Sensors are a key part of the shock and vibration tests performed on mission-critical automotive and aerospace products. Unless the sensors are applied properly to the product under test, the data-acquisition system will collect faulty data.

To learn more about the proper use of sensors during shock and vibration tests, I spoke with Craig Aszkler, the director of sales and marketing for vibration, electronics, and acoustics at PCB Piezotronics, a manufacturer of products such as accelerometers, sensors, and transducers.

Q: What roles do environmental stress screening (ESS), highly accelerated stress screening (HASS), and highly accelerated life testing (HALT) play in automotive and aerospace test?

A: Typical HALT/HASS/ESS applications usually involve product or component life-cycle testing, and ensuring that what is being tested will not only survive, but will continue to function reliably, in a particular application environment, over its planned lifetime. Usually, this is conducted in an accelerated testing environment, which will uncover design flaws and potential areas of product failure and contamination before that product is introduced to market.

When customers are interested in conducting those sorts of tests, sensors are critical for helping to determine pass/fail criteria of the products and testing chamber environment. If an automotive company is performing tests to monitor component life cycles, we supply sensors that are used in both the monitoring and control loop of the chamber, as well as on the test component itself. Examples would be the monitoring of an air-conditioning compressor for planned installation into automobiles, a mirror, steer wheel, suspension, or brake component. In the aerospace industry, it's pretty much the same scenario of product and related component life-cycle testing, although the components are typically going into a test setup for testing such components as compressors, guidance systems, electronics, and other internal or external hardware.

Q: What are some practical tips for mounting sensors and calibrating test setups?

A: Proper mounting of sensors and proper cable strain relief is critical when performing full-frequency sweeps during calibration. One of the most important considerations of mounting accelerometers is the effect that the mounting technique itself has on the accuracy of the sensor's measured frequency response. Good sensors can fail calibration due to poor mounting and strain-relief techniques.

At lower frequencies, it is essential to have a cable properly tied down and secured, as cable motion can affect the overall response of a calibrated sensor below 100 Hz.
For higher-frequency measurements, a smooth, flat mounting surface is important, as well as either stud mounting with silicon grease, or semi-permanent or permanent adhesive mounting to ensure good high-frequency response. Care should be exercised in selecting and testing an adhesive, when concern exists regarding the possible discoloration or damage to the test structure finish. Also, be sure to use a debonding agent to soften the adhesive before removing the sensor from the structure.

Stud mounting typically yields best results when calibrating, and should be used whenever possible. Particular attention should be paid if an adapter is used between a test accelerometer and a reference sensor, or back to back, because the mounting adapter itself can also affect the frequency response. Having an adapter of minimum size and maximum stiffness for the sensor type is important.

Another important mounting consideration is to ensure that proper cabling is strain relieved with a service loop. Two of the larger issues encountered in testing environments, from a troubleshooting perspective, are cable and cable strain-relief issues. The most common problems we see is poor cabling, where the cable is not tight enough on the sensor connector, which results in intermittent failure.

Q: Are there special challenges associated with data acquisition and analysis?

A: When using sensors with data-acquisition systems, one might find that sensors respond to all frequencies in and above the frequency range of interest of the test. For instance, a particular test may require test frequencies to 2 kHz, but the accelerometer responds to frequencies of 20 kHz. Therefore, care must be taken so that phenomena encountered outside of a desired testing range do not adversely affect measurement data in the frequency range of interest.

If excitation is present outside the frequency range of interest, especially at high frequency, it is possible for this energy to “wash over” into the measurement range and distort the data. To prevent this from happening, companies must use proper filtering and sampling. For this purpose, it is equally important that the correct accelerometer be used. For example, if a testing environment requires 100-g full-scale range and a frequency response to 5 kHz, using only a 50-g range sensor with response to 2 kHz will cause the sensor to overload, negatively impacting other data and inhibiting the collection and analysis capabilities of the data-acquisition system.

When selecting a data-acquisition system, much like when selecting a sensor, users must consider the type of test involved, the portability requirements of the system, testing requirements, desired sensor sensitivities, and shock limits and frequency responses, and they must also ensure that appropriate signal conditioning is available-either built-in to the sensor or as a stand-alone option. Transducer electronic data sheet (TEDS) sensors offer the added benefit of calibration data stored right on the sensor. As these are frequently used in automotive testing applications, and require the use of a data-acquisition system, the system must be able to read calibration data directly at the sensor level; normally a system with built-in capabilities is required for this purpose.

Q: What criteria do you suggest for purchasing shock and vibration test equipment destined for high-reliability applications?

A: The most important criteria for the purchase of shock and vibration testing equipment is to purchase from a reliable vendor. Any reliable vendor should be willing to stand by the quality of its product, use current manufacturing techniques, incorporate calibration services that are A2LA accredited to ISO17025, and have an ISO9001:2000 certified manufacturing and quality system. For aerospace sensors and instrumentation, a vendor having AS9100:2004 certification will provide a high-quality product, tested under rigorous quality standards.
For some of the more specialized automotive and aerospace testing applications, it is important to ensure that a sensor is properly designed for high-reliability applications. An example would be a sensor that uses specially welded housing to reduce contamination and a 100-hr temperature cycle test to break in the internal electronics of the accelerometer.

**Q: Can design for reliability/durability eliminate or reduce shock and vibration testing in automotive and aerospace applications?**

A: New developments in technology and design for reliability and durability, with new computer-aided design (CAD) and simulation software, can certainly help improve the overall functionality of a product, in terms of reducing undesirable effects of shock and vibration. The design improvement capabilities may reduce the amount of time required to test these products, the cost associated with manufacture of multiple iterations, and help better identify the weaknesses of a product design prior to initiating the testing phase.

But because automotive and aerospace applications place a high priority on human safety, this design and associated software developments will never fully eliminate the need for reliability testing. Instead, the design for reliability provides a parallel set of objective data on which design engineers and testing technicians may make more informed decisions.

Final design validation must be done with real-world data in real and simulated conditions, and thus there will always be a need to validate computer modeling to ensure that the product does not break in its actual environment. Shock and vibration testing techniques will provide the added check and balance to ensure that automotive and aerospace components and the finished product will operate safely and efficiently, and in accordance with industry standards.