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Truck Safety

Expensive, Complex, and Critically Important

There once was a time when automakers resisted some new safety standards—not so much early basic necessities such as collapsible steering columns, dual brake hydraulic systems, and crash-compliant interiors, but later fast-accumulating rules that seemed much less cost-effective. Experience showed that consumers typically rejected available safety features in favor of comfort, convenience, and entertainment options, and no business can afford to absorb significant added costs without increasing product prices. Of course, automakers always lost these battles and damaged their public images in the process.

Those days are gone. Today's vast, complex web of federal safety requirements is taken for granted by our safety-conscious public, and its cumulative cost is built into every new vehicle. Automakers invest heavily in developing, adopting, and touting new safety features, often ahead of new requirements. There's even been industry/government cooperation on certain important new technologies. A joint program on stability control, for example, matured to where data was shared and challenges jointly defined. "We worked hand in hand with NHTSA, shared the data, and opted to make it standard on U.S. vehicles before they had to think about a regulation," says Larry Burns, GM's recently retired R&D vice president.

HUNDREDS OF ENGINEERS, THOUSANDS OF TESTS

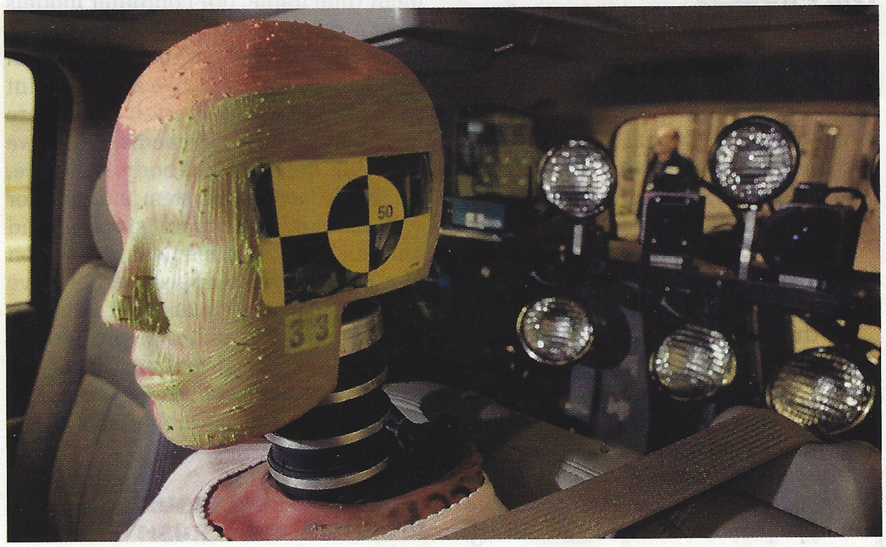
Stephen Kozak, Ford's Global Safety Systems chief engineer, counts 160 engineers in his Ford North America group alone, supported by a couple dozen engineers and technicians in the labs and running the tests. "We run approximately 500 full-vehicle crashes a year," he says, "which is down about 40 percent from just three years ago. The reason it's down is because we run literally thousands of component tests and something in the neighborhood of 3500 sled tests a year. Those are simulations of a vehicle's cockpit, each with representative production instrument panel, steering wheel, seats, seatbelts, and airbags, on what looks like a rocket sled." Projecting a sled occupied by intricately designed simulated humans known as "crash dummies" suddenly backward simulates a frontal impact. "My 160 employees operate 60 percent of all the computing power within Ford Motor Company North America," Kozak adds. "The rest of the company combined accounts for the other 40 percent."

Beyond the hefty list of federal frontal, side, rear, structural, and roof-crush requirements that must be met before any new vehicle can be sold in North America is a second, tougher set of "public domain guidelines" from bot[h] the U.S. government and the Insurance Institute for Highway Safety. These are the U.S. New Car Assessment Program full-frontal impact and IIHS offset frontal and side-impact tests that result

Certification

by Gary Witzenburg

ABOVE: A 2006 Buick Ranier undergoes a rollover test at GM's facility in Milford, Michigan. BELOW: Closeup of a modern-era crash dummy.



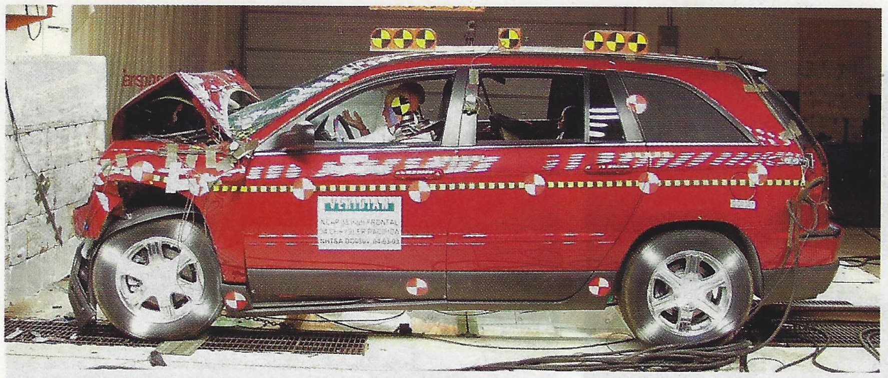
in widely publicized one- to five-star (poor, marginal, acceptable, or good) ratings. Vehicles failing to earn four or five stars for any of these tests can be legally sold, but at a key competitive disadvantage to those that do.

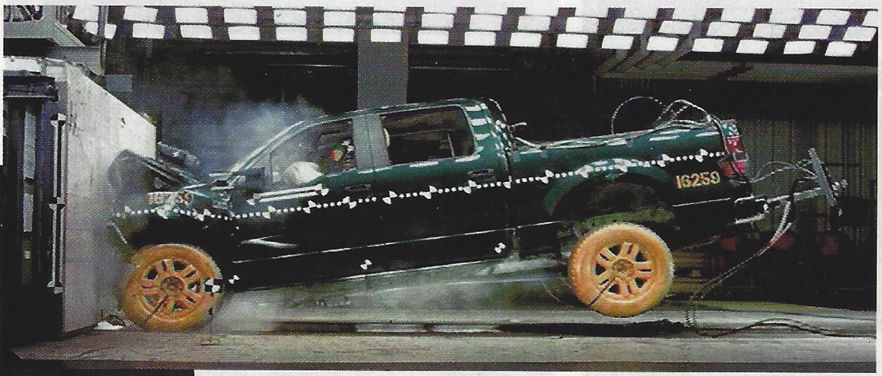
Over and above all that, each automaker has its own internal tests and requirements carefully designed to ensure that every vehicle it makes will meet or exceed every safety standard and guideline. This adds even more cost, complexity, and resource needs, of course, but none can afford not to comply in today's cutthroat competitive U.S. marketplace.

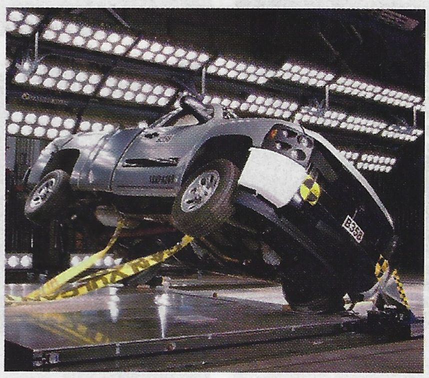
Ford's Kozak points out that the full set of federal and IIHS standards and guidelines are the same for cars and trucks below 5500 pounds (unloaded vehicle weight) or 8500-pound GVW, that a smaller subset of the federal rules applies for vehicles above those weights, and that Ford has its own internal requirements for those heavier vehicles that some OEMs do not.

THE TESTS

Federal Motor Vehicle Safety Standard (FMVSS) 208 requires seven frontal-impact tests that stuff complete vehicles into concrete barriers. These are 25- and 35-mph "full" frontal, 25-mph Front Angular Left and Front Angular Right, and 25-mph Front Offset Deformable Barrier, plus Out-of-Position Driver and Out-of-Position Passenger airbag tests. Each requires specific-size dummies—for example, a 50th-percentile male and







LEFT: The Pacifica's three-row side curtain airbags, inflatable knee airbag, energy-absorbing steering column, and rigid body structure helped lead to a five-star crash rating.

BELOW LEFT: The F-150 undergoes an impact study (crash test) and earns five-star ratings.

BELOW: A full-size GM pickup goes up on two wheels during a "curb trip" test.

a fifth-percentile female—sometimes unbelted.

FMVSS 201 adds specific frontal-crash requirements, FMVSS 214 specifies four different side-impact tests, and FMVSS 216 is the new static roof crush test. Then there are five "structural" standards for Fuel System Integrity, Windshield Mounting, Windshield Zone Intrusion, Interior Component Doors, and Steering Column Rearward Intrusion.

THE PROCESS

"We engineer all the different load cases into every vehicle, from Corvettes to trucks," says Brian Latouf, director of GM's Global Vehicle Structure & Safety Integration Center. "A load case is a specific crash event, and we evaluate approximately 150 of them for not just the federal safety standards but also the third-party tests, the public domain consumer metrics, and our own internal requirements."

In the beginning of every new product's Vehicle Development Plan, Latouf explains, engineers start with "math," aka Computer-Aided Design data, and from that develop highly detailed Computer-Aided Engineering models that drive the design. Once prototype parts are available for testing, those results are correlated with the computer models to further improve them. The final crash performance validation tests are conducted with production-intent parts and systems.

"We also do CAE validation for a variety of different load cases that are beyond FMVSS and the consumer metrics," he points out. "We specifically pick worst-case conditions and different body styles for tests of cars and trucks. For a full-size pickup, we look at crew cab, extended cab, and regular cab and crash them separately for front, side, and rear impact."

Latouf continues, "As the quantity of regulations and requirements continues to grow, to manage that with quick throughput within a vehicle's development time frame, our computer models have grown, so our ability to engineer more quickly and get that throughput has increased as well. We are at a point where our [computer] crash models are roughly 2.5 million elements, where we have the detail of the body structure, chassis system, fuel system, and interior seats, trim parts, restraint systems, and dummies." A finite element is a section of a part's surface approximately five mils [0.005 inch] square that includes its contours and material properties. It's a mathematical tool engineers use to analyze and predict dynamic performance in virtual crash tests using CAE tools.

FULL-FRAME VERSUS UNIBODY AND CRUSH VERSUS STRENGTH

We ask whether body-on-frame pickups and SUVs present more or less of a safety compliance challenge than unibody cars and crossovers. "We are able to get to the same level of safety with both," Latouf relates. "It's just a different engineering approach. The frame is a significant load path for front, side, and rear impacts that we can optimize, and the interfaces where the body is attached to the frame are important. You need to make sure you have good body mount connectivity in a crash event so you don't separate the mounts or have relative motion between the body and frame."

One of the toughest challenges is balancing the crush required to absorb impact energy with the structural strength necessary to keep the passenger compartment intact. "Our philosophy on crashworthiness is threefold," Latouf says. "One is maintaining occupant compartment integrity, so the compartment itself needs significant strength. The second is absorbing crash energy, so things like the front and rear rail systems must be engineered to crush and absorb energy to minimize deceleration levels to the occupants. The third is restraining the occupants so they will not experience significant loading during the crash. Our computer tools help us work through thousands of iterations to get to an optimal design."

Another is sufficiently protecting occupants too foolish to buckle up. "FMVSS 208 has an unbelted frontal impact requirement," he says. "The airbags, seats, and knee bolster systems are engineered to provide the restraint."

Can he provide specific examples where GM internal requirements go beyond federal and IIHS measures? "Sure. We look at all sorts of different crash scenarios, and different crash dummies, including fifth, 50th, and 95th percentile. We look at things like hot and cold airbag tests, where we'll warm up the bags to 185 degrees F or cool them down to -22 degrees F to represent different conditions where customers may get into crashes. We also look at threshold speed crashes, where the airbags may or may not deploy."

We were unable to speak to engineers from Chrysler, Toyota, or Nissan for this story, but Chrysler spokesman Nick Cappa provided an excellent description of the safety design process used for the current Dodge Ram pickup: "Many vehicles need to be designed to meet not only current regulations but future requirements," he wrote. "These requirements may not be clearly defined when development begins, four years before the vehicle hits the showroom. For example, when we began developing the new Dodge Ram, FMVSS 216 (roof strength) was not finalized, so we were 'protecting' for criteria published in a Notice of Proposed Rulemaking that forewarned of potential future standards.

"Development on the new Ram began with just a computer version of the pickup. Engineering teams created computer models and identified the best combination of airbags, seatbelts, and vehicle structure to optimize protection in a wide variety of possible crashes. After several months of computer modeling, an interior "buck" of the Ram was created to verify the computer models with physical hardware. Buck testing and engineering continued for about two more years to optimize performance in many potential crash scenarios outlined by Chrysler, regulatory agencies, and third-party agencies.

"We then tested a prototype vehicle at our Chelsea, Michigan, proving grounds and analyzed the results to ensure that our original data agreed and the appropriate countermeasures were included. Every test is important and very complex."

There's no question that all this work required to design, develop, and test, test, test to ensure that every one of today's passenger cars and trucks meet or exceed all the various safety requirements and guidelines adds enormous cost and complexity to the vehicle engineering process. There is also no question anymore that it is more than worth it. "I drive them, my wife drives them, my son drives them," Latouf reminds us. "Our intention is absolutely to make them as safe as they can possibly be." *TT*

ABOVE: This Servo-Hydraulic Reverse Crash Simultor studies full-vehicle collisions including pitching and nonpitching modes, rear crashes, and side impacts.