WHEN — Q1 2014
Why Wheel Studs Break

Update #2325

Attention: Dayton Parts' Distributors and Business Partners.

The second issue... **WHEN (WHeel End News)**

First off I want to thank everyone for all of the positive feedback on the first edition of WHEN. It's much appreciated and going forward we'll make sure this feature stays informative with content that will help you grow your business. Anyone can sell a part for less, that's really easy to do. It's a whole other thing to have the knowledge or *"know how"* to solve a customer's problem. That builds customer confidence in your business and we always want our business relationships to be about more than just price. Business easily won with just price can also be easily taken away with just price.

Remember that when competing against a *"low cost provider"* in the market. Their solution to make the sale is to always cut the price because they don't have anything else. This approach to business takes absolutely no product knowledge whatsoever nor does constantly cutting the price require them to ever learn anything about what they're selling. If a customer of their's does have a problem with a product they bought from them, most likely they won't be able to solve it and there's your opportunity. When there's a problem, product knowledge and knowing how to solve the problem is *"worth its weight in gold"* as the old saying goes. Don't mean to digress here, but it's so important to always find new ways to reiterate what all your company *"brings to the table"* and *"break through the clutter and noise"* as they say in the advertising business. We work in an industry that sells service parts for vehicles that gross out at 80,000 lbs can easily go 60 mph and be over 65 feet long bumper to bumper. That being said, it's obviously best to deal with people who know what they're doing and what they're talking about. Later on in this article I'll give one example of what can happen when there's a *"void"* of product knowledge. As my grandpa use to say *"thanks for letting me bend your ear for a minute."*

For this edition of WHEN, I want to follow-up on what we discussed about brake drums with **"Why Wheel Studs Break"**. There are some older vehicles still in service with the stud piloted *"double cap nut"* wheel mount system but they are becoming few and far between. Since hub piloted wheels with outboard mounted drums have been the standard wheel end system on new vehicles for over twenty years, we'll limit our discussion here to just that system.

Here's a typical scenario we've all run into on the parts counter numerous times...

Why Wheel Studs Break -

A parts runner sits down at the counter with what's left of a broken stud that came out of a hub. You measure the OD of the thread and its .860"/.861", a little less than 22mm (.8661") so you know this stud came from a hub piloted wheel mount system. Since part of the stud is missing, you're not sure how long it was. In an effort to narrow down the application, you ask the parts runner if the vehicle has steel or aluminum wheels. Of course they don't know, they just need the right stud so they can head back to the shop. You continue your process of elimination until you come up with one and you send the parts runner on their way with what you're pretty sure is the right stud. Sound familiar?

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Why Wheel Studs Break - *(continued)*

Sure it does, we've all been there many times. However, all things being equal as they say, if everything in the wheel mount system was correct the stud should not have broken in the first place. So why did it? Like many other parts we can determine a lot from the broken stud if we know what we're looking for. Once again therein lies the key, knowing what to look for.

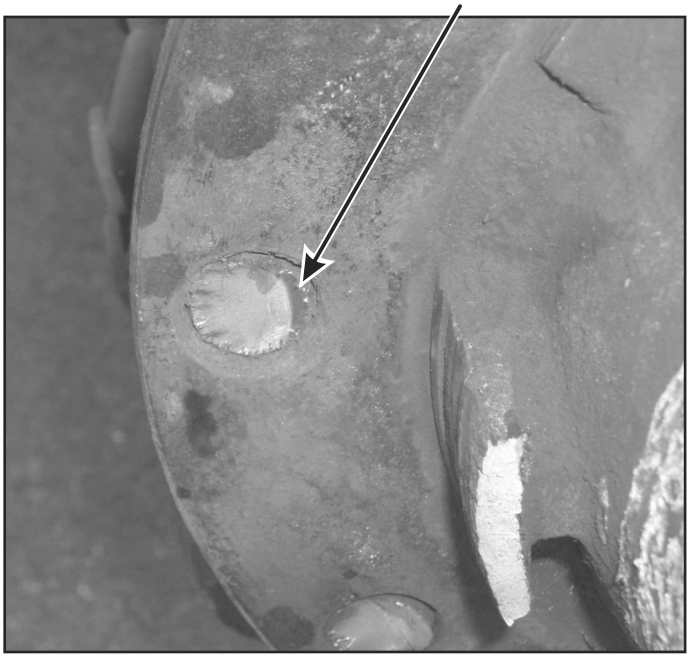
Hub piloted wheel mount systems use headed studs. When I get a broken headed stud back for failure analysis, the first thing I look at is the outer edge of the lip around the head. When replacing wheel studs they should be installed with a press but most are not. Here are two very common wheel stud replacement practices in use today.

1. Hammer & Punch – This practice is usually done with the whole wheel end assembly including the disc wheels & tires still on the vehicle. This is not good from the get-go because whenever wheel studs break you should always do a visual inspection of the hub itself to make sure everything is in good condition. More about that a little later when we look at the whole hub piloted wheel mount system.

So the wheel end assembly is elevated and rotated to where the broken stud can be driven out of the hub from the outside without hitting anything in the brake assembly. Obviously this means driving the stud out with nothing to support the backside of the hub mounting flange. The important thing to remember about a casting is it does not *"give",* it cracks. Most hubs today have a body casting that is considerably thinner between the stud holes to save material and thereby part cost. Driving a stud out like this, with a hammer and punch, could lead to the hub mounting flange cracking, especially if the stud is stubborn about coming out of the hub. If the hub mounting flange does crack, most likely it will go unnoticed since the disc wheels & tires are still mounted on the hub (no way to see it has cracked). Once a casting cracks it will continue to crack further. Not good.

Next the new stud is put into the hub from the backside and driven in with a hammer and punch. For driving in the new stud with the disc wheels still mounted on the hub at least there is very good support for the hub mounting flange. However there are some downsides. First off, the punch is a lot harder than the head of the stud. Second, the end of the punch is small and it will focus the hammer blow onto a very small portion of the stud head. Third, there's no way to hit the stud head except from an angle which leads to hitting the outer edge of the head where the lip is. What this does is deform the lip of the head by leaving a raised portion where it was hit with the punch. This raised portion is a small part of the entire circumference of the head but it will keep the stud from seating properly. Also there's no way to reach in and check under the lip of the head with a feeler gauge to make sure the stud is properly seated in the stud hole but since the lip of the head is deformed that's kind of irrelevant isn't it? Yea, it is.

Later when the wheel nut is installed on this stud and tightened down, the tension created as the stud is pulled will be focused on this one raised portion of the lip. This very unequal distribution of tension will cause the stud to crack at the first thread of engagement with the wheel nut right in line with the raised portion on the lip of the head. The stud will crack about a third of the way across the diameter and then shear off. The broken end of the stud will have a dark portion shaped like the end of your thumbnail where the crack started. The rest of the diameter where the stud sheared off will be a light shade of gray. Here is a photo of what I'm talking about.



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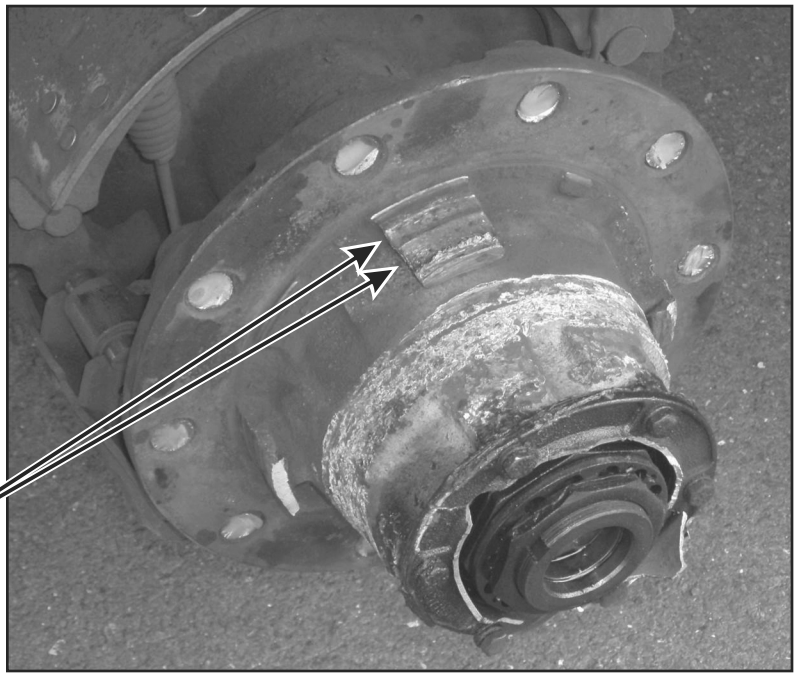
1. Hammer & Punch – *(continued)* This covers the majority of broken studs I get back for failure analysis. A stud installed like this will not last long. I've gotten back studs installed like this that didn't even last a whole day. Of course removing the disc wheels and brake drum would provide better access to the hub in order to replace the wheel stud. Still there's no support for the hub mounting flange when driving out the stud and removing the disc wheels has now taken away what support there was for the hub mounting flange when driving in the new stud. Also the punch is still harder than the head of the stud. A brass drift is better since it's softer than the head of the stud. However trying to hit the stud squarely on the head with a brass drift in one hand and the hammer in the other and keep the hub from rotating while trying to drive the stud in or out might prove to be a bit daunting. A hub that's properly supported will take the incremental increase in pressure from a press much better than the sharp, sudden blow of a hammer. When replacing broken wheel studs it's always best to remove the hub from the vehicle and use a press. Now on to the other very common wheel stud installation method used today.

2. Wheel stud installer – This tool is used with the disc wheels and drum removed from the wheel end assembly. It is usually a *"C clamp"* design and turning the clamp screw is what pushes the wheel stud in or out. The top of the clamp has an open hole for the broken stud to go through when it's pushed out and this portion clamps against the machined surface of the hub mounting flange right around the stud hole. Understand though, the tool doesn't really support the hub mounting flange independent of the pressure being applied. What it does in a sense is *"pinch"* the hub mounting flange (which is cast) right around the stud hole and the stud should move. Most of the time the stud will probably move but what if it doesn't? The only option is to continue to tighten the clamp and exert even more pressure on the hub mounting flange to get the stud to move. A brief side note here. If the stud is being stubborn, **DO NOT** grab the *"smoke wrench"* to *"help"* the stud move, ok? Never apply heat to a casting like a hub. Heat will change the properties of the steel and not for the better.

When installing the new stud, this tool uses an adapter plug in the open hole at the top of the clamp to push against the stud head and a spacer tube with a removable plug on the other side for the face of the hub mounting flange. The clamp screw turns against the spacer tube plug and the top of the clamp pushes the stud into the stud hole. By design the spacer tube focuses all of the pressure on the very small contact area it has with the hub mounting flange. A tool like this can make an indentation in the face of the hub mounting flange leaving a raised burr line that can keep the brake drum from having full metal to metal contact with the entire face of the hub mounting flange. This can make the brake drum run untrue to the hub and cause other issues which we'll talk about in more detail in just a bit.

Obviously this tool is designed to replace a wheel stud while the hub is still on the vehicle saving time and money. It's definitely a better installation method than a hammer and punch no doubt. Using a tool like this doesn't deform the stud head lip and allows for checking under the lip to make sure the stud is properly seated in the stud hole. The spacer tube design is what I would be concerned about. Now on to the hub piloted wheel system itself.

Hub Piloted Wheel System – As I stated earlier whenever a wheel stud breaks, it's always best to make a visual inspection of the hub to make sure the casting itself is in good condition. As we discussed in the first edition of WHEN, the common brake drum pilot diameter is 8.78" and the pilot diameter for hub piloted disc wheels is 8.66". Check the pilot lands on the hub for the brake drum and disc wheels to make sure there are no wear marks in any of them. Any wear marks that can catch a thumbnail means the hub should be replaced. Here's a photo of a hub that was ran way beyond its safe service life.



Worn Pilot Lands

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Hub Piloted Wheel System – *(continued)*
All of the wheel studs on this hub sheared off at the same time and the set of duals went freewheeling down the road on their own. Luckily no vehicle was hit with either mounted tire. For the sake of discussion let's say one of the mounted tires weighed 175 lbs and came loose from the vehicle at 60 mph. If that projectile hits a car going in the opposite direction at 60 mph that would be like a 350 lb boulder hitting the car at 120 mph. That would have been a tragedy to say the least. Several things we can glean from this. One, what we do in the heavy duty industry, if it's not done right, can have serious consequences. Kinda' gets back to what I was saying about dealing with people that know what they're doing and what they're talking about. Should the hub have ever gotten to this point of wear? Of course not. However, in defense of the service manager for this fleet maintenance location, the first thing he did when he found out about this incident was to pull all of their disc wheel maintenance procedures for review. He also called the distributor he bought his wheel attaching parts from and asked them to send someone out from their wheel attaching supplier to help determine what happened. When he learned that the hub was way beyond its safe service life, he asked that supplier to help him review their disc wheel maintenance procedures and make recommendations for changes. Once that was done, he asked that same supplier to put together a presentation for the technicians and go over all of the revised disc wheel maintenance procedures, which they did. To my knowledge this fleet has never lost another set of duals since then and they have this service manager to thank for that. All I can add to that is a wise man is always willing to listen and make changes where necessary.

When making a visual inspection of the hub casting always check the drum pilot radius and make sure it's completely clean and free of any oxidation/corrosion build-up. Any build-up left on the drum pilot radius will cause the brake drum to run untrue to the hub. The drum will try to compensate for this by *"flexing"* every time the brakes are applied which will make the drum crack and then break not far down the road. A casting does not *"flex"* either, it just cracks. Also any raised burrs on the face of the hub mounting flange (like from a wheel stud installation tool) will need to be removed. Check the face of the hub mounting flange with a straight edge to be sure.

Before installing wheel studs always check the OD of the stud body where there are no serrations and the ID of the stud hole in the hub to make sure the stud will go in, EVEN if you have the right stud by application for the hub. There are a lot of hubs and studs in the market made by different manufacturers so check and make sure, don't assume.

Also check the chamfer of the stud hole for burrs and remove as needed before installing the stud. A burr can keep the lip of the stud head from being flush with the machined surface on the backside of the stud hole. Next drop one of the studs into each stud hole and see how much of the serration band goes in. The serration band is what keeps the stud from rotating when the wheel nut is installed or removed. If more than half of the serration band goes into any of the stud holes there's not a lot of grip left and the hub should be replaced.

For wheel stud installation use a small press. A *"brass puck"* between the press and the stud head will provide a little *"give"* when the stud head makes contact with the hub. Check under the outer lip of the stud head at four equally spaced points with a .001" feeler gauge. If the .001" feeler gauge doesn't go under the lip at any of the four points the stud is properly seated in the stud hole. If the stud isn't properly seated it will move while in service and change the grip length which changes the clamp load. Also when replacing wheel studs if one stud in the hub breaks replace that stud and the studs on each side if it. If two or more studs break in a hub replace the whole set. Why? We'll answer that in a bit.

All of the studs have been installed and properly seated in the hub. Another side note here. Any rust or oxidation on a wheel stud should be removed with a wire brush. No lubricant of any kind on the wheel stud threads. More about that in a bit.

The hub is now ready to install back on the vehicle according the manufacturer's instructions. Once the hub is properly installed the outboard mounted brake drum is next. Remember to make sure one of the drum pilot lands on the hub is at the 12 o'clock position for the drum to *"hang on"* as it's installed.

Finally we're ready to install the disc wheel & tire assemblies. Once again a good visual inspection is in order. Check the pilot of each disc wheel and look for wear marks. Any wear marks that can catch a thumbnail the disc wheel should be replaced. The following photo is a good example of what to look for.

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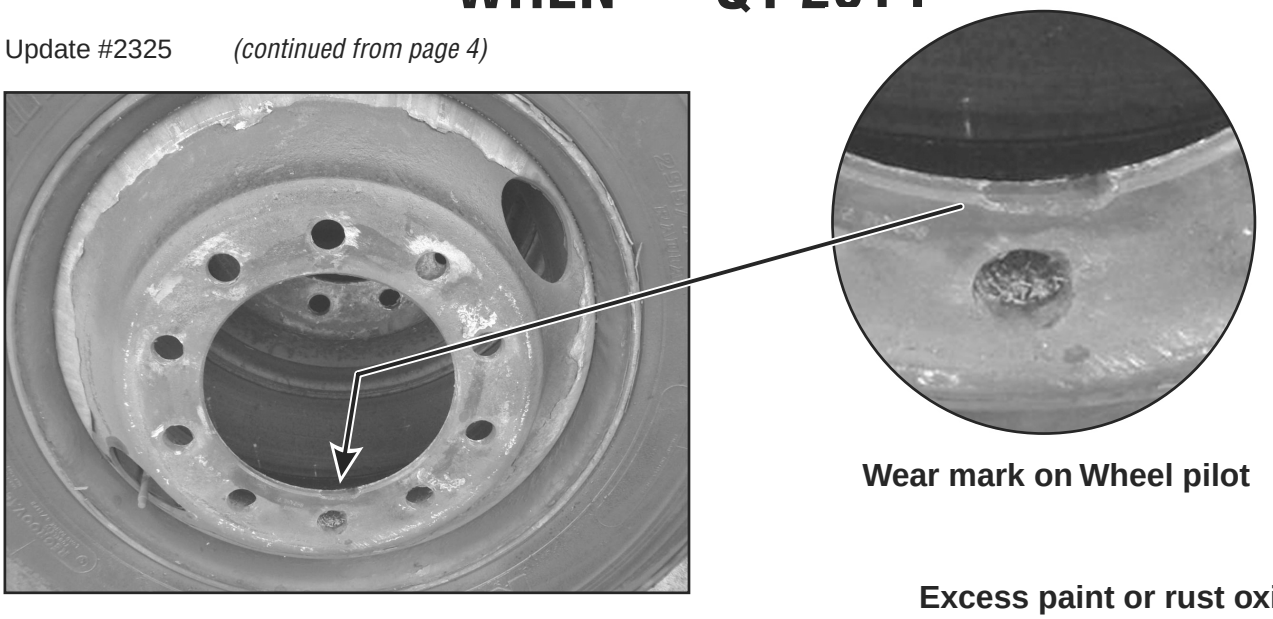
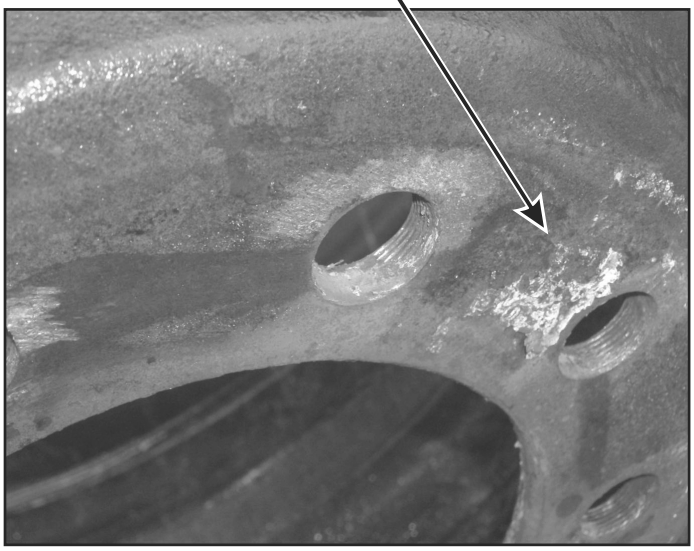


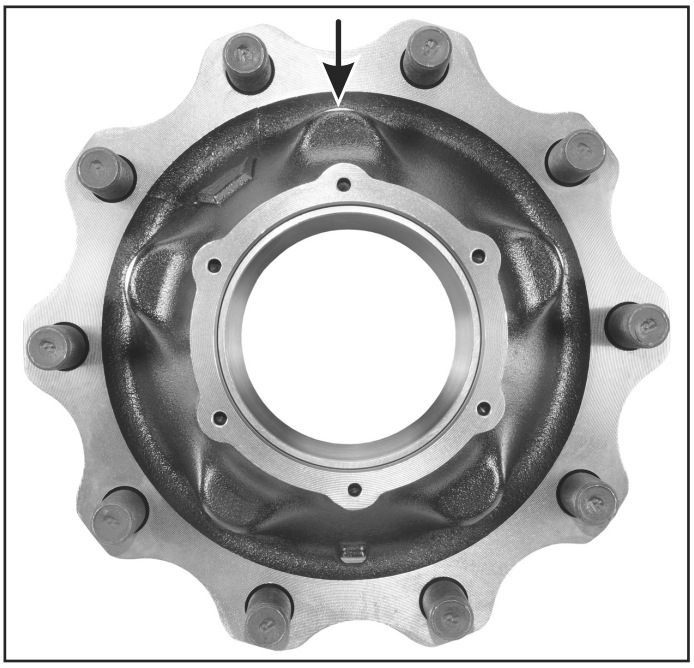
Wear mark on Wheel pilot

Excess paint or rust oxidation



Also check the mounting face on both sides of each disc wheel for any excess paint or rust oxidation. Even a *"small"* amount like in the photo to the right needs to be removed. More about that also in a bit.

Pilot Land at 12 O'clock Position



Two disc wheels have been checked and are in good condition. When installing the disc wheels remember to have one of the drum pilot lands at the 12 o'clock position for the drum to hang on. On some hub designs the drum pilot lands are located between two of the wheel studs so placing a drum pilot land at 12 o'clock will put two wheel studs at the top. Here's a photo of the trailer hub from the first edition of WHEN.

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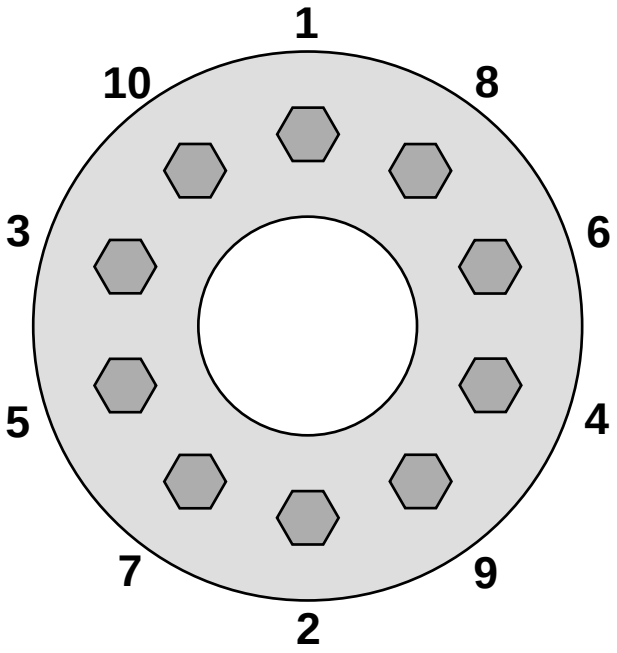
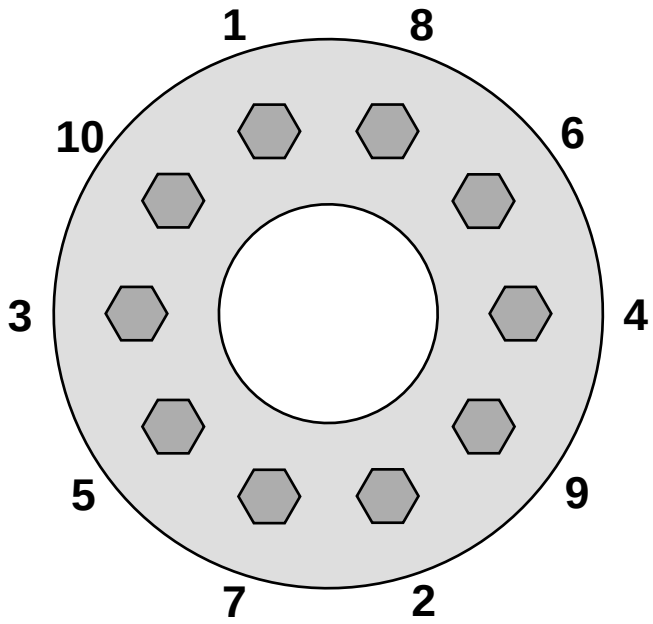
Now here's the tightening sequence chart that we're all familiar with which puts one of the wheel studs at the 12 o' clock position.



So which is it? Good question? Remember the drum and disc wheels both pilot on the same lands.
Leave the drum pilot land at the 12 o'clock position and just slightly rotate the tightening sequence like below.



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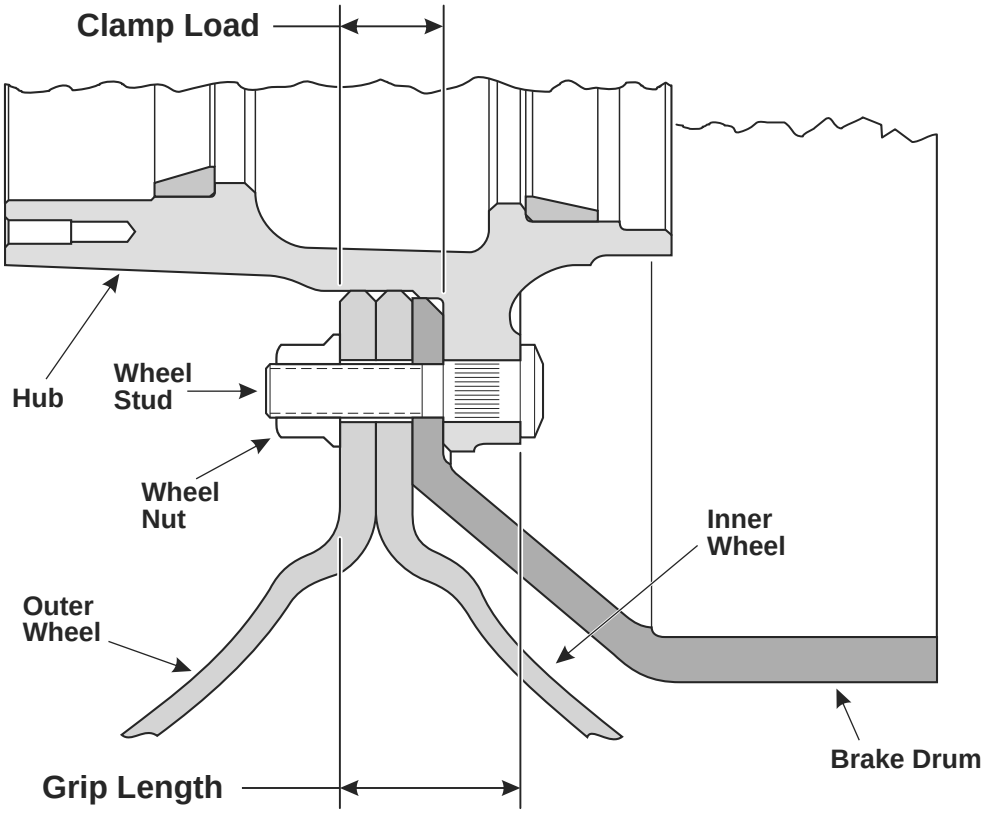
Install the wheel nuts in this sequence and hand tighten all of them. Next grab that very familiar tool for wheel nut installation and it's not the 1" air impact gun, it's the torque wrench. Torque spec for a 22mm two piece wheel nut is 450-550 ft/lbs. on clean, dry threads. Torque is a measurement of friction, not tightness. The torque specified is calculated in order to achieve the proper clamp load. Putting any kind of lubricant on the wheel stud threads will change the amount of friction between the wheel stud and nut. This reduction in the amount of friction will greatly increase the clamp load at the same torque spec. So again, no lubricant on the wheel stud threads. Follow the same tightening sequence and torque all of the wheel nuts to 250 ft/lbs. Then go back and follow the same tightening sequence and torque all the wheel nuts to 500 ft/lbs. I know this will take more time than using the impact gun but how often are the wheel nuts removed? Tire replacement, brake work, leaking seal, in other words not very often so use a torque wrench. When everything is mounted properly on the hub it should look like the drawing below.



500 ft/lbs of torque on clean, dry threads will properly tension the wheel stud and achieve about 50,000 lbs of clamp load. That's a total clamp load of 500,000 lbs on a 10 hole hub piloted wheel! Which begs the question, "With that amount of clamp load how in the world do wheel nuts ever come loose?" Good question. When the wheel nut is properly torqued and the stud is tensioned this will set the grip length. Any change in the grip length will result in the loss of clamp load. The stud head not being completely seated in the hub and then settling in later or burr marks on the face of the hub mounting flange that later compress or excess paint/oxidation on any disc wheel mounting face that later compress and fall out, all of these scenarios will change the grip length. Every .001" change in the grip length will result in about a 10% loss of clamp load. In other words a change of .010" in the grip length and the wheel nut is basically loose. Not good at all.

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When there is a change in the grip length and a wheel stud starts to lose clamp load the disc wheels will begin to *"separate"* from each other. As the tires rotate and the loose wheel stud comes around toward the *"footprint"* (the part of the tire that actually contacts the road) the weight of the vehicle will cause the disc wheels to separate from each other creating a gap between them. As the loose wheel stud moves past the footprint the weight distribution changes and the gap between the disc wheels closes until that stud comes back around to the footprint again. The constant opening and closing of this gap with the tires rotating about 525 times a mile will start a vibration in the disc wheel assembly. This vibration will begin to work on the loose wheel stud at the first thread of engagement with the wheel nut and it will begin to crack. As the wheel stud cracks it will lose more clamp load, the vibration will increase and start to work on the wheel studs on each side of it (this is why when one broken stud is replaced the studs on each side of it are also replaced and if two or more are broken the whole set is replaced). Eventually the wheel stud will crack far enough, usually about a third of the diameter, and then shear off. Enough wheel studs shear off at the same time and a set of duals will go freewheeling down the road.

It doesn't take much of a change in the grip length for a set of duals to come loose and separate from the vehicle. This is why the attention to detail is so important. Once again the little things we do make a big difference especially when it comes to safety.

Hope you found this edition of WHEN informative.

Regards,

Steven S. Wolf

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