Sound Impact Limitation - Design for Industrialized Solutions (SILDIS): a single Excel based software for a wide range of applications

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Overview of features

- the prediction of performances of products and construction systems for noise control engineering often requires an approach whose nature is computationally intensive, making its application difficult for most acoustics practitioners. The software SILDIS (Sound Impact Limitation Design for Industrialized Solutions) has been developed in order to make possible such a prediction without any computational effort from users, by the means of a single PC-tool appropriate for a wide range of industrial engineering purposes, with a reliability based on the agreement of the prediction results with existing computation schemes and with measurement results (hundreds of comparisons for various types of computations)

- regarding the multi-disciplinary scientific and technical background, suitable approaches of all times, able to be included in the general layout of the program, have been selected and encapsulated in a easy-to-use Excel based software using drop-down menus and providing results in tabular and graphical form (French or English language) with comprehensive input/output data on a unique printable simulation report.

- as far as materials are concerned (such as porous media, series cloths, series perforated protections, and thin plates: see below), specific libraries (data bases) with more than 20 references for each kind of acoustic layer allow the design to be made with in-built engineering data (constants).

- almost all acoustics calculations are performed at single frequencies (20-20kHz) and displayed per 1/3 and/or 1/1 octave band: global values with respect to a chosen reference spectrum are computed whenever it makes sense.

MODULE 1 prediction of acoustic and aerodynamic performance of silencers

- either dissipative silencers (for those equipments the considered cross section can be either rectangular or round, with or without a central pod, with or without an intermediate annular splitter) for a lining including up to 4 porous media, up to 4 series cloths, up to 4 series perforated protections selected among a library including for each kind of layer more than 20 referenced materials.

- or resonant silencers with so called Pine Tree splitters (for those equipments the considered cross section can be rectangular) for a lining including up to 4 porous media, up to 4 series cloths, up to 4 series perforated protections selected among a library including for each kind of layer more than 20 referenced materials

For a rectangular silencer the results of the calculations are comparable with the standardized measurement: see NF EN ISO 7235 Acoustics - Laboratory measurement procedures for ducted silencers and air terminal units- Insertion loss, flow noise and total pressure loss.

MODULE 1A prediction of acoustic and aerodynamic performance of silencers with discontinued splitters:

- dissipative silencers (considered cross section being rectangular) for a lining including 1 porous medium, 1 series cloth, 1 series perforated protection (material properties registered in database)

For a rectangular silencer the results of the calculations are comparable with the standardized measurement: see NF EN ISO 7235 Acoustics - Laboratory measurement procedures for ducted silencers and air terminal units- Insertion loss, flow noise and total pressure loss.

MODULE 1B prediction of acoustic and aerodynamic performance of reactive silencers:

For those equipments the considered cross section can be round) for an elements combination including up to 1 uniform tube, up to 2 extended tubes

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 2 prediction of acoustic performance of plane partitions

- for an acoustic structure including up to 2 porous media, up to 2 series cloths, up to 2 series perforated protections, up to 2 sets of identical series thin plates with up to 1 complementary rear set of identical series thin plates selected among a library including for each kind of layer more than 20 referenced materials (with an atmospheric back or with an impervious rigid back).

The results of the calculations are comparable with the standardized measurement: (in case of an atmospheric back) see NF EN ISO 10140-2 Acoustics. Laboratory measurement of sound insulation of building elements. Measurement of airborne sound insulation and (in case of rigid impervious back) see NF EN ISO 354 Acoustics – Measurement of sound absorption in a reverberation room and also ISO 10534-1 Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 1: Method using standing wave ratio.

MODULE 3 prediction of acoustic performance of duct walls

- either with a rectangular cross section, or with a circular cross section (including folded spiral seam ducts)

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 4 prediction of acoustic performance of straight ducts

- either with a rectangular cross section, or with a circular cross section (including folded spiral seam ducts)

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 5 prediction of break-out noise

- either of straight ducts with a rectangular cross section, or with a circular cross section - including folded spiral seam ducts or of silencers

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 5A prediction of break-out noise of ducts with variable cross section (with a rectangular cross section)

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 6 prediction of acoustic performances of bends and junctions (in ducts systems)

- with a rectangular cross section, or with a circular cross section, or with mixed cross sections)

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 7 prediction of nozzle reflection

- with a rectangular cross section or with a circular cross section

The obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures.

MODULE 8 prediction of the sound impact of duct systems

- including components such as silencers (dissipative or resonant), straight ducts sections, bends with a rectangular cross section, or with a circular cross section, or with mixed cross sections (for some components)

MODULE 8A prediction of stacks directivity

Some of the obtained results are comparable with some input data envisaged in standardized calculation: cf. NF EN ISO 9613-2 Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation (1996)

MODULE 8B prediction of atmospheric sound absorption

Some of the obtained results are comparable with some input data envisaged in standardized calculation: cf. NF EN ISO 9613-2 Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation (1996)

MODULE 8C prediction of control valves aerodynamic noise

MODULE 8D prediction of jet noise (including safety valves noise)

MODULE 8E prediction of piping systems discharge parameters

MODULE 8F determination of the performance & sizing of safety valves

MODULE 8G simulation of the discharge of a fluid trough a valve vent stack

MODULE 8H prediction of acoustic and aerodynamic performance of vent silencers for pressurized fluids

MODULE 9 prediction of sound decay in enclosed spaces

The obtained results are comparable with standardized measurement: cf. NF EN ISO 3382-2 Acoustics - Measurement of room acoustics parameters- Part 2: reverberation time in ordinary rooms.

MODULE 9A prediction of sound spatial decay in open-plan offices

Some of the obtained results are comparable with standardized measurement NF EN ISO 3382-3 Acoustics - Measurement of room acoustics parameters- Part 3: Open plan offices.

MODULE 10 prediction of the noise emissions from buildings and other constructions

Some of the obtained results are comparable with standardized calculations: cf. ISO 12354-4 Building acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 4: Transmission of indoor sound to the outside

ITS acoustique

Applications

- **SILDIS is useful for consulting projects and products/construction systems development projects involving sound reduction/airborne noise insulation by the means of passive acoustics solutions in various domains**: protection of workers, protection of environment, energy sector, measurement rooms, building

MODULE 1

Prediction of acoustic and aerodynamic performance of silencers

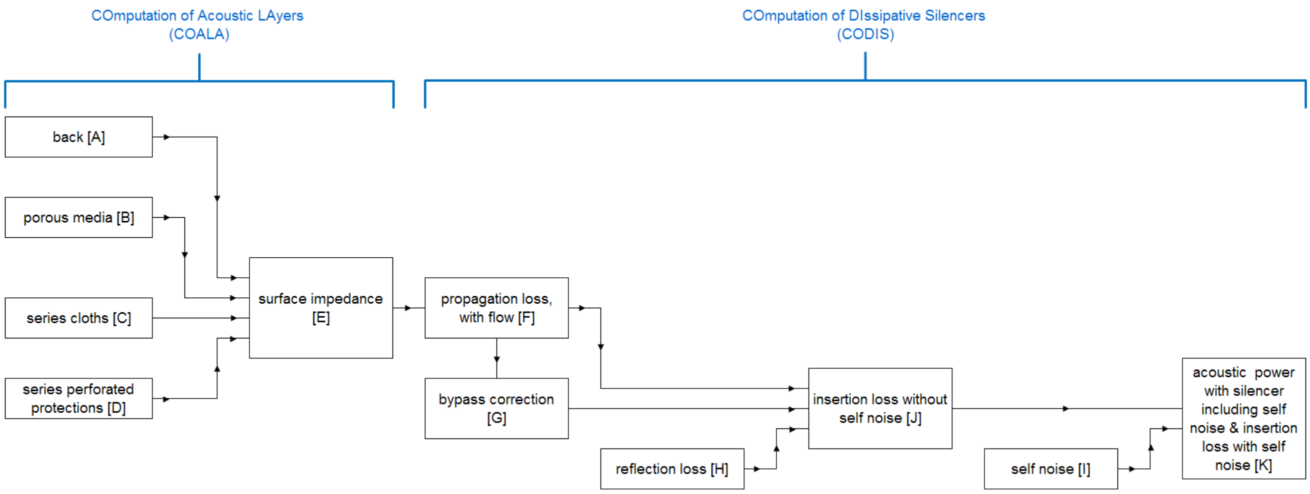
Scope of computation

- design of devices reducing the acoustic transmission in a duct, a pipe or an aperture, without preventing the carriage of the fluid (dissipative: attenuating the wideband sounds with a relatively low pressure loss and converting partially the acoustic energy into heat by friction on tubes having a porous or fibrous structure or resonant: with Pine Tree splitters producing an acoustic attenuation from weakly damped resonances of elements containing or not containing absorbing materials - at the rear of the chambers or lateral -).

Applications

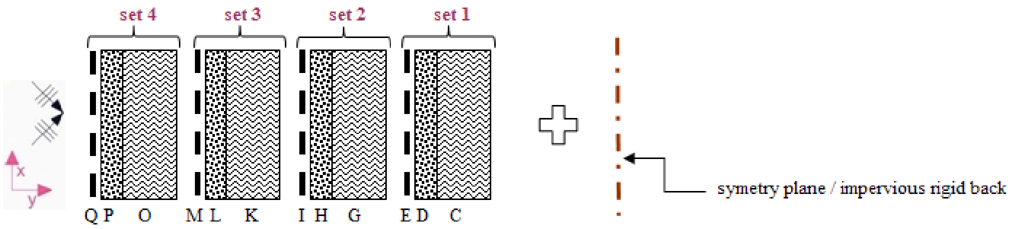
- **creation of a sound transmission loss by the means of the construction of a silencer** possibly included in a (soundproofing) industrial building/ booth/wall/screen: protection of workers, protection of environment, energy sector, measurement rooms, building, notably:
  - ✓ **ventilation of enclosures and/or air input for thermodynamic processes** for various noisy equipments such as **fans, aero condensers, engines, gas turbines**…
  - ✓ **ventilation of test benches and/or air input for thermodynamic processes of test benches**…
  - ✓ **noise reduction of stacks, exhaust of gas turbines**…

Computation scheme (bloc diagram) for dissipative silencers: adapted for resonant silencers



Main/special features, main effects taken into account

- **design possible for multilayered acoustic structures:** most sophisticated acoustic structure available (for the lining / for half a splitter) as shown on the figure below (air flow according x-direction, thickness of the lining / half a splitter according y-direction)



item	layer (*)
C, G, K, O	porous medium (**)
D, H, L, P	series cloth (**)
E, I, M, Q	series perforated protection (**)

* selected among a library including for each kind of layer more than 20 referenced materials

**some cloths and some perforated protections can also be considered as porous layers for the computation

- for an acoustic structure including a **porous medium** (i.e. polyester, rock wool, basalt wool, glass wool, foam …for which the engineering data can be referenced or air): **behavior taken into account from to the microscopic scale level** in relation with the properties such as flow resistivity [cf. fig. 1] and other parameters for a locally reacting absorber or a bulk reacting absorber with a possible inhomogeneity of properties such as flow resistivity (σx, σy on figures below) or other parameters, of 1 layer in directions perpendicular to and parallel to its surface [cf. fig. 2]

- **effect of a laminated lining** (for each layer: different properties such as flow resistivity [cf. fig. 3] or other different parameters): **taken into account**
- **effect of a cloth** (i.e. fabric, unwoven…for which the engineering data can be referenced): **taken into account** [cf. fig. 4]
- for an acoustic structure including a **perforated protection** (i.e. perforated sheet with circular holes and square or hexagonal array, perforated sheet with square holes, infinite slots… for which the engineering data can be referenced): **interaction of the protection with a porous medium at the front/at the rear taken into account** [cf. fig. 5]
- **by-pass correction taken into account** [cf. fig. 6]
- **reflection loss taken into account** [cf. fig. 7]
- **effect of temperature/of pressure taken into account** [cf. fig. 8] [cf. fig. 9]
- **effect of the velocity of air flow** (other than self noise [cf. fig. 10], self noise [cf. fig. 11]) **taken into account**
- **different possible geometries for the splitters/the lining:** rectangular, semi circular or profiled aerodynamic type upstream/downstream (cross section for a dissipative silencer: rectangular, square or round - with or without central pod, with or without up to 3 intermediate annular splitters -, cross section for a resonant silencer: rectangular)

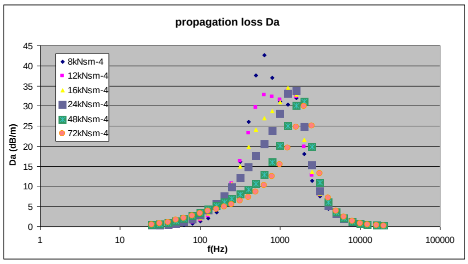


Fig. 1

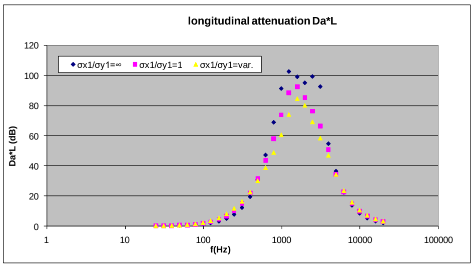


Fig. 2

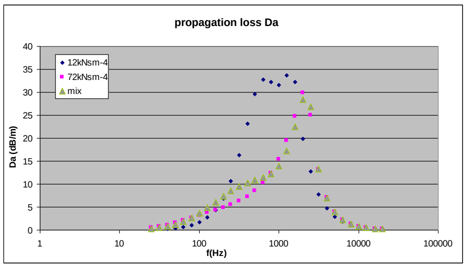


Fig. 3

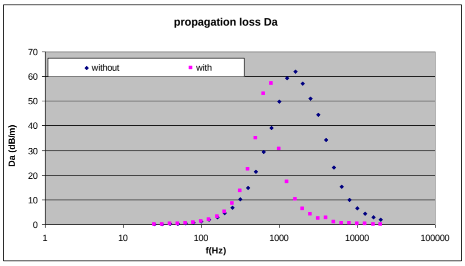


Fig. 4

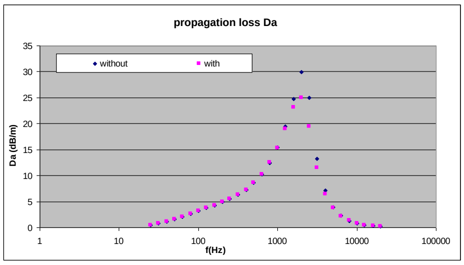


Fig. 5

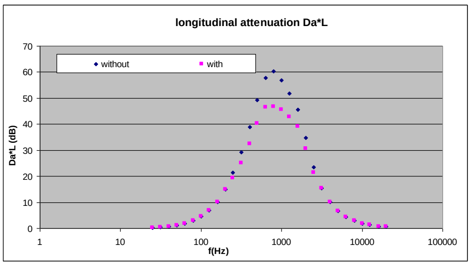


Fig. 6

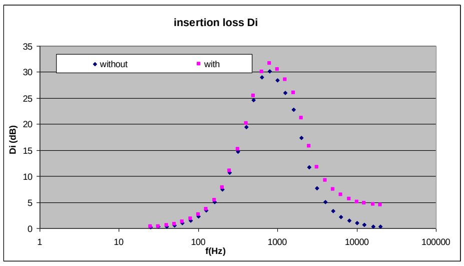


Fig. 7

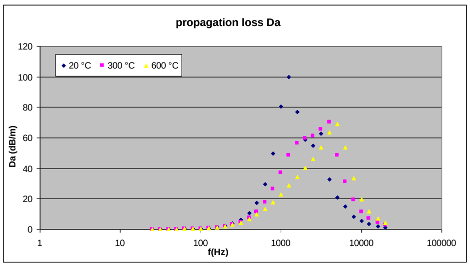


Fig. 8

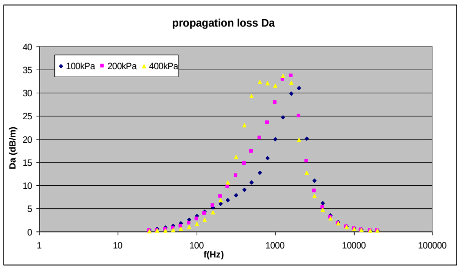


Fig. 9

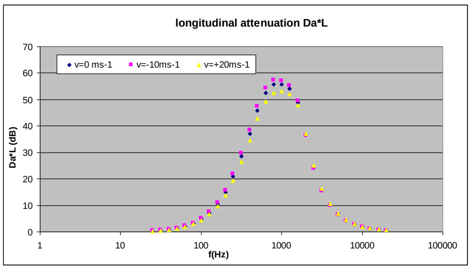


Fig. 10

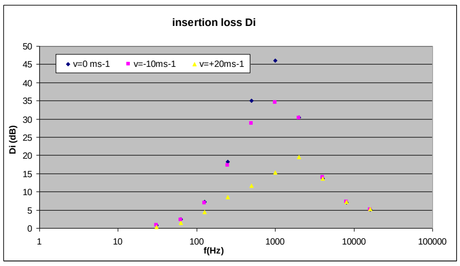


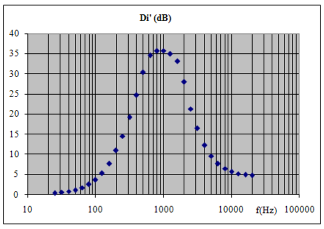
Fig. 11

<u>Main results displayed for the acoustic structure used for the lining/half a splitter (with an impervious rigid back/a symmetry plane):</u>

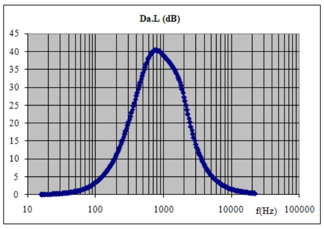
- **complex surface impedance for normal incidence: Z per 1/3 and 1/1 octave frequency band**
- **absorption coefficient at normal incidence: α0 per 1/3 and 1/1 octave frequency band**
- **the results of the calculations are comparable with the standardized measurement:** see **ISO 10534-1 Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 1: Method using standing wave ratio.**

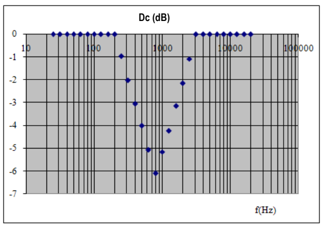
<u>Main displayed results for the silencer (tables and graphs):</u>

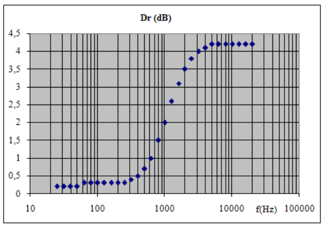
- **total pressure loss (and non dimensional total pressure loss coefficient)**
- **insertion loss without flow:** for 3 usual different conditions of propagation of sound inside the lining **per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**
- **insertion loss with flow without flow noise Di'(detailing longitudinal attenuation Da.L, bypass correction Dc and reflection loss Dr)** for 3 usual different conditions of propagation of sound inside the lining **per 1/3 and 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



f (Hz)	Di' (dB) 1/3 oct	Di' (dB) 1/1 oct	f (Hz)	Di' (dB) 1/3 oct	Di' (dB) 1/1 oct
25	0,4		800	35,7	
31,5	0,6	0,6	**1k**	35,8	35,5
40	0,8		1,25k	35,0	
50	1,1		1,60k	33,2	
63	1,7	1,8	**2k**	28,1	25,1
80	2,5		2,50k	21,3	
100	3,6		3,15k	16,4	
125	5,3	5,3	**4k**	12,3	12,0
160	7,7		5k	9,6	
200	11,0		6,30k	7,7	
250	14,5	13,8	**8k**	6,5	6,6
315	19,2		10k	5,7	
400	24,7		12,50k	5,2	
500	30,4	28,1	**16k**	4,9	5,0
630	34,6		20k	4,7	
		ref: Lw0	**A**	**11,9**	**ref: Lw0**

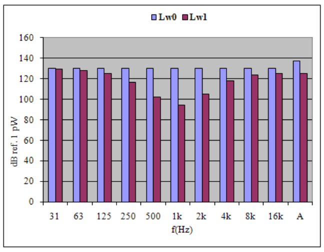




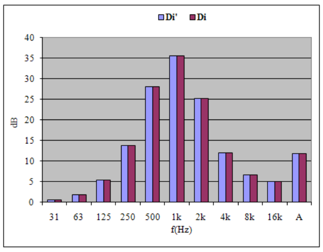


- **self noise (acoustic power of flow noise) per 1/1 octave frequency band (as well as A-weighted overall value)**

- **A-weighted and not A-weighted acoustic power with silencer Lw1** for 3 usual different conditions of propagation of sound inside the lining (**comparable with the not A-weighted acoustic power without silencer Lw0) per 1/1 octave frequency band**



- **insertion loss with flow and self noise** for 3 usual different conditions of propagation of sound inside the lining **per 1/3 and 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



… etc

- **the results of the calculations for a rectangular silencer are comparable with the standardized measurement: see NF EN ISO 7235 Acoustics - Laboratory measurement procedures for ducted silencers and air terminal units- Insertion loss, flow noise and total pressure loss**

MODULE 1A Prediction of acoustic and aerodynamic performance of silencers with discontinued splitters

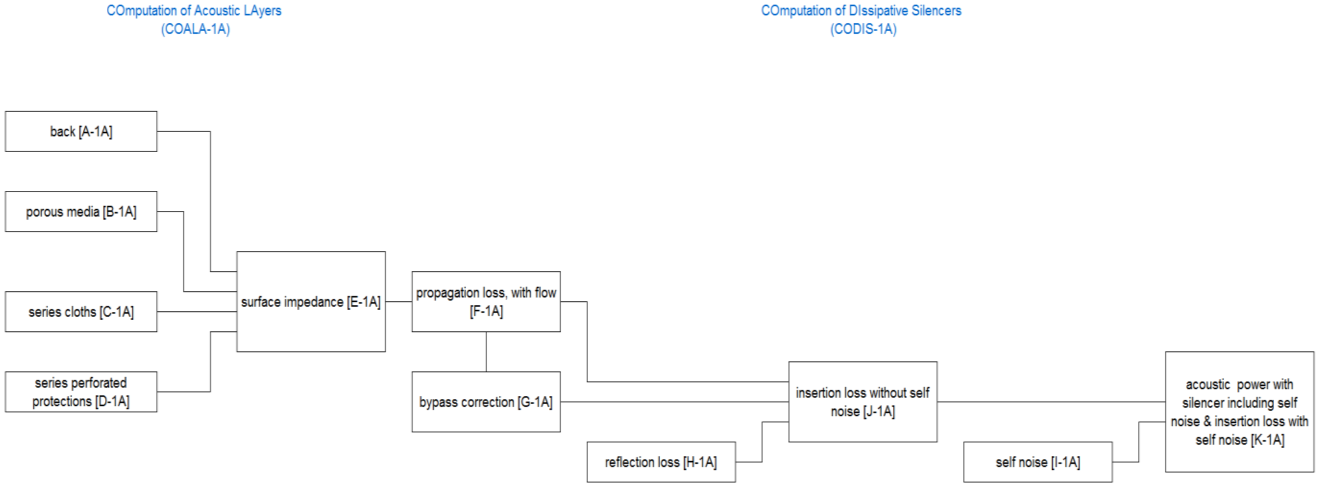
Scope of computation

- design of devices reducing the acoustic transmission in a duct, a pipe or an aperture, without preventing the carriage of the fluid (dissipative: attenuating the wideband sounds with a relatively low pressure loss and converting partially the acoustic energy into heat by friction on tubes having a porous or fibrous structure).

Applications

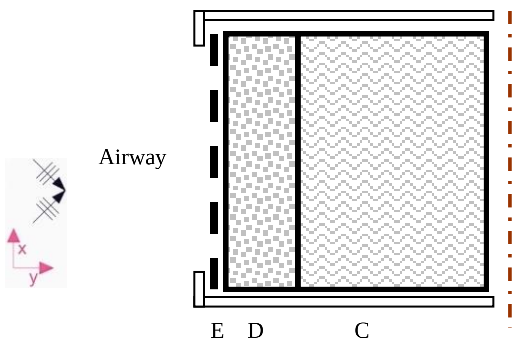
- **creation of a sound transmission loss by the means of the construction of a silencer** possibly included in a (soundproofing) industrial building/ booth/wall/screen: protection of workers, protection of environment, energy sector, measurement rooms, building, notably:
  - ✓ **ventilation of enclosures and/or air input for thermodynamic processes** for various noisy equipments such as **fans, aero condensers, engines, gas turbines**…
  - ✓ **ventilation of test benches and/or air input for thermodynamic processes of test benches**…
  - ✓ **noise reduction of stacks, exhaust of gas turbines**…

Computation scheme (bloc diagram) for dissipative silencers:



Main/special features, main effects taken into account

- **design possible for 1 multilayered acoustic structure**



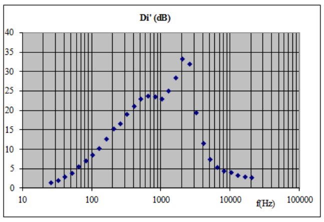
land mark	element
E	series perforated protection
D	series cloth
C	porous medium

- **porous medium** (i.e. rock wool) **behavior taken into account** for an absorber with an inhomogeneity of flow resistivity of the layer in directions perpendicular to and parallel to its surface
- **effect of a negligible cloth** for which the engineering are referenced): **taken into account**
- **perforated protection** (i.e. perforated sheet with circular holes for which the engineering data are referenced): taken into account as negligible
- **by-pass correction taken into account**

- **reflection loss taken into account**
- **effect of temperature/of pressure taken into account** within in the limit of room conditions
- **effect of the velocity of air flow** (other than self noise & as self noise) **taken into account** within of Mach number from -0.3 to 0.3
- **different possible geometries for the splitters/the lining:** rectangular, semi circular or profiled aerodynamic type upstream/downstream (cross section for a dissipative silencer: rectangular)

Main displayed results for the silencer (tables and graphs):

- **total pressure loss (and non dimensional total pressure loss coefficient)**
- **insertion loss without flow** for 1 condition of propagation of sound inside the splitters filling **1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**
- **insertion loss with flow without flow noise Di'(detailing longitudinal attenuation Da.L, bypass correction Dc and reflection loss Dr)** for 1 condition of propagation of sound inside the lining **per 1/3 and 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



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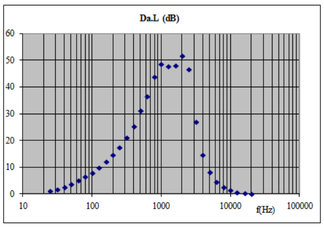
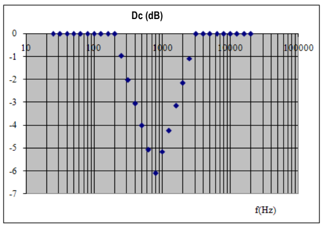
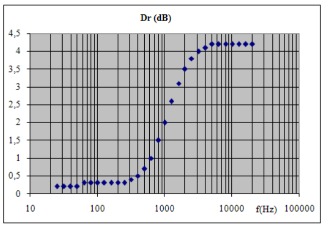
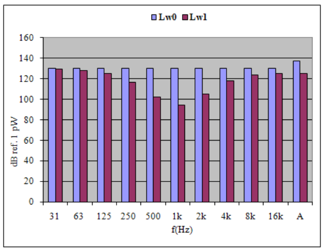
630	34,6		20k	4,7	
		ref: Lw0	**A**	**11,9**	**ref: Lw0**



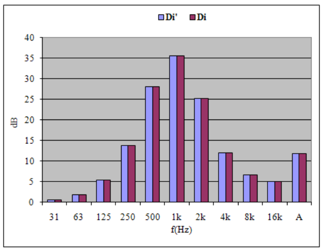




- **self noise (acoustic power of flow noise) per 1/1 octave frequency band (as well as A-weighted overall value)**
- **A-weighted and not A-weighted acoustic power with silencer Lw1** for 1 condition of propagation of sound inside the lining (**comparable with the not A-weighted acoustic power without silencer Lw0) per 1/1 octave frequency band**



- **insertion loss with flow and self noise** for 1 condition of propagation of sound inside the splitters filling **per 1/3 and 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



… etc

- **the results of the calculations for a rectangular silencer are comparable with the standardized measurement: see NF EN ISO 7235 Acoustics - Laboratory measurement procedures for ducted silencers and air terminal units- Insertion loss, flow noise and total pressure loss**

MODULE 1B

Prediction of acoustic and aerodynamic performance of reactive silencers

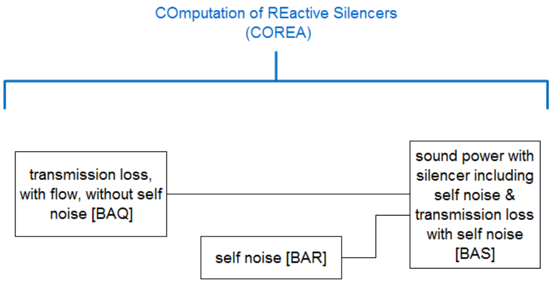
Scope of computation

- design of devices reducing the acoustic transmission in a duct, a pipe or an aperture, without preventing the carriage of the fluid (reactive: silencer for which the major part of the attenuation involves no acoustic energy dissipation).

Applications

- **creation of a sound transmission loss by the means of the construction of a silencer**: protection of workers, protection of environment, energy sector, measurement rooms, building, notably:
  - ✓ **noise reduction of stacks, exhaust of thermal engines**…

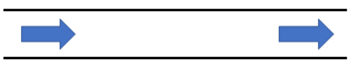
Computation scheme (bloc diagram) for dissipative silencers:



Main/special features, main effects taken into account

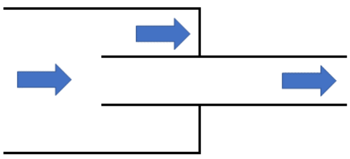
- **design possible for various types of tubes**

Uniform Tube(s) group (UT)

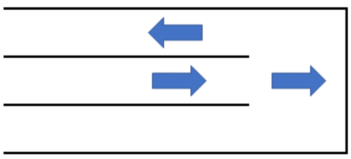


Uniform Tube (UT)

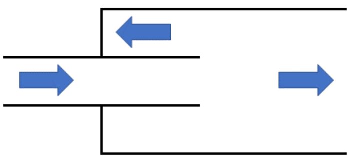
Extended Tube(s) group (ET)



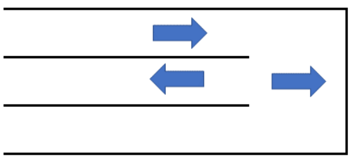
Extended Outlet (EO)



Reversal Expansion (RE)

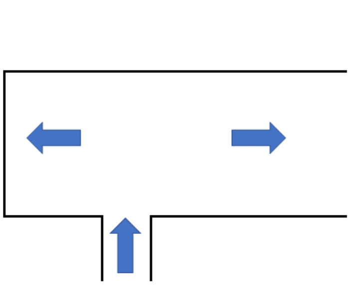


Extended Inlet (EI)

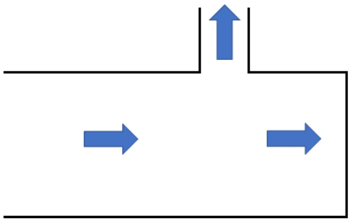


Reversal Contraction (RC)

Side Tube(s) group (ST)

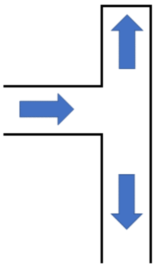


Side Inlet (SI)

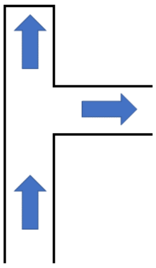


Side Outlet (SO)

Transverse Tube(s) group (TT)

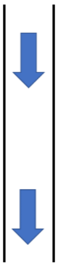


Transverse Inlet (TI)



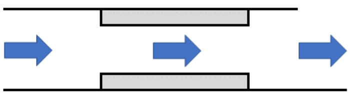
Transverse Outlet (TO)

Variable Tube(s) group (VT)



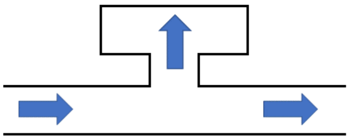
Variable Tube (VT)

Dissipative Section (DS) as computed with Module 1 of software SILDIS

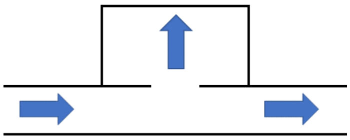


Dissipative Section (DS) as computed with
Module 1 of software SILDIS

Helmoltz Resonator(s) group (HR)

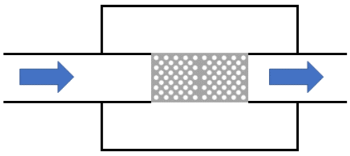


Helmoltz Resonator (HR) side branch

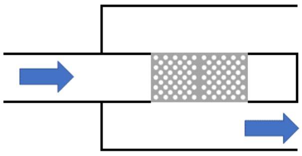


Helmoltz Resonator (HR) concentric

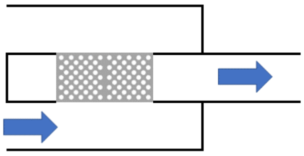
Perforated tube(s) group (PT)



Concentric Tube Resonator (CTR)



Cross Flow Expansion (CFE)

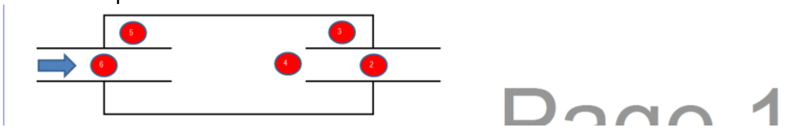


Cross Flow Contraction (CFC)

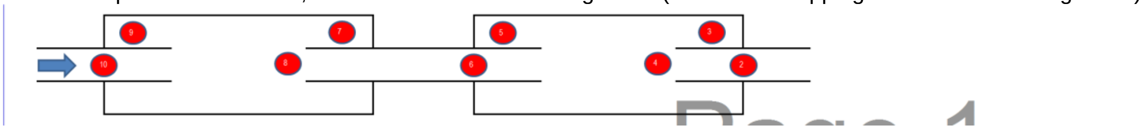
- preconfigured mountings involving **<u>long expansion chambers</u>**

✓ **in-line chambers**

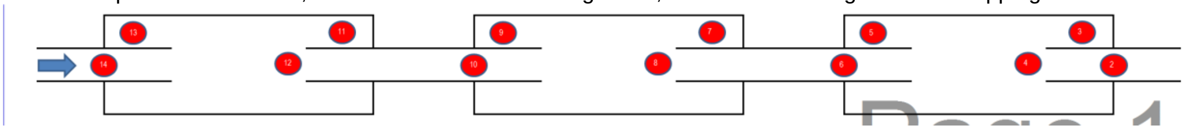
EC1 = 1 expansion chamber



EC2 = 2 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes)

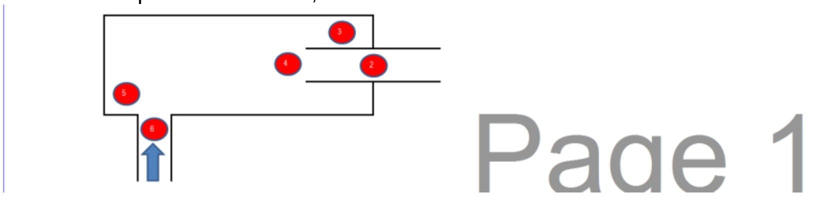


EC3 = 3 expansion chambers, with 1 or several connecting tubes, without connecting tubes overlapping

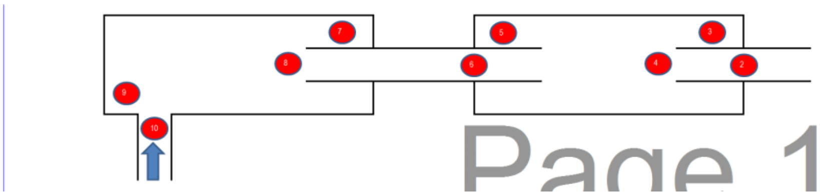


✓ **chambers with side inlet**

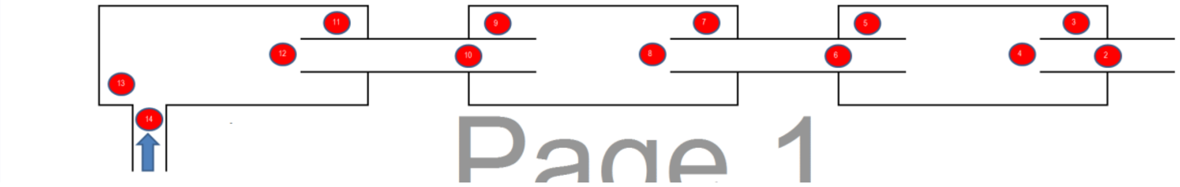
EC1SI = 1 expansion chamber, with side inlet



EC2SI = 2 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes), with side inlet

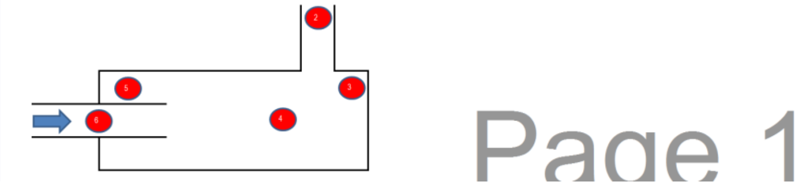


EC3SI = 3 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes), with side inlet

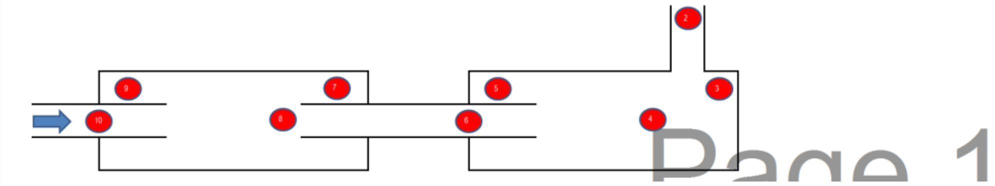


- ✓ **chambers with side outlet**

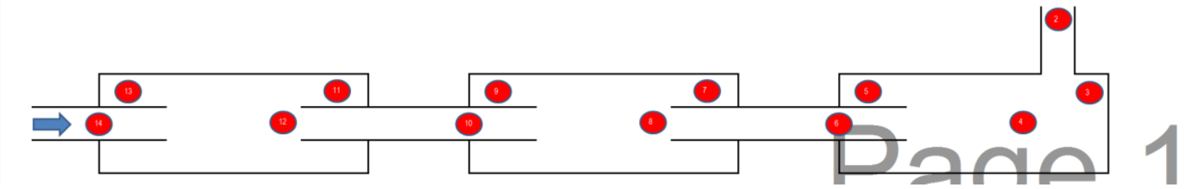
EC1SO = 1 expansion chamber, with side outlet



EC2SO = 2 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes), with side outlet

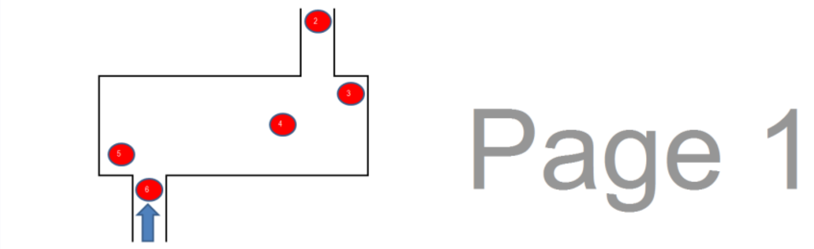


EC3SO = 3 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes), with side outlet

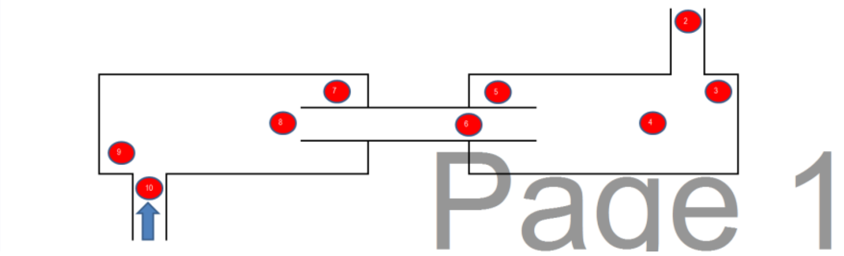


- ✓ **chambers with side inlet & with side outlet**

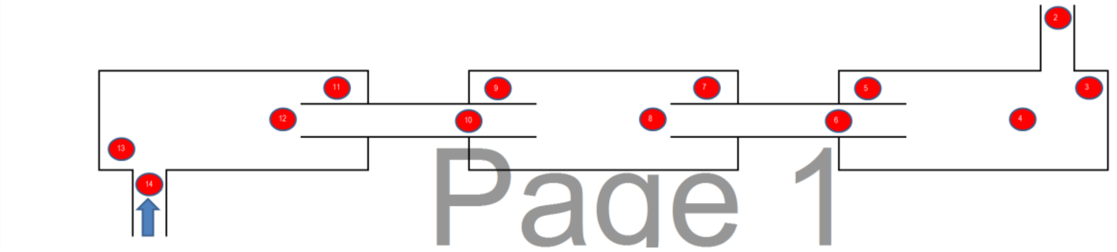
EC1SISO = 1 expansion chamber, with side inlet, with side outlet



EC2SISO = 2 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes), with side inlet, with side outlet



EC3SISO = 3 expansion chambers, with 1 or several connecting tubes (without overlapping between connecting tubes), with side inlet, with side outlet

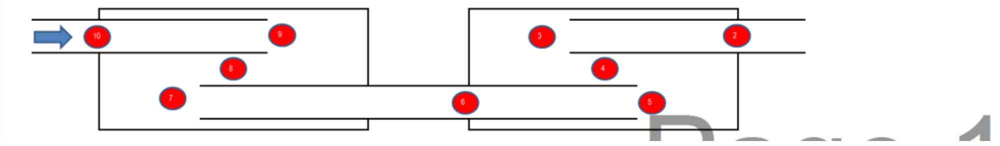


✓ **chambers with overlapping tubes**

EC1R1 = 1 expansion chamber, with overlapping tubes

EC1R2 = 1 expansion chamber, with 2 overlapping tubes in expansion chamber 1

EC2R22 = 2 expansion chambers, with 2 overlapping tubes in expansion chamber 1, with 2 overlapping tubes in expansion chamber 2



- preconfigured mountings involving **<u>short expansion chambers</u>**

EC1R1* = 1 expansion chamber, with 1 flow reversal

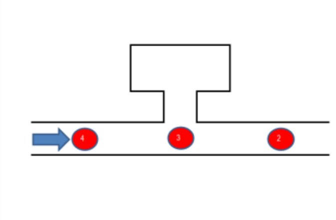
- the **<u>preconfigurated</u>** mouuntings **<u>(involving dissipative sections</u>**) for which performance acoustic & aerodynamic simulation is possible are as follows:

CDE = splitter section as calculated with module of software SILDIS

- the **preconfigurated** mountings **(involving Helmoltz Resonators**) for which performance acoustic & aerodynamic simulation is possible are as follows:

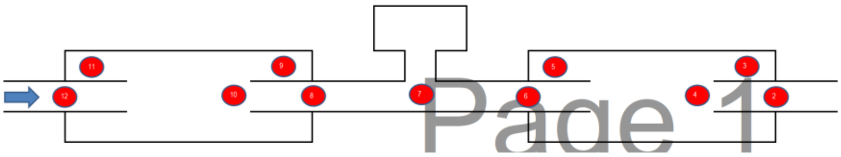
HR1SN = single Helmholtz Resonator Short Neck & HR1LN = single Helmholtz Resonator Long Neck

Side branch



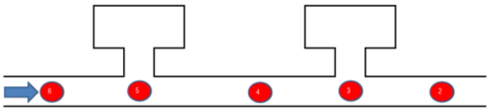
Concentric

ECHRLNEC = Expansion Chamber + Helmholtz Resonator Long Neck + Expansion Chamber

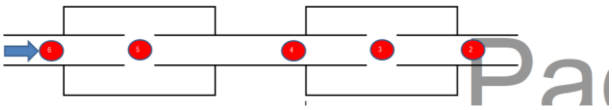


HR2SN = double Helmholtz Resonator Short Neck & HR1LN = double Helmholtz Resonator Long Neck

Side branch

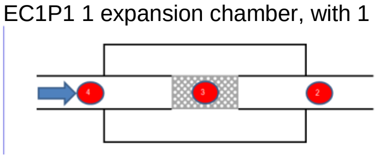


Concentric

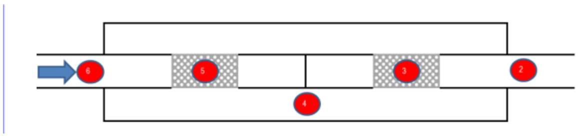


- the **preconfigurated** mountings **(involving Perforated Tubes**) for which performance acoustic & aerodynamic simulation is possible are as follows:

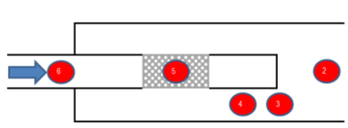
EC1P1 1 expansion chamber, with 1 perforated tube



EC1P2 1 expansion chamber, with 2 perforated tubes

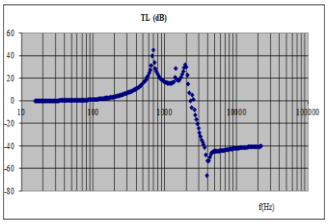


ECF+ expansion with perforated tube, uniform tubes



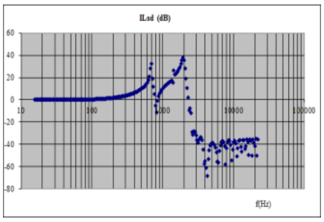
Main displayed results for the silencer (tables and graphs):

- **total pressure loss**
- **transmission loss with flow per 1/3 & 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



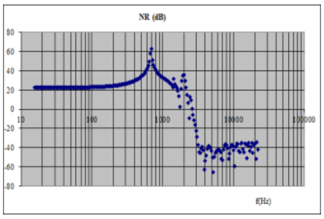
f (Hz)	TL (dB) 1/3 oct	TL (dB) 1/1 oct	f (Hz)	TL (dB) 1/3 oct	TL (dB) 1/1 oct
25	0,1		800	23,3	
31,5	0,1	0,2	**1k**	17,0	18,0
40	0,2		1,25k	16,3	
50	0,3		1,60k	20,0	
63	0,4	0,5	**2k**	14,7	-5,8
80	0,7		2,50k	-10,6	
100	1,1		3,15k	-34,1	
125	1,6	1,7	**4k**	-58,3	-53,7
160	2,4		5k	-45,0	
200	3,6		6,30k	-44,1	
250	5,2	5,2	**8k**	-43,0	-43,1
315	7,4		10k	-42,1	
400	10,5		12,50k	-41,4	
500	15,4	14,0	**16k**	-41,0	-41,0
630	25,2		20k	-40,6	
		ref: Lw0	**A**	**-47,9**	**ref: Lw0**

- **insertion loss with flow with a substitution duct per 1/3 & 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



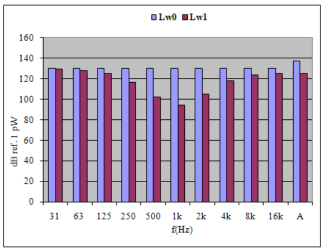
f (Hz)	ILsd (dB) 1/3 oct	ILsd (dB) 1/1 oct	f (Hz)	ILsd (dB) 1/3 oct	ILsd (dB) 1/1 oct
25	0,0		800	-4,2	
31,5	0,0	0,1	**1k**	9,1	0,4
40	0,1		1,25k	15,6	
50	0,1		1,60k	25,3	
63	0,2	0,2	**2k**	18,5	-21,3
80	0,3		2,50k	-26,1	
100	0,5		3,15k	-34,9	
125	0,7	0,8	**4k**	-61,0	-56,3
160	1,2		5k	-41,5	
200	1,8		6,30k	-51,1	
250	2,8	2,9	**8k**	-50,1	-49,9
315	4,2		10k	-47,9	
400	6,3		12,50k	-41,6	
500	9,7	9,2	**16k**	-43,3	-43,7
630	17,0		20k	-45,4	
		ref: Lw0	**A**	**-50,8**	**ref: Lw0**

- **noise reduction with flow with an additional duct per 1/3 & 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**

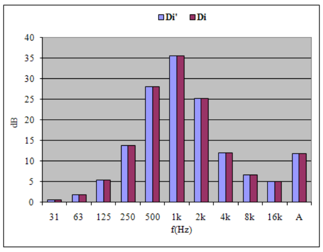


f (Hz)	NR (dB) 1/3 oct	NR (dB) 1/1 oct	f (Hz)	NR (dB) 1/3 oct	NR (dB) 1/1 oct
25	22,6		800	40,5	
31,5	22,6	22,7	**1k**	32,7	30,2
40	22,7		1,25k	26,4	
50	22,7		1,60k	10,7	
63	22,8	22,8	**2k**	21,9	-1,1
80	22,9		2,50k	-5,8	
100	23,1		3,15k	-40,6	
125	23,3	23,4	**4k**	-54,9	-54,7
160	23,7		5k	-57,5	
200	24,4		6,30k	-48,0	
250	25,4	25,5	**8k**	-45,0	-48,6
315	27,0		10k	-50,9	
400	29,6		12,50k	-41,8	
500	34,0	32,9	**16k**	-43,9	-43,7
630	43,4		20k	-44,9	
		ref: Lw0	**A**	**-48,9**	**ref: Lw0**

- **self noise (acoustic power of flow noise) per 1/1 octave frequency band (as well as A-weighted overall value)**
- **A-weighted and not A-weighted acoustic power with silencer Lw1 (comparable with the not A-weighted acoustic power without silencer Lw0) per 1/1 octave frequency band**
- **transmission loss with flow and self noise per 1/3 and 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**



- **the results of the calculations for a rectangular silencer are comparable with the standardized measurement: see NF EN ISO 7235 Acoustics - Laboratory measurement procedures for ducted silencers and air terminal units- Insertion loss, flow noise and total pressure loss**



MODULE 2

Prediction of acoustic performance of plane partitions

Scope of computation

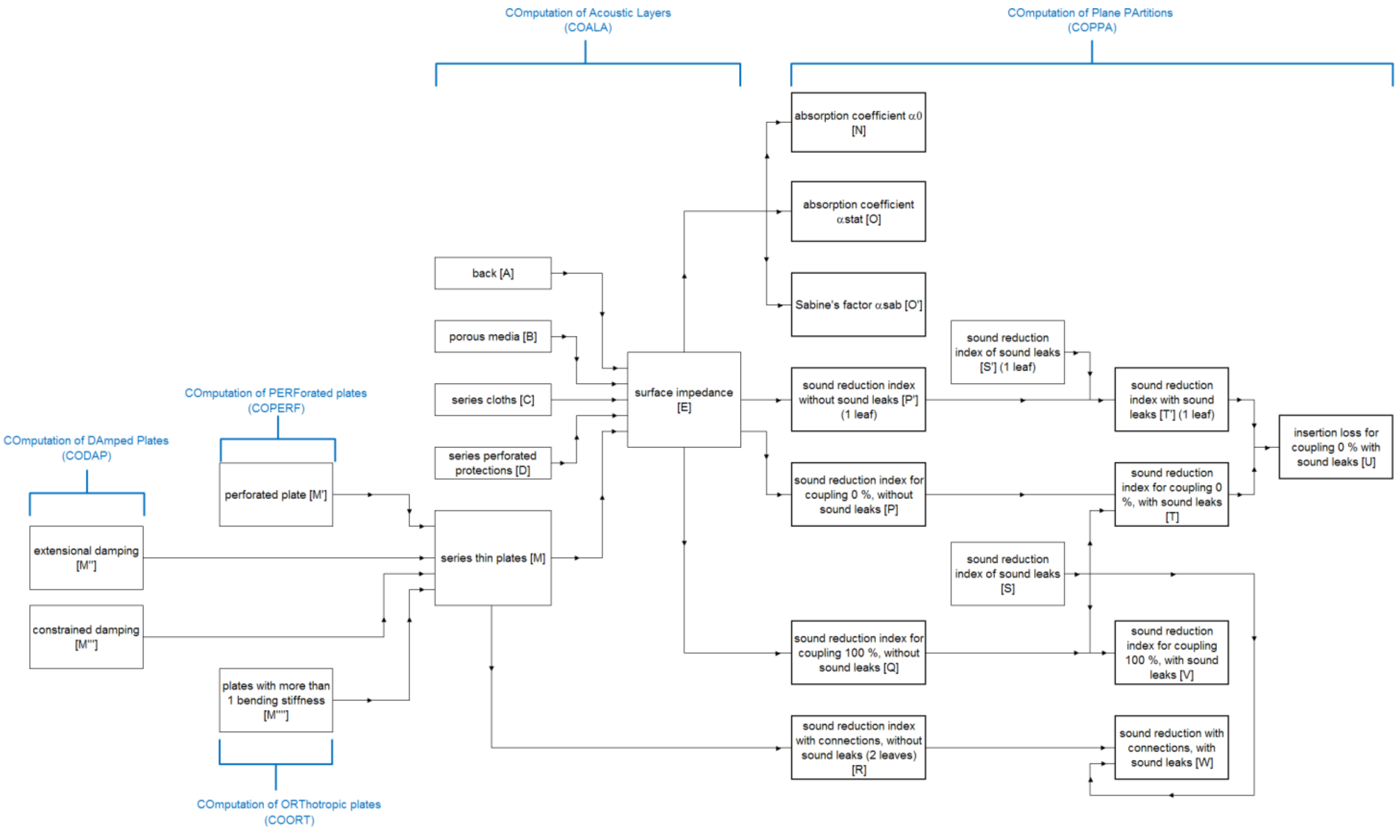
- design of acoustic structures (products and construction systems) for which the shape of the surfaces from the one hand: facing the front atmosphere and from the other hand: at the rear are sufficiently close to a plane (for example: including corrugated plates and profiled claddings)

Applications

- **creation of a sound reduction by the means of the construction of a (soundproofing) industrial building/ booth/wall/screen with or without limiting the amplification of sound level on 1 or 2 sides of the acoustic protection (0,1 or 2 absorbing faces)**
- **limitation of the amplification of sound level on 1 or 2 sides of an acoustic protection:** protection of workers, protection of environment, energy sector, measurement rooms, building, notably:

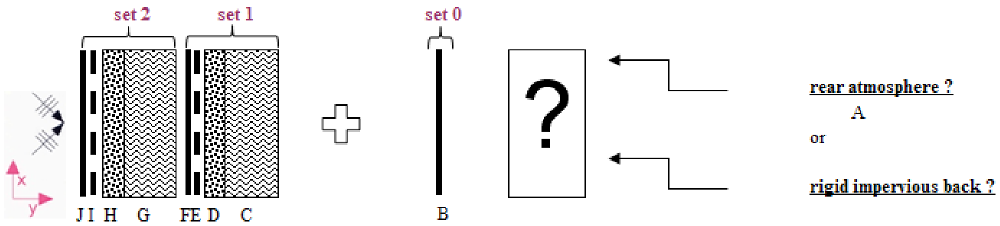
  - ✓ **construction of enclosures for various noisy equipments such as fans, aero condensers, engines, gas turbines**…
  - ✓ **construction of test benches**…
  - ✓ **noise reduction of stacks, exhaust of gas turbines**…

Computation scheme (bloc diagram)



Main/special features, main effects taken into account

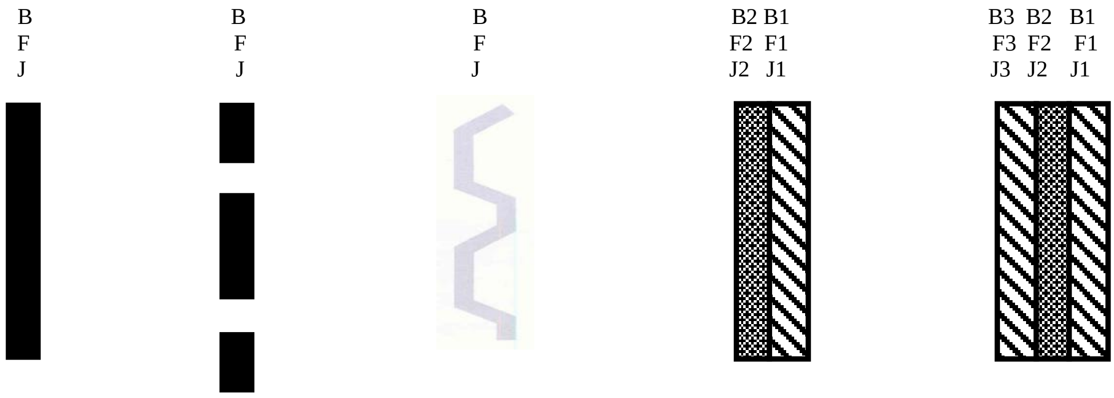
- **design possible for multilayered acoustic structures** (including: laminated absorbing materials)



item	layer (*)
C, G	porous medium (**)
D, H	series cloth (**)
E, I	series perforated protection (**)
B, F, J	plate (***)

* selected among a library including for each kind of layer more than 20 referenced materials
**some cloths and some perforated protections can also be considered as porous layers for the computation
***indeed: 1 or several identical plate(s) treated as a whole

B (resp. F, J) monolithic or B=B2+B1or B=B3+B2+B1 (resp. F=F2+F1 or F=F3+F2+F1; J=J2+J1 or J=J3+J2+J1) as shown below (zoom)



basic monolithic plate | when monolithic the plate can be perforated | when monolithic the plate can be profiled | plate with extensional damping | plate with constrained damping

- for an acoustic structure including a **porous medium** (i.e. polyester, rock wool, basalt wool, glass wool, foam …for which the engineering data can be referenced or air): **behavior taken into account up to the microscopic scale** in relation with the properties such as flow resistivity [cf. fig. 12] and other parameters for a locally reacting absorber

- **effect of a laminated lining** (for each layer: different properties such as flow resistivity [cf. fig. 13] or other different parameters): **taken into account**

- **effect of a cloth** (i.e. fabric, unwoven…for which the engineering data can be referenced): **taken into account** [cf. fig. 14]

- for an acoustic structure including a **perforated protection** (i.e. perforated sheet with circular holes and square or hexagonal array, perforated sheet with square holes, infinite slots…for which the engineering data can be referenced): **interaction of the protection with a porous medium at the front/at the rear taken into account** [cf. fig. 15]

- for an acoustic structure including a **thin plate (**i.e. metal sheet, masonry, gypsum board, wood, glass …for basic plates): **perforated plates taken into account**, **extensional damping (**for example: steel sheet + viscoelastic**)** or **constrained damping (**for example steel sheet + viscoelastic + steel sheet) **taken into account**, **orthotropic plates (**for example: corrugated plates, ribbed plates, profiled cladding....**) taken into account**

- **effect of temperature/of pressure taken into account** [cf. fig. 16] [cf. fig. 17]

- **effect of back** (rear atmosphere or impervious rigid back) **taken into account** [cf. fig. 18]

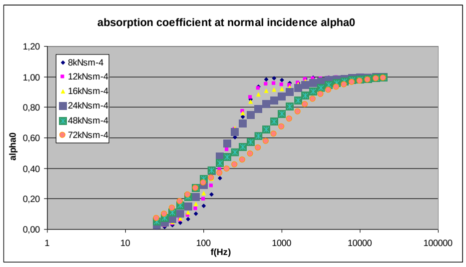


Fig. 12

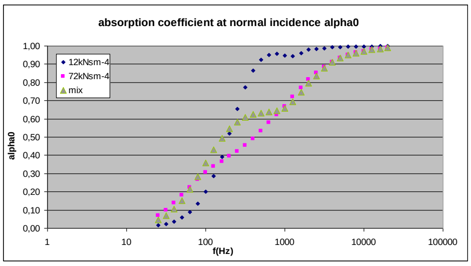


Fig. 13

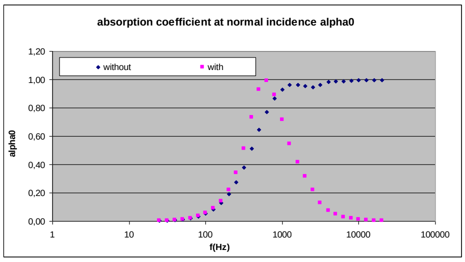


Fig. 14

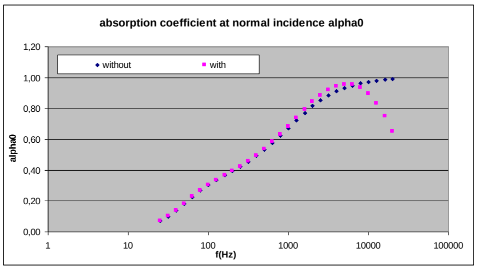


Fig. 15

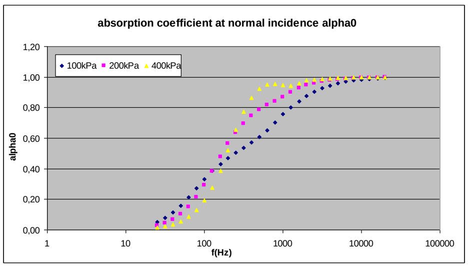


Fig. 16

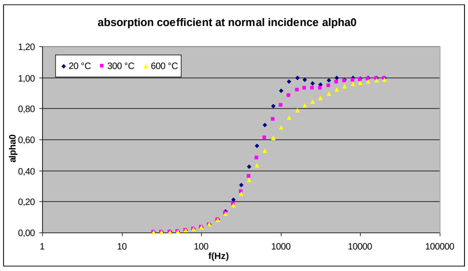


Fig. 17

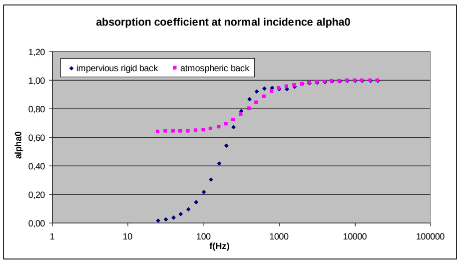


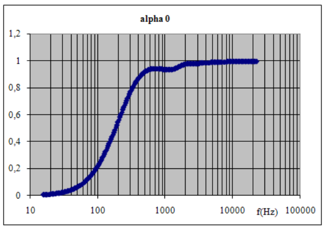
Fig. 18

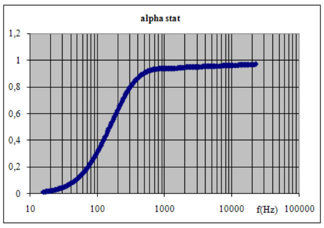
Main displayed results for plates (only):

- **engineering constants of thin plates equivalent to perforated plates, damped plates, orthotropic plates**
- **radiation ratio,** (lowest & highest in case of orthotropic plates) **critical frequency of thin plates** & **lowest natural frequency of thin plates** (*with the exception of plates with a constrained damping*)

Main displayed results for the whole acoustic structure (tables and graphs):

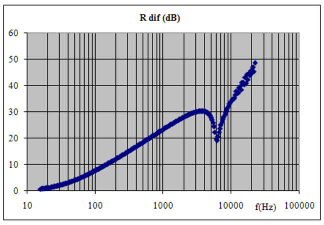
- **absorption coefficient at normal incidence: α0, absorption coefficient for a statistic incidence: αstat, Sabine's factor: αsab per 1/3 and 1/1 octave frequency band, unique index αw** (figure below: for a porous medium with an impervious rigid back)





f (Hz)	alpha stat 1/3 oct	alpha stat 1/1 oct		f (Hz)	alpha stat 1/3 oct	alpha stat 1/1 oct	
25	0,03			800	0,94		
31,5	0,05	0,05	**0,05**	**1k**	0,94	0,94	**0,95**
40	0,07			1,25k	0,94		
50	0,11			1,60k	0,94		
63	0,16	0,17	**0,15**	**2k**	0,95	0,95	**0,95**
80	0,23			2,50k	0,95		
100	0,31			3,15k	0,95		
125	0,41	0,41	**0,40**	**4k**	0,95	0,95	**0,95**
160	0,52			5k	0,96		
200	0,62			6,30k	0,96		
250	0,72	0,72	**0,70**	**8k**	0,96	0,96	**0,95**
315	0,81			10k	0,96		
400	0,87			12,50k	0,96		
500	0,90	0,90	**0,90**	**16k**	0,97	0,97	**0,95**
630	0,93			20k	0,97		
			αp				αp
			αw	0,95	class	A	

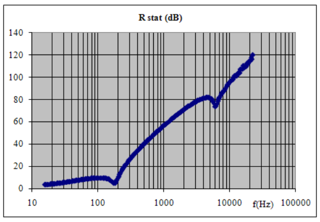
- **sound reduction index with sound leaks: Rstat per 1/3 and 1/1 octave frequency band, unique index Rw and correction terms (for a single leaf, or a double leaf or a triple leaf partition with 0 % coupling)** (figure below: for a single isotropic thin plate with an atmospheric back)



f (Hz)	R dif (dB) 1/3 oct	R dif (dB) 1/1 oct	f (Hz)	R dif (dB) 1/3 oct	R dif (dB) 1/1 oct
25	1,7		800	21,8	
31,5	2,3	2,4	**1k**	23,4	23,2
40	3,1		1,25k	25,0	
50	4,1		1,60k	26,6	
63	5,2	5,2	**2k**	28,0	27,9
80	6,4		2,50k	29,3	
100	7,7		3,15k	30,2	
125	9,1	9,0	**4k**	30,2	29,0
160	10,5		5k	27,2	
200	12,0		6,30k	21,5	
250	13,6	13,4	**8k**	28,6	25,3
315	15,2		10k	33,9	
400	16,8		12,50k	38,0	
500	18,4	18,3	**16k**	41,7	40,8
630	20,1		20k	45,6	
		ref: Lw0	**A**	**22,7**	**ref: Lw0**

Rw (dB)	23	C	-1	C50-5000	-1	C50-3150	-1	C100-5000	-1
		Ctr	-4	Ctr50-5000	-6	Ctr50-3150	-6	Ctr100-5000	-4

- **sound reduction index for a double-leaf partition with connections between thin plates with sound leaks: Rstat per 1/3 and 1/1 octave frequency band, unique index Rw and correction terms**

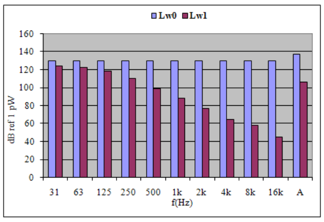


f (Hz)	R stat (dB) 1/3 oct	R stat (dB) 1/1 oct	f (Hz)	R stat (dB) 1/3 oct	R stat (dB) 1/1 oct
25	4,9		800	51,1	
31,5	5,7	5,7	**1k**	56,4	54,5
40	6,6		1,25k	61,4	
50	7,5		1,60k	66,2	
63	8,5	8,4	**2k**	70,7	69,3
80	9,3		2,50k	74,9	
100	9,7		3,15k	78,5	
125	9,4	8,5	**4k**	81,1	79,9
160	6,9		5k	80,5	
200	8,2		6,30k	76,5	
250	19,0	12,6	**8k**	86,7	80,9
315	27,0		10k	95,4	
400	33,7		12,50k	101,9	
500	39,9	37,3	**16k**	108,4	105,6
630	45,6		20k	114,6	
		ref: Lw0	**A**	**27,2**	**ref: Lw0**

Rw (dB)	30	C	-5	C50-5000	-4	C50-3150	-5	C100-5000	-4
		Ctr	-10	Ctr50-5000	-11	Ctr50-3150	-11	Ctr100-5000	-10

- **the results of the calculations are comparable with the standardized measurement:** (in case of atmospheric back) **see NF EN ISO 10140-2 Acoustics. Laboratory measurement of sound insulation of building elements. Measurement of airborne sound insulation** and (in case of rigid impervious back) **see NF EN ISO 354 Acoustics – Measurement of sound absorption in a reverberation room** and also **ISO 10534-1 Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 1: Method using standing wave ratio.**

- **acoustic power with the partition Lw1** (**comparable with the acoustic power without partition Lw0) per 1/1 octave frequency band**



f (Hz)	dB ref. 1 pW 1/1 oct	
31	130,0	124,0
63	130,0	122,8
125	130,0	118,5
250	130,0	109,8
500	130,0	99,1
1k	130,0	88,3
2k	130,0	77,0
4k	130,0	64,7
8k	130,0	58,2
16k	130,0	45,4
A	137,1	106,0
	Lw0	Lw1

… etc

MODULE 3 — Prediction of acoustic performance of duct walls

Scope of computation

- design of duct walls for which the cross section is either rectangular or circular (for example: including folded spiral seam tubes)

Applications

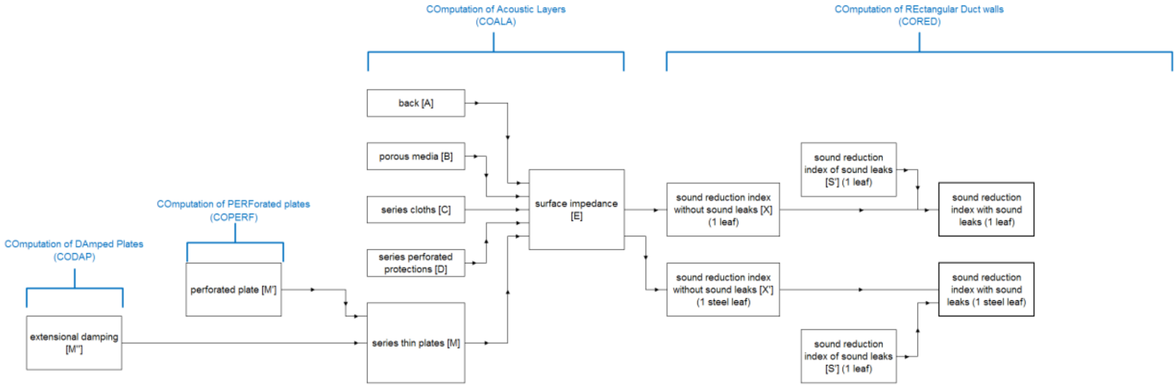
- **creation of a sound reduction by the means of the construction of a (soundproofing) duct wall/silencer wall:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

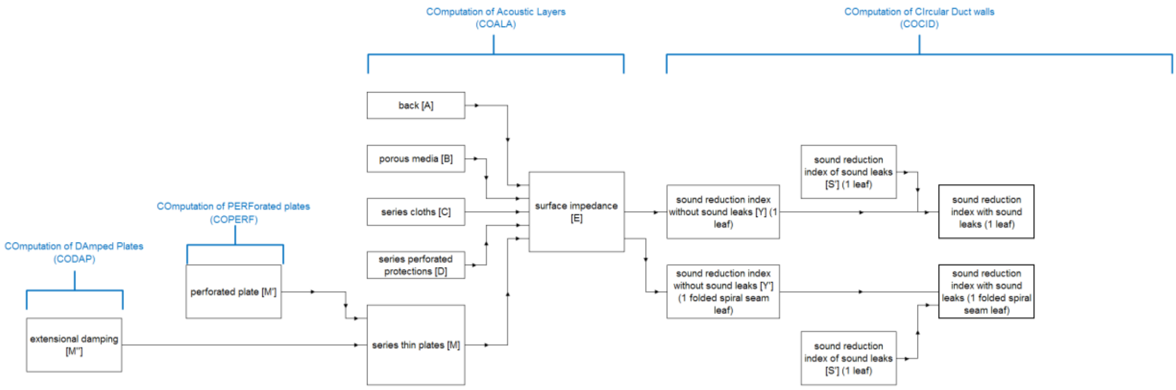
  - ✓ **construction of ventilation inlet/outlet for enclosures for various noisy equipments such as fans, aero condensers, engines, gas turbines**…
  - ✓ **construction of ventilation inlet/outlet of test benches**…
  - ✓ **construction of stacks, exhaust silencers of gas turbines**…

Computation scheme (bloc diagram)

- **rectangular duct**



- **circular duct**



Main/special features, main effects taken into account

- **design possible for 1 leaf acoustic structures** (for the present revision of the software), with a rectangular or circular cross section **(including folded spiral-seam ducts)**

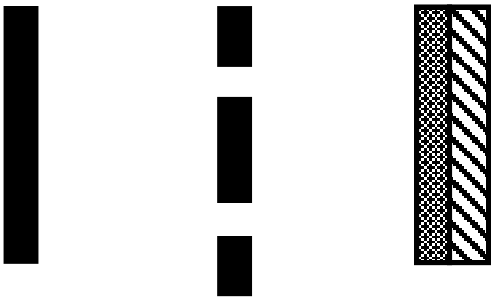
item	layer (*)
B	plate (***)

* selected among a library including for each kind of layer more than 20 referenced materials

***indeed: 1 or several identical plate(s) treated as a whole

B monolithic or B=B2+B1as shown below (zoom

B B B2 B1



basic monolithic plate

when monolithic the plate can be perforated

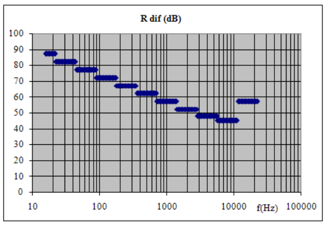
plate with extensional damping

- for an acoustic structure including a **thin plate (**i.e. metal sheet, masonry, gypsum board, wood, glass …for basic plates): **perforated plates taken into account**, **extensional damping (**for example: steel sheet + viscoelastic**)** or **constrained damping (**for example steel sheet + viscoelastic + steel sheet) **taken into account**, **orthotropic plates (**for example: corrugated plates, ribbed plates, profiled cladding....**) taken into account**

- **effect of temperature/of pressure taken into account**

Main displayed results for the whole acoustic structure (tables and graphs):

- **sound reduction index with sound leaks: Rstat per 1/1 octave frequency band, unique index Rw and correction terms (for a single leaf)** (figure below: for a steel pipe with an atmospheric back)



f (Hz)	R dif (dB) 1/3 oct	R dif (dB) 1/1 oct	f (Hz)	R dif (dB) 1/3 oct	R dif (dB) 1/1 oct
25	82,1		800	57,2	
31,5	82,1	82,1	**1k**	57,2	57,2
40	82,1		1,25k	57,2	
50	77,0		1,60k	52,4	
63	77,0	77,0	**2k**	52,4	52,4
80	77,0		2,50k	52,4	
100	72,1		3,15k	48,0	
125	72,1	72,1	**4k**	48,0	48,0
160	72,1		5k	48,0	
200	67,2		6,30k	45,2	
250	67,2	67,2	**8k**	45,2	45,2
315	67,2		10k	45,2	
400	62,2		12,50k	57,3	
500	62,2	62,2	**16k**	57,3	57,3
630	62,2		20k	57,3	
		ref: Lw0	**A**	**49,9**	**ref: Lw0**

… etc

- **the obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures**

MODULE 4 Prediction of acoustic performance performance of straight ducts

Scope of computation

- design of components of a duct system with a constant cross section being either rectangular or circular

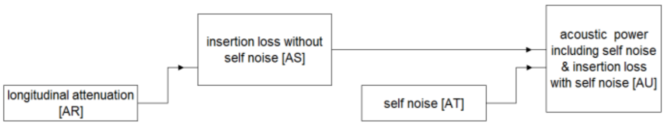
Applications

- **consideration of the sound reduction of the components of duct systems on the occasion of the evaluation of the sound levels at the extremity (mouth) of duct systems:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

  ✓ **construction of air conditioning systems as well as ventilation systems for enclosures for various noisy equipments necessitating duct systems with horizontal or vertical duct sections (stacks) such as fans, engines, gas turbines**…
  ✓ **construction of ventilation systems for auxiliary premises or buildings, test benches**…

Computation scheme (bloc diagram)



Main/special features, main effects taken into account

- **design possible** with a rectangular or circular cross section (including folded spiral seam tubes)
- **design possible for thin ducts (e.g. for conditioning systems applications) as well as for thick ducts (e.g. for stacks)**

Main displayed results (tables):

- **insertion loss without self noise of straight duct section Di' per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**
- **self noise of straight duct section Lw per 1/1 octave frequency band (as well as A-weighted overall value)**
- **sound power level downstream of considered straight duct section Lw1 per 1/1 octave frequency band (as well as A-weighted overall value)**
- **insertion loss with self noise of straight duct section Di per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**

  (figure below: for a rectangular duct)

Di' — insertion loss without self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Di' (dB)	2,4	2,4	2,4	1,2	0,6	0,6	0,6	0,6	0,6	0,6	2,7

Lw — self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw (dB ref. 1pW)	8,2	6,0	2,5	-2,3	-8,2	-15,0	-22,2	-29,8	-37,4	-45,2	-6,0
Lw (dBA ref. 1pW)	-31,2	-20,2	-13,6	-10,9	-11,4	-15,0	-21,0	-28,8	-38,5	-51,8	

Lw1 — sound power level downstream of considered duct

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw1 (dB ref. 1pW)	8,2	62,3	48,7	37,4	30,9	25,5	19,8	22,3	24,3	-45,2	39,1
Lw1 (dBA ref. 1pW)	-31,2	36,1	32,6	28,8	27,7	25,5	21,0	23,3	23,2	-51,8	

Di — insertion loss with self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Di (dB)	-208,2	2,4	2,4	1,2	0,6	0,6	0,6	0,6	0,6	-154,8	2,7

- **the obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures**

MODULE 5

Prediction of break-out noise

Scope of computation

- design of components of a duct system with a cross section being either rectangular or circular

Applications

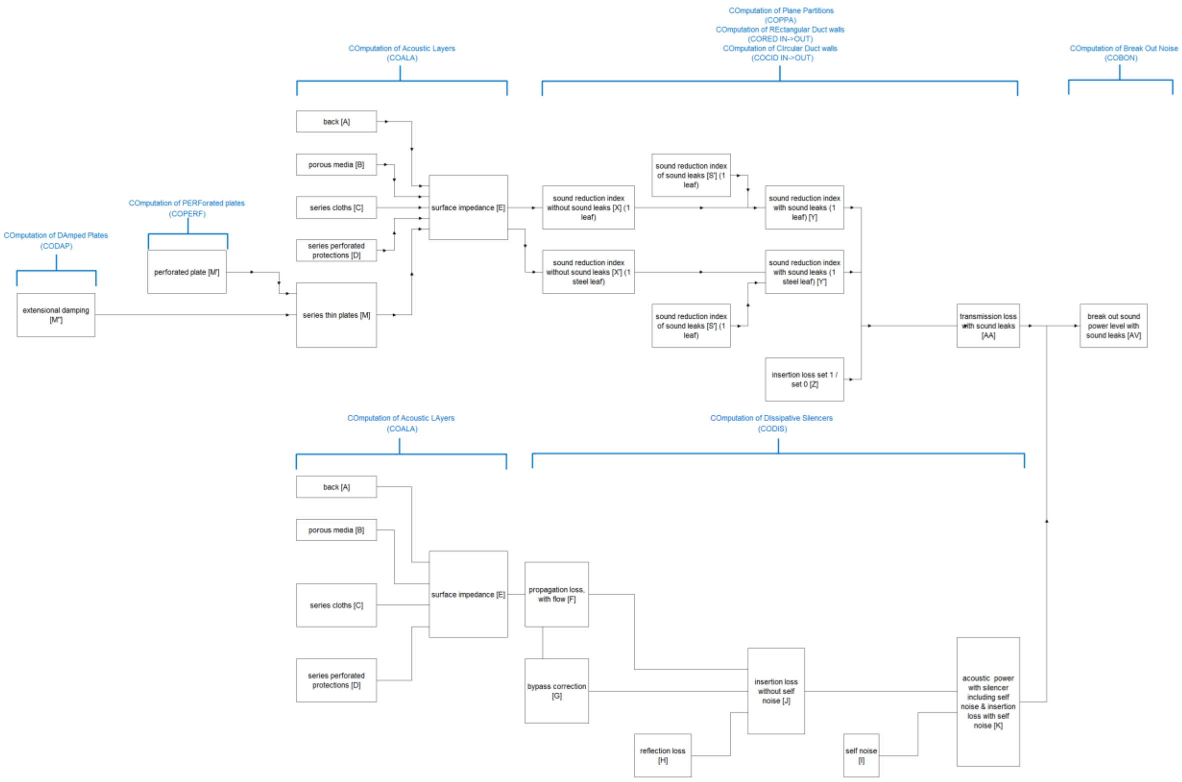
- **consideration of the sound emission of the components of duct systems on the occasion of the evaluation of the sound levels due to noise transmission trough the duct walls:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

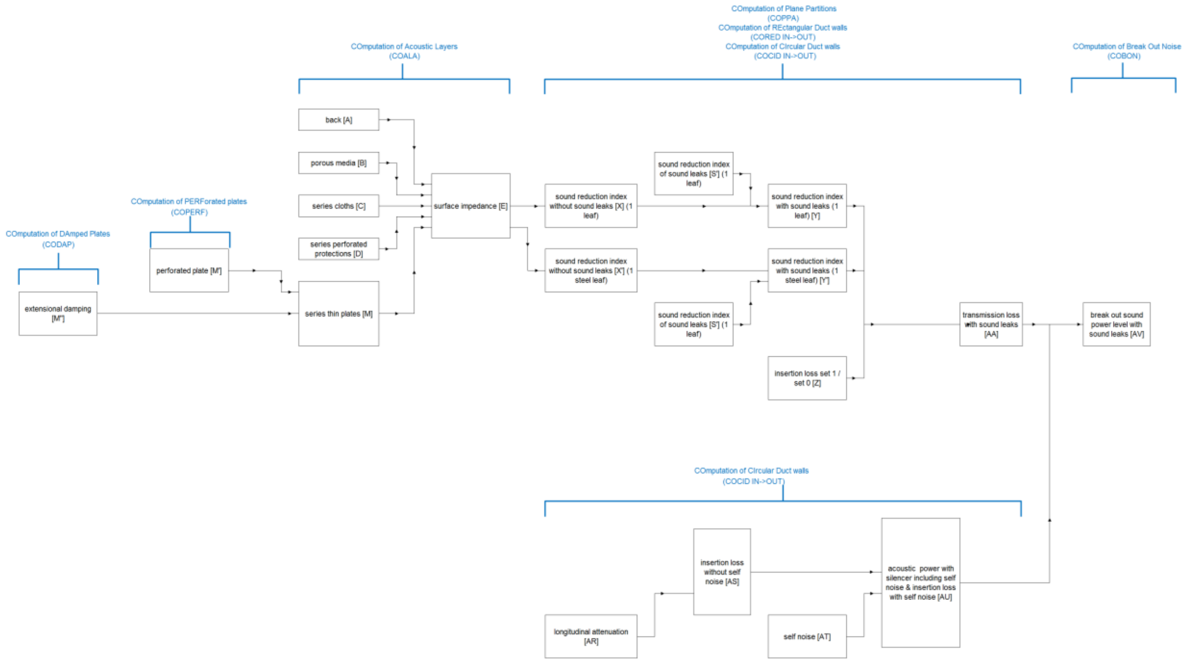
  ✓ **construction of air conditioning systems as well as ventilation systems for enclosures for various noisy equipments necessitating duct systems with horizontal or vertical duct sections (stacks) such as fans, engines, gas turbines**…
  ✓ **construction of ventilation systems for auxiliary premises or buildings, test benches**…

Computation scheme (bloc diagram)

- **Bloc diagram in case of a silencer**



- **Bloc diagram in case of an empty duct**



ITS acoustique Main/special features, main effects taken into account

- **design possible either for straight ducts (with a rectangular cross section, or with a circular cross section - including folded spiral seam ducts) or for silencers**
- **design possible for thin duct casings (e.g. for conditioning systems applications) as well as for thick ducts casings (e.g. for stacks)**

ITS acoustique Main displayed results (tables):

- **sound power level transmitted by the walls of duct / of silencer Lwout per 1/1 octave frequency band (as well as A-weighted overall value)**

  (figure below: for a rectangular duct)

Lw out	sound power level transmitted by the walls of duct / of silencer										
f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw out (dB ref. 1 pW)	12,7	55,3	37,7	19,2	4,3	-10,3	-24,8	-34,2	-32,0	-79,4	29,9
Lw out (dBA ref. 1 pW)	-26,7	29,1	21,6	10,6	1,1	-10,3	-23,6	-33,2	-33,1	-86,0	

- **the obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures**

MODULE 5A — Prediction of break-out noise of ducts with variable cross section

ITS Scope of computation

- design of components of a duct system with a cross section being rectangular (with a width being constant, with a height at duct section inlet being different from height at duct section outlet)

ITS Applications

- **consideration of the sound emission of the components of duct systems on the occasion of the evaluation of the sound levels due to noise transmission trough the duct walls:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

  - ✓ **construction of air conditioning systems as well as ventilation systems for enclosures for various noisy equipments necessitating duct systems with horizontal or vertical duct sections (stacks) such as fans, engines, gas turbines**…
  - ✓ **construction of ventilation systems for auxiliary premises or buildings, test benches**…

ITS Computation scheme (bloc diagram)

- **Bloc diagram in case of an empty duct: as in section 5 (downstream step to be considered only)**

ITS Main/special features, main effects taken into account

- **design possible for ducts with a rectangular cross section**
- **design possible for thin duct casings (e.g. for conditioning systems applications) as well as for thick ducts casings (e.g. for stacks)**

ITS Main displayed results (tables):

- **sound power level transmitted by the walls of duct / of silencer Lwout per 1/1 octave frequency band (as well as A-weighted overall value)**

  (figure below: for a rectangular duct)

Lw out — sound power level transmitted by the walls of duct / of silencer

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw out (dB ref. 1 pW)	12,7	55,3	37,7	19,2	4,3	-10,3	-24,8	-34,2	-32,0	-79,4	29,9
Lw out (dBA ref. 1 pW)	-26,7	29,1	21,6	10,6	1,1	-10,3	-23,6	-33,2	-33,1	-86,0	

- **the obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures**

MODULE 6

Prediction of acoustic performance of bends and junctions

Scope of computation

design of components of a duct system**: with a rectangular cross section, or with a circular cross section, or with mixed cross sections**

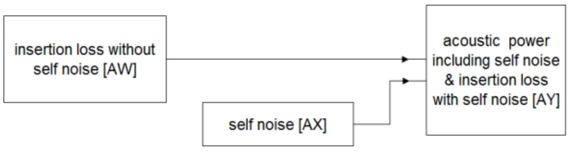
Applications

- **consideration of the sound reduction of the components of duct systems on the occasion of the evaluation of the sound levels at the extremity (mouth) of duct systems:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

  - ✓ **construction of air conditioning systems as well as ventilation systems for enclosures for various noisy equipments necessitating duct systems with horizontal or vertical duct sections (stacks) such as fans, engines, gas turbines**…
  - ✓ **construction of ventilation systems for auxiliary premises or buildings, test benches**…

Computation scheme (bloc diagram)



Main/special features, main effects taken into account

- **design possible** with a rectangular or circular cross section **or with mixed cross sections**

Main displayed results (tables):

Or junction

- **insertion loss without self noise of bend Di' per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**
- **self noise of bend or junction Lw per 1/1 octave frequency band (as well as A-weighted overall value)**
- **sound power level downstream of considered bend or junction Lw1 per 1/1 octave frequency band (as well as A-weighted overall value)**
- **insertion loss with self noise of bend or junction Di per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**

  (figure below: for a bend with a rectangular cross section)

Di' — insertion loss without self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Di' (dB)	0,0	1,0	2,0	3,0	3,0	3,0	3,0	3,0	3,0	0,0	2,3

Lw — self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw (dB ref. 1pW)	-76,4	-84,1	-92,2	-100,4	-108,9	-117,7	-126,8	-136,0	-145,5	-155,2	-103,2
Lw (dBA ref. 1pW)	-115,8	-110,3	-108,3	-109,0	-112,1	-117,7	-125,6	-135,0	-146,6	-161,8	

Lw1 — sound power level downstream of considered bend

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw1 (dB ref. 1pW)	-76,4	63,7	49,1	35,6	28,5	23,1	17,4	19,9	21,9	-155,2	39,5
Lw1 (dBA ref. 1pW)	-115,8	37,5	33,0	27,0	25,3	23,1	18,6	20,9	20,8	-161,8	

Di — insertion loss with self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Di (dB)	-123,6	1,0	2,0	3,0	3,0	3,0	3,0	3,0	3,0	-44,8	2,3

- **the obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures**

MODULE 7

Prediction of nozzle reflexion

Scope of computation

design of components of a duct system**: with a rectangular cross section, or with a circular cross section**

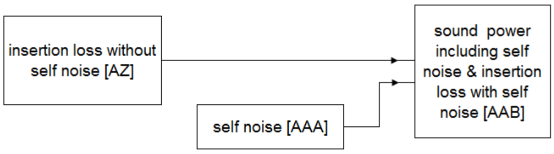
Applications

- **consideration of the sound reduction of the components of duct systems on the occasion of the evaluation of the sound levels at the extremity (mouth) of duct systems:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

  - ✓ **construction of air conditioning systems as well as ventilation systems for enclosures for various noisy equipments necessitating duct systems with horizontal or vertical duct sections (stacks) such as fans, engines, gas turbines**…
  - ✓ **construction of ventilation systems for auxiliary premises or buildings, test benches**…

Computation scheme (bloc diagram)



Main/special features, main effects taken into account

- **design possible** with a rectangular or circular cross section

Main displayed results (tables):

- **insertion loss without self noise Di' per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**
- **self noise Lw per 1/1 octave frequency band (as well as A-weighted overall value)**
- **sound power level downstream Lw1 per 1/1 octave frequency band (as well as A-weighted overall value)**
- **insertion loss with self noise of bend Di per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**

  (figure below: for a mouth with a circular cross section)

Di' — insertion loss without self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Di' (dB)	15,0	15,0	10,2	5,3	2,1	0,7	0,2	0,1	0,1	0,1	0,4

Lw — self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw (dB ref. 1pW)	-400,0	-400,0	-400,0	-400,0	-400,0	-400,0	-400,0	-400,0	-400,0	-400,0	-392,8
Lw (dBA ref. 1pW)	-439,4	-426,2	-416,1	-408,6	-403,2	-400,0	-398,8	-399,0	-401,1	-406,6	

Lw1 — sound power level downstream of considered duct

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Lw1 (dB ref. 1pW)	115,0	115,0	119,8	124,7	127,9	129,3	129,8	129,9	129,9	129,9	136,7
Lw1 (dBA ref. 1pW)	75,6	88,8	103,7	116,1	124,7	129,3	131,0	130,9	128,8	123,3	

Di — insertion loss with self noise

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	16000	A
Di (dB)	15,0	15,0	10,2	5,3	2,1	0,7	0,2	0,1	0,1	0,1	0,4

- **the obtained results are not comparable with standardized measurement due to the lack of documents formalizing corresponding measurement procedures**

MODULE 8

Prediction of the sound impact of duct systems

Scope of computation

prediction of the sound impact of duct systems including components such as silencers (dissipative or resonant), straight ducts sections, bends with a rectangular cross section, or with a circular cross section, or with mixed cross sections (for some components).

Applications

- **consideration of the sound reduction of the components of duct systems on the occasion of the evaluation of the sound levels at the extremity (mouth) of duct systems as well as sound levels due to noise transmission trough duct walls:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

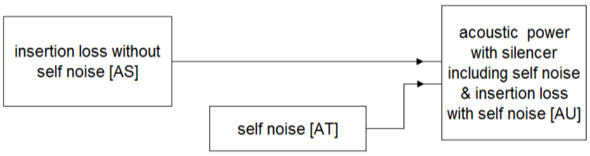
  ✓ **construction of air conditioning systems as well as ventilation systems for enclosures for various noisy equipments necessitating duct systems with horizontal or vertical duct sections (stacks) such as fans, engines, gas turbines**…

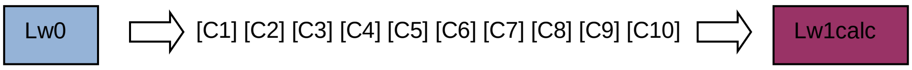
  ✓ **construction of ventilation systems for auxiliary premises or buildings, test benches**…

Computation scheme (bloc diagram)

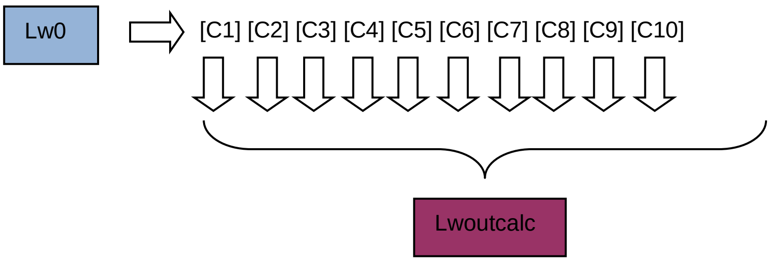
- **Bloc diagram regarding the longitudinal noise propagation i.e. for the computation of the sound power level downstream of the duct system:**

  Note: this bloc diagram is used within a waterfall computation for all the components of the system, referred to as C1 to C10)





- **Bloc diagram regarding the transverse noise propagation i.e. for the computation of the sound power level transmitted by the walls of the duct system:**



Main/special features, main effects taken into account

- **design possible for silencers (dissipative or resonant), straight ducts sections, bends with a rectangular cross section, or with a circular cross section, or with mixed cross sections (for some components)**
- **design possible for thin duct casings (e.g. for conditioning systems applications) as well as for thick ducts casings (e.g. for stacks)**
- **design possible in case of acoustic performance computed with software SILDIS or not (*Bring-Your-Own* approach) or mixed approach**

Main displayed results (tables):

- **Main displayed results regarding the longitudinal noise propagation i.e. for the computation of the sound power level downstream of the duct system:**

  - **sound power level downstream of each considered component of the duct system Lw1 per 1/1 octave frequency band (as well as A-weighted overall value)**
  - **insertion loss with self noise of each considered component of the duct system Di per 1/1 octave frequency band (as well as A-weighted overall value with respect to a reference spectrum)**
  - **sound power level of the silenced source Lw1calc per 1/1 octave frequency band (as well as A-weighted overall value)**
  - **sound pressure level at a specified distance of the silenced source Lp1calc per 1/1 octave frequency band (as well as A-weighted overall value)**

  (table below: for a silencer + a bend + a duct with a circular cross section)

Lw1 **Sound power level downstream of components**

	Component	Matrix / f(Hz)	31	63	125	250	500	1000	2000	4000	8000	A	C
C1	cylindrical attenuator without core	BYO17	-197,0	62,7	47,1	30,6	15,5	-4,9	-1,6	10,9	13,9	37,7	62
C2	bend	BYO18	-195,2	62,7	47,1	30,8	16,6	6,7	1,2	8,0	10,9	37,7	62
C3	duct	BYO19	-194,0	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C4	0	ZER10	-193,0	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C5	0	ZER10	-192,2	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C6	0	ZER10	-191,5	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C7	0	ZER10	-190,9	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C8	0	ZER10	-190,4	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C9	0	ZER10	-189,9	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9
C10	0	ZER10	-189,5	62,6	47,0	30,6	16,4	6,4	0,9	7,7	10,6	37,6	61,9

Di **Insertion loss of components with flow noise**

	Component	Matrix / f(Hz)	31	63	125	250	500	1000	2000	4000	8000	A	C
C1	cylindrical attenuator without core	BYO17	-3,0	2,0	4,0	8,0	16,0	31,0	22,0	12,0	11,0	3,4	2,1
C2	bend	BYO18	-1,8	0,0	0,0	-0,2	-1,1	-11,6	-2,8	2,9	3,0	0,0	0,0
C3	duct	BYO19	-1,2	0,1	0,1	0,2	0,2	0,3	0,3	0,3	0,3	0,1	0,1
C4	0	ZER10	-1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C5	0	ZER10	-0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C6	0	ZER10	-0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C7	0	ZER10	-0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C8	0	ZER10	-0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C9	0	ZER10	-0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C10	0	ZER10	-0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Lw1calc **Sound power level of the silenced noise source**

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	A	C
Lw1calc (dB ref. 1pW)	**-189,5**	**62,6**	**47,0**	**30,6**	**16,4**	**6,4**	**0,9**	**7,7**	**10,6**	**37,6**	**61,9**
Lw1calc + A weighting (dB ref. 1pW)	*-228,9*	*36,4*	*30,9*	*22,0*	*13,2*	*6,4*	*2,1*	*8,7*	*9,5*		

Lp1calc **Sound pressure level of the silenced noise source** Lp1calc-Lw1calc-DI (dB) -15,5

f (Hz)	31	63	125	250	500	1000	2000	4000	8000	A	C
Lp1calc (dB ref. 20µPa)	**-205,0**	**47,1**	**31,5**	**15,1**	**0,9**	**-9,1**	**-14,6**	**-7,8**	**-4,9**	**22,1**	**46,4**
Lp1calc + A weighing (dB ref. 20µPa)	*-244,4*	*20,9*	*15,4*	*6,5*	*-2,3*	*-9,1*	*-13,4*	*-6,8*	*-6,0*		

- **Main displayed results regarding the transverse noise propagation i.e. for the computation of the sound power level transmitted by the walls of the duct system:**

  - **sound pressure level at a specified distance of each component Lpoutcalc per 1/1 octave frequency band (as well as A-weighted overall value)**

  (figure below: for a silencer + a bend + a duct with a circular cross section)

Lpoutcalc **Sound pressure level of the silenced noise source (un-weighted)**

	Component	31	63	125	250	500	1000	2000	4000	8000	A	C
C1	cylindrical attenuator without core	**92,0**	**89,0**	**86,0**	**83,0**	**80,0**	**77,0**	**74,0**	**71,0**	**68,0**	**82,8**	**95,0**
C2	bend	**91,0**	**88,0**	**85,0**	**82,0**	**79,0**	**76,0**	**73,0**	**70,0**	**67,0**	**81,8**	**94,0**
C3	duct	**90,0**	**87,0**	**84,0**	**81,0**	**78,0**	**75,0**	**72,0**	**69,0**	**66,0**	**80,8**	**93,0**
C4	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**
C5	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**
C6	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**
C7	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**
C8	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**
C9	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**
C10	0	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-199,0**	**-192,0**	**-189,5**

MODULE 8A — Prediction of stacks directivity

Scope of computation

prediction of the sound impact of piping & duct systems ends

Applications

- **evaluation of the noise emissions at the extremity (mouth) of piping & duct systems:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

  ✓ stacks for fans, engines, gas turbines…
  ✓ industrial process exhausts…

Computation scheme (bloc diagram)

- Not applicable

Main/special features, main effects taken into account

- **angle with respect to stack axis**
- **stack radius**
- **speed of sound**

Main displayed results (tables):

- **directivity index (1/3 & 1/1 octave bands)**

(screenshot below: for a an exhaust duct with small diameter)

prediction of the directivity of a stack

angle model selection		45°											
stack radius	a (m)	0,1											
speed of sound	c (m/s)	340											
Directivity index accoring to angle model selection		DI (dB)		0,3	0,3	0,3	0,7	1,5	2,2	2,7	2,9	3,1	2,7

MODULE 8B

Prediction of atmospheric sound absorption

Scope of computation

prediction of the attenuation of sound in relation to propagation path through atmosphere

Applications

- **evaluation of the noise impact of sound sources outdoor:** protection of workers, protection of environment, energy sector in particular
- **room acoustics:** protection of workers, measurement rooms, acoustic comfort in buildings

Computation scheme (bloc diagram)

- Not applicable

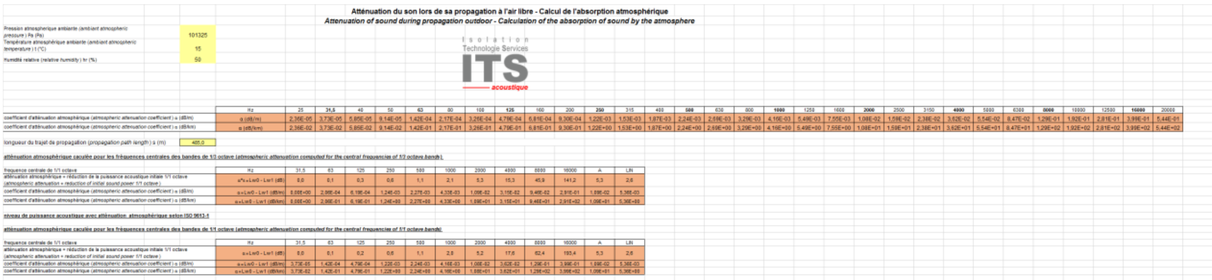
Main/special features, main effects taken into account

- **ambient atmospheric pressure**
- **ambient atmospheric temperature**
- **relative humidity**
- **propagation path length**

Main displayed results (tables):

- **atmospheric attenuation coefficient (1/3 & 1/1 octave bands)**
- **atmospheric attenuation for a given propagation path (1/3 & 1/1 octave bands)**

(screenshot below: example)

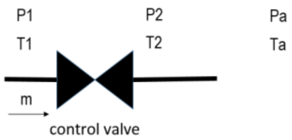


MODULE 8C

Prediction of control valves aerodynamic noise

Scope of computation

prediction of the external sound pressure level generated in a control valve and within adjacent pipe expanders by the flow of compressible fluids, considering only single-phase dry gases and vapours and based on the perfect gas laws



Applications

- **evaluation of the noise impact of industrial processes exhausts outdoor:** protection of workers, protection of environment, energy sector in particular

Computation scheme (bloc diagram)

- Not applicable

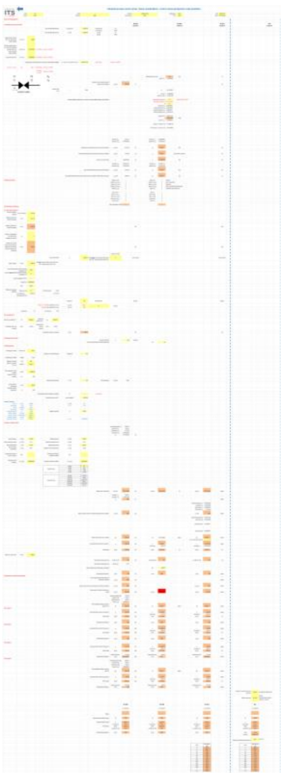
Main/special features, main effects taken into account

- **control valves parameters**
- **process parameters**

Main displayed results (tables):

- **sound power level (OA)**
- **generated peak frequency**
- **sound power level (1/3 & 1/1 octave bands)**
- **Mach number at valve outlet**

(table below: example)



MODULE 8D

Prediction of jet noise (including safety valves noise)

Scope of computation

prediction of the external sound levels generated by a jet i.e. a fluid flow between a high pressure zone & a low pressure zone: either at extremities of a component of a piping system (excluding control valves, including safety valves) or at its end (discharge) for a compressible fluid, considering only single-phase dry gases and vapours and based on the perfect gas laws

Applications

- **evaluation of the noise impact of gas discharges from safety valves or pipes outdoor:** protection of workers, protection of environment, energy sector in particular

Computation scheme (bloc diagram)

- Not applicable

Main/special features, main effects taken into account

- **high pressure zone parameters**
- **low pressure zone parameters**
- **piping component parameters**

Main displayed results (tables):

- **sound power level (OA)**
- **generated peak frequency**
- **sound power level (1/3 & 1/1 octave bands)**

(table below: example)

jet without diffuser (& safety valves)

High pressure conditions			Low pressure conditions		
Pressure	Php (Pa)	1,743E+05	Pressure	Plp (Pa)	1,010E+05
Temperature	Thp (K)	311,00	Temperature	Tlp (K)	311,00
Density	1/vhp (kg/m3)	1,955	Density	rolp (kg/m3)	1,133
Speed of sound	whp m/s	353,0	Speed of sound	clp (m/s)	353,3
Mach number	Mhp	1,000	Mach number	Mlp	0,900
Velocity	Vhp (m/s)	353,0	Velocity	Vlp (m/s)	300,0
Isentropic exponent	γhp	1,4000			

Miscellaneous

Pressure ratio multiplicator	PRM	1,893				Expanded Jet Normalized Velocity	EJNV	0,999
Pressure super ratio	PSR	3,267				Density & Temperature Combined Parameter	DTCP	1,726
Pressure	Php x PRM (Pa)	3,300E+05						
		turbulent	choked	undefined				
Model for acoustic efficiency η		ZER	FRA	ZER	HAN,BER-FIG,BER-EX,EDF,FRA,ZER			
					HAN,BER,FRA,HEL,ZER			
					API,ISO,C&M,VDI,BUR,3733,TUP,NOR,ZER			
Nozzle diameter	d (m)		0,0500					
Downstream pipe diameter	Dp (m)		0,05000					
Downstream pipe wall thickness	t (m)		0,00156					
Consideration of downstream pipe diameter for peak frequency (0/1) ?			0					
		turbulent	choked	undefined				
Model for Strouhal number St		BYO	BYO	BYO	BER-C, FRA, BYO	Strouhal number for peak frequency calculation	St_p	2,00E-01 (for model BYO only)
		turbulent	choked	undefined				
Model for spectrum		BER-T	HAN	HAN	IEC,IEC-3RD,R&W,HAN,FRA,BER-T,BER-C,TUP,3733			
		turbulent	choked	undefined				
Sound power level Lwi (dB ref. 1pW)		-320,4	154,9	-200,0				
	f_p (Hz)	1412	1412	1412				
	f_p oct (Hz)	1,000E+03	1,000E+03	1,000E+03				
	Model for fp	NAT	NAT	NAT	NAT,OCT			
Sound pressure level (ref. 20µPa)	L1 (dB)		143,5					
	L1 (dBA)		143,3					
	L30 (dB)		114,2					
	L30 (dBA)		114,0					

L1 = sound pressure level at 1 m from the point of discharge, based on spherical spreading
L30 = sound pressure level at 30 m from the point of discharge, based on spherical spreading

unsilenced noise

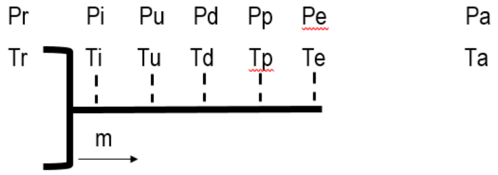
f (Hz)	Lwi(f) (dB ref. 1pW)
16	117,9
31	124,6
63	131,3
125	137,3
250	142,4
500	146,6
1000	149,2
2000	149,1
4000	146,5
8000	141,5
16000	135
A	154,5
LIN	154,7

MODULE 8E

Prediction of piping systems discharge parameters

Scope of computation

prediction of flow indicators for sets of components through which the discharge of a fluid occurs, from a reservoir towards atmosphere via a pipe



Subscripts
r, i, u, d, p, e: location along piping system path
reservoir
inlet
upstream (e.g. from a valve)
downstream (e.g. from a valve)
penultimate (e.g.silencer inlet)
exit (e.g. silence routlet)

Applications

- **evaluation of the noise impact of industrial processes exhausts outdoor:** protection of workers, protection of environment, energy sector in particular e.g. blowdown lines with or without valves

Computation scheme (bloc diagram)

- Not applicable

Main/special features, main effects taken into account

- **fluid thermodynamic parameters**
- **piping system resistance parameters**
- **most comprehensive set of output data available for ideal gas (1 phase), nevertheless minimum set of output data available for all gases (including saturated water steam)**

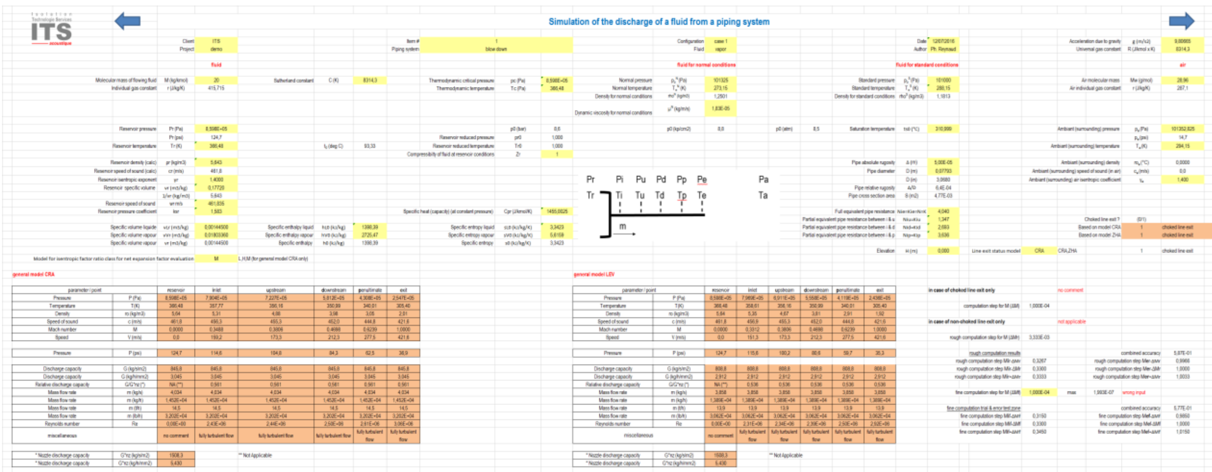
Main displayed results (tables):

- **exit line status (choked or non-choked)**
- **exit pressure**
- **discharge capacity & mass flow rate**

Additional output data relevant in case of ideal gases (at various locations along piping system path):

- **temperature**
- **density**
- **speed of sound**
- **Mach number**
- **(gas) speed**
- **Reynolds number Re (dimensionless)**

(table below: example)



MODULE 8F

Determination of the performance & sizing of safety valves

Scope of computation

- **prediction of discharge capacity of safety valves**

Applications

- **Sizing of safety valves in the context of engineering studies of pressurized fluid networks discharging to atmosphere**

Computation scheme (bloc diagram)

- **Not applicable**

Main/special features, main effects taken into account

- **design possible for steam or undefined fluid**

Main displayed results (tables):

- **discharge capacity**
- **mass flow rate when flow area is known**

(screenshot below: example)

MODULE 8G

Simulation of the discharge of a fluid trough a valve vent stack

ITS Scope of computation

- sizing of valves vent stacks

ITS Applications

- Sizing of safety valves vent stacks in the context of engineering studies of pressurized fluid networks discharging to atmosphere

ITS Computation scheme (bloc diagram)

- Not applicable

ITS Main/special features, main effects taken into account

- design possible for superheated steam or saturated steam

ITS Main displayed results (tables):

- pressure, temperature, density, sound speed, Mach number, gas speed at various locations: valve exit, vent stack inlet, vent stack outlet
(screenshot below: example)

		Choking ? (0/1)		Choking ? (0/1)	
	Based on model LIA	1	Based on model LIA	1	
Parameter / point		valve exit (2)	vent stack inlet (3)	vent stack outlet (4)	
Pressure	P (Pa)	2.124E+05	3.245E+05	1.227E+05	
	P (MPa)	0.21	0.32	0.12	
	P (bar)	2.12	3.25	1.23	
	P (atm)	2.10	3.20	1.21	
	P (kp/cm2)	2.17	3.31	1.25	
	P (psi)	30.80	47.07	17.79	
Temperature	T(K)	610.77	685.88	609.64	(**)
	t(°C)	337.62	412.73	336.49	(**)
	T(F)	639.71	774.92	637.69	(**)
Density	ρ (kg/m3)	0.757	1.030	0.437	(**)
	ρ (lb/cu ft)	0.047	0.064	0.027	(**)
Speed of sound	c (m/s)	604.0	640.1	604.0	(**)
	c (fps)	1981.7	2100.0	1981.7	(**)
Mach number	M	1.0000	0.4005	1.0000	(**)
Gas speed	V (m/s)	604.0	256.4	604.0	(**)
	V (fps)	1981.7	841.1	1981.7	(**)
Specific volume	m3/kg	1.32143	0.97117	2.28822	
	cu ft / lb	2.117E+01	1.556E+01	3.665E+01	
Miscellaneous		choking conditions, flow sonic	non choking conditions, flow subsonic	choking conditions, flow sonic	
Entropy variation		entropy criterion (between locations 2 & 3) satisfied			
Momentum for non choking flow at valve exit		momentum criterion for non choking flow at valve exit (between locations 2 & 3) not satisfied			
Minimum atteignable back pressure in case of choking flow at valve exit	P'b (Pa)	7.687E+04			
	P'b (psi)	1.115E+01			
Additionnal criterion for choking flow at valve exit		additionnal criterion based on minimum atteignable back pressure for choking flow on valve exit satisfied, desired back pressure can be kept			

MODULE 8H

Prediction of acoustic and aerodynamic performance of vent silencers for pressurized fluids

Scope of computation

- sizing of vent silencers diffusers

Applications

- sizing of vent silencers diffusers in the context of engineering studies of pressurized fluid networks discharging to atmosphere

Computation scheme (bloc diagram)

- Not applicable

Main/special features, main effects taken into account

- design possible for superheated steam or saturated steam

Main displayed results (tables):

- pressure, temperature, density, sound speed, Mach number, gas speed at silencer outlet
- silenced sound power level

(screenshot below: example)

general model SPA

Parameter / point		silencer inlet (1)	silencer outlet (2)
Pressure	P (Pa)	1.562E+06	1.014E+05
	P (MPa)	1.56	0.10
	P (bar)	15.62	1.01
	P (atm)	15.41	1.00
	P (kp/cm2)	15.92	1.03
	P (psi)	226.48	14.70
Temperature	T(K)	318.68	327.88
	t (deg C)	45.53	54.73
	TF (F)	113.95	130.51
Density	ρ (kg/m3)	11.79	0.74
	ρ (lb / cu ft)	0.736	0.046
Speed of sound	c (m/s)	415.0	421.0
	c (ft/s)	1361.6	1381.1
Mach number	M	1.0000	0.8859
Speed	V (m/s)	415.0	372.9
	V (ft/s)	1361.6	1223.5

Mass flow rate	m (kg/s)	82.232	82.232
Mass flow rate	m (kg/h)	296033.9	296033.9
Mass flow rate	m (t/h)	296.034	296.034
Mass flow rate	m (lb/h)	652754.7	652754.7

criterion for P0 (P0 ≥ Pc1 ?)	inlet flow sonic	outlet flow subsonic

Parameter / point		hypothetic silencer inlet (1)	hypothetic silencer outlet (2)
Critical pressure	Pc (Pa)	1.857E+05	3.276E+06
	Pc (MPa)	0.19	3.28
	Pc (bar)	1.86	32.76
	Pc (atm)	1.83	32.33
	Pc (kp/cm2)	1.89	33.41
	Pc (psi)	26.94	475.16

Model for calculation of critical flow rate		R	C (critical), R (Reservoir)
Exhaust noise regeneration in dB below the noise level generated in open stack conditions (i.e with no silencer attached)		15.3	negative value means more noise
Unsilenced sound power level (aka open stack noise level)	Lw0 (dB ref. 1pW)	120.0	
Silenced sound power level	Lw1 (dB ref. 1pW)	108.0	
Sound power level diminution	Lw0-Lw1 (dB)	12	
Suggested insertion loss without self noise	TL (dB)	15	
Suggested self noise reduction	deltaSN (dB)	15	
		For sonic exhaust: parameters corresponding to delta SN for sonic	
	d2/d1	5.623	
	d2 (m)	0.822727852	
	d2 (in)	3.239E+01	

MODULE 9

Prediction of sound decay in enclosed spaces

Scope of computation

- room acoustics design study

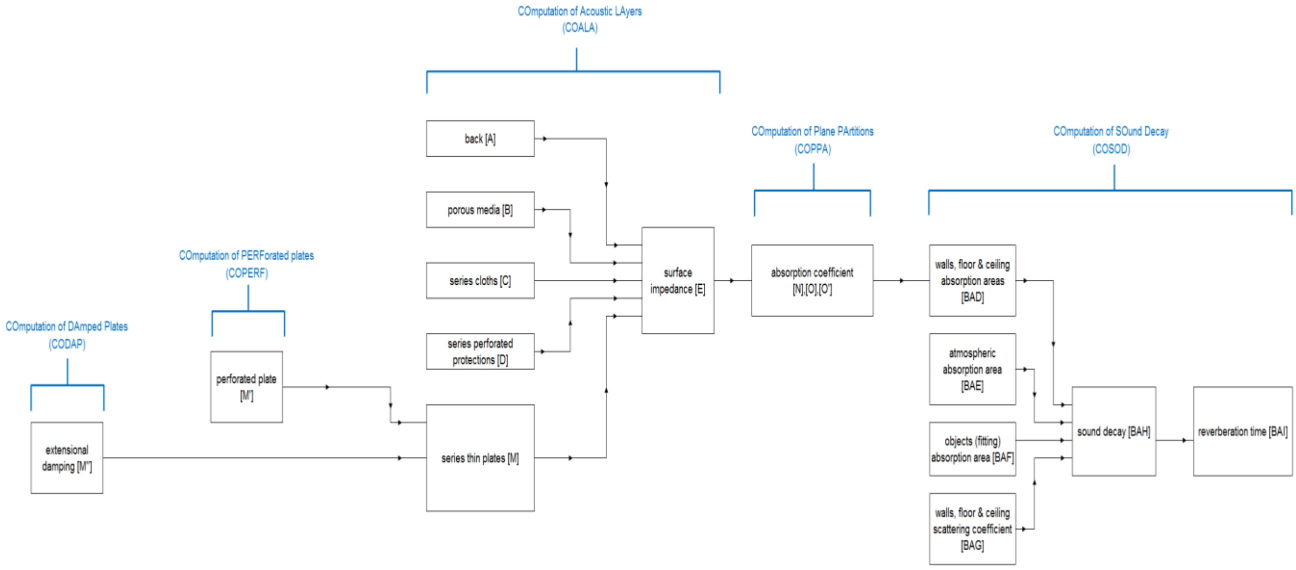
Applications

- **consideration of the impact of reverberation on the acoustical quality of premises:** protection of workers, protection of environment, energy sector, measurement rooms, building

  notably:

  - ✓ soundproofing industrial buildings
  - ✓ large machine enclosures
  - ✓ test benches
  - ✓ premises dedicated to technical equipments
  - ✓ room intended to house activities such as catering, education, sports and recreation

Computation scheme (bloc diagram)



Main/special features, main effects taken into account

- **design possible** with a rectangular shape or with different shapes
- **scattering effects accounted** for premises with a rectangular shape
- **fitting accounted**
- **atmospheric absorption accounted**

Main displayed results (tables):

- **reverberation time per 1/1 octave frequency band**

  (screenshot below: for a rectangular room)

not considering atmospheric attenuation, not considering objects		31	63	125	250	500	1000	2000	4000	8000	500-2000
T60 (s) general model SAB		0,77	0,77	0,77	0,77	0,77	0,77	0,77	0,77	0,77	**0,80**
T60 (s) general model EYR		0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	**0,70**
T60 (s) general model MIL		0,63	0,63	0,63	0,63	0,63	0,63	0,63	0,63	0,63	**0,60**
T60 (s) general model CRE		0,63	0,63	0,63	0,63	0,63	0,63	0,63	0,63	0,63	**0,60**
T60 (s) general model KUT	inhomogeneity accounted as differences between elementary surfaces	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	**0,70**
	inhomogeneity accounted as differences between partitions	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	**0,70**
	inhomogeneity accounted as differences between opposite partitions couples	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	0,65	**0,70**
T60 (s) general model FIT		0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,87	**0,90**
T60 (s) general model NEU		0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	**0,70**
T60 (s) general model ARA		0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72	**0,70**
T60 (s) general model ISO (for standard deviation between Tx,Ty,Tz,Td low)		1,09	1,09	1,09	1,09	0,77	0,76	0,75	0,72	0,62	**0,80**
	standard deviation between Tx,Ty,Tz,Td	34,3%	38,6%	62,0%	69,7%	68,9%	65,4%	61,5%	58,4%	57,3%	**70,0%**
T20 (s) general model ISO (for standard deviation between Tx,Ty,Tz,Td high)		1,09	1,09	1,09	1,09	1,29	1,07	0,89	0,74	0,60	**1,10**
T (s) model ISO (for selected evaluation range)		1,09	1,09	1,09	1,09	2,82	2,28	1,81	1,44	1,14	**2,30**
T60 (s) general model NIJ		0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	**0,90**
T (s) general model SAK for selected evaluation range		0,72	1,02	1,23	1,25	1,08	0,90	0,78	0,72	0,68	**0,90**
T60 (s) general model HOD											**0,00**

- **the obtained results are comparable with standardized measurement NF EN ISO 3382-2 Acoustics - Measurement of room acoustics parameters- Part 2: reverberation time in ordinary rooms.**

MODULE 9A

Prediction of sound spatial decay in open-plan offices

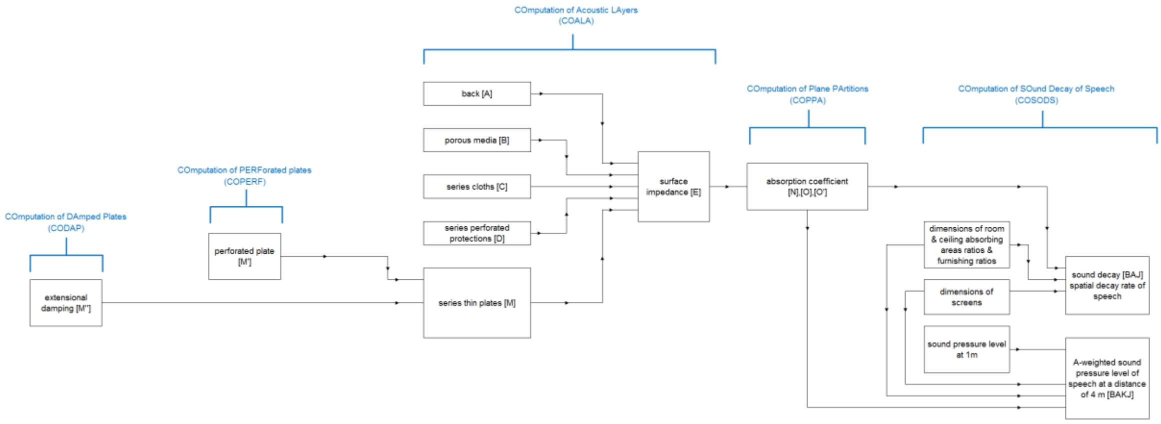
Scope of computation

- working places rooms acoustics design study

Applications

- **evaluation of acoustical comfort of tertiary premises:** protection of workers

Computation scheme (bloc diagram)



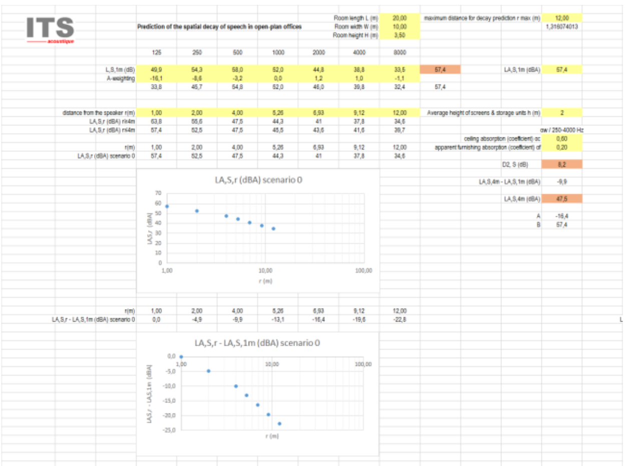
Main/special features, main effects taken into account

- **room dimensions**
- **average height of screens & storage units**
- **ceiling absorption**
- **apparent furnishing absorption**

Main displayed results (tables):

- **spatial decay rate of speech**
- **A-weighted sound pressure level of speech at a distance of 4 m**
- **spatial decay of speech (A-weighted sound pressure level of speech at a variable distance)**

(screenshot below: example)



Some of the obtained results are comparable with standardized measurement NF EN ISO 3382-3 Acoustics - Measurement of room acoustics parameters- Part 3: Open plan offices.

MODULE 10 Prediction of prediction of the noise emissions from buildings and other constructions

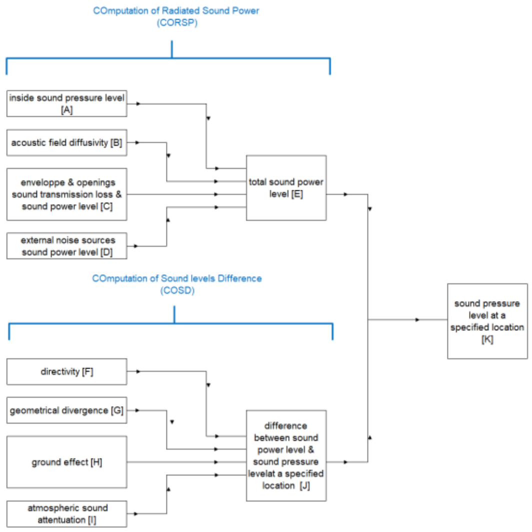
ITS Scope of computation

- buildings and other constructions (e.g. sound enclosures, gas turbine air inlet and outlet ducts) design study

ITS Applications

- **evaluation of noise impact for environment**

ITS Computation scheme (bloc diagram)



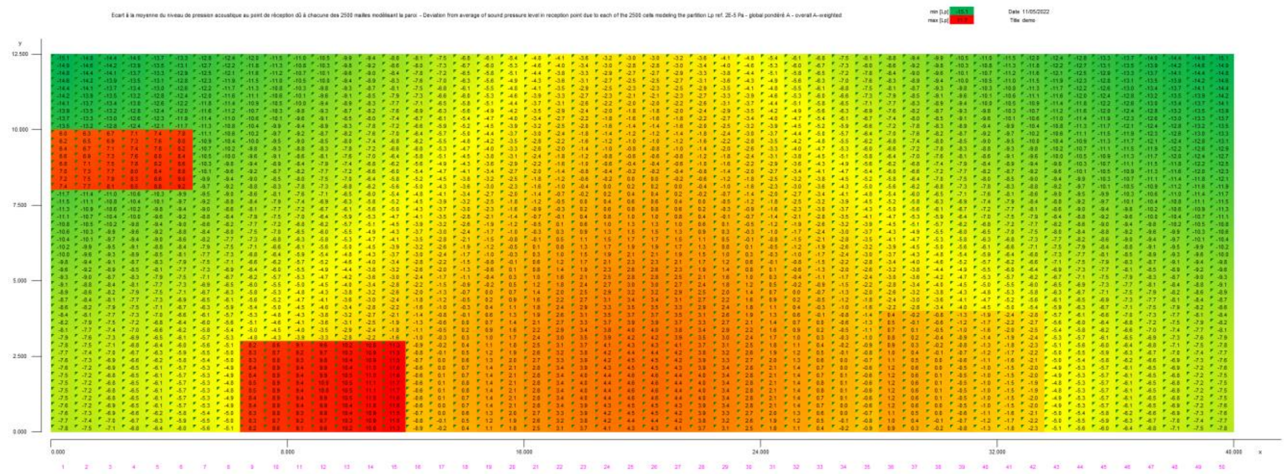
ITS Main/special features, main effects taken into account

- **building or other construction face dimensions and macro-directivity**
- **envelope sound reduction index**
- **(up to 5) openings sound reduction index, sound power level (self noise), directivity index**
- **(up to 2) external sources, sound power level, directivity index**
- **ground effect**
- **atmospheric sound attenuation**

ITS Main displayed results (tables):

- **total sound power level (per 1/1 octave frequency band and overall, A-weighted)**
- **sound pressure level at a specified location (per 1/1 octave frequency band and overall, A-weighted)**
- **noise map of partition (per 1/1 octave frequency band and overall, A-weighted)**

(screenshot below: example for an industrial building wall with a length 40 m and a height 12.5 m)



Some of the obtained results are comparable with standardized calculations: cf. ISO 12354-4 Building acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 4: Transmission of indoor sound to the outside