Technical Brief No.:
TB-09-0124

DIESELBIKES

Title: The Importance of Drive Chain Lubrication

The drive chain is probably one of the most important and probably one of the most neglected components on your mountain bike. It transfers a majority of your pedaling force to the rear hub, contains more individual moving parts than your whole bicycle and truly requires the most lubrication. Many riders never think of their drive chain, even fewer understand the importance and affect it has on our physical and mental riding performance. This technical brief will speak to importance of drive chain lubrication as it relates to mountain bikes and review some interesting points that you may or may not have known.

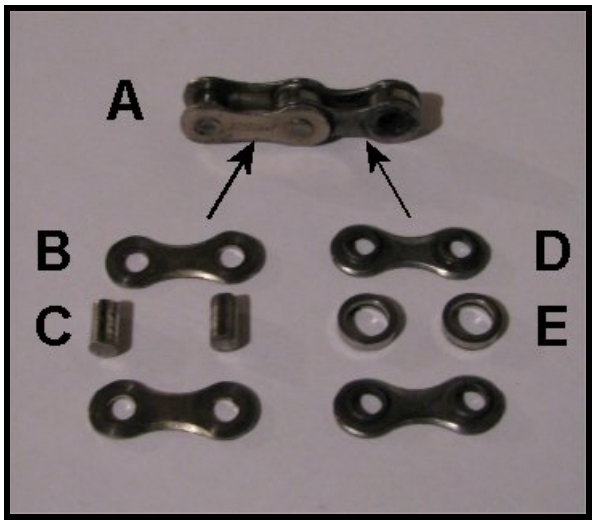
Technical Brief Sections:
Below are the following sections covered in this technical brief. Each section provides a basic level of information relative to the topic. This document does not cover all technical, engineering and or maintenance aspects of roller chain lubrication.

1.0 Anatomy of a Mountain Bike Drive Chain.

To appreciate the importance of drive chain lubrication, we first need to identify the structure of the average mountain bike chain. Bicycle drive chains come in all shapes and sizes but they all primarily do the same job…transfer your pedaling force to your rear hub. Bicycle drive chains are classed as "Roller Chains" in non-related industries outside of the bicycle industry. Roller chains are one of the most efficient and cost effective ways to transmit mechanical power between to shafts, i.e. the crank shaft and rear axle. The general construction of a roller chain consists of two alternating link assemblies when put together create a chain segment. The outer link assembly consists of 2 outer link plates containing 2 pressed-in cross pins. The inner link assembly consists of 2 bushing less inner plates less and 2 slip-fit rollers. One chain segment consists of 8 separate components with 6 moving contact points. Apply this to the average chain length (45 segments) for a mountain bike and you have 360 separate components with 270 moving parts. To make matters worst, all these moving parts are directly exposed to the elements of riding (water, dirt, rocks etc) unlike pivot bearings and headsets.

Figure 1.0:
Anatomy of a Bicycle Chain
(Bushing Less Shown)

A – Complete Chain Segment
B – Outer Link Plates
C – Cross Pins
D – Inner Link Plates (Bushing Less Shown)
E – Slip-fit Rollers



Now…there are various roller chain designs for mountain bikes. You have bushing-less chain links, hollow-pin point links, even mixing metal composition between outer and inner plates to reduce friction. In the end, none of these designs eliminate pivot joints of a chain segment and the importance of lubrication.

2.0 Anatomy of Roller Chain Lubricate.

There are thousands of lubricant brand names claiming to be the best for your mountain bike. The reality is all manufactured lubricants in the United States and many other countries must conform to ASTM D 2422 Standards. If you do not know what this is or never heard of it, simply Google search the standard and you can read about it. This standard classify all petroleum-base fluid lubricants and to those non-petroleum materials which may be readily blended to produce fluid lubricants of a desired viscosity. We can write a book (but who needs another one) regarding the chemical, bonding and distillation of lubricating fluids, but that is not what this brief is about. So, if you want to learn more about lubricant composition, feel free to look up the ASTM Standard.

With that said, you really have only a hand full (as relates to bicycle chains) of lubricant types to choose from. Manufactures mix or blend additives in to these standard lubricants to create a well balanced fluid for a specific application. Thus you have specific bicycle lubrication oils for wet, dry and muddy conditions.

Figure 2.0: Different Bicycle Chain Lubricants

Example of White Lighting's available bicycle chain lubricants. Visit their website for more information www.whitelightningco.com

All these specific lubrication come at a premium price and do serve their purpose. However, if you are not one to maintain you chain on a weekly basis, much of these lubricant benefits are lost and become a waste of money. There are pros and cons regarding the use of these specialty lubricants and many people claim simple non-additive lubricants work better and are far cheaper. This is a true statement, but it ultimately boils down to your preferred lubrication method, how often you apply these oils and under what condition you're applying them. There are no existing "certified" publications that prove hands down a particular blend or non-blend of lubricant is more superior for roller chains. If this publication did exist, the ASTM D 2422 Standard would require republication.

2.1 Which Lubricant Brand to Use?

Thousands of lubricants exist to choose from and most have a specific application. Refer to Section 5.2 of this technical brief for more information regarding viscosity grades. What is important for the average mountain biker to understand is the viscosity of the lubricant used. The standard roller chain used on mountain bikes is 1/2 inch making the areas requiring lubrication small. If you were to use a high viscosity lubricant like 10W30, all you would really do is coat the outside of the bike chain missing the internal components. A low viscosity lubricant like machine air-tool oil will completely lubricate your bike chain but you loose frictional performance. Bottom line, which lubricant to use will ultimately depend on your frequency of riding, elements you ride in, style of riding and how often you want to maintenance your chain. Riding in the Moab (Utah) may require a wax or Teflon additive lubricant blend to keep dust and light sand of sticking to the chain. Riding here, in New England, a heavier viscosity lubricant may be required to create a virtual seal keeping soil particles from contacting critical pivot points inside the link assembly.

Dieselbikes has not conducted studies between different types, brands and blends of lubricants available to mountain bikers, so we cannot state one is better over the other. What we can state are a few important factors that determine the type of lubricant to use. These factors are frequency of riding, elements you ride in, style of riding and how often you want to maintenance your chain. Use these factors to help determine the type of lubricant to use, then compare price to determine how much you want to spend.

3.0 Inspecting your chain.

Since this article is written towards aggressive mountain biking (freeriding/downhilling including), there are some inspection points to look for on your chain before you go through the process of cleaning and re-lubrication. Chains that are put through harsh riding conditions and not maintained can result in aggravating drive-train problems. Furthermore, if you spend time simply cleaning then applying oil but never bother to checking each link, you will just carry over the problem and continue the aggravation. What we are suggesting does not need to be conducted every time you ride, but should become a schedule habit depending on your riding style and frequency.

There are a number of inspection points when checking your bike chain; however, we narrowed it down to what we believe are 3 important inspection points to look for. Note: to conduct a good inspection, it is best practice to remove the chain from the bike.

3.1 Check for Binding.

Binding of connecting links can cause havoc for shifting, slack control during rear suspension movement and cause power slippage right when you need the power most. Binding may result from contamination around both link plates or between the roller, bushing and pin components. Damaged link plates caused from a rock that slammed into the chain or oxidation (rust) of the link assembly may also result in binding. You can simply check for binding by rotating each link by hand or over an old sprocket. If you come across a binding link you must pay strict attention and identify the cause of binding. Working the connected links back and forth in a bath of cleaning/lubrication solution is one best practice. If you are unable to resolve the links from binding, you may want to consider replacing the chain. Removing the links and replacing them is an option, but any time you re-install a link pin, you create a weak point in the assembly.

Figure 3.1 – Chain Binding

3.2 Check for Pin Alignment.

Pin alignment is critical to the chain's strength and your personal safety when riding. Since most mountain bikes have one or two derailleur for shifting, your chain becomes subjected to torsional forces that apply uneven stress to the pins increase wear and possible misalignment. You can check for pin alignment by visual inspection or laying the chain on its side and running a small metal (or plastic) ruler across the pins to visually see if they are all at a similar height. If you find a pin is misaligned or appears to be working its way out, you may want to consider removing this link assembly and try living with a slightly shorter chain length. Again, any time you're re-installing a link pin, you create a weak point in the assembly. Replacement with power-links are also an option but sometimes not recommended.

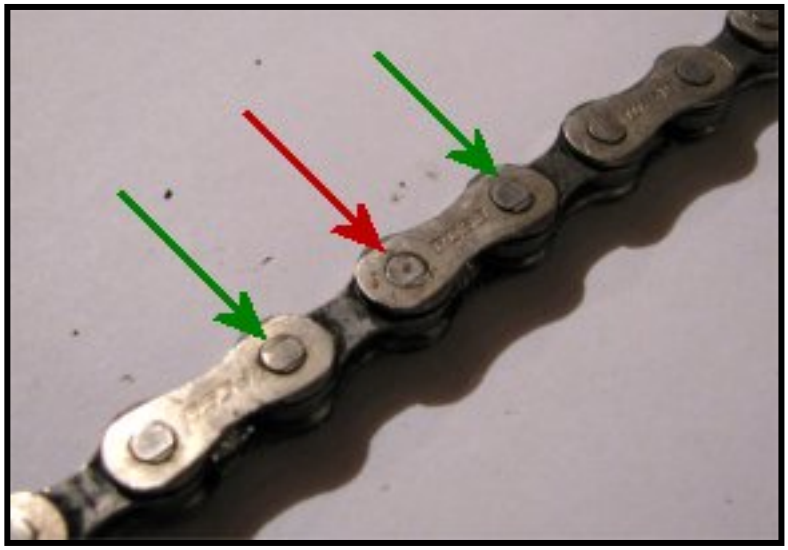


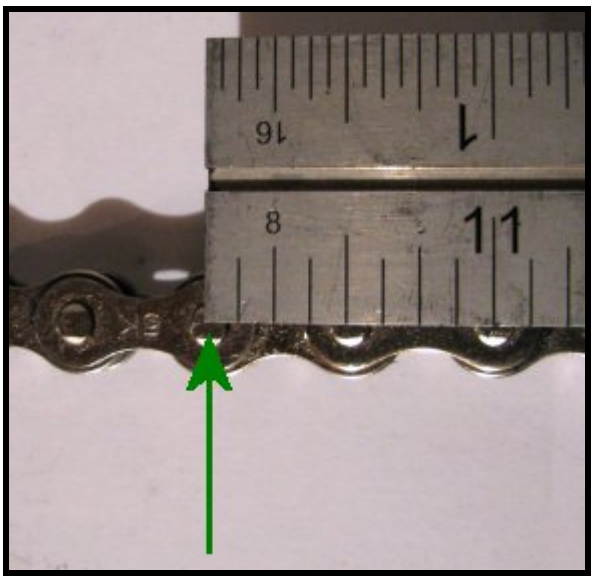
Figure 3.2 – Red Arrow Indicates misaligned Cross Pin

3.3 Check for Chain Growth.

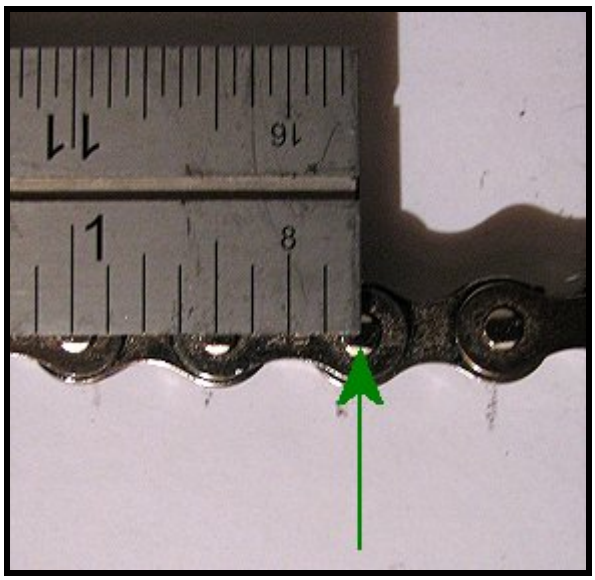
Chain growth and chain stretch are two completely different effects that occur with roller chains. Many bicycle articles use these terms interchangeable with each other and can be misleading. In short, chain growth is the physical wear of link assembly components and chain stretch is the physical deformation of link assembly material. ASME Chain Standards Section B29 covers a good majority of these two different characteristics.

Take it for what its worth, industrial standards for 1/2 inch roller chain growth is less then 1% per foot. This means if you conduct a simple measurement with a ruler and measure a 1-foot section of your chain by placing the 0" mark on the center of any link pin then view the corresponding link pin located at or near the 12 mark; if the last link pin is greater then 1/16" (0.0625) past the 12 inch mark on your ruler, the chain would be out of specification and possibly unsafe to use. There are a number of measurement tools to check chain growth accurately, but the simple ruler method is sufficient for the every day rider.

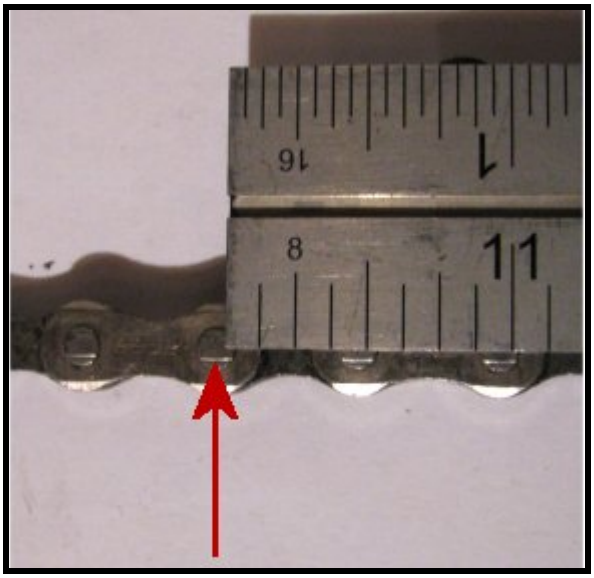
Figure 3.3 – Chain Growth



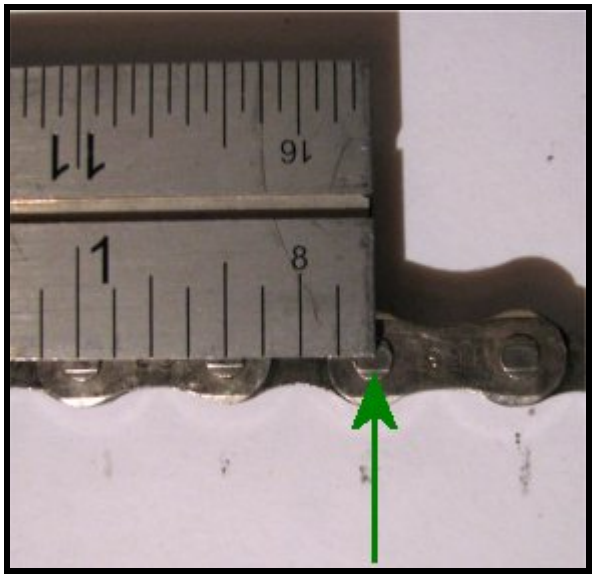
New Chain "End" Measuring Point.
Ruler alignment with cross pin center is good.



New Chain "Start" Measuring Point.
Ruler on-center with cross pin.



Used Chain (Stretched) Measuring Point
Ruler alignment with cross pin is greater then 1/16inch.



Used Chain "Start" Measuring Point
Ruler on-center with cross pin.

Figure 3.4 – Chain Stretch Leading to Link Assembly Failure.

4.0 Cleaning your Chain.

Just as lubricants, there are thousands of cleaning fluids with brand names claiming to be the best. In short, for us mountain bikers we have two basic choices for cleaning fluids, either solvent-base or water-base. Both have their pros and cons and argued across industry professionals day and night. Since the majority of us will purchase our cleaners from retail stores, our choices will be limited to somewhat environmentally friendly fluids.

Solvent-base solutions are excellent as a cleaner, but tend to have rapid evaporation and require more safety precautions to avoid an accident. Water-base solvent solutions are also excellent cleaners, but tend to leave a water residue which can result in oxidation (rust). You can avoid oxidation by heating your chain (example: hair dryer) to accelerate evaporation of this water residue before allowing oxidation to begin. For the most part, the choice is yours on which type of solvent to use.

In our opinion, the more important factor is the method in which you clean your chain and how often. If you ride all the time and the only time your chain gets cleaned is when it rains, then you are just asking for an accident to happen. Once again, there are two basic methods to clean your chain. You either clean it on the bike or off the bike, it's that simple. The technique you decide to use can be debated until the cows come home. This technical brief is not going to dive into cleaning techniques because what routine, tools and solvent solution you use may work for YOU but not for someone else. The point we want to make is the following…You will effectively clean, inspect and lubricate your chain better and faster if you remove it from the bike. Why is that you may ask…well here is the short answer.

4.1 Cleaning ON the Bike.

If you clean your chain on the bike you have a good chance a fair amount of foreign contamination will remain on or inside the link assemblies. Even using best cleaning practices, if the chain is dirty, then your drive train is dirty. Every time you wipe a section of chain, the minute it passed through the front sprocket or rear cog set, you are transferring cleaning solution and contamination back-an-forth. Obviously if you take time to clean your chain, you should spend some time wiping down the rest of the drive train, but your cleaning techniques are limited when leaving the chain on the bike. We are not saying you should never clean your chain this way…just keep it to a limited basis.

4.2 Cleaning OFF the Bike.

We prefer this method because it offers an unlimited amount of cleaning techniques that will work for you. Using this method also provides a better means to check for link assembly damage, chain binding and component wear.

Again, if you spent the time cleaning the chain and place it back on a dirt drive train, you have just defeated the purpose of cleaning it.

If we boil this all down to basics, your primary goal in cleaning the chain is to ensure you have the minimal amount of foreign contamination left before applying lubricating fluid. The technique in which you clean your chain is totally up to you. There is plenty of available information on the web regarding different cleaning techniques for on the bike and off the bike method. Find what works best for you and run with it.

5.0 Chain Lubrication.

Frequently lubricating the bike chain is the most important step in maintaining efficient power transfer between your crank shaft and hub assembly. Many bicycle industry articles regarding chain maintenance do not address the full importance and benefits of lubrication only stating lubricants simply extend the life of your chain and sprockets. Bicycle chains will perform better and last longer when timely and adequate lubrication is provided, but lubrication also provides these important benefits:

a. Protects and drastically reduces frictional wear of the pins, bushings, rollers and link plates.
b. Cushions impact loads as the link assembly contacts the sprocket.
c. Dissipates frictional heat created during operation.
d. Assist in flushing away foreign materials on the rollers
e. Creates a virtual fluid seal between the link pin, bushing and roller.
f. Helps retard oxidation.

Because mountain bike chains are accepted to operate in harsh environments, lubricating for longer-life may not be the best practice. There are a number of circumstances that can occur during bike rides that will destroy the chain. Lubrication for chain performance may be the best approach so you can limit drive-train issues caused by poor chain performance.

5.1 Lubricant Viscosity.

Just as stated in section 2.0 of this technical brief, most manufactured lubricants must conform to ASTM D 2422. ASTM D 2422 Sub section 97 defines the categories of lubricant viscosity. Many bicycle industry articles state to use a low viscosity fluid for your bike chain, but what is considered low viscosity? First, let's define what viscosity means. The basic definition of viscosity is the measure of the lubricant's (oil) resistance to flow (shear stress) under certain conditions. If you apply a high viscosity lubricant on your chain, the lubricant may want to stay in one place when pushed (sheared) by a moving mechanical component and NOT reach all the internal critical moving components. By applying a low viscosity lubricant, the lubricant will easily be pushed (sheared) by moving mechanical components reaching internal critical moving components and create a uniform film of protection. Viscosity is an important factor because we must lubricate the outside of the chain allowing the lubricant to work (penetrate) its way to the internal components.

5.2 Viscosity Grades.

In 1975, the International Standards Organization (ISO) in unison with American Society for Testing and Materials (ASTM) and a host of other United States and International organizations developed the International Standards Organization Viscosity Grade, ISO VG for short. The ISO VG chart ranges from ISO VG 2 through ISO VG 3200 identifying categories of lubricant properties. What this means for YOU the mountain biker is having the ability to physical compare the performance of any bicycle chain lubricant of similar properties based upon your specific requirements.

There is no standardized chart that categories the ISO VG range into low, moderate or high viscosity for all industries due to the tens-of-thousands existing applications. The rule of thumb for the ISO VG chart typically

states: the lower number indicates a lower viscosity. But just because a lubricant has a low viscosity, does not necessarily mean it should be used on a bike chain.

The typical viscosity range for roller chains used on mountain bikes is ISO VG10 to ISO VG32. This range typically provides performance characteristic required for a mountain bike application. However, you would not want to use low viscosity motor oil because the lubricant is designed to create a thin film under high speed application in high temperature environments. Using low viscosity motor oil on a bicycle chain will do nothing other than attract more foreign contamination. The bicycle chain application will never reach the rotating speed or temperature required for the lubricant to perform its designed function.

In most cases, manufactures and distributors of bicycle lubricants are not just blowing smoke when they state their lubricant is for use on bicycles. Many have done their homework and created or re-packaged a blend of fluid that contains the right performance characteristics for bicycle chain applications. It becomes a matter of argument whether or not purchasing bike chain lubricant, blending your own lubricant or using chain saw oil (example) is the best choice. Refer to Section 2.1 of this technical brief for more information regarding which lubricant brand to use.

5.3 Applying Lubrication.

Methods to apply lubricant can be considered an art form. Several common techniques exist and argued by industry professionals. This technical brief is not going to dive into application techniques because what routine, tools and lubricants you use may work for YOU but not for someone else. Regardless what technique is used, you either apply lubrication when the chain is on the bike or off the bike.

When applying lubrication, one best practice is to apply a droplet of fluid on the top of each link assembly pivot point vertical to the roller. This is the shortest distance for the fluid to travel and provides direct lubrication to critical moving components. Running lubricant directly over the center point of the roller will effectively require more fluid, creating waste and over lubrication. Choose a method of application that works for you but remember your goal is to lubricate the internal moving components and contact points of each link plate.

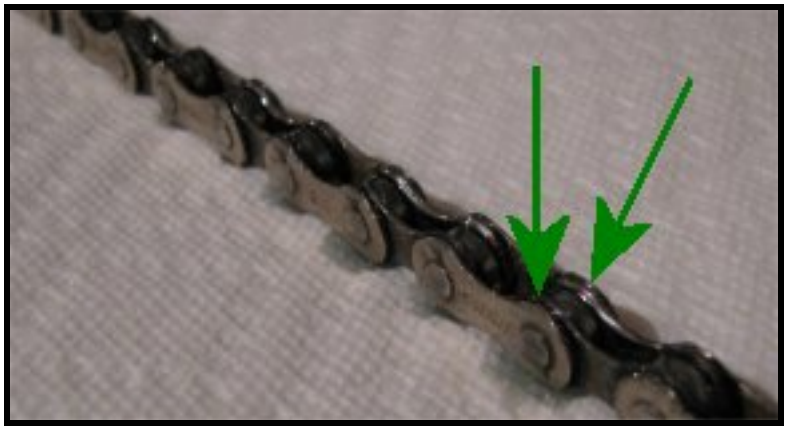


Figure 5.3 – Green Arrows Indicate Points of Lubrication. Lubrication should be applied on both sides of each link pivot point(s).

5.4 Over lubrication.

Over lubrication of a bike chain can be just a damaging as not having any lubrication. If too much lubrication is applied to the chain, it creates a thick film that works towards attracting foreign contamination rather assisting in flushing it away from the rollers. A sandpaper effect occurs as frictional forces increase due to foreign contamination resulting in poor chain performance.

Once lubricant has been applied, ensure you have wiped the chain so no extra fluid is present between the rollers or droplets form on the links. A simple method to draw extra lubricant off the chain is to place each side of the chain on a cotton towel (lint free or any absorbent material) for one minute. The towel will draw excess surface fluid, but leave a residue on the chain surface.

6.0 Technical Wrap-up.

We hope this technical brief stressed the importance of chain maintenance and provided additional information you may not have known. Because the bike chain has the most moving parts and continuous frictional contact with other metal components, by default it becomes the most serviceable item on your mountain bike. Proper cleaning and lubrication will not only extend the cycle life of your chain, but more importantly dramatically increases the performance of your drive-train giving you more confidence when you ride.

Creating an individual maintenance schedule based upon your frequency of riding, elements you ride in and style of riding will resolve a number of aggravating drive-train issues at can result or be influenced by the chain. You should also determine at what point you replace the chain. If you decide replacement is only determined by chain growth, be warned that chain stretch can occur unnoticed resulting in failure at the wrong moment.

We honestly believe the best practice is frequent chain maintenance and replacement annually. This may sound overkill, but your bike chain is continuously under various loads, withstands extreme torsional force and is directly exposed to the elements. Probably the worst conditions for a mechanical assembly to operate in and YOU rely on it every single time you pedal.