STANLEY
Engineered Fastening

Vehicle Lightweighting

How government standards – and the rise of electric vehicles – have manufacturers scrutinizing every component

The dilemma faced by every vehicle maker today: How to add safety features and options desired by consumers while minimizing a car's weight?

Every pound or kilogram in a vehicle really counts in light of standards — such as the United States' Corporate Average Fuel Economy (CAFE) — that demand higher overall mileage. Vehicle makers must also contend with efficiency mandates in Asia and Europe as well as consumers calling for greater range in electric vehicles. Additional weight uses more fuel in a combustion engine car, and in EVs, takes more power from the battery and reduces the range.

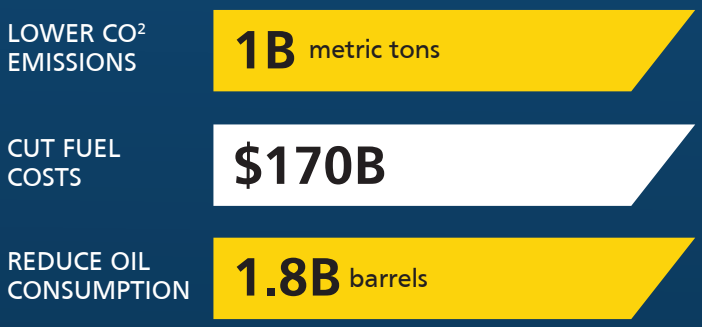
"As long as automobiles have more security, motors, and air bags inside, the industry is hunting for every pound or kilogram of weight to save," says Wolfgang Lange, European Business Unit Director, STANLEY Engineered Fastening.

With EVs, weight becomes even more crucial, because the batteries are so heavy — each weighs an estimated range of 220-661 pounds (100-300 kg). ***Read more about Electric Vehicle Trends***.[1]

"The balance among traditional internal combustion, hybrid, and electric vehicles is very important, although it will not change the imperative to achieve lighter weight vehicle bodies. In fact, increased use of batteries will increase that emphasis," says Thomas Ehrhardt, President of Global Automotive at STANLEY Engineered Fastening in Fastener + Fixing magazine. Lightweighting to achieve better fuel economy may sound like a straightforward task, but is it? "It's not just taking a piece of steel and replacing it with a piece of aluminum or magnesium," says Dave Cole, chairman emeritus of the Center for Automotive Research in Ann Arbor. "Then you have other issues that you have to consider."

A BRIEF HISTORY OF LIGHTWEIGHTING AND REGULATION

2016 U.S. Government added standards for medium and heavy-duty vehicles



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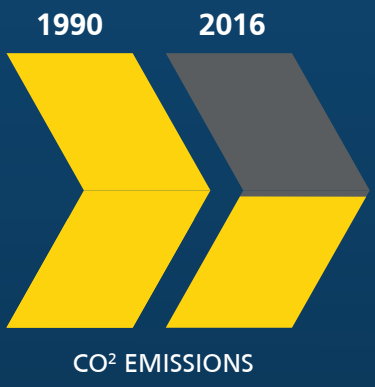

An element of uncertainty cropped up recently when the U.S. government started efforts to roll back its vehicle mileage standards. However, some say the effects of these changes may be diminished because vehicle makers have already invested billions to comply with stricter fuel standards implemented in 2016. In addition, strict fuel-efficiency regulations are in place in major markets like China and Europe, and even larger American vehicles have slowly been becoming more fuel-efficient. On top of all that, California and other states coordinate their own regulations with CAFE, and automakers would rather not produce higher-mileage vehicles just for those smaller markets, even though they've done so in the past.

The U.S.'s CAFE program was established in 1975 to reduce energy consumption by increasing fuel economy in cars and light trucks. It was Washington's response to the 1973-74 OPEC oil embargo, when Americans waited in long lines for gas, dialed down their home thermostats and put on sweaters. CAFE's initial objective was to improve the nation's energy security and save consumers money at the pump as gas prices soared, prompting manufacturing innovation.

Eventually, the standards were also seen as a way to cut tailpipe emissions, carbon pollution and the rate of climate change.

Forty-one years later, in 2016, the federal government added standards for medium and heavy-duty vehicles, which were expected to lower CO^2 emissions by approximately 1 billion metric tons, cut fuel costs by about $170 billion and reduce oil consumption by up to 1.8 billion barrels over the lifetime of vehicles sold under the program. These reductions are nearly equal to the greenhouse gas emissions associated with energy use by all U.S. residences in one year.

In Europe, Regulation 2009/443 limits CO2 emissions from cars and vans by 60% by 2050, compared to 1990 levels.[2] Unfortunately, emissions from transport have actually increased by 20% since 1990, increasing pressure to consider lightweight materials as part of the solution. The Chinese government is aggressively trying to rein in dangerous air pollution, propelling their support of electric cars, as well as tougher "China 6" emission standards, which will take effect beginning mid-2020[3].

What about using high strength steel that's rolled to a thinner gauge? What about a redesign of parts around the different characteristics of the material? "And then you have issues like galvanic corrosion where you could say 'I'm going to put this piece of aluminum next to some steel parts and now I've got to worry about something I didn't have to worry about before," Cole says. "So the complexity here gets pretty amazing pretty quickly."

STANLEY is doing its part to manage complexities like these. "If the OEM wants to transition from a steel body to an aluminum one, we help the designers and engineers keep the same fastening system, which saves time and money," says Rupert Becker, Director of Global Product Line Management, Automotive at STANLEY Engineered Fastening.

"For example, our studs are designed to be welded to lighter weight materials such as ultra-high strength steel or aluminum. You can't simply replace steel studs with aluminum ones, because there is no functional way to weld aluminum to a steel body."

"The imperative for lightweighting and the associated challenges of multi-material body assembly demand that the engineers at STANLEY Engineered Fastening are immersed in what is happening in research laboratories, universities, and the advanced engineering departments of its customers," Ehrhardt told ***Fastener + Fixing***. "This is crucial in anticipating customer needs."

"The people involved in vehicle body fastening may not know what is coming to them," Ehrhardt told the technical magazine. "We try to anticipate the joining, plastic fastening, tightening, welding or riveting issues they may face in the future."

"If the OEM wants to transition from a steel body to an aluminum one, we help the designers and engineers keep the same fastening system, which saves time and money."

Rupert Becker
Director of Global Product Line Management, Automotive at STANLEY Engineered Fastening

The kind of knowledge Ehrhardt describes is crucial to companies that want to survive, Cole says. "We're in this era where you have to look at the variety of different things that are going on that relate to your product and make sure that you have the agility to move in that direction as things happen," said Cole. He sees a bright future for aluminum, for example, but that can change with advances in steel, plastics and magnesium.

"This is just the nature of the game, and any company has to look in the near term at what their customers want now, but also has to look to the future of the technology that they're in and the competitive technologies that are on the horizon," Cole says. "You always have to be prepared to be surprised."

Makers trim weight with thinner steel, mixed materials

When almost all vehicle bodies were made of steel, and weight was not an issue, spot welding was an easy and cheap way of joining the body components. After the OPEC oil embargo, however, vehicle lightweighting became the Holy Grail for automotive manufacturers, as lighter aluminum and magnesium alloys were used to reduce vehicle mass, thus reducing both fuel consumption and greenhouse emissions. Today, driving lighter vehicles that use less energy is not only a government mandate under CAFE standards, it's the greener alternative, too.

"So-called 'lightweighting' has taken 100 to 300 pounds out of newer generations of vehicles, even as they add interior volume and many new features to keep pace with competitors," according to a May 2017 article on ***Green Car Reports***. "Those lighter weights have spread throughout new cars over the last decade.

"One of the first steps for lightweighting was to move away from using only heavy steel parts and start making vehicle bodies with aluminum, or a combination of materials like aluminum and carbon-fiber composites, along with steel. Aluminum, after all, is one-third the density of advanced high-strength steel.

But the solution of using lighter-weight materials and not all steel raised a new question: how to join the new vehicles' parts together? Spot welding and steel joiners once used to assemble a vehicle's body weren't enough to do the job anymore.

"Without the proper joining technology, you're not able to build a multi-materials car today," says Becker. "This was a really big driver for self-piercing rivets, for blind rivets and for other solutions out on the market."

One problem. Many solutions.

SPR Systems (self-piercing rivet systems) join two different materials together that aren't weldable: alumi- num to steel, aluminum to carbon fiber, aluminum to aluminum, without a pre-drilled or punched hole.[4] Blind riveting systems can also be used for joining non-weldable materials when only one side of the joint being made is accessible.

"This is where it's all about light-weighting these days," Becker says. "The permanent joining of various aluminum grades (sheeted, extruded or casted), high and ultra-strength steel, CFRP (carbon fiber reinforced plastic), and magnesium and mild steel, which contains a small percentage of carbon."

Today several popular luxury automakers like BMW and Acura use a STANLEY Vgrip ZRE blind rivet to join carbon fiber composite to high-strength steel.

Since stud welding isn't possible for adding products to a carbon fiber composite car body, a stud-gluing system is the solution. STANLEY worked with an external laboratory to develop a stud with a pre-applied adhesive. The stud gluing system allows manufacturers to place studs even on extreme materials such as magnesium, CFRP (Carbon Fiber Reinforced Plastic), several plastic grades and glass.

"And for products applied on the studs or fixed to other areas to the car, a high portion of our plastic fas- teners are designed to fit to a stud," explained Becker. "As long as we are able to place a stud to a material, we or the OEM can choose from a large variety of existing designs. This reduction in the complexity of fasteners used in a car has potential to deliver significant cost savings because no additional investment in tooling is needed to support higher production volumes."

Average European Vehicle Aluminum Content

Audi also makes complete vehicle bodies out of aluminum, along with JLR and Ford Motor Company. Ford introduced the all-aluminum F-150 pickup truck in 2014.

"Self-piercing rivets are well-entrenched on European vehicle applications after their 1990s debut on the aluminum body Audi A8," according to a 2016 article posted on the Society of Automotive Engineers' website. "As automakers in North America turn to aluminum sheet and other lightweight materials that can't be joined by traditional welding techniques, SPRs are gaining momentum."

Total aluminum content on vehicles made in North America is expected to grow from 397 pounds per vehicle in 2015 to 565 pounds per vehicle by 2028, representing 16 percent of total vehicle weight, according to a survey of automakers conducted by market research and consulting company Ducker Worldwide for the Aluminum Association's Aluminum Transportation group. The survey, ***Aluminum Content in North American Light Vehicles 2016 To 2028***, indicates aluminum will usually be used selectively to make doors, hoods and trunk lids, bodies-in-white, bumpers and crash boxes.

As Ehrhardt says, STANLEY engineers work with advanced-material developers to find and bring new solutions to its customers.

For example, a vehicle maker wants an aluminum stud for an all-aluminum car body. Achieving the same strength as steel M6, which the OEM has used before, requires an aluminum M8 thread, which is one size bigger.

Total North American Vehicle Content

Some engineers claim it might even require a M10. It's still lighter, because it's aluminum, but the part itself is bigger. In order to reduce its size, STANLEY would need a higher or better grade of aluminum.

"If you have a higher strength of aluminum, you could go down in size," Total North American Vehicle Aluminum Content 2015 2028 says Becker. "We are about to launch products using new material grades, which will be the next enabler for this industry." Along with lightweighting, another desirable goal would be to reduce the number of types of joiners used to hold a vehicle body together. The ideal situation would be to have one joining technology. However, vehicle makers currently work with seven or eight.

"This is important because each additional joining technology used for a body adds additional complexity and cost," says Becker, adding that the self-piercing rivets from STANLEY offer a way to get to using only one or two joiners. "So, the more we can offer in terms of a solution to fix a car body, the more we would be helpful to them."

Ehrhardt points out to ***Fastener + Fixing*** that there is an ideal joining process for each material, but vehicle makers can't afford a proliferation of processes in the body shop, due to limitations imposed by cost, training, maintaining an inventory of spare parts, technical availability, and the number of partners involved. "We see a trend towards using more universal technology – stud welding together with stud gluing is definitely one," he says. "Self-piercing riveting for us is one of the biggest potentials the automotive industry has.

With recent developments, we can now join carbon fiber using self-piercing rivets – even carbon fiber to carbon fiber joints – which was not possible before. We can solve the challenges with high strength steels, even with self-piercing riveting. Even with thin sheet mild steel, self-piercing riveting has its position because spot welding has some limitations."

Consumers' love of car gadgets creates need for fasteners

In addition to the chassis and body, vehicles have a myriad of parts and components — brake lines, panels, carpets and more — that have to be affixed so they don't start rattling or making noise, and in a lot of cases manufacturers use a plastic fastener. The wire harness alone, which would measure a few miles or kilometers if laid out in a straight line, can take up to 300 or more fasteners.

"As a driver, what do you want?" Becker asks rhetorically. "The more modules and systems, the more luxurious it is, the more fasteners you need to use." He recalls his first car, in the late 1970s, had just one-third of the number of fasteners that are in vehicles today. Back then there were just lights, a radio and windshield wipers. He had to roll the windows up and down manually.

Today, consumers want electronics, including radio, TV and wi-fi. Vehicles are outfitted with advanced driver-assistance systems that may include cruise control, cameras to show what's in a driver's blind spot, automated lighting or braking, lane departure warning systems, automatic lane centering and more. Autonomous vehicles also include car-to-car communications.

In the future, Becker expects that cars will need a lot more electricity. In just a single door, for example, there is likely to be a loudspeaker, a window opener, a switch to close the doors, and another to adjust the mirror or even a camera replacing the mirror.

"What's coming next?" Becker says. "I've seen things where your window is more or less a touchpad that you use to change the color of the window. If you drive an autonomous vehicle, why should you look outside? You could make it dark and take a nap. Or you could put a game on the window that your children can play during the drive."All of this requires more wiring in the door that must be fastened somehow.

Conversely, while dashboards in the past were held together with screws and blind rivets, new tooling technology has helped make it economically feasible to eliminate most fasteners in the dash today. Tabs that click and lock into holes, with both tabs and holes engineered in plastic in a process that was prohibitively expensive in the past, have taken the place of screws and blind rivets.

Going deep on expertise, and wide on product portfolio
If complexity is the enemy of manufacturing, STANLEY has solutions that simplify vehicle joining and fastening that no other producer can match.

"The major differentiator for STANLEY Engineered Fastening is that we are not obliged to sell a single solution because it's the only thing we do," says Ehrhardt. "If the best answer is a self-piercing rivet, that's fine. If stud welding works best, we're happy. If not, we can talk about stud gluing or a pure plastic solution. At the end of the day, the best solution for that particular customer wins. We have the breadth of product portfolio of a distributor, but we have the depth of manufacturing expertise to develop a unique solution."

The participation of STANLEY engineers in research laboratories, universities and the advanced engineering departments of its customers, and their work side by side with developers and manufacturers of advanced materials, are what's helped develop almost 6,000 "unique" fastener solutions in every vehicle.

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