HAL
open science

Achieving Qualitative and Quantitative Noise Target Settings using a broadband tuned panel/shield

Vincent Manet

To cite this version:

Vincent Manet. Achieving Qualitative and Quantitative Noise Target Settings using a broadband tuned panel/shield. 17th international scientific conference IWKM05, Nov 2005, Mitweida, Germany. pp.30-33. hal-00659224

HAL Id: hal-00659224

https://hal.science/hal-00659224

Submitted on 12 Jan 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

ACHIEVING QUANTITATIVE AND QUALITATIVE NOISE TARGET SETTINGS USING A BROADBAND TUNED PANEL/SHIELD

Vincent Manet
Marmonier S.A.S / 35, rue du dauphiné / 69960 Corbas / France

The noise level of recent vehicles or machines is more and more well mastered, and it is not an insolvable issue for manufacturers to meet requirements imposed by national and international standards. Nevertheless, from the end-user point of view the acoustical signature of two noise sources (vehicle, machine…) having the same global acoustic power can be drastically different from one to another depending on the kind of treatment used.
In this article we propose to discuss two things. Firstly, the experimental/numerical tools leading to the understanding and then to the modelling and simulation (listening of solution, with both quantitative and qualitative goals) of simple or complex acoustical problems is briefly presented. Emphasize will be put on the different aspects which has to be taken into account in order to avoid a certain number of errors. Secondly, a patented solution, the broadband tuned panel, allowing treatment at medium/high frequencies and at the same time at low frequencies is presented. This "broadband" approach permits to achieve simultaneously qualitative targets, as well as quantitative ones.

1 Introduction

During the last decades, noise and vibration control improved to respect the increasing level of needs and regulations.
The number of publications and dedicated test devices in the field of vibro-acoustic demonstrate how dynamic this area is, from a research point of view, as well as from an industrial one.
Tracking down more and more fine phenomena has led to the development of very refined test devices and simulation tools.

Two factors are driving this speeding-up of this field:

- *The regulation:*
  The regulation is always pushing, and the only way to reach the vibro-acoustic targets to be set in the future is to consider the vibro-acoustic field as only one area, *i.e.* not to separate problems according to their frequency range and hence to be able to furnish broadband solutions (from low to high frequencies). From a regulation point of view, solutions have to fulfil quantitative targets.
- *The need:*
  The end-user has got used to more and more comfortable vibro-acoustic levels and now needs for specific ambiance. It becomes essential to be able to design the acoustic signature of considered machinery. From users' needs point of view, solutions have to fulfil qualitative targets.

The purpose of the broadband tuned panel or shield is to furnish a solution designed to achieve both qualitative and quantitative performances.

2 Vibro-acoustic as an unified field

The link between experimental data and numerical models has now reached maturity.
For example, for each test device we have (alpha cabin, small cabin, impedance tube, RTC III device…), a *specific numerical model* has been developed and validated with now thousands of experiments.
It means that, in our methodology for designing acoustical solution, we only use simulation tools to design the material to be used in the solution. Only a final validation is done at the very end, generally at an advanced prototype stage (with final geometry and representative production process).

These models are then considered as sub-models in a more complex *simulation tool* allowing us to simulate a *whole module* (a complete engine box for example) or a *whole vehicle*.
These macro-models are supplied with noise sources records and are able to recreate the sound of the considered module with the simulated solution, allowing for both qualitative and quantitative decisions, and above all allowing hearing performances of the treatment.

This last task (to connect sub-models) is not only a computer addition: it requires adding *links between phenomena* to be fully representative of reality.
For example, an engine vibration which as not been stopped by a damper can propagate along the whole structure, without being very annoying, but make a panel start resonating at the very end of the structure. It is typically the case with large structures like buses or very small one as small cars (without driving license).
The problem of a vibrating element is not always crucial in terms of structural safety and reliability but may be very unpleasant to be heard.
The question is then to know if the damper can be improved, or if other systems have to be added to solve the problem (from a structural and/or a perception point of view).

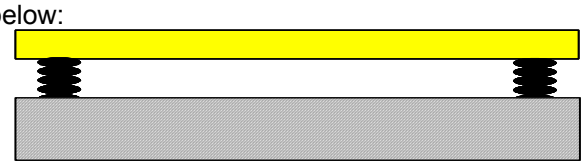
3 Principle of the broadband tuned panel / shield

On one side, classical insulators are made of specific "acoustic material" and only use material properties (or Helmotz resonators) to solve the

acoustical problem. These solutions, by nature, are working very well at high frequencies, and “not to bad” at medium frequencies, but do not exhibit very interesting feature at low frequencies.
On the other hand, low frequencies are generally only reached by structural deformation.

The principle of the broadband tuned panel is to combine low/medium frequencies structural deformation with medium/high frequencies material dissipation.

We consider a plate lying on dampers as depicted below:

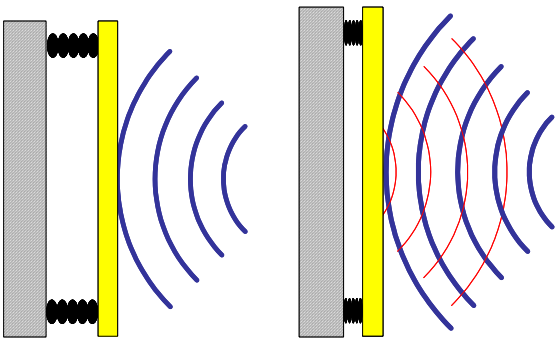


This plate has the following response to an incident acoustical wave:

- Considering the acoustic speed at the plate different from zero, it works as a Kelvin-Voigt oscillator with frequency:

$$\omega = \sqrt{\frac{k}{M}}$$

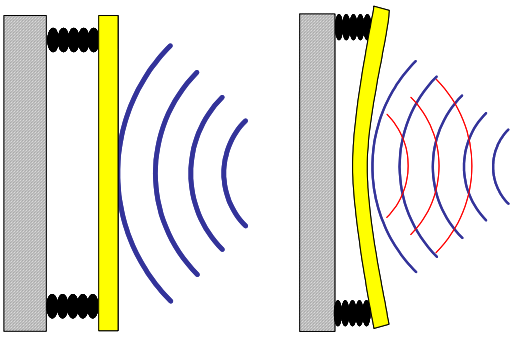
k being the total stiffness, and *M* the mass.



- Considering the boundary conditions (at dampers) as invariable in time, it works as a Helmotz resonator with frequency:

$$\omega = \pi^2 \left[\frac{1}{a^2} + \frac{1}{b^2} \right] \sqrt{\frac{D}{\rho h}}$$

a and *b* being the dimensions of the plate, *D* its flexural stiffness, ρ its density and *h* its thickness.



Hence, target low/medium frequencies can be reached by choosing the appropriate geometry and materials.

If then, an insulator is added to the plate then:

- medium/high frequencies absorption is directly added
- more damping to the structural modes described before is also added

Choosing the geometry and material of the plate in accord with the geometry and the material of the dampers and in accord with the material of the insulator is called “to tune the panel”.

Of course, geometries and materials must be compliant with the chosen production process.

4 First application : acoustical room

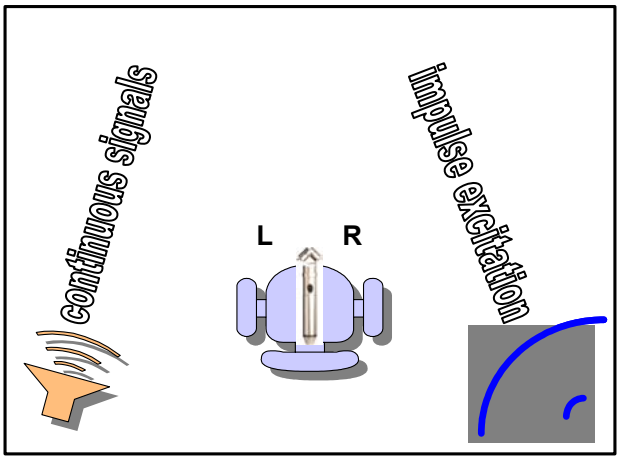
As a first example, we present the treatment of a small room, which is intended to be a room dedicated to high quality sound reproduction.
The aim of the study is not really to increase sound absorption, but to improve the perception.

This room has the following dimensions:

- Length = 2.48 m
- Width = 1,80m
- Height = 1,82m

With these values, the first acoustical modes are the following: 70, 89, 95Hz (axial modes), 113, 118, 131Hz (tangential modes) and 148, 191, 222Hz (oblique modes).

The engineer using this room will sit in a seat located in the room. A biaxial microphone is used to make the measures at the location of hears.



Three configurations have been tested:

- The room without treatment on the wall
- The room treated with classical insulators
- The room treated with tuned panels

Different signals have been used:

- Background noise

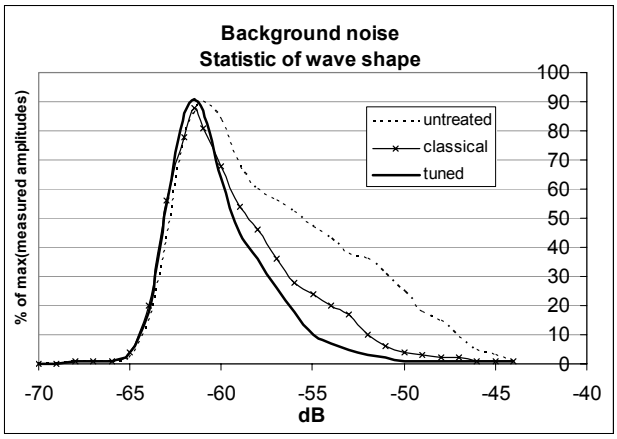
- White noise
- Impulse excitation
- Different engine records

Sources are located on the left side of the room for continuous signals and on the right side for impulse excitations and results are recorded for both left and right hears.

Background noise
The background noise is recorded and analysed when directly impacted by the noise (left hear):

	Max of RMS power (dB)	Average RMS power (dB)
Untreated	-43.43	-56.06
Classical	-45.50	-58.35
Tuned	-47.11	-59.78

Results show that:
- The background noise is decreased (see values of RMS power before)
- The figure below shows that the low frequencies fluctuations are absorbed. The room is quieter and sounds more muffled.

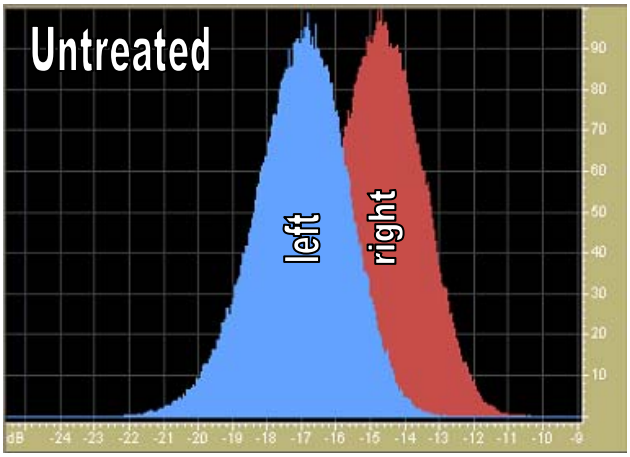


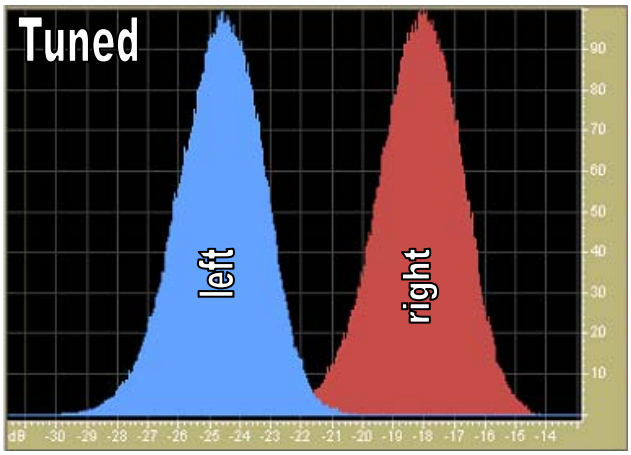
White noise excitation:
The statistics of wave shape are presented for left and right hears.
The right channel corresponds to direct field measurement whereas the left one corresponds to reflected field.

Measures show that le direct field level is decreased by 3.5bB (it is centred around -14.5dB for the untreated room, and -18dB for the tuned solution). A reduction of 7.7dB is observed for the indirect field (it is centred around -16.5dB for the untreated room, and -24.2dB for the tuned solution).

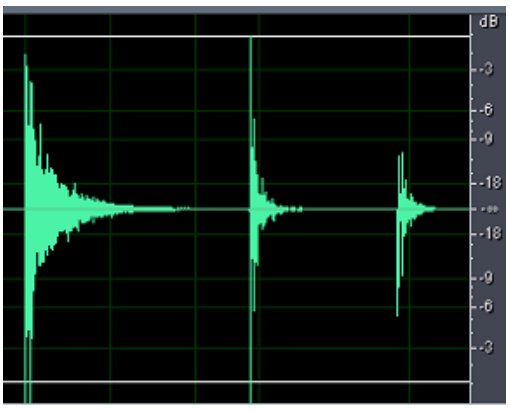
The most important thing to be noticed in this example is that the gap between the left and right measures increases with the treatment (2dB without treatment, 5dB with classical treatment and 6.2dB with tuned treatment).

These results show that the sound restitution in this room will be of better quality since the direct field is less altered by the reflected one.
Hence, after having equipped the room with the complete set of speakers (necessary for a spatial high quality restitution), the sound perception will be greatly enhanced.





Impulse response of the room
The figure hereunder shows the response of the room for the three cases (untreated, classical treatment, and tuned treatment) in terms of reverberation time.

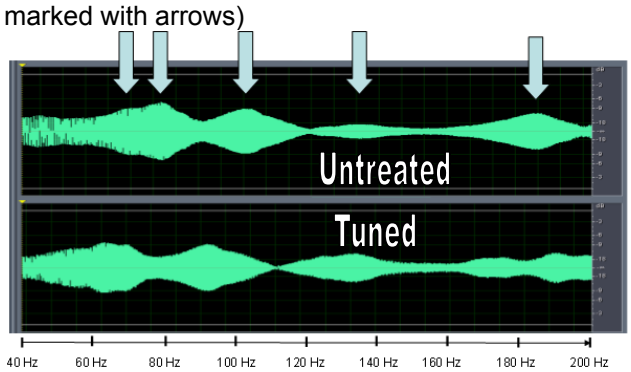


Next figures show the variation of reverberation time more precisely.

Between the untreated room and the tuned panels, we can notice that:

- The clarity rating (C80) is improved from 21.49 to 43.50 dB Lin. The C80 rating is the ratio of the energy over the total energy. We recall that C80 is the ratio of the energy contents during the first 80ms over the whole energy contents.
- The reverberation time decreases from 0.21 to 0.06s

It is also important to note that the rate of stationary waves in the room is reduced. It is shown in the figure below (on which the modes of the room are marked with arrows)



5 Others Industrial applications

In this section, we present some industrial applications which have already been done or are underway.

Applications for 2D panels and 3D shields:
As mentioned in the title, this broadband tuned solution can be plat panel or a 3D shield.

The underlying principle remains the same, but a plat panel does not fit any industrial case:

- A tuned panel may be used as engine under cover insulator
- But a tuned shield must be used as an arch wheel insulator
- A tuned panel may fit as an hood insulator
- But a tuned shield must be used as an engine mask insulator…

The case of the treated room can be duplicated to the case of an anechoic room: the wall being covered with broadband tuned panels instead of glass fibre pyramids, the same performance can be reached within only 3 to 5cm for the tuned solution compared to at least 20cm glass fibre pyramids; and the walls remains “flat”.

Broadband tuned panels/shields as a vector for new ways of vibro-acoustical treatment:
Using broadband tuned shields, the strategy to treat a whole engine box may be quite different from what is generally done.

An engine box is generally treated on its 6 faces: under, over, laterals, front and back insulator (+ engine mask and arch wheels insulators).
One or two of these surfaces can be chosen (for example the engine mask and the back insulator between engine and passenger compartment) to be treated with a tuned solution: enhancing the performance of these parts allows to lower the performance of the others, and on some vehicles to suppress parts.

We believe that an engine box can be treated on two faces instead of six, with at least the same global vibro-acoustical performances.

Due to a lack of space, some of the aforementioned industrial applications will be developed during the oral presentation.

6 Conclusions

In this short paper, we briefly presented the principle of the broadband tuned panel / shield.

The case of an acoustical restitution room has been presented in order to show some of the performances of this concept.

The point we want to focus on is that problems cannot be separated according to frequency ranges any more, and that there is therefore a real need for broadband solutions.

Firstly, these broadband solutions can be tuned in order to use a minimum of material, since the solution performance is exactly centred on the vibro-acoustical requirements.

Secondly, tuned solutions can (and should) lead to new design (or re-design) of modules.