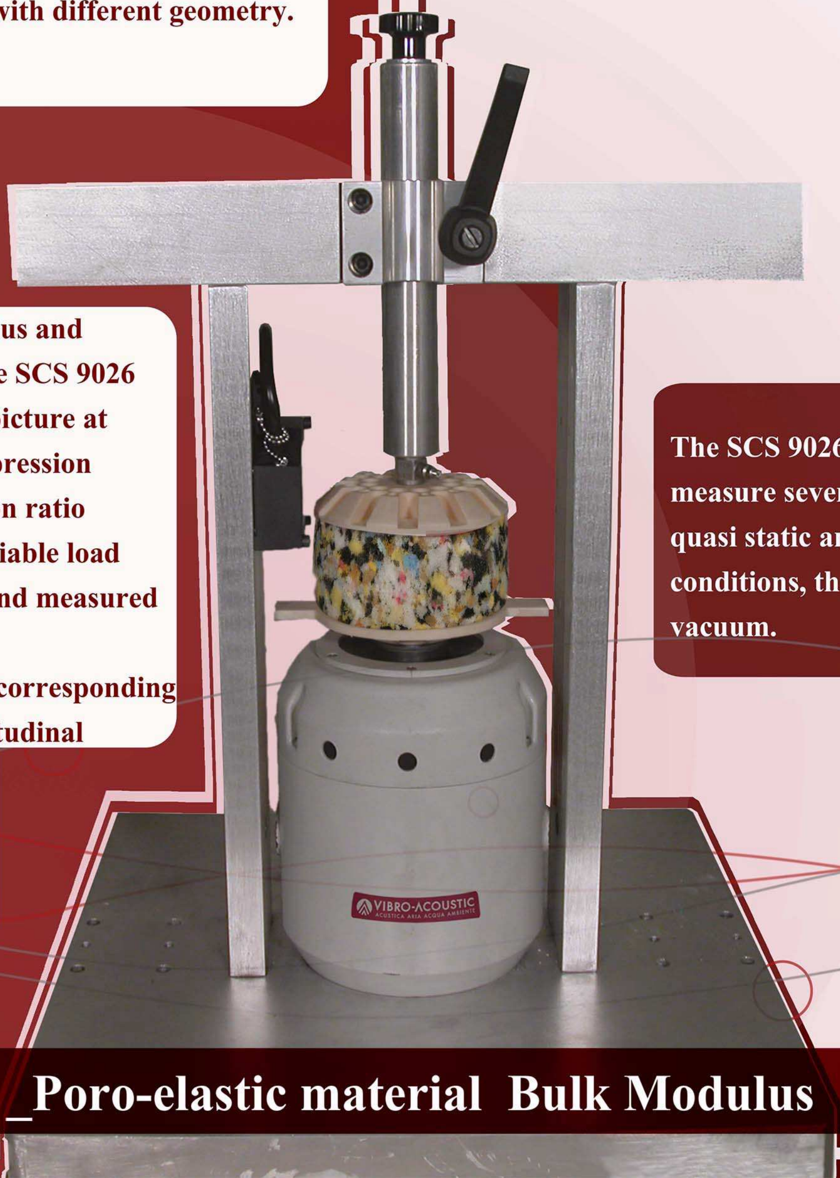
_How it works:

The determinination of frame K (Bulk Modulus) is a dynamic experiment in which the sample of porous material is placed between an electro-dynamic shaker and a rigid structure at the top or,alternatively, a free suspended mass.

Measuring the transfer function between the displacement of the lower plate to the Force resulting to the upper plate (rigid case) yeald to dynamic E from which we can derive K (bulk modulus) out of a set of test on sample of the same materials but with different geometry.

Theory applied is from Lindley for cylinder geometry rigid connected to both ends, in which the Compressibillity modules G is calculated from experimental results for at least 2 different geometries (ratio of samples diameter to samples length).

From the 2 measurements it is possible to calculate G and ν, and than K, the solution of a 2-linear equations system in G and ν using Newton-Raphson method.



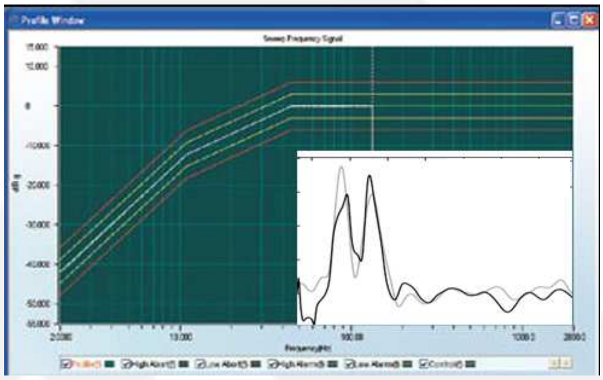
Quasi static elastic modulus and Poisson ratio use the same SCS 9026 device adapted as in the picture at side, to measure the compression modulus E and the Poisson ratio using Laser beams. A variable load is applied to the sample and measured quantities are:
the Load (Load cell), the corresponding thickness variation longitudinal (LVDT sensor) and the lateral deformation (Laser beam).

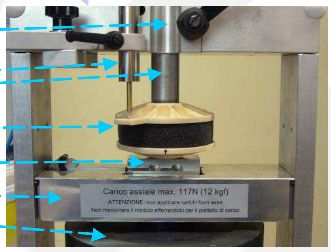
The SCS 9026 device allows to measure several quantities both in quasi static and dynamic conditions, the later also in vacuum.

_Poro-elastic material Bulk Modulus

VIBRO-ACOUSTIC

Determination of Elastic properties and Damping loss factor of porous materials samples





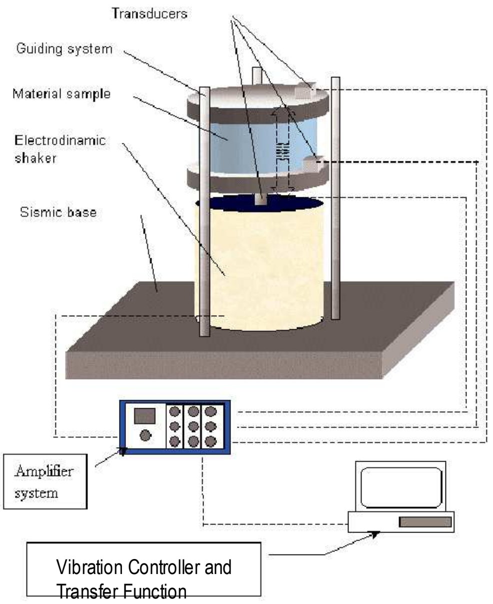
Measured Parameters:

- Damping Loss Factor
- Young Modulus
- Poisson ratio

•**Details**:

- ➔ Young Elastic Modulus of porous materials along the longitudinal axe – Static condition
- ➔ Lateral deformation (radial) under load to calculate Poisson ratio – Static condition
- ➔ Young Elastic Modulus of porous materials along the longitudinal axe – Dynamic condition
- ➔ Any preferred Dynamic measurement along the longitudinal axe

Schematic representation of the porosity device



SCS9026 Bulk Modulus consists of an aluminum frame, rigidly mounted on a seismic table, an electrodynamic shaker, measuring transducers as: static load cell, displacement transducer / axial strain, strain transducer (radial), and measuring transducers as: dynamic load cell, accelerometer.

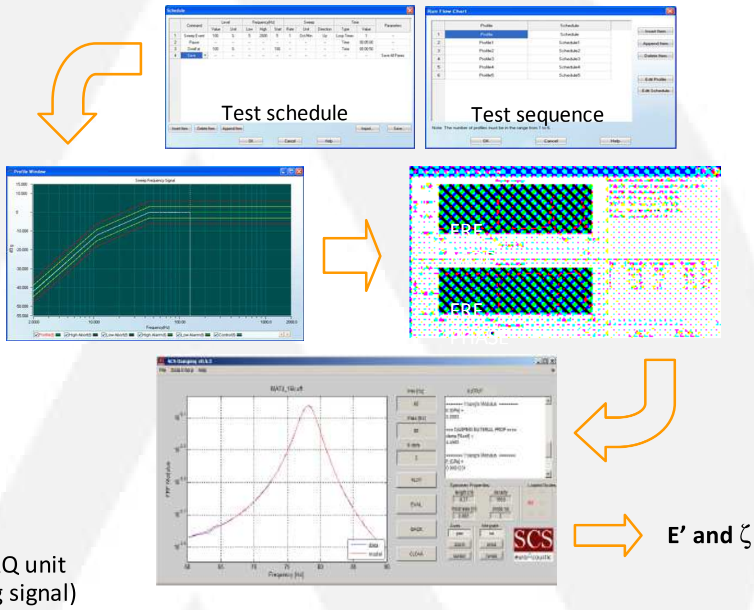
A mobile transparent bell and a vacuum pump are optional, allowing to create a sealed chamber around the frame, within which the static pressure of the air can be lowered to about 100 mbar.

Since all transducers are mobile and can be easily mounted on the various organs that make up the system, you can configure the system itself for a variety of measurement types.

VIBRO-ACOUSTIC

Determination of Elastic properties and Damping loss factor of PU foam samples

SCS9026-S-PU is a simplified version of SCS9026



Sinthesys of operations

Setup: (Store of any number of setup)

1. Transducer ICP type connect directly to DAQ unit
2. Shaker-Amplifier input connection (Driving signal) from DAQ unit
3. Transducer 1: as close loop and System Input (rigid with shaker head)
4. Transducer 2: as System output (from up plates of sample holder)

Preliminary operations:

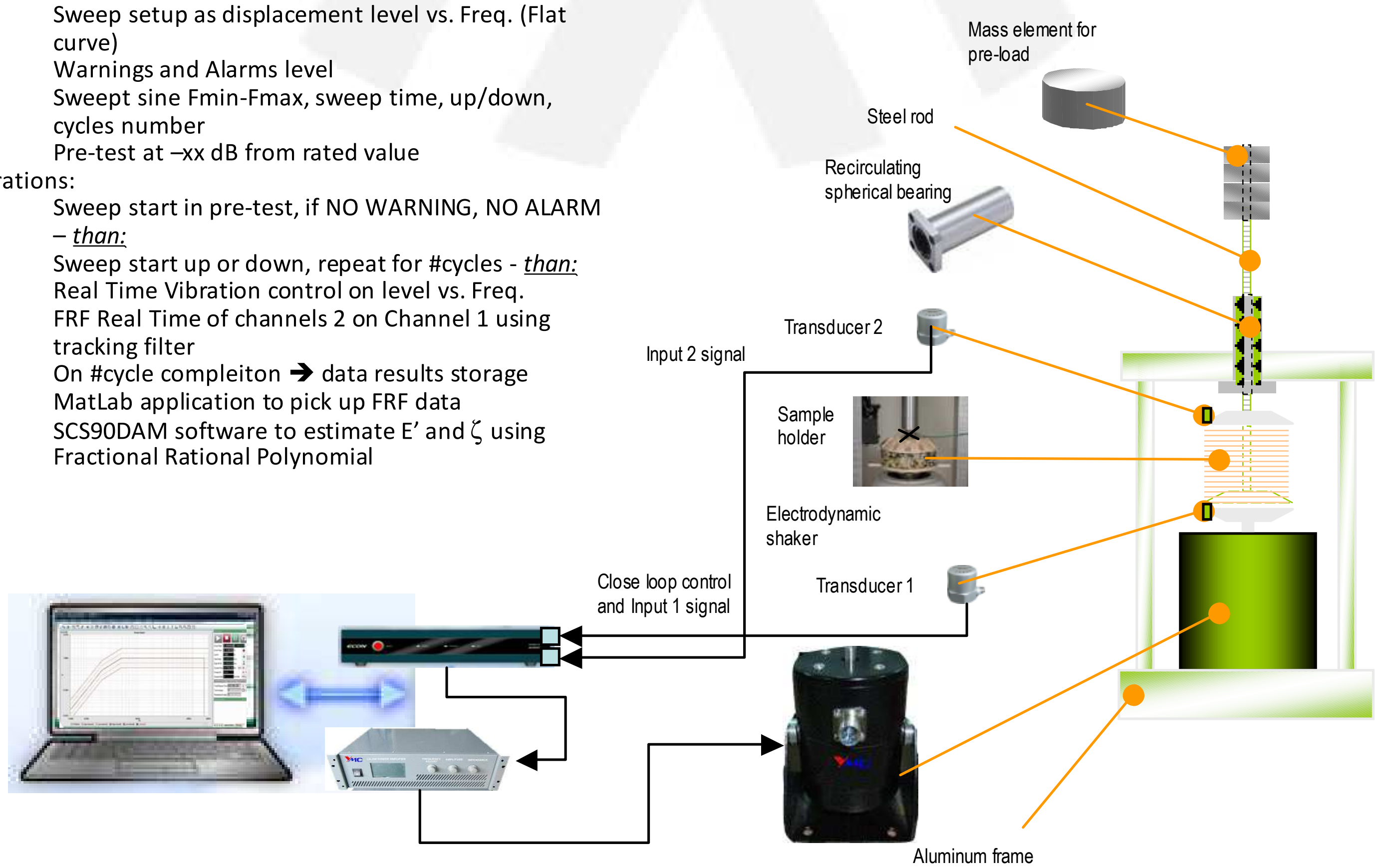
1. Sensors data setup and calibration
2. Shaker data: max current, max displacement
3. Sweep setup as displacement level vs. Freq. (Flat curve)
4. Warnings and Alarms level
5. Sweept sine Fmin-Fmax, sweep time, up/down, cycles number
6. Pre-test at –xx dB from rated value

Operations:

1. Sweep start in pre-test, if NO WARNING, NO ALARM – *than:*
2. Sweep start up or down, repeat for #cycles - *than:*
3. Real Time Vibration control on level vs. Freq.
4. FRF Real Time of channels 2 on Channel 1 using tracking filter
5. On #cycle compleiton ➔ data results storage
6. MatLab application to pick up FRF data
7. SCS90DAM software to estimate E' and ζ using Fractional Rational Polynomial

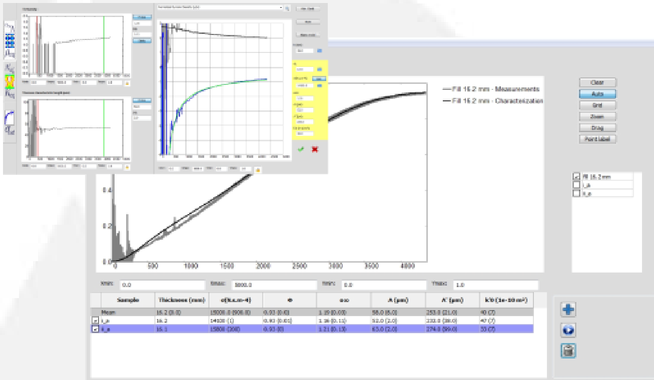
Measured Parameters:

- Damping Loss Factor
- Young Modulus



Physical Models and Prediction Softwares

Physical Parameters estimation from JCAL Physical Model of poro-Acoustic materials



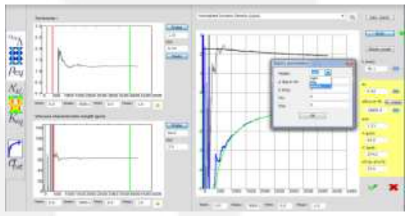
PAM-RC RoKCell software determine parameters related to visco-inertial and thermal dissipation inside a porous material following JCAL *(Johnson Champoux Allard Lafarge)* model. It allows for the determination of 5 parameters:
•the static air flow resistivity,
•the high frequency limit of the dynamic tortuosity,
•the viscous and thermal characteristic lengths
•the static thermal permeability.

PAM-RC RoKCell software is "unique" for 2 reasons:
•the implemented method consists in an analytical inversion of all non-directly measurable parameters, it means that it does not rely on any curve fitting; method described by Panneton & Olny in their 2006 and 2008 publications.
•It allows the determination of the static thermal permeability, a parameter introduced by Lafarge et al. to improve the description of the thermal dissipation inside porous media.

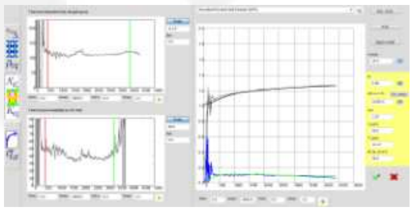
***PAM-RC* RoKCell software - How it works? ➔ As simple as 1, 2 and 3**

Preliminary: Get Kundt tube data: Complex impedance, TL, complex mass density and Bulk modulus, Get Open porosity or try a first guess (0.8 to 0.9)

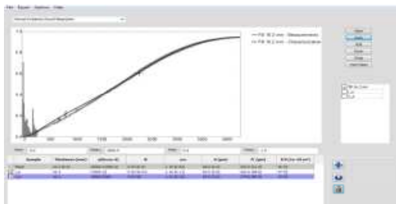
Step 1: just use cursors for visco-inertial characteristics matching (tortuosity, viscous characteristic length):
➔ main parameter is complex mass density in the low frequency range: the goal is to match experimental data and prediction

1 

Step 2: just use cursors for thermal characteristical parameters (thermal characteristic length, static thermal permeability):
➔ main parameter is Bulk modulus in the mid frequency range: the goal is to match experimental data and prediction

2 

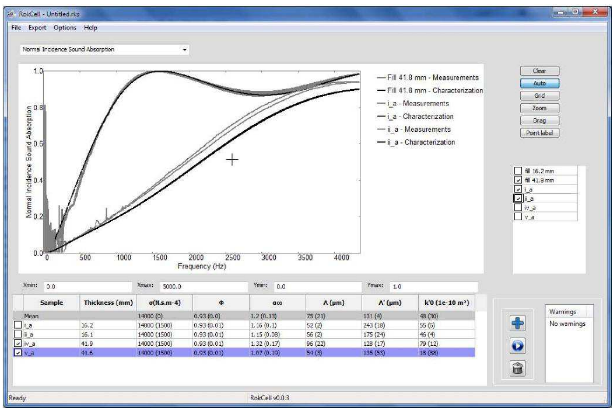
Step 3: on the main software panel are shown "Normal incidence absorption coefficient", "TL", "Impedance", and others:
➔ adjust porosity value to obtain the best correspondance between measured vs. estimated results

3 

Validation: Run "Auto" mode to estimate the whole set of parameters and check if the previous analytical results are confirmed.

TEST RESULTS

Experimental Input data:
•SCS9020 Tubes: Modal density and Bulk Modulus;
•SCS9023: Proosity and Flow-resistivity (Optional);
•Material thikness and ambient parameters.



PHYSICAL MODELS

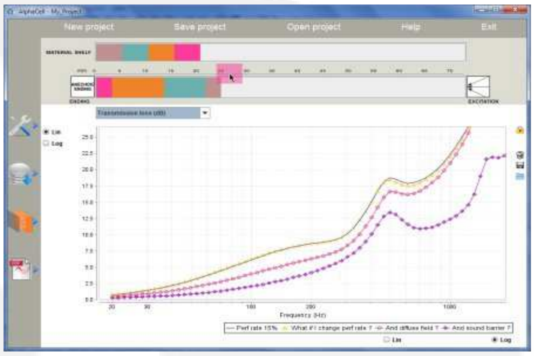
PAM-RC Data estimation:
•*Viscous characteristic length*
•*Thermal characteristic length*
•Normal incidence Sound Absorption;
•Normalized Dynamic density
•Normalized Surface Impedance
•Reflection coefficient

VIBRO-ACOUSTIC

Simple & Multi-layered Acoustic materials and Sound Packages perfomances prediction

***PAM-P* AlphaCell is a software based on the Tranfer Matrix Method (TMM/FTMM)**
➔ It predicts the sound absorption or sound transmission performances of material layers.

***PAM-P* AlphaCell** layers can describe porous media, solid materials or fluids (air) and the user can apply simple and advanced models:
•*Delany Bazley* (1 parameter),
•*JAC Johnson Champoux Allard* (5 parameters),
•*JACL Johnson Champoux Allard Pride Lafarge* (8 parameters),
•*Olny Boutin* double prosoity model, micro-perforated facings with circular, rectangular or slit-like perforations,
•*Biot* model (isotropic skeleton, 4 parameters) which can be applied to all previous acoustic models to include the elastic effects of the porous frame.



PAM-P AlphaCell features:
•an intuitive interface,
•a database of materials (from experiments or from PAM-RC estimation),
•a project management for simulations,
•a customizable PDF report generation,
•a data export/import for comparisons…

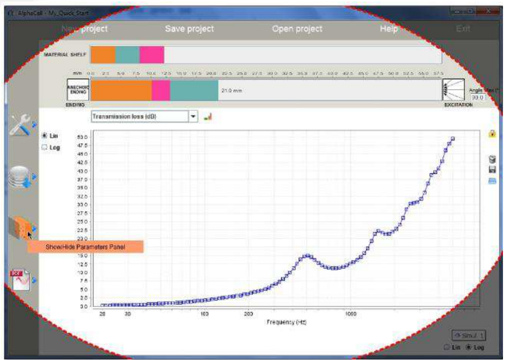
Data Input

Experimental Input data:
•SCS9020 Tubes: Modal density and Bulk Modulus;
•SCS9023: Proosity and Flow-resistivity;
•SCS9025: Tortuosity
•SCS9021-22: Damping Loss factor
•SCS9031: Random incidence absorption coeff-
•SCS9026: Bulk modulus
•Material thikness and ambient parameters.

PAM-RC Data estimation:
•*Viscous characteristic length*
•*Thermal characteristic length*
•Normal incidence Sound Absorption;
•Normalized Dynamic density
•Normalized Surface Impedance
•Reflection coefficient

Data Output

PAM-P AlphaCell provide calculation the following quantities:
•sound absorption coefficient α, reflection coefficient R,
•normalized surface impedance Z_s/Z0,
•normalized equivalent volumic mass ρeq/ρ0,
•normalized equivalent bulk modulus Keq/P0,
•sound transmission loss TL.
•complex valued quantities, Module and/or Phase, Re/Im parts).



Type of sound excitation upstream may be chosen from:
•plane waves under normal incidence (default),
•plane waves under oblique incidence (angle in degrees, E[0 – 90]°),
•diffuse sound field (maximum angle of integration, E[0 – 90]°).
Boundary frontier downstream may be chosen from:
•rigid backing, anechoic termination.
Global indicators in diffuse field sound excitation are computed according to the corresponding ISO standards:
•averaged sound absorption α_w,
•noise reduction coefficient NRC,
•sound absorption average SAA,
•weighted sound reduction index and adaptation terms R_w(C; Ctr).
Additional features:
•spatial windowing may be included to cope with the effects due to the finite size of the tested system :
•VIGRAN method for sound transmission only, GHINET *et al.* method for sound absorption and transmission.
•Adapt values of ρ0 and c0 with the ambient conditions of temperature T0, pressure P0 and humidity H.

SCS
& Partners

VIBRO-ACOUSTIC

http://www.vibro-acoutic.eu http://scs-controlsys.com

Services and Consulting >>

Environment

- Environmental Noise
- Building Acoustic
- Architectural Acoustic
- Noise and Vibrational annoyance in buildings
- Noise and VIbration at workplace
- Noise and Vibration of roads, railways, ports and airport
- Noise assesment and reduction
- Noise Prediction and mapping

Monitor

- Environmental monitoring of Noise, Vibration, Air pollution
- Traffic Analysi and vehicles calssification
- Design and development of Monitor Network and urban surveillance

Vibro-Acustic

- Automotive NVH on vehicles for passengers, goods and earth moving
- Acoustic materials properties poro-elastic and poro-acoustic
- Noise reduction devices design and installation in industrial, civil and environment
- Vibro-Acoustic calculation
- Design and supply of Noise Barriers, Silensers, Acoustc chambers

Others

- Technical and Legal assistance
- Measurement of non-ionizing radiation

Products >>

Portable Sound Level Meter and Vibrometer

Environemntal monitoring systems

Scientific Softwares

Multichannels

- ECON Technologies: 16 channels - 24 bits - 192 kHz/channel
- ECON Technologies: up to 1024 channels - 24 bits - 192 kHz/channel
- Data Translation: 4-8 canali – 24 bits – 52 kHz/channel

Vibration testing

- Anco: Vibration tables and actuators
- TL: Electrodynamic shakers
- Ucon: 1-4 channels vibration controllers

Acoustic Images

- Nittobo Acoustic: "Noise Vision" - Beamforming 3d su sfera chiusa featuring 31 microphones and 12 video-camera
- CAE-System: "Noise Inspector" - Digital interface I^2S, Acoustic Holography and Beamforming 40/60 microphone channels and 20 Intesity (x2) channels

Laser Vibrometer

- MetroLaser: Vibromet 500 - Laser Doppler vibormeter

Transducers and accessories

- Microphones and Accelerometers

Vibro-Acoustic – SCS & Partners:
40 years experience in Noise and Vibration

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