

Aqueous Heat Reflective Coating for Engine Compartment Isolators

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ABSTRACT

To satisfy the increased expectations of customers, engineers are challenged to increase fuel economy while also improving noise, vibration, and harshness (NVH) performance. In order to improve fuel economy, engine compartment designs have become more compact with reduced air flow. Elevated temperatures caused by these designs can degrade the durability and acoustic performance of the fibrous acoustic insulator material. A typical method for protecting insulators from elevated temperatures is to apply an aluminum foil patch to the surface. However, foil patches can restrict the insulator's ability to absorb sound and can be difficult to apply to complex part shapes. Foil patches can be perforated to allow the insulator to absorb sound, but there is a cost penalty as well as potential for long term performance degradation due to blocked perforations. Since NVH targets are also increasing, it's important to maximize the benefit of each part. Given these performance challenges, a heat reflective coating (HRC) has been developed as a cost effective alternative to perforated foils. HRC can be easily spray applied directly to the insulator surface and reduces the operating temperature of parts exposed to radiant heat. The thickness of this coating can be controlled to allow the insulator to maintain sound absorption performance. HRC has also been formulated as an aqueous coating to reduce environmental restrictions along with a flame retardant package to meet UL94-V0 requirements. This paper will discuss this new type of heat protection solution for fibrous insulators.

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INTRODUCTION

Engineers are faced with meeting the corporate average fuel economy standards while improving noise vibration and harshness (NVH) performance. Vehicles are increasingly utilizing underbody covers and new engine technology to meet these requirements. Engine compartment designs have become more compact with restricted air flow. Underbody covers can cause elevated engine bay temperatures by reduced air flow for cooling. Elevated temperatures are of a particular concern for fibrous acoustic insulators. They can degrade the durability and acoustic performance of the material in the engine bay. Selecting heat protection countermeasures that are light weight, low cost, and maintain NVH performance are important to help meet model development targets.

The previous generation of heat protection for insulators utilized aluminum baffles to reflect heat away from the insulator. Although effective at heat protection, the cost and weight were higher than the more recent method of bonding

aluminum foil patches to the insulator. However, absorption studies show that as the relative foil patch size increases, absorption performance significantly decreases. In order to counteract this affect, a heat reflective coating (HRC) was developed to reflect radiant heat while allowing sound to be absorbed by the insulator. This paper is organized in the following manner to describe the processes and testing that were required to develop this novel solution:

- Discussion
- Development Concept
 - Technical Challenges
 - Radiant Heat Reflectivity
 - Adhesion
 - Chemical Resistance
 - Sound Absorption
 - Flame Resistance
- Coating Application



- Technology Overview
- Conclusions
- Future Considerations

DISCUSSION

Vehicle trends have model development teams adding underbody and engine bay covers to improve aerodynamics. Aerodynamics affects fuel economy. Fuel economy can be improved through full underbody coverage. Maximum coverage will accelerate the airflow below the vehicle and further improve driving performance and improve fuel consumption. At 70 mph, aerodynamic drag accounts for ~ 50% of the energy loss. [1]

However, aerodynamic covers restrict air flow and cause engine compartment temperatures to rise.



Figure 1. Underbody Cover

Engineers are also challenged to improve NVH performance. Insulator covers are used to dampen sound. Adding acoustic absorbers near the noise sources can be an effective means of reducing noise. These noise sources are also sources of heat. This, combined with restricted air flow, can result in higher part temperatures. High temperature can degrade the physical integrity of the absorber materials, causing degradation of the material properties and absorption performance of the insulators. Multiple engine insulators can be affected including hood, dash upper and dash outer insulators.

Since heat can adversely affect absorption performance, engineers design ways to provide heat protection for the insulators. Traditional heat protection solutions included adding aluminum baffle plates and attaching them to the body of the vehicle. Figure 3 illustrates an aluminum baffle. These are being replaced with aluminum foil patches that are bonded to the insulator. This design is illustrated in Figure 4. The foil patch approach was selected as the countermeasure to excessive temperatures during hill climb simulations because it offered a 9% reduction in cost and a 40% reduction in system weight.

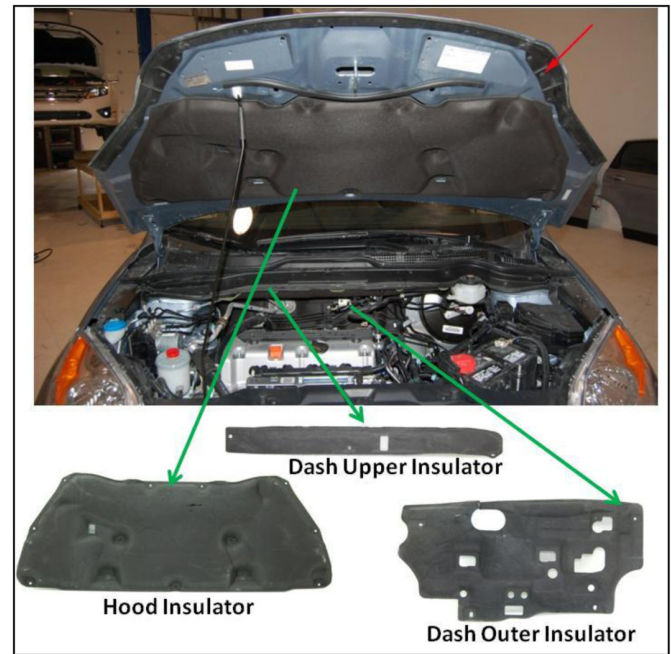


Figure 2. Engine Compartment Insulators

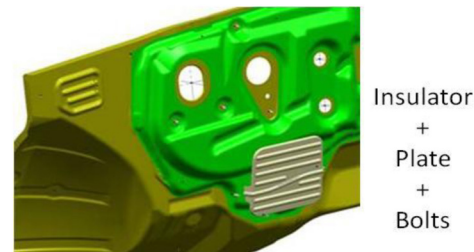


Figure 3. Baffle plate construction includes insulator plus plate and bolts.

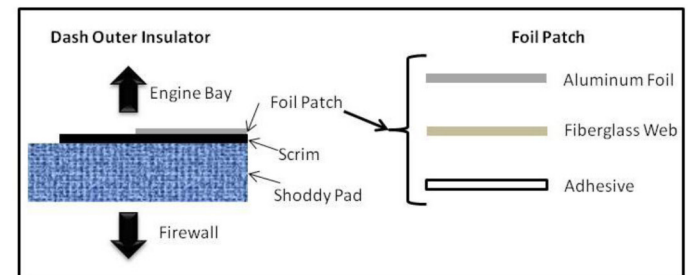


Figure 4. Foil patch part construction



Figure 5. Foil patch method selected as countermeasure

Although the foil patch provided the necessary heat protection to the insulators, it raised concerns in NVH performance, appearance and formability. At the same time, as the engine room becomes smaller, the heat increases, and the areas on the insulators requiring protection become larger.

To that end, random incidence acoustic absorption performance was measured by UGN, Inc. using the Alpha Cabin (small reverberant room method). All samples tested were on 3F-TACA with a standard 75g/m² scrim. Nominal sample thickness was 20mm. Evaluation was done with five levels of treatment coverage (1.2 × 1.0m sample divided into nine equal sections). Figure 6 shows the insulators with the portions covered with foil.

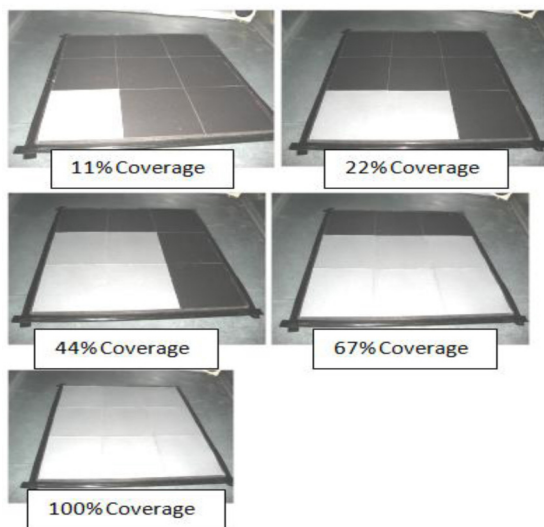


Figure 6. Percent treatment coverage for acoustic evaluation.

The standard non-perforated foil degraded the acoustic absorption of the 3F-TACA pad because it acts as an impervious membrane.

In short, as the relative surface area of the foil patch increases, the sound absorption decreases.

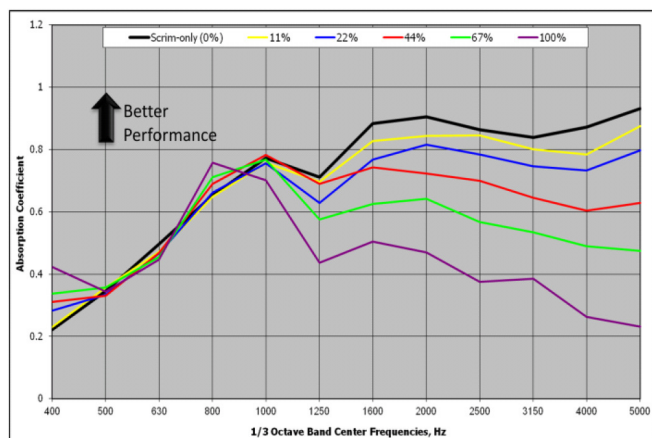


Figure 7. Random incidence absorption at various foil coverage. (Alpha Cabin)

To maintain part performance, an alternate heat protection method was needed. One method was a perforated foil patch. The perforations can be tuned to allow sound absorption. However, there are concerns with this approach:

1. The cost is higher than standard foil
2. Long term NVH performance due to pore blockage
3. Lacks formability over complex 3D part shapes

Development Concept

The concept of using a coating for engine compartment insulators require that the coating film be porous, reflect significant amounts of heat, meet critical material requirements, and be cost effective. The goal was to develop cost effective heat protection countermeasure that maintains sound absorption performance of the part when applied to a large area.

Table 1. Sound absorption targets.

Targets: Key: = Equivalent - Worse + Better

Heat Protection Method	Cost	Weight	Heat Resistance	Sound Absorption
Standard Foil Patch	=	=	=	=
HRC	=	=	=	+
Perforated Foil Patch	-	=	=	+
Baffle Plate	-	-	=	=

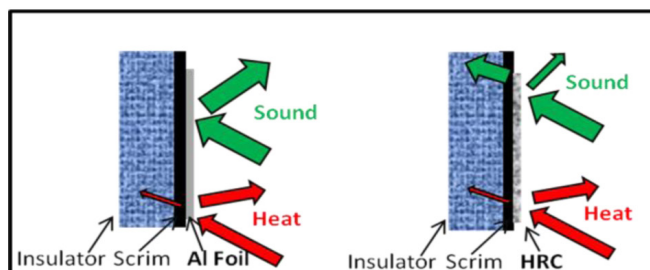


Figure 8. HRC-11 maintains sound absorption performance of the part when applied to a large area.

Technical Challenges

Development of this technology came with technical challenges. The coating was required to have the following material properties:

- Aqueous
- Reflect radiant heat
- Adhere to the insulator
- Offer chemical resistance
- Sound absorption properties
- UL94 flame resistance