Specialized Noise Control Materials in the Automotive Industry

Sharad R. Mahajan, Prasad Vilas Bapat

Abstract — The automotive industry is currently spending millions of dollars on NVH work to develop new materials and damping techniques. The new design methods are starting to consider NVH issues throughout the whole design process. This involves integrating extensive modeling, simulation, evaluation, and optimization techniques into the design process to insure both noise and vibration comfort. New materials and techniques are also being developed so that the damping treatments are lighter, cheaper, and more effective.

Some of the methods used to control noise, vibration, and harshness include the use of different carpeting treatments, the addition of rubber or asphalt material to car panels, gap sealant, and the injection of expandable foam into body panels. The carpeting treatments include varying types of foam padding combined with different weights of rubber-backed carpet.

The overall result of this technique is a mass-spring system that acts as a vibration absorber. The rubber or asphalt materials are attached to various car panels to add damping and mass loading to reduce vibration levels and the rattling sounds from the panels. Sealant is applied to close gaps in order to increase the transmission loss from the engine, wind, and road noise sources to the vehicle interior. Expandable foam injected between panels, such as the dashboard and firewall, helps to add stiffness and vibration absorption. All of these current methods are effective at reducing sound and vibration levels in a vehicle at higher frequencies. However, some of the treatments become almost ineffective at lower frequencies below 200 Hz. The treatments also add a substantial amount of weight to the vehicle, thus affecting its fuel economy, as well as adding cost. Choosing the correct product for your application can be really easy if you properly identify the noise from the start. There are many contributors to automotive noise and the noise exists across a wide bandwidth of frequencies. To effectively reduce the noise floor within a vehicle, a combination of materials must be used. This technique will result in a greatly reduced installation time, a serious reduction in the amount of added weight to the vehicle and bunch of money saved in your wallet. When trying to reduce or eliminate various types of automotive noise, it is often necessary to utilize a variety of specialized noise control materials.

Index Terms — noise, vibration, and harshness, Floor Barrier, vinyl barrier, Thermo-Acoustic under hood Liner, Gasketing Foam.

I. INTRODUCTION

Vinyl based vibration damping material is a high-performance, lightweight, vibration damping sheet that has been engineered to convert vibration energy into low level heat through viscous friction. Vinyl damping materials feature a silica-mica and ceramic mineral load.

This material offers significantly higher damping performance than asphalt based materials. This is highly moldable and features an aggressive acrylic adhesive which allows for 100% adhesion to a vibrating structure.

Automotive body panels constructed of sheet metal, fiberglass or plastic vibrate at various frequencies. If they vibrate at a high rate, noise can be heard throughout the passenger compartment and contribute to driver fatigue. This type of noise can also negatively affect the performance of an auto sound system. This will reduce vibration of the body panels by increasing their "mass" and converting the vibration energy (mechanical) into thermal energy. The installation of Vinyl based vibration damping material will assist in reducing interior noise levels as well as improving performance from auto sound systems by preventing the conversion of sound energy into vibration energy. Vinyl based vibration damping material may also be used to create or replace flimsy plastic or paper vapor barriers behind interior panels.

II. TYPES OF SOUND CONTROL PRODUCTS

There are several types of sound control products and they can be broken down into these categories

A. Vibration Dampers: These are used to eliminate or reduce structural resonance and vibration. Vibration dampers are not designed to block sound.

B. Sound Barriers: These are used to block and reflect high energy airborne sound like road noise in the form of exhaust, airflow, drive train and tire noise.

C. Sound Absorbers: These are primarily used to soak up mid band and high frequency airborne sound and reflect thermal energy. Absorbers are typically very lightweight and do not damp vibration.

D. Gasketing Materials : These are used to eliminate squeaks, rattles and buzzes and to seal speakers.

A sound control system typically consists of vibration dampers, sound barriers, sound absorbers and gasketing products. The sound control products are modular by design and may be installed in stages. The benefit is in the installation time saved and the minimal amount of weight added to the vehicle. The addition of an automotive noise control system will not only produce a quieter, more comfortable ride but it will also dramatically improve the performance of automotive audio systems. This means you can use less power to achieve sonic perfection once thought impossible.

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III. ELIMINATE THE SHAKE AND RATTLE FROM YOUR RIDE.

There is a wide variety of damping products ideal for sheet metal, plastic, fiberglass and wood. Vibration damping materials are designed to be lightweight while maintaining a very high level of performance. There is variety of liquid based and sheet based products that are ideally suited for a wide variety of installation applications, time schedules and budgets.

IV. LIQUID VIBRATION DAMPING COMPOUND

This is an air curing, liquid vibration damping compound (fig.1).Its combination of silica-mica, ceramics and an advanced chemical binder greatly reduces structural resonance by converting vibration into "viscous" friction or low level heat. This will also increase speaker output by 0.5 to 1 db when applied onto the inside of a speaker enclosure.

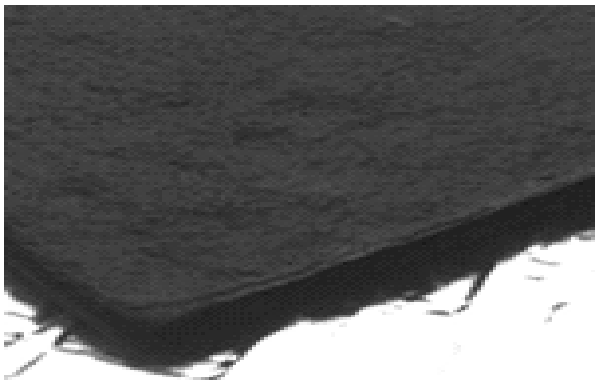

Fig.1. liquid vibration damping compound

This is a water based, sprayable vibration damping compound that has been engineered to damp vibration by converting it into low level heat. This is loaded with silica-mica and ceramic components that create friction when vibration occurs. It is commonly used on the inside of outer body panels including the floor pan. One benefit of using this is that it covers large surface areas very quickly when using the spray gun. When sprayed, it is purple and as it cures it will change to black. It is also frequently used to improve the performance of speaker enclosures of all types. In wood enclosures, this will soak into the wood and seal up the pores, seams and gaps between the panels. This will also damp fiberglass and plastic enclosures extremely well. When cured, creates an impedance mismatch that results in an increase in overall output by 1 to 1.5 db. Spray gun will save a massive amount of install time. This may also be applied with a paint brush or roller. This cleans up easily with warm water. This is water resistant, not water proof.

V. VINYL VIBRATION DAMPING MATERIAL

This is a thin, moldable, odorless and lightweight mineral filled vinyl-copolymer formulated to handle the demanding extremes of aircraft vibration and noise control. (fig.2). It has twice the damping and less than half the weight of asphalt damping materials and the ability to handle continuous temperatures to 250°F.

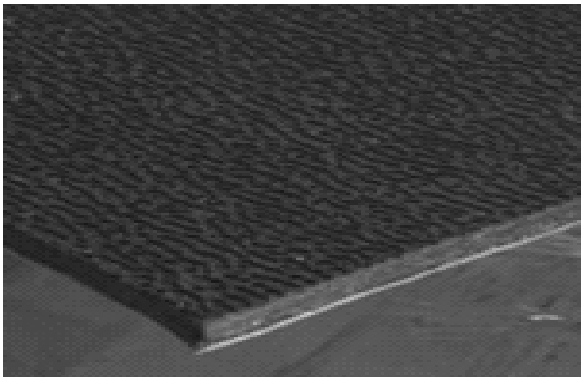

Fig.2. Close up of the Vinyl Vibration Damping surface

VI. VINYL VIBRATION DAMPING SHEET

This is a thin, lightweight and highly moldable vinyl based vibration damping sheet material. This is designed to mold and conform to irregular surfaces to achieve 100% bond and maximum damping performance. This will stretch up to 40% to make an irregular surface appear as if it has been dipped in plastic. (fig.3,fig.4 & fig5). Vinyl Vibration Damping consists of a silica-mica and ceramic load suspended in a thin, lightweight vinyl carrier. This has been engineered to convert structural resonance (vibration) into low level heat through friction. The friction occurs as the silica-mica and ceramic platelets come in contact with each other as the substrate vibrates. The adhesive layer is an aggressive, modified acrylic that bonds extremely well to wood, metal and fiberglass substrates and is stable to 250° F. Vinyl Vibration Damping is ideally suited to create or replace a vapor barrier behind an interior door panel. This is much denser than flimsy plastic making it much more capable of blocking airborne sound that normally enters the vehicle via the doors. Vinyl Vibration Damping also blocks speaker back wave and prevents an acoustical short circuit.

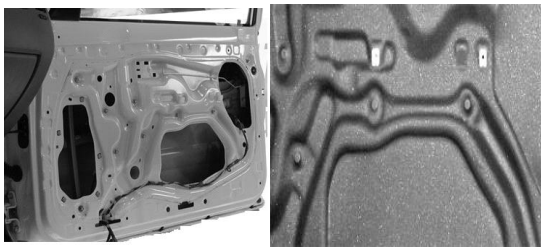

Fig.3.and Fig.4.Before application Vinyl Vibration Damping

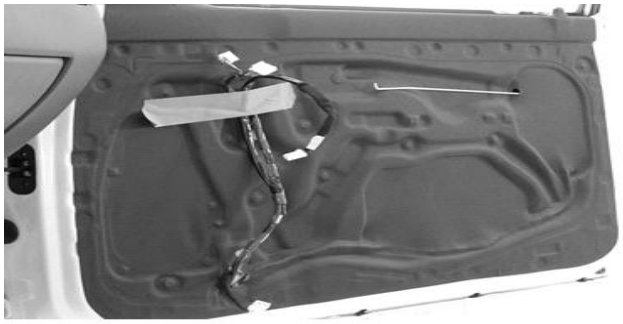

Fig.5.The completed door with VBD installed

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There is another thick, moldable, odorless and lightweight mineral filled vinyl-copolymer formulated to handle the demanding extremes of aircraft vibration and noise control. (fig.6, fig.7(a)and (b)). This is extremely moldable and will stretch up to 70% while withstanding temperatures in excess of 250°F.

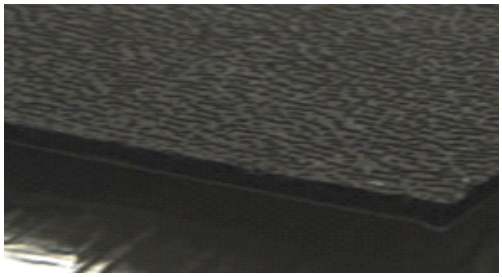

Fig.6. thick Vinyl Vibration Damping surface

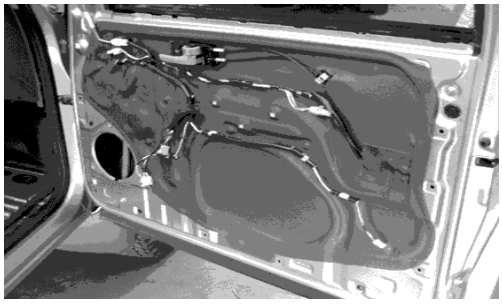

Fig.7(a) Door treated with Vinyl Vibration Damping.

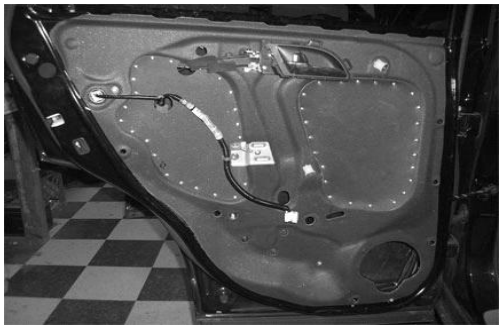

Fig.7(b) Door treated with Vinyl Vibration Damping.

VII. CLD VIBRATION DAMPING SHEET (CONSTRAINED LAYER DAMPER)

Vibration damping sheets are designed to eliminate vibration through sheer force.

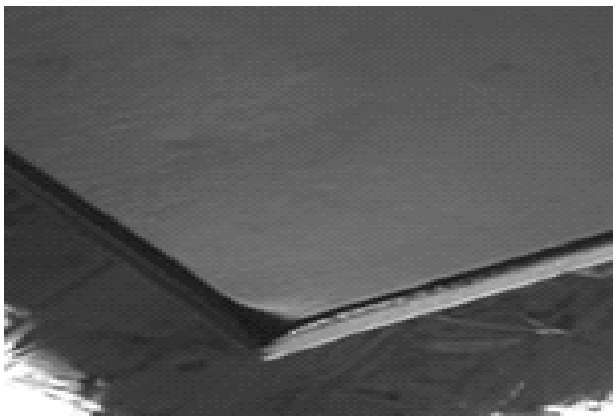

Fig.8. Vibration damping sheet

CLD Vibration Damping Material is a lightweight that is designed to use sheer force to reduce or eliminate vibration. Weight is kept to an absolute minimum while producing the highest performance possible. This features a light weight butylenes layer that is bonded to a 4 mil, black anodized aluminum sheet. (fig.8). The butylenes layer is loaded with ceramic microspheres which reduces the overall weight of the product and increases its resistance to heat. The butyl, or adhesive layer, is very aggressive and the bond will actually improve over time. Another characteristic that is unique to this material is that it can be removed and re-installed easily. (fig.9). In most automotive applications, one layer of CLD vibration damping material is all you will need to properly damp a vibrating substrate.

fig.9. CLD vibration damping material fitted in boot

VIII. AEROSOL VIBRATION DAMPING COMPOUND

This is an advanced vibration damping compound well suited for application onto exterior automotive panels such as inside the fender wells, wheel arches and the underside of the floor pan. (fig.10).This contains a silica-mica and ceramic load to help convert structural resonance and vibration into low level heat through friction. When cured, the product remains soft which allows it to absorb the impact of road debris.

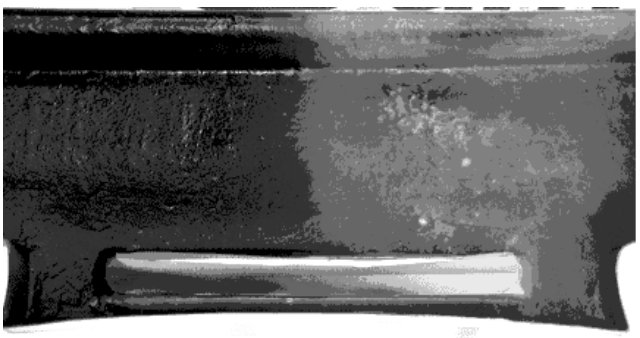

Fig.10.CLD Vibration Damping Material applied onto the backside of a front bumper cover.

IX. USE DEDICATED FLOOR BARRIER MATERIALS TO BLOCK ROAD NOISE.

Low frequency road noise is the largest contributor to the overall noise floor within the passenger compartment. Specialized "floating" barriers are designed to block and reflect high energy sound waves across a wide frequency range. Long gone are the days of using multiple layers of heavy vibration damping sheets.

There are number of specialized barrier materials to help you reduce the time, weight and cost of making your vehicle as quiet as possible.

A. Formable Floor Barrier Material

This is designed to be used over highly irregular areas of the floor pan such as the transmission tunnel and over the wheel arches. It consists of two layers of 1/8" neoprene foam that sandwich a lead core. (fig.11).One lightweight layer of Formable Floor Barrier Material is equivalent to 4 or 6 layers of a heavy vibration damping sheet

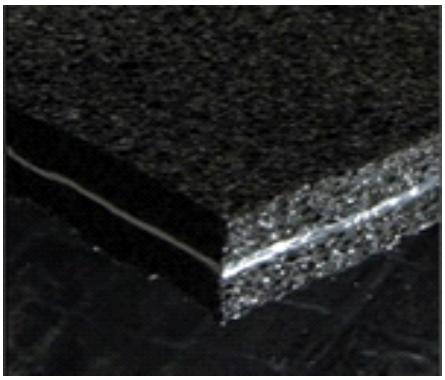

Fig.11. layer of Formable Floor Barrier Material

B. Moldable Road Noise Barrier

This is a composite product that has been engineered to block and reflect high energy, low frequency road noise, an airborne sound, across a wide frequency range. This consists of two 1/8" layers of closed cell neoprene foam that sandwich a 15 mil thick lead sheet. (fig.12). One of the neoprene foam layers will create an "air spring" that floats or decouples the dense layer of lead. It is this air spring that allows for the reflection of high energy sound waves and prevents the sound energy from passing through the dense layer. The foam layer does not absorb sound nor does it "filter" because it is far too thin to absorb high energy, low frequency sound waves. Be cautious of any company that promotes a barrier material in this way. Conversely, this will prevent sound energy from escaping the vehicle which may be of particular interest to those of you who compete in car audio competitions.

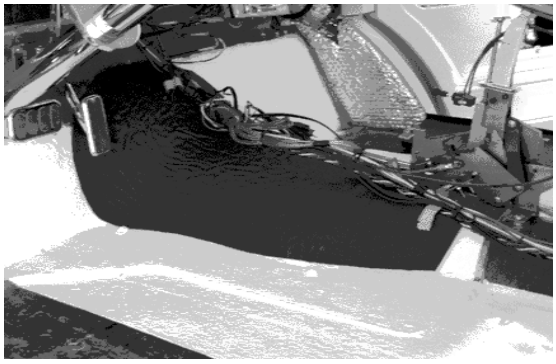

Fig.12.Moldable Road Noise Barrier has been installed over the transmission tunnel. Notice how well the material forms to the irregular shape.

This is a highly formable, moldable product and is well suited for use over highly irregular surfaces such as the transmission tunnel and over wheel arches. Often times when a material is introduced underneath the carpet kit, problems will arise when the center console is installed. This moldable road noise barrier will prevent any fitment issues that come up because it forms to and hold the shape of the sheet metal surface below. Before fixing floor barrier materials, always take time to examine the padding material below the carpet. Some vehicles (i.e. Mercedes, BMW, and Toyota Supra) have a molded foam backing that causes the carpet kit to fit precisely onto the floor pan. If this is the case then, consider using moldable road noise barrier exclusively as it will form absolutely to the shape of the floor pan and the carpet kit will then fit perfectly. Moldable road noise barrier material weighs 1lb ft² and is equivalent to 6 layers of a vibration damping sheet.

C. Flexible Floor Barrier:

This is a composite material with a flexible, loaded vinyl mass barrier, and a foam decoupling layer which reduces road noise by impeding the passage of sound waves. (fig.13).

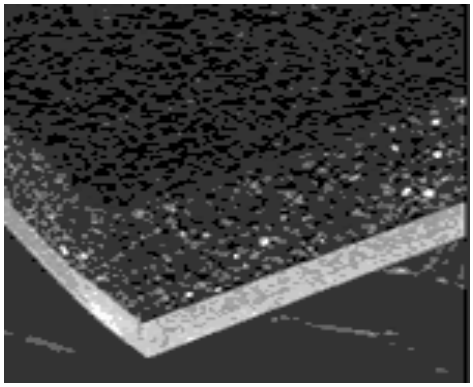

Fig.13. Flexible Floor Barrier

D. Flexible Road Noise Barrier:

Flexible Road Noise Barrier is a composite product that has been engineered to block and reflect high energy, low frequency road noise, an airborne sound, across a wide frequency range. (fig.15). It consists of a closed cell neoprene foam layer that is bonded to a dense 1lb ft² vinyl barrier. The neoprene foam layer creates an "air spring" that floats or decouples the dense layer of vinyl. It is this air spring that allows for the reflection of high energy sound waves and prevents the sound energy from passing through the dense layer. The foam layer does not absorb sound nor does it "filter" because it is far too thin to absorb high energy, low frequency sound waves. Conversely, this material will prevent sound energy from escaping the vehicle. This is used primarily on flat areas of the floor pan and on the floor of the trunk or cargo area. (fig.16). Vinyl barrier is installed onto the floor pan with the neoprene foam side down facing the floor pan. (fig.17).

Fig.14.vinyl barrier installed on the flat areas of the floor pan and firewall.

A common misunderstanding is that vibration damping sheets are designed to block road noise, an airborne sound problem. Although this technique can yield a reduction in the overall noise floor, it requires 4-6 layers of material which will increase the cost, installation time and considerably increases the amount of weight added to the vehicle. Vinyl barrier saves a lot of time, money and hassle by using a dedicated "floating" barrier material first. This weighs 1lb ft² and is equivalent to 6 layers of a vibration damping sheet. Vinyl barrier is a lightweight, composite material with a flexible, loaded vinyl mass barrier, and a foam decoupling layer which reduces road noise by impeding the passage of sound waves.

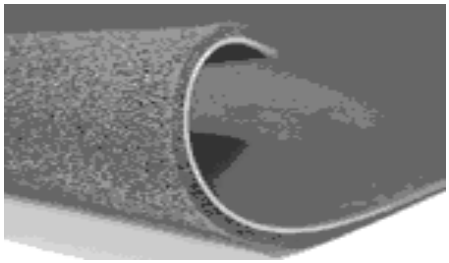

Fig.15.Lightweight, flexible Floor Barrier

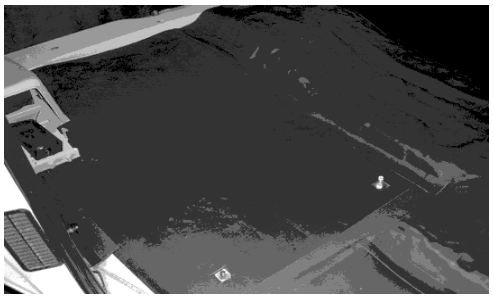

Fig.16.vinyl barrier installed onto the rear floor pan

Fig.17. installed on the flat areas of the floor pan, firewall and back wall of a truck cab

E. Open Cell Foam Vinyl Barrier:

This is a decoupled barrier product featuring an open cell foam bonded to a dense, 1lb ft² vinyl barrier. (fig.18).

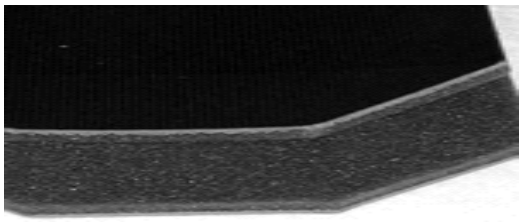

Fig.18. Open Cell Foam

This road noise barrier product is designed to block and reflect high energy sound waves in the form of road noise. Similar to other barrier products, this features an open cell foam layer that is designed to create an air spring or "airspace" below the dense, 1lb ft² vinyl layer. The dense layer of vinyl is not coupled to the supporting structure, in this case the vehicles floor pan, and therefore sound energy is reflected. If the foam layer was not present and the vinyl layer is in direct contact with the floor pan or supporting structure, slightly reduced sound energy will migrate into the passenger compartment because the sound energy perceives the floor pan to be slightly thicker.

F. Thermo-Acoustic Engine / Generator Box Liner:

This liner is the perfect for severe noise control problems. It is especially effective for marine engine compartments and generator housings. This is a unique, high performance composite material incorporating two layers of acoustical foam, a loaded vinyl barrier and an aluminized layer thermally reflective skin. (fig.19).

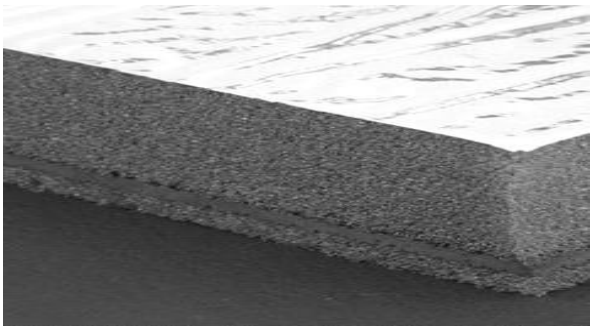

Fig.19. Thermo-Acoustic Engine / Generator Box Liner

A ¼” foam isolation layer decouples the barrier while the 1” thick acoustical foam layer absorbs airborne sound. (TABLE I: and TABLE II)

The aluminized layer surface skin provides thermal protection for use in the extreme environments.

TABLE I:

Sound Absorption Coefficients						
Octave Band Center Frequency (Hz)						
125	250	500	1000	2000	4000	NRC
.33	.24	.63	1.23	1.35	1.14	.85

TABLE II:

Sound Transmission Class
Octave Band Center Frequency (Hz)

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125	250	500	1000	2000	4000	STC
20	21	25	28	32	42	29

X. USE THERMAL CONTROL MATERIALS TO KEEP YOUR VEHICLE COOL AND COMFORTABLE.

Typical automotive applications include treatment of the firewall, floor pan and the underside of the roof, also coating the exterior of air intake pipes to maintain cooler air temperatures.

A. Thermal Control Compound:

This is a thermal insulating coating made up of air filled glass beads held in suspension (fig.20) by a high temp latex acrylic binder.

Fig.20.Thermal Insulating Coating

B. Thermo-Acoustic Under hood Liner:

This is an adhesive backed, low profile combination thermal barrier and acoustic absorber designed to reflect thermal energy and absorb upper mid band and high frequency mechanical noise. (fig.21). The 3/8" high temperature acoustic foam traps air and acts as an insulator while the aluminum layer surface scrim reflects engine heat. Additionally, the foam will trap and dissipate mechanical noise generated by engine components. This was primarily designed as an insulator / absorber product for engine compartments and high heat areas. This can also be used to protect any of the damping or barrier materials in high heat environments.

Fig.21.Thermo-Acoustic Liner applied onto the underside of a hood

C. Thermo-Acoustic Blanket:

The Insulator Thermo-Acoustic Blanket will guard against the intrusion of heat, sound, vibration and airflow. (fig.22). The insulator consists of an all natural cotton fiber layer with surface layers of foil and offers R-6 insulating capabilities.

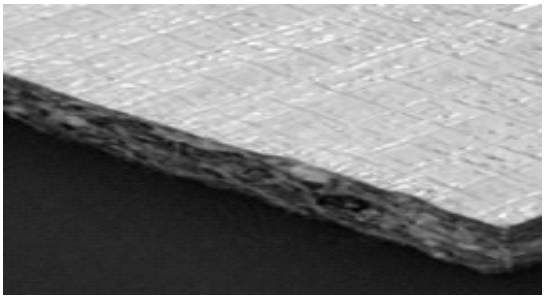

Fig.22.Thermo-Acoustic Blanket

D. The Insulator:

The Insulator is a lightweight, cost effective thermo-acoustic blanket that has been designed to reflect thermal energy as well as absorb mid band and high frequency airborne sound. This material consists of two thin layers of aluminum that sandwich a dense cotton core. (fig.23.and fig.24.).This material provides up to 50% greater R-value than other reflective insulation materials and meets Federal Motor Vehicle Safety Standards (FMVSS 302).

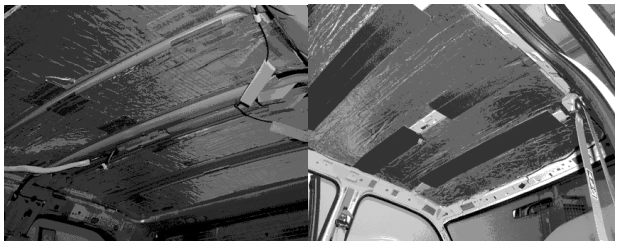

Fig.23.Thermo-Acoustic Blanket applied onto the underside of the roof

Fig.24.Thermo-Acoustic Blanket used to cover surfaces of back wall and quarter panels

E. Thermo-Acoustic Under hood Liner:

This is an adhesive backed, low profile combination thermal barrier and acoustic absorber.

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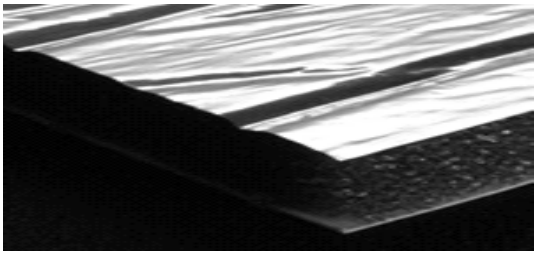

Fig.25. Thermo-Acoustic Under hood Liner

It reflects thermal energy and absorbs upper mid-band and high frequency mechanical noise. (fig.25).

XI. CAR NOISE CONTROL KITS

A. Universal Door Kit:

Vinyl vibration damping material is a highly moldable vinyl damping material that offers the professional results. It is a four 13.5" x 37" sheets (13.88 sq.ft.) of thin, moldable vinyl vibration damping material. (fig.26).This will stretch, mold and bond to the most irregular shapes imaginable. It is ideally suited to replace the plastic vapor barrier behind the door panel. This is one 10" x 10" square of Vinyl Barrier, thin neoprene gasket foam. This material is used in small pieces to eliminate any potential squeaks, rattles or buzzes caused by linkages, cables or harnesses.

Fig.26.Passenger door treated with vinyl vibration damping material

B. Gasketing Foam:

Gasketing foam is commonly used to eliminate annoying squeaks, rattles and buzzes. This is a thin, neoprene product that may also be used to gasket and seal speakers airtight. (fig.27).

Fig.27.Gasket Foam installed behind a linkage rod to eliminate a potential rattle.

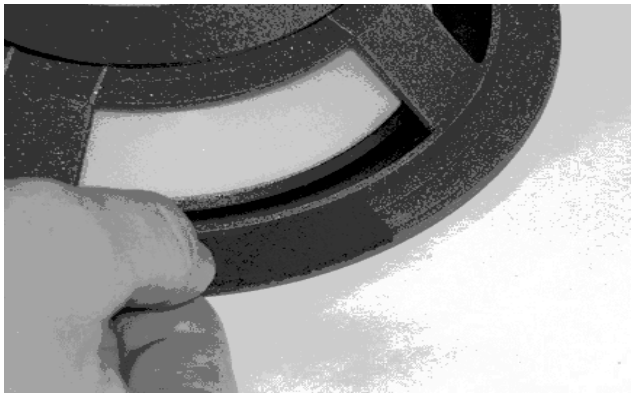

Fig.28.Foam used to gasket the mounting flange of a speaker.

This is thin, closed cell urethane foam designed to decouple independently vibrating structures and eliminate squeaks, rattles and buzzes.(fig.28).This features an aggressive, modified acrylic adhesive which makes it suitable for exterior applications and is impervious to water and harsh chemicals.

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