MICA

for structural vibration damping

- Structure-borne vibration damping through dissipation
- Broad temperature range of use

IMERYS
Performance Additives

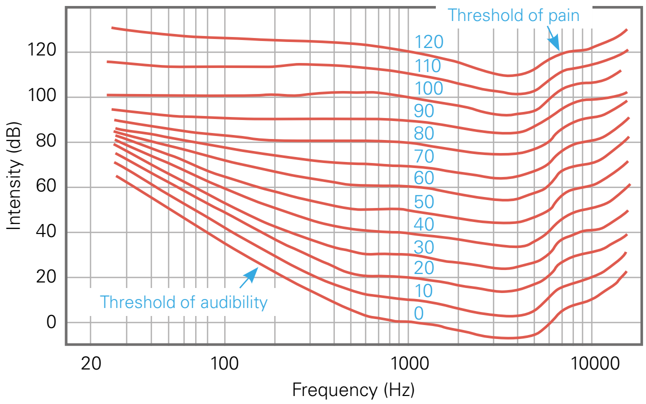
INTRODUCTION

Noise is defined as a vibration transmitted mechanically through an elastic medium such as air or water. A vibration always takes the path of least resistance from its source to the outside world. The process of noise management involves blocking these paths and eliminating the energy whenever possible. Specific materials have been developed to reduce noise emissions. Integrating mica into these products renders them more efficient.

NOISE MANAGEMENT METHODS

Noise is most frequently described as a non-periodic waveform with a too high intensity in the audible frequency range (20-20000 Hz), as shown in Figure 1.

Figure 1. The average range of sound intensities for human hearing
(Source : Courtesey Bell Telephone Laboratories)



With about 25% of the European population exposed to rail or road noise higher than 65dB(A), managing noise generated by electric or combustion engines is a key issue. Noise at these levels can seriously disturb sleep, resulting in potential health problems.

The most cost-effective way of managing noise is to prevent structural vibrations from becoming airborne in the first place, since materials used to absorb and control noise downstream tend to be more expensive. To prevent vibrations from becoming airborne, passive damping materials are applied to the vibrating surfaces.

In an automotive context, materials used to control noise are commonly referred to as Noise Vibration Harshness materials (NVH based on SAEJ670e Standard (July 1952)) whereby 'noise', 'vibration' and 'harshness' are defined as follows:

Noise
Vibrations perceived audibly, characterised by a sensation of pressure in the ears.

Vibration
Perceived tactually —at vehicle occupant interface points such as the steering column, seats, etc.

Harshness
Related to the transient nature of the vibration and noise associated with an abrupt transition in vehicle motion. Can be perceived both tactually and audibly.

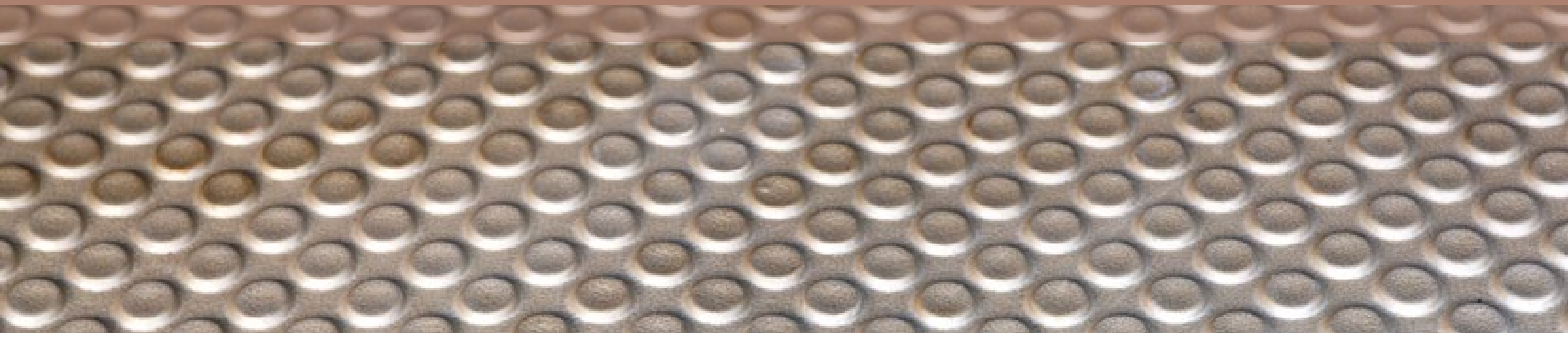


Figure 2. Different noise management methods and corresponding NVH material solutions

Structure-borne noise

Structural damping

Functionality	• Converts mechanical energy into heat, removing vibration energy from the system.
Mechanism	• Dissipation
NVH Materials	• Bitumen (viscoelastic materials), plastic sheets, spray-on polymers (LASD), sealants, coatings, rubber
Solutions	• Mica
Measurement	• ASTM E756-93 (Oberst method)

Insulation

Functionality	• Lowers the natural frequency of a system to below the excitation (or disturbing) frequency. Keeping these two frequencies "out-of-sync" greatly reduces the problems of vibration-noise.
Mechanism	• Spring mass model
NVH Materials	• Equipment mounts, plastic and rubber bushings and grommets.
Solutions	• Technical rubber reinforcing minerals, AF silica fines
Measurement	• ASTM D4065, D4440, D5279 (*DMTA)

Airborne noise

Absorption

Functionality	• Soundwave energy absorbed in porous materials by air displacement and reflected by the barrier.
Mechanism	• Dissipation
NVH Materials	• Acoustic foams, fibreglass batts, blankets, acoustic tiles, urethane semi-reticulated foams, cork, carpets
Solutions	• Diatomaceous earth, perlite (micro-spheres), wollastonite
Measurement	• BS EN ISO 10534-2:2001 (impedance tube) BS EN ISO 354/2003 (reverberation chamber)

Barrier

Functionality	• Acoustic reflector which interrupts the path of the sound wave.
Mechanism	• Spring mass model
NVH Materials	• PA enclosures, weighted materials, walls, flexible noise curtains
Solutions	• Barium sulphate, calcium carbonate
Measurement	• BS EN ISO 10534-2:2001 (impedance tube) BS EN ISO 354/2003 (reverberation chamber)

WHAT IS TAN(δ) ?

The ability of an NVH material to damp structure-borne noise is defined by the loss factor or tan (δ) of the material.

When materials which are not perfectly elastic are stressed cyclically, strain is not in phase with the stress applied. The phase difference observed is referred to as delta (δ). In each cycle of loading, there is energy dissipation in such materials. tan(δ) is a measure of damping, i.e., energy dissipation in such materials during each loading cycle.

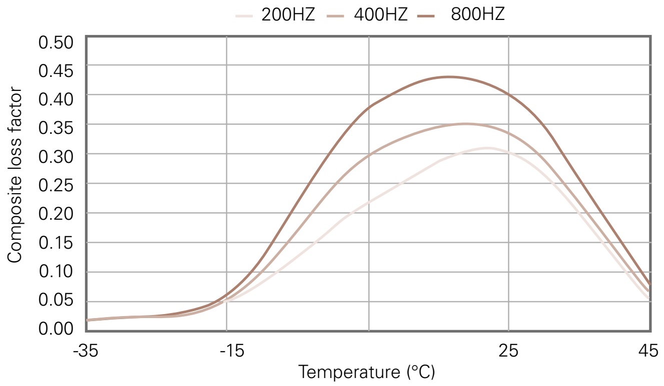
tan(δ) = *ƒ*(frequency, temperature, stress (time), strain)

tan (δ=90°)	**liquid**	**= + ∞**
tan (0°<δ<90°)	**visco-elastic**	**= 0 & + ∞**
tan (δ=0°)	**elastic**	**= 0**

δ is the phase angle difference between strain and stress observed

The method used to determine the loss factor of NVH materials (steel /NVH material composite) is the Oberst method used under controlled frequency and temperature conditions.

Figure 3.
Oberst method, loss factor temperature sweep at different frequencies of a steel LASD composite (constrained damping)



DAMPING OF STRUCTURE-BORNE VIBRATIONS (NOISE)

This brochure focuses on the use of mica to reduce structure-borne noise in mostly unconstrained (non-sandwich) NVH materials.

Many types of minerals can be used for achieving the maximum amount of heat dissipation (read tan(δ)) but, as seen in Figure 4., mica is the most efficient.

Figure 4. tan(δ) maximum peak heights at 10m% mineral loading for different minerals in Latex Interpenetrating Polymer Networks (LIPN).
(Shucai et al intJ Polym. Mat vol 29 issue 1-1 pp37-42 1995)

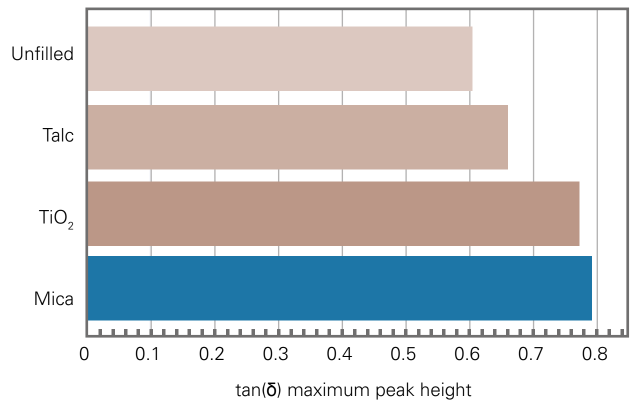
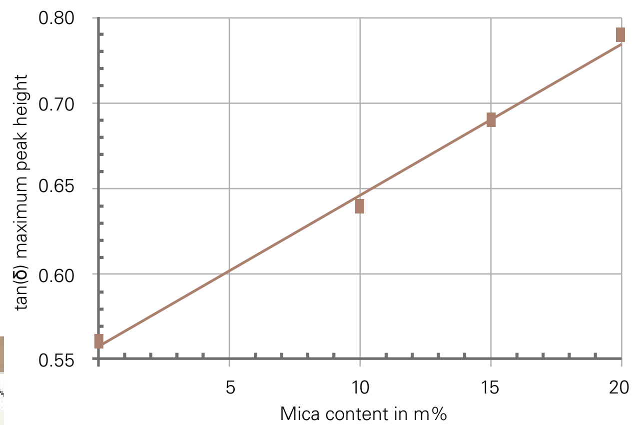


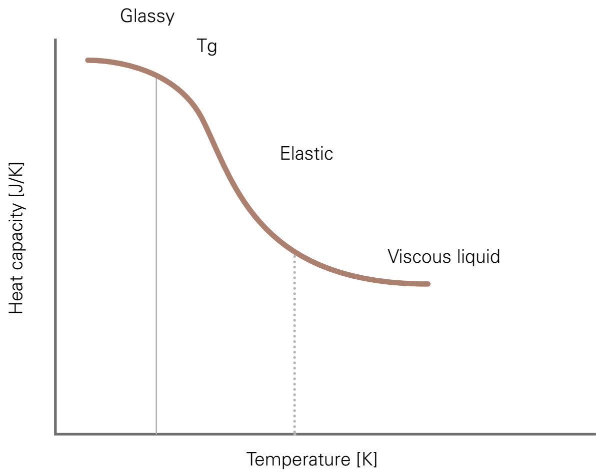
Figure 5.
tan(δ) maximum peak heights for different mica concentrations in Latex Interpenetrating Polymer Networks (LIPN)
(Shucai et al intJ Polym. Mat vol 29 issue 1-1 pp37-42 1995)



The use of mica to improve the vibration damping properties of viscoelastic materials over a broad temperature range is well known.

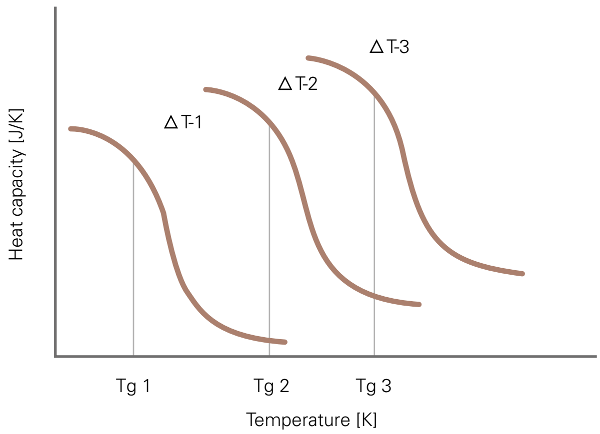
Polymers are a good example of viscoelastic materials. If the polymer changes from the glass phase to the elastic phase, the temperature at which this occurs is called the glass transition temperature.

Figure 6. Polymer phase changes



The polymer reaches the viscous phase as the temperature increases (at constant frequency): this phase is useful for damping. However, as the polymer's ability to recover fades, the loss factor increases.

Figure 7. Change in temperature Tg with change in rate of temperature change
(The faster the rate, the higher the apparent Tg)



The glass transition temperature of a viscoelastic material depends on:

- temperature increase/decrease rate, created by surrounding temperature as well as dissipation heat,
- frequency of the structural vibration itself.

Typical examples of viscoelastic NVH materials in which mica is used to improve damping properties within a pre-defined temperature window and vibration frequency are:

- SBR, atactic PP modified bitumen membranes,
- solvent-based/solvent-free liquid spray-on dampers,
- bitumen emulsion impregnated cellulose membranes.

In many situations, structural vibration damping is not the only functionality desired from a polymer-based composite. Mica also provides other application benefits including:

- increased flexural modulus and strength
- improved heat deflection temperature (HDT) performance
- increased tensile strength
- enhanced impact properties
- improved mud cracking
- anti-warping
- decorative effects
- demonstrable cost advantages

APPLICATIONS IN POLYAMIDE 6.6 AND POLYPROPYLENE

Imerys phlogopite and muscovite micas of varying particle size were investigated in a noise reduction study in polypropylene (PP) compounds and as a replacement of glass fibre in polyamide 6.6 (PA 6.6). Selected grades of mica (Suzorite 60S and L125) were tested at different loadings.

Figure 8. Relative noise reduction vs. neat PP
Frequency 20Hz-20kHz

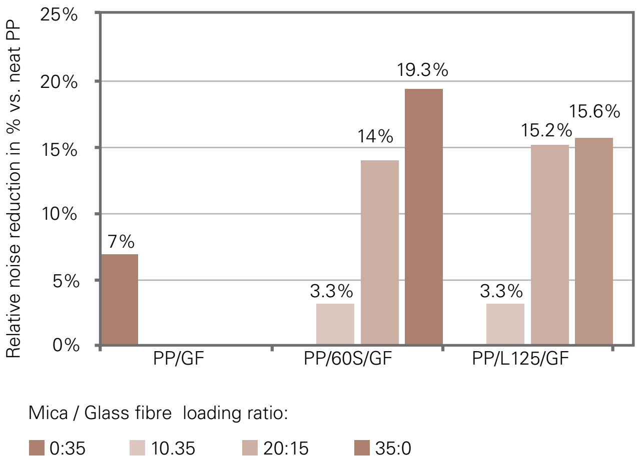
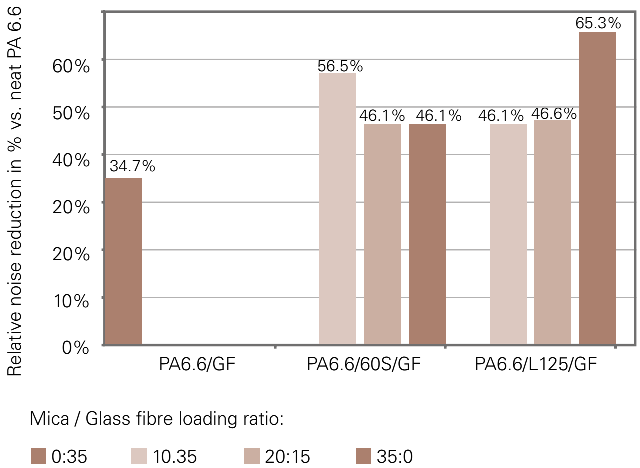


Figure 9. Relative noise reduction vs. neat PA 6.6
Frequency 20Hz-20kHz



Using mica in the formulations generates sound damping properties which are comparable to, or exceed, glass fibre and which are, in all cases, superior to those of the virgin resin.

APPLICATIONS IN LIPN

Latex interpenetrating polymer networks (LIPN) have a specific structure that gives the product a high viscoelastic state between its glassy and rubbery state, rendering it suitable for many damping applications. The damping properties of an LIPN with different fillers (10% loading) were investigated by DMTA at a frequency of 35Hz and a heat rate of 2°C/min.

Table 1. Damping properties of filled LIPN [70/30 PS/P(EA-nBA)]

Sample	tan(δ) max peak	Rate of tan(δ) max increase %	Temperature range of tan(δ) >0.4 ΔT (°C)		
			T1	T2 (°C)	ΔT
Unfilled	0.607		-33.2	14.7	47.9
Mica	0.793	31	-55.0	32.9	87.9
TiO^2	0.774	28	-45.0	33.0	78.0
Talc	0.661	9	-46.0	19.0	65.0

PS = PS (Polystyrene), EA (Ethyl Acrylate), nBA (n-Butyl Acrylate)

Mica gives the highest tan(δ) peak and the broadest temperature window in which a tan (δ) > 0.4 can be maintained for an LIPN with composition 70/30 PS/P(EA-nBA)(ratio EA: nBa=50:50).

PRODUCT RECOMMENDATIONS

Table 2.

NHV Material	Function	Mineral	Product	Key properties
Bitumen foils	Damping	Mica	Suzorite® 40S M880K	• Loss factor = ƒ(Hz,T) • Cuttable
LASD PVC Acrylic/EVA	Damping	Mica	Suzorite® 200S Suzorite® 80SF	• Loss Factor = ƒ(Hz,T) • Sprayable
Coatings	Damping	Mica	MU454 C3000	• Loss Factor = ƒ(Hz,T) • Cuttable • Esthetics
Bitumen impregnated board	Damping	Mica	Suzorite® 200S	• Loss Factor = ƒ(Hz,T) • Curtain coatable
PP/Nylon injection moulded parts	Barrier, HDT	Mica	Suzorite® 325HK WG 333	• Transmission loss • HDT • Anti-warping

ABOUT IMERYS

Imerys is the world leader in mineral-based specialty solutions for industry. We transform a unique range of minerals to deliver functional specialty solutions that are essential to customers' products and manufacturing processes. With 300 scientists, eight research and technology centres, 21 market-focused regional laboratories and close ties with renowned research institutes, we lead the way in engineering minerals for industry.

ABOUT PERFORMANCE ADDITIVES

Performance Additives is a division of Imerys. With over a hundred years' experience in the minerals business, we offer customers engineered solutions derived from our portfolio of diatomite, mica, perlite, talc and wollastonite. We refine and engineer these minerals through various—often proprietary—processes that influence their concentration, size, shape, structure and surface chemistry to obtain the exact properties our customers require. Each year, we process thousands of tons of materials to the highest standards of quality, consistency and reliability.

Our polymers team has in-depth knowledge of polymer processing and of how minerals interact in polymers and a proven track record for developing new, value-added solutions for customers. Our product and applications laboratories are equipped with a full range of analytical and polymer-specific equipment enabling us to spearhead applications innovation as well as to provide customers with bespoke formulation services and technical support.

DELIVERING THE GOODS

With production sites in Australia, Belgium, Canada, France, Italy, Japan, Mexico, Spain and USA we are able to provide customers with optimised logistics and costs. Our sales administrators organise the optimum transport, warehousing and product delivery form to meet our customers' specific needs.

MEETING TODAY'S NEEDS, SECURING TOMORROW'S

We believe that running a successful business and sustaining quality of life and the environment go hand in hand. From implementing behaviour-based safety training to rehabilitating the land, we think it's important that future generations' needs are not compromised by our actions today.

OUR FUNDAMENTAL SUSTAINABILITY PRINCIPLES

- SAFETY - We promote the health and safety of employees, contractors, customers, neighbours and consumers through active caring.
- PARTNERSHIP - We seek to understand the issues that are important to our neighbours, and to make a lasting contribution to the communities in which we operate.
- ENVIRONMENTAL PROTECTION - We work to minimise our environmental footprint by using natural resources efficiently, preventing pollution, complying with applicable laws and regulations and continually improving our performance.
- ACCOUNTABILITY - We conduct business in an accountable and transparent manner, relying on external auditing and reporting to understand and reflect our stakeholders' interests.
- PRODUCT STEWARDSHIP - We are committed to ensuring that our products are safe for people and the environment, employing best available technology and following best-in-class procedures to ensure that our standards and practices meet or exceed safety requirements everywhere we do business.

We conduct life cycle assessments (LCA) at all our operations to quantify the environmental effects associated with producing our products from the mine to factory gate, and to identify areas for improvement. Likewise, we compile life cycle inventories (LCI) of the energy consumption, materials used and emissions generated by each of our product ranges. These LCI can be made available to customers and research institutions on request.

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