

# Module Wire Harness with Sound Absorbing Function

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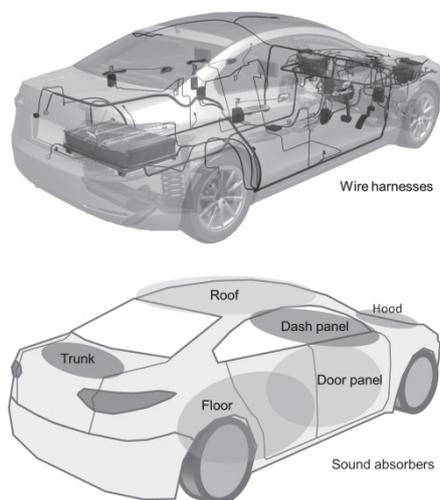
In accord with recent trends of environmental consideration and pursuit for comfortableness of hybrid vehicles have been popular. Simultaneously, higher functionality in vehicles requires increasing number of electrical components. Such vehicles mount sound absorbers in every corner in the vehicle for silence. These hybrid vehicles and luxury vehicles increasingly adopt high performance sound absorbers. On the other hand, as in-vehicle electrical components increase, the number of parts to manage are also increasing at car plants. Thereby, functional integration for reduction of parts is enhanced by modularization. We developed modularization technology with wire harness and sound absorber. The technology realized reduction in both components to manage and work process at plants, and has been adopted at major car manufactures.

Keywords: low pressure wire harness, sound absorber, nonwoven fabric, modularization, technology for mounting on vehicles

## 1. Introduction

In recent years, quietness in vehicles has been increasingly demanded. In these circumstances, development and adoption of high performance sound absorbers has been actively carried out. Furthermore, in conjunction with the higher functionality and enhanced safety of vehicles, the numbers of electrical components tend to increase from year to year. Wire harnesses\*<sup>1</sup> that establish connections between pieces of equipment are mounted in narrow spaces similarly to the way blood vessels are located in human bodies.

**Figure 1** shows sound absorbers and wire harnesses mounted on a vehicle.

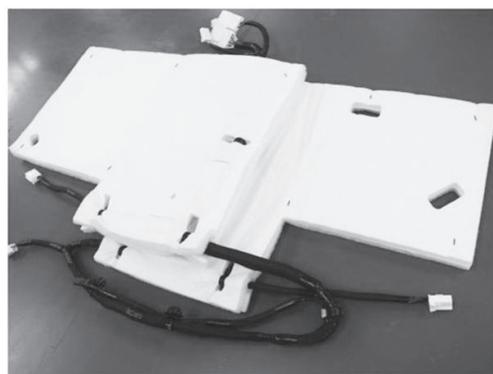


**Fig. 1.** Wire harnesses and sound absorbers mounted on a vehicle

In response to such user needs, the numbers of parts controlled continues to increase in vehicle assembly plants, with the result that increased workload

and work complexity are regarded as issues. This being so, modularization, in which parts functions are integrated and the numbers of parts reduced, has been promoted.

Sumitomo Wiring Systems, Ltd. and AutoNetworks Technologies, Ltd., both of which are members of our company group, have modularized together sound absorbers and wire harnesses, and have, in cooperation with automobile manufacturers, realized the work of mounting these modularized assemblies on vehicles. These modular wire harnesses into which the sound absorbing function is introduced (hereinafter referred to as “Sound Absorber AssyWH” or “Sound Absorber AssyWHs,” respectively, depending on the singularity or plurality of the term) can realize reductions in the numbers of parts controlled and the numbers of work processes in vehicle assembly plants. **Photo 1** shows a product that was adopted.



**Photo 1.** Sound Absorber AssyWH

## 2. Specifications of Modularization

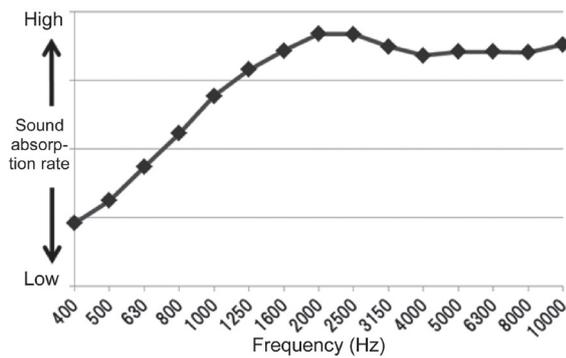
Protection elements for preventing abnormal sounds are installed in wire harnesses mounted on vehi-

cles for the purpose of preventing abnormal sounds from being produced during interference with surrounding parts caused by vibrations. Meanwhile, sound absorbers are also mounted in various places in vehicles, in such a way as to be located adjacent to wire harnesses in terms of a positional relationship. We paid attention to the buffering properties (abnormal sound prevention function) of nonwoven fabrics, and devised a structure in which a wire harness is held between two nonwoven fabrics.

Described below are the sound absorbing performance and modularized structures, which are elemental technologies for Sound Absorber AssyWHs.

### 3. Sound Absorbing Performance of Absorber AssyWHs

In order to absorb various noises in vehicles, it is necessary that high sound absorbing performance be provided over a broad frequency band. The sound absorbing performance shown in **Fig. 2** was set as a target.



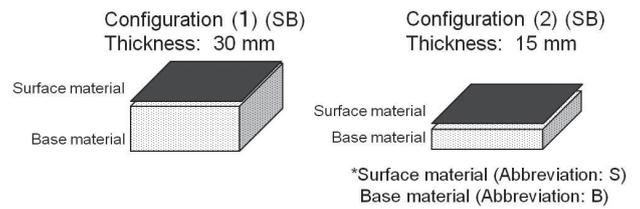
**Fig. 2.** Target sound absorbing performance

A well-known approach is where the thicknesses of sound absorbers are changed to improve the sound absorbing performance of sound absorbers. The relationship between sound absorber thicknesses and sound absorbing performance is shown in **Equation (a)**. When a sound wave is reflected by a solid wall, a standing wave\*2 is formed. At a position  $\lambda/4$  ( $\lambda$  = sound wave length) away from the solid wall, the sound wave energy shows the maximum value. For this reason, by placing in position a sound absorber having a thickness of  $\lambda/4$  shown in **Equation (a)**, effective sound absorption is carried out<sup>(1)</sup>.

$$\lambda/4 = C/(4f) \dots\dots\dots (a)$$

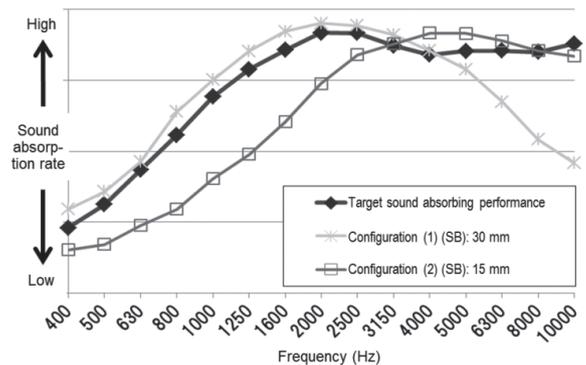
where f is the frequency of sound (Hz), and C is the speed of the sound wave in air, 340 m/s at 15°C.

Furthermore, it is known that the sound absorbing performance can be improved across all frequency bands by bonding the following two types of items into a single item: a “surface material” in which the airflow quantity is controlled by increasing the surface density of a nonwoven fabric; and a “base material” in which the thickness is controlled by lowering the surface density of a nonwoven fabric. We thought that even in a sound absorber in which a “surface material” and a “base material” are bonded together, there would be a relationship between sound absorber thicknesses and sound absorbing performance. Therefore, we made adjustments by fabricating sound absorbers that have different thicknesses and are shown in **Fig. 3**.



**Fig. 3.** Chart of visualization of samples of thickness-adjusted sound absorbers

The sound absorbing performance of sound absorbers in which adjustments of thicknesses were made was measured, and the measurements were compared with the target sound absorbing performance. The results are shown in **Fig. 4**.



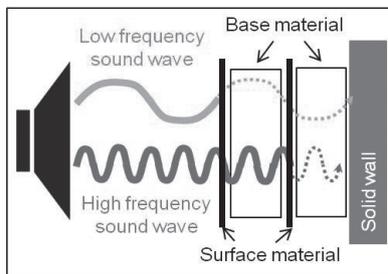
**Fig. 4.** Comparison of the sound absorbing performance of sound absorbers having different thicknesses

The sound absorber of Configuration (1) shows the following tendency: The sound absorbing performance in low frequency bands is high; the sound absorbing performance in high frequency bands is low. The sound absorber of Configuration (2) exhibits the following

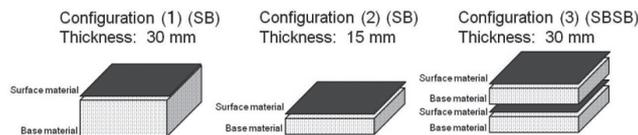
tendency: The sound absorbing performance in high frequency bands is high; the sound absorbing performance in low frequency bands is low. It was found from the above that sound absorbing performance varies with changes in sound absorber thicknesses. However, a trade-off relationship is noticed between sound absorber thicknesses and the frequency characteristics of sound absorbing performance. The sound absorbing performance was inferior to the target sound absorbing performance.

Changes in sound absorber thicknesses lead to changes in distances between the “surface material” and the wall. Sound absorbing performance varies with changes in thicknesses. Such being the case, we paid attention to the positional relationship between the solid wall and the “surface material” of the sound absorber. As indicated in the schematic shown in **Fig. 5**, if the “surface material” is located at a position close to the solid wall, high frequency sound waves are absorbed, and if this element is located at a position far from the solid state, low frequency sound waves are absorbed. Therefore, we set up the hypothesis that if a sound absorber is configured in such a way as to have both of the above-mentioned positional relationships, then both low frequency sound waves and high frequency sound waves will be absorbed.

Consequently, as indicated in Configuration (3) shown in **Fig. 6**, a sound absorber was configured in such a way that two sound absorbers of Configuration (2) were placed on top of each other, resulting in the thickness being equal to that of Configuration (1).

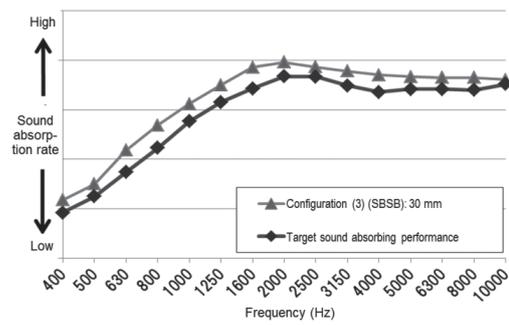


**Fig. 5.** Schematic of the effectiveness of a surface material



**Fig. 6.** Chart of visualization of samples of the features of sound absorber configurations

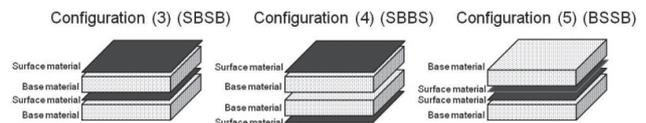
**Figure 7** shows the target sound absorbing performance and the sound absorption rates of Configuration (3), which has a two-layer configuration.



**Fig. 7.** Sound absorbing performance of Configuration (3) (SBSB)

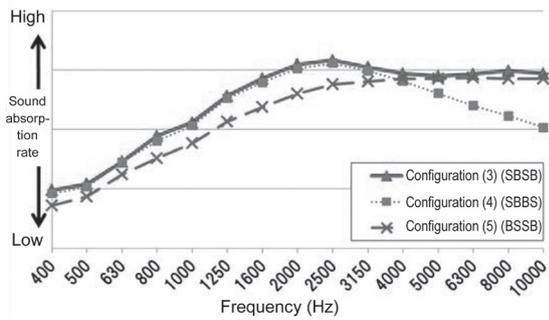
In the case of Configuration (3), it was possible to achieve high sound absorbing performance over broad frequency bands, similarly to the case of the target sound absorbing performance.

Furthermore, for the purpose of verifying the sound absorbing mechanism of Configuration (3), we took measurements of the sound absorbing rates of the sound absorber configurations shown in **Fig. 8**. Configuration (4) was configured in such a way that “surface material” were present on the outermost surfaces, and that no “surface material” was present in any intermediate position. Configuration (5) was configured in such a way that “surface material” were present in intermediate positions, and that no “surface material” was present on either outermost surface.



**Fig. 8.** Chart of visualization of sound absorber configurations

**Figure 9** shows the sound absorbing performance of Configurations (3), (4), and (5). The following tendencies were exhibited by Configurations (4) and (5), compared to Configuration (3): In Configuration (4), the sound absorbing performance in the high frequency range became low; in Configuration (5), the sound absorbing performance in the low frequency range became low. On the basis of the above, the sound absorbing mechanism of Configuration (3) is considered to be as follows: The “surface material” on the outermost surface causes the properties of a thick sound absorber to appear; the intermediate “surface material” that are held between a “base material” and the other “base material” causes the properties of a thin sound absorber to appear; as a result, high sound absorbing performance can be exhibited for a wide frequency range.



**Fig. 9.** Comparison of the sound absorbing performance of sound absorbers having different configurations

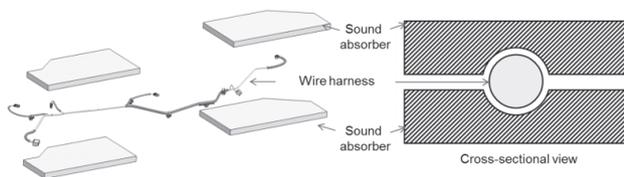
In the case of this technology, it is possible to control sound absorbing performance in specific frequency bands and over broad frequency bands by adjusting the following items: the specifications of “surface material” and “base material”; and the configurations of the sound absorbers. For this reason, it is possible to design sound absorbers appropriate for the noises that are generated. Consequently, it is expected that vehicle interior silence will be further improved.

#### 4. Specifications of Products

##### 4-1 Structure where wire harness and sound absorbers are modularized together

Generally, protection elements for preventing abnormal sounds installed in wire harnesses serve to protect wire harnesses from surrounding parts in perimetric directions, in such a way that these protection elements are wound around the wire harnesses.

For the purpose of causing sound absorbers to provide perimetric protection to wire harnesses, similarly to the case of protection elements for preventing abnormal sounds in wire harnesses, we devised a structure where a wire harness is held by two sound absorbers shown in **Fig. 10**, and we have confirmed that there is no problem with sound absorbing performance either.



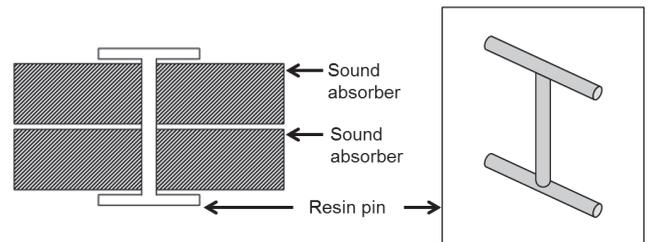
**Fig. 10.** Structure where a wire harness and sound absorbers are modularized together

By holding a wire harness between two sound absorbers, it becomes possible to integrate together

the abnormal sound preventing function and the sound absorbing performance function. Furthermore, a wire harness held between two sound absorbers becomes capable of being routed linearly. Therefore, it is possible to improve the degrees of freedom of wire harness routing paths.

##### 4-2 Fixing sound absorbers to each other

As the method of fixing two piled-up sound absorbers to each other, general purpose resin pins were adopted. **Fig. 11** shows a structure in which sound absorbers are fixed to each other with a pin.



**Fig. 11.** Fixing with a resin pin (Cross-sectional view)

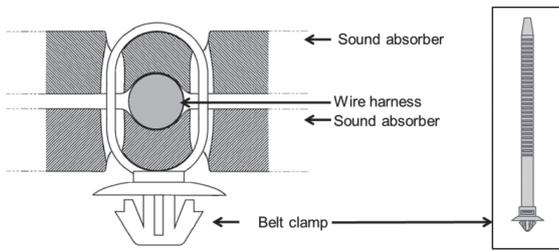
Generally, deposition is used to fix nonwoven fabrics to each other. However, in the course of deposition, it is necessary to apply heat to such an extent as to melt the sound absorbers, and to compress the deposited portions. Therefore, it is presumed that sound absorbing performance will be degraded.

In this respect, the use of resin pins does not entail heating. Also, it is possible to select resin pins of an appropriate length. Therefore, by using resin pins, it became possible to fix two sound absorbers without crushing them. Furthermore, the diameters of resin pins are small. Therefore, the processing areas for permitting sound absorbers to be fixed to each other are smaller than in the case of deposition. Consequently, the negative effects on sound absorbing performance can be minimized.

##### 4-3 Fixing together wire harnesses and sound absorbers

For the method of fixing together wire harnesses and sound absorbers, clamps were selected, which are generally used to fix wire harnesses to vehicles. In particular, belt clamps are structured in such a way as to be capable of being wound around wire harnesses. **Fig. 12** shows a fixing method that uses a belt clamp.

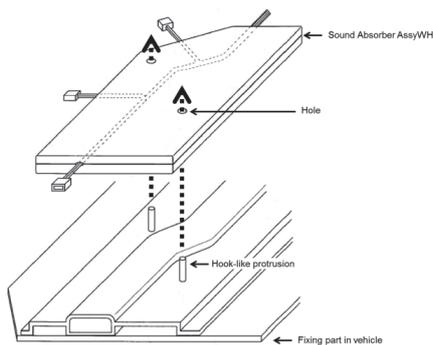
Sound Absorber AssyWHs can be installed in vehicles similarly to the case of conventional wire harnesses for the following reasons: Wire harnesses and sound absorbers are clamped together by belt clamps; fixing parts are made to serve fixing both wire harnesses and sound absorbers. Consequently, positioning work for sound absorbers is facilitated, with the result that it is possible to improve the installation accuracy.



**Fig. 12.** Fixing together a wire harness and sound absorbers (Cross-sectional view)

#### 4-4 Mounting Absorber AssyWHs on vehicles

For the method of mounting Sound Absorber AssyWHs on vehicles, a structure was devised, in addition to the utilization of the clamps mentioned in paragraph 4-3, in cooperation with automobile manufacturers. This structure is as follows: Openings are provided in sound absorbers; hook-like protrusions provided in fixing parts in vehicles are made to be inserted into these openings. **Figure 13** shows a structure in which protrusions are inserted into holes in a Sound Absorber AssyWH.



**Fig. 13.** Structure in which protrusions are inserted into holes in a Sound Absorber AssyWH

In vehicles, there are positions where clamps cannot be installed. However, due to the above-mentioned structure, Absorber AssyWHs can be collectively mounted, even in these positions, in wire harness installation processes in vehicle assembly plants. In the past, dedicated parts and equipment, such as deposition devices, tackers\*<sup>3</sup>, and double-sided adhesive tape, were required to install sound absorbers in vehicle assembly plants. However, in the case of the aforementioned structure, no use is made of such parts or equipment, with the result that it is possible to reduce the numbers of sound absorber installation processes.

## 7. Conclusion

Success was achieved in developing Sound Absorber AssyWHs having the following features:

- (1) The numbers of parts to manage and work processes in vehicle assembly plants are reduced.
- (2) Needs for sound absorption at specific frequencies and over broad frequency bands are dealt with.
- (3) The degrees of freedom of wire harness routing paths are improved.
- (4) Sound absorber installation accuracy is improved.

Rapid progress is made in the activities for the following items that are based on the integration of functional parts: reduction of numbers of parts; and improvement of installation workability. For the purpose of making a contribution to modularization activities from now on as well, technical development will be pushed forward with the aim of expanding the application of these activities.

### Technical Terms

- \*1 Wire harness: A set of electrical wires which electrically connects electronic parts and electrical equipment mounted on vehicles, copy machines, printers, etc., and which relays the transmission of reciprocal information and electric power. A wire harness consists of electrical wires, protection elements, clamps, etc. The roles of individual wires constituting a wire harness include provision of electric power supply, transmission of signals, etc.
- \*2 Standing wave: In the case where one end of a tube is closed, while the other end is open, it follows that if a traveling wave is generated by emitting a sound from the open end of this tube, the sound is reflected by the closed end, resulting in the generation of a regressive wave. At this time, both waves interfere with each other and can be observed to result in a standing amplitude. This phenomenon is referred to as a standing wave.
- \*3 Tacker: This equipment is also called a tacking device. This is a tool whereby U-shaped staples are thrust into cloth-like or net-like articles, thereby fixing these articles.

### References

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