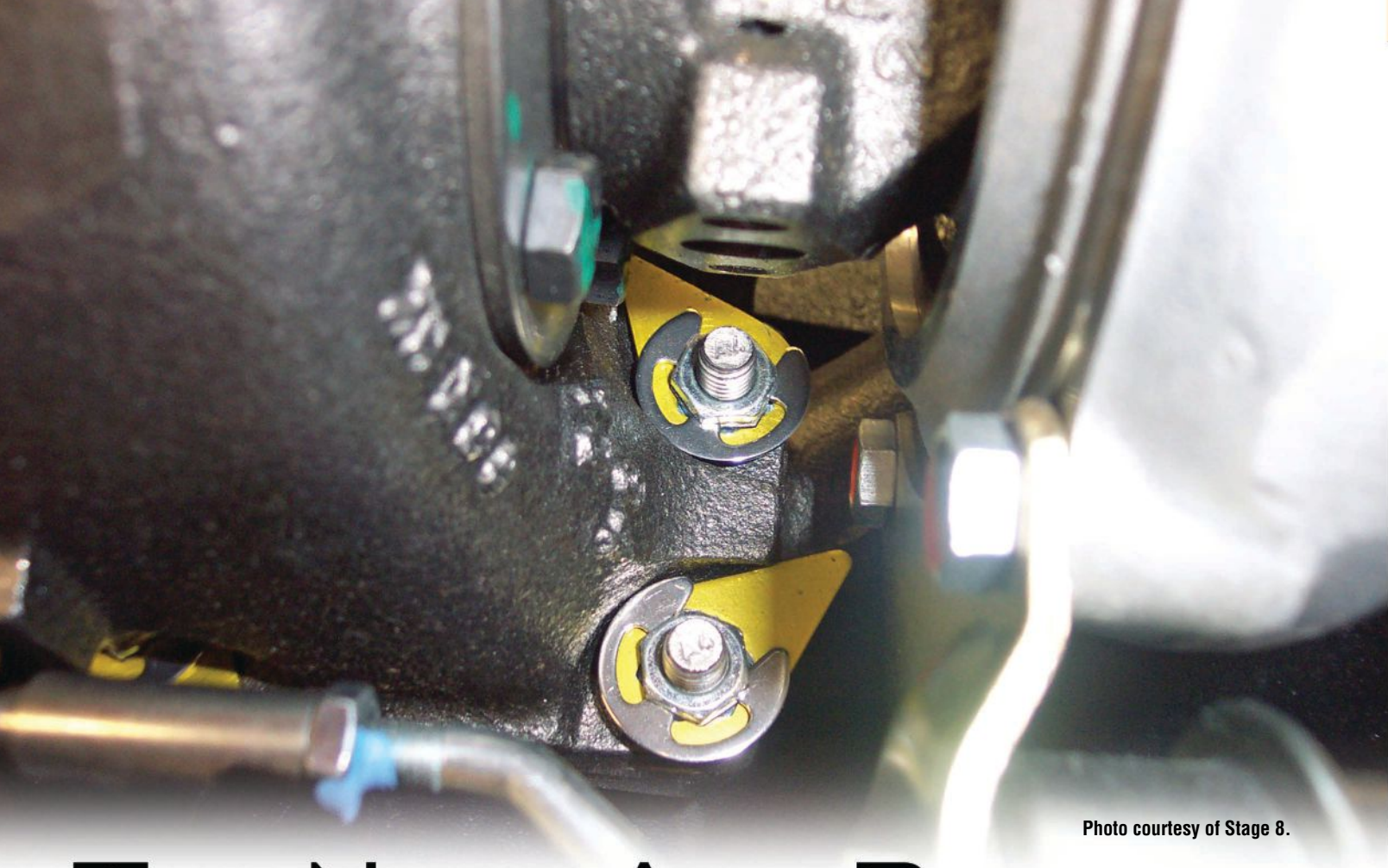


Photo courtesy of Stage 8.

# The Nuts And Bolts Of Racing Fasteners

There's nothing glamorous about fasteners. You're unlikely to hear a winning driver in victory lane gushing over the car's nuts, bolts, studs and rivets. But that driver wouldn't be there without them, and properly engineered racing versions are as specialized as the rest of the vehicle.

"Factory hardware is adequate for going down the freeway, but racing puts greater stresses on everything, whether it's the precision fasteners that keep the engine together or the stronger wheel studs that handle the loads generated by a high-performance car entering a corner at speed," said Chris Raschke of Automotive Racing Products (ARP), Ventura, California.

Some of the problems that differentiate the racing environment from street applications are heat, vibration, weight and strength, so those are the areas where fastener manufacturers and their dealers place substantial emphasis.

"The main issues with bolts backing off are heat and vibration," confirmed Mike Wymore of Taylor Cable Products, Grandview, Missouri. "We specialize in header bolts, and loosened bolts cause leaks not only in headers, but in transmission or oil pans—anything that uses a fastener."

Todd English of Roush Yates Performance Products in Mooresville, North Carolina, told us that engineers have developed unique materials for use in racing's demanding conditions. The better material properties allow for smaller fasteners to accomplish the same task as larger, lower-grade materials, thus saving in both weight and packaging space. Additionally, advances in coatings have allowed for longer life in certain situations by preventing rust or corrosion.

Mike Lang of Coast Fabrication in Huntington Beach, California, said that top-level professional teams have taken an engineering-based approach to fastener design. "Chassis fasteners—which are primarily what we provide—are typically loaded in shear, which means that the clamped materials are trying to break the bolt like a stick," he said. "Most of the design and development work on those types of fasteners has been done by the aircraft and aerospace industries, where they want the highest possible performance and the lightest possible weight, with maximum durability."

The most common grades in aerospace are AN, MS and NAS, standing for Army Navy, Military Specification and National Aerospace Standard. Each standard stipulates how a fastener is produced, tested and packaged, and the specifications also define which

By Steve Campbell

Discover the differences between motorsports fasteners and their counterparts in street, military and aerospace applications as we present the latest innovations to fortify race vehicles of today—and tomorrow.

companies can make those fasteners.

So let's take a look at the fasteners that may have their roots in aerospace and military applications, but have transitioned into motorsports-specific products, even designed solely for racing.

**Evolution of Motorsports Fasteners**

Milodon in Simi Valley, California, has been in the fastener business since the early 1970s, and its fastener products also originated with the aerospace industry, though its mainstay in the fastener segment now is 8740 chromoly head and main studs. As an aerospace legacy, materials and processes are crucial to Milodon's approach.

"Metal is basically like wood, in that it has grain structure," said Ken Sink. "If you cut the threads into a stud, for instance, the metal is weakened in the threaded area. When you roll the threads under extreme pressure, the metal is compacted and actually becomes denser at the threaded area. A lot of the cheap fasteners that come in from offshore have cut threads, and they can shear, snapping the stud."

Nuts and bolts are also graded on strength levels, which are based on the maximum stress that a material can support without breaking, expressed in pounds per square inch. For instance, Grade 2, the lowest, has a minimum rating of 74,000 psi, while Grade 8 has a minimum tensile strength of 150,000 psi. The grades are indicated using a marking system. Grade 2 has no markings, Grade 5 has three radial lines on the head, and

**Among the conditions that differentiate a racing environment from street applications are heat, vibration, weight and strength, and those are the areas upon which fastener manufacturers and their dealers place substantial emphasis. One common problem encountered by racers occurs when bolts back off due to heat and vibration—a scenario that a number of manufacturers have designed products to specifically resolve. Photo courtesy of Coast Fabrication.**

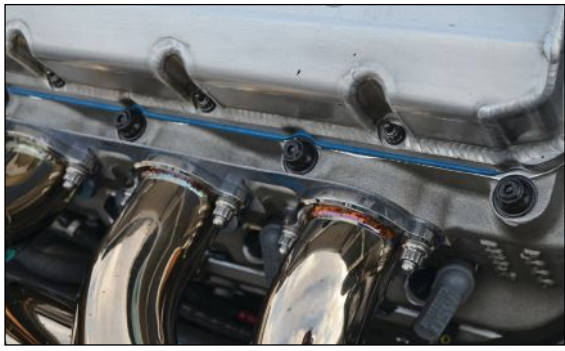
Grade 8 shows six radial lines.

"All of our bolts are also stamped ARP," Raschke said. "When we go above 8740 alloy steel, we stamp ARP2000, or L19, or Custom Age to identify the material, all based on strength."

The chemical makeup of the material determines its hardness. According to ARP, 4130 alloy steel has only .3 percent carbon and can't be hardened as high as 8740, which has .4 percent carbon. Also, 8740 has about .45 percent nickel and 4130 has none. Both have molybdenum (most alloy steels have moly), but the chromium content of 4130 is slightly higher at .95 percent instead of .55 percent. However, 8740 is generally considered to have slightly better toughness due to its nickel content. The term "chromoly" refers to strong steel alloys that are made principally of chromium and molybdenum.

Threaded fasteners stretch as they are torqued into the mating surface. Sufficient stretching of a stud or bolt—also called preload or tension—is what holds it in place. In some applications, vibration, or constant heating and cooling, can loosen a threaded fastener. That's why some bolts, such as those used to attach exhaust headers or in turbochargers, for instance, are designed with some type of locking feature.

**Significant progress in the design and manufacture of race fasteners, particularly in the materials used, has been noted in recent years. One supplier explained how engineers have developed unique materials for use in racing's harsh conditions. Better material properties allow for smaller fasteners to accomplish the same task as larger, lower-grade materials, which saves both weight and packaging space. And, advances in coatings can also promote longer life.**



"We offer a very simple locking header bolt," said Booth Platt of Proform, part of Specialty Auto Parts in Warren, Michigan. "Each of our Grade 8 header bolts is permanently assembled with a pair of special washers that are harder than the bolt or the header flange. When the bolt is torqued to more than 28 ft.-lbs., the washers' external teeth bite into and grip the bottom of the bolt head and the top surface of the header. Once they're locked, vibration that might ordinarily loosen the bolt actually increases the wedge-locking tension. The bolts can be untightened with a normal wrench, then lubricated and reused."

In contrast, Stage 8 Locking Fasteners of San Rafael, California, uses a mechanical retainer system to lock its bolts on header and turbocharger applications. The retainer wedges against the bolt head, stopping it from rotating.

"The retainers are typically aluminum for the vast majority of cases, because their strength is fine and they're light in weight for racing," said Glenn Thompson. "On turbocharger applications, we go to stainless-steel locking pieces, mainly because of the heat. Aluminum starts getting soft at 1200 degrees, and turbos easily go to 1500 degrees."

Wymore reported that Taylor Cable's locking bolts use a spring under tension to prevent them from loosening. "It's basically like putting on a regular bolt," he said. "All you have to do is tighten a set screw before you torque the bolt in and then back the set screw off. The set screw adjusts tension on a spring that locks or unlocks a keeper. When it comes time to remove the bolt, you tighten the set screw to release the tension off the spring so that the spring comes down and sits in place on the locking washer, and you can take the bolt out and reuse it several times. The set screw doesn't affect the torque of the bolt."

In applications where stretch supplies the clamping force in a threaded fastener, it's crucial to apply the proper tension. "Stretch is based on the diameter, length and tensile strength of the material," Raschke explained. "You want the fastener to work like a spring. When the components in the engine expand due to heat, the fastener has to give. When you tighten it, the fastener stretches so that it's preloaded."

### Preventing & Addressing Failures

Proper preload can be established by using a torque wrench, using a stretch gauge, or by rotating the fastener a predetermined amount. Measuring stretch with a gauge is the most accurate, but oftentimes only professional racing teams are likely to have a stretch gauge to set the preload on items such as connecting-rod bolts. On the other hand, the nut-turning method requires precise awareness of material compression specifications and when the bolt head initially contacts the mating surface. Setting preload with a torque wrench is the solution most technicians use.

"Most critical to us is ensuring that the torque wrench is in calibration," Raschke cautioned. "If your torque wrench is not properly calibrated, the fastener may be too loose or too tight. If you use the wrong lubricant, the torque specification will change. If you under-load the fastener in a final application, the bolt may shear. In flywheels, higher rpm will cause different harmonics, requiring more clamp load, which is the same as preload."

Over-tightening and fatigue of threaded fasteners are common causes of failure. Each fastener has a yield point, which means that it has been stretched so far that it won't return to its original dimensions. Once the fastener has been torqued beyond its yield strength, it must be replaced. And if a fastener is torqued and loosened too many times, it can be subject to tiny cracks or notches called stress risers, which can cause breaks.

"LS engines have torque-to-yield fasteners, so they're not reusable," Raschke said. "All of our fasteners could be torque-to-yield fasteners, but I recommend using stronger fasteners on those installations to achieve the proper torque at 75–80 percent of yield. That gives you a cushion where you can continue to use the fastener so long as you don't over-torque or overload it."

Engine and race car builders also must be aware of strength versus brittleness. Toughness and fatigue resistance require fine-grain metals, but a bolt with too fine a grain becomes brittle. Threads may accentuate brittleness because of the thinness of the material at the thread.

"You don't want to go with a super-brittle fastener," Sink said. "If you torque them after a couple of heat cycles, they could snap. The 8740 that we use is a very forgiving but super-strong material."

Some of the newer developments in high-end racing include composite materials. Lang said that some Formula 1 and IndyCar teams are taking advantage of the strength and light weight of those materials in building their chassis and bodies. But composites offer their own fastener challenges.

"The primary goal is to increase fatigue resistance of the composite structures at the attachment points," Lang said. "Everybody hates to drill holes in composites to attach a nut plate because it kills the tools, and you have to be extremely careful with hole sizing. The aerospace industry has developed a nut plate that attaches without rivets, and that actually increases the fatigue resistance of the material around the hole for the fastener to go through. But those are expensive components, so it's a question of what advantages they hold versus the costs. As those products come into the mainstream and are produced in higher quantities, the price will come down."

Failures in chassis applications are generally caused by one of three primary problems, according to Lang: using the wrong fastener for the job and creating a mismatch in strength requirements; improper installation through simple mistakes such as incorrect torque specifications or using the wrong lubrication; and lax maintenance.

Troubleshooting a threaded-fastener problem can often be traced to a

**While factory hardware is adequate for a street car, racing puts greater stress on components, especially precision fasteners that keep the engine together, or stronger wheel studs that are designed to handle the loads generated by a high-performance car entering a corner at speed, reported one fastener manufacturer.**

change in the car's configuration or new assemblies. "Sometimes the racer only wants to go to the heart of the problem, but I back up and ask how long he's been using the fastener in question," said Les Figueroa of Figspeed, a speed shop in Las Vegas, Nevada. "Is it something he just recently tried? Is this a new engine combination? A new transmission combination? What has changed? Problems generally come to light early in the season because something has been altered, and parts are rarely the problem. If they are, it's usually that the wrong part was used for the application."

The same holds true for other types of fasteners, such as the rivets, latches and body bolts that are used to assemble a race car's skin and accessory components. Those applications also require purpose-built products.

"You need strong attaching and latching fasteners because of the high vibration and heavy pounding that a chassis will take, especially on a dirt track," said Gene Virus of Great Plains Fastening Systems, Concordia, Missouri. "They have to be vibration resistant and be quickly removed and installed. Some fasteners can be used with locking devices or thread lock, but rivets have a different nature. Once they're set, they don't vibrate loose—but only if the correct rivet is used for the desired application. They must be sized and installed correctly to achieve maximum fastening capabilities."

### Understanding Rivets

A rivet has a body (or shank) and, within it, a mandrel (or nail). Pop rivets get their name from the distinctive snapping sound the mandrels make when they break off during installation.

To install a rivet, a hole is drilled through two materials or more that are to be joined, such as a body panel and a chassis attachment point. The rivet is inserted into the hole, and a rivet gun is used to pull on the top of the mandrel. As the mandrel pulls against the body, the body upsets (deforms), pulling the mated materials together. The force of the gun then snaps off the mandrel head at a premade break point.

"Rivets can be used anywhere you're assembling a chassis or a body and you can't get to the back side," Virus said. "That's why they're called 'blind fasteners.' You either need a threaded receiver, a nut-type fastener that is set or installed on part of the chassis, or you use a rivet."

Rivets are classified by shear strength, tensile strength, body and mandrel material, body style, break load and grip range. Shear strength is determined by how much pressure it takes to cut a rivet in half; tensile strength refers to how much pressure it takes to pull the rivet apart longitudinally; and break load is the amount of pressure it takes to snap off the head and therefore determines clamping load. Grip range is the thickness of the material the rivet is designed to clamp.

Body styles can be a standard open-end type, a multi-grip type for hole filling capabilities and mandrel retention, a closed-end type for water resistance and 100 percent mandrel retention, a high-strength type with a mandrel locking feature that breaks flush with the top of the rivet head in the shear plane of the joint, and a tri-fold type for a large bearing surface on the blind side of the material.

Like other fasteners, rivets are made from a variety of materials, including aluminum and steel alloys, as well as brass, copper and plastic. Most race car rivets are aluminum, steel or a combination, where easily drilled aluminum is preferred when quick replacement may be needed, and steel used for more permanent installations.

The tri-fold or "exploding" rivet is used extensively in attaching body panels. With a tri-fold, the body of the rivet splits into three pieces as it is compressed and offers a larger clamping area on the back side of the mating material. "The tri-fold rivet we helped develop back in the 1980s was made of soft aluminum, and it had a break load of about 350 pounds," said Butch Novak of Speedbear Fasteners, Imperial, Pennsylvania. "In the last few years, guys began building body panels with different types of plastic that had irregular surfaces. When a panel of aluminum is put together with the plastic, there could be a gap. A rivet with a low break load won't pull that stuff together tightly before it snaps. We did a lot of research and made an all-aluminum rivet with about a 700-pound break load, which doubles the tightness of a standard rivet to pull those panels together."

Norm Dunn of Number 1 Speed Equipment in Watertown, New York, said that most of a race car's body is hung with a screw fastener, a twist fastener or a pop rivet. "Our customers are Northeast modified guys who run dirt cars. We also have street-stock, pro-stock and Late-Model customers, and they all have their

own different styles of fasteners. The Late-Model bodies are all held on with aluminum pop rivets front to rear, because other fasteners weigh too much," he said.

Dave Poske's Performance Parts in Parkersburg, West Virginia, offers rivets and body bolts or washers to help keep the fastener from pulling through the sheet metal. "You put a lot of stress on the fasteners because you're bending the body panels," said Allen Hamrick. "Most of the racers we deal with use aluminum sheeting for their bodies, so they need fasteners with larger bearing surfaces to keep from pulling through."

Both chassis and body panels are now built with lighter materials, noted Kevin Smith of Irvan-Smith, Concord, North Carolina. "We see very few stainless parts or all-steel parts until you get into threaded fasteners, which are used to satisfy torque requirements. Racers are now working with very thin aluminum as well as fiberglass or composites. Tri-fold rivets give you a large secondary bearing surface for either thin aluminum or thin composites. We also offer our TorqueLox system, which uses an insert that takes the place of a nut. It is installed on the frame and is set with a tool. Blind fasteners go beyond just rivets," he said.

Virus of Great Plains Fastening Systems pointed out that builders previously used rivets exclusively to attach body panels, and would install between 200 and 250 rivets per car. Now they want easy access to one side for cleaning out weight-adding mud and dirt, and doing service work, so they'll use body bolts, which can be removed and replaced in seconds using a cordless tool. Great Plains also designed a finish washer with a hex-head socket to prevent mud from building up in the old-style, Allen-head fastener, making the washers easier to remove and reinstall.

Accessibility is also of paramount importance for the engine compartment and other areas that may need immediate service during a race. The most common types of fittings for those applications have been Dzus fasteners, hood latches or hood pins. But Australian company Proflow, in Epping, Victoria, now offers pushbutton fasteners that come in various styles and sizes, and can be directly retrofitted to replace the older styles.

Tom Casamento said Proflow's Quick Latch can handle nearly 200 pounds of tensile force and doesn't require any tools to release. The pushbutton mechanism is machined from 6061T6 billet alloy, and the latching mechanism is S303 stainless steel, including a ball pin. "They can be used for bonnets, boots, panels, sump guards, air cleaners and more," Casamento said. "They're available in polished or high-gloss black finishes, and are show-car quality." PRI