You don't have to be an engineer to build a successful products liability case. But you should understand how some common forensic engineering tests can help you prove that the product in your client's case is defective.

HIGH-TECH TESTING

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Imagine that you are on *Jeopardy*. You pick "torts" for $100 and are given the answer "Law schools and treatises teach this about products liability cases." You know the question: "What is strict liability, negligence, and warranty?" You win the $100!

But because you are reading *Trial*, we'll up the ante and make it torts for $1,000. The answer is "Scanning electron microscopy, Fourier transform infrared spectroscopy, pyrolysis gas chromatography mass spectroscopy, and 3-D industrial computed tomography." This one's a little tougher—no one mentioned anything about forensic engineering tests in law school or in any of the treatises on your bookshelf. Here's the question: "What are four tests commonly used by forensic engineers to determine product defects?"

In any products case, you need to understand the legal principles that govern products liability. But ultimately, where the rubber meets the road is in proving that the product is defective. Sometimes the defect is obvious, but often, identifying and proving the defect requires some high-tech detective work. That is where forensic engineering comes into play.

Forensic engineering applies a broad range of tests and examination techniques to answer questions of interest in legal matters.[1] The ultimate forensic question in a products liability case is: Why did the product fail in a way that caused the plaintiff's injury? To answer that question, you must also answer these: Was its design sufficiently robust to withstand expected use and abuse? Were proper materials selected for its construction? Was it manufactured consistent with the design—considering both the assembly and materials? Was it destined to fail and cause injury? To answer those questions, you need forensic testing.

Dozens, if not hundreds, of techniques are available to examine a product for defects. Some, like using a ruler or magnifying glass, are simple; others are much more complex and expensive. In forensic engineering, there are two kinds of examinations: nondestructive ones, which do not affect either the product or its immediate environment, and destructive examinations, which substantially modify or even destroy the product or the items to which it is attached.

Before you allow an expert to perform any type of examination other than the most basic external observation, he or she should prepare a written examination protocol, which serves several important functions.

First, it is part of the scientific method, and an expert who follows a written protocol is more likely to survive a *Daubert* challenge.[2] Second, it can prevent financial surprises by giving you an idea of what the expert wants to do, how much it will cost, and what it will accomplish. Third, it ensures that the expert, who might not understand issues like spoliation and evidence preservation, does not do anything to harm your case.

With any kind of testing and examination, the methodology used must be appropriate and have a *Daubert*- and spoliation-proof basis.[3] Your expert must understand the concept of spoliation, and you must know what your obligations are. To avoid sanctions, make sure you consult the law in your state.

But, you might ask, how can I determine whether there is a defect without examining the product? Aren't there sanctions for filing lawsuits without an adequate investigation?[4] There are two solutions to this conundrum. First, use nondestructive testing. Second, if the evidence must be modified or destroyed as part of the examination, ask the defendant to observe and participate in the process. Making sure that you and your client are safe from a spoliation claim is more important than any loss of secrecy.

Keep in mind that a defendant may have a valid claim of spoliation even if the product is perfectly preserved. The manufacturer may claim that its ability to defend against the plaintiff's claims—to blame the event on something other than its dangerous product—is lost when the environment in which the product was located at the time of the event is damaged. For example, taking a chainsaw and sledgehammer to a boat to access the part that was assumed to cause a fire will result in sanctions.[5] Preserving a car's seat belt and the B-pillar to which it was attached, but allowing the rest of the car to be destroyed before the manufacturer has a chance to inspect it, is not a good idea either.[6]

Even seemingly benign tests, like using a bright light, can spoliate the product. This happened when a manufacturer's expert melted the case of a seat belt buckle by allowing a hot light he was using to look inside the buckle to rest against the case for too long.[7]

To reduce these risks, you should acquire several exemplars whenever possible. This allows your experts to conduct testing on them first as a "control," and this allows for easy comparison. Also, a 3-D scan of the inside of a part is much easier to interpret when an exemplar has been disassembled for comparison.

Failure Analysis Techniques

Because modern forensic examination techniques are sophisticated, destructive testing is rarely necessary. The techniques may be broken down into two basic categories: methods to determine what the product looks like and methods to determine what the product is made of. Several techniques are commonly used in products cases.

Scanning electron microscopy

(SEM). A scanning electron microscope is a natural extension of optical microscopy in failure analysis. Although the sample that is examined under the microscope is not destroyed, it must be small enough to get into the machine—usually between the size of an egg and a shoe. This obviously creates a danger of spoliation if the part must be cut up to fit in the chamber. You must ensure that the expert does not take this risk lightly and, if the product will be disassembled or sectioned before being examined, that the manufacturer is given a well-documented opportunity to examine the product first and possibly to be involved in the protocol.

SEM's use of electrons instead of a light source provides much higher magnification (up to 200,000 times) and much better depth of field, unique imaging, and the opportunity to perform elemental analysis and phase identification (to discover the presence of impurities in the materials the product is manufactured from). In standard SEM, the specimen is in a vacuum and the images produced are black and white. But in environmental SEM, the specimen is in a pressure chamber that is pumped to pressures that are 10,000 times higher than that of traditional SEM, without contaminating the microscope, making color images possible.

One of the best uses of SEM is fractography, which lets the examiner see the surface of a broken part in great detail. It allows a metallurgist to determine whether a fracture resulted from fatigue, a single event, or any combination thereof—and a polymer expert to inspect the surface of broken plastic and determine the cause of failure.

Radiography. Radiography using X-rays or neutrons is useful in examining the internal condition of seemingly solid products, such as the inside of a broken ratchet tool, to look for internal defects before beginning destructive examination. High-energy X-rays can help experts visualize what is inside an item, even behind several inches of solid steel.

As with SEM examinations, the product has to fit in the X-ray machine. Also, the machine must be powerful enough to penetrate the item to expose the film on the other side. Top-quality industrial X-ray machines can penetrate as much as eight inches of solid steel. But even if the item is too big to move to the X-ray machine, it could be examined with a portable or hand-held X-ray device. For example, the seat of an automobile might be difficult to remove and get to a traditional X-ray machine without potentially spoliating it, but a portable or hand-held unit could examine it with relative ease and with little to no risk of damage.[8]

A CT scan is a more sophisticated kind of X-ray, combining the power of a computer with X-ray technologies to take multiple images and put them together in 2-D and 3-D images. 3-D industrial computed tomography is particularly helpful because it can create a clear image of how internal components are arranged inside a product, which would otherwise have to be disassembled to be inspected. With computer filters, the user can visualize just the plastic, just the metal, or all the parts together.

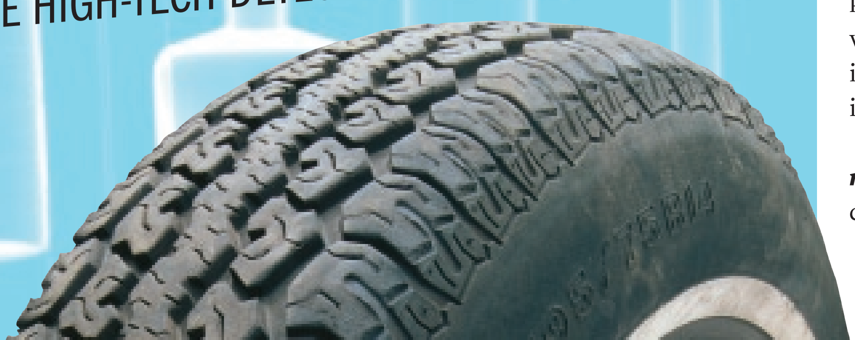
Magnafluxing. This technology permits the testing of ferrous metals for surface and subsurface flaws. The component being tested must be made of a ferromagnetic material such as iron, nickel, cobalt, or one of their alloys.

A magnetic slurry is poured onto the product, and with the aid of magnets, it gathers in otherwise difficult-to-discern cracks and surface defects and can be seen with a black light. There is a spoliation risk with this technique, because once the magnetic material is used on the product, the cracks are contaminated with charged particles that have the potential to affect the quality of other examinations, such as fractography.

Fourier transform infrared spectroscopy (FTIR). This type of spectroscopy is used to identify organic materials such as polymers, adhesives, organic residues, and lubricants to determine what a product or substance is made of. Each of these materials gives off a signature spectrum when exposed to infrared light. This spectrum is then compared to known organic materials. A qualified lab will have more than 60,000 spectra in its spectral libraries for comparing and identifying unknown spectra.

Pyrolysis gas chromatography mass spectroscopy. In this method of chemical analysis, the sample is heated

Ultimately, where the rubber meets the road is in proving that the product is defective. SOMETIMES THE DEFECT IS OBVIOUS, BUT OFTEN, IDENTIFYING AND PROVING THE DEFECT REQUIRES SOME HIGH-TECH DETECTIVE WORK.



to decomposition to produce smaller molecules that are then separated by gas chromatography and detected using mass spectrometry. This test is particularly helpful for determining the organic components of an unknown material—such as whether the black glob on a bumper is tar, plastic, paint, or parts of a dead squirrel.

The data can be used as a high-tech fingerprint to prove material identity or to identify individual fragments to obtain structural information. One type of this spectroscopy, called graphite furnace atomic absorption spectroscopy, has been used to develop a quick and accurate test for tire cord dip pickup, which helps determine whether a manufacturing defect prevented a tire's component parts from completely integrating with one another.

Finite element analysis. This is not an examination technique but an engineering methodology often used in products liability cases to examine the expected design performance of mechanical devices and parts. The part being analyzed is divided into small regions and is examined, typically with the aid of computer software, to determine its expected physical behavior. A key concept of finite element analysis is that if the elements are made small enough (if the part is divided into the right number of sections that are spread appropriately across the part), a numerical solution is created that will closely resemble reality. A properly conducted finite element analysis predicts what will happen to a product when stressed—or subjected to an impact or load—just as accurately as actual product testing will.

Real-world Examples

A few examples of products liability cases we have handled illustrate the value of these forensic tests. In some cases, we have combined tests to determine what caused the product to fail.

The UV-degraded seat belt buckle. In this case, the automobile's seat belt buckle was worn through in several places, but it still latched and buckled when the plaintiff put it on, only to release during the rollover that led to the plaintiff's injury. After the rollover, the seat belt would latch but wouldn't stay latched when subjected to forces from certain directions.

First, the expert wrote a testing protocol that included inviting the manufacturer to inspect the belt before it was removed. Two areas of interest were evident: the plastic case that was flexible and worn, and the internal parts that sounded and acted as if they were broken. FTIR was used on a small sliver of the case to determine that it was made of acrylonitrile butadeine styrene, or ABS plastic, a common material, but that it was not UV-stabilized to protect it from degrading as a result of exposure to sunlight. (The inside of the tested sliver showed a different spectrum than the outside.) This explained the case's premature wear and lack of strength, which prevented it from protecting internal components of the buckle from impact damage.

Next, the buckle was examined with both plain X-rays and 3-D industrial computed tomography to demonstrate exactly which internal part failed and how a poor choice of case materials caused the failure. The testing showed that although the device was manufactured as designed, the choice of materials led to its failure and made the seat belt defective.

The poorly designed seat belt release button. During the collision in this case, the release button was fractured. Other investigators in similar cases had determined that the problem was associated with the use of improper materials. However, FTIR showed that adequate UV stabilizers were in place and, despite the fact that the plastic looked degraded, it was not degraded in a relevant manner. (Samples from the surface and inside showed the same spectra.)

Finite element analysis was used to demonstrate that the real culprit was inadequate ribbing in the design of the buckle. This testing supported a claim that the buckle was made of appropriate materials but was defectively designed.

The broken tree pruner. When being used to cut a branch, the blade separated from the pruner at its pivot screw, which appeared to have sheared off. The user suffered a serious fall as a result. The defendant manufacturer claimed that the pruner had been misused. The plaintiff argued that the screw was inadequate and destined to fail. Hardness testing demonstrated that the screw was significantly softer than the blade, so it was likely to lose a battle between the two.

SEM examination showed that the screw did not fail from a single event but as a result of multiple insults that created a cleavage point and ultimately led to failure. Experiments on exemplars recreated the pattern shown on the SEM examination of the screw. This testing demonstrated that the screw was inadequate for the task and was likely to fail.

The mystery telephone pole marks. After a wheel on a man's truck came off while he was driving, his truck crashed. The plaintiff asserted that the aftermarket wheel had been stylized to the point that it was too thin to withstand the loads associated with normal road hazards, leading to a failure in which the wheel

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separated from the vehicle. The manufacturer claimed that after the driver lost control, the truck climbed a guy wire and hit a utility pole about six feet off the ground, which fractured the wheel and left a black rubber residue on the pole.

Our experts used finite element analysis and SEM on the wheel, but the test that saved the case was the FTIR analysis of a small sample of the black material on the pole. It allowed the plaintiff to show that the material was not tire rubber from the truck wheel but a tar substance used in the processing of the pole.

Knowing the law is not enough. Successful prosecution of a products liability case requires that you prove the defect, and making sure that experienced professionals carefully apply sophisticated technologies is essential. You never know what you'll find when you look carefully. T

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Notes

1. The word "forensic" comes from the Latin adjective *forensis*, meaning "of or before the forum."
2. *Daubert v. Merrell Dow Pharms., Inc.*, 509 U.S. 579 (1993). Often, the exercise of preparing a written protocol offers an early opportunity to evaluate an expert under *Daubert* and remedy any weaknesses.
3. ASTM Intl., E2332-04: Standard Practice for Investigation and Analysis of Physical Component Failures; *see also* ASTM Intl., E860-07: Standard Practice for Examining and Preparing Items That Are or May Become Involved in Criminal or Civil Litigation. ASTM standards may be purchased at www.astm.org. See also the American Society for Nondestructive Testing Web site at www.asnt.org.
4. Fed. R. Civ. P. 11; *See Nazarenus v. J.F. Daley Intl., Ltd.*, 714 F. Supp. 361, 364–66 (N.D. Ill. 1989).
5. *Vodusek v. Bayliner Marine Corp.*, 71 F.3d 148, 155–56 (4th Cir. 1995).
6. *Dillon v. Nissan Motor Co.*, 986 F.2d 263, 267 (8th Cir. 1993).
7. *Linden v. CNH Am., LLC*, No. 3:09-CV-JEG-CFB (S.D. Iowa filed Jan. 30, 2009) (ruling pending).
8. For a more thorough discussion of radiographic inspection methods, see R.D. Bowman et al., *Radiographic Inspection in Failure Investigations*, Practical Failure Analysis 73 (June 2003).