

Rod ends: easy to forget, until they break

by Wayne Scraba

Rod ends get no respect. They all look the same, and because they're buried under the car, racers tend not to think about them. Trouble is, rod ends may be one of the most common pieces on a race car, and they're used in plenty of places other than four-link or ladder-bar suspension systems. Rod ends can be found on track locators, carburetor and clutch linkages, steering components, and other seemingly insignificant spots. They're easy to forget about — until they break.

When a rod end breaks, things can get ugly fast. Most rod ends are used in places where they're charged with handling considerable loads, so they are critical. And even more acute is that not all rod ends are created equal. Some are of aerospace quality; others are junk. But it's hard to differentiate between the two.

A rod end consists of a spherical ball that is designed to rotate inside a housing. This ball is the bearing, and its housing is the race. The spherical ball is machined flat on each side, and it is bored through the center.

When shopping for rod ends, you'll come across commercial and economy models. Though a number of economy rod ends are available, the best type is the fully swaged, two-piece model. On this rod end, the body is formed, or swaged, around the ball so that the race the ball rides on is part of the body. This is the only inexpensive rod end that offers decent radial or pull strength and good axial strength (axial strength is the resistance of the ball being pushed out of the side of the body).

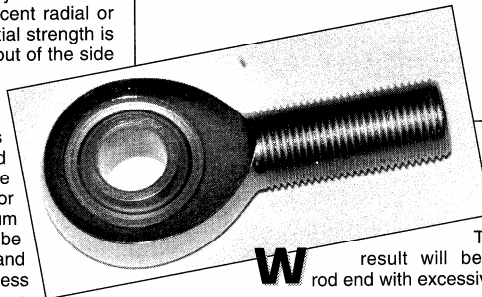
Real racing rod ends use a three-piece precision design, often called an aircraft rod end, and its design allows different materials to be incorporated during construction, which makes for the best match. Races are made of alloy or mild or stainless steel (brass or aluminum bronze is sometimes used but should be avoided because of their low strength), and bodies are made of alloy, mild or stainless steel, aluminum, or titanium. In this three-piece application, the race is formed around the ball, then the race insert is staked into the body. This construction offers a much closer fit and a much higher degree of precision between the ball and the race.

Another common option is a Teflon liner, which allows the rod end to self-lubricate. This is important because it's usually difficult (if not impossible) to grease or oil a rod end once it has been installed in a car. More important is that grease fittings can physically weaken the rod end, and grease on the rod-end ball also attracts grit that works its way between the ball and the race, accelerating wear.

A Teflon liner eliminates most, if not all, of those circumstances. The liner is bonded to the race so that the ball actually rides on the liner. The movement of the ball rubs Teflon on it, which provides lubrication. When looking at Teflon-lined rod ends, beware of inexpensive examples with virgin Teflon because it's relatively soft. A Teflon liner eliminates clearance between the ball and the race, which makes for a tighter fit.

One term you'll come across when dealing with rod ends is "beating out," which refers to a couple of problems. The first is the deformation of low-strength self-lubricating liners. Some economy rod ends have races that are constructed with molded plastic (occasionally mixed with a fiberglass filler). Teflon may also be added for lubricity. These units have a compressive strength of no more than 15,000psi, which causes the race to deform long before the body sees any damage.

The other type of liner failure involves the physical bond between the liner and the race. The liner's self-lubricating nature sometimes makes it difficult for it to bond to the race. If the manufacturer can't make this bond strong enough, then the liner will detach from the race. Each time there is a misalignment of the rod end (more on this later), pieces of the liner will disintegrate.



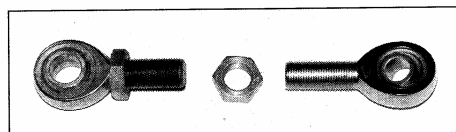
When shopping for rod ends, look for models like this three-piece precision design. The race is formed around the ball, then the race insert is staked into the body. This type of construction offers a much closer fit and a much higher degree of precision between the ball and the race. The three-piece design allows different materials to be used during construction, which makes for an ideal match of

W result will be a rod end with excessive clearance.

What is rod-end misalignment? Because a bolt or fastener fits in the hole bored through the rod end's center, the ball can't rotate inside the housing 360 degrees (without the fastener through the center, the ball can rotate through a full circle). Given that, all rod ends have limitations in how far they can be misaligned before the ball binds in the housing. The angle of misalignment is a crucial factor when selecting rod ends because not all rod ends can accept the same degree of misalignment. If you exceed the manufacturer's recommended maximum angles, the smallest problem you'll see is premature rod-end wear; the worst is rod-end failure.

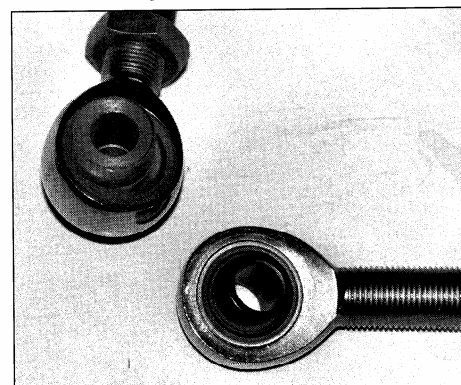
Use a protractor to measure the angles mandated for the application, then compare your measured angles to those in the manufacturer's catalog to select the correct rod end for the application. The biggest mistake is to shortcut this measurement and buy a rod end that simply looks as if it can handle the job.

Aside from misalignment, other things should be considered when selecting a rod end. A rod end is typically constructed in one of two ways. One type has a shank (the threaded segment) that is exactly the same diameter as the hole in the ball (for example, a 3/4-inch bore coupled with a 3/4-inch shank). The other type has a shank that is one size larger than the bore (one example is a 5/8-inch bore mated to a 3/4-inch shank). The second type (smaller bore, larger shank) has an advantage, especially where bending loads may

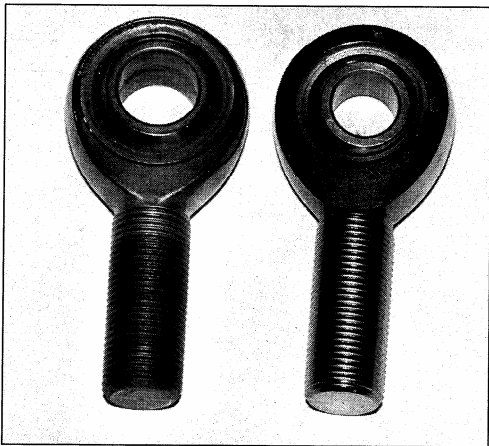


be present. For example, in a four-link suspension package, the larger shank provides more strength and a considerable amount of reserve strength capacity.

An oversize shank is generally constructed by installing an insert one size smaller in the body of the part with the larger shank. Because of this, a 5/8x3/4-inch rod end will exhibit higher load capacities than a 3/4x3/4-inch



(Above) Take a close look at this rod end. See how the ball isn't centered? This is the misalignment that the rod-end design can handle. Without a fastener through the center, the ball can rotate completely in the race. With a fastener, all rod ends are limited in how far they can be misaligned before the ball binds in the housing. The angle of misalignment is a critical factor when selecting rod ends because not all rod ends can accept the same degree of misalignment. Check the manufacturer's recommended maximum angles before ordering bearings. (Left) Rod ends are usually available with left- or right-hand threads. Be careful when purchasing jam nuts: Not all are created equal.



Both of these Aurora rod ends have 3/4-inch shanks. The rod end on the left is a heavy-duty model, and the rod end on the right is a standard model. What's the difference? The heavy-duty model has a 5/8-inch bore, and the standard version has a larger 3/4-inch bore. An oversized shank is generally constructed by installing an insert one size smaller in the body of the part with the larger shank. Because of this, a rod end with a 5/8-inch bore and a 3/4-inch shank will exhibit higher load capacities than a rod end with a 3/4-inch bore and a 3/4-inch shank, provided both are manufactured from similar materials. An exception is a larger shank added to a smaller body, which serves the same purpose as the oversized shank but has less material surrounding the spherical bearing.

rod end, provided both are manufactured from similar materials. This is because more body material surrounds the insert. You'll also find that asymmetrical rod ends provide superior wrench access on many suspension components. Some companies offer a rod end with a larger shank added to a smaller body. Though this configuration serves the same purpose as the oversized-shank situation, less material surrounds the spherical bearing.

Once the misalignment and dimensions are figured out, the elements used to construct the rod end need to be considered. As was mentioned, a number of materials are used to manufacture rod ends. The balls usually are subjected to the highest loads encountered by the rod end, so they require the greatest hardness and strength. Some commercial rod-end balls are manufactured from bronze- or even sintered-steel balls. Strengthwise, these materials aren't so hot, but know this: Some sintered steels are fully

up to the job. Automotive giants such as Ford Motor Co. and German manufacturer BMW have begun to use sintered steel for high-stress applications such as connecting rods. With a proper heat treatment, sintered steels can live happily in a medium-duty rod-end ball application. On the other hand, high-quality rod ends normally incorporate heat-treated steel balls (typically, chromoly steel and stainless and 52100 bearing steel are used). To remain round, the balls must be extremely hard (often the balls are chrome-plated to provide a smooth bearing surface), which is critical when the ball is placed under a load.

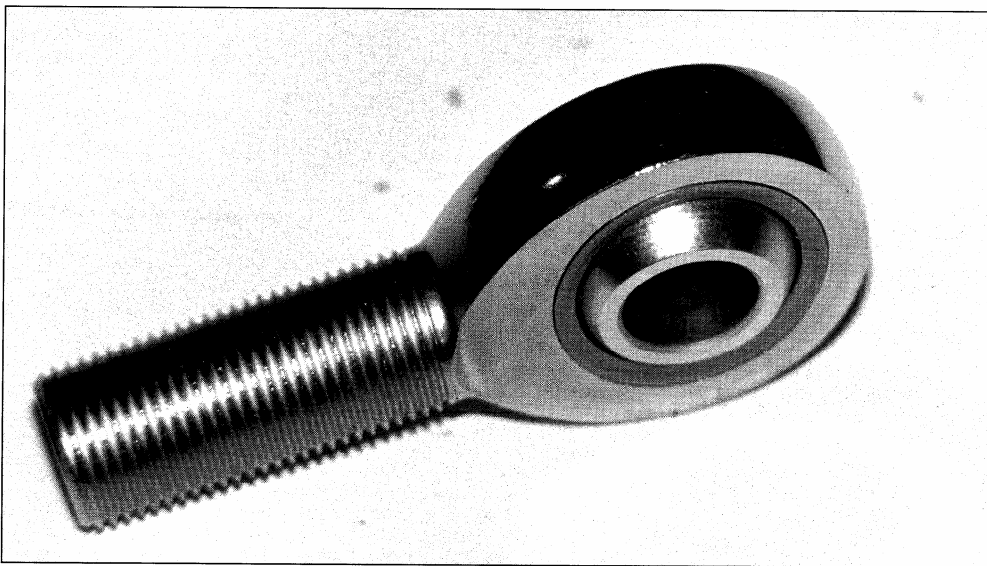
Because of the heat treatment and overall hardness of the ball, the outer rod-end race has to be hard but not as hard as the ball. Most three-piece rod ends use a race manufactured from through-hardened steel alloy or a stainless steel that can be hardened. In both of these instances, the outer races are heat-treated for wear resistance and strength.

Commercial or economy rod ends usually have bodies constructed from low-carbon mild steels. It is not possible to through-harden this material. Though this less-expensive material might work in a lightly loaded application, rod-end bodies manufactured from chromoly or heat-treated stainless steel are far superior for race car applications. If a chromoly or stainless-steel body is used, then the size of the rod end can be reduced (simply because the material is stronger). Some manufacturers have used 7075-T6 aluminum for rod-end bodies. This grade and type is one of the strongest of aluminum and has a tensile strength slightly greater than mild steel. Unfortunately, aluminum will not stretch or bend as much as mild steel will before breaking. Heat-treated or chromoly-steel rod ends are almost twice as strong as aluminum versions.

Are used or surplus rod ends a good deal? Don't even think about it. Just like any piece of hardware, a rod end has a finite mechanical life, and you don't know if a surplus or used rod end has reached the end of its usefulness. There is no safe way to repair or tighten a worn rod-end bearing.

So how can you tell if a rod end is a high-quality piece? Look at a rod end the same way you'd look at any precision racing component. Inspect the machine work. Is the surface on the race rough or smooth? The same with the ball: Is it well-machined and smooth? If the rod end is a non-Teflon configuration, does the ball fit inside the body precisely or does it rattle or bind? When looking at a Teflon bearing, do you see gaps in the Teflon liner or are there areas where the liner is actually loose? A Teflon-lined rod end should be one tightly bonded piece.

In the end, the best rod ends for racing are those designed and constructed through proper engineering and backed by a rigorous R&D program. The rod end you're searching for should feature precision-ground steel balls, and it must be constructed with the highest-quality materials. Quality costs money. This is no place to get cheap.



This Aurora rod end has a composite Teflon liner (usually, you can purchase two- or three-piece rod ends with Teflon liners). The liner consists of a carrier component, usually a fabric (which provides compressive strength), a Teflon component for lubricity, and various bonding resins. The Teflon liner is bonded to the race so that the ball actually rides on the liner. The movement of the ball rubs Teflon on it, which provides lubrication. When looking at Teflon-lined rod ends, watch out for cheap ones made with virgin Teflon because it's relatively soft.

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