



Choose Your Fasteners Carefully

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Many fasteners on the market today have been specifically designed to remain tight and to not work loose under vibration and temperature change cycles. They do a good job staying tight, but some types may actually provide poor electrical connections. Some fasteners can cause problems for you and your customers when their connections must carry high electrical loads, such as cables to starters or alternators.

To understand this, you have to know how current flows between a cable and a threaded post, such as that on a solenoid or alternator battery terminal (see *Figure 1*). The wire or cable should be solidly connected to the terminal by crimping, soldering or both. To get from the terminal to the threaded post, however, current must flow through the fasteners that hold it in place. It is the actual contact area between the terminal and the fastener where a problem may occur.

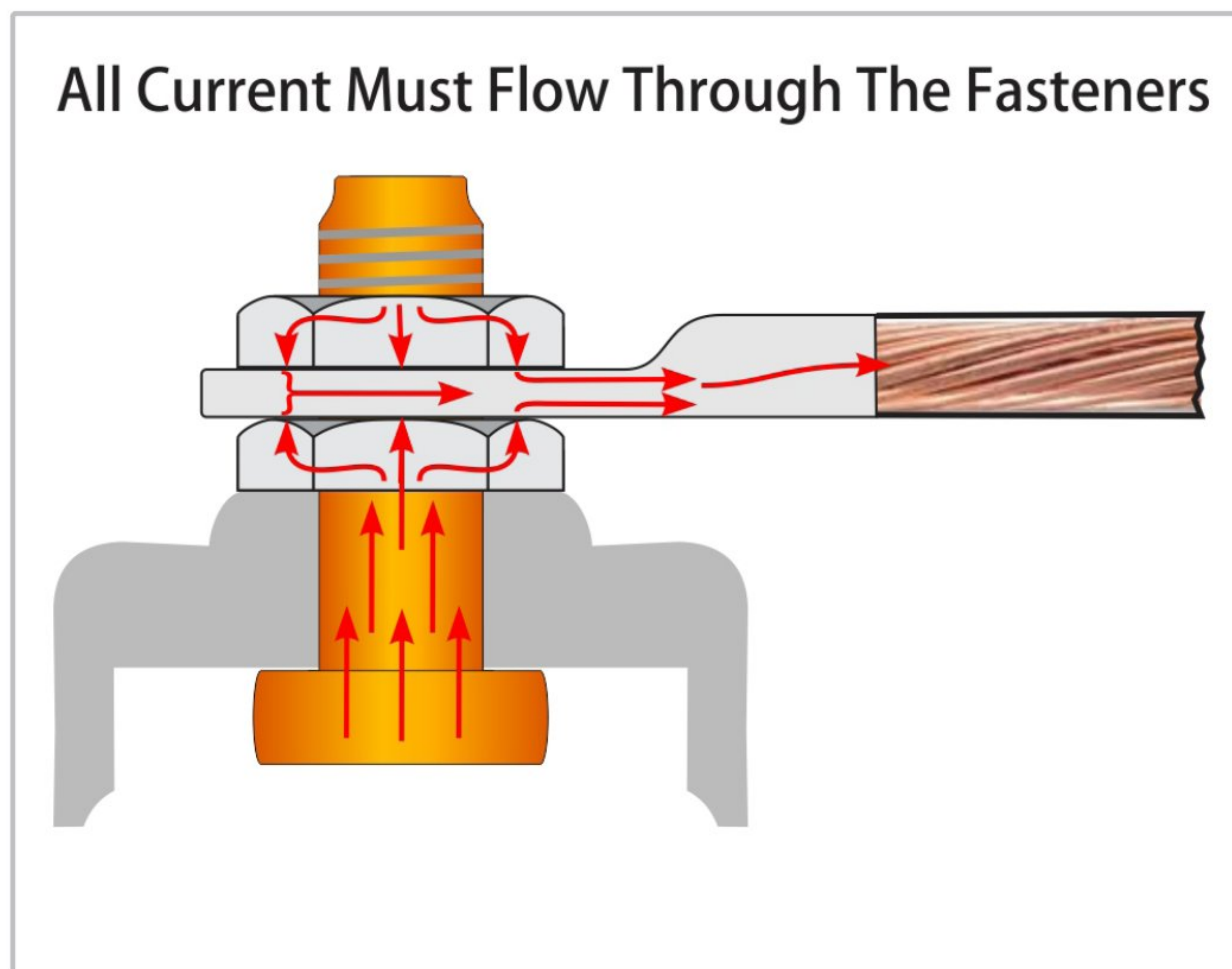


Figure 1—Current Flow Through Fasteners

In an ideal electrical connection, the actual contact surfaces are clean, smooth and have as much surface area as possible. Current does not flow well between rough surfaces. Air gaps, no matter how minimal, cannot conduct current. It is called a “contact” for a reason. Another problem with air gaps is that they accelerate oxidation of steel fasteners. Most fasteners used by rebuilders are made of plated steel for strength. While steel is a conductor, its properties are inferior to copper, and even with plating, steel is prone to oxidation. Rusted steel (ferrous oxide) is not a conductor. Brass fasteners

can provide both strength and resistance to oxidation but are generally not used in automotive applications due to their high cost. It is worth mentioning that stainless steel is an inferior conductor in spite of its high resistance to corrosion and oxidation. Stainless hardware should not be

used to fasten electrical connections that must carry high electrical loads.

For these reasons, the fasteners you send out with alternators and starters are important. So let's look at all the fasteners and locking mechanisms that are available.



Figure 2—Hex Nut and Split Lock-Washer

Hex Nuts and Lock-Washers

The hex nut has been the standard means of fastening since the industrial revolution, and it is still widely used today. The most popular locking device used with a hex nut is the *split* lock-washer (see *Figure 2*). When you buy a new aftermarket solenoid today, chances are it will come with hex nuts and split lock-washers. It may be acceptable to use a split lock-washer on the switch terminal, because of its low current requirements. Using a split lock-washer on a high-current battery post, however, can cause problems. Depending on the width of the split lock-washer, the electrical contact area can be reduced by as much as 50%. The locking ability of the split washer has also been questioned in several studies over the last 20 years. As a result, the *serrated* or *star* washer came into use (see *Figure 3*). There is no doubt that these newer-style washers were an improvement when it came to



Figure 3—External and Internal Serrated Lock-Washers



Figure 4—Wave Lock-Washer

locking the hex nut, but they still greatly reduced the contact area and allowed plenty of air space for oxidation to take place. Wave washers have recently become more popular and work well for keeping connections tight (see Figure 4). If the wave washer is wide enough to cover 100% of the hex nut surface, it makes an excellent locking washer for high load electrical connections.

A conical washer is a dished-shaped washer made of spring steel which flattens out under pressure when the nut is tightened (see Figure 5). The spring tension of the washer helps keep the nut from backing off while keeping the electrical connection tight at all times. Conical washers have been around for 100 years and were called *Belleville* washers after the man who invented them. Delco used a type of Belleville washer under the rivet for the ground-brush lead on many of their generators.



Figure 5—A Conical (Belleville) Washer

Keps Nuts

A big innovation in locking hex nuts was the *Keps* nut from ITW (Illinois Tool Works Inc). It is a hex nut with a free-spinning washer which is permanently attached. Keps nuts utilize serrated lock-washers or conical washers (see Figure 6). The conical washer lock-nut makes a much better electrical connection. It is the fastener of choice for the alternator B+ connection with most automotive manufacturers. Many use it for the starter B+ connection as well.

As a side note, when ITW introduced the Keps nut, they trademarked the name *Shakeproof*. The marketing department wanted a shorter nickname and got it by taking



Figure 6—Serrated and Conical Keps Nuts

the three letters out of the middle of the proper name. The “S” was added to make it plural, as the story goes. Today they are commonly known in the fastener world as Keps nuts.

Flange Nuts

There is a type of hex nut known as a *flange* nut, which has a smooth flat washer-sized area around the bottom of the nut. While there is no locking mechanism, these nuts make excellent electrical connections by providing a larger surface contact area with the cable terminal—larger than a hex nut alone. Delco has been supplying this type of flange nut on all of their heavy duty starters for decades. Unfortunately, there is also a serrated flange nut out there, with a locking washer essentially cut into bottom of the nut (see Figure 7). No doubt, this helps lock the nut in place, but it also makes a very poor electrical connection. The actual contact area ends up being only the tips of the serrated flange teeth, leaving



Figure 7—Serrated Flange Nut and OE Flange Nut

air space for oxidation to occur (see Figure 8). Denso used a serrated flange nut to hold the solenoid on some of their small-case SD starters, a perfect place to use it. However, no OE manufacturer that we are aware of has used serrated flange nuts for solenoid studs or motor studs on heavy duty starters. Unfortunately, if you purchase a new heavy duty aftermarket solenoid today, it probably will come with the serrated flange nuts. My guess is that one supplier started using them, and everyone else just copied them—believing it was a good idea. *It's not.*

- In the case of an alternator B+ connection, use a Keps-type conical locking nut.
- In the case of a starter, use a Keps-type conical locking nut if available—if not, use a smooth flange nut.

Dielectric grease is a good way to prevent the degradation of any electrical connection. Simply apply a liberal amount to all of the contact surfaces before you tighten the fastener. It will not inhibit current flow, but it will prevent oxidation of the connection.

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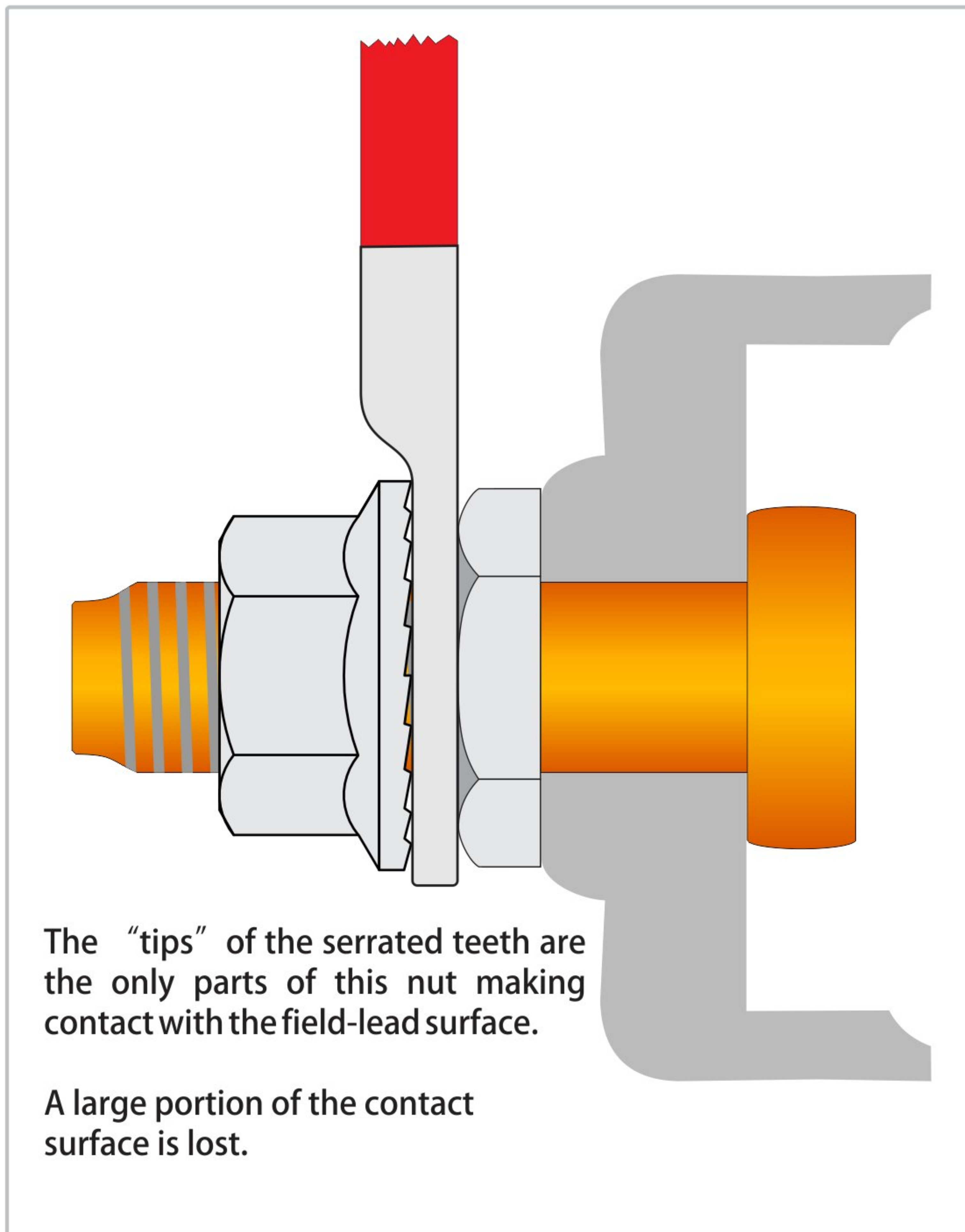


Figure 8—Serrated Teeth Offer Poor Contact Area

Best Practices

So what type of fasteners do you send out with your rebuilt alternators and starters? How many times have you seen your units come back, in or out of warranty, with a rusted hex nut on a B+ or motor terminal connection? And what kind of washer, if any, was used? Keep in mind that the rust you see is a sign that the connection has been extremely hot because of a voltage drop caused by a bad connection.

You cannot go wrong by following the OE manufacturer—if possible use what came on the vehicle from the factory.