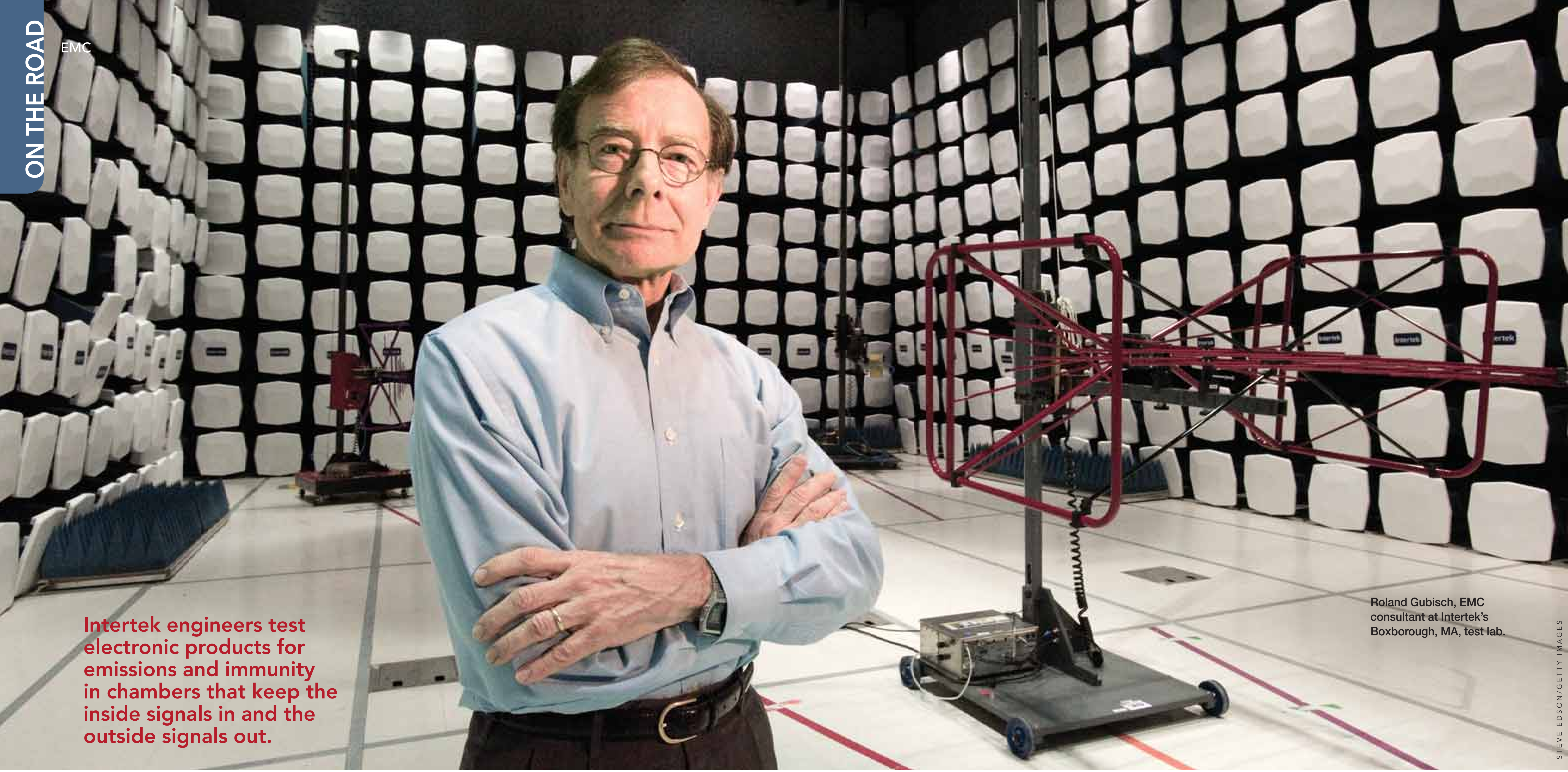

Intertek engineers test electronic products for emissions and immunity in chambers that keep the inside signals in and the outside signals out.

Roland Gubisch, EMC consultant at Intertek's Boxborough, MA, test lab.

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A place for COMPLIANCE TESTS

BY MARTIN ROWE
SENIOR TECHNICAL EDITOR

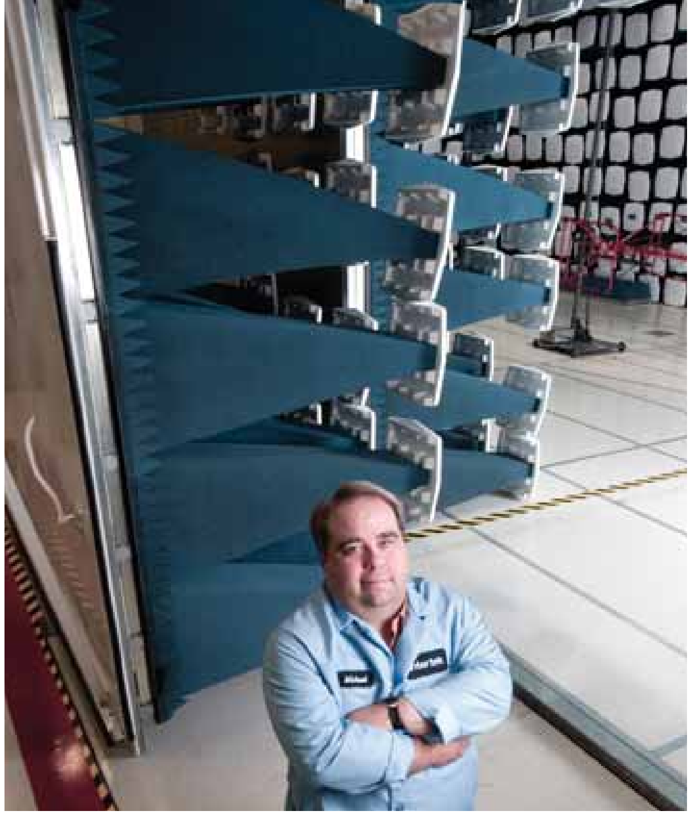
Boxborough, MA—On September weekends, people flock to this town and those around it to pick apples and other types of fruit. During the week, engineers from numerous manufacturers come here to test the fruits of their labor at any of several labs, including one run by Intertek.

At the Boxborough facility, which is one of many Intertek labs worldwide, engineers perform compliance and precompliance tests for EMC (electromagnetic compatibility) and safety as well as numerous other types of tests, including radio tests, environmental tests, telecom compliance tests, and laser-performance tests. Products that come through the lab include automotive components, military components and systems, home appliances, industrial products, consumer electronics, aerospace subsystems, telecom and wireless products, and medical equipment.

My visit to the lab focused on the company's EMC and radio RF performance testing. Compliance tests that Intertek performs include those for FCC, UL, CSA, CENELEC, ANSI, military, and automotive standards. The Boxborough facility is also a Telecom Certification Body for the US and Canada, and a Notified Body for European EMC and radio testing.

The facility includes a lab that contains screen rooms, shielded rooms, a GTEM (gigahertz transverse electromagnetic mode) cell, and custom test setups for EMC and RF testing. A new building houses what Intertek says is the only independent 10-m anechoic chamber in New England. It also houses a recently constructed 5-m anechoic chamber.

Engineers use the screen rooms for conducted emissions and immunity testing. They perform BCI (bulk-current injection) tests on cables using current clamps and coupling-decoupling networks. "Using decoupling networks lets the injected noise



Mike Koffink supervised several engineers during the design, construction, and test of a 10-m anechoic chamber.

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current flow into wires in one direction only, but current clamps let the injected current flow in both directions," said EMC staff engineer Bob Mitchell. "Different industries use particular methods for injecting noise into the cables."

A custom cable tester in the lab lets engineers inject noise into a cable's individual wires. **Figure 1** shows how engineers can place an excitation wire over the wires, which lets the engineers test for shielding effectiveness.

The engineers can connect each wire to a connection box, which provides access to a Tektronix oscilloscope for measuring induced current in the wires. The box also connects the wires under test to a signal source such as a function generator.

The engineers sometimes substitute an Agilent Technologies or Wavetek arbitrary waveform generator for the function generator when they need to create custom waveforms and triggers. The waveforms simulate the interference that can result during vehicle start-up, mostly produced by alternators and starters. Engineers may also use noise generators from NoiseKen to inject interference into automotive cables for Japanese automakers.

Intertek's engineers conduct ESD (electrostatic discharge) tests in a shielded room from ETS-Lindgren. **Figure 2** shows a test setup that uses a stripline test fixture. Using a NoiseKen ESD simulator, the engineers inject ESD into the fixture's isolation pads. Current from the discharge travels through the cables to the EUT (equipment under test), where engineers check for ESD immunity.

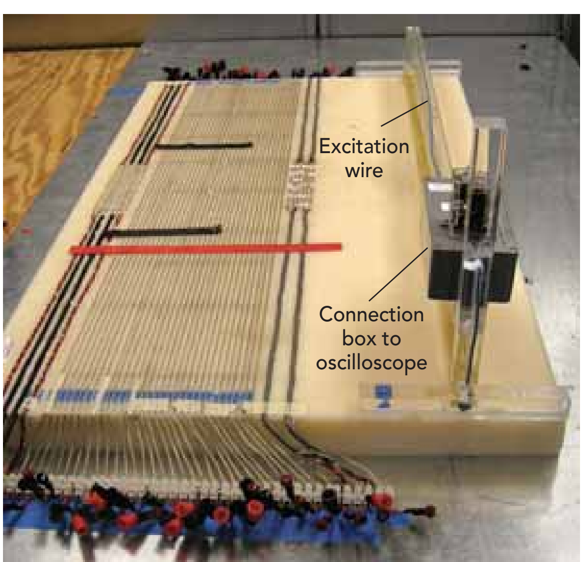

FIGURE 1. A custom-built conducted-immunity tester holds cable wires in place during a test.

Another shielded room lets engineers test the shielding effectiveness of materials such as composites and gaskets that are designed to reduce RF emissions from gaps between product enclosure doors, walls, and other openings. Roland Gubisch, former chief EMC engineer at Intertek and now an onsite consultant, pointed out that the materials are not always effective. "We once had a client who wanted us to test the shielding effectiveness of clothing material that its maker claimed would protect people from RF energy," said Gubisch. "Its shielding effectiveness was, unfortunately, nonexistent."

Figure 3 illustrates a chamber with a removable plate. A gasket (not shown) around the shielding material under test holds it in place against the plate. A transmitting antenna is just inside the chamber, connected to an HP (now Agilent) or Rohde & Schwarz signal generator. A Kalmus (now AR) RF amplifier boosts the signal to levels from 20 W to 1000 W, per MIL-DTL-83528 (Ref. 1). A receiving antenna just outside the chamber connects to an Agilent or Rohde & Schwarz spectrum analyzer to measure the exiting signal strength.

Mike Koffink, EMC operations manager, explained how engineers run the test: "We start with the plate removed and measure the power of the transmitted signal over the frequencies of interest. That gives us a baseline measurement. Then, we tighten the gasket around the plate with the shielding material in place. We then run an identical scan and measure how much the material attenuates the transmitted signal."

Koffink noted that the frequency range can be anywhere from 10 kHz to 18 GHz, depending on the customer requirements. The difference in decibels between the baseline signal and the attenuated signal is the material's shielding effectiveness.

The lab also has an ETS-Lindgren GTEM cell, because some standards require EMI (electromagnetic interference) measurements to be made in such a structure. A GTEM cell is a small anechoic chamber where the outer skin is the transmitting or receiving antenna. GTEM cells are often used for radiated emissions and immunity testing of small or board-level products.

Not all EMC testing is about high-frequency signals. Engineers use a table-top stripline tester to perform radiated immunity testing on audio and video products (**Figure 4**). The tester generates fields at frequencies from a few kilohertz to a few megahertz by stimulating an active plate mounted between two grounded plates. "The field stays well contained," said Koffink. "We check it with isotropic probes."

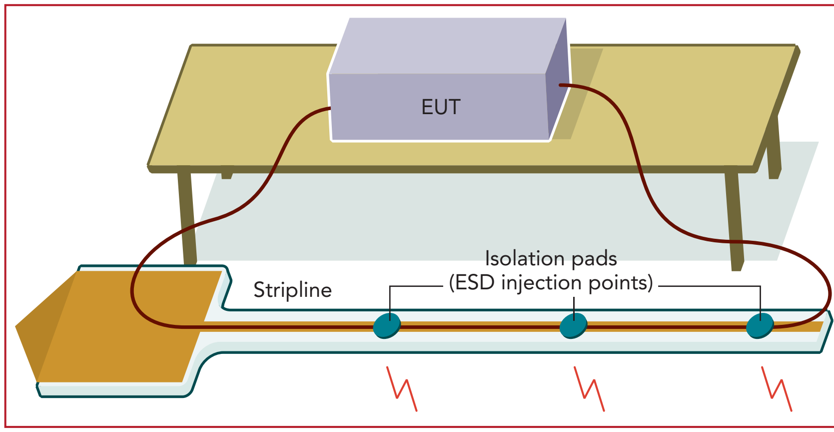

FIGURE 2. Intertek's engineers use a stripline test fixture for ISO 10605 automotive ESD tests.

Keep the outside noise out

In an ideal world, engineers perform radiated emissions testing in an environment with no ambient signals present. Intertek's Boxborough facility has two open area test sites that at one time had ambient signal levels low enough to permit the testing of many products. The low ambient signals were the reason that several companies built EMC labs around the apple orchards. Today, cellphones, cell towers, and other intentional radiators have arrived in the area, making the test sites less usable; in fact, one cell tower is in clear view of the Intertek sites. Digital TV, which has a wider bandwidth than analog TV, has also increased ambient emissions.

To create the necessary low-noise environment, Intertek has turned to using anechoic chambers, which shield most of the ambient signals from an EUT. In May 2009, the company completed work on an ETS-Lindgren 10-m anechoic chamber. During my visit in late June, a 5-m chamber was under construction, having been moved from a facility in nearby Littleton, MA, that Intertek owns as a result of its acquisition of Entela in 2004 (Ref. 2).

Both Koffink and Mitchell were Entela employees who stayed on after the acquisition. Koffink was responsible for the construction and certification of the building that houses the 10-m chamber. Mitchell spent the better part of a year working with suppliers and contractors on the design and construction of the chamber. His job was to produce the chamber to meet the requirements of 56 standards for EMI emissions and immunity as well as transmitter performance standards. Thus, Mitchell had to specify the chamber's design and materials.

For starters, the chamber's door had to be large enough to let vehicles in, and the flush-mounted turntable had to support 10,000 lbs. The motorized main door opens by backing out from the chamber wall and sliding away. Intertek chose the motorized design because the door is too large for one person to open, and a swinging door would be impractical because of the limited space outside the chamber.

Like most anechoic chambers, Intertek's chamber consists of two linings—ferrite tiles and absorbing cones—inside the shielded room. "Ferrite tiles and cones minimize reflections inside the chamber," said Mitchell. "The tiles absorb signals from 30 MHz to 1 GHz, and the cones absorb signals above 1 GHz."

The chamber is certified for emissions and immunity tests up to 40 GHz. To achieve that, Mitchell and others spent two weeks checking every seam and screw hole in the chamber. Every seam and hole needed shielding material such as copper or bronze foil to make openings electrically disappear. Mitchell worked with engineers from ETS-Lindgren to generate fields inside the chamber and check for leaks. "The chamber has about 50,000 screws," he said. "We checked them all."

The result: no ambient signals inside the chamber. At 40 GHz, the chamber attenuates outside signals by about 100 dB.

Gubisch explained why even small screw holes and gaps let signals penetrate a shielded chamber. "At 40 GHz, the signal wavelength is about 7.5 mm," he said. "Holes of 4 mm to 2 mm are enough to let half and quarter wavelengths pass through. You have to keep openings to less than 2 mm."

The 10-m chamber has Kalmus (now AR) amplifiers in an adja-

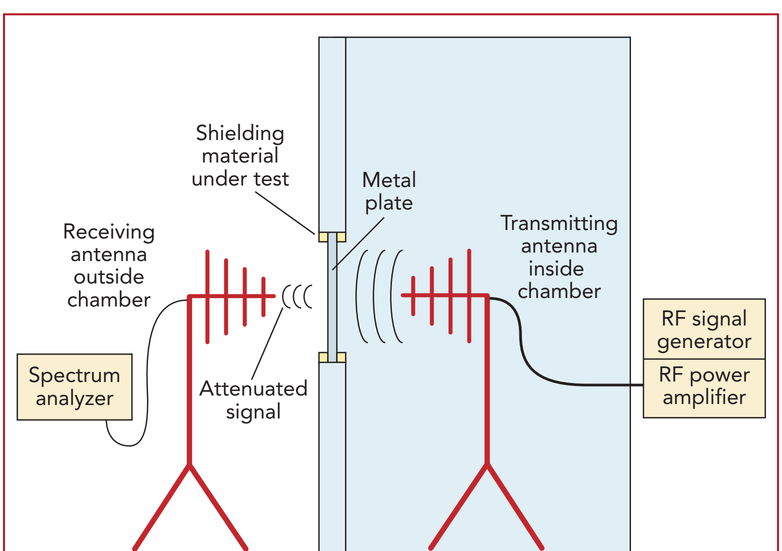

FIGURE 3. Antennas inside and outside a shielded room let engineers measure the shielding effectiveness of materials.

cent shielded room. These amplifiers produce 500-W signals, so they generate considerable heat. Rather than exhaust that heat to the outside, the chamber's ventilation system circulates it back into the building, which reduces heating costs.

EMI chambers need test equipment such as signal generators, amplifiers, oscilloscopes, spectrum analyzers, antennas, and antenna masts for engineers to run tests. The equipment requires automation to minimize test time and maximize measurement repeatability.

Intertek engineers prefer to automate test equipment with commercially available EMI automation software from Tektronix and Rohde & Schwarz. "We work with equipment manufacturers to get the software we want," said Scott Lambert, operations manager for product safety. "Writing and maintaining your own automation software is difficult." In particular, Lambert cited a need for software that could automate a test site that has multiple antennas.

Lambert also needs custom reports in graphical and tabular format. A radiated immunity test can have hundreds of scans because of different frequencies, turntable positions, and antenna positions. For customers who want raw data, the software can move data directly into Microsoft Word.

Hidden industry

The Intertek test labs handle a wide variety of equipment, but engineers in Boxborough do a surprising amount of automotive testing for a lab so far from Detroit. "Automotive products are a kind of hidden industry in New England," noted Albert Noyes, commercial and industrial department manager. "We test audio products, position sensors, heat sensors, and collision-avoidance systems." Audio systems include those from a major local manufacturer.

As the auto industry looks into alternative power sources, Intertek engineers find themselves testing battery packs for electric vehicles. Noyes described a test he performed on a battery system that measured 4 ft wide by 9 ft long by 1 ft thick. The battery is used to power buses in several major cities. Intertek engineers tested the battery's control electronics for emissions and immunity.

Automotive EMC testing differs from EMC testing for most other products because the automotive products are vehicle components rather than complete systems. Automotive EMC standards apply to entire vehicles rather than components. Thus, it's the system-level tests that count. Suppliers of automotive components go to test labs to verify that their product won't cause vehicle emissions or immunity tests to fail. But they can afford to sell products that might have emissions that are 1 dB or 2 dB above design specifications without needing to lower emissions.

"US automakers won't accept test results for validation programs from EMC labs they haven't certified," said Koffink. "Although we work with suppliers to the Big Three automakers, we need their certification before the suppliers accept our tests." Koffink noted that the lab has certification from Ford and General Motors. The automotive expertise came to Intertek through the Entela acquisition.

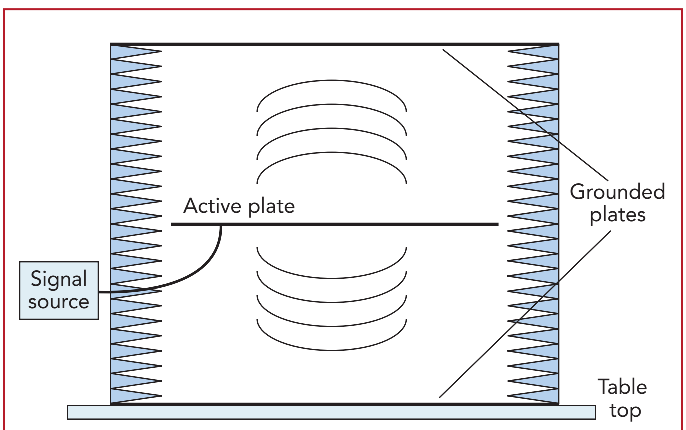

FIGURE 4. The combination of an active plate, grounded plates, and absorbing cones produce a uniform field for low-frequency immunity testing.

Automotive products designed for passenger vehicles must pass more stringent tests than products for emergency (police and fire) vehicles. Besides performing EMC tests, Intertek engineers also test transmitters used in emergency vehicles. They measure output power and frequency. "Police and fire vehicles can have 20-W transmitters," said senior project engineer Nick Abbondante. "That much power can heat human tissue, but radio operators are trained to minimize transmission time. You can't do that with consumer transmitters, so they must have lower power."

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Nick Abbondante tests RF transmitters for output power, spectral density, and other characteristics.

Abbondante tests transmitters for Bluetooth, WiFi, and cellular use. He looks at in-band output power, adjacent-channel power, power spectral density, frequency stability, and harmonic emissions. "A 2.4-GHz signal has harmonics at 4.8 GHz and 7.2 GHz. Those frequencies are used by licensed services," he said. "Unlicensed 2.4-GHz devices can interfere with those services."

Keeping up

Intertek engineers must keep up-to-date on the wide array of standards in use today. EMC alone has dozens. Add safety and military standards for automotive products, IT/telecom products, medical products, and more, and you could have a full-time job just keeping up with the latest developments. To help the company anticipate changes and prepare for them, Intertek has industry and technology experts that serve on numerous standards committees. *(continued)*

Even though engineers in Boxborough regularly converse with Intertek's committee representatives, they must keep abreast of standards development and adoption on a daily basis. The International Electrotechnical Commission, for example, publishes newsletters that inform engineers when a new standard is published (Ref. 3).

"Just because a standard is published," added Gubisch, "doesn't mean anyone has adopted it as a legal requirement. I have to check the EU [European Union] Website every day to see if a standard has been adopted in Europe." He also checks the FCC, ANSI, and Food and Drug Administration Websites for recognitions of standards. In the US, problems arise because the FCC may not adopt a new version of a standard such as ANSI C63.4 (Ref. 4).

Even when a standard is adopted, it may have a transition period, particularly in the EU. A transition period covers a date of publication, a date of implementation, and a date of withdrawal (if a standard supersedes a previous one).

Gubisch also checks the content of a standard, because it could call for new test methods or combine test methods from other standards. When he finds the technical details of a standard to be unclear, he may contact an Intertek representative to a standards development organization to find out the organization's intent. He cited an example of CISPR 22, a standard containing telecom port emissions limits. "You couldn't perform the test as described. When labs tried to perform the tests, we found differences from 20 dB to 30 dB."

EMC and product safety testing, while not as transient as other engineering disciplines, do continue to evolve. Test labs such as Intertek must adapt to a myriad of changes in regulatory standards. That requires adding equipment (including chambers), monitoring standards bodies, and training its staff in new requirements. T&MW

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