Acoustical Standards in the Mobility Industry

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I would like to share some of my thoughts with you on developing a few sound package material standards that we use quite regularly in the mobility industry. These standards have been developed by the Acoustical Materials Committee, a standards group, under the Technical Standards Board of SAE International. These and many other standards are routinely used by sound package materials engineers in the automotive, commercial vehicle, and off-highway vehicle industries. I have included some of these standards in Table 1.

A specification is a document that can be very specific in terms of expectations and findings. A specification is developed by the user of a product or a commodity; for example, a specification for an absorber material that will be used in a vehicle. The specification may indicate what procedure or methodology should be followed to determine the property or performance of a product. The specification could be so specific that it may not only say what the maximum background noise level should be of the environment where measurements will be made, but it may also say where the measurements should be made. The procedure or the methodology could be available in a standard, or it could be a unique approach that has been developed or endorsed by the user.

A standard on the other hand is a document that includes a procedure, a methodology, and/or information that can be followed to evaluate the performance of a product, or assess the properties of a product, or something similar that will allow one to understand how the product performs in relation to a competitive product. Standards are generated by organizations (such as SAE International) where individuals from different sectors and disciplines with the same interest participate to develop the standard. The purpose of the standard is to identify a methodology that should be followed to get meaningful measurements characterizing the material performance. A standard also identifies the limitations and concerns that a test method may have.

A standard should not be specific in terms of endorsing any companies or manufacturers who may be able to construct a test room or a test instrument, but if necessary (also depending on the specialty and uniqueness of the product), may recommend a few names at the end of the standard. Likewise, a standard should not have any acoustic target, unless it is really unique to the program and necessary to make a valid measurement.

Here, we will discuss the development of three SAE sound package material standards for measuring the acoustic performance of absorbers, barriers, and dampers.

Absorption standard SAE J2883 is designed for conducting random-incidence sound absorption testing using a small reverberation room. The key reason for developing and publishing this standard in 2015 has been to test samples that are small and of comparable size to that of the parts that are actually used in the application. The ASTM C423 standard that is widely used for absorption measurements requires that a 6.7 m^2 sample be tested in a 200 m^3 reverberation room and has the potential to provide data from the 125 Hz, 1/3-octave frequency band and up. The samples and parts used in the mobility industry are much smaller than 6.7 m^2 and generally don't provide much acoustical performance below the 315 Hz, 1/3-octave frequency band. The size of the samples along with the frequency dependency on the performance presented an opportunity for SAE to have a unique standard using a small reverberation room. Some of the uniquenesses of the test method are:

- Suitable to test actual parts and components that are generally small
- Test small, flat samples
- Easy to ship samples and parts and components due to size
- Less expense to build a small reverberation room and takes less space

Table 1. Sound standards from various industries.

Types of Tests		SAE	ASTM	ISO	JIS
Airflow Resistance			C522	9053	
Sound Absorption	Normal Incidence		C384	10534-1	A 1405-1
			E1050	10534-2	A 1405-2
	Random Incidence	J2883 (Small reverb room)	C423	354	A1409
Sound Trans. Loss	Normal Incidence		E2611		
	Random/Field Incidence		E90	10140-2	A1416
		J1400			
			E2249 (SI)	15186-1 (SI)	A 1441-1 (SI)
		J2846 (IL)			
Damping	Geiger	J671			
	Oberst	J1637	E756		
	Mechanical Impedance			16940	G0602

Sound transmission loss (STL) standard SAE J1400 is designed for conducting a sound transmission loss test using a small receiving room. The initial work of developing a measurement procedure for conducting sound transmission loss of samples that are more suitable for the mobility industry started in the late 1960s at the OEMs test labs. The thought was: "I can justify having a large reverberation room in my lab where I can do sound absorption tests (this measurement would be made using ASTM C423) and I can also use this room as the source room for STL tests. But do I really need to have another reverberation room in my lab to be used as a receiving room that is the basis of the ASTM E90 test method?"

So, work started to understand what the receiving room could be for one to make an STL measurement correctly without using two reverberation rooms. In the mid and late 1970s, this work was also pursued by a few suppliers of sound package materials that had the capability to conduct sound transmission loss tests. The receiving room used was a very small enclosure, where the construction ranged from a typical space made of a partition wall to an anechoic termination.

Numerous different measurement approaches were used to determine the STL performance, starting from noise reduction measurements and combining that value with the inherent loss of an opening, to combining that value with 6 dB that was considered to be the difference in sound level measured in a reverberation room and just inside an adjacent anechoic room. This is indicated in the attached document.

Eventually, the SAE J1400 standard was developed and published in 1982, based on the use of a reference material whose sound transmission loss can be computed from theory. The reference material is used to generate a frequency-dependent correlation factor used to adjust the reference material's measured noise reduction to its theoretical STL. This correlation factor is applied to the measured noise reduction of the unknown sample to determine its STL. The size of the opening between the source room and the receiving room is generally small (somewhere between 0.51 m × 0.51 m to about 1.2 m × 1.2 m). This was justified by the fact that the actual test parts in the application were also small. As a result, we have the SAE J1400 test method. The standard had a minor revision in 1990, and a major revision in 2010.

Sometimes, when people from the same industry work on a program, they often take certain things for granted. A similar situation happened when the SAE J1400 was initially being developed. Although all participants on the committee were knowledgeable in acoustics, they forgot to mention that the source room needs to be a reverberation room and that the size of the room along with the size of the opening played a key role in establishing the lowest frequency where the measurements will be meaningful. These have been revised in the 2010 version of the standard along with the use of a revised equation to compute the field incidence STL of the reference material to obtain the correlation factor that is necessary for determining the STL of the test sample.

Vibration damping standard SAE J1637 is designed for conducting damping test to obtain composite loss factor values. This standard was released in 1993 with a revision in 2007. However, work for understanding the feasibility of a standard like this started in 1986. An acoustical engineer was given an assignment to sort out much data obtained from Oberst-bar damping tests done by different suppliers. Unfortunately, the results did not make sense. All results were provided at 70° F and at 200 Hz with no other information. While it is possible to get data at 70° F, it is not possible to get data of all different materials at 200 Hz unless some processing is done with the measured data. Also, the data provided were identified as a loss factor. A lot of questions were raised on the data, and eventually they were cleared up. The final conclusions were:

- Different types of bars were used to do the study although they were all steel bars. These included spring coil, cold-rolled mild steel, precision-gauge, and other types of steel bars.
- The damping values provided in terms of loss factor were the combined performance of the damping material bonded to a steel bar. This performance will depend not only on the damping material but also on the size of the bar, including its thickness and free length.
- Different size bars, including length and thickness, were used in this study, where the resonance frequencies for different modes were not even close to one another. The data provided were normalized in some fashion to 200 Hz but was not mentioned.

All of these prompted the development of an SAE standard using a thin bar. As a part of the process of developing a standard, questions were asked and discussions were held to understand the following:

- What test methods are available in the industry for measuring the vibration-damping performance of a visco-elastic material?
- Benefits and limitations of the existing methods.
- Basis and benefit for developing an SAE standard for measuring the damping performance.
- Benefits and limitations of a Geiger plate test and an Oberst-bar test.
- Whether to have a test procedure for determining the material property or the composite property and whether to test the bars with or without roots.

Effort in developing another standard. Currently, the Acoustical Materials Committee is studying the feasibility of developing a different type of vibration damping test method, where a bar will be excited at the center using a shaker and the vibration response measured in terms of acceleration for the input force excitation. This is a mechanical-impedance method and is often called the center-point method. Studies have shown that this method could be related to the Oberst-bar test method (SAE J1637). Key benefits of this method are to be able to excite and test non-ferrous bars and relatively thick steel bars that are difficult to excite in the Oberst-bar test.

I hope this information gives you some understanding on the process of developing a standard, and why the standard may need to be revised periodically.If you would like to share your views on this, you can send me an e-mail at prsaha@kandse.com. SV