Minerals solutions for various modes of noise reduction in Polyolefins

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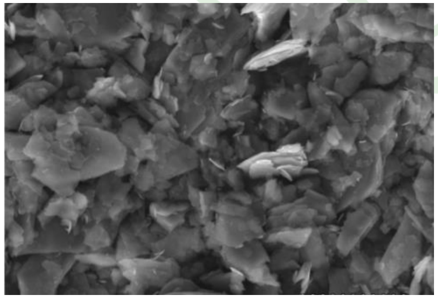
**IMERYS Performance Minerals
North America**

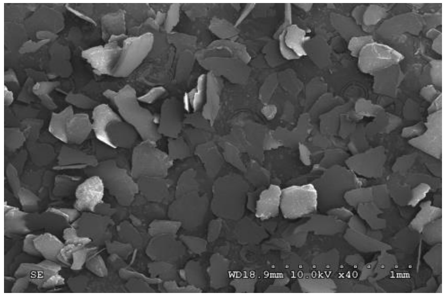
Outline

- IMERYS
- Background
- Objectives/Approach
- Noise Reduction Modes & Test Results
  - DMA
  - CenterPoint
  - STL
- Mechanicals
- Conclusions

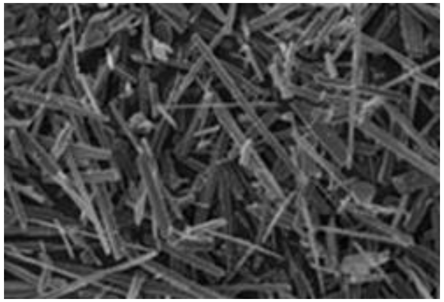
Talc



Mica



Wollastonite



IMERYS - Leading Global Supplier of Performance Minerals

INNOVATION
ENGINE FOR GROWTH

€4.6 billion
Revenue*

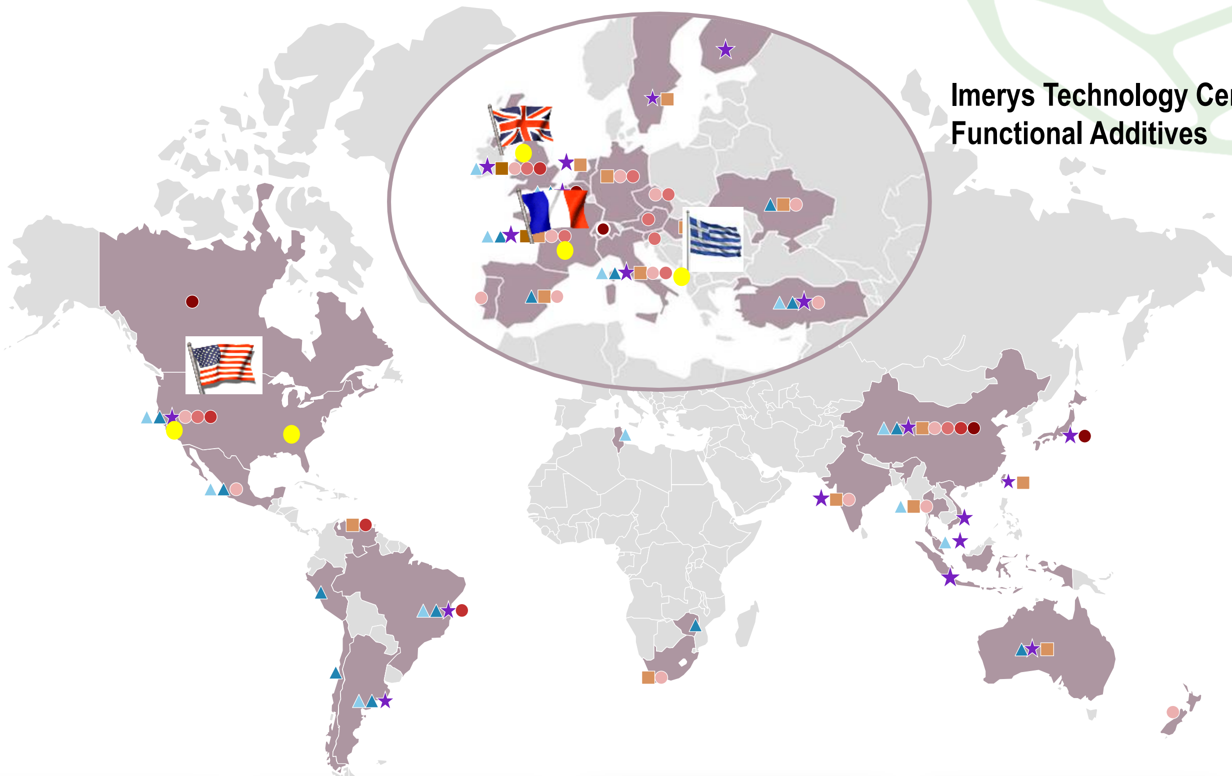
+50
Countries

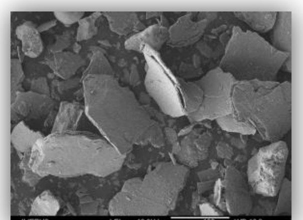
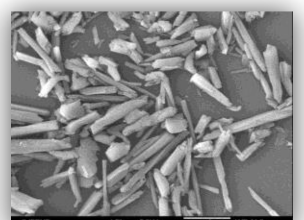
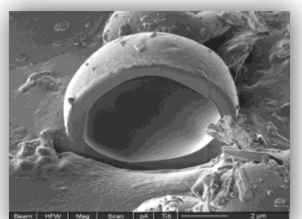
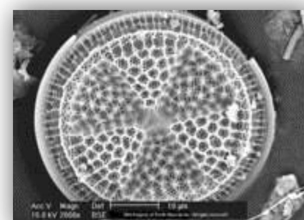
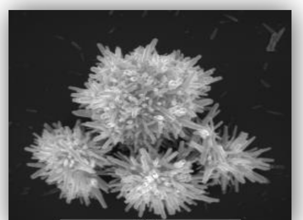
18,300
Employees

+ 90
New products in 2016

270
Operating sites

#1 or #2
On most of our markets



Over +30 Functional Minerals

IMERYS

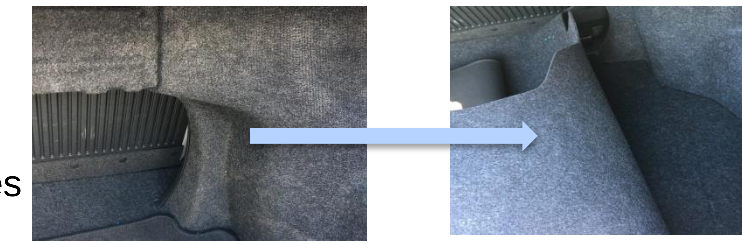
Background

Vehicle Interior Noise

- Noise: Environment pollution
- Car noise: Caused by powertrain, wind/air and tire/road
- Electric/hybrid vehicles: Induction machines whines, higher vibration level, wind/air and tire/road. Zero BSR (buzz, squeak and rattle)[1]

Current strategies (noise, vibration and shock control)

- Absorptive: Foams, coatings, perforated sheet metal
- Barrier: Mass-Loaded Plastics, Sealants and Sealing Tapes
- Vibration: Isolators, dampers, constraint layers
- Barrier/Foam composites
- Silencers



Dampers

Absorber

References
1) Sound & Vibration/April 2011, The Future of Electric Vehicle Noise Control
2) Images: https://earglobal.com/media/5748/floortreatment.jpg (accessed on 07.22.2018)

Screening Objectives

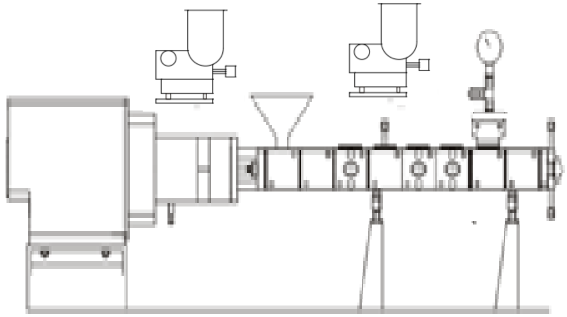
Objectives

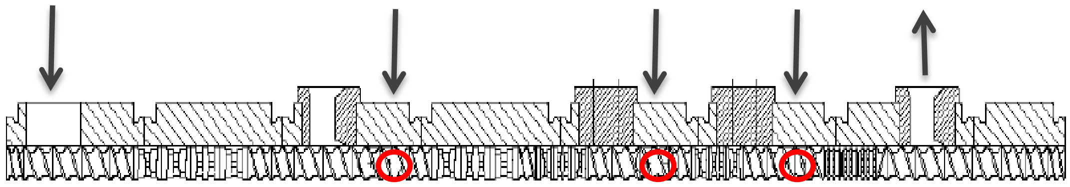
- Evaluate performance of various minerals/grades for noise reduction
- Capture perfromance space in various noise tretaments
  - Barrier
  - Damper
  - Absorber
- Understand relative mechnical performanc of various mineral grades
- Identify difference in noise and mechanical performance as a function of particle size

Approach

Experimental

- Melt compound via 25mm co-rotating/intermeshing TSE (46:1, L/D)
- ASTM test specimen prepared via 66T Arburg injection molding unit





Screw Design

Sound Testing

- Dynamic mechanical analysis
- CenterPoint
- Sound transmission loss

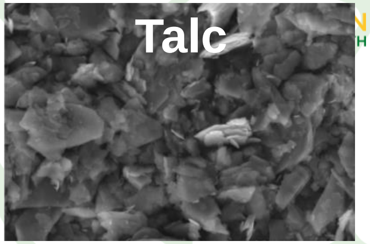
Mechanical

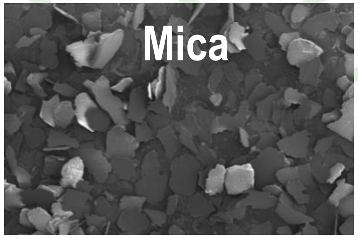
- Test specimen conditioned 1 week at 23 ˚C/50% Rh prior to testing
- Testing conducted via ASTM standards/guidelines (D792, D1238, D256, D790, D638 and D648), and other internal methods

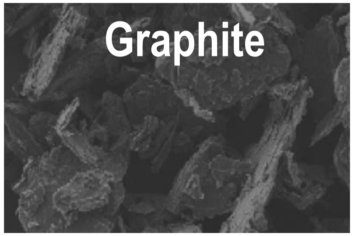
Materials

- PP Homopolymer - Ineos PP- H13M00
  - MFI = 13.5 g/10 min (@230 ˚C, 2.16 kg)
  - Flex Modulus = 1655 MPa
- Addivant Polybond 3000
  - Maleated PP
  - MFI = 405 g/ 10 min (@190 ˚C, 2.16 kg)
- Strucktol RP 11
  - Processing Aid (viscosity modifier)

- **Minerals**
  - Talc
    - Coarse (4.5 µm), fine (1.2 µm) and HAR (2.3 µm)
  - Mica
    - Coarse (150 µm) and fine (30 µm)
  - Wollastonite
    - HAR Coarse (18 µm, laser) and HAR medium (12 µm, laser)
  - $CaCO_3$
    - Fine (3 µm) and Ultra-fine (1.1 µm)
  - Graphite
    - Coarse (<150 µm) and fine (39 µm, d90)
  - $BaSO_4$ (3 µm, laser)
  - Chopped GF (10 µm x 4mm)





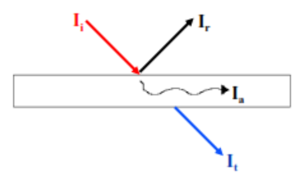


Noise Reduction Process

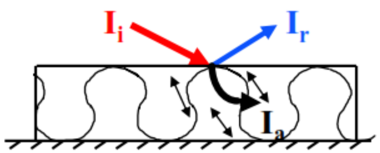
- **Type of sound**
  - Airborne noise (sound)
  - Structure-borne noise (vibration)

- **Type of treatments to reduce the noise**
  - Barrier treatment
    - Airborne Noise
  - Absorption treatment
    - Airborne Noise
  - Damping treatment
    - Structure-borne noise

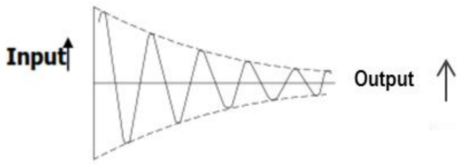
Barrier treatment



Absorption treatment



Damping treatment



- All treatments are frequency dependent
- Performance of damper is also temperature dependent

Noise reduction testing

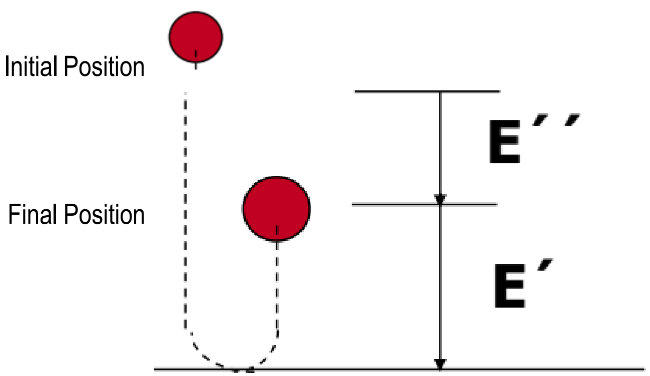
1) Dynamic Mechanical Analysis (Damping)
2) CenterPoint (Damping)
3) Sound Transmission Loss (Barrier)

Dynamic Mechanical Analysis

Damping

- Reduction of kinetic energy present in a system, through transformation into another form of energy
- Damping performance is commonly expressed in terms of loss factor

Viscoelastic material



Loss tangent, tan δ

$$\tan \delta = \frac{E''}{E'}$$

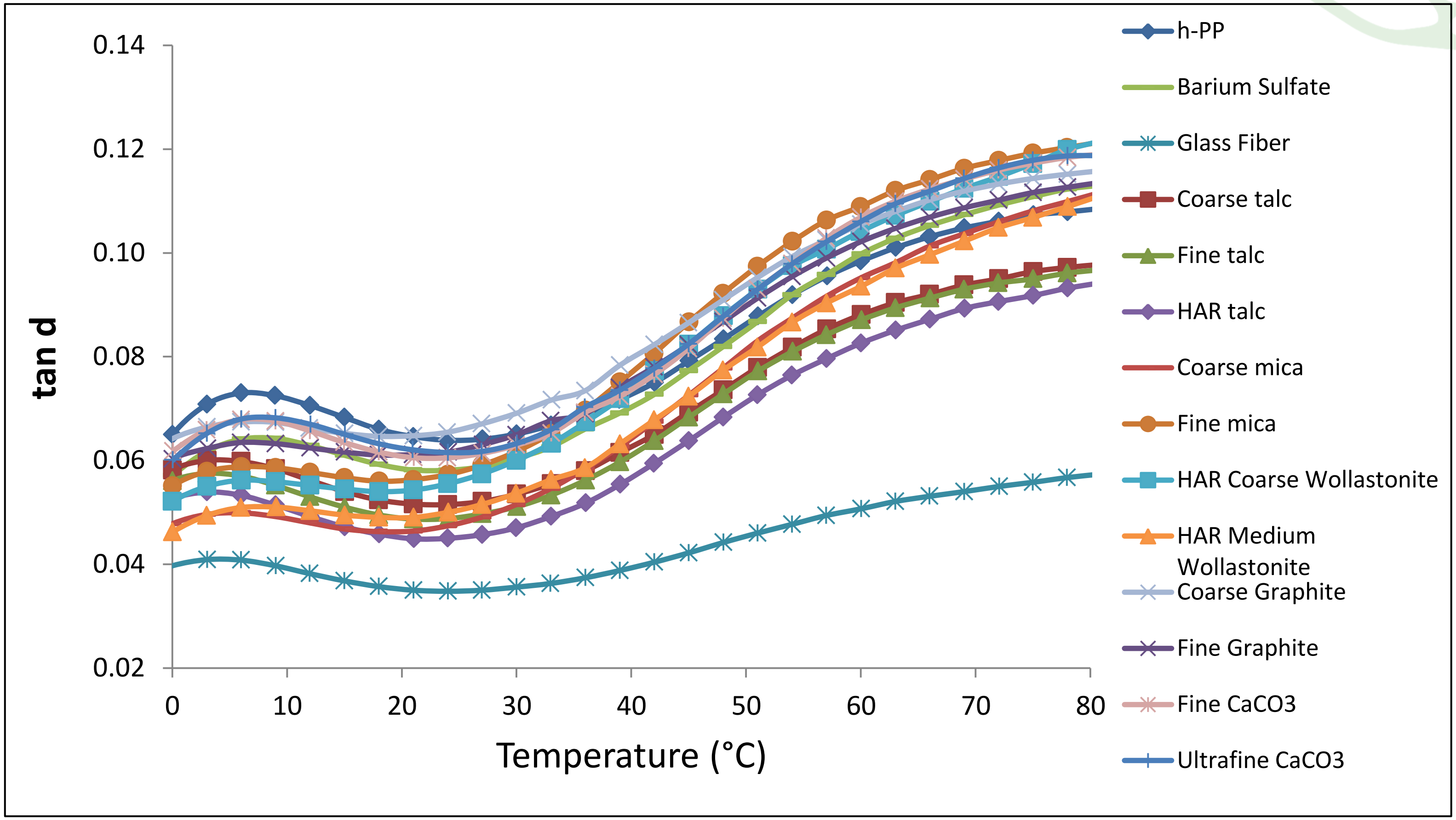
E´´: Loss modulus (viscous factor, dissipates energy)

E´: Storage modulus (elastic factor stores energy)

DMA
Three point bending mode

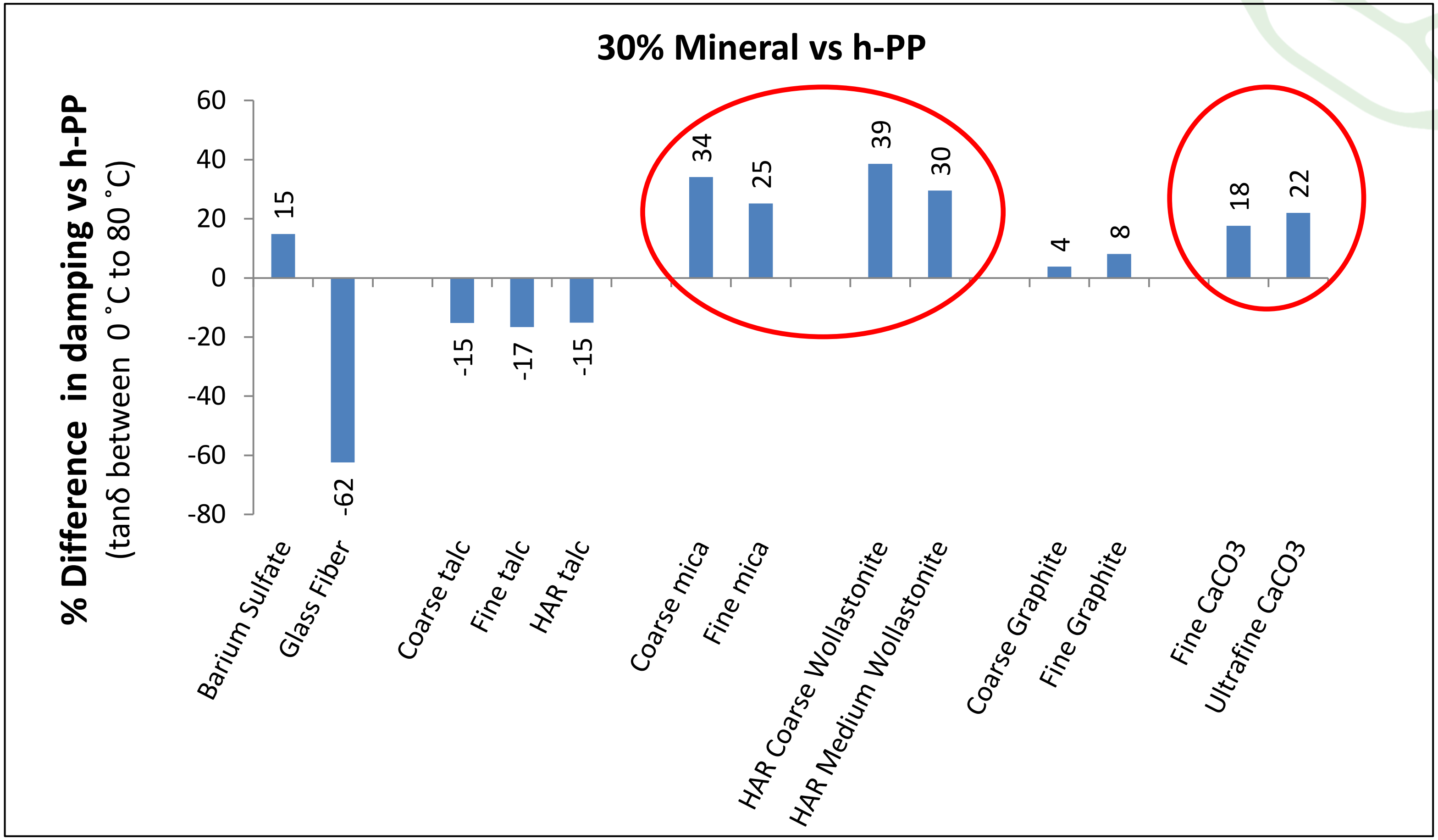
Test Results - Dynamic Mechanical Analysis

DMA performed in three point bending mode at 10 Hz frequency from -3 ˚C to 80 ˚C
30% Mineral filled PP



- Wide range of performances with mineral filled compounds
- Glass fiber filled compounds have lowest viscoelastic loss

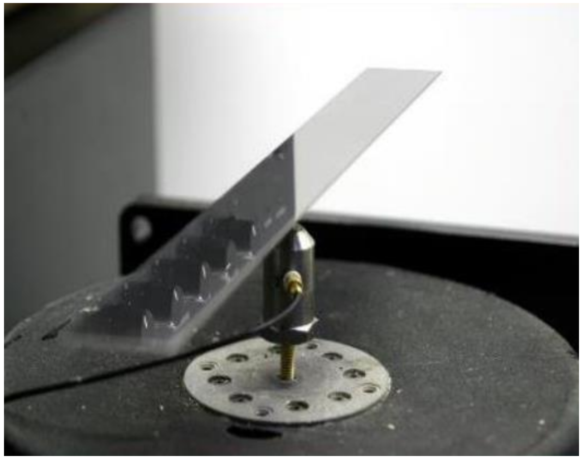
Test Results - Dynamic Mechanical Analysis



Mica, wollastonite and $CaCO_3$ grades show superior damping behavior as compared to the neat resin

CenterPoint Test (ISO16940)

Obtains the response (acceleration) as the bar is excited with specific force



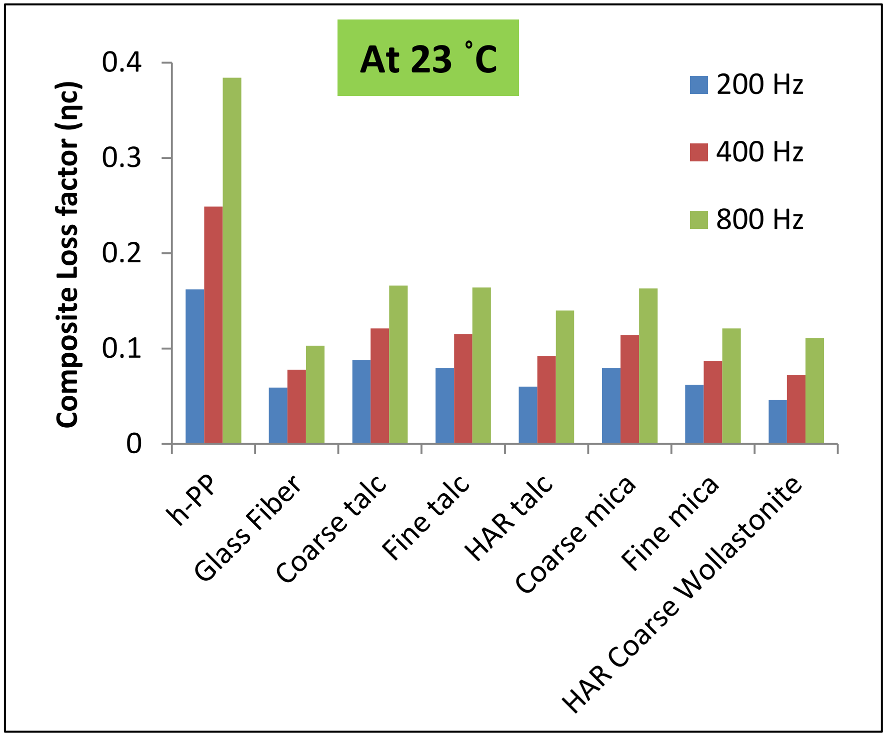
$$\text{Loss factor } (\eta) = \frac{\text{Amount ofenergy lost or dissipated}}{\text{Maximum potential energy in the vibrating system}}$$

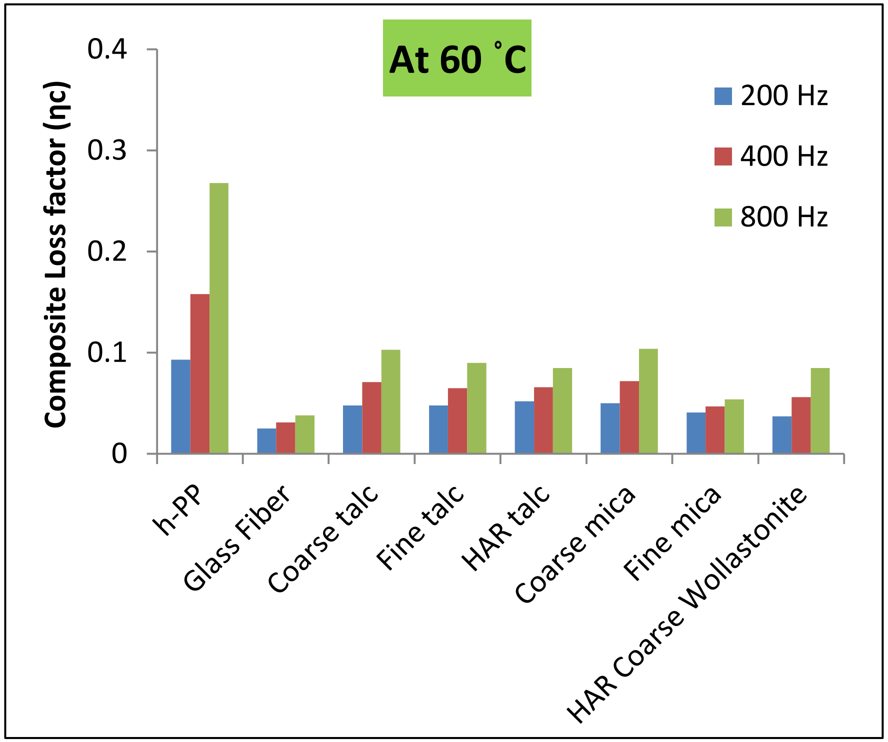
Test Conditions

- Temperature - 23 ˚C and 60 ˚C
- Frequency - 200, 400 and 800 Hz

Test Results - CenterPoint (ISO 16940)

- Test performed at 23 ˚C and 60 ˚C
- Loss factor at resonant frequencies are interpolated to 200, 400 and 800 Hz





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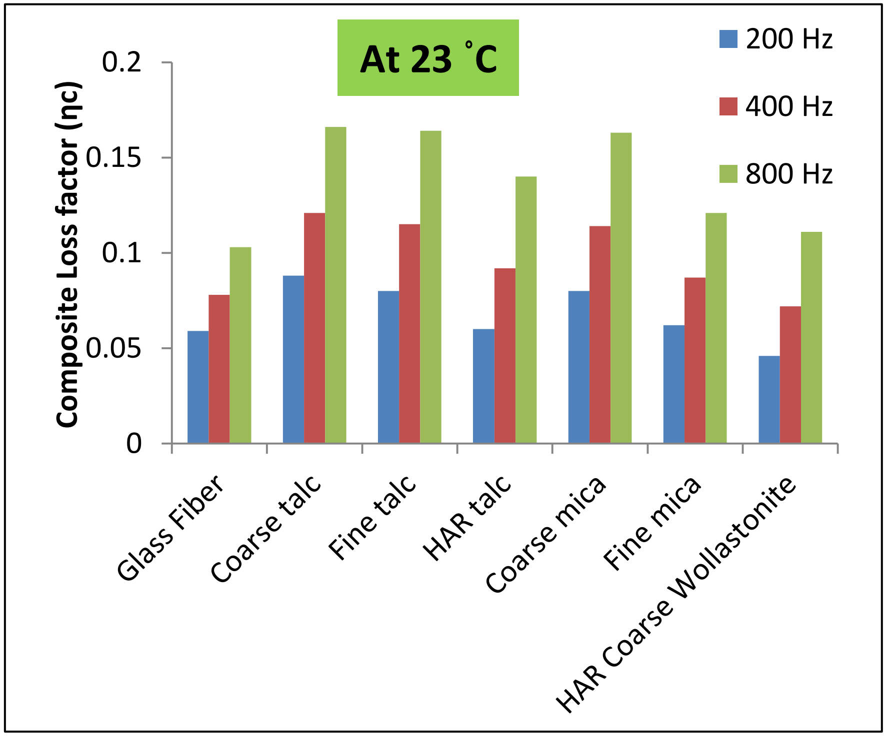
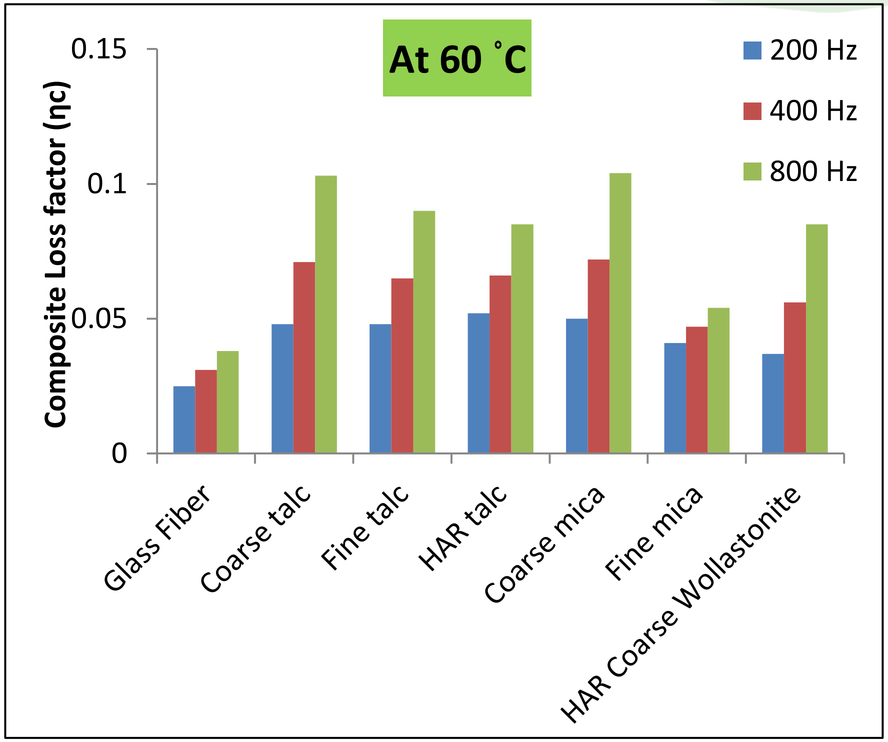
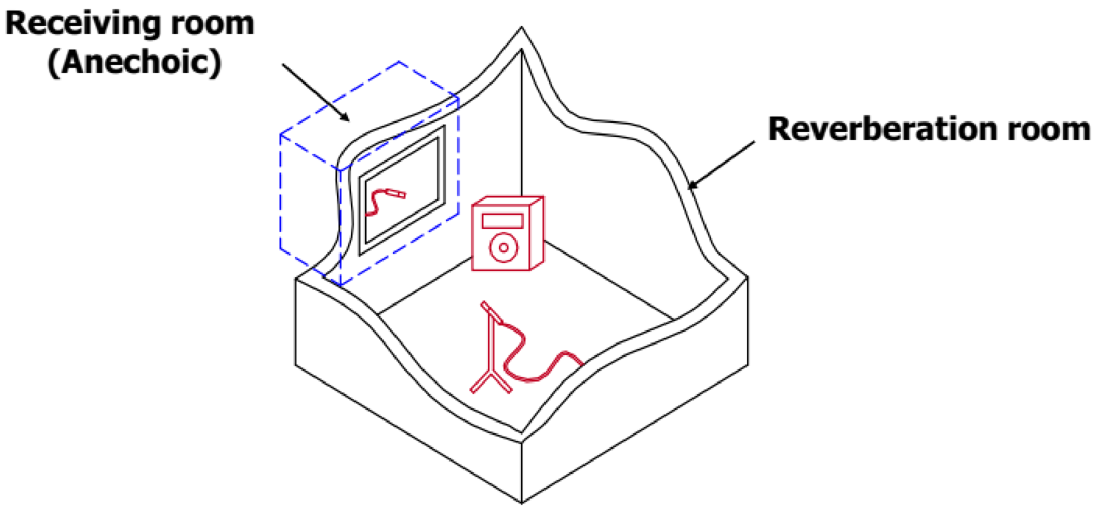


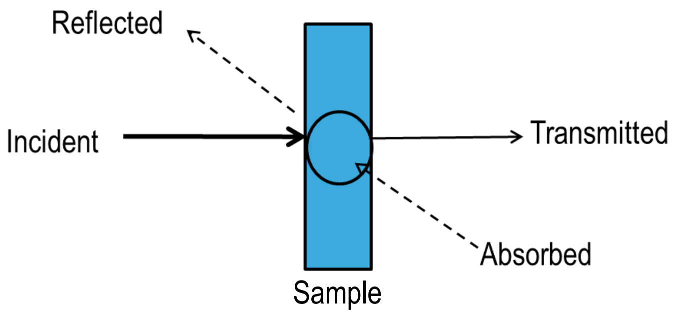


- Performance is temperature dependent
- Talc, mica coarser grades to be superior to their fine counterparts

Sound transmission loss testing (per SAE J1400 (2017))

Sound transmission loss (STL)

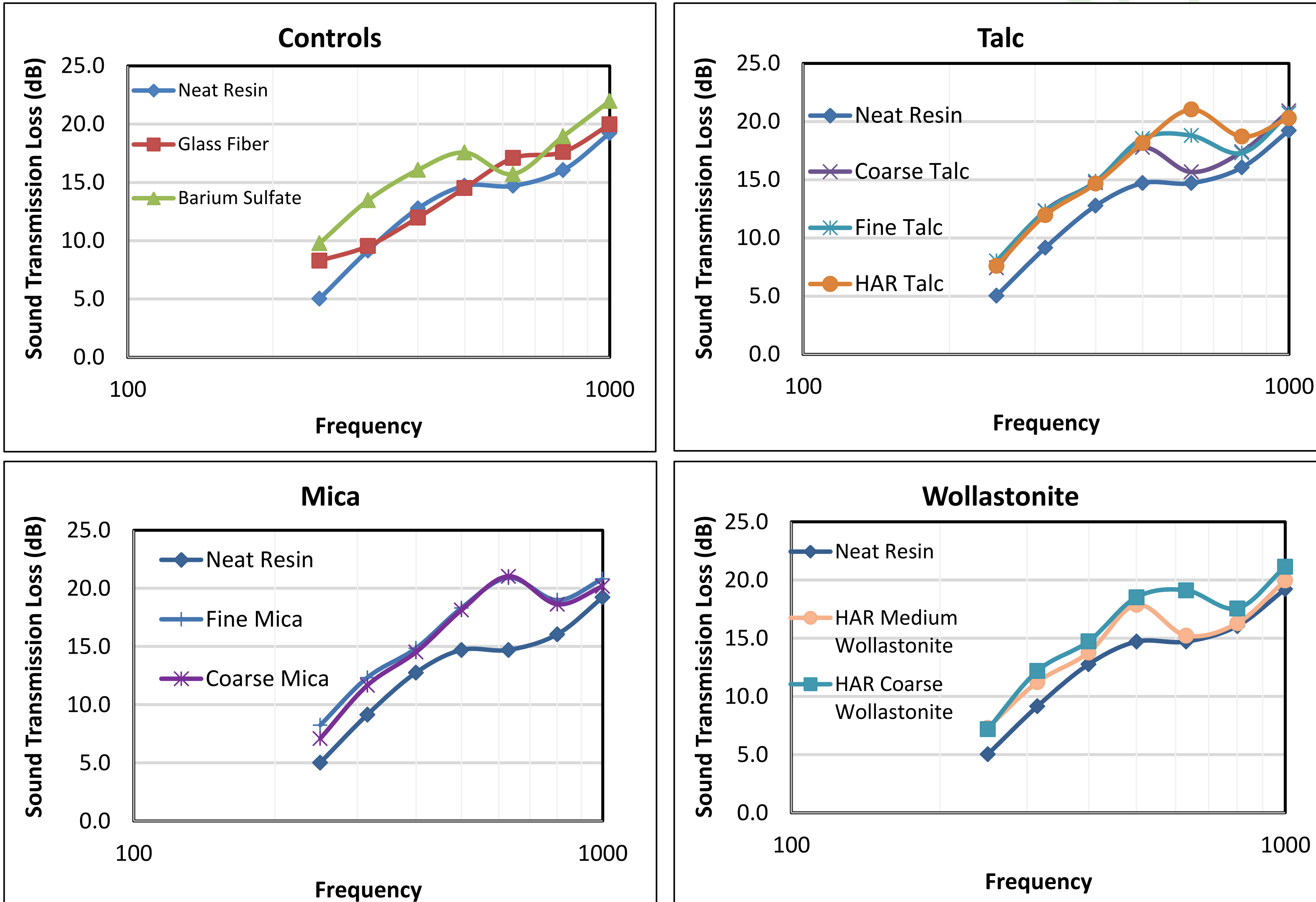




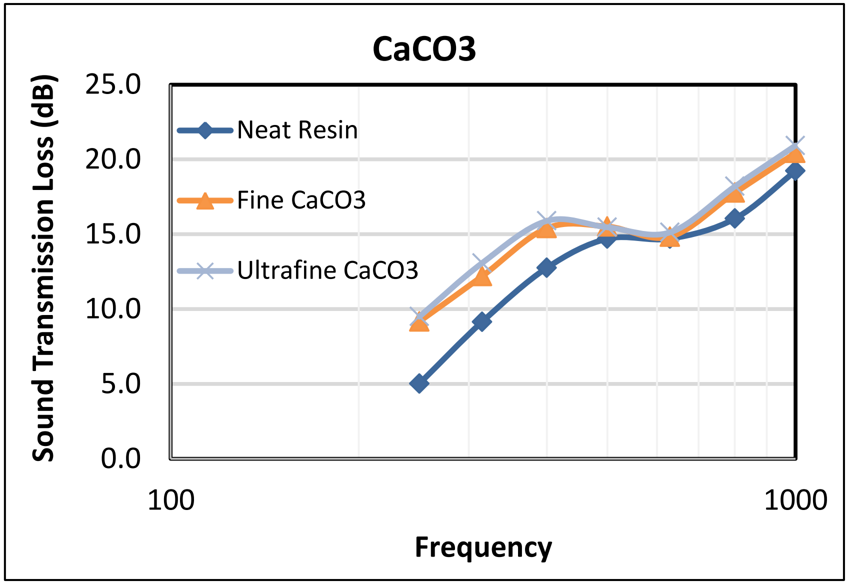
$$\tau = \frac{\text{sound transmitted}}{\text{sound incident}}$$

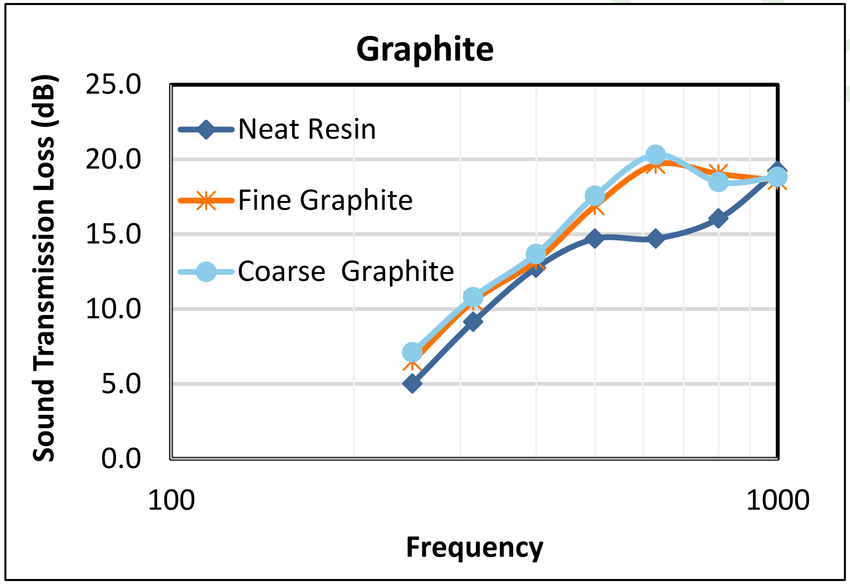
$$STL = 10 \log\left(\frac{1}{\tau}\right) \, dB$$

Test Results - Sound transmission loss testing (SAE J1400)



Test Results - Sound transmission loss testing (SAE J1400)



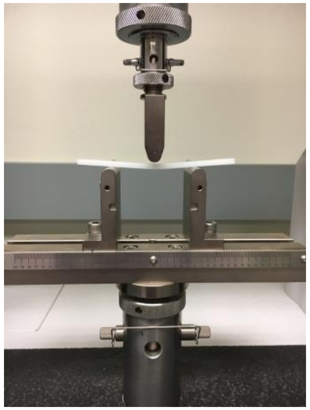


- All mineral filled compounds show 2-3 dB STL as compared to the neat resin
- Performance is density dependent; morphology has minimal influence

Summary: Noise reduction testing

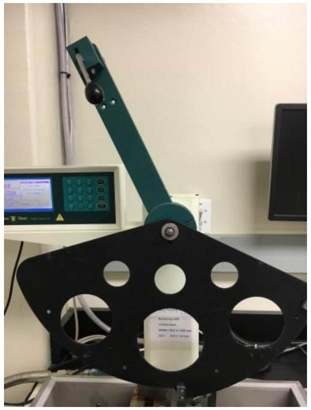
- No universal solution for different types of noise treatments
- Dynamic mechanical analysis which imparts viscoelastic loss indicates mica, wollastonite and $CaCO_3$ are better than h-PP
  - **Recommendations**: **Suzorite® Mica** and **Nyglos® , Aspect® Wollastonite** line of products
- CenterPoint test which imparts vibrational damping shows **coarser grades** to be superior than their fine counterparts
  - **Recommendations**:
    - Room Temperature: **JetFil®** and **Suzorite®** coarser grades
    - Elevated temperature: **JetFil®, Suzorite®** and **Nyglos ®** coarser grades
- STL data indicate improved barrier performance using all the mineral filled compounds (surface density effect)
  - **Potential Recommendations: JetFil®, Suzorite®** and **Nyglos®** line of products

Mechanical and thermal testing



Flex

Tensile



Izod Impact

Mechanical Properties

At 30% loading, tested in ASTM

		Measured Density, g/cc	Flexural Modulus (Young's Automatic), MPa	Tensile Strength, MPa	Notched Izod, J/m (RT)	HDT (66 psi), deg C	Noise mode
h-PP		0.913	1497	38	7	113	
Glass Fiber		1.112	5350	104	73	161	-
Barium Sulfate		1.197	1884	34	22	120	B
Talc	Coarse	1.129	3496	37	23	142	B, V
	HAR	1.131	4636	42	23	145	
Mica	Coarse	1.135	4887	32	20	141	VE, V, B
	Fine	1.138	4126	33	22	140	
Wollastonite	HAR Coarse	1.140	4378	32	23	140	VE, V, B
	HAR Medium	1.146	4958	36	21	143	
$CaCO_3$	Fine	1.133	2344	36	24	126	VE, B
	Ultrafine	1.128	2370	33	22	121	
Graphite	Coarse	1.103	4219	34	20	146	-
	Fine	1.101	5100	36	20	147	

- Various possibility among different minerals
- Range of properties within various grades of mineral

Conclusion

- Noise reduction using minerals:
  - **No universal solution**
  - Selection is dependent on type of noise treatment; also needs to meet mechanical properties
    - **Visco-elastic** damping: improvement with addition of mica, wollastonite and/or ground calcium carbonate
    - **Vibration** damping: improvement with coarser mineral grades
    - **Barrier**: improvement with mineral addition; performance appears to be density dependent

- Range of mechanical properties possible among various minerals and within specific mineral type

Conclusion

Selection is dependent upon specification requirements and cost

- Talc
  - Good stiffness-impact balance, color, compatibility, nucleation, vibrational and barrier. Exact grade depending on specification
  - **Recommendations:** Macro-crystalline/**Jetfil**®, **Jetfine**® grades (balance of vibrational-barrier and mechanical performance), Micro-crystalline/**Nicron**®**, Mistrocell**® (foaming, absorption)

- Mica
  - Material of choice for vibrational damping; bitumen/heavy layers
  - **Recommendations: Suzorite**® for maximum reinforcement, dimensional stability, potentially for all noise modes

- Wollastonite
  - Improves viscoelastic damping and barrier performance
  - **Recommendations: Nyglos**®**, Aspect**® for superior mechanical properties, flow and color

Thank you for your attention !

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