# The Dynamics of Automotive Wheel Failures

**Part 3**

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In the previous article we established that unregulated impact guns will contribute to the loss of clamping force of the wheel by severely damaging the threads of the wheel nut. The prolonged impacts will cause damage to the seating area of the wheel and create embedment into the wheel.

Embedment will weaken the seating area enough to enable the wheel nut to further embed itself into the wheel material, which will create a relaxation. A joint relaxation loss of only 0.001" (0.254 mm) will cause a loss of clamp load of approximately 30,000 psi (1.44 MPa).

Fig. 1 illustrates swiping marks into the wheel in the 'on' position during installation.

When any part of the joint connection becomes weak, it allows the other fasteners in the joint to absorb the excess loads. In a dynamic loading situation, the load vectors constantly change from outside influences and the loosening process begins.

## Rust and Corrosion:

The term 'rust never sleeps' is a very true statement. Rust will continue to 'grow' after the surface rust particles have been removed. This is due to the embedded chlorides into the steel. The only way to completely remove red iron rust is by sand blasting, grinding or chemical treatment. Salt and chloride compounds are significantly aggressive to the point where their reaction with an electrolyte becomes autocatalytic: it will continue to grow upon itself.

Wire brushing will help in most instances to remove surface rust, but it will never completely remove embedded chlorides. An example is with bridges on the coasts. They are constantly being painted but they must be perfectly clean, otherwise the rust will continue to grow and blister through the paint. Bridges are sand blasted to remove the rust and chlorides. The surfaces are then chemically tested for embedded chlorides. If none are found, the painting continues. Otherwise, the steel must be treated by either chemically, grinding or more sand blasting before painting. If the surface is not treated and exposed to weathering elements and salt air, the rust will immediately return and continue to grow.

Trucks have had problems with their brake linings delaminating due to rust. Rust is tenacious and will apply pressure between parts to cause separation. The growth of the rust will cause a connection to lose clamping force by applying a pressure against the tightened wheel nuts.

Salt and brine, though effective in melting ice, are sprayed on the road and will be thrown all throughout the wheel assemblies and as a liquid, will penetrate tight areas. This will cause spreading of the electrolyte, which becomes trapped in some areas and will cause the rust to grow significantly. The pressure created against the joint connection would weaken the threads of the wheel nut, further weaken the threads of previously damaged threads and even cause joint separation.

Fig. 2 shows red rust and white corrosion product from the alloy wheel. Corrosion products will inhibit the proper seating or tightening of any fastener and joint connection. The corrosion products form a cushion layer which will compress under loads, thereby relaxing the clamping force of the connection as the loads settle in.

Fig. 1. Swiping mark


Fig. 2. Red rust and white corrosion product

## Roads:

Roads are designed so that water drains to the side. The center of the road, the crown, is higher and thicker than the sides to promote drainage. However, because the roads are thinner at the sides, they deteriorate faster and spawn the dreaded pot holes. Shock absorber / strut and wheel damages are more prone to the right side of the vehicle due to storm grates, pot holes and other road hazards.

## Vehicle Active Systems:

Metal fatigue of the wheel studs is also more prone to occur on the right side of the vehicle. Hitting road hazards will cause a loss of clamp load while wheel spin control devices will exacerbate the fatigue stresses.

As mentioned in Part 1, once a stress raiser begins, metal fatigue is like the continual flexing of a coat hanger wire until it breaks. This 'flexing' could come in the form of impacts with road irregularities or the action of the vehicle's AWD, Traction Control or ABS system. The spin control on most vehicles today only allows the wheel to rotate one-quarter turn before the automatic traction control brake is applied in a sudden manner. To compensate, the quick brake action is applied and released to other wheels for balance.

Of course, snowy and icy roads will cause the traction control devices to be more active more frequently. However, traction is lost on fall leaves and wet roads. Traction is also lost after it rains, where the surface oils will cause the tires to spin when starting from a stop, especially with worn tires.

The sudden stuttering and shock to the wheels while the traction systems are engaging will contribute to further wheel stud stress, loosening and wheel nut damage. However, if the wheels have been maintained and are sufficiently tightened, there will be no problem.

## Driver's Side (Left):

Since the right side is more prone to metal fatigue failures, what happens to the left side? The nuts back off.

The left side wheels rotate in a counter clock-wise motion when moving forward. Tightening any fastener on helix threads requires a clock-wise motion. To loosen the fastener requires a counter clock-wise rotation. If clamp load is reduced or lost, the wheel nuts have a natural tendency to slide down the helix angle and become loose or rotate off completely.

## Mounting the Wheels:

Improper wheel mounting techniques and poor maintenance have been noted as being a major factor with wheel failure as cited from the NTSB (National Transportation Safety Board) and others, for trucks and passenger vehicles.

When brakes are inspected, replaced or rotors replaced, the mechanics remounting the wheel is not a wheel technician. The mechanic is good at what he does, but does not necessarily pay attention to properly mounting a tire.

When rotors are replaced, they come with new wheel studs. They never come with new wheel nuts because of the variety of different styles of wheels and nut requirements. Remember, there are short nuts, medium length and long nuts: do not mix different types of nuts on the same wheel. Therefore, it is common practice to reuse the old wheel nuts, and the thread damage continues, which places the new wheel studs in jeopardy of fatigue stresses from underloading.

The SAE (Society of Automotive Engineers) standard J1102 and J1102M had specified the strength of serrated and non-serrated wheel bolts as being 120 ksi and 830 MPa, respectively. Basically, the wheel studs are Grade 5 or Class 8.8. High performance vehicles or some European vehicles may use stronger fasteners, such as the stud bolt. The stud bolt system will last longer than a wheel nut as the rotor is a stronger, heat treated material.

Lubricants can either help or destroy threads, depending upon the type and amount. A light oil on the first few threads of the wheel stud will help overcome some of the built-up thread friction of a used wheel nut. Anti-seize is very efficient at lowering friction that the threads of either or both the wheel nut and wheel stud can strip when tightening and will definitely strip when using a power wrench. In any case, never use a power tool in the presence of a lubricant.

The better wheel mounting shops will use brake clean to eliminate road grime and any other forms of lubricants, then torque in a criss-cross sequence. An excellent procedure would be to re-apply the torque again to the first wheel after tightening the last wheel, then retighten the other wheels again. During the time interval between the first wheel torquing to the last, the joint has had time to relax. Then retorque the wheels again after driving at least 25 miles (40 km).

## Concerns:

Some have doubted the fact that the degradation of wheel nuts is valid or critical since the SAE has not issued any papers concerning this. They are of the auto industry, not the fastener industry. The SAE is only concerned with the assembly of new parts, not maintaining and reusing the same part. There is no practical way of monitoring the number of times the wheel was remounted or how the wheel was installed. As mentioned earlier, statistics indicate 100,000 miles (161,000 km) is where trouble begins.

If a tire technician told you your wheel nuts were worn and need to be replaced, you would think he is just trying to sell new wheel nuts. It is not always possible to see any visible thread damage by looking at the internal threads of the wheel nut and more impossible to see any fatigue crack starting. The only sure and safe method is by replacing the wheel nuts after a new rotor has been installed, because using old wheel nuts on new wheel studs will compromise the wheel studs and cause metal fatigue.

No matter how careful you are, parts will still wear out and need replacement. Let's hope they are replaced before its failure causes serious damage. Safe motoring to all.

## Rules of Thumb:

- Avoid lubricants on stud threads and on wheel boss surfaces. This will introduce an uncontrolled set of variables, unless you perform your own work and use a torque wrench. Clean all parts with a brake cleaner if they are dirty, but let the cleaner dry sufficiently before assembly.
- The only 'safe' way to use an impact wrench is to run all the nuts up slowly, in a criss-cross pattern, without allowing the wrench to begin impacting. Finish with a torque wrench.
- If the wrench 'clicks' after using the impact gun, there is no way of knowing how far past the torque value you have gone.
- Use a criss-cross torque pattern and torque in increments.
- If one stud has broken, replace both of the other studs on either side, even if they don't look damaged, they are. If more than one stud has failed, replace them all.
- Nuts are cheap. If you forgot how many times they have been reused, replace them. Generally, don't go beyond three reuses, especially if you regularly tow something and/or live in the mountains.
- Retighten the wheel hardware at least 100 miles after installation, if not before.
- Check all wheel components when disassembled, for: cracking; rust; flat spots; elongation.
- If the nut will not go back on, get a new nut.
- If the new nut cannot be threaded past the half-way point of the wheel stud, replace the wheel stud.
- Start the nut/wheel stud by hand to avoid cross threading. Never start parts with an air wrench.
- Always keep an eye on the right-side wheels first because of road hazards.
- Vehicles with AWD and stability controls will allow for a certain amount of free wheel spin before the brake is automatically and suddenly applied. This also produces sudden stresses on the wheel studs. Observe and check all of the wheels on a regular basis; check for missing wheel nuts.
- Keep an eye on both front wheels. This is due to engine weight and even more so with front wheel drive vehicles. The left side is also prone to failure due to engine torque. All wheels are prone to failure on vehicles with ABS.
- Get OEM parts from your auto dealer.
- Aftermarket studs and bolts are plated, OE are not: be consistent.
- Some OEM wheel hardware are specially coated: do not change or mix with other coatings.
- Many dealers use torque sticks or torque wrenches. If not, find out why.
- When in doubt, throw it out!

As a side note; there is one vehicle manufacturer that has not had a wheel failure in the many hundreds of wheel off investigations I have covered. There is a reason why. If you are interested in who it is and what tire store has the best practices, drop me an email and I'll respond.