4TH EDITION

BIG BLUE BOOK OF BICYCLE REPAIR

By C. Calvin Jones

BBB-4

Park Tool®

BIG BLUE BOOK
OF BICYCLE REPAIR

A Do-It-Yourself Bicycle Repair Guide from Park Tool

By C. Calvin Jones

4TH EDITION

Park Tool Company

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Special thanks to the manufacturers of components and bicycles featured within this publication.

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FOREWORD

We're proud to present the BBB-4, the fourth edition of The Big Blue Book of Bicycle Repair. Contemplated, researched, tested and written by Park Tool's resident Director of Education; Calvin Jones. This book, along with our expansive library of Repair Help videos on YouTube can help you better understand how a bicycle works as well as give you step-by-step instruction on everything from cleaning to overhauling just about any type of bike.

In 1956 my father Howard and his partner Art Engstrom had just bought a small fix-it shop on the east side of St. Paul, Minnesota, named Hazel Park Radio and Bicycle. Both loved to get their hands dirty, so the shop seemed to be a good fit with their skills. Along with the lawn mowers and ice skates, the shop sold bicycles, although neither knew much about bikes. As they dug into their new venture and bicycles evolved to include hand brakes and shifting systems, Howard and Art soon tired of working on bikes turned upside down while squatting on the floor. With the help of a longtime friend, Jim Johnson, they designed their first bicycle repair stand. Soon, they realized there was a need for other tools that could make their lives easier, and a tool business was born. At first Howard and Art produced tools under the Schwinn label, then shortened Hazel Park Cycle Center Repair Stand Company into Park Tool Company. So begins our history.

Today, Park Tool produces and supplies over 500 different bicycle specialty tools to more than 70 countries worldwide. Go into any bike shop in America or just about any shop around the globe, and you'll find our famous Park Tool Blue tools in use in the back room and for sale on the showroom floor. Our goal is simple: Build the best bicycle tools to help mechanics work faster, smarter and more precisely. We are constantly improving and expanding our line to meet the expectations of team and professional mechanics as well as those doing their own work at home or on the trail.

This, the fourth edition of our Big Blue Book, contains new chapters, new photos and most importantly advice and mechanical procedures using some of the newest components and parts available alongside hundreds of other repairs and basic maintenance instruction. While we love to sell tools, we feel strongly that information and knowledge are the most valuable tools of all. Once you gain some of this knowledge and the confidence to use it, a whole new side of bicycling opens up to you. With a basic understanding of the bicycle and how it works, you'll be free to ride longer and farther. You'll understand what makes one bike or one component better than another. You may even take apart your bike and put it back together just for fun. This manual is designed to give you a complete, well-rounded look at the mechanics of a bicycle. We've designed the BBB-4 to help guide you through a wide variety of repairs, from flat tires to bearing replacement; from repairing a chain to lacing spokes; and from truing a wheel to dropping in a headset. Road or mountain, recumbent or kids bike, tandem or city bike, whatever you ride, we've included information that can help you maintain and repair your bike.

The Big Blue Book of Bicycle Repair is researched and written by Park Tool's Director of Education, Calvin Jones. With over 45 years in the industry, Calvin not only lives, eats, and breathes bicycles, his curiosity with the mechanics of bicycles and his unique and comprehensive teaching style make him one the most trusted and thorough teachers of bicycle repair in the world. Here is a short list of Calvin's qualifications:

- U.S. Olympic Team Mechanic
- 15-time U.S. National Team Mechanic and Manager of National Team Mechanics at the Mountain Bike World Championships
- Instructor at USA Cycling Race Mechanics Clinic for 30+ years
- Instructor at Barnett Bicycle Institute for eight years
- Author of The Big Blue Book of Bicycle Repair and the Park Tool School Instructor Manual (editions 1, 2, 3 and 4)
- Mechanical consultant to bicycle industry manufacturers, professional race teams and retailers
- Director of Education at Park Tool Company since 1997

We're sure you'll agree that Calvin has done his homework and created a complete and concise manual. It's sure to be a reference for nearly any mechanical procedure you choose to tackle. This is the book Howard and Art could only dream would ever be written. With a special thanks to Calvin for all his hard work, late nights and early mornings, we're proud to present the 4th Edition of The Big Blue Book of Bicycle Repair.

Eric Hawkins

Owner/President
Park Tool Company

INTRODUCTION

In my years of working on bikes and teaching people about working on bikes, I have come to realize that people learn in many different modes. One person may prefer to see pictures of something and not read any text. Another person may want to strictly read written procedures, step by step. And yet another may like to have the basic principles of a part explained, and then just figure it out themselves. If I have done my job in writing, this book will have something for the many different types of learning.

We all have our reasons why we are repairing a bike and this can at least partially determine the way we work. It is sometimes assumed the reason for any work is to simply get the job done so we can get back out to riding as soon as possible. However, the repair itself can oftentimes be the reason why we are working on the bike. For some, building a wheel is a perfect example of this. Selecting the ideal hub, spokes and rim, then going through the process of lacing, tensioning and truing all of the components to create a strong and reliable wheel can provide a great sense of accomplishment.

Every opportunity to fix something is an opportunity to learn. Try to keep this in mind, even when you are working on that flat tire, in the rain, at night, in the cold. More than just learning on bike repairs, also try to learn from any issue that needs repair. Leaky faucets, a computer problem, a squeaky door, all things mechanical things offer chances to apply basic concepts of leverage, friction, tension, material strength, bonding and, hopefully, logic.

A big part of any repair is first having the confidence that you can do it. Gain confidence with simple repairs, and then expand your skill set as your knowledge grows. That is why these other opportunities are important. Those basic concepts of engineering apply to all engineering, even to bike repair. It is said bike repair “ain’t rocket science,” but in fact, it is.

There are, of course, many sources of information, and much of it is on the Internet. A first source of information should be manufacturers websites. Search for up-to-date information, as well as useful exploded parts diagrams. While there are also a variety of Internet forums and other online sources that share other peoples experiences, always take into consider the source of information. Attempt to confirm any advise gained there with your own experience and common sense.

I hope you find useful information in each chapter, however, Chapter 1—Basic Mechanical Knowledge, really lays out the foundation for the rest of the book. No book can give you all the solutions and fixes you could need on every possible repair of every model and year of bike. In some cases you will need to apply the principles of engineering to find your own solution.

Thank you for reading this book. Remember to have fun and enjoy the work. It should all be interesting and a chance to learn, from creating the initial problem with the riding, to your diagnosis, to the work of fixing it, and finally of course, the test ride. The fun never stops.

C. Calvin Jones
Park Tool Company

CHAPTER 1

BASIC MECHANICAL SKILLS

This chapter will review basic mechanical and tool concepts useful in bike repair. No matter your level of experience or inexperience, there are certain basics to working on a bike that should be learned and understood. Routine maintenance, repair, assembly and troubleshooting all use these basic concepts.

THREADED FASTENER TENSION & TORQUE

Manufacturers use threaded fasteners to hold many components to the bike. Even the bike itself can act as a “nut” or internal threading for certain threaded components, such as bottom bracket bearing cups and adaptors. Understanding threaded fasteners (i.e., bolts, screws and nuts) is a critical part of bicycle maintenance. Fasteners are how the component parts are attached, adjusted, and with time, replaced. Fasteners are made of two parts: the external thread, which is the bolt or screw, and the internal thread, the nut.

Fastener threads are made in different sizes depending upon their intended use. Thread sizing and naming is determined by two measurements, the “diameter” and the “pitch” (figure 1.1). The diameter is given as a nominal outside diameter (OD) of the external thread, measured from the top of the thread peaks. However, the actual measurement is slightly smaller than the common name given to a thread size. For example, for fractional inch size threads, a 9⁄16" pedal thread may actually measure 0.551", not the true 9⁄16" decimal equivalent of 0.5625". However, it is still referred as 9⁄16" thread.

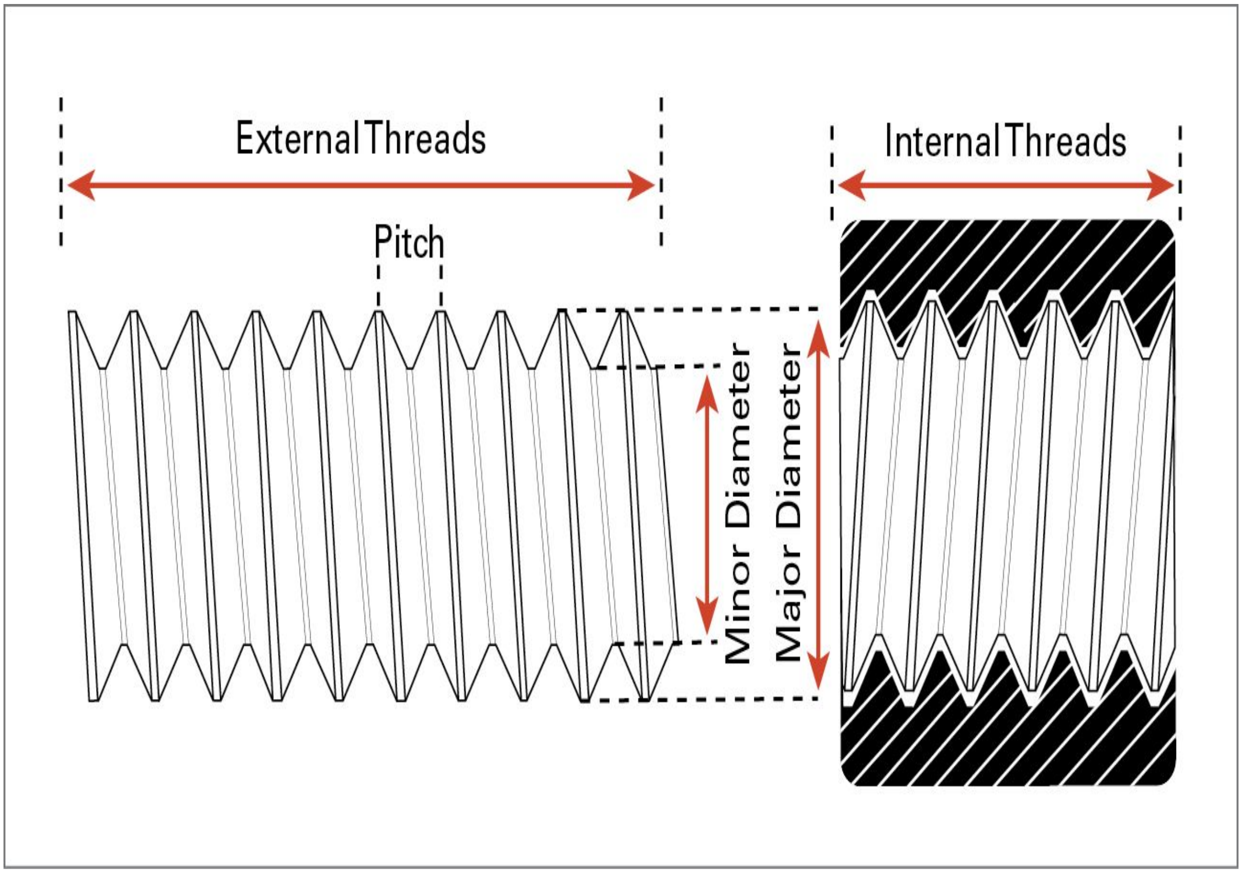


FIGURE 1.1: The parts of a threaded fastener

Metric thread sizing is given in millimeters and given the prefix “M.” For example, M6 threads may actually measure between 5.8mm and 5.9mm, but they are called M6 threads, or sometimes 6mm threads. As with fraction threads, there are some allowances for tolerance, so not every bolt in a M6 class is made exactly the same as every other.

Thread pitch is the distance from the crest of one thread to another measured along the length of the thread. Thread diameter can be measured with a caliper, but pitch is best measured with a thread pitch gauge.

The fractional threads are designated by the frequency of how many threads are counted along one inch. This is called “threads per inch” and is abbreviated as “tpi.” For example the common pedals threading is 9⁄16 inch x 20 tpi.

Metric threading uses the direct pitch measurement in millimeters from thread crest to the adjacent thread crest measured along the thread axis. An example of metric thread would be a rear derailleur mounting bolt using M10 with a 1mm pitch. There are also M10 bolts made in M10 x 1.25mm, and the two would not be interchangeable.

Threads are made to advance as they rotate. Many threaded fasteners, but not all, tighten when turned clockwise. These are called “right-hand threads.” Some threads on the bicycle are made to advance and tighten when turned counterclockwise and are called “left-hand threads.” All threads are made at a slight angle when viewed along the axis of the thread. If the threaded bolt or screw is held vertically, the threads will appear to slope upward toward its tightening direction. Right-hand threads slope upward to the right, and left-hand threads slope upward to the left (figure 1.2).

FIGURE 1.2: Left-hand threads are seen on left pedals and right-hand threads on right pedals. Threads slope upward toward direction of tightening.

As a fastener is tightened, the fastener and the threads in the component joint actually flex and stretch, much like a rubber band. This stretching is not permanent but it does give force to the joint, holding it together (figure 1.3). The stretching force is called “preload” or “tension.” Each fastener is designed for a certain range of tension. Too much tightening can damage the part or deform the threads. However, a fastener with too little preload will loosen with use, which can also cause damage to the parts. For example, riding with a loose crank bolt will eventually damage the crank. Loose bolts and nuts are also a common source of creaking noises on the bike as the component parts move and rub one another under the stress of riding.

FIGURE 1.3: Bolt under tension creates pressure to keep the crank pressed securely to spindle

Thread preparation should be given consideration when assembling any threaded joint. It is common to lubricate threads before assembly. Without being lubricated, internal and external threads rub and scrape together. This gives the appearance that the fastener may be tight but the joint is actually lacking the tension of preload. Lubricating the threads allows them to fully tighten and create a level of tension in the joint that will hold firmly until you disassemble it. Lubrication also aids in preventing corrosion. As a rule of thumb, if the threads are relatively small with a fine thread pitch, a liquid lubricant is adequate. If the thread size is relatively large, grease is preferred. For example, a small bolt holding a derailleur shift cable can be oiled, but the large threads of pedals should have grease or anti-seize. Other options are discussed below under Lubrication, Threadlockers and Grease.

There are exceptions to always lubricating a thread. Either the internal or external thread may have nylon fittings, commonly called “Nyloc.” The nylon insert in the thread prevents the screw or bolt from turning freely. Nyloc systems are used for adjustments when there is low torque or even no torque on the fastener. For example, derailleur limit screws use plastic fittings to prevent the screws from turning and changing the derailleur adjustment. Do not lubricate the limit screw threads. Additionally, do not lubricate a fastener with preinstalled threadlocker.

When assembling threaded components, it is important to align threads correctly when you first begin to engage the inner and outer threads. The critical threads are these first ones, and damaging the first threads from misalignment can make components very difficult or impossible to install. Take note of the axis of both inner and outer threads and make sure you are rotating parts square to this axis. One technique for beginning a difficult-to-start thread is to purposely rotate the threaded part backwards to feel the first thread engagement. Begin to rotate the correct direction after you feel a “click” or “give” in the part, which tells you this is the beginning of the thread.

Generally, a threaded fastener joint should be tightened as tight as the weakest member of the bolt or nut component system can withstand. For example, crank bolts are large and can take a very high torque. However, the cranks they hold are typically made from aluminum and cannot withstand as much pressure as the bolt could potentially generate. The crank is the weak link in that spindle-crank joint system, and manufacturers limit recommended torque accordingly.

To prevent overtightening and undertightening, many manufacturers provide specific torque values, best achieved by using a torque measuring device (figure 1.4). Torque wrenches are simply a type of measuring tool, like a tape measure or a ruler.

FIGURE 1.4: Using a torque limiter tool to secure handlebar binder

Torque wrenches measure the amount of turning effort applied to the bolt or nut. A torque wrench should be part of the bicycle tool kit, but it is possible to work without one at some risk.

Measured torque may be given in Newton-meter (Nm), inch-pound, or foot-pound units. These units of measure refer to the force applied to the end of a lever. For example, torque of 60 inch-pounds is equal to 60 pounds of force at the end of a 1-inch wrench. If the wrench were 2 inches long, 30 pounds of force would be required to achieve the same torque on the bolt. If force were applied at 12 inches from the bolt, only 5 pounds of effort would be required.

The bicycle industry uses a variety of torque designations. To convert inch-pound units into foot-pound units, divide the inch-pound number by 12. For example, 60 inch-pounds of torque are equal to 5 foot-pounds. To convert foot-pound units into inch-pounds, multiply foot-pounds by 12. Three foot-pounds are equal to 36 inch-pounds. To convert Newton-meters to inch-pounds, multiply Newton-meters by 8.85. There is a list of recommended torque specifications in Appendix C. Use the component manufacturer's recommended torque when available.

With experience, a person may learn the amount of force to apply to a wrench when tightening a fastener. It may require both overtightening and then undertightening fasteners in order to learn acceptable torques. Tightening by feel relies on "perceived effort" and is an important skill to develop and understand. Perceived effort is subjective and will change with the length of the tool used and where your hand holds the tool. Think about lifting a six-pack of 12-ounce beverage cans. The six-pack weighs approximately 4.7 pounds. This effort applied to a wrench held 6 inches from the bolt is about 30 inch-pounds of torque, just about what is required to tighten a derailleur cable pinch bolt. Now consider hefting, with one hand, a 24-count case of 12-ounce beverage cans. Typically, that effort will be close to 20 pounds. That much effort on a wrench held 6 inches from the bolt is 120 inch-pounds, approximately the amount of torque required for hub cone locknuts and a minimum torque for pedal threads. Cranks with a single bolt typically require about 300–400 inch-pounds, which is one of the highest torque values on a bicycle. That is at least 50 pounds of effort holding a wrench 6 inches from the crank bolt.

If you are not using a torque wrench, it is still useful to use torque values as a guideline for perceived effort. To determine the effort, divide the inch-pound torque by the number of inches from the middle of your hand to the bolt or nut. For example, in the image below, a 300 inch-pound torque is desired to hold the wheel to the frame. The hand is holding a wrench 6 inches from the nut. Attempt to apply an effort of 50 pounds force (figure 1.5). There are certain situations where a torque wrench cannot fit, so it is important to develop a feel for the load. Using a torque wrench and feeling by hand can help speed this learning process.

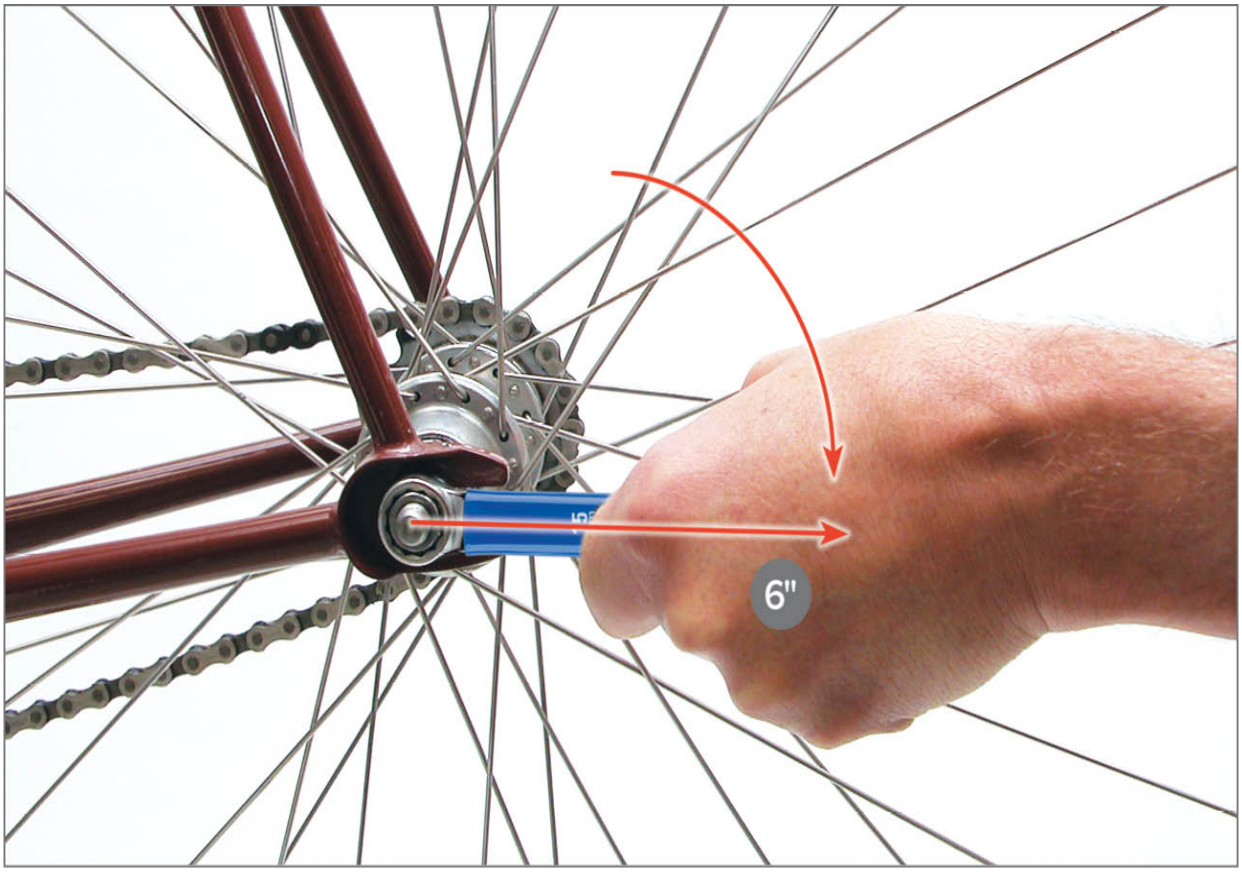


FIGURE 1.5: Apply force to wrench according to distance from hand

It is very useful to understand the concept of "mechanical advantage" when working on tight bolts and nuts. The wrench acts as a lever that pivots on the bolt or nut. In situations where two wrenches are used, position the wrenches to form a "V," with the bolt or nut at the point of the "V." This position allows more force to be applied effectively to the bolt head. Avoid positioning the wrench so the levers form an angle greater than 90 degrees. When using one wrench, look for the second lever. This will sometimes be in the form of the opposite crank when working on pedals or the frame tubing when working on the bottom bracket (figure 1.6 and 1.7).

FIGURE 1.6: Poor mechanical advantage

FIGURE 1.7: Good mechanical advantage

LUBRICATION, THREADLOCKERS, & CLEANERS

Bicycles require various types of lubricants depending upon the component part and how it is used. Lubricants vary in how well they work, what they are composed of, and how they are sold.

Lubrication prevents friction and also helps prevent corrosion. Engines use motor oil under pressure to ensure that pistons and bearings run smoothly. The car engine powers pumps to maintain oil pressure, which forces oil between parts to keep friction low. That's a luxury the self-propelled cyclist cannot afford. Lubrication on bicycles is based on a much simpler concept called "boundary lubrication," which refers to a very thin film of lubricant that separates moving bearing surfaces. This boundary of just a few molecules of lubrication is all we have to prevent metal from being ripped off a hub bearing or chain rivet.

A good lubricant should stick to the part requiring lubrication. Unfortunately, that means dirt and grit may want to stick to the part as well. Water tends to wash off lubricants. Liquids such as chain lubricants vary in their resistance to being washed off. It is useful to have around several lubrication choices. A light liquid lubricant will penetrate easier into smaller areas, such as derailleur cable housing. Examples of a light lubricant are Park Tool CL-1 Synthetic Blend Chain Lube or Triflow®. Heavy lubricants stick better in very wet conditions and are good for lubrication where grease is not useful. A chain used in the rain or the internals of a freehub would be good areas for a heavier lubricant. An example of a heavy lubricant would be Phil Wood® Tenacious Oil®, or Finish Line® Cross Country.

Grease is simply oil suspended in a mixture of surfactant, soap, or other compounds. Grease keeps the lubricating oil in place on the component part, but it is the oil in the grease that provides the lubrication. When grease gets pushed out of the way of the bearings, there will be little or no lubrication left. Grease should be changed when it becomes contaminated with grit and dirt or when the oil in the grease becomes old and dry, which reduces its lubricating properties. Water may also wash out grease. The bottom bracket bearings are the lowest part of the bicycle and especially vulnerable to this type of failure.

It can be difficult to know when the grease used in the component parts is contaminated. It will be necessary to simply disassemble a hub or part and inspect. By the time a bearing is making noise and you feel a rumbling in the part as it spins, the damage from poor lubrication is already done. As a rule of thumb, the grease should be replaced once a year. If the bike is used for racing or ridden daily, replace the grease two to three times per year.

Grease is commonly sold in tubes or in tubs. Use care to always replace the lid when using the tub so the grease does not become contaminated. Liquid lubricants come in spray aerosol and non-aerosol bottles. The non-aerosol bottles use a tube for dripping the lubricant, which allows the user to place it where it does the most good. Aerosols can easily over lubricate parts by spraying too much lubrication, but they can be helpful when flushing away dirt. If the bike is ridden in heavy rain, taken through stream crossings, or washed with soap and water, liquid lubricants should be applied to suspension pivot points. Do not drip or spray oil into greased bearings such as hubs, headsets, and bottom brackets.

Another option for thread preparation and some press fit parts is anti-seize compound. This provides a thick and durable coating for surfaces. Anti-seize solutions are typically made of ground metals such as aluminum or copper that are combined with lubricants. These compounds are not appropriate for moving bearing surfaces such as hub or bottom bracket bearings. Anti-seize compound, such as Park Tool ASC-1 Anti-Seize Compound, tends to outlast grease when exposed to water and makes a long-lasting preparation for applications such as threaded bottom bracket installations or press fit situations.

Threadlockers and retaining compounds are special liquid adhesives for threaded and pressed fittings. Commonly available threadlockers are referred to as the “anaerobic” type. These liquids dry independently of air and will harden and expand when sealed in the threads of the part. This process is what gives the threadlockers and compounds their special features. It should be stressed, however, that these products should not be used to replace proper torque and preload when the clamping load is important. Most threadlockers are designed for use with metals. Unless a special primer is used, do not use the compound on plastic or resin.

Lighter duty threadlockers are considered “service removable.” This means the part can be unthreaded and removed with normal service procedures. An example of a service removable product is the Park Tool TLR-1 Medium Strength Threadlocker. Stronger compounds require extra procedures to disassemble the part, such as mild heating with a heat gun or a hair dryer. In a pinch, even hot water poured on the part can be enough heat to soften the compound.

Retaining compounds, such as Park Tool RC-1, are intended for press fit applications. On a bicycle, they may be used for poor or marginal cartridge bearing press fits and poor headset cup fits. Retaining compounds tend to have a higher viscosity than the threadlocking compounds. Many retaining compounds require special techniques for removal, such as excess force or mild heat or both.

Retaining compounds are less effective for plastic or carbon fiber press fit situations. When attempting to use a retaining compound, such as on a PF30 press fit bottom bracket, use the special liquid primers from the compound manufacturers, following their directions. These primers allow the compounds to harden and expand. Without use of the primer, the compounds may simply remain liquid and not cure.

Another compound useful on carbon fiber bikes is an “assembly compound,” such as Park Tool SAC-2 Super Assembly Compound. These compounds are basically a silicon dioxide (sand-like) material in a liquid or paste carrier. Do not confuse an assembly compound with grease! It is not lubrication and should never be used as lubrication! It provides extra friction wherever it is placed and can be useful in carbon fiber seat tubes that have difficulty holding the seat post secure. It can also be useful in clamping a front derailleur bracket to a carbon fiber frame. The grit in this compound will not structurally harm carbon fiber, but you should expect some surface marring.

Servicing bicycle components, such as the chain, will require cleaners and solvents. Never use highly flammable liquids such as gasoline, kerosene, or diesel as cleaning solvent. There are safer solvent choices on the market, including Park Tool CB-4 Chain and Parts Cleaning Fluid.

It is possible to reuse solvents for an extended period of time. Save used solvent in a sealed container and allow it to settle for days. The dirt and grit will settle to the bottom. Carefully pour off the solvent and reuse. Scrape the grit from the bottom and dispose of it along with spent solvent by contacting your local hazardous waste disposal site, which is typically with a state or county agency.

For cleaning the paint on the frame use mild cleaners, such as a window cleaner, or simply soap and water. Isopropyl rubbing alcohol is usually adequate for cleaning rim braking surfaces. It is important that cleaners for braking surfaces not leave an oily film.

BEARING SYSTEMS

Bearing systems on bikes allow component parts to move and/or rotate. These systems can be a simple bearing, also called a "journal bearing," or more typically, ball bearings. The journal bearing system is simply one surface sliding or turning inside another. An example is a pedal axle turning inside a bushing without needle or ball bearings.

Round ball bearing systems trap balls between two bearing surfaces, called "races." The two basic ball bearing systems are cartridge bearing systems and adjustable "cup-and-cone" bearing systems. Neither system is inherently better for use on a bicycle. Adjustable-type systems can be overhauled by disassembly, inspection, and regreasing.

Even the highest quality bearing surfaces will have slight marks and imperfections from grinding as they are manufactured. Better quality bearing surfaces are ground smoother and will have less friction and resistance to turning. All bearings, however, will have some friction as they rotate. This is normal and does not significantly affect the ride. Generally, the lighter load a bearing is expected to experience, the "smoother" the feel of that bearing. Bearing systems experiencing more stress and pressure will seem to have more drag, even when the adjustment is correct. For example, a bearing for a rear derailleur pulley, which is designed for low stress loads, will seem to have less spinning resistance compared to a bottom bracket bearing, which is designed to handle more load.

The races and balls are greased to minimize wear. The bearing system is commonly shielded from dirt by covers and seals to maximize bearing surface life. Exposure to the elements will increase wear on the bearing surfaces and shorten bearing life.

Cartridge bearings use an industrial, or rolling element, bearing. Ball bearings are trapped between inner and outer rotating races (figure 1.8). There should be no play between new bearings at the inner and outer races of the cartridge. With use, however, play will develop between these two races. The bearing may also feel rough as it rotates.

FIGURE 1.8: Cutaway view of a cartridge bearing

Cartridge-type systems are designed to be disposable and rely on replacement of the entire cartridge bearing rather than cleaning and greasing the existing bearing. However, if the axle or spindle can be removed from the center of the bearing, it is often possible to lift the seal from the inside lip and flush the bearings clean with a solvent. The bearing should be blown dry and repacked with grease. Return the seal and press into place. If the axle or spindle cannot be removed, it will damage the seal to remove it.

DIAGNOSING & SOLVING MECHANICAL PROBLEMS

As you develop mechanical skills and become more experienced with the technical side of the bicycle, diagnosing particular problems will become easier. To learn this skill, begin by paying attention to your bike while you ride and become accustomed to how it sounds and feels when things are operating properly.

A basic component of diagnosing and discussing technical or mechanical issues is knowing the names of the component parts. Being familiar with what shop mechanics call a part will enable you to converse and provide useful information. Appendix F is a Bike Map, showing the common names of the various component parts of the bike. Additionally, a glossary of bicycle specific terms can be found in Appendix B.

Diagnosing from the saddle, while riding, can be quite useful when repairing the problem later. For example, note if an unusual noise is repetitive or occurs with every pedal revolution. This would place the problem in the crankset area, like the pedal, bottom bracket, or chainring. A noise every second or third revolution might be in the chain, such as a stiff link as it passes by the derailleur pulley wheels. Ask yourself if the noise occurs when pedaling only or also when coasting. Make a mental note if the noise or problem occurs under load, such as on a hill or when you hit a small bump.

It can be very helpful to use another mechanically-minded friend when diagnosing problems. For example, a friend can stress the suspect part of the bike, such as the crank, while you listen and feel for creaking. Creaking can often be felt through the frame and parts as a resonance. It can also be useful to ride with a friend, first describing what you think you are hearing and experiencing before you both ride. Use extra care during these diagnosing/riding sessions so you don’t run into each other or into parked cars!

At the end of the chapters are “Troubleshooting” tables. These are listed by “symptom” or what the part of the bike seems to be doing. Next is listed the likely “problem” that would cause the symptom. Last is the “solution.” While these can help get things fixed, going straight to the troubleshooting chart without an understanding of what the section of the bike does will lead to inconsistent results. Additionally, no chart can be fully complete with every possible issue listed. You will need to think through the system that is causing issues, consider basic mechanical principles as to the cause, and then apply solutions that match. That is the enjoyable part of repair.

TOOL SELECTION

Having the correct tool for the job makes the work easier. Bicycles require both general maintenance tools common in any toolbox and specialty tools unique to the bicycle industry. There are a wide variety of sources for tools, such as bicycle retailers, department stores, automotive stores, and general tool retailers. In some cities, there are also public workshops that rent special tools and workbench space by the hour.

It is possible to purchase tools only as they are required. This is economical in one sense but not timely in another. When a part fails, the tools to repair the problem must be sought out, which can create a long delay in fixing the bike. Anticipating the use of tools and purchasing them ahead of time means initially spending money, but the tools are there when you need them. Your priorities in purchasing tools depend upon your bike's components, the type of maintenance you want to do yourself, the frequency of the work, and your growing mechanical interests and skill level.

Tools differ between manufacturers in many ways, including tool finish, fit in the hand, type of material, and tool fit to the part. The finish affects both the look of the tool and how it will resist corrosion. A hand tool should fit the hand comfortably and not be awkward to use. The type of material may affect the durability of the tool. Good quality steel will longer than softer grades. Tools are typically made to a certain size. The size should fit the part correctly without being too large or too small. Bicycle component manufacturers sometimes limit what tool companies can do for tool design. For example, if a component part was poorly thought out and service considered only after the design was completed, a "correct" fitting tool may not be possible.

Box-end wrenches and open-end wrenches fit over the outside of a bolt head or nut. When choosing a wrench for a particular bolt, pick the smallest size that will fit over the head/nut. This also applies to spoke wrenches. Two different wrenches can appear to fit, but the smaller one will grab the part better.

Hex wrenches and screwdrivers (Phillips®, cross-tip, and straight blade) fit inside a screw head. The proper size here is the largest one that will fit inside. Although two different screwdriver tips may fit inside a screw head, always choose the larger one for more engagement to the head.

A tool table for a very complete home shop is listed in Appendix A. However, the table does not include some tools that professionals might use, such as frame machining equipment.

It is important for all mechanics, whether casual home mechanics or professional mechanics, to always use tools correctly. Wrenches should be placed fully on the nut or bolt head before turning. Hex wrenches should be fully inserted into the socket fitting before turning. Hold wrenches for comfort and good mechanical advantage. When using a file or hacksaw, apply pressure on the forward cutting stroke, not on the backstroke. These basic habits may seem obvious and pedestrian, but they are what make good mechanics.

TOOL USE AND TOOL FITTINGS

A basic part of working on a bike or any mechanical object is knowing how to use the tools. Although tools are in some ways extensions of our hands, proper use of tools is not always intuitive. Especially if you are teaching someone, it is worthwhile to begin with a review.

Wrenches are leverage tools, with ends made to fit onto fasteners. When using a wrench, select the smallest size that fits the part. Metric sizes are only 1mm different, and a larger wrench can still engage a part that is a too small for it. For example, a 14mm wrench will partially catch the corners of a 13mm nut. Both the tool and component can become damaged from the wrong tool size.

It is important to develop the habit of correctly fitting the wrench to the part, getting good “purchase” on the tool fitting. Make sure a wrench is all the way on the part before applying force. For hex keys, make sure they are fully seated inside the socket head (figure 1.9)

FIGURE 1.9: Poor tool alignment will damage bolt and wrench

For screwdrivers, use care that the shaft of the tool is in line with the axis of the thread (figure 1.10)

FIGURE 1.10: Example of poor tool alignment to part

Especially when dealing with a heavier torque, arrange yourself and the bike appropriately. For example, if your arms are too far up, it is difficult to apply a lot of stress. Bring the work down so you are above it. In a similar vein, rotate the bike upward if you need a better look at it. That is the advantage of a repair stand that permits rotation of the bike.

REPAIR STANDS

The repair stand (work stand) is the basic and most crucial piece of equipment for any shop or home. Getting the bike off the ground makes the repair quicker, easier, and more fun. A good work stand brings the work up to the mechanic, instead of forcing the mechanic to bend over to get to the work. Work stands also allow the mechanic to pedal the bicycle by hand and quickly diagnose problems. Many stands come with a rotational feature that allows the bike to rotate up to the mechanic. Repair stands often have a height adjustment feature, which allows for raising and lowering the bicycle.

Some bike frames have oval, square, or other non-round shaped tubing, making it difficult to clamp onto the frame tubing. Bicycle manufacturers often recommend clamping the seat post, rather than the frame tubing. Seat posts, even if carbon fiber, are quite strong because they must support the full weight of the rider (figure 1.11). When in doubt, check with the manufacturer for acceptable areas to clamp.

FIGURE 1.11: Clamping the bike by seat post

There are also repair stands available that do not clamp the bike on any tube (figure 1.12). These stands require a wheel to be removed so the stand grabs the fork dropouts.

FIGURE 1.12: A repair stand that holds the bike without any tube being clamped

HOME SHOP SETUP

Home mechanics may enjoy setting up a dedicated repair area or, basically, their own "bike shop." The primary requirement for a shop is space for a workbench, a repair stand, the bike, and enough room to maneuver. A common size for commercial workbenches is 72 inches by 30 inches (182cm by 75cm). This is deep enough to hold a wheel. It is possible to use a bench shorter than the 72 inches, but avoid benches narrower than 30 inches deep. If you are building a custom workbench, it can be set for the height of the user. This may range from 32 inches to 40 inches high. For general technical work, the top of the workbench should be approximately 4 inches to 6 inches (100–150mm) below the height of the user's elbow. The bench top can be made of many different materials, but expect the top to take some punishment during work. It is very useful to bolt the bench to the floor and to a wall. This is especially important if you plan to mount a vise to the bench.

Tools may be mounted to a board on the wall. This allows the mechanic to quickly find the right tool. A pegboard provides a versatile system to hang and arrange tools. Higher quality pegboard measures 1⁄4 inch thick. The pegboard should be at least as wide as the workbench. Hardware stores and home supply stores stock pegboard hooks. A mix of short and long hooks will be needed. However, the short hooks are better, as this avoids stacking too many tools on one hook. A tool magnet is also a very useful item for the work area. It can hold odd shaped steel tools and even bolts that you don't want to lose during a repair.

Try to arrange for good lighting, and even use supplemental lighting if necessary, such as a head lamp. There are a lot of small parts on a bike and getting a proper view of them is important. If you use glasses for a better view, consider them simply another tool in helping you repair bikes.

A good repair stand is the most critical part of the repair shop. The repair stand should be positioned next to the work area. Keep the stand close to the workbench to avoid taking even one step to the bike, but not so close you are crowded. Be sure to use the rotation and height adjustment features of the stand to move the work area of the bike closer to you, rather than bending over. Save your back for riding.

If possible, get a bench-mounted vise. A 4-inch vise is typically adequate for bicycle repair. Mount the vise on a corner of the bench so the non-moving jaw is even with the bench edge.

When arranging tools on the wall, place the tools likely to be used in conjunction with the vise close to the vise. For example, place the axle vise, cone wrenches, hammer, and freewheel tools closer to the vise.

Another very useful piece of equipment is an air compressor. A floor pump can, of course, provide enough air pressure for clincher-type tires. A small air compressor, however, is useful for drying parts after washing them with a solvent. A compressor is also very useful when inflating tubeless tires.

Tool arrangement preferences will vary from mechanic to mechanic, but try to group specialty tools together. Brake tools should be with other brake tools. Non-specialty tools should be together with hex wrenches grouped together and combination wrenches lined up in order (figure 1.13). With time you will develop the system that is best for you.

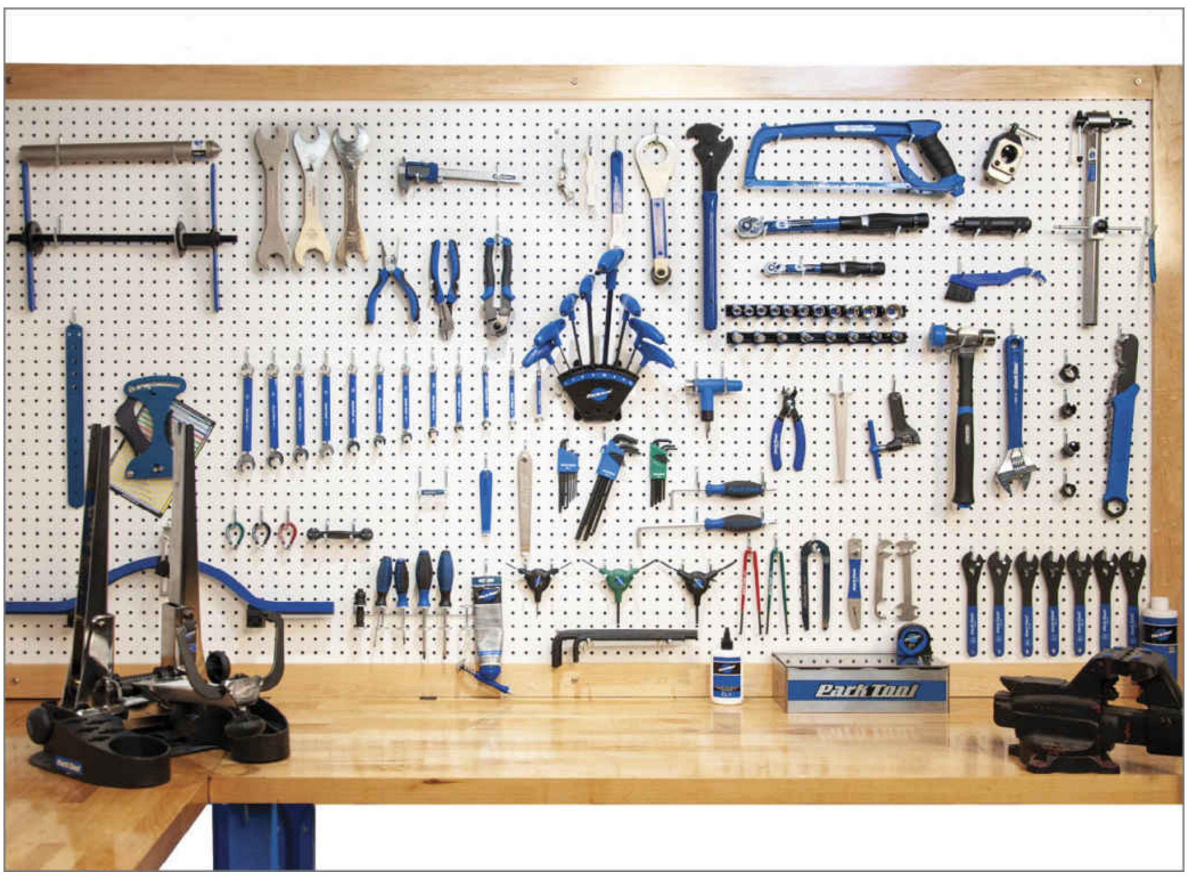


FIGURE 1.13: Example of possible tool arrangement

WORK PROCEDURES AND SAFETY

As with any work you do with your hands, bicycle repair holds certain risks that can be minimized by following basic safety procedures. Keeping safe and healthy is the idea here, because it lets you work on more bikes.

Begin safety by considering how you work. Try to schedule your time so as not to be too rushed. Work with a mind to good leverage and body posture, which just makes things easier. You will work longer with less fatigue. For example, bring the bike up to you, don't bend yourself in half to see a crank bolt. Arrange yourself when lifting heavy things, or applying a heavy torque. Try not to lean over and reach out to tighten a crank bolt, for example. Especially when stresses are greater, move yourself closer to the work.

There are times where striking with a hammer is part of the job, and that means stuff may be flying about. A good pair of safety glasses is a worthy investment. Get a lightweight pair that fits well, and you won't even know you are wearing them after the first few minutes. Then, remember to occasionally clean them.

Remember that your skin is porous, and liquids do enter through these pores. Use care when working with degreasers, solvents and lubricants. If in doubt about a product's health consequences, find the SDS (Safety Data Sheet). Nitrile gloves are also an option, such as Park Tool MG-2 Mechanics Gloves.

Bikes of course are full of metal parts, some with sharp edges. Think before you just grab part of the bike or component. Although you should of course minimize any cuts or abrasions, it should not be unexpected to get a minor injury. A tetanus shot is a good precaution for a mechanic.

CHAPTER 2

TIRES & TUBES

Tires are rubber and fabric casings fitted over the wheel rim. Common bicycle wheels use pneumatic tires referred to as “wired-on” tires or “clinchers.” The wheel’s rim uses a channel or U-shape to hold tire beads. The bicycle’s smooth ride is due in large part to the air in the tires. Inside conventional tires is an inner tube to hold the air. The tire’s body and casing around the inner tube takes the stress of air pressure, bumps, and bruises of riding. There are also “tubeless” systems using special rims and tires that are similar in design to car tire systems and contain no inner tube. Many professional level road racers also use “sew-up” or “tubular” tire systems that use a tire with tube built inside that are glued to special rims.

Servicing flat tires is a basic skill required for any cyclist. Anything from sharp thorns, glass or nails can puncture tires and inner tubes, and the tire itself will wear out with use and time.

WHEEL REMOVAL

Wheels must be removed to replace the tube and tire. If possible, begin by mounting the bike in a repair stand. If no stand is available, lay the bike on the non-drive side to avoid damage to the rear derailleur when the rear wheel is removed. Do not stand the bike upright without the rear wheel in place, as this will damage the rear derailleur. The bicycle may also be turned upside down on the ground if there is no chance of lever or accessory damage on the handlebars. Bikes with quick-release hubs do not require tools for wheel removal. Bikes with axle nuts and bikes with some types of thru axles will require the correct type and size wrench.

Many common bike designs use fork and frame dropouts with an open slot to accept wheels (figure 2.1). Front forks tend to use a 9mm front axle and slot, and the rear a 10mm rear axle and slot. Front forks also commonly have an extra retention device intended to hold a wheel should the axle nuts or quick-release fail.

FIGURE 2.1: Open slot design of fork seen without skewer

It is common for open dropout bikes to use quick-release wheels. These have a hollow hub axle fitted with a shaft, a lever that operates a cam mechanism and an adjusting nut. Swinging the lever to the closed position puts tension on the shaft and pulls both the cam and the adjusting nut tight against the fork or frame dropouts. This tension holds the wheel securely to the frame. The adjusting nut determines the amount of tension on the quick-release lever and cam.

Non-quick-release hubs for open dropout bikes use a solid axle with nuts outside the dropouts. An axle nut may have a built-in washer, or there may be a separate washer under the nut. If the washer has teeth or a knurled surface, these face the dropout to help secure the wheel. When removing wheels with axle nuts, loosen only the nuts outside the dropouts. Lubricate the axle threads while the wheel is off the bike.

Procedure for wheel removal:

a. **Rear Wheel:** Shift derailleurs to outermost rear cog and innermost front chainring.
b. **Front and Rear:** Release rim brake caliper quick-release, if any (figure 2.2, figure 2.3, figure 2.4, figure 2.5).

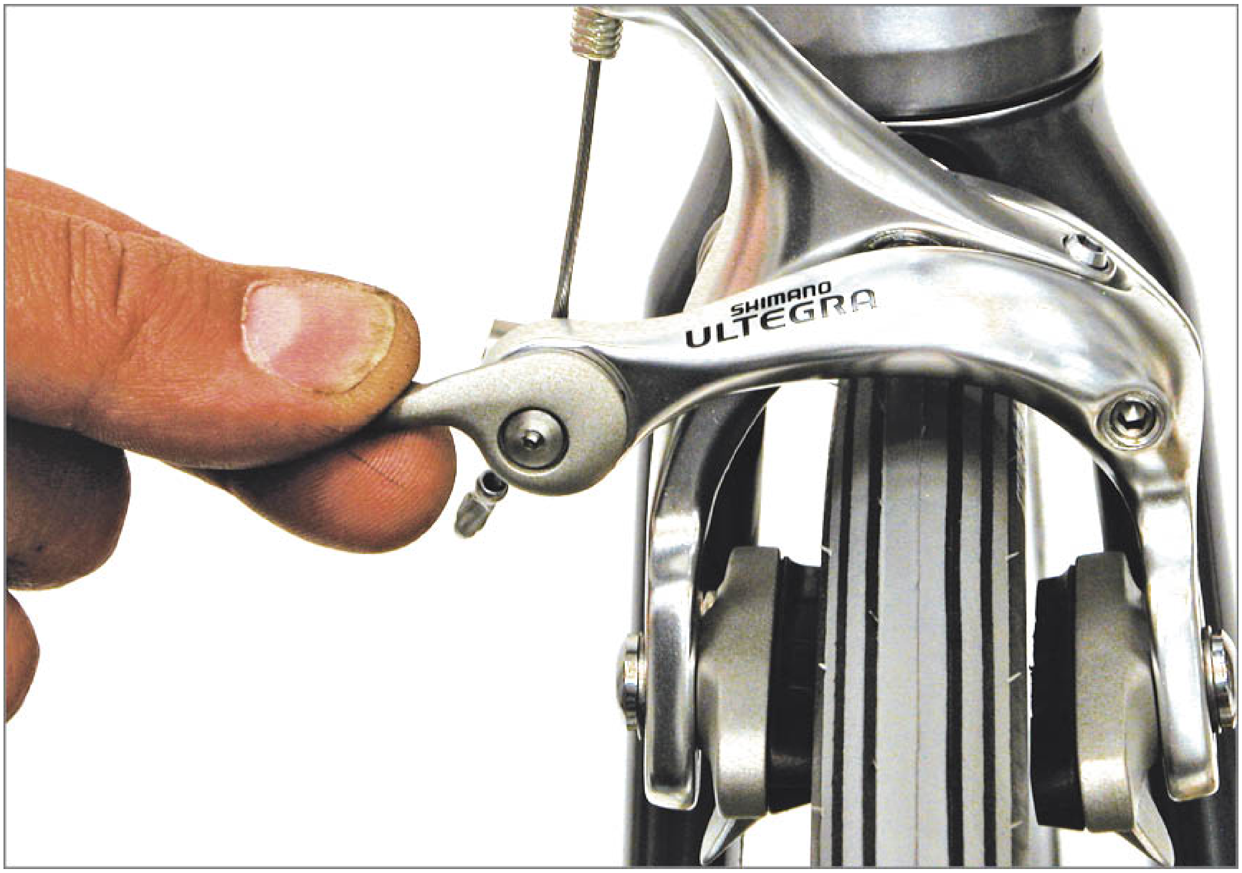


FIGURE 2.2: Side-pull or dual-pivot rim caliper may have quick-release at caliper arm

FIGURE 2.3: Quick-release located at brake lever

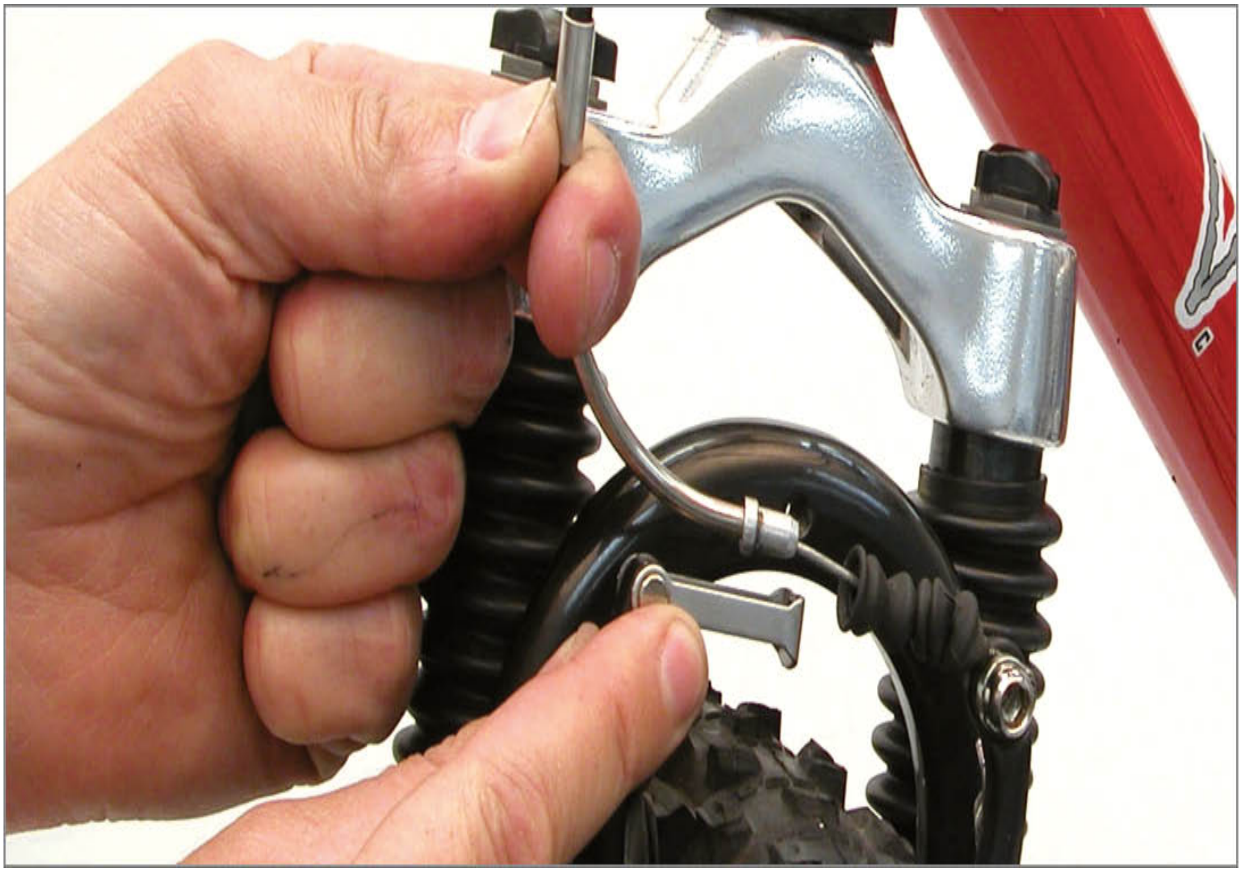


FIGURE 2.4: Squeeze linear-pull calipers together and disconnect cable “noodle” from linkage

FIGURE 2.5: Squeeze the cantilever calipers together and disconnect the straddle wire cable

c. **Front and Rear:** Release wheel quick-release by pulling quick-release lever outward. If necessary, loosen quick-release adjusting nut to clear any tabs at end of fork (figure 2.6). If quick-release is used on a thru axle fork and hub, it is necessary to remove axle completely from hub. For non-quick-release wheels, loosen both axle nuts.

FIGURE 2.6: Puller lever from closed to open position

d. **Front:** Guide wheel through brake pads and out fork ends.

e. **Rear:** Pull back on rear derailleur to allow cogs to clear chain (figure 2.7). Lower wheel, guiding wheel down through caliper brake pads and forward to clear chain and derailleur. **Note:** Some bike dropouts are rear facing. Pull wheel back to remove it from dropouts. Unhook chain from cog for removal.

FIGURE 2.7: Pivot rear derailleur back to clear wheel and cogs of frame

There are rear derailleur systems that use a clutch mechanism in their pivots, which could make it awkward to remove the rear wheel because of a very stiff lower cage pivot. Shimano® Shadow Plus® and SRAM® Type 2 derailleurs use clutch mechanisms that provide resistance at the lower pulley, which are intended to prevent the chain from bouncing off, slapping the frame, or wrapping around the bottom bracket during rough travel.

When changing the rear wheel with the Shimano® clutch system, look for a lever on the lower pivot of the derailleur body. Pull the lever down to disengage the clutch feature (figure 2.8). The derailleur will now easily pivot backward to release the rear wheel. After the wheel is reinstalled, pull the lever back up to engage the clutch.

FIGURE 2.8: Push on-off lever upward to return derailleur to clutch operation mode

SRAM® Type 2 derailleurs do not use an “on-off” lever. The lower pulley is pushed forward, and a button is pushed to engage and hold the cage forward, creating chain slack (figure 2.9).

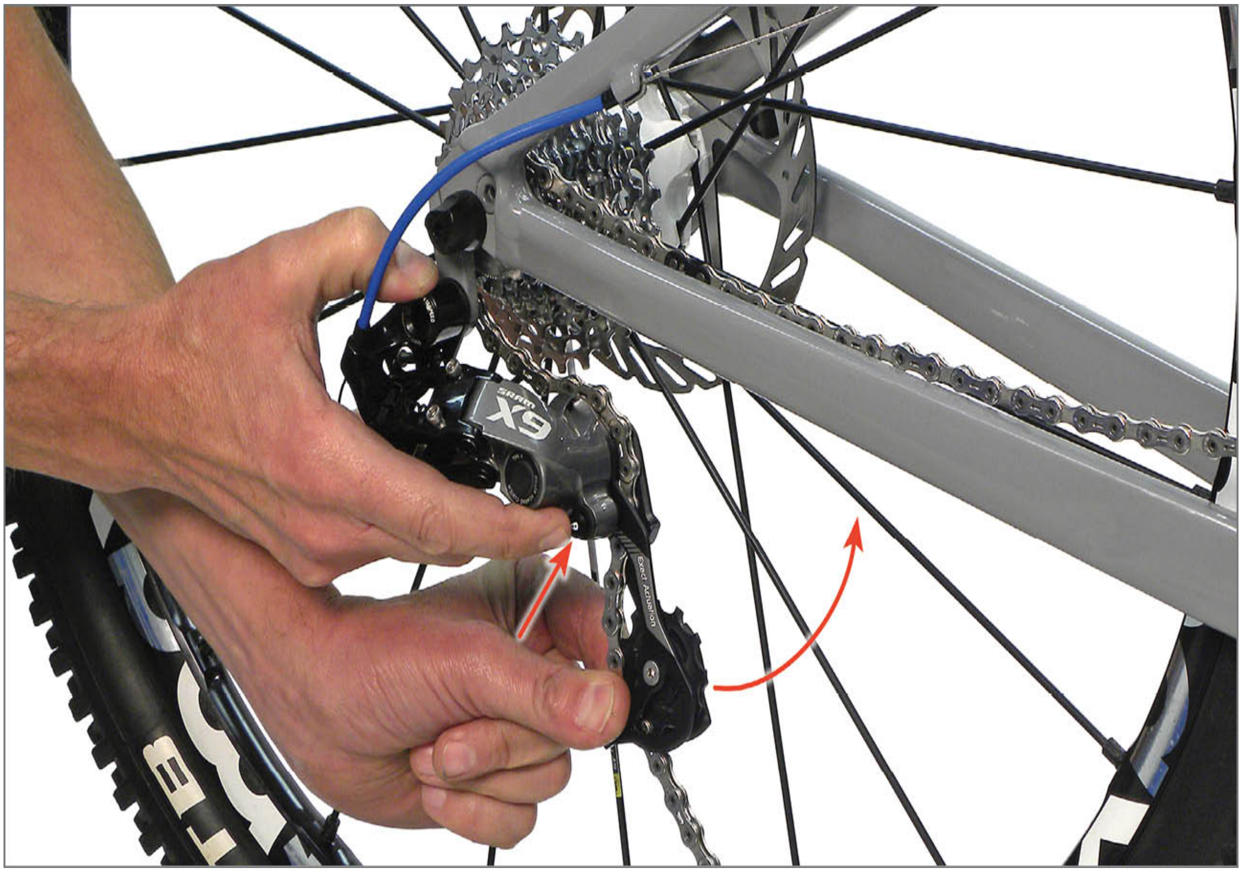


FIGURE 2.9: Push forward on lower pulley and depress cage lock button to hold

Remove the wheel with the cage in the locked mode (figure 2.10). Reinstall wheel and push forward on the lower pulley to release the cage lock and to return the derailleur to the working mode.

FIGURE 2.10: Remove and install wheel with cage in locked position

THRU AXLE SYSTEMS

Thru axle frame and fork designs use dropouts that are completely enclosed (figure 2.11). The wheel is installed with a connecting shaft called a “thru axle.” This system permits a stronger retention system, with more precise and consistent wheel and brake rotor positioning in the bike. The thru axle is fitted through the frame/fork dropout, into the thru axle hub, and engages a thread on the opposite dropout (figure 2.12). This thru axle must be removed completely to remove the wheel. The system of removal can vary with the design of the bike. Once the thru axle is removed, the wheel is removed and installed the same as an open dropout wheel.

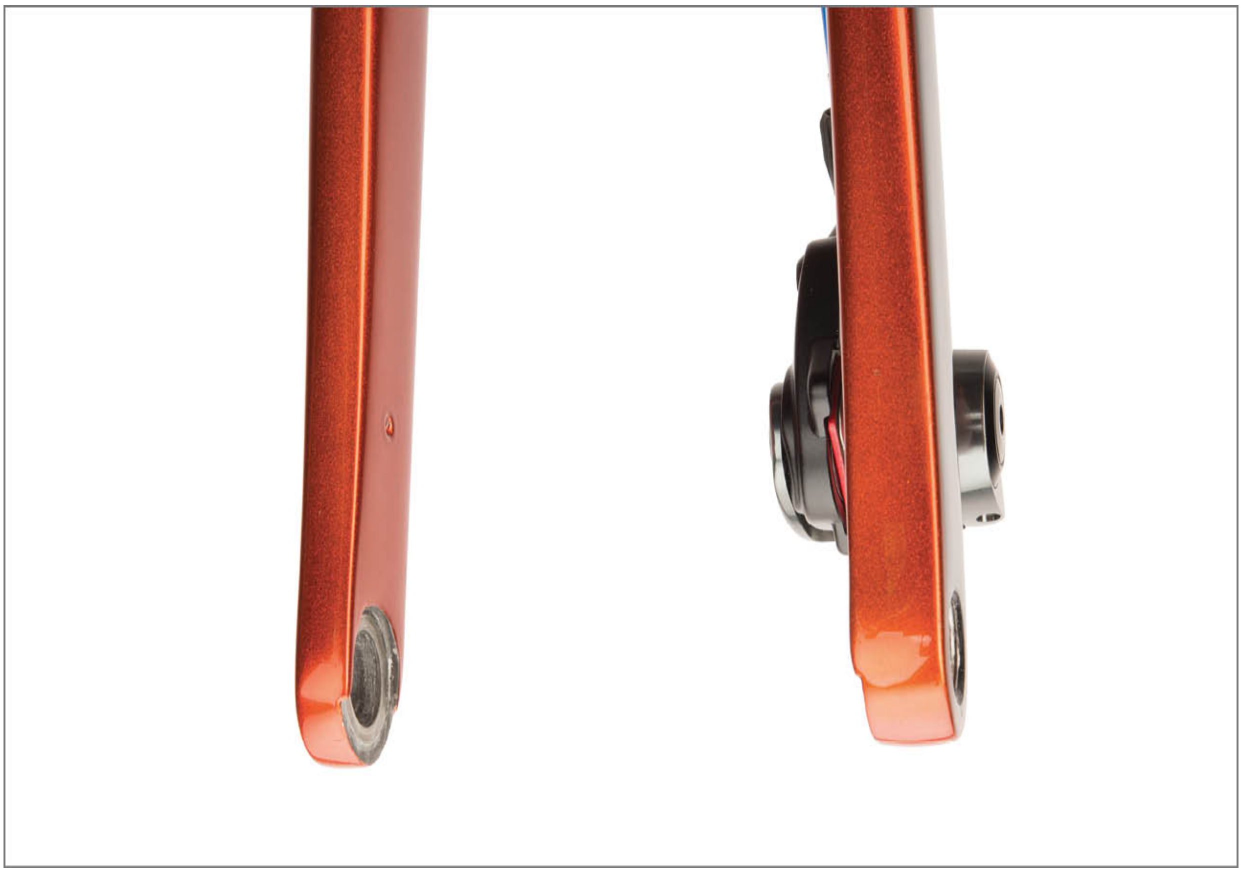


FIGURE 2.11: Enclosed fork ends of a thru axle bike

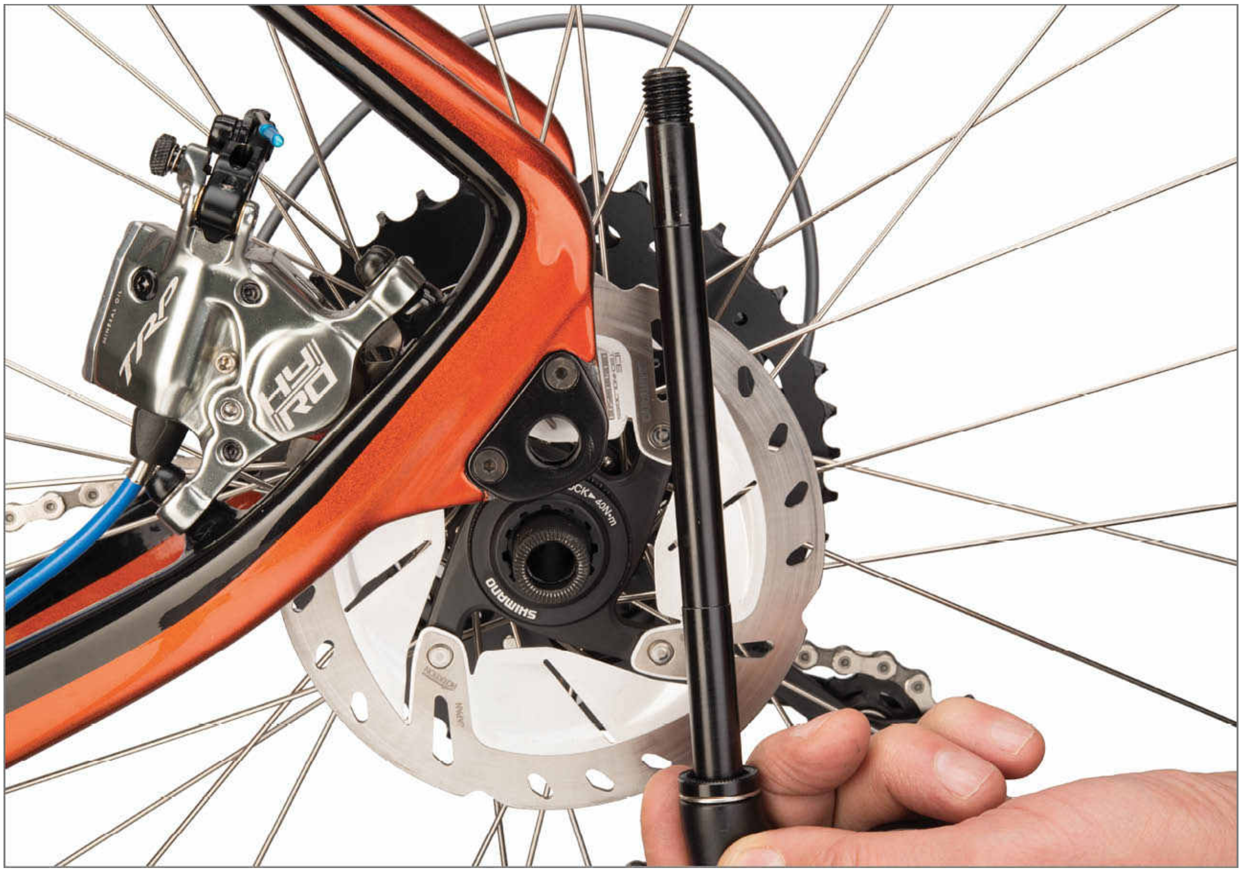


FIGURE 2.12: Rear thru axle wheel being installed

Thru axle diameter standards for front fork thru axles are: 12mm, 15mm or 20mm. Width can vary with common standards of 100, 110mm, 135mm and 150mm

Thru axle systems for rear hubs use a 12mm diameter axle, and can come in widths of 135, 142, 148, 150, 157, 160, 170 and 197mm.

Although there are diameter standards for thru axle systems, thru axle thread pitch can vary. When selecting a new thru axle, the frame standard and thru axle standard must match. Measure thread pitch if in doubt.

Quick-release thru axle systems use a cam system similar to conventional systems. The lever system rotates the thru axle to press the dropouts against the wheel end caps. The axle lever is then cammed over similar to an open dropout hub. Adjust the cam so there is resistance approximately halfway through the swing from open to closed (figure 2.13). The thru axle must be turned counterclockwise and pulled completely out of the frame or fork to pull the wheel from the bike.

FIGURE 2.13: Cam style quick-release

The thru axle may also use a simple lever built into the end (figure 2.14). Rotate the lever to unthread it from the opposite dropout. Reinstall the thru axle after installing the wheel and tighten the lever. The torque is typically 10–12Nm, meaning when pulling by hand on these short levers apply approximately 30 pounds of pulling effort.

FIGURE 2.14: Tighten lever and then position lever as desired

The thru axle can be designed with a hex socket accepting a 5, 6, or 8mm hex wrench. Remove axle using the appropriate wrench (figure 2.15).

FIGURE 2.15: 6mm hex wrench removing axle

There are fork end designs that use compression pinch system at the dropout. Screws are used to hold the axle after it is installed (figure 2.16).

FIGURE 2.16: 20mm thru-axle fork and hub

REMOVAL OF TIRE & TUBE FROM RIM

Remove the tire and tube (if any) from the wheel for a complete inspection. A mounted clincher tire has two beads that are fitted to the wheel rim inner walls. Use tire levers to pry one tire bead up and over the rim sidewall. Tire levers come in different shapes, sizes and materials. Plastic levers (Park Tool TL-1.2, TL-4.2 or TL-6.2) are typically adequate and will not leave blemishes on the rim. Use only plastic tire levers for carbon fiber clincher wheels to avoid damaging the rim surface.

Some tire and rim combinations are extremely tight and may require a steel lever, such as Park Tool TL-5 Steel Tire Levers. Some cosmetic marring may occur with any metal lever, but this will not harm the function of the rim. To avoid cosmetic damage, you may use composite-covered Park Tool TL-6.2 steel core tire levers.

When possible, mark the tire at the valve to help in locating any holes in the tube. Use the mark to trace the location back to the tire. However, always inspect all surfaces of the tire, tube, rim strip and tire bead seat inside the rim.

Procedure for tire and tube removal:

a. Remove valve cap. Fully threaded valve shafts may also have a locking nut next to rim. Loosen and remove this locknut before deflating inner tube.

b. Deflate tube completely. Presta valves: open and depress locknut at top of valve. Schrader valves: depress valve plunger with small hex wrench. Even a small amount of air left in tube can make it more difficult to get tire off rim. For best results, press downward on wheel while depressing valve.

c. The tire bead will be pressed tight against rim sidewall. Grab tire with both hands and push above tire bead using both thumbs. This will move tire toward the center of rim to loosen bead (figure 2.17).

FIGURE 2.17: Push tire bead from sidewall the entire perimeter of wheel

d. Engage one tire lever under bead of tire. Engage second lever 1–2 inches (2–5cm) from first lever then push both levers down towards spokes to lift bead up and off rim (figure 2.18).

FIGURE 2.18: Engage tire levers under tire bead and lift

e. Disengage one lever. Move it approximately 2 inches (5cm) along rim and engage this lever under bead. Push lever to lift next section of bead off rim.
f. Repeat engaging lever until bead loosens. Then slide lever along rim under bead until bead is completely removed from rim.
g. Starting opposite valve, pull inner tube out from inside of tire. Lift valve from valve hole and remove tube from wheel.
h. Remove second bead from rim, which removes tire completely from rim. To fully inspect tube and tire, it is best to remove tire completely.

INNER TUBE INSPECTION

When servicing a flat tire, always inspect tire and tube carefully to locate the cause of failure. If you intend to replace the inner tube, knowing the cause of the flat can help prevent future flats.

Procedure for inner tube inspection:

a. Reinflate inner tube, if possible, to twice or three times its normal width. This extra pressure makes small leaks easier to locate (figure 2.19 and figure 2.20).

FIGURE 2.19: Inner tube before inflation

FIGURE 2.20: Inner tube inflated for inspection of small holes

b. Inspect for air leaks. Slowly move tube closely past sensitive skin such as lips or cheeks. Small leaks can also sometimes be heard. Check around entire tube. If this does not work, then submerge tube in water and watch for bubbles at hole.

c. If you plan to repair inner tube, use a marking pen to make four marks, one on each side of hole (figure 2.21). Do not mark directly on hole, as marks may be sanded off, making the puncture's location difficult to find.

FIGURE 2.21: Mark inner tube after location hole

d. Inspect remainder of inner tube for more holes.

The type of cut or hole in the tube will help determine the cause of the flat. Common cuts and their causes include:

CUT AT VALVE BASE

Misalignment of inner tube in rim, a crooked valve or riding with low pressure. Be sure inner tube valve is mounted straight inside rim and check tire pressure before every ride. With time and use, a faulty valve stem may also simply separate from the inner tube.

LEAKY VALVE CORE

Schrader valves may have loose cores inside valve stem. Test mounted tube and tire at full pressure with soapy water or saliva sealing the core. Inspect for bubbles appearing at core (figure 2.22). Presta valves may have a loose locknut or loose valve core inside stem. Tighten valve cores with a valve core tool such as the Park Tool VC-1.

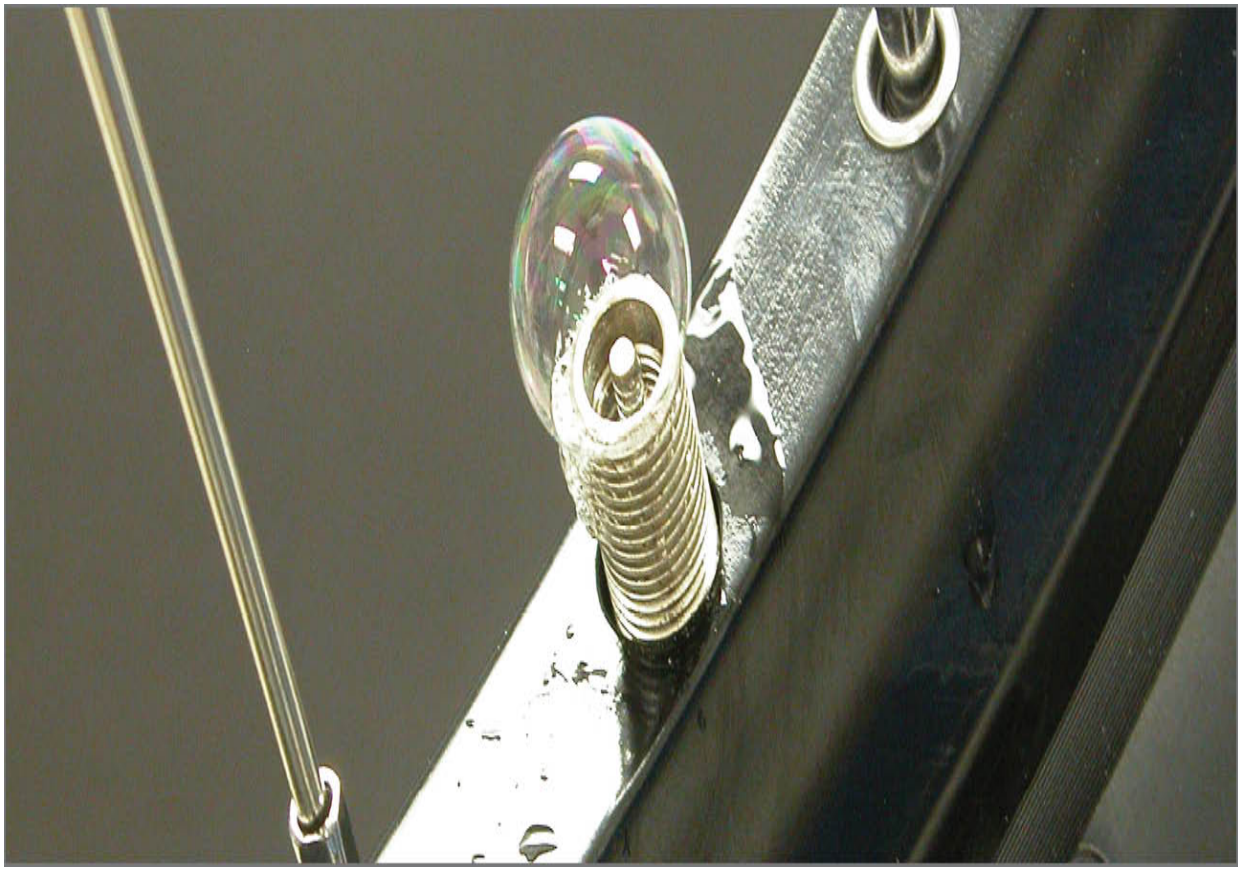


FIGURE 2.22: Test valve core for leaks

LARGE SHREDDED HOLE

Tire blowouts are not repairable. Check tire and rim for seating problems. Also check for hole in tire casing (figure 2.23).

FIGURE 2.23: Shredded holes indicate blow out

HOLE ON RIM STRIP SIDE OF TUBE

Rim strip failure. Inspect inside of rim for protruding spokes, sharp points or lack of rim strip coverage over inner rim holes.

LONG CUT OR RIP

Tire blowout. Inner tube is usually not repairable. Check tire and rim for seating problems. Use care when seating tire during installation.

SINGLE PUNCTURE OR SMALL HOLE

Thorn, wire, glass. These holes may be repairable. Check tire as well. The cause of the puncture may still be embedded in the tire.

DOUBLE SLITS

Rim pinch. Tube was pinched between rim and an object on the road or trail. Increase air pressure or use wider tires (figure 2.24).

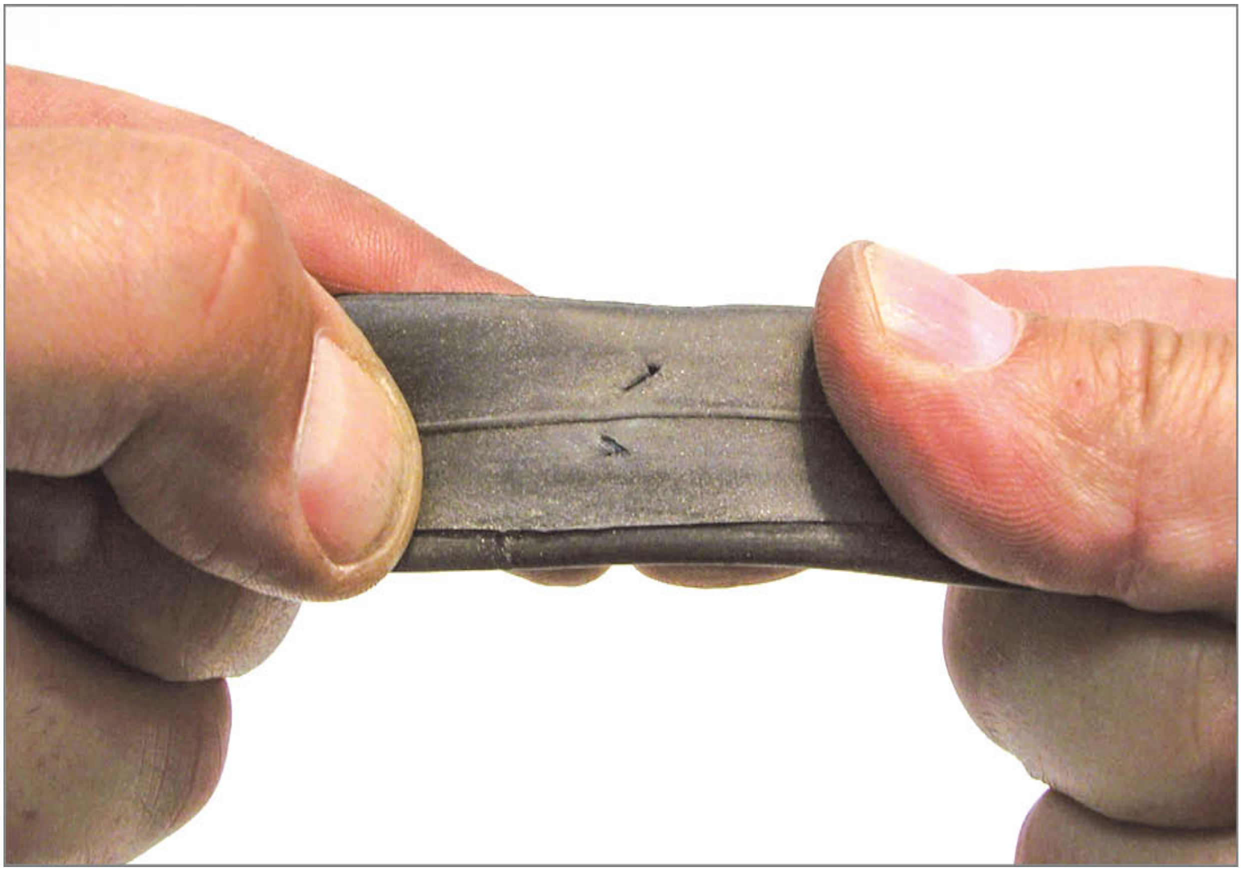


FIGURE 2.24: Two parallel cuts indicate tube was pinched between rim and object during an impact

TIRE INSPECTION

It is important to always inspect the tire as well as the inner tube. The cause of the flat, such as a nail or piece of glass, may still be embedded in the tire or tread. Inspect both outside of rubber tread and inside the casing. Again, mark the tire near the valve core as a reference.

Inspect for protruding nails, pieces of glass, thorns, or other objects. Squeeze any cut to look inside for objects such as slivers of glass. Use a seal pick, scribe, or pointed knife to carefully pick out small pieces of glass or thorns lodged in the tread. Visually inspect inside of tire casing for nails, glass or debris. Wipe inside of casing with a rag and then carefully feel inside with fingers. Proceed slowly as there may be sharp objects still in the casing (figure 2.25).

FIGURE 2.25: Carefully feel inside the case with fingertips

Inspect tire bead for damage. A broken or cut bead will not permit the tire to hold to rim. Any exposed bead will require tire replacement (figure 2.26).

FIGURE 2.26: Failure of tire bead cannot be repaired

Check for "tire rot," or tire casing deterioration. Old and rotted tires are more susceptible to punctures and blowouts from sidewall failure (figure 2.27). Even if the tire has an adequate amount of tread, replace rotted tires.


FIGURE 2.27: Cracks in casing or tread indicate tire rot

Inspect sidewall for rips, abrasions, holes or damage to casing (figure 2.28). Damage to cords may only be seen when the tire is fully inflated. Failed cords will show as bulges and irregularities in tire shape. These can be seen as the tire spins. Hold your fingers gently to the sidewalls as it the tire moves to feel for areas of bulging.

FIGURE 2.28: Bulges or deformities in casing indicate thread failures

Tires will eventually wear out from use and become very thin at the tread. For tires ridden on pavement, look for a tire crown flattening in the middle. For off-road tires, top knobs will become worn and rounded compared to knobs on the side. If the cord is showing or the casing appears deformed, the tire should be replaced (figure 2.29).

FIGURE 2.29: Damaged tread and casing

RIM STRIP

The wheel rim may have holes between the rim sidewalls for spoke nipples. Rim strips cover the holes or nipples. It protects inner tubes from nipples and sharp edges in the rim base. Rim strips can be made of cloth, rubber or polyurethane plastic. It should be wide enough to cover the bottom of the rim but not so wide that it interferes with seating the tire bead. Inspect the rim strip whenever changing a tire or inner tube. Look for tears and rips. Make sure the rim strip is centered over the nipple holes and completely covers each hole (figure 2.30).

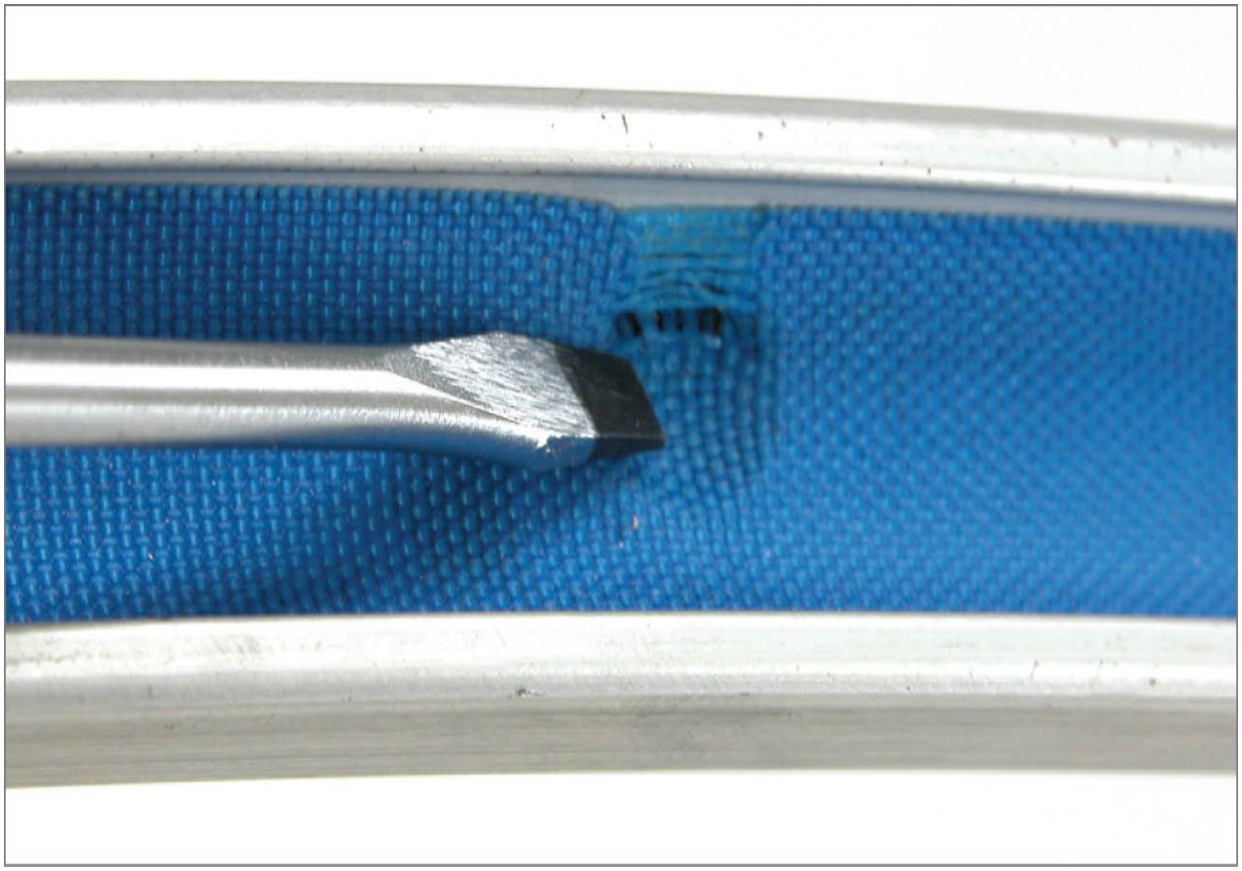


FIGURE 2.30: Holes in rim strip will cause flats

High-pressure tires require a strong rim strip. Without a sturdy support, the inner tube will push down into the nipple holes, resulting in a blowout. Do not use soft and flexible rubber rim strips in rims with eyelet holes.

Tubeless rims commonly use a plastic adhesive tape to seal the holes. Even a small tear will result in a slow leak.

INNER TUBE REPAIR

Inner tubes are commonly made of black butyl rubber. Latex inner tubes are lightweight and tend to be a cream or light gray color. Latex material is more porous than butyl rubber and will require air before every ride. Both types can be patched.

Replacing punctured inner tubes with a new tube is always the safest and most reliable procedure. In some cases, it is safe to repair a small hole in an inner tube. If the hole is large, such as from a blowout, it may not be possible to repair. When in doubt, replace the tube.

PRE-GLUED PATCH REPAIR

The Park Tool GP-2 Super Patch Kit uses pre-glued patches. This patch relies on the tube pressing against the tire to seal the puncture. If the inner tube is too small relative to the tire casing, the patch may become too stretched to hold effectively. Double-check to be sure the inner tube is an appropriate size for the tire when using a pre-glued patch.

Procedure for inner tube repair using Park Tool GP-2 Pre-Glued Super Patch:

a. Locate hole marked during inspection. Using a fine emery cloth or sandpaper, clean tube by lightly abrading area around hole. Excessive sanding or heavy pressure can cause grooves in rubber leading to patch failure.

b. If possible, clean area with a rag and alcohol. Allow it to dry completely.

c. Peel patch from patch backing. Handle patch as little as possible and by edges only (figure 2.31).

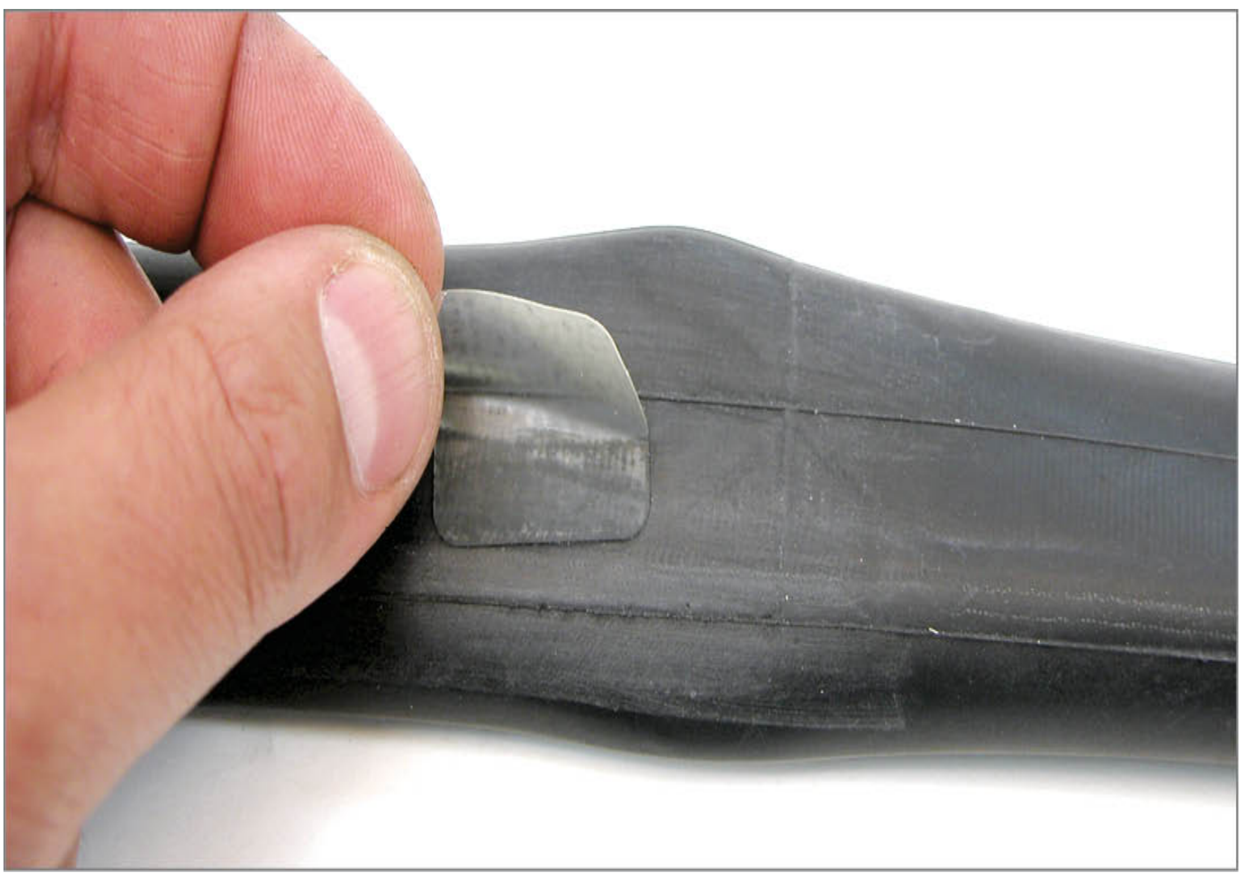


FIGURE 2.31: Center patch over hole and press evenly to bond patch to tube

d. Center patch to hole and lay patch flat on tube.
e. Apply pressure for patch to seal. Roll patch and tube between thumb and forefingers.
f. Tube is ready to install. *Do not* test patch by inflating tube while outside of mounted tire. This may stretch tube body under patch, which may weaken the patch bond.

INNER TUBE REPAIR WITH SELF-VULCANIZING PATCHES

Self-vulcanizing patches require the application of a thin layer of self-vulcanizing fluid on the tube before the patch is applied. The patch reacts with the fluid to bond with the inner tube. Inner tubes differ in their component chemical compounds, so patching may result in mixed success.

Procedure for inner tube repair with self-vulcanizing patch:

a. Locate hole marked during inspection.

b. Using a fine emery cloth or sandpaper, lightly abrade area around hole. Abrade an area larger than patch size.

c. When possible, clean area with alcohol and allow it to dry completely.

d. Open self-vulcanizing fluid tube and puncture seal. Apply thin coat of self-vulcanizing fluid and spread evenly around hole area (figure 2.32). Use a clean finger or back of patch to spread self-vulcanizing fluid evenly over an area that is larger than the patch size. Do not apply too much fluid. The layer should not appear “glopped” on. Return and tighten glue tube cap.

FIGURE 2.32: Spread a thin, wide layer of self-vulcanizing fluid

e. Allow self-vulcanizing fluid to dry. This may take several minutes. Test by touching perimeter area of self-vulcanizing fluid only. Do not touch self-vulcanizing fluid where patch will contact.
f. Peel patch from backing. Leave clear plastic cover on patch. Handle patch by its edges.
g. Center patch to hole and lay on tube.
h. Apply pressure to patch, especially at edges, to seal. If possible, maintain pressure for several minutes.
i. Inspect edges of patch. Edges should lay flat and appear bonded to tube (figure 2.33 and figure 2.34).

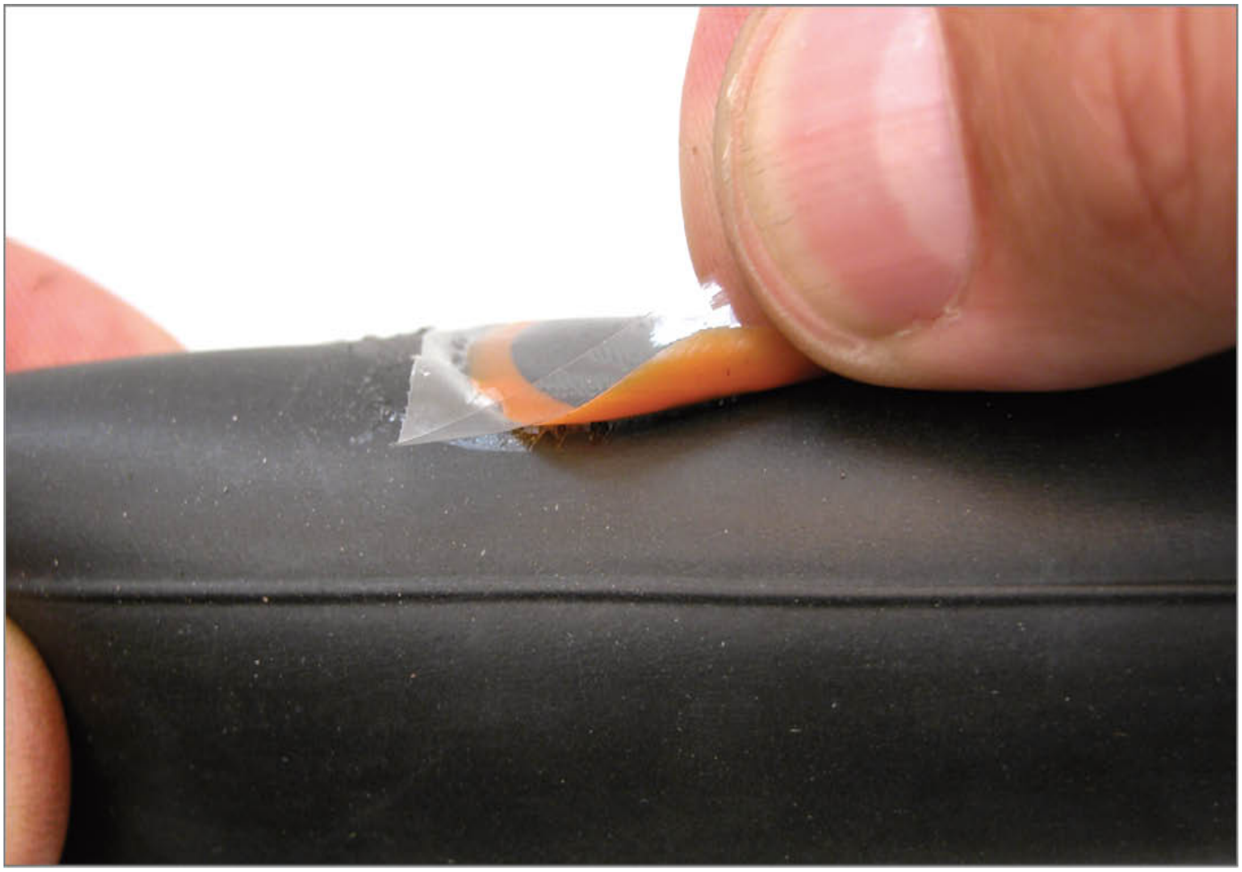


FIGURE 2.33: Edges of patch did not seal well in this poorly bonded patch

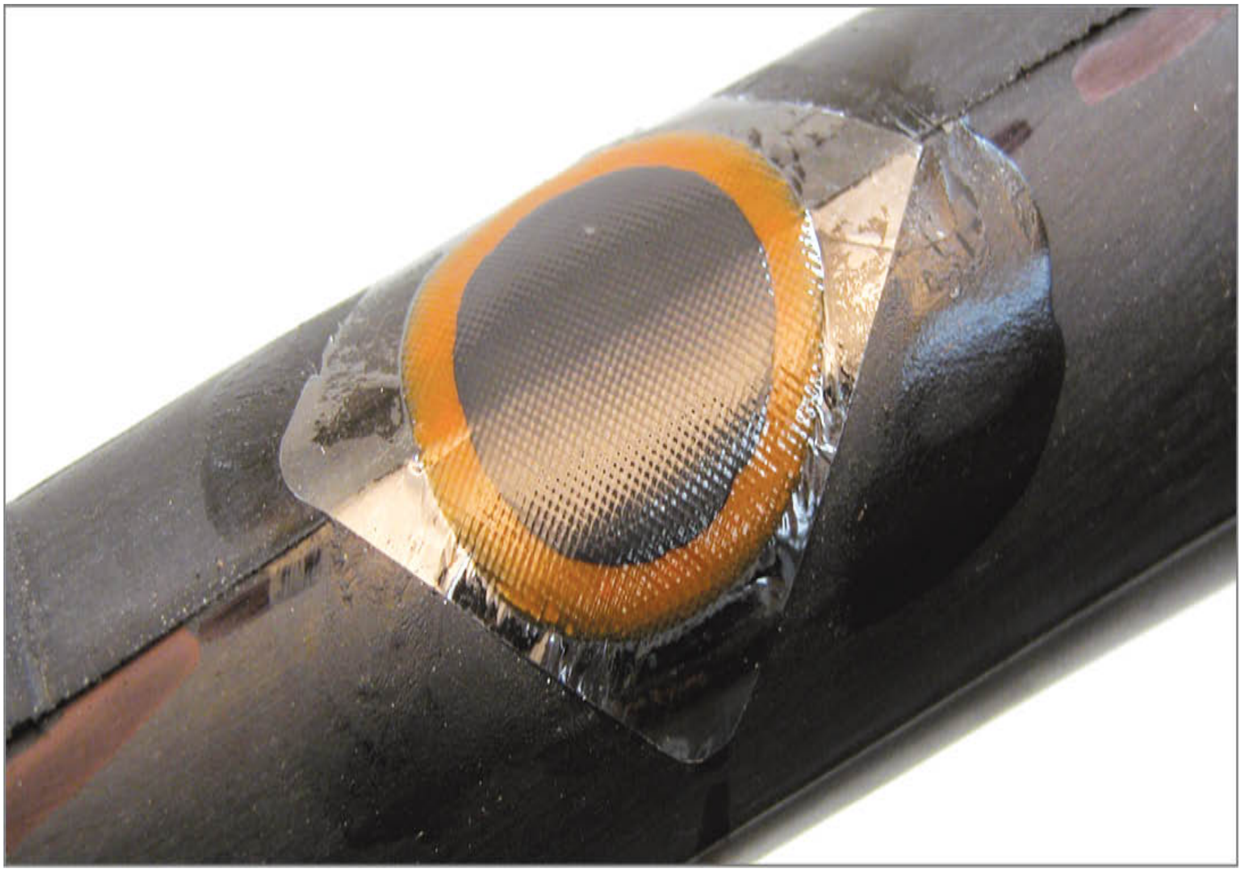


FIGURE 2.34: Edges lay flat in a successful patch

j. Tube is ready to install. Do not remove plastic cover from patch. It could pull on the freshly-bonded patch and cause the repair to fail.

INNER TUBE SEALANTS

Liquid sealants can be added to the inner tube. These products are available from various manufacturers and are only intended to seal small holes in the tube. To add sealant to the inner tube, install inner tube into wheel as normal. For Schrader valves, remove the core using a valve core tool, such as the Park Tool VC-1. Only some Presta model tubes use a valve with a removable core. Inspect Presta valves for two wrench flats below the stem locknut. To remove this valve core from the Presta tube, use the VC-1 Valve Core tool or a small adjustable wrench (figure 2.35).

FIGURE 2.35: Inspect end of Presta valve for wrench flats

Place valve at four o’clock or eight o’clock position, making the valve slightly downhill (figure 2.36). Inject the sealant according to the manufacturer’s directions. Replace valve core and inflate tire. Spin the wheel to spread sealant. When inflating or deflating the tire, rotate the wheel so the valve is on the upper horizontal section of the rim.


FIGURE 2.36: Rotate valve to allow sealant to easily enter the tube

Installing sealant will make patching the inner tube difficult or impossible. The sealant tends to prevent good patch bonding. Valve cores can also become plugged and sealed with time. Sealants can also plug a tire pump head used to pump this tube. Avoid having the valve at the lower section of tire when pumping.

TIRE LINERS

Tire liners are specially made strips of a tough, flexible material placed inside the tire body. Liners are installed between the tire and inner tube and may help prevent thorns, glass, and other sharp objects from reaching the inner tube (figures 2.37). Liners should be installed centered on the tire midline. Liners will not prevent pinch flats and do not protect from sharp objects penetrating the tire sidewall area.

FIGURE 2.37: Tire liner placed inside tire body

TEMPORARY TIRE REPAIR WITH TIRE BOOT

If the tire has been ripped and the casing damaged, it may not hold an inner tube. It is possible, in some cases, to make a temporary repair with a Park Tool TB-2 Emergency Tire Boot. A booted tire should not be considered a permanent repair. The tire should be replaced as soon as possible.

Begin repair by locating rip in tire. Compare rip to size of tire boot. Tire boot must completely overlap the rip to be effective. Clean inside tire adjacent to the rip. When necessary, cut boot to fit inside tire casing. Cut boot as large as possible but not so large it will stick out beyond tire bead. Align boot making sure edges do not extend beyond tire bed to tire beads. Center boot to rip and press it inside of tire casing (figure 2.38).

FIGURE 2.38: Place TB-2 Emergency Tire Boot over the cut in tire and replace tire as soon as possible

It is possible to make a temporary boot using other material. Use a strong material that is resistant to tearing. Paper currency should not be considered acceptable tire boot material.

INNER TUBE VALVES

There are two common types of valve stems on bicycles: Schrader ("American" type) and Presta ("French" type) (figure 2.39). The Schrader valve is common on cars, motorcycles and on many bicycles. The valve stem is approximately 8mm (5⁄16") diameter and has an internal spring plunger (valve core) to assist in shutting the valve.

FIGURE 2.39: From left to right: a long stem Presta valve with cap, a standard length Presta valve without a cap, and a Schrader valve without a cap

To deflate a Schrader valve tube, it is necessary to stick a small hex wrench or other object into the valve in order to press on the stem and release air. Upon release of the stem, the valve spring shuts. Schrader-compatible pump fittings press on the internal stem with a small peg inside the pump head, which allows the tube to be filled.

Schrader valve cores can be removed from the tube if necessary. The valve core may be loose and cause a slow leak, or it may become jammed with dirt and not open and close properly. Removing the valve core also permits sealant to be injected inside. Use a valve core tool such as the Park Tool VC-1 Valve Core Remover to remove or tighten the core (figure 2.40).

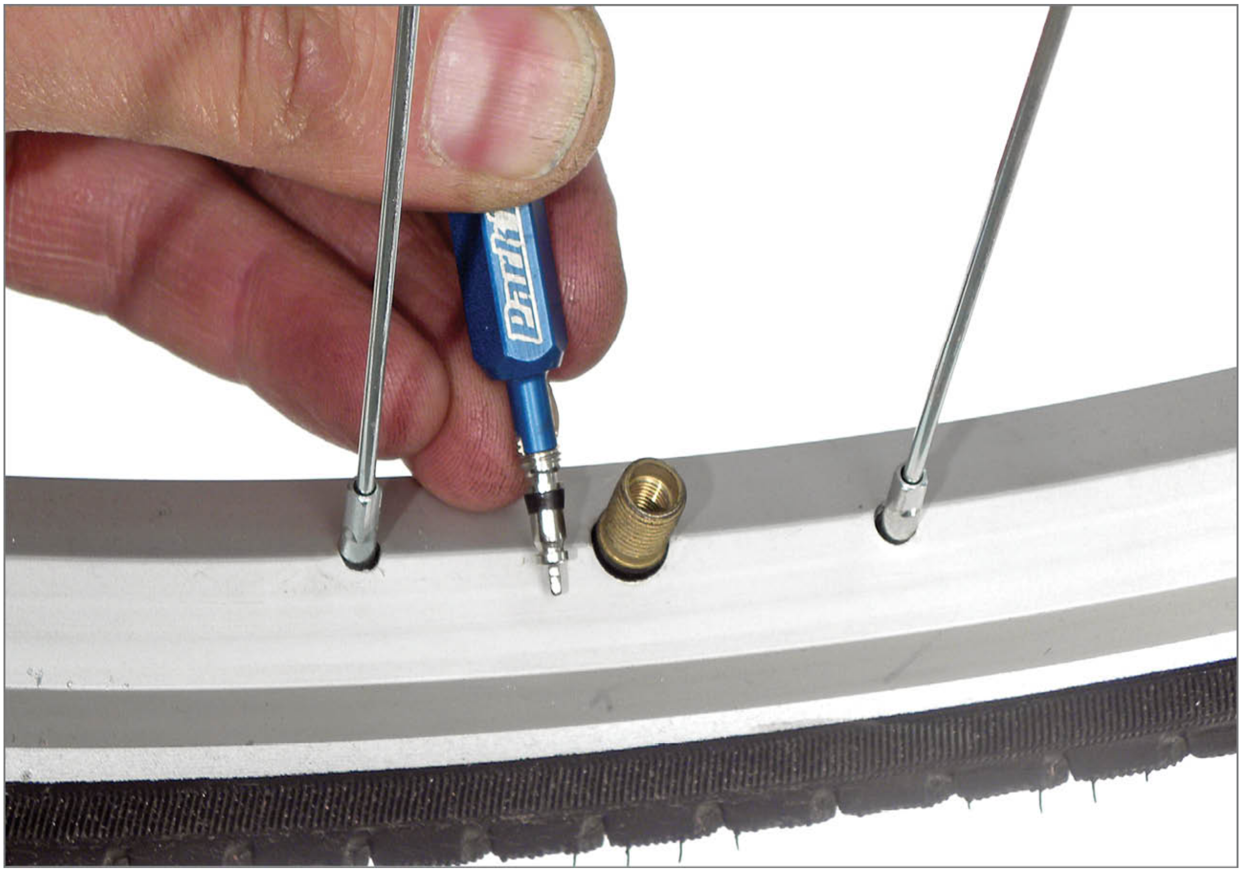


FIGURE 2.40: Schrader valve core removed for cleaning and inspection with Park Tool VC-1

The rim's valve hole should match the tube valve. If a rim has been made with the smaller valve hole for Presta valves, it can be drilled and enlarged to the 8mm size by using an electric drill fitted with an 11⁄32 inch (8.5mm) drill bit. After drilling, use a small round file to remove any sharp edges. Rims that are less than 15mm outside width should not be drilled. It is also possible to use the smaller Presta valve in a rim intended for the larger Schrader by using an adaptor sleeve.

Presta valves are common on mid and higher-priced road bikes and on higher-priced mountain bikes. Presta stems are thinner than Schrader valves (6mm diameter, nominally 1⁄4 inch). At the top of the Presta stem is a small valve locknut, which must be unthreaded before air can enter the tube (figure 2.41). To deflate the inner tube, unthread the locknut and depress the valve stem. To inflate the tube, unthread the locknut and inflate using a Presta-compatible pump.

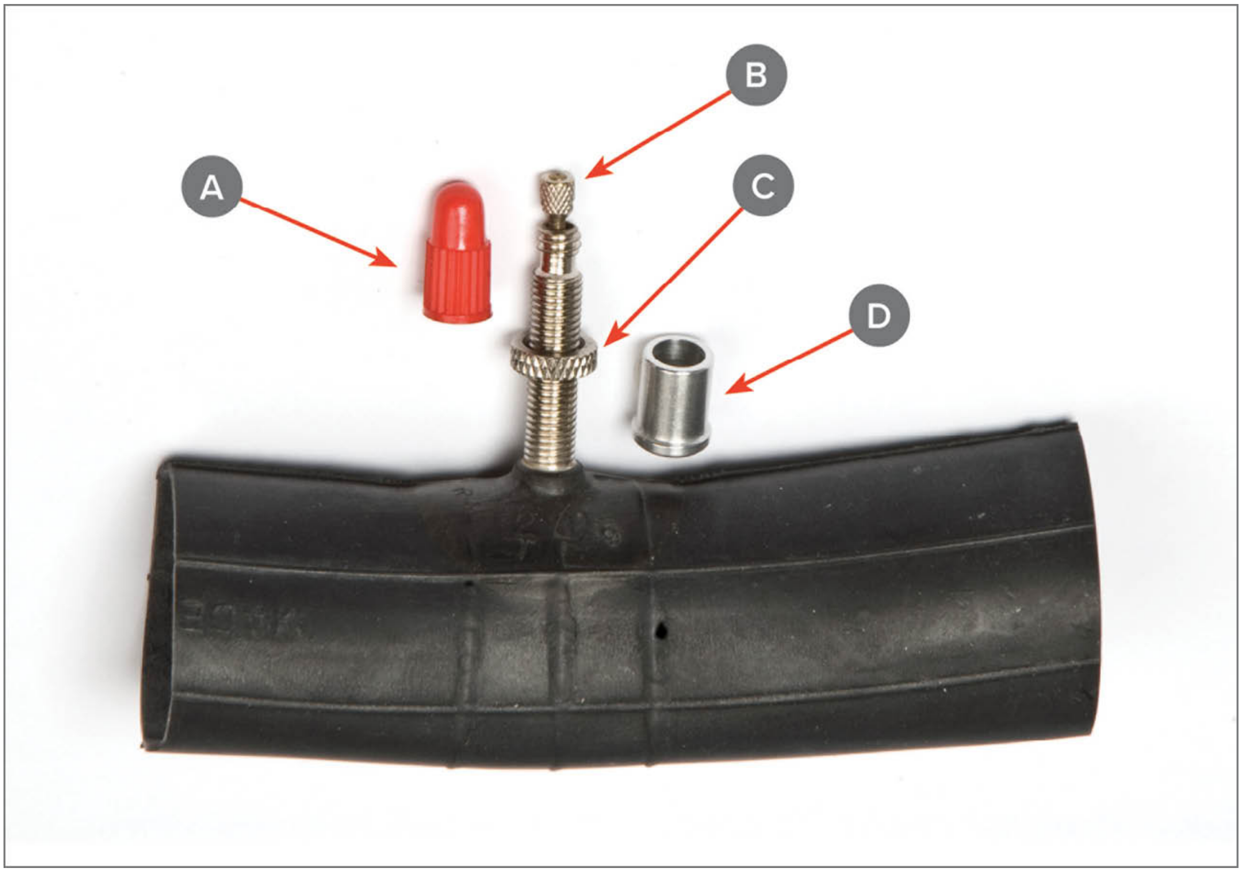


FIGURE 2.41: Component parts of the Presta valve: (A) valve cap, (B) valve locknut, (C) valve stem lockring, (D) valve adaptor for Schrader drilled rim

Some brands of Presta tubes use a valve shaft that is fully threaded. These come with an extra locking nut or ring. Loosen the ring by hand and remove it before installing the tube. Install and fully inflate the tube. Then install the lockring and snug only by hand. When deflating the tube, loosen and remove the nut first. When a tire is fully inflated and is then deflated, the valve moves back into the tire casing. The valve may be ripped from the tube if the locknut is left locked too tightly to the rim.

Some models of Presta inner tubes use a valve with a removable core. Inspect the valve end for two wrench flats. Use a valve core tool such as the

Park Tool VC-1 or a small adjustable wrench to secure or remove the core (figure 2.42).

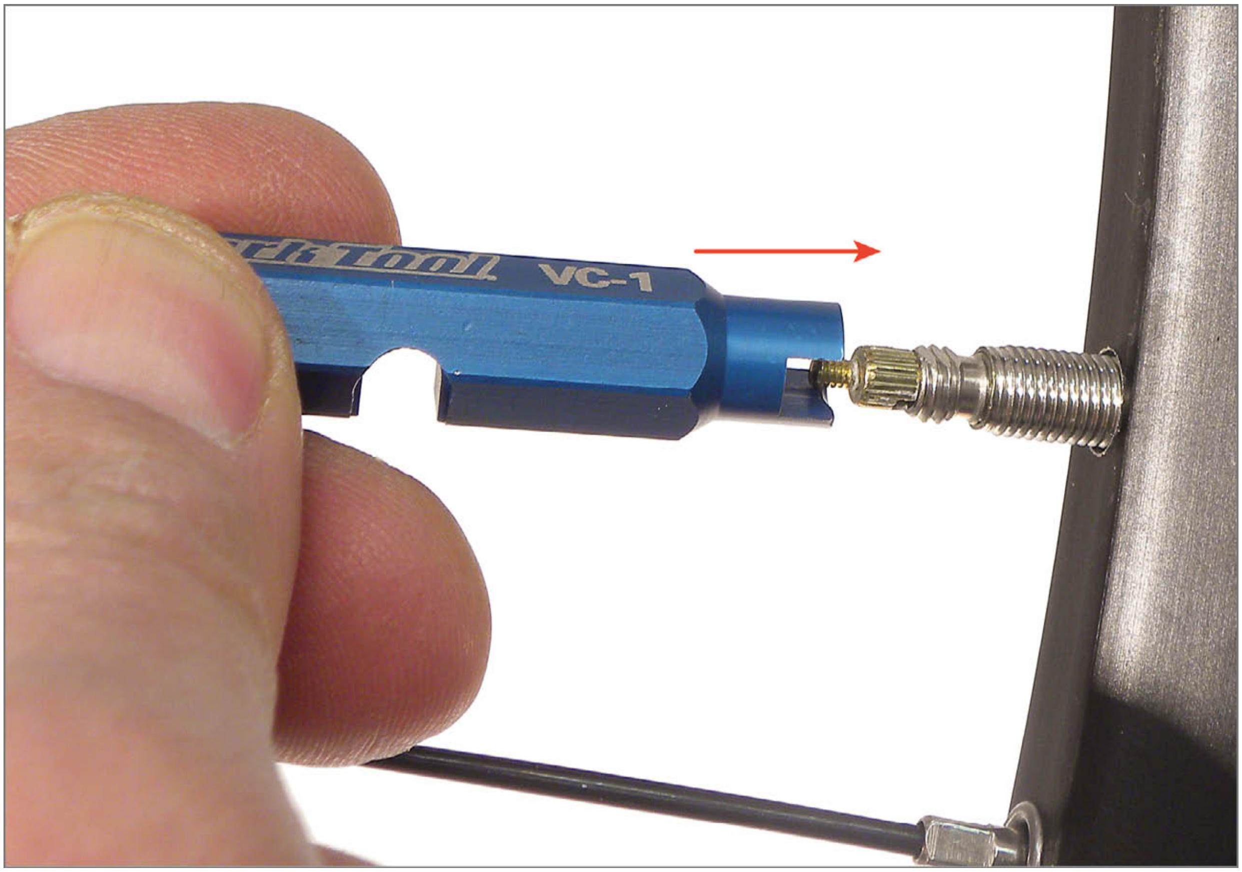


FIGURE 2.42: A removable Presta valve and the VC-1

Presta-compatible pump heads do not have a small peg inside the pump head. Also, the seal of a Presta pump head is smaller than the Schrader pump head. To inflate a Presta tube, unthread the valve stem locknut and tap lightly to release the valve seal. The seal tends to stick over time and tapping the stem breaks it free, which makes it easier to inflate. Press the Presta-compatible pump head onto the stem and inflate the tube. Some pump heads may have a lever-operated cam to help seal the gap between the pump head and the valve.

There is no performance difference between the two kinds of valves. Schrader valves, however, are wider and require a larger rubber base to bond it to the tube. Consequently, very narrow tubes use the Presta valve. A Presta-to-Schrader adaptor is available, which allows Schrader pump heads to be used on Presta valves (figure 2.43).

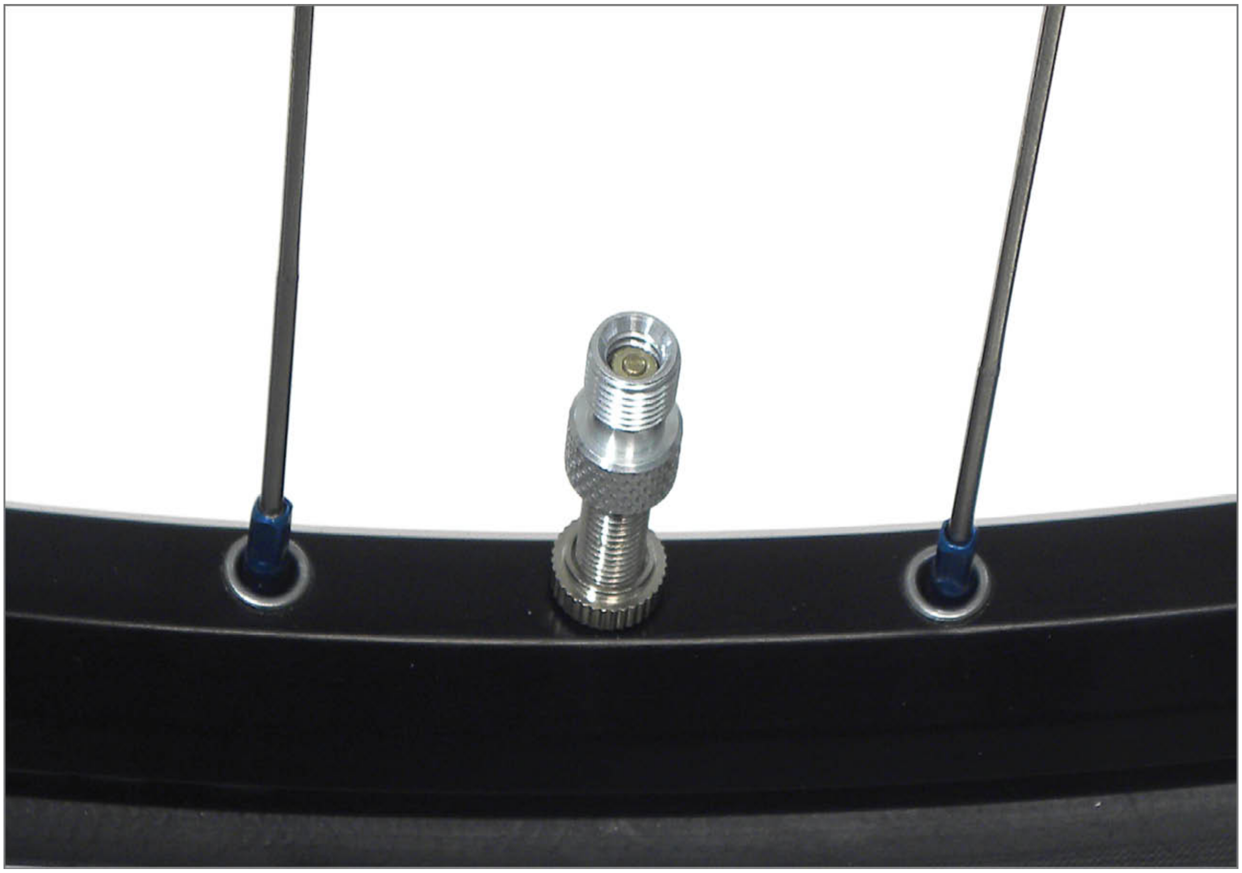


FIGURE 2.43: A Presta-to-Schrader valve adaptor

Inner tube valve stems are available in different lengths. Rims with a very tall cross section require longer valve stems (60mm or 80mm). There are valve extenders available that screw onto the Presta valve and allow the tube to be inflated (figure 2.44). If the inner tube uses a removable valve core, use an extension that screws into the valve's inner threads. There are also designs that are simply a tube to lengthen the stem but do not permit the Presta valve locking nut to be secured. If the locking nut cannot be closed, the valve may leak. Extenders that do not allow the valve nut to be tightened may allow the tube to leak slowly.

FIGURE 2.44: Left: simple valve extender with locknut loose
Right: removable valve core with double-threaded extender

TIRE & TUBE SIZING

Tires are made with a steel wire or fabric cord, called the “bead,” which is molded into each tire edge. The bead forms a circle. The circle diameter determines the tire fit to the rim. The tire bead is made to fit into the rim bead seat, which is the area below the outer rim edge (figure 2.45)

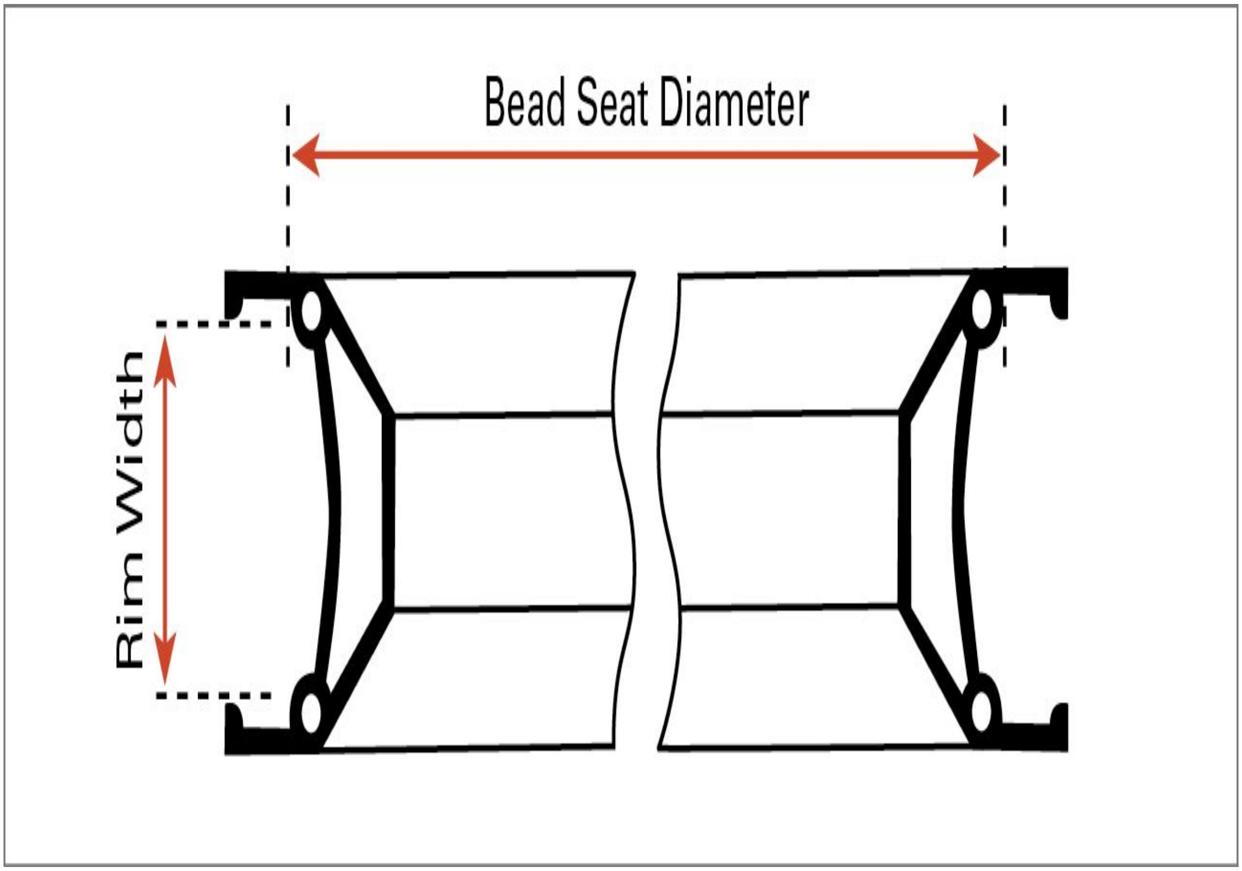


FIGURE 2.45: Rim width and rim bead seat diameter

Do not attempt to mix tires and wheels with different bead seat diameters. Although the bead seat diameter determines the tire and wheel fit, there is little consistency between manufacturers in how tires are labeled or identified. Different countries at times have used different nomenclature marking systems. This can cause confusion when selecting a tire for a wheel and frustration when installing a tire.

An antiquated but still common system uses “inch” designations, such as 26-inch, 27-inch, or 29-inch. The inch size does not directly refer to the bead seat measurement. It is a simply code, and it refers to the approximate outside diameter of an inflated tire. For example, there are several 26-inch tires that use different bead seat diameters. A 26 x 1 3⁄8 inch tire, for example, will not interchange with the common MTB 26 x 1.5 inch tire. There are three even more obscure tire standards also referred to as 26-inch diameter, but none are interchangeable. As a rule, tires marked with fraction sizes, such as 1⁄2, 3⁄4, etc., do not interchange with tires marked in decimal sizing, such as 0.5, 0.75, etc.

Another common system is the older French system of sizing. The numbers are reference numbers and are not accurate measurements of anything. Road bicycles commonly use a 700c tire that has a bead diameter of 622mm. The “700c” does not refer to bead diameter. The “c” is part of the code system. There are also 700a and 700b tires and wheels, but none interchange with the more common 700c. Additionally, the 650b tires and wheels will not interchange with the 650c tires.

The ETRTO (European Tire and Rim Technical Organization) system, which is the same as the ISO system (International Standards Organization) is now becoming more common. The ISO or ETRTO system uses two number designations for tire and rim sizing. The larger number is always the bead seat diameter. Rims and tires with the same number are made to fit one another. For example, tires marked 622 will fit rims marked 622, because the bead seat diameter is 622 millimeters for both. Look for this sizing system on the tire. Rims may also have ISO sizing on the label (figure 2.46).

FIGURE 2.46: ISO (ETRTO) sizing numbers on tire label along with French sizing

Rim markings may also provide a two number system, separated by a hyphen, for example, “23-622.” The smaller number is the width in millimeters between rim sidewalls. Generally, a wider rim will accept a wider tire. A narrow tire on a relatively wide rim will mean the tire profile shape will be less rounded. A wide tire on a narrow rim will result in less support for the tire in cornering, which can cause the tire to laterally roll or twist. Additionally, rim caliper brakes will have very little room to clear the tire with this combination. As a loose rule, the ISO tire width should be between one and a half to two times ISO rim widths. A rim width 25mm between the sidewalls should use an ISO tire width of about 37mm to 50mm.

The inner tube should match the tire size diameter closely. Tires that are close in bead diameter may use the same inner tube. For example, an inner tube for an ISO 630 tire (27-inch) will also fit an ISO 622 (700c) tire. The inner tube should also match the tire width, but, because inner tubes are elastic, one inner tube may fit a range of tire widths. If the inner tube is too narrow for the tire width, it will become very thin when inflated inside the tire body. This will cause it to be more susceptible to punctures and failures. If the tube is too wide for the tire, it will be difficult or impossible to properly fit inside the tire casing and seat in the rim. The tube may stick out of the tire and blow out when the tire is fully inflated. Refer to Table 2.1 for common sizes for the tire and wheel bead-seating systems.

TABLE 2.1: Tire Sizing

COMMON SIZING NAME	ETRTO/ISO BEAD SEAT DIAMETER	COMMON USES
29-inch	622	MTB using the 29-inch tires. Rim is same diameter as 622 below.
27-inch	630	Older road bikes and less expensive road bikes
700c	622	Road bikes, hybrid bikes
26 x 1 3/8 inch S-6	597	Older Schwinn® S-6 sizing
26 x 1 3/8 inch	590	Department store three-speeds, English three-speeds
650b or 27.5-inch	584	MTB and some touring “randonneur” bikes
26 x 1–3.7 inch	559	MTB using 26-inch sizing
26 x 1 1/2 inch or 650c	571	Smaller road bikes or special triathlete bikes
24 x 1–1.75 inch	507	Juvenile MTB
20 x 1–1 1/2 inch	451	BMX racing and recumbent (fractional inch widths)
20 x 1–2.2 inch	406	Juvenile bikes, BMX, freestyle bikes, recumbents
16 x 1 3/8 inch	346	Front small wheel recumbent
16 x 1–2.2 inch	305	Some recumbents and juvenile bikes

INSTALLATION OF TIRE & TUBE ON WHEEL

Tires are sized to match the rim. However, even within the same rim and tire sizing standard, certain tire/rim manufacturer combinations are more easily mounted by hand than others. Companies may not hold the same tolerances, and the result may be that some combinations will be tight and may be difficult to mount by hand. These combinations require tire levers for installation. Never use a screwdriver, knife or other sharp tool to mount the tire.

Procedure for tire installation:

a. Note any directional arrows by the tire manufacturer. Directional arrows printed on sidewalls indicate rotation of wheel. Not all tires have direction orientation.

b. Inflate tube enough for tube to hold its shape.

c. Install tube inside tire. Install with tube valve adjacent to air pressure recommendations written on tire sidewall (figure 2.47).

FIGURE 2.47: Place tube into tire before mounting tire to rim

d. Lean rim vertically against your legs with valve hole facing up.
e. Lower tire and valve into rim valve hole and align valve so it is pointing straight toward hub. A crooked valve can lead to a flat tire later (figure 2.48).

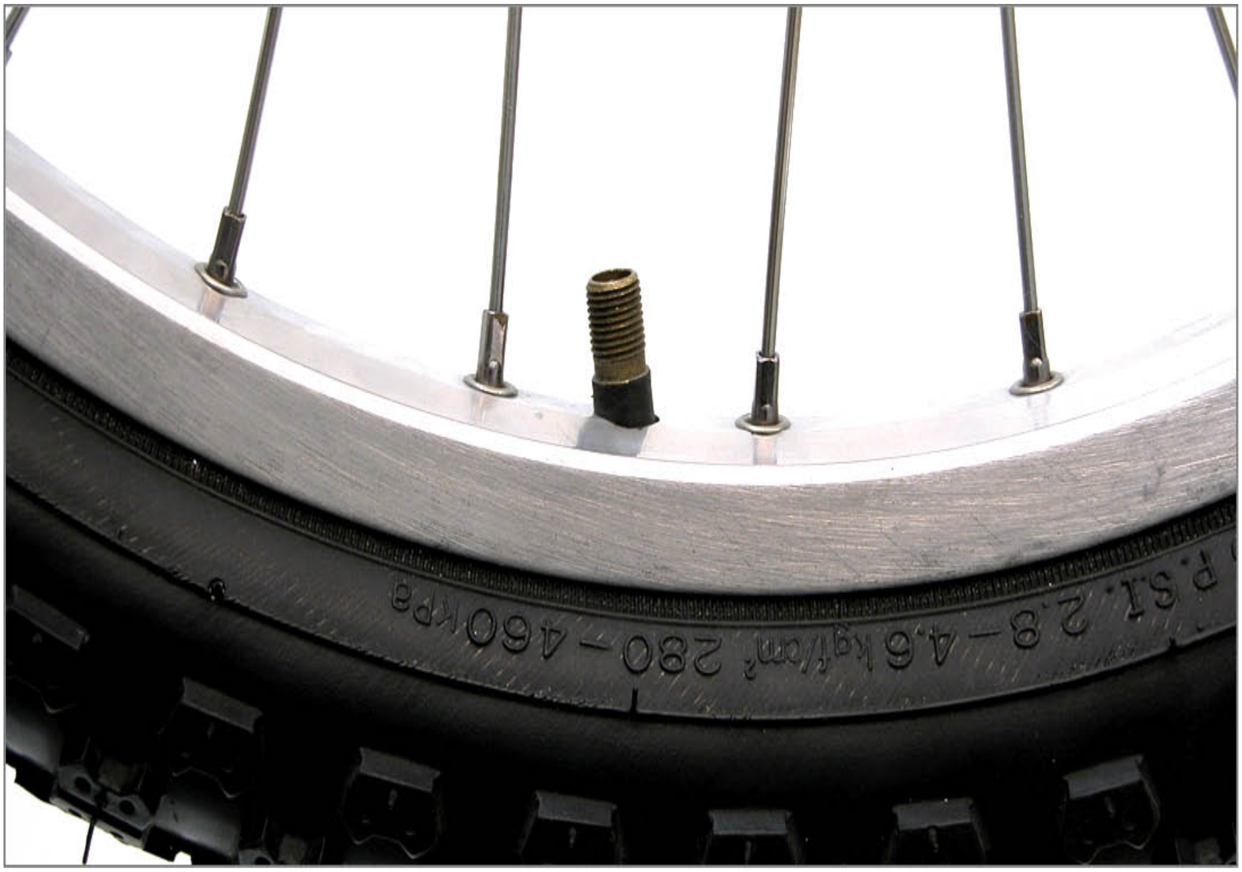


FIGURE 2.48: This crooked valve will eventually be cut by the rim valve hole

f. Install one bead at a time, beginning with one adjacent to your legs. Center of rim is slightly smaller in diameter, so work bead toward center to make it easier to get on rim.
g. Work tire bead onto rim with hands. If tire bead will not seat using hands, use a tire lever as a resort. Use caution when using tire levers to avoid pinching inner tube. Use tire lever in same orientation as removal method.
h. Work tube over rim sidewall and into rim cavity.
i. Install second bead onto rim (figure 2.49). Use care if using a tire lever. Do not lift lever beyond 90 degrees from wheel plane (figure 2.50).

FIGURE 2.49: Push tire bead up and over rim sidewalls

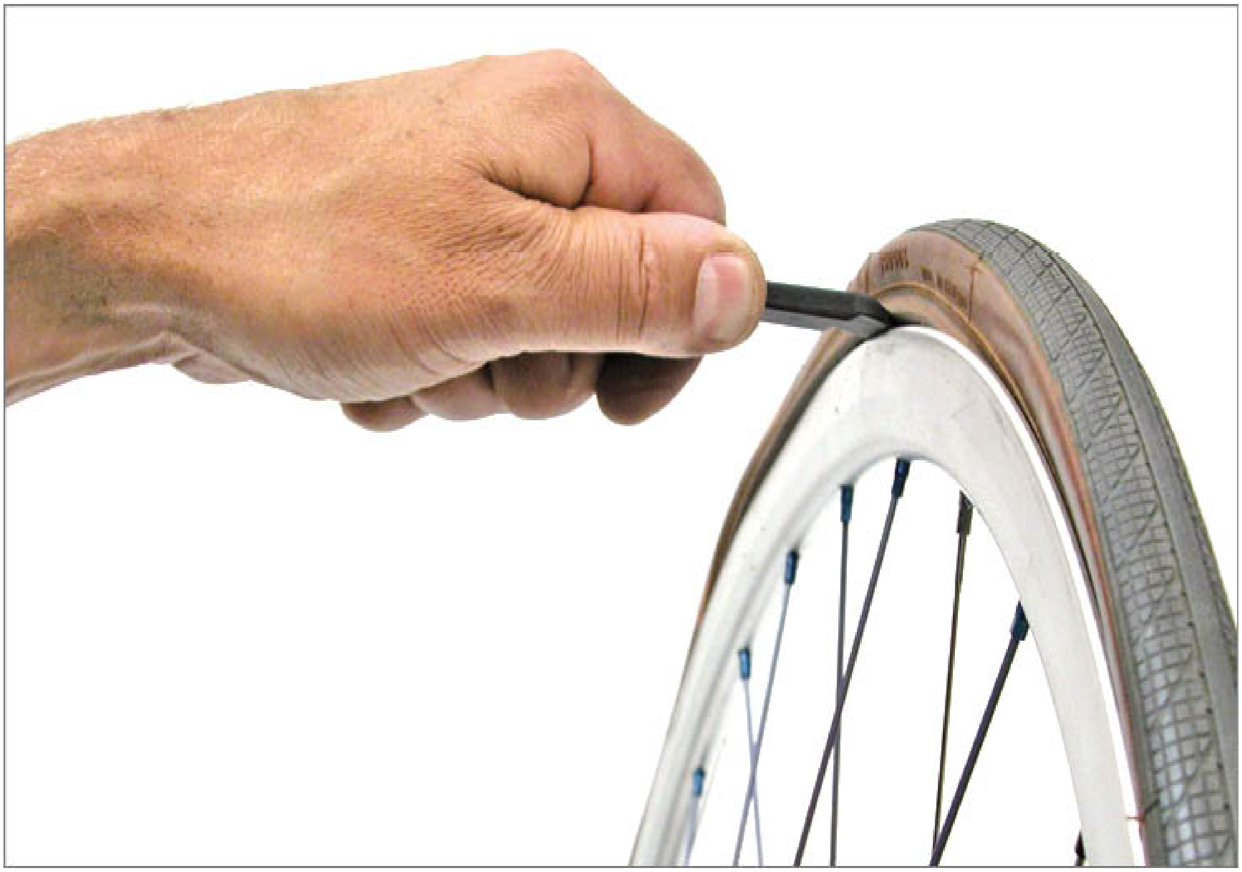


FIGURE 2.50: Use levers if necessary to lift bead over edge of rim

j. Inspect both sides of tire for bead seating and for any sign inner tube sticking out. If tube is visible under tire bead, remove tire and reinstall.

k. Inflate to low pressure and inspect bead again on both sides. Look for a small molding line above bead. This line should run consistently above rim (figure 2.51).

FIGURE 2.51: This bead seat line is bulging upward from improper tire seating. Deflate immediately and reseat tire.

l. Inflate to full pressure and check with a pressure gauge. It may be necessary to press downward above valve in order to engage pump head. For fully threaded valve shafts, reinstall any locking nut only lightly finger tight.

TUBELESS TIRE SYSTEMS

Tubeless tire systems are similar to those used on cars and motorcycles. The tire is sealed airtight to the rim bead hook without an internal inner tube. The rim's inner perimeter must also be airtight. Tubeless tires can increase the tire contact area to the ground because they can be ridden at low relative air pressure, which can improve the ride feel and handling of MTB bikes and cyclocross bikes. The tubeless system is also available in a road bike version. The road bike tubeless system can reduce rolling resistance because there is no movement between the inner tube and the tire.

A common cause of flat tires, especially for off-road riding, is a "rim pinch." The inner tube is pinched when the tire strikes a rock or other object. Tubeless tire systems have no inner tube to pinch when used at low pressures and are not susceptible to this common flat. There is not a practical method to "repair" a tubeless tire that has been punctured. If the sealant will not fill the hole and stop the flow of air, the tire should be replaced. During a ride with a damaged tire, it is best to install a spare inner tube.

Tubeless tires are still prone to punctures from nails, glass, thorns, etc. Additionally, the system is liable to leak if the tire bead or rim seat has become damaged or disengages. Hard lateral impacts to the tire can result in a "burp." This occurs when the tire bead is momentarily pushed away and disengages from the rim sidewall, allowing air to escape. This reduces air pressure and weakens the tire bead to rim strength, making the wheel and tire susceptible to more burps, at least until the tire is reinflated.

There have been different design standards for tubeless systems. Universal System Tubeless (UST) is the original rim and tubeless design standard. A UST tire will have a special butyl liner to hold air without an inner tube, and will have a specially shaped tire bead. The UST rims will have either no nipple holes in the rim tire bed or these holes will be completely sealed. The UST rim bead seat is designed to accept and hold the UST tire beads.

When removing any tubeless tires, work with care because there may be sealant inside the tire body. Begin by fully deflating tire. Next, push one tire bead into rim center well all around the wheel to free it from the rim bead hook. Push the second bead away from the rim. The center part of the rim has a smaller circumference than the bead seat area, and this creates slack at the tire bead. Use only plastic levers to remove tire from rim. Pull loose bead over rim edge. Push second bead from tire seat and then pull whole tire from rim.

Tubeless systems may use either a special Presta or Schrader valve secured into the rim with a nut (figure 2.52). The valve forms an airtight joint at the inner perimeter of the rim. The tire bead to rim fit can be very tight. Keep the bead toward the middle “valley” of the rim to create slack at the bead and make installation easier. When installing the tire, begin by engaging the bead opposite of valve core.

FIGURE 2.52: Tubeless valve system

Special tubeless tire seating compounds can be useful to help the bead seat properly and seal to the rim. Soapy water on the tire bead can also help lubricate tight fitting beads (figure 2.53).

FIGURE 2.53: Soapy water can help bead seat into rim

Procedure for tubeless tire installation:

a. Check that valve is fully seated inside rim and valve nut is secure. Clean tire bead and rim seat as needed.

b. Beginning opposite valve, insert one bead over rim wall and into rim center. Work only this bead fully into rim, ending at valve core.

c. If necessary lift this first bead over valve core. The valve must be between two tire beads.

d. Begin to work second bead over rim edge and into rim center beginning again opposite valve.

e. Inspect that beads are between rim sidewalls and valve in between bead. Tire is now ready for inflation. After inflating, allow tire to sit for some hours and check that there are no slow leaks. Set tire to desired riding pressure.

Inflation for tubeless installation is easiest done with an air compressor. This provides large amounts of air to quickly force the bead to the rim, creating a seal. Over inflate the tire if the bead is not fully seated. Bead will often seat with a “popping” sound. Inspect for bead leaks using soapy water at the bead and look for any bubbles. Deflate and reseat as necessary.

If air leaks from the bead, seating can be difficult. It can help to increase airflow by taking out any removable valve core. Use the VC-1 Valve Core Tool, pull the core, and try the compressor again. Inflate tire until beads seat, using care not to remove inflator from valve. Hearing the bead pop as it seats is common and a good sign. If the tire has seated, hold it off the ground, then release the valve. Expect air to rush from the open valve. The bead has been pushed outward and is seating against the rim. Release the air, but do not set the wheel on the ground, which may unseat the bead. Reinstall the valve core and inflate again.

If no compressor is available, quickly pump to form a seal. It’s helpful to have a friend assist by holding the tire centered to the rim during inflation.

The uninflated tubeless tire relies on high air volume to push the tire bead to the rim and create a seal. This is why an air compressor is so useful when installing the tire. If it does not seem possible to seat the bead well enough to inflate the tire, it can help to use a long strap or even a flat inner tube around the tire circumference. The strap helps to apply pressure to bead, squeezing it evenly around the rim while the tire is inflated (figure 2.54).

FIGURE 2.54: Use an inner tube as a strap to hold bead to rim

It can also be very helpful to block air rushing from a bead by using use a mixture of dish soap and water. Even using straight liquid soap without dilution will help block air and permit the tire bead to catch the rim. After the bead holds and the tire inflates, soap bubbles will show any potential weak points in tire-to-rim seating.

Liquid sealants for tubeless tires are available from various manufacturers and are intended to seal small holes in the tire. These are best applied to the tire before mounting. All tubeless systems are susceptible to some slight air loss, more so than conventional inner tube systems. All tubeless tire manufactures assume that tires are checked for pressure before each use.

Procedure for tubeless tire sealant installation:

a. Install one tire bead on wheel.

b. Hang wheel vertically with valve at either three or nine o’clock position. If bike is mounted in a repair stand, handlebar ends can be used as a hanger.

c. Pour sealant into tire at six o’clock position. Consult sealant manufacturer’s instructions for amount of sealant to pour (figure 2.55).

FIGURE 2.55: Pour in fluid at bead opening at bottom

d. Leave tire and wheel hanging. Carefully engage second bead while working from bottom upward on both sides (figure 2.56).

FIGURE 2.56: Engage beads from bottom working upward

e. Remove wheel from hanger and inflate tire and seat bead.
f. Inflate wheel to full a pressure and inspect seating. Spin wheel to distribute fluid.

When tire valve has a removable core, another practical option is to inject tire sealants through the valves that have removable valve cores (figure 2.57). This requires use of a large syringe or similar tool. These can often be purchased at veterinarian supply stores, farm supply stores and pet stores. Install and inflate tire without sealant. Hang wheel from hook to prevent dislodging of tire bead. Remove valve core. Fill syringe with quantity of fluid recommended by sealant manufacture. Reinstall valve core and inflate tire. Spin wheel to spread and disperse sealant. Actually going on a ride so the wheel turn side to side and can bounce is the best method to disperse the sealant.

FIGURE 2.57: Inject sealant after tire bead is seated

TUBELESS CONVERSION SYSTEMS

Manufacturers offer conversion kits for using a traditional inner tube compatible rim with “tubeless ready” tires. There will be mixed results with these systems depending upon the rim and the application of the kit. For the best results from a tubeless tire system, use both tire and wheels designated as UST.

The conversion kits available on the market share commonalities. There will be a strong heavy-duty tape to install into the rim interior. There will be a valve core that tightens into the rim and which seals into the tape. Sealing liquids are used to account for any inadequate fit between the rim fit and the tire. These liquids congeal upon contact with ambient air and dry to a rubbery consistency. Conversion systems are susceptible to air loss through several points in the system including seepage of air through sidewalls.

Procedure for tubeless tire conversion:

a. Remove old tire, tube and rim strip. Inspect inside wheel for dents in rim bead or other anomalies. Inspect also for burrs in the aluminum bed or nipple eyelets, and make sure rim has a smooth finish.

b. Clean inside rim well, using acetone, alcohol or similar solvent that will not leave an oily film.

c. Install conversion rim sealing tape in rim bed, pulling tape snugly as tape unrolls to cover entire bed inside wheel circumference (figure 2.58). Overlap tape, covering valve hole. Work with care to cover rim evenly with no loose area of tape. Press down on tape to ensure a good bond to rim. Tape must seal inner perimeter airtight.

FIGURE 2.58: Install rim-sealing tape directly over valve hole

d. Use a pointed sharp object to make a hole in the tape at the rim valve hole. Carefully puncture a hole. Do not tear or shred tape at the valve hole.

e. Install tubeless tire valve and align in rim (figure 2.59). Secure with nut fully tightened by hand. Do not use pliers to tighten nut.

FIGURE 2.59: Secure tubeless valve through rim sealing tape

f. Install tire and sealant as described above in “Procedure for tubeless tire sealant installation.”

g. Inflate tire immediately. Begin with low pressure and inspect tire seating. Continue to fully inflate tire.

h. Spin wheel to spread sealant inside tire. Next, place wheel horizontally on a bench and spin to work sealant into tire-bead interface. Flip wheel to other side and repeat spinning. Check tire in a few hours and repeat spinning to spread sealant.

Because these tubeless conversion kits are commonly used on non-UST rims, it can sometimes be difficult to get a tire successfully mounted. The rim bead seat may be too deep to push upward on tire bead. If a tire will not seat, it can be helpful to remove the tire and build up rim tape inside rim. Install extra tape directly over conversion kit sealing tape. Use one or two rounds of an electrician’s tape or a duct tape. Reinstall tire and attempt to inflate.

It is not uncommon for “tubeless ready” or non-UST tire casings to be porous enough to allow air to escape directly through sidewalls. This considered "normal" by some manufacturers as long as it does not escape at an unacceptable rate. This seepage can be seen when soapy water is applied to sidewalls. Bubbles will appear from this air seepage along sidewall (figure 2.60). The design of non-UST systems is that tire sealant will eventually seal this area. Other than using a different model of tire, there is no other solution. Hold the wheel horizontal and spin to spread fluid inside sidewall areas. Going for a slow ride is a good option to spread the sealant.

FIGURE 2.60: Bubbles showing air seepage through tire sidewalls of a conversion system

WHEEL INSTALLATION

Wheels must be properly mounted to the bicycle frame. Misalignment can result in problems with shifting, brake pad alignment, and bike handling. If the wheel is not securely mounted in the dropouts, it may come out and possibly injure the rider. Wheels may be held to the bike with a quick-release system, axle nuts or a thru axle system.

For open dropout bikes, the quick-release shaft is fitted with two conically shaped springs. The small end of the spring faces the axle, and the large end faces outward away from hub. These springs make the wheel easier to install. If one or both springs become twisted or damaged they can be removed. The springs serve no purpose once the wheel is tight on the bike (figure 2.61).

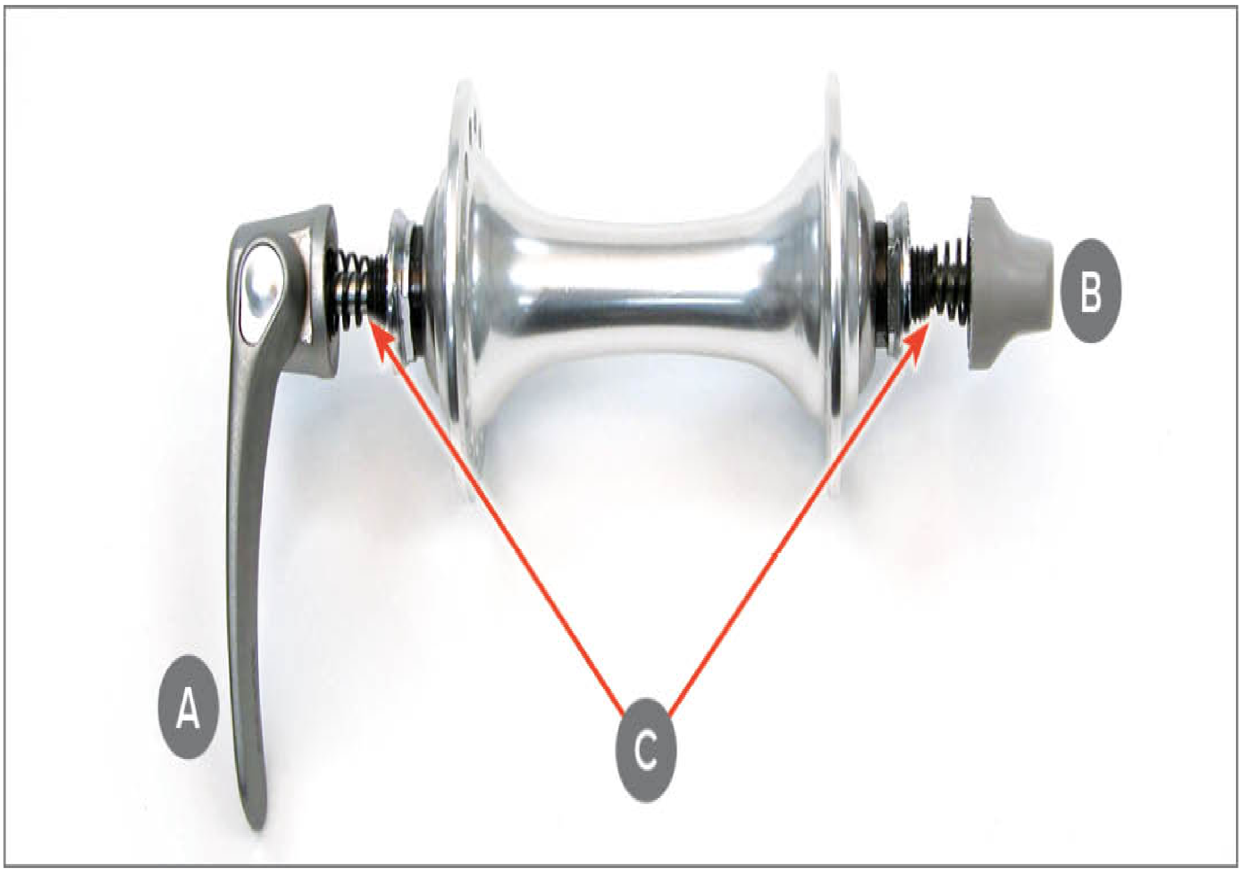


FIGURE 2.61: Common quick-release hub with (A) lever, (B) adjusting nut, (C) centering springs

Quick-release skewers use a cam device to hold the wheel securely to frame dropouts. It is important that the skewer be fully and consistently tightened before each ride. This is also important for the pressure applied to the hub bearings. For most brands of skewers, hold lever parallel to the hub axle, which is half way through its swing from fully open to fully closed (figures 2.62, 2.63, 2.64 and 2.65). Tighten adjusting nut snug against dropout. Check results by moving lever. Lever should meet resistance to closing halfway through the swing. Lubricate the cam mechanism if it appears sticky or dry.

FIGURE 2.62: Quick-release lever in fully open position

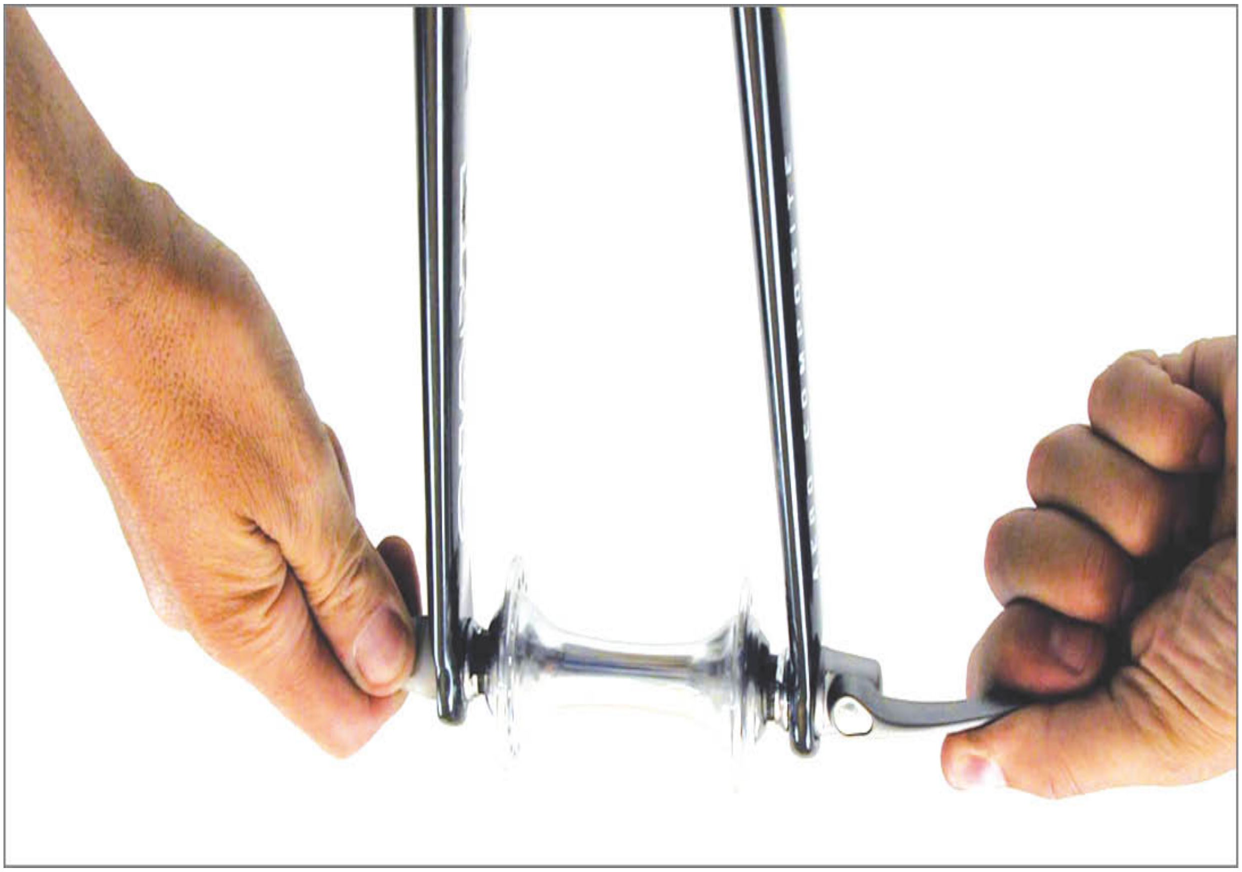


FIGURE 2.63: Adjusting nut used to set lever resistance

FIGURE 2.64: Closed skewer lever should be parallel to center plane of bike

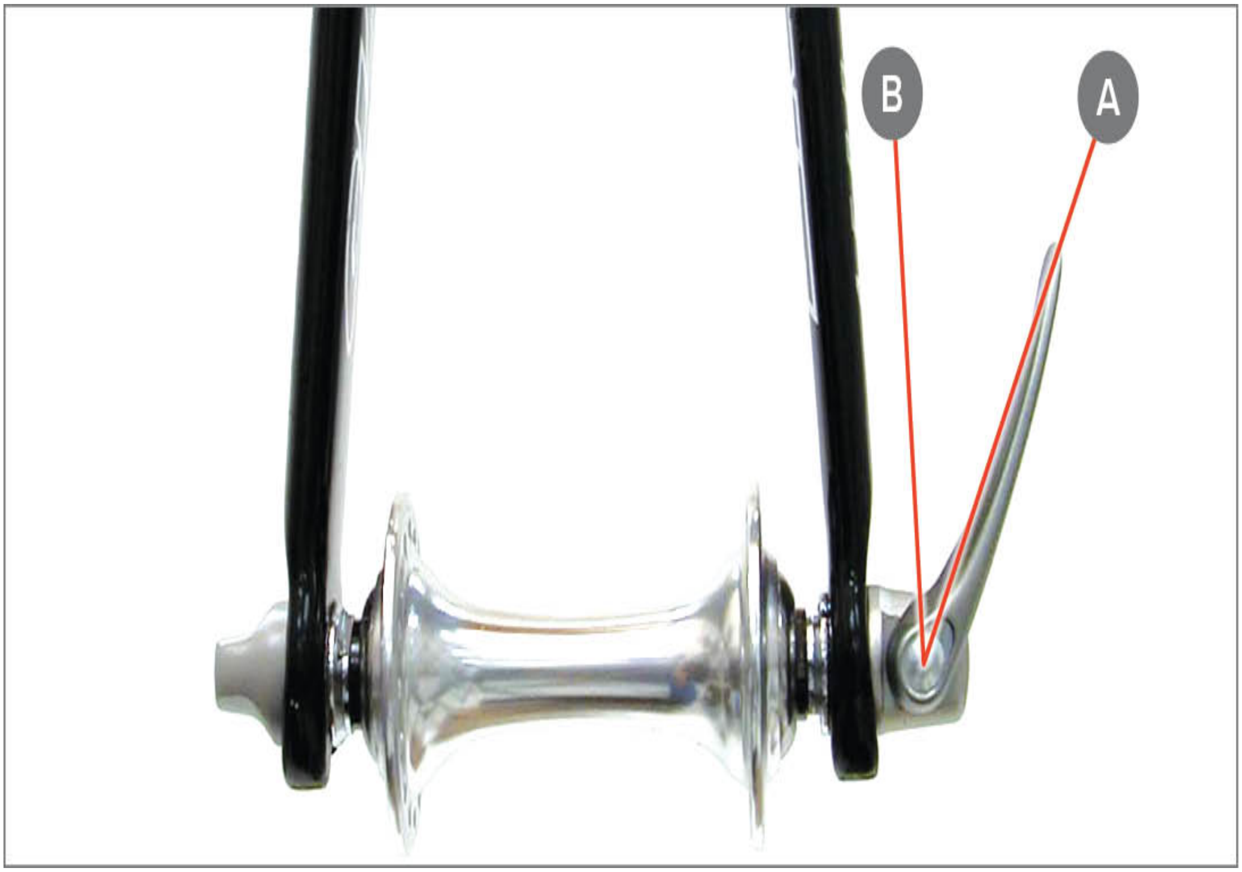


FIGURE 2.65: (A) Lever not fully closed, (B) position for lever in fully closed position

The cam mechanism is designed to lock when the lever is parallel to the bike's center plane. Inspect section of lever adjacent to the cam. If the lever arm is not fully closed, the wheel is not properly secured (figure 2.66). Double-check skewer adjusting nuts and the pressure on the lever.

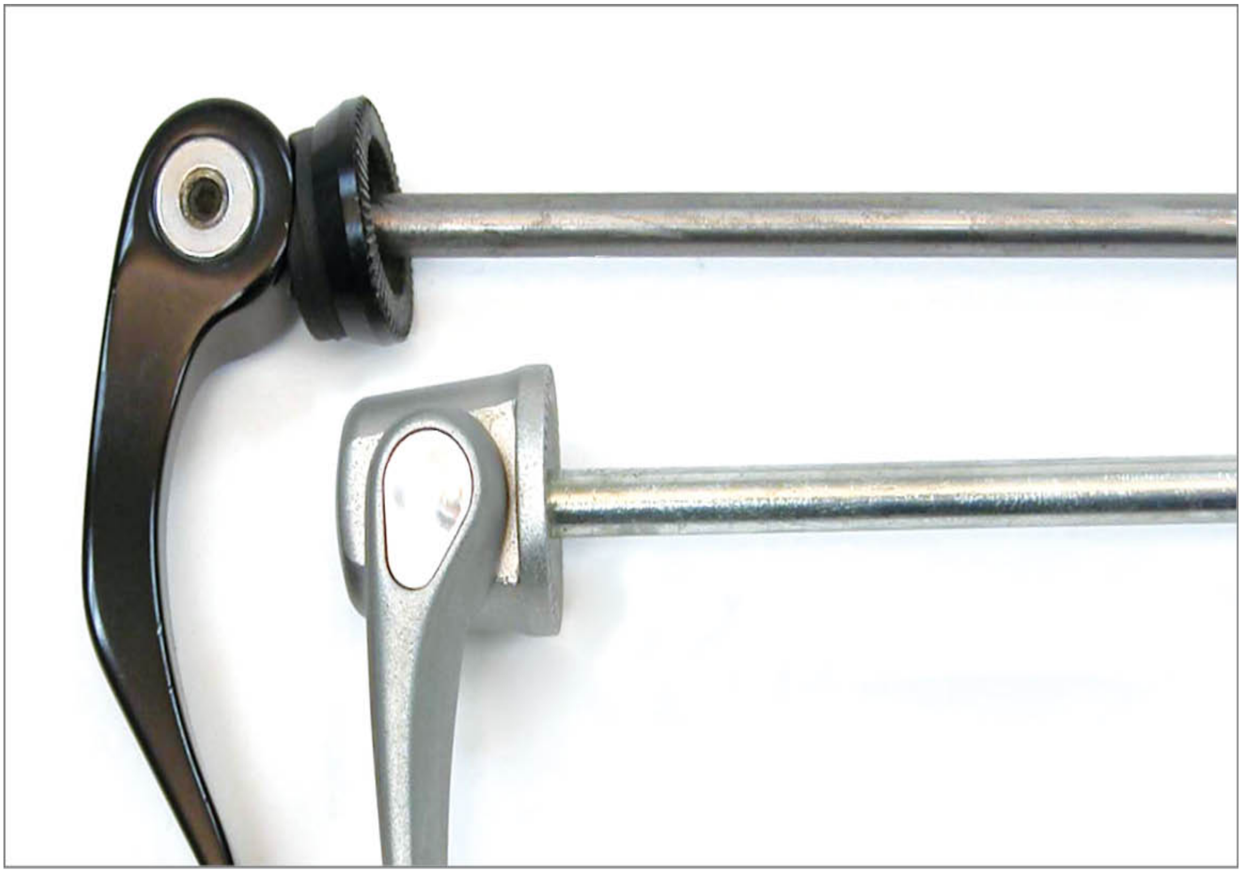


FIGURE 2.66: Open cam style seen at top, and closed cam seen below

Quick-release hub axle ends must sit inside the dropouts in order for the quick-release to secure tightly against the frame or fork. If the axle is too long for the bike's dropout spacing, it will not permit the wheel to be properly secure. If you have borrowed a wheel, check that the axle ends sit inside the dropout face.

Quick-release skewers come in two basic designs, "open cam" and "closed cam." In the open cam, the cam mechanism and pressure points are visible and exposed to dirt and grime. Setting lever resistance at halfway through swing may be too tight for some models. However, these skewers should still close with force. Open cam models should be lubricated to work effectively. Consult specific manufacturer for recommended pressure of closing. The closed cams should also be lubricated, but the working parts are better shielded from dirt and grime.

Procedure for wheel installation in open-dropout fork or frame:

a. Open brake quick-release mechanism for rim caliper brakes only.

b. Move wheel quick-release skewer to open position.

c. Install between dropouts with quick-release skewer lever on non-drive side.

Front: Guide rim or disc rotor between brake pads. Pull hub up fully into dropout.

Rear: Check that rear derailleur is in most outboard position. Pull rear derailleur back to open chain (figure 2.67). Place cogs between upper and lower sections of chain and engage chain on smallest cog.

FIGURE 2.67: Pivot derailleur back to clear wheel and cogs

d. Guide rim or disc rotor between brake pads. Guide axle up and fully into dropouts. Pull up and/or back depending upon dropout style. It may be necessary to flex dropouts open to get wheel in.

e. Adjust closing tension of quick-release skewer and close lever. Wheel should be centered between fork blades or rear stays. If necessary, open skewer, move wheel either left or right until wheel appears centered, then close skewer. Quick-release skewer cam and adjusting nut must be fully engaged on dropout surfaces.

f. Determine final closing position of quick-release lever.

Front: Rotate lever and adjusting nut so lever is just in front of fork when firmly and fully closed (figures 2.68 and 2.69). However, with some dropout designs or suspension forks, it will be necessary to use an alternate position if lever will not fully close.

FIGURE 2.68: Place lever just in front of fork blade when possible

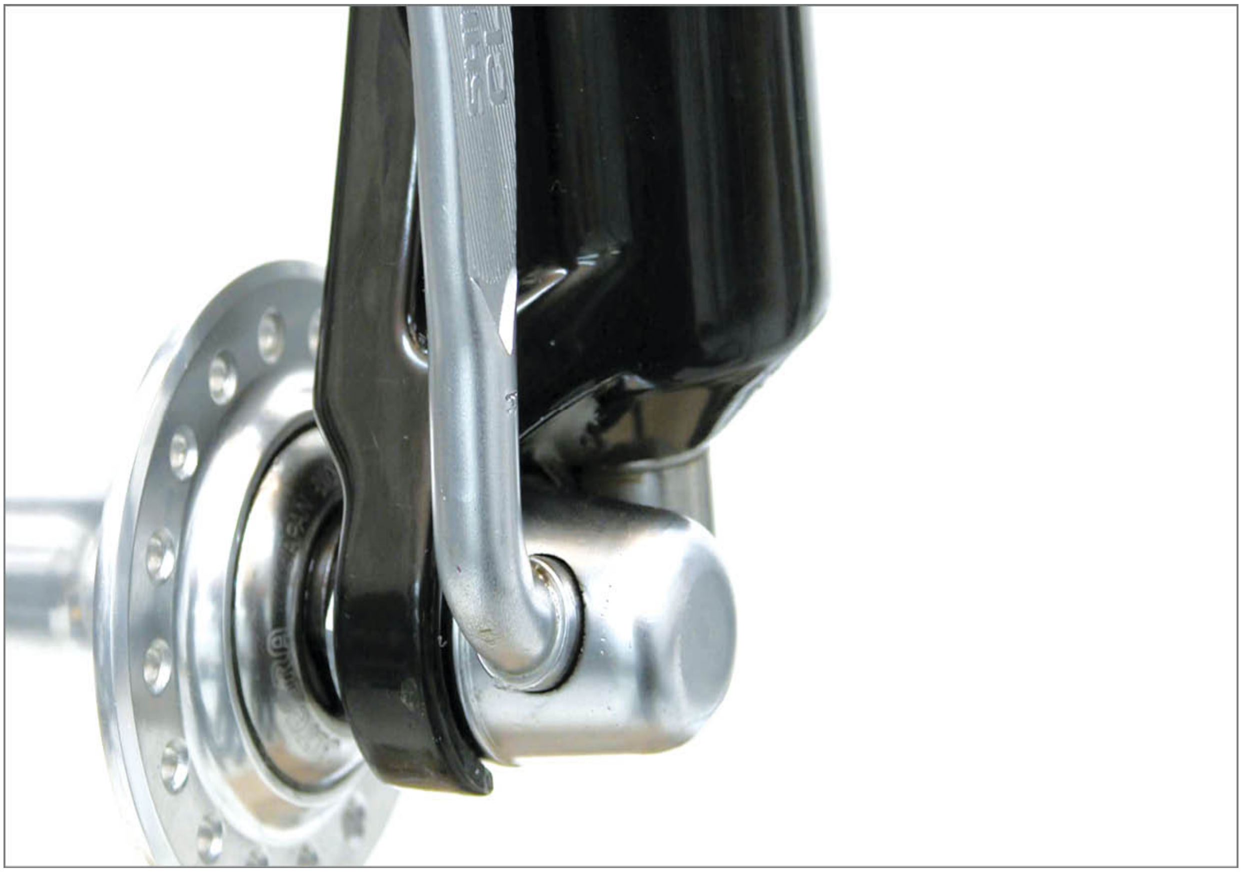


FIGURE 2.69: Skewer orientation must allow lever to be fully closed

Rear: Orient skewer so lever will end up between seat stay and chain stay, unless this prevents lever from fully closing (figure 2.70). This position provides leverage for closing and opening.

FIGURE 2.70: Align lever between chain and seat stays

g. Close rim caliper brake quick-release mechanism (if any).

h. Inspect brake pad alignment and centering by closing and opening pads with brake lever. Spin wheel and check pad alignment to rim (disc). If brake pads are not centered, see Chapter 13—Caliper Disc Brake Systems, or Chapter 14—Caliper Rim Brake Systems. If wheel fails to adequately center in frame, either frame or wheel may be misaligned. Seek professional help.

View centering of wheel between chain stays and seat stays. Open skewer and adjust as necessary to center wheel in frame. If rim brake pads are not centered to wheel, see Chapter 14—Caliper Rim Brake Systems. If further attempts to align wheel fail to adequately center it in frame, either the frame or wheel may be misaligned. Seek professional help.

If it is difficult to maneuver the wheel into the dropouts, install front wheel when the bike is standing on the ground. By placing the bike on the ground, the axle will seat fully up into the dropouts.

FRONT WHEELS WITH DISC BRAKES AND OPEN DROPOUTS

The process of wheel installation is basically the same when there are disc brakes. The rotor should be placed between caliper pads as it is installed. Use care not to displace brake pads when installing the wheel (figure 2.71).

FIGURE 2.71: Guide rotor between caliper disc brake pads

If the bike uses a hydraulic brake, use care not to squeeze the lever with the wheel out of the bike. This will close the pistons and brake pads, which makes wheel installation difficult. If the pads of a hydraulic brake were moved inward, spread them outward.

Front wheels with open dropouts and a disc brake must always be fully and properly secured. The caliper disc brake applies a load to the disc rotor, which applies a pulling force on the hub in the dropout. This force tends to pull on the wheel in a direction to remove it from the fork. If the wheel is poorly mounted, it may result in the wheel coming out of the fork during use.

THRU AXLE SYSTEMS

The process for wheel installation on thru axle designs is similar to the open dropout style, except the connecting pin, the thru axle, is left out of the wheel during installation. The closed thru axle dropouts commonly have a recess to engage and align axle end caps in the fork or frame (figure 2.72). This make the process of installing the connecting shaft through the dropouts and hub easier.

FIGURE 2.72: Recess in thru axle fork to accept end cap of hub

For the front wheel, guide the rotor disc between the brake pads and up into the dropouts. Install the thru axle through the non-threaded side. It may be necessary to slightly wiggle the wheel to assist hub alignment in the dropouts before the thru axle will thread into the opposite dropout. Secure thru axle fully. For the rear wheel, pull the derailleur back to create a open for the sprockets, then guide the rotor up into the caliper pads, and then engage the dropout with the hub end caps. Install and secure the connection pin.

SOLID AXLE TYPES

For wheels with axle nuts, washers go on the outside of dropouts (figure 2.73). Secure axle nuts fully and then double-check alignment. Front wheels may use a special washer that acts as a wheel retention redundancy.

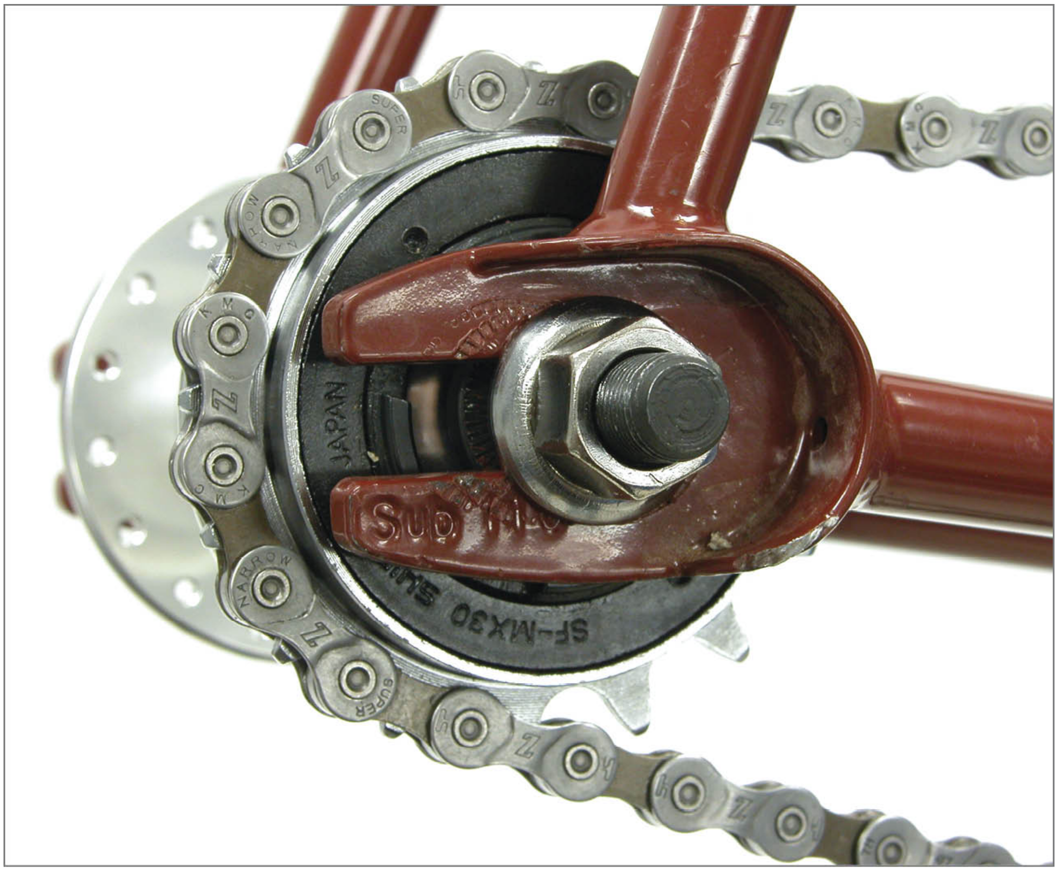


FIGURE 2.73: Solid axle in a horizontal dropout

TABLE 2.2: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
A new tube in and it won't hold air	Pinched the tube on install	Get a new tube and install carefully, extra care is needed when using levers to reinstall
Newly installed tire blows up right away	1. Possible slice in tire allowing the tube to blow out 2. Failure at the bead not allowing the tire to seat properly	Get a new tube and tire as needed, then install carefully
Newly installed tire does not spin straight on rim	1. The tire is not fully seated 2. Damaged tire casing in sidewalls	1. Deflate tire, use soapy water to lubricate bead and reinflate 2. If properly seated, tire possibly defective and should be replaced
Tubeless tire not able to inflate	Tire bead not seating well to rim	1. Remove valve core and use compressed air 2. Check for incompatible tire/rim combinations
Newly installed inner tube flats again in one day	Cause of flat tire still imbedded inside tire casing	Remove tire, inspect inside, and replace inner tube
Newly patched inner tube leaking at patch	Improper patching technique, possibly from lack of glue or contaminants	Remove tube and attempt to remove and replace patch. This is difficult, and tube replacement is often the best solution.

CHAPTER 3

REAR SPROCKETS

Rear sprockets are gears mounted to the drive wheel of the bike, usually the rear wheel. Sprocket teeth mesh with the chain and drive the wheel and bike forward. Sprockets wear with use and must be replaced eventually. Sprockets are also removed in order to service hub bearings.

The clutch or ratchet systems used on derailleur-equipped, multi-speed bikes and some single-speed bikes allow for coasting. Sprockets spin relative to the hub when the rider stops pedaling but will lock and drive the rear wheel when the pedals and chain are turned forward. Bearings fitted in sprocket systems allow gears to turn freely. It is common and normal to have a slight amount of play between inner and outer parts of sprocket bearing systems. Additionally, when the wheel turns during coasting, rear sprockets may appear to wobble slightly side to side. This is also common and not usually a problem because when the bike is pedaled, inner and outer parts lock together as they drive and this eliminates the wobble.

Rear sprockets on multi-speed bikes are attached to hubs using either a “freehub” system or a “freewheel” system. A “freehub” is a ratchet system mounted to the hub body (figure 3.1). This cylindrical mechanism acts as a clutch that ratchets for coasting and locks for driving the bike when pedaling. The freehub body has a series of splines on the outer shell. “Cassette” sprockets, also called the “cassette stack,” mate to these splines. The pattern, spacing, size and width of freehub and cassette splines can vary between manufacturers. Many models from brands such as Shimano®, SRAM®, Microshift® share a common pattern and will interchange with sprockets and freehubs. However, there are also unique and proprietary systems from Shimano®, SRAM® and Campagnolo® that use unique proprietary patterns that do not interchange with the common style splines.

FIGURE 3.1: Cassette sprockets on left with freehub body on right

Sprockets secure to freehub bodies with a lockring (figure 3.2). When sprockets are removed, the ratcheting freehub remains on the hub body. Most modern derailleur bicycles now use freehub systems. The spacing between sprockets tends to get narrower with more and more sprockets added to the cassette system. Freehubs designed for more sprockets can accept cassettes with fewer sprockets if the appropriate spacers are used. However, you cannot add more cassette sprockets than the freehub was designed to accept.

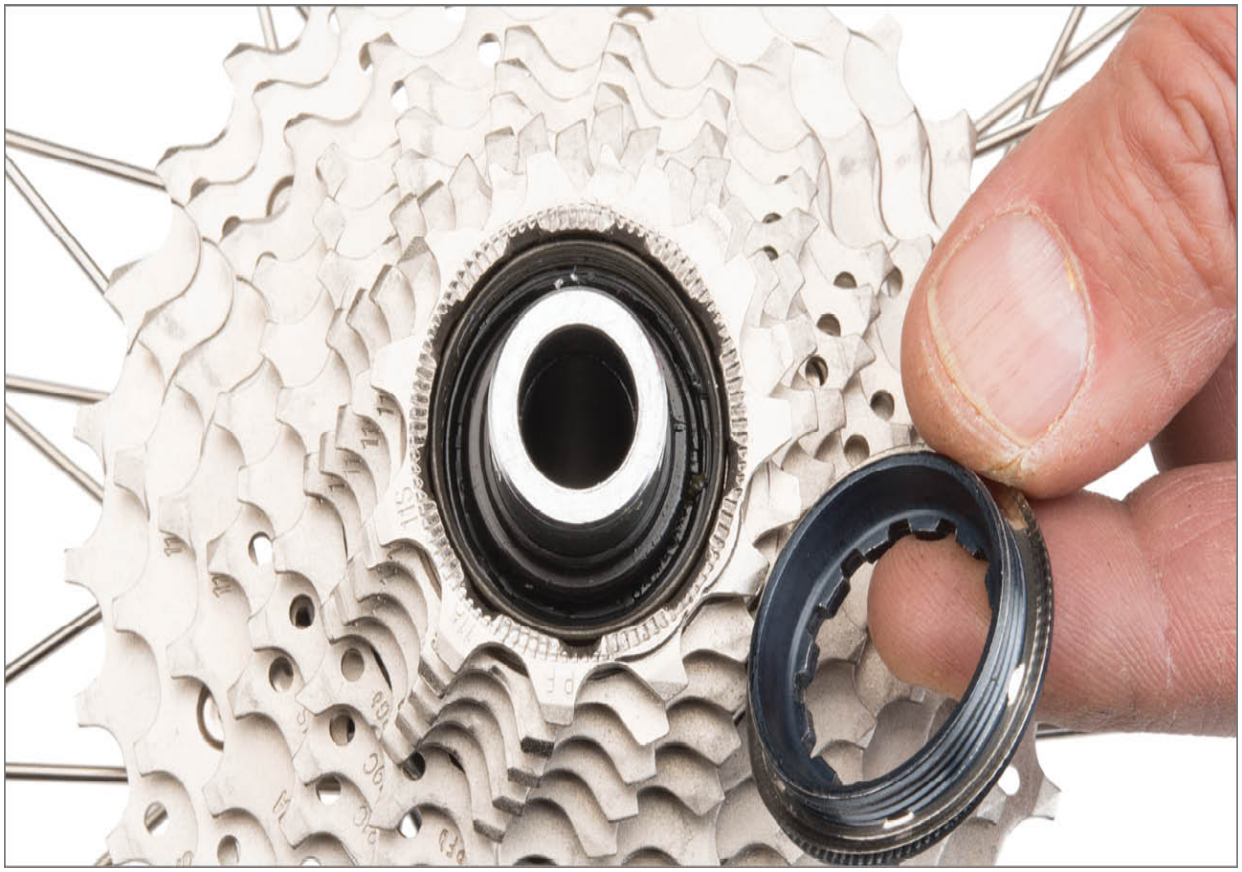


FIGURE 3.2: Cassette lockring with cassette sprockets on freehub

Older bikes, entry-level bikes and some one-speed bikes use a "freewheel" system. A freewheel contains the sprockets and ratchet mechanism in one removable unit. Hubs designed for freewheels use a large machined thread on the hub (figure 3.3). Individual sprockets for freewheels are typically not available separately, and the entire freewheel is replaced as the sprockets wear out.

FIGURE 3.3: Rear threaded hub with thread-on freewheel

A simple test to determine if the sprockets are a freewheel or cassette system is to inspect the tool fitting as sprockets rotate backward. Remove the wheel from the bike. Look at the most inward part of the sprocket system, adjacent to the axle or axle nuts. There are either splines or notches of some sort to accept a tool. Spin the sprockets backward. With the cassette system the splines will also spin with the sprockets. With a freewheel the splines/notches will not spin as the sprockets move.

CASSETTE SPROCKET REMOVAL & INSTALLATION

Pressure from freehub lockrings prevent the sprockets from moving side to side on the freehub and also helps prevent sprockets from damaging the freehub body by rotation in the freehub splines. These lockrings are often marked with the word “LOCK,” an arrow indicating the direction to turn for locking, and recommend torque.

There are two non-interchangeable lockring tool standards. Cassettes compatible with Shimano®, SRAM®, Chris King®, Microshift®, Sun Race®, American Classic® and others require a lockring tool with 12 splines. The tool fitting is approximately 23.5mm diameter and will accept the Park Tool FR-5 series of cassette lockring tools. See Table 3.1, Cassette, Lockring and Freewheel Removal Tools.

TABLE 3.1: Cassette, Lockring and Freewheel Removal Tools

CASSETTE OR FREEWHEEL BRAND	FITTING	APPROPRIATE TOOL	TOOL & DESCRIPTION
Cassette systems: Shimano®, SRAM®, Sun Race®, Microshift®			Park Tool FR-5.2, FR-5.2G, FR-5.2GT, FR-5H 12 splines 23.5mm approx. diameter
Cassette systems: Campagnolo®, Miche®			Park Tool BBT-5/FR-11 12 splines 22.8mm approx. diameter
Freewheels: Shimano®, Sun Race®, and Sachs®			Park Tool FR-1.3 12 splines 23mm approx. diameter
Freewheels: Suntour® two-notched			Park Tool FR-2 2 notches 25mm across
Freewheels: Suntour® four-notched			Park Tool FR-3 4 notches 24mm across
Freewheels: Atom®, Regina®, some "Schwinn® approved"			Park Tool FR-4 20 splines 21.6mm approx. diameter
Freewheel: Single speed, BMX			Park Tool FR-6 4 notches 40mm across
Freewheels: Falcon®			Park Tool FR-7 12 splines 23mm approx. diameter (slightly larger than FR-1)
Freewheel: Compact single speed (30mm thread, "flip-flop hub")			Park Tool FR-8 4 notches 32mm across

Campagnolo® cassettes also require a lockring tool with 12 splines. However, the tool fitting is approximately 22.8mm in diameter. Use the Park

Tool BBT-5/FR-11. Although the both the FR-5 and BBT-5/FR-11 lockring removers look similar, the two are not interchangeable.

Cassette sprockets are separated on the freehub by spacers. Cassette manufacturers may design spacers into the sprockets, or the spacers can be pinned between sprockets. Spacers may also simply be fitted loose between sprockets. Generally the spacers are the same within a cassette system, and if the order of spacers is mixed, it will not affect the sprocket spacing. However, always note orientation of spacers when taking off a cassette. Use a zip tie or string through the sprockets to maintain their orientation when removed.

After removing the cassette, note if there are any spacers behind the largest cassette sprocket. Some hub manufacturers use these as corrective spacing. Extra spacers here can also be used to convert a freehub to use fewer sprockets then it was designed for. For example, using an 8-speed cassette stack on a 10-speed freehub.

The procedure for cassette sprocket removal is the same for most all designs and brands. The axle design can often prevent full tool engagement into the lockring. If the wheel uses a quick-release skewer, the skewer can be used as a holder for the lockring tool. Thru axle hubs do not use the skewer to hold the tool, and consequently the tool should be held carefully to the lockring during removal so it does not slip.

Procedure for cassette sprocket removal:

a. Mount bike in repair stand and remove rear wheel.

b. For open dropout hubs, remove quick-release skewer. If using FR-5.2H, leave skewer in place as skewer nut acts as guide for tool.

c. Inspect cassette and select correct type of cassette lockring tool.

d. Engage tool into lockring splines.

   1. For open dropout hubs using FR-5.2, install quick-release skewer and install skewer nut on outside of lockring tool (figure 3.4). Skewer acts as a holding device for remover.
   2. If using FR-5.2G or FR-5.2GT Lockring Tool, guide pin takes place of skewer.

FIGURE 3.4: Use skewer and nut to hold tool firmly in place

e. Hold sprockets from rotating in a counterclockwise direction with chain whip tool. Turn lockring tool counterclockwise with a large adjustable wrench (figure 3.5). It should require some force to remove lockring.

FIGURE 3.5: Use body weight to help loosen lockring, with wrenches

f. Turn lockring tool only one full revolution counterclockwise. Loosen and remove skewer before continuing to remove lockring.
g. Continue to hold sprockets and turn lockring tool counterclockwise until lockring is unthreaded from freehub body.
h. Remove lockring and sprockets. Note orientation of spacers behind sprockets. Spacers should be replaced in same order as removed.

A chain whip tool is not required to install the cassette sprockets and lockring. The cassette ratcheting mechanism will hold the freehub body and keep the sprockets from rotating clockwise, the lockring tightening direction. Hold wheel firmly as cassette lockring is tightened. For corrosion protection, grease or anti-seize may be applied to the freehub body.

Procedure for cassette sprocket installation:

a. Inspect splines of freehub body. Look for a wide space between splines.
b. Inspect internal splines of sprockets. Look for a single, wide spline to mate with wide space on the freehub body (figure 3.6).

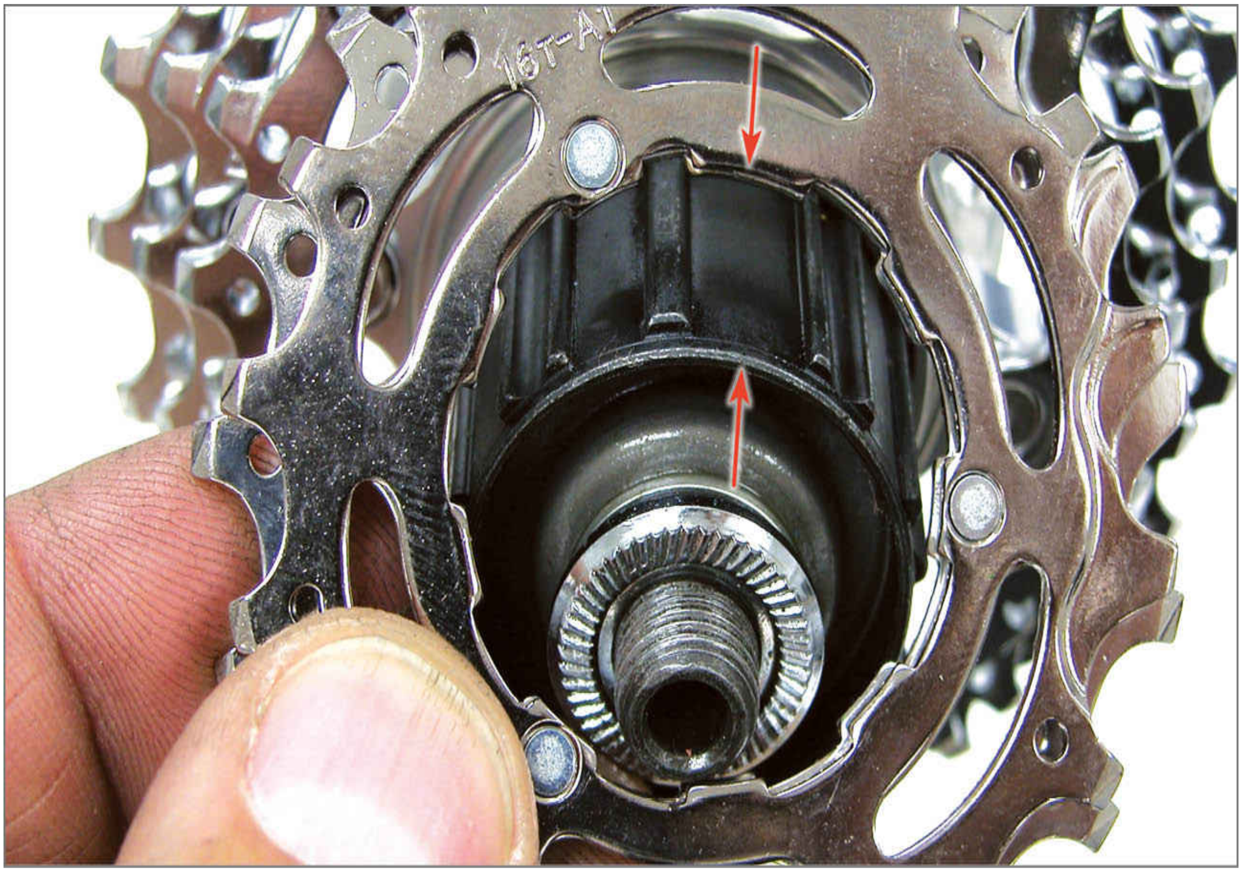


FIGURE 3.6: Align wide spline inside sprocket with wide space on freehub body

c. Align splines and engage all sprockets and spacers.
d. Grease threads of lockring and thread lockring into freehub body.
e. Insert cassette lockring tool into splines of lockring.
f. Install quick-release skewer and thread skewer nut on outside of lockring tool.
g. Snug skewer nut against lockring tool. Skewer acts as a holding device for lockring tool.
h. Turn cassette lockring tool clockwise until lockring is fully tight (figure 3.7).

FIGURE 3.7: Tighten lockring clockwise

The spline pattern is common between many brands of freehubs and cassette which allows some interchangeability between brands and models. However, freehubs vary in width and consequently the cassette stack must be compatible with the freehub. Older 7-speed freehubs will not accept wider cassettes for the 8 to 12-speed cassettes. Shimano® has different freehubs to accept "Dynasys" MTB cassette versus their road systems with the same number of sprockets. Check with the manufacturer for details on compatibility.

The Shimano® 12-speed system cassette system is a proprietary design that differs from their traditional system. The 12-speed still uses an external lockring with the same tool fitting as other Shimano® cassettes, but a smaller diameter thread fitting. Use the same procedures as above to remove and install.

SRAM® 11 and 12-speed systems use a proprietary freehub body and cassette design. Cassettes compatible with SRAM® XD™ and XDR™ freehub bodies will not interchange with freehub bodies using traditional removable lockring at the outer end of the freehub. Instead, a lockring is integrated into the cassette body and is turned by the tool fitting at the small end of the cassette (figure 3.8). SRAM® XD™ and XDR™ compatible cassettes use the Park Tool FR-5 series of lockring tools.

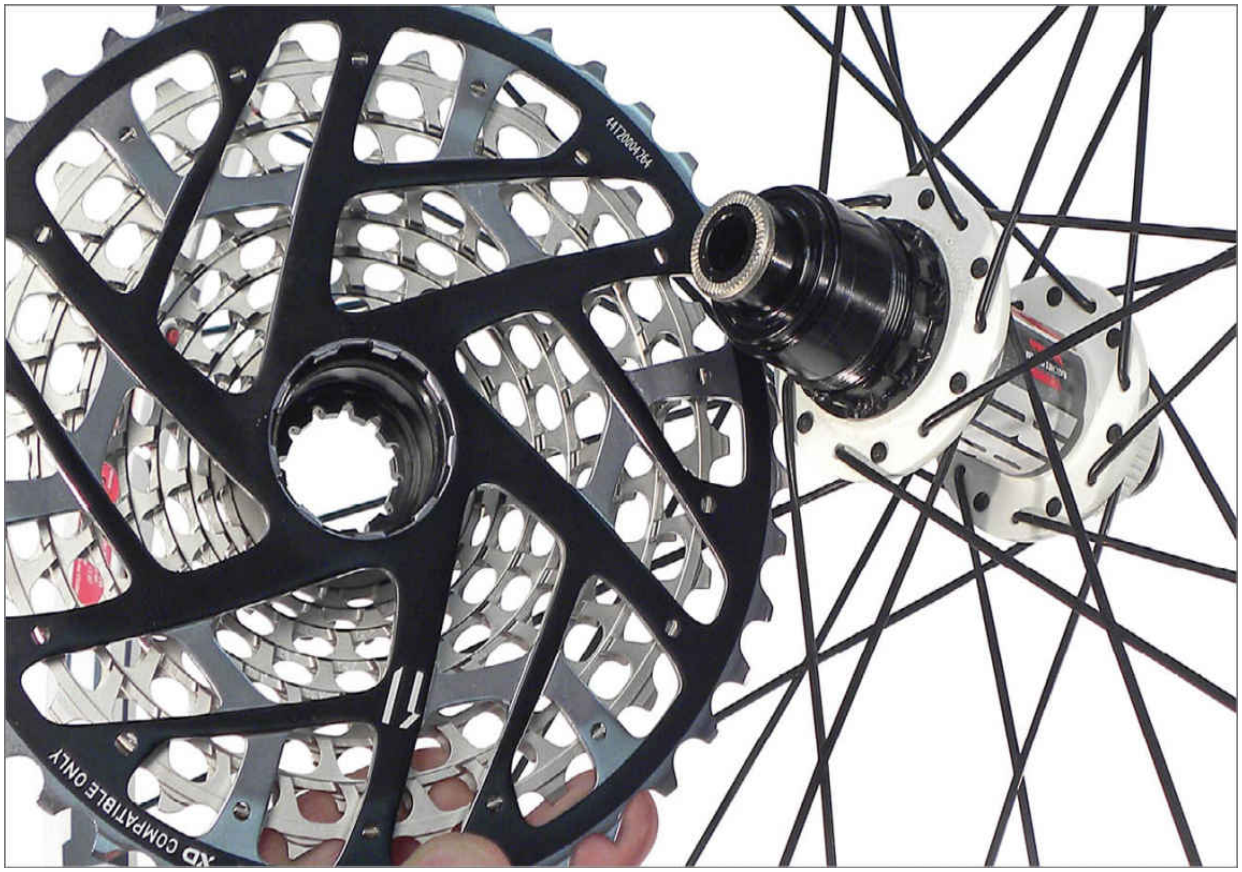


FIGURE 3.8: SRAM® XX1® cassette with special freehub body

To install the SRAM® cassette place cassette onto the freehub body and engage splines of cassette with splines of freehub. Splines are symmetrical and any orientation will work. Use the lockring tool to thread the system lockring to the freehub. Secure fully to recommend torque as any other type of cassette stack.

Removal of SRAM® XD™ and XDR™ compatible cassettes is the same as other systems. Use a chain whip to hold the cassette stack and to keep it from turning counterclockwise (figure 3.9). Engage a lockring tool into the lockring tool fittings and turn counterclockwise until the threads are disengaged. Pull cassette from freehub.

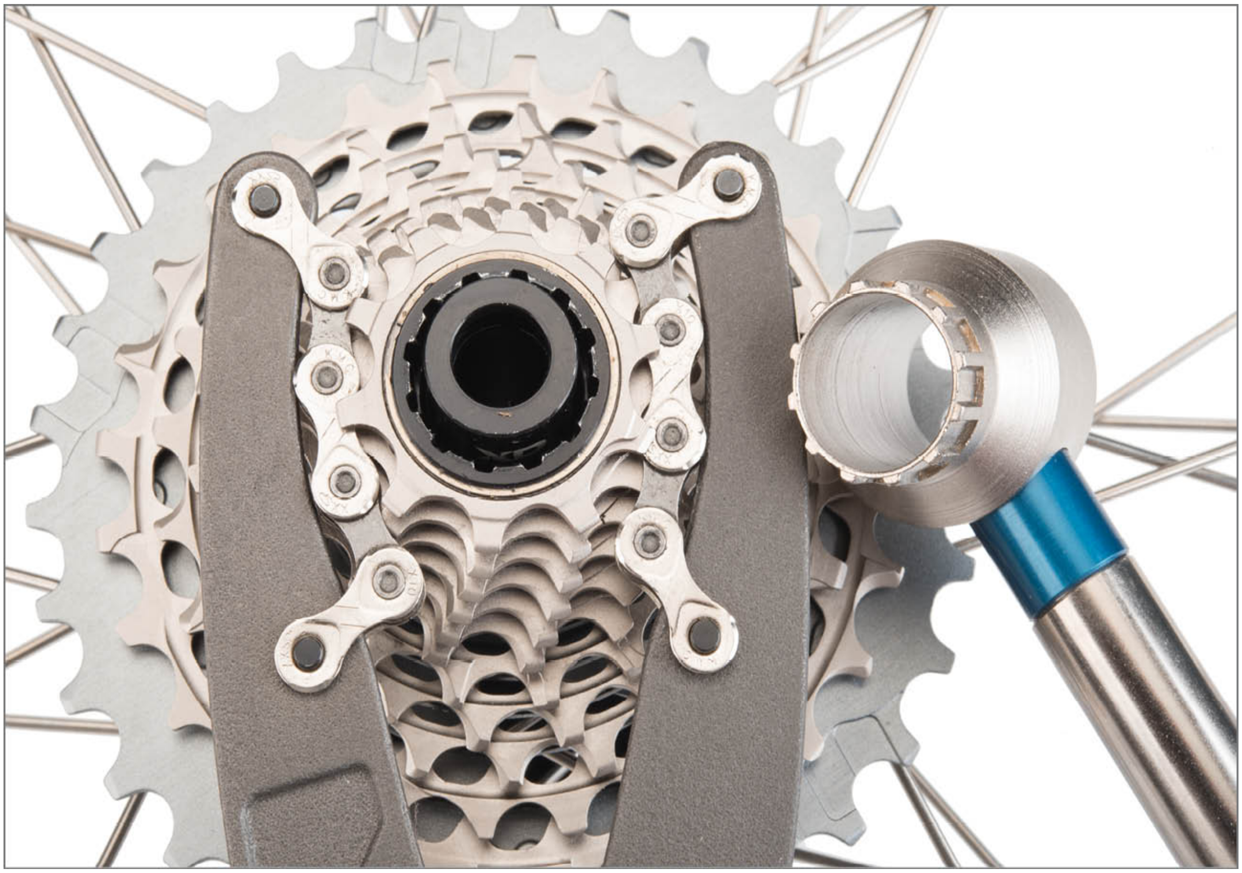


FIGURE 3.9: XD™ and XDR™ compatible cassette removal

FREEWHEEL SPROCKET REMOVAL & INSTALLATION

A freewheel is a self-contained system of sprockets together with a ratcheting mechanism. The outer body with sprockets will rotate freely counterclockwise to allow for coasting. The inner body has internal threads that secure to external mount threads of the compatible hub. The inner body of a freewheel will have a tool fitting for the remover with either recessed notches or splines in the body. There have been numerous brands and models of freewheels through the years, and some may not have any tool available.

To remove freewheels, begin by determining type or brand of freewheel and the removal tool required. Removal tools must fit the part correctly, or both may become damaged. To determine the type or brand of freewheel, remove wheel from the bike and look at the tool fittings of the freewheel near the axle for a brand name. There are also freewheels with lockrings holding the cogs to the freewheel body. These freewheels should not be confused with cassette systems. See Table 3.1, Cassette, Lockring and Freewheel Removal Tools for the appropriate tool.

Procedure for freewheel removal:

a. Mount bike in a repair stand and remove rear wheel.
b. Remove quick-release skewer or drive-side axle nut.
c. Inspect freewheel center and select correct type of remover.
d. Engage remover onto tool fittings of freewheel.
e. Install quick-release skewer. Skewer nut should be on outside of remover.
f. Snug skewer nut or axle nut against remover. Nut acts as a holding device for remover.
g. Turn remover counterclockwise using a large adjustable wrench or other tool (figure 3.10). It will require some force to remove freewheel. Another option is to mount remover tool flats in jaws of a vise and turn rim counterclockwise.

FIGURE 3.10: Turn tool counterclockwise to loosen freewheel

h. Turn remover only one full revolution counterclockwise. Loosen and remove skewer or axle nut before continuing to remove freewheel.

i. Turn remover counterclockwise until freewheel is unthreaded from hub. Lift freewheel from hub.

Procedure for freewheel installation:

a. Apply grease or anti-seize heavily inside mounting threads of freewheel (figure 3.11). Lack of thread lubrication may seize freewheel to hub.

FIGURE 3.11: Heavily grease threads of freewheel

b. Lay wheel on bench and hold flat. Hold freewheel sprockets parallel to wheel and lower freewheel onto threads. Axle should be centered in hole of freewheel. If axle appears off-center, freewheel is cross-threaded on hub threads (figure 3.12). Remove and realign.

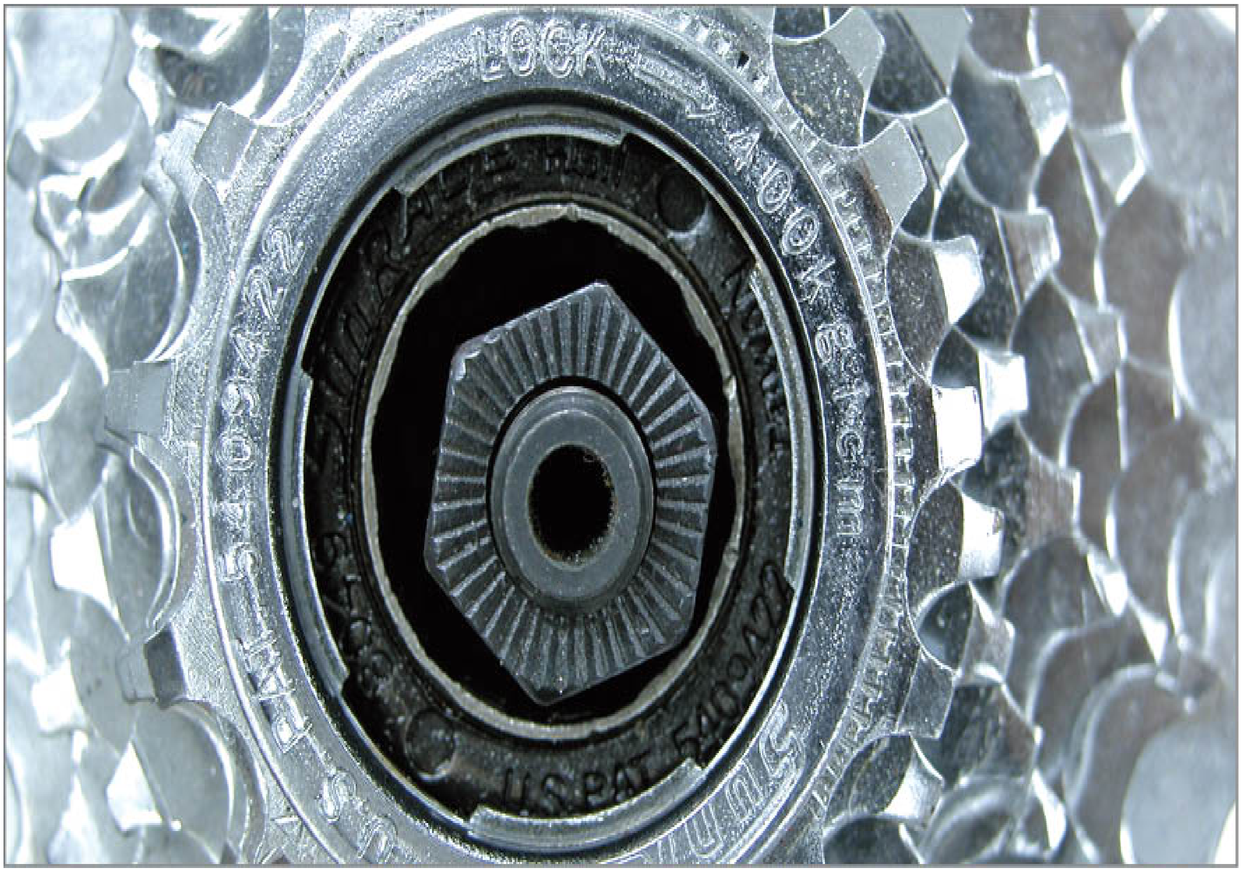


FIGURE 3.12: Example of off-center freewheel from cross-threading on hub

c. Begin threading freewheel clockwise by hand until freewheel feels fully threaded.
d. Use chain whip tool to fully seat freewheel clockwise against hub, so that derailleur adjustments will be correct when the wheel is installed in the bike. It is also possible to install the wheel in the bike and use the pedals to fully seat the freewheel. The freewheel must be seated to accurately adjust rear derailleur settings.
e. If either a new freewheel or new wheel is installed, check rear derailleur limit screw settings and indexing. See Chapter 10—Derailleur Systems.

Some freewheel models allow for removal of individual sprockets. Sprockets can be held to the freewheel body with a lockring, or the first cog may act as the lockring. However, individual replacement sprockets for freewheels are not available, so there is no need to remove sprockets from the freewheel body. Sprockets can be cleaned while in place on the freewheel body.

SINGLE-SPEED SPROCKET REMOVAL

Single-speed rear hubs may use either a cassette system or a screw-on freewheel, depending upon make and model. For threaded freewheels use the same procedures as multiple cog freewheel removal and installation.

Cassette system single-speeds may come with a lockring similar to multiple speed cassettes. Use one of the Park Tool FR-5 series and the same procedures as multiple speed cassette systems. There may also be a notched lockring or a lockring with flats retaining the cog. If the lockring has flats, measure across the flats and use the appropriate size wrench or a large adjustable wrench. Notched lockrings are removed and tightened with the Park Tool HCW-17 Lockring Tool (figure 3.13).

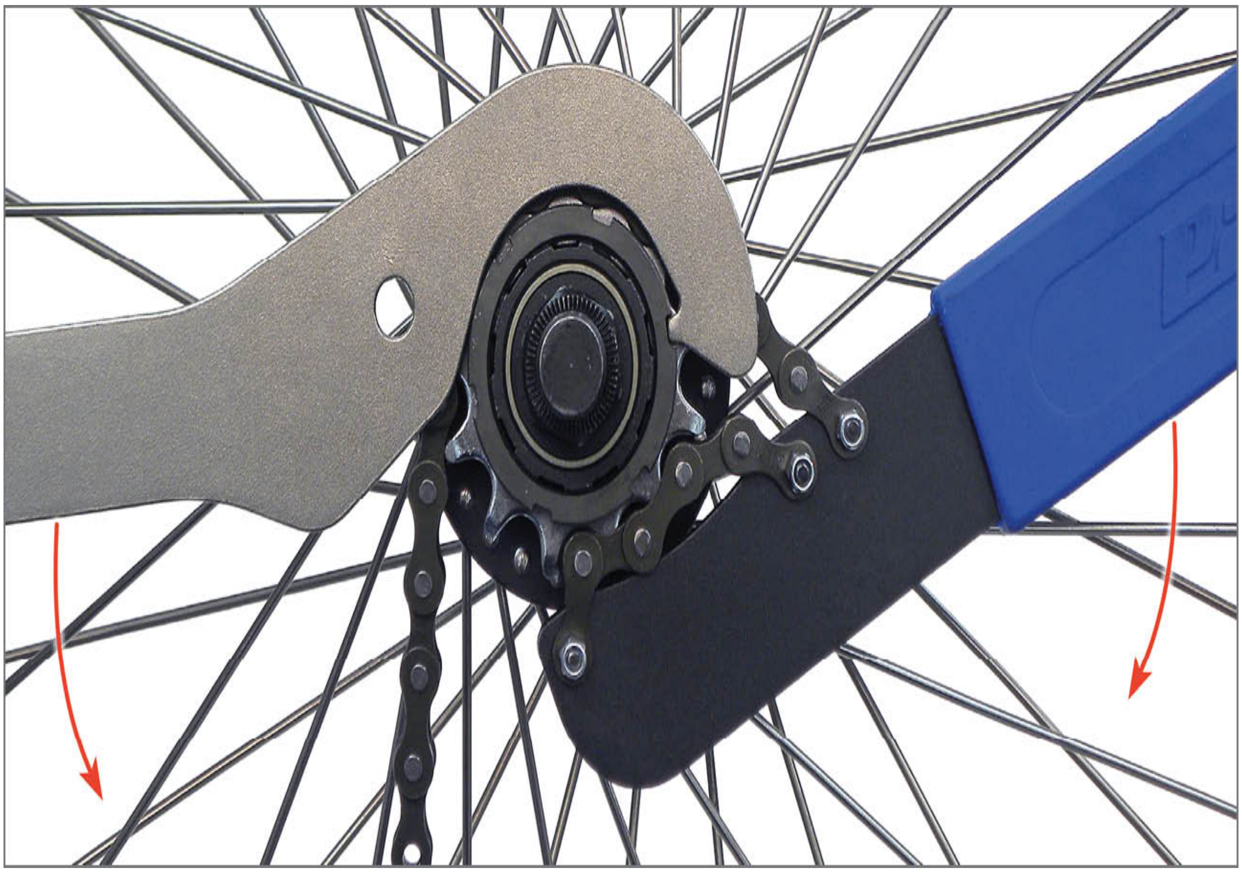


FIGURE 3.13: Single speed cassette system with notched lockring

SPROCKET INSPECTION & CLEANING

Teeth of the cassette or freewheel are cut to fit chain with a 1⁄2 inch pitch. Rear sprockets eventually wear out. As chains are ridden it loads only the back side of the sprocket teeth. Material is eventually ground away, changing the shape and widening the space between the teeth (figure 3.14). The chain rollers will then not properly engage the teeth and, on derailleur bikes, the chain may skip over a worn cog when load is applied, such as when going up a hill.

FIGURE 3.14: Left: chain rollers sitting in a worn sprocket showing poor engagement Right: chain rollers showing good engagement on a new sprocket

Visually inspect the sprockets from behind where the chain engages each sprocket. Look at various sprockets and notice any that are shiny and smooth compared to the rest (figure 3.15 and figure 3.16). A polished backside indicates a relatively worn cog. The best test for a worn cog is to ride it with a new or unworn chain. If the sprocket does not skip under load, it is not worn out. If it does skip, the sprocket is worn beyond use.

Cyclists tend to use two or three favorite rear sprockets more than the others. These, naturally, will wear out first. Commonly, these are the 15 to 18-tooth sprockets. If individual sprocket replacements are available, replace these worn sprockets. Otherwise, all rear cassette sprockets are typically replaced together. When a new cassette or freewheel is installed, a new chain should also be installed.

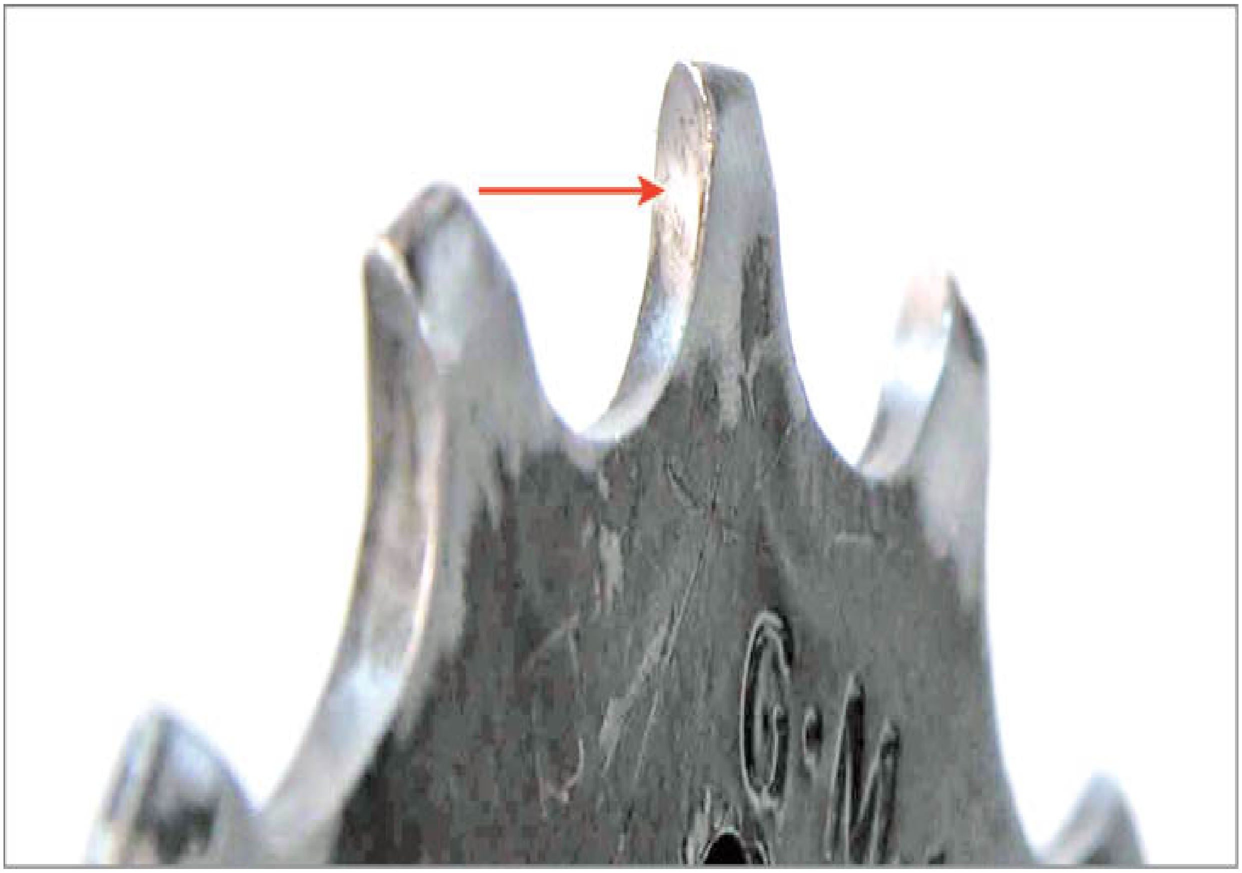


FIGURE 3.15: Inspect for a smooth and shiny surface indicating a worn sprocket tooth

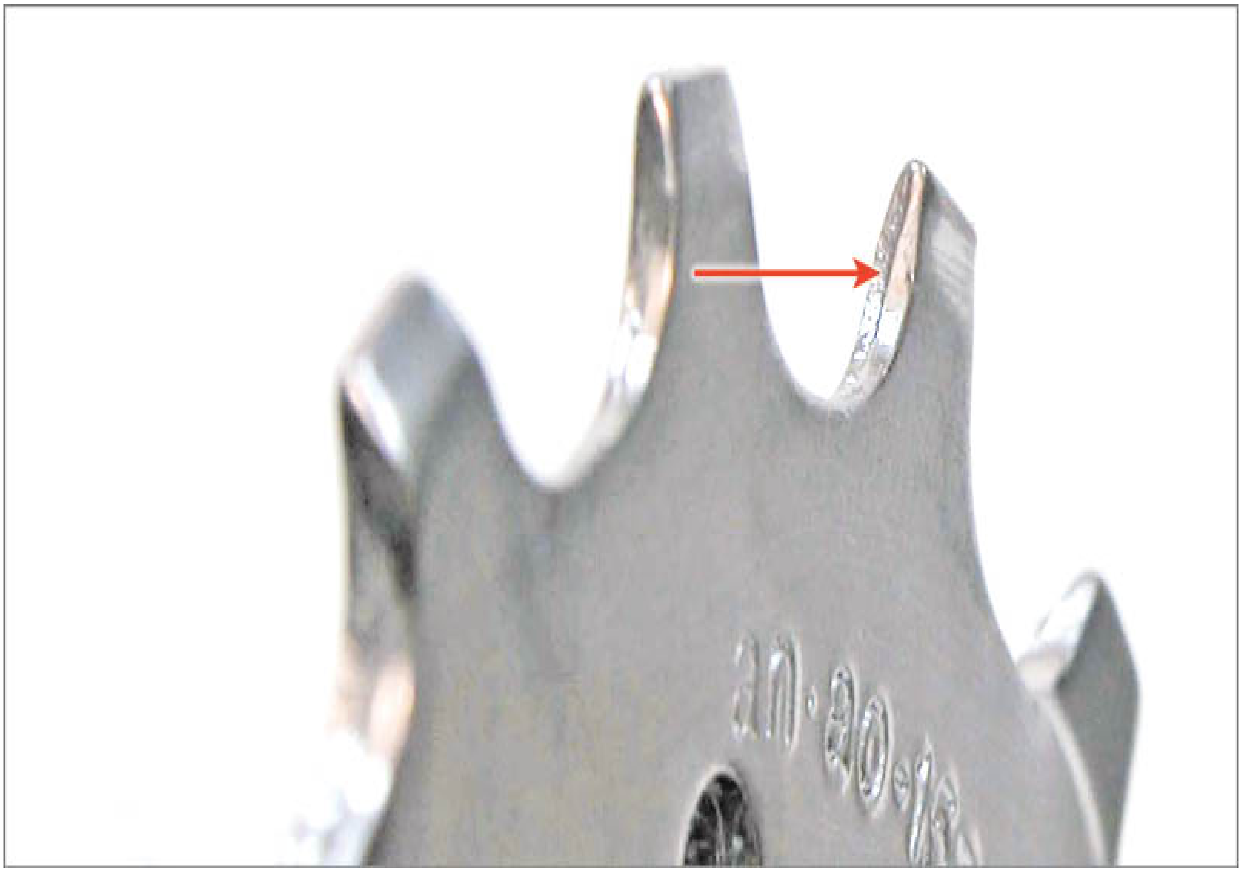


FIGURE 3.16: Sprocket showing signs of original stamping marks indicating very little wear

One-speed bikes will also wear at the rear sprocket. The chain will not skip under load like a derailleur bike, but it will begin to make excessive noise and become less efficient as the teeth become hooked. As sprockets become badly worn, the teeth become hooked and do not easily release chains as it passes over the sprocket.

Rear sprockets and front chainrings require cleaning if the entire drivetrain is to be maintained. Use care not to get solvent into bearings of the freewheel/freehub or bearings of the bottom bracket. Freehub mechanisms and freewheel bodies use ball bearings running on bearing surfaces and small springs and pawls. These component parts are not typically “overhauled” by complete disassembly. The unit may be removed, flushed and scrubbed clean in solvent. The solvent should then be blown out with compressed air or allowed to evaporate. Lubrication is then dripped into the mechanism. Grease is not recommended for freehub or freewheel internals because it may cause the small springs and pawls to stick. If the freewheel/freehub spins roughly after cleaning, the bearing surfaces are worn out, and the unit should be replaced. There typically are no internal parts available for freehubs or freewheels from manufacturers.

Rear sprockets can be cleaned while still mounted to the wheel. Begin by scraping between sprockets with the comb part of the Park Tool GSC-1 GearClean™ Brush (figure 3.17) or a thin screwdriver to remove dirt and debris. Hold wheel so sprockets are tilted downward underneath the wheel, then use a dry stiff bristle brush between sprockets. Dip brush in solvent and scrub sprockets while holding sprockets facing downward. This helps to keep solvent out of the bearings. Use a rag to wipe solvent off sprockets, rim, and tire. Grab two corners of a rag and pull taut. Use this section to "floss" between sprockets.

FIGURE 3.17: Cleaning debris between sprockets with the "comb" of GSC-1

Freehubs can be removed for internal cleaning. This process is described in Chapter 4—Hubs. Although the freehub can be pulled, it is not designed be taken apart down to the bearings and ratcheting pawls. Worn freehubs are replaced, not overhauled.

FIXED GEAR SPROCKETS

A fixed gear is a single-speed sprocket that is locked to the hub shell. When the rear wheel is turning the cog must turn and, consequently, the chain and cranks must turn. Fixed gear drivetrains are used for velodrome racing (track bikes) and some street bikes. It is possible to modulate speed by changing leg speed, but for street use this is not a substitute for a caliper braking system with a hand lever.

Fixed gear cog threading is the same pitch and diameter of common threaded freewheels and will fit hubs threaded for freewheels. However, fixed sprockets are intended for hubs designed with a lockring (figure 3.18). The lockring of a fixed gear hub is slightly smaller than the cog and is left-hand threaded. Because of the left-hand thread of the lockring, it would be self-tightening if the rear cog were to begin loosening. Lockrings only need to be snug; do not overtighten.

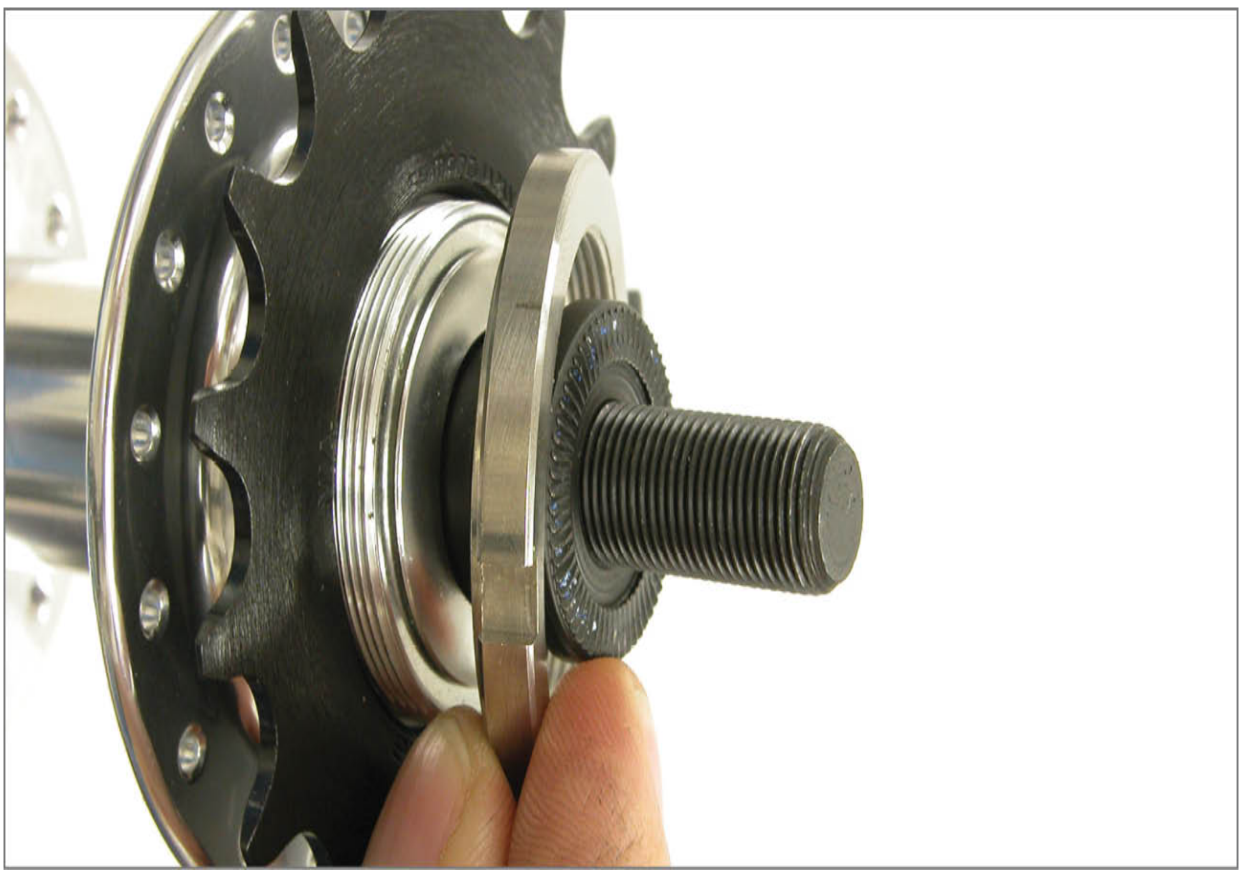


FIGURE 3.18: Lockring and single speed fixed gear cog

Fixed gear sprockets come in 1⁄8 inch and 3⁄32 inch widths (nominally 3mm and 2.4mm, respectively) and must match the chain roller width. To install the fixed cog, grease threads of both the cog and lockring. Thread cog onto hub and tighten with chain whip. Install lockring and snug. Chain length and tension is determined in the same way as a single-speed bike. Chain length on two-sprocket bikes is reviewed in the Repair Help section of www.parktool.com.

TABLE 3.2: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Newly installed cassette skips gears with old chain	Old chain not properly engaging on new sprockets	Install a new chain
Rattling at back of bike with cassette hubs when riding over bumps	The sprockets are loose on freehub body	Remove wheel and fully tighten lockring
Some teeth of cassette appear broken or misshapen	Many modern sprockets are purposely shaped and vary in height to aid in shifting performance	A broken tooth will be uneven and jagged. If teeth are only shorter, it is by design.
Cassette cogs loose on freehub even after tightening lockring	Incompatible cassette or thin spacer missing behind cassette stack	Remove cassette and install appropriate spacer
With cassette lockring removed sprockets seem stuck in place and will not remove	Sprockets have pressed into splines of freehub and created notches	Using one chain whip, hold a larger cog clockwise while using a second chain whip to hold and rotate the smallest cog counter-clockwise to free it from notch. Pry up as needed.
Rear sprockets wobble side to side when wheel is coasting	Slight oscillation from bearing system during coasting spins straight when pedaling	If during pedaling there is no wobble, coasting oscillation considered normal
Sprockets want to move forward even during coasting	1. Freehub body or freewheel body may be internally dirty and binding 2. Hub adjustment is too tight causing binding in freehub with cup-and-cone hub designs	1. Overhaul hub and clean freehub bearings, then relubricate and assemble 2. Check hub adjustment and correct

CHAPTER 4

HUBS

Hubs are mechanisms at the center of wheels that allow the rim, spokes, and tires to rotate in the frame. Hubs consist of an axle assembly, a bearing system, and a hub shell to hold the spokes. Bearings inside the hub shell will require servicing for wear from use, and from exposure to moisture and dirt. An improperly adjusted hub greatly accelerates wear on the bearings.

The hub axle is fixed to the fork or frame, while the hub shell rotates with the rim, spokes and tires around the axle. On derailleur bicycles, multiple rear sprockets are affixed to the rear hub with a clutch mechanism that allows the rider to either coast or to drive the wheel forward. On disc brake bikes, the hub will also hold the disc rotor used for braking. Hubs can also be designed to hold an internal gear system. For internal gear hub systems see Chapter 12—Internal Gear Hubs.

Bikes with "open dropouts" have fork and frame ends with a U-shaped open slot to accept compatible hubs (figure 4.1). Front wheel dropouts accept axle ends of 9mm diameter and rear wheel dropouts accept axle ends of 10mm.

FIGURE 4.1: Open dropout on fork seen without quick-release skewer

Hub width for open dropout hubs is measured where the face of each axle locknut contacts the frame or fork dropout (figure 4.2). It is also called the “over-locknut width.” Hub width is not measured by the length of the axle.

FIGURE 4.2: Measuring rear hub width

Bikes with “closed dropouts” have frame and fork ends with a hole to accept a connecting shaft, called the “thru axle.” Thru axles pass through a dropout, bearing end cap, bearings, and the hub shell to the opposite bearing end caps, and connect into the opposite dropout (figure 4.3). The thru axle is removed fully from the bike to get the wheel out. Hub width on a thru axle hub is measured from the point of contact with the frame or fork, which is outside-to-outside of each hub end cap.

FIGURE 4.3: 15mm axle thru axle hub in 100mm hub width

Typically, inside width of frame or fork should match hub width hub by 1–2mm. It does not harm the frame or fork to either open or close to match the hub by this small amount.

Fork thru axle designs are made in 12, 15 and 20mm diameter standards. Rear hub thru axle designs are commonly 12mm diameter (figure 4.4). Front and rear thru axle width standards are listed in Table 4.1, Hub Standards.

TABLE 4.1: Common Hub Standards

FRONT OR REAR	AXLE / THRU AXLE DIAMETER (MM)	NUMBER OF SPEEDS	HUB WIDTH	TYPICAL USES & OTHER INFO
Open Dropout				
Front	9	N/A	100	Common bikes
Rear	10	1	110	Older track bike, coaster hub
	10	5, or 1 for track bikes	120	Older road bikes and track bikes
	10	6, 7	126	Older road bikes
	10	8–12	130	Modern road bikes, hybrids
	10	6–12	135	MTB internal gear hubs, road disc brake hubs
	10	9–12	140	Tandem
	10	9–12	145	Tandem
	10	10–12	148	Rear "Boost" standard
	10	10–12	160	Tandem
	10	10–12	170	Fat tire rear open
	10	10–12	185	MTB fat tire
	10	10–12	190	MTB fat tire open dropout
Thru Axle				
Front	12	N/A	100	Cyclocross and road
	15	N/A	100	Suspension XC forks
	20	N/A	110	Suspension DH forks
	15	N/A	135	MTB fat tire thru axle
	15	N/A	142	Fork
	15	N/A	150	Fork, MTB fat tire
Rear	12	9	135	Older rear MTB thru axles
	12	9–12	142	Thru axle
	12	10–12	148	Rear "Boost" standard
	12	8–9	150	Older downhill standard
	12	10–12	157	MTB "Super Boost Plus"
	12	10–12	160	MTB
	12	10–12	177	MTB fat tire thru axle
	12	10–12	197	MTB fat tire

FIGURE 4.4: Closed dropout and a 12mm rear thru axle hub

It is possible to manipulate some rear hub designs and change to different over-locknut widths. If the hub uses a straight threaded axle, a new axle of a different length can be installed and spacers adjusted accordingly. Some thru axle designs use replaceable end caps that allow for changes in width. However, the majority of modern hub designs do not allow for changes or manipulation to hub over-locknut widths.

HUB BEARING SERVICE FOR ADJUSTABLE CUP-AND-CONE TYPE

Procedures below are written for adjustable cup-and-cone hubs, including thru axle designs such as those from Shimano®. The procedures and concepts are basically the same for threaded freewheel style hubs using the cup-and-cone design.

Adjustable-type hubs use cone-shaped races threaded onto an axle. Cup-shaped races are fitted into the hub shell. Ball bearings are trapped between the cones and cups. The cone can be adjusted tighter or looser to the ball bearings during the hub adjustment and then locked in place. Rear hubs must allow for sprockets and tend to be more complex than front hubs. Modern freehubs or cassette hubs use a separate clutch mechanism to hold cassette sprockets. These freehub bodies may be removed from hub shells in a separate operation but are normally left in place for axle bearing service.

Ball bearings and bearing surfaces are covered with grease to minimize wear. Parts are shielded from dirt by dust covers and seals. Exposure to the elements will increase wear on the bearing surfaces and shorten ball bearing and bearing surface life. Water is capable of penetrating most hub seals and will carry dirt inside. Hubs should see occasional service to prevent wear and to maximize life.

Hub cones have narrow wrench flats that require a special, thin spanner called a cone wrench (figure 4.5). Cones are made with wrench flats ranging from 13mm to 28mm. For front hubs, the wrench flats on the cone tend to be 13mm, 14mm and occasionally 15mm. In rear hubs, 15mm and 17mm are the most common wrench flat sizes. Thru axle adjustable hubs will use larger sizes. If the locknut is a simple hex nut, use a combination wrench or even an adjustable wrench. Hex locknuts are commonly 17mm or 16mm. However, some locknuts will accept only a cone wrench.

FIGURE 4.5: Cone wrenches are required to service the narrow flats of hub cones

Freehub bodies on rear hubs are lubricated internally with a light lubricant. Avoid getting solvent into the mechanism during hub disassembly and cleaning. Simply wipe the freehub clean of old grease with rags.

DISASSEMBLY

During any disassembly, it is a good idea to take notes or even take parts orientation pictures as you work. Note especially any differences between left and right-side parts. For example, an axle may be asymmetrical with more threading on one side than the other. Make a note of axle protrusion past the locknut face. The parts arrangement of a common Shimano® hub is seen below (figure 4.6).

FIGURE 4.6: Parts of a common Shimano® rear hub: (A) hub shell, (B) ball bearings, (C) axle, (D) locknuts (E) cones, (F) washers, (G) rubber seal

Procedure for hub disassembly:

a. For rear hubs, begin by removing rear sprockets (See Chapter 3—Rear Sprockets).
b. Remove quick-release skewer. For solid axle-type hubs, remove axle nuts. If hub has a disc brake rotor, remove it to avoid contamination

from grease.

c. Inspect axle ends. Measure and note the amount of axle protruding past locknut. For quick-release hubs, counting the number of threads is an adequate measurement (figure 4.7).

FIGURE 4.7: Count the number of threads past locknut face for a reference of axle protrusion

d. Begin dismantling hub from the left side. If available, mount hub in an axle vise. Mount right side of hub down with left side facing upward.

e. Remove rubber cover or seal from left side, if any.

f. Hold cone using cone wrench and loosen locknut counterclockwise. On hubs with oversized axles, inspect axle end for a hex fitting. This is a locking cap locknut. Use a 5mm hex to loosen left-side locknut while holding cone (figure 4.8).

FIGURE 4.8: Loosen any left-side locknut

g. Remove locknut and washers. To make reassembly easier, place parts on a string, piece of wire, or zip tie as an organization aid, in the same orientation as they came off hub (figure 4.9).

FIGURE 4.9: Hold parts together in disassembly order with zip tie or string

h. Remove cone by turning counterclockwise and place on your organization zip tie in same orientation as it came off the axle.
i. Place one hand below right side of hub and lift wheel slowly. Be prepared to catch loose bearings that fall from hub. Place wheel on bench.
j. If inspecting for a bent axle, remove right-side locknut and cones. Note that left-side and right-side cones, washers, and locknuts may be different. Do not confuse left and right-side parts. Use a zip tie or some other method to keep track of parts. Also note axle threading may be asymmetrical. The side with more axle spacers gets more axle thread.
k. Ball bearings may be in a retainer or loose. Count bearings on each side and then use a pencil magnet to remove bearings from hub shell.
l. Leave dust caps in place. Dust caps tend to be fragile and any attempt at removal may result in damage. Use a small brush or a rag used over a small screwdriver to clean inside and under dust caps.

m. Clean and dry all parts. Wipe freehub mechanism using damp rag. Do not soak freehub in solvent unless it is to be removed.

Thru axle hubs with cup-and-cone systems are a variation on the common adjustable hub designs, such as from Shimano®. Inspect for a wrench fitting on the locknut and cone. Both cone and locknut will have wrench flats. Use cone wrenches to remove the locknut and disassemble the cone from the hub shell (figure 4.10).

FIGURE 4.10: Adjustable cup-and-cone thru axle front hub

PARTS INSPECTION

Inspect hub cups and cones for pitting or damage. Use a ballpoint pen to trace the bearing path. Roughness and wear will be felt as the small ball of the pen passes over pits (figure 4.11). Any pitting or roughness in the ball path will only continue to get worse with use. Cones are often available as a replacement part. Inspect ball bearings for brightness. If balls are dull looking, they should be replaced. If the cup in the hub shell is damaged, it typically cannot be replaced, and the entire hub must be replaced. To inspect the axle, roll it on a flat surface and watch for a gap along the axle-to-flat surface area appearing as the axle rolls. Bent axles cannot be straightened and should be replaced.

FIGURE 4.11: Look and feel for pits along ball path of cone

ASSEMBLY

Refer to any notes or photos you made from the disassembly procedure. For example, the axle thread length may vary between left and right side. Do not take apart the cone, spacer, and locknut zip tie until ready to install.

Procedure for hub assembly:

a. Grease axle threads.

b. Apply a thick layer of grease inside hub shell cups. Place ball bearings in both cups and cover with more grease. Make sure balls are seated flat in cup.

c. If all parts were removed from axle, install right-side parts onto axle. Use care to install in the same orientation as they came off. Note rear axle thread length may be asymmetrical. Refer to earlier notes.

d. Adjust right-side cone and locknut to return right-side axle protrusion to the original measurement past locknut face, as noted in disassembly. Tighten right-side locknut fully against cone.

e. Install axle through right side of hub.

f. Install left-side axle parts, using care to install in the same orientation as they came off. Do not set axle protrusion on this side and do not tighten locknut at this time.

g. For quick-release hubs, snug the cone clockwise until it contacts the ball bearings, then turn back counterclockwise one-quarter turn (90 degrees). This will purposely make bearing adjustment too loose. Hold cone with the cone wrench without turning it any farther and, while holding the cone one-quarter turn from snug, fully tighten the locknut. There should be axle play at this early setting. Proceed to Hub Adjustment: Cup-and-Cone.

It is important to check that the threaded axle of an open dropout quick-release hub does not protrude past the dropout face (figure 4.12). The quick-release skewer must press on the dropout, not the axle end. If the quick-release skewer presses on the hub axle end, check the axle alignment between the left and right locknuts or shorten the axle by grinding or filing the ends slightly, if necessary.

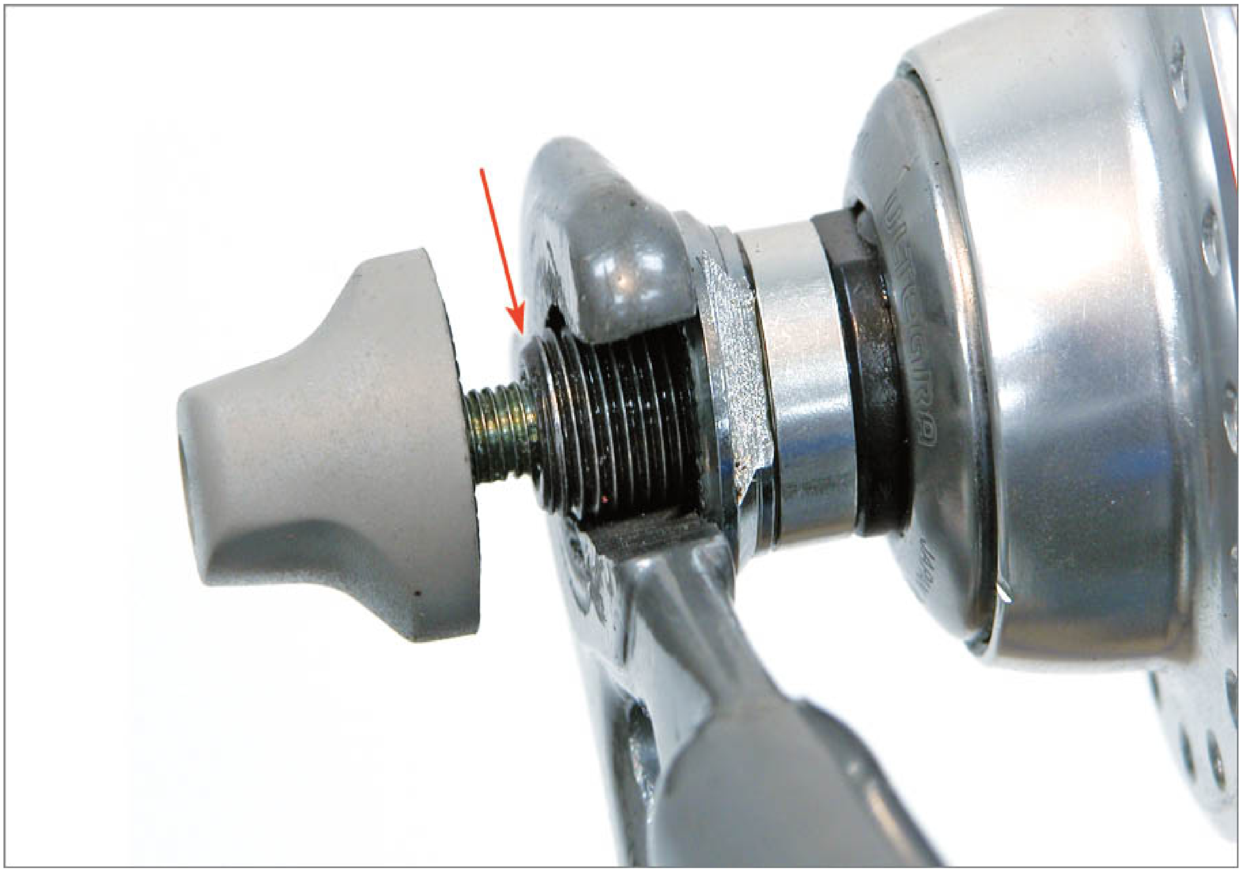


FIGURE 4.12: Any axle protruding past dropout will not permit quick-release skewer to fully lock wheel

HUB ADJUSTMENT

Bearing adjustment is done by moving the threaded cone races closer or away from the cup races. Locknuts then lock against the cone to hold it in place. If the adjustment is overly tight there will be too much pressure on the balls and on the bearing surfaces and the system will quickly wear out. A rear hub bearing that is too tight can also result in freehub drag. If the adjustment is too loose, it will cause play in the wheel and this can also prematurely wear out the hub. Proper bearing adjustment is a precise and sometimes time-consuming job. Several attempts at adjustment should be expected before an acceptable adjustment is found.

It is normal to have play between the internal thread of the cone and the axle external threads. A hub cone will wiggle on the axle thread until the cone locknut is tightened down against the cone. Because of this normal thread play, you must first tighten the locknut against the cone when checking bearing adjustments.

The goal for adjustable bearings is to have the bearings rotate as freely as possible without any knocking or play. When beginning a bearing adjustment, start with it loose and then proceed to tighten the adjustment in small increments until the play disappears. This ensures the adjustment is as loose as possible but is without play. In most cases, try to make small changes, in increments of 1⁄32 of a complete rotation (figure 4.13). Assuming you have the common 32-hole rim, imagine rotating a cone wrench only the angle of spoke to spoke while making adjustments.

FIGURE 4.13: Make only small incremental adjustments to hub bearings

Common threaded quick-release hubs have hollow axles that allow for the quick-release skewer shaft. The axle and axle threads flex slightly when the quick-release lever is closed and pressure is applied to the dropouts, effectively pushing on the cone and tightening the bearing adjustment. Hub bearing adjustments must account for this slight change. For adjustable-type hubs there should be a slight amount of play in the axle when the wheel is out of the bike. This play should disappear when the hub and wheel are clamped tightly in the frame. Thru axle hubs and hub models with large oversized axle systems effectively have no flex. If a slight amount of play does not disappear when the wheel is secured when installed, tighten the bearing so there is no play when outside the bike and the hub is unloaded.

Procedure for hub adjustment:

a. With wheel mounted in the bike, pull rim side-to-side to check for bearing play (figure 4.14). If no play is present, it is necessary to remove and again check for play out of the bike.

FIGURE 4.14: Grab wheel and pull side-to-side laterally to check for knocking of bearing play

b. Remove wheel from bike. Test bearing adjustment by pulling up and down on axle and feeling for play or knocking. If there is no play in the hub when mounted in the bike, and there is play present when hub is outside the bike, the adjustment is adequate. If there is no play in the axle when the hub is outside the bike, the adjustment is too tight. Remove quick-release skewer and springs. Remove any rubber boot covering cones and locknuts on side being adjusted.
c. Secure the right side of the axle in an axle vise, if available.
d. Hold left-side cone with a cone wrench and loosen the locknut.
e. Loosen cone counter clockwise a small amount (1⁄32 turn). Hold cone and secure locknut. If hub feels very tight outside of bike, loosen 1⁄4 turn in order to create play.
f. Reinstall skewer and install wheel into frame/fork. Secure quick-release fully.
g. Test bearing adjustment by pulling side-to-side, checking for knocking.

Play will resonate through frame or fork.

h. If play is felt, remove wheel and remove skewer. Repeat steps “c” to “g,” proceeding with small adjustments, until no play is felt when the wheel is installed.

i. Reinstall any seals or rubber boots removed during disassembly and install wheel in bike. The wheel must be installed with the same quick-release pressure used when checking bearing play.

If an adjustment cannot be found to allow smooth rotation of the axle, the bearing surfaces may be worn out. If play does not disappear until bearing adjustment is very tight, a locknut may not be tight against cone, which will allow movement. It may also be that the bearing cups inside the hub shell have come loose. It may be possible to use a retaining compound behind the cup to resecure it. However, hub or wheel replacement is the best option.

OVERSIZED AXLE SERVICE: CAMPAGNOLO® AND SHIMANO®

Both Campagnolo® and Shimano® are using “oversized” axle designs for select models (figure 4.15). The oversized axle provides a stronger and stiffer connection between front or rear dropouts.

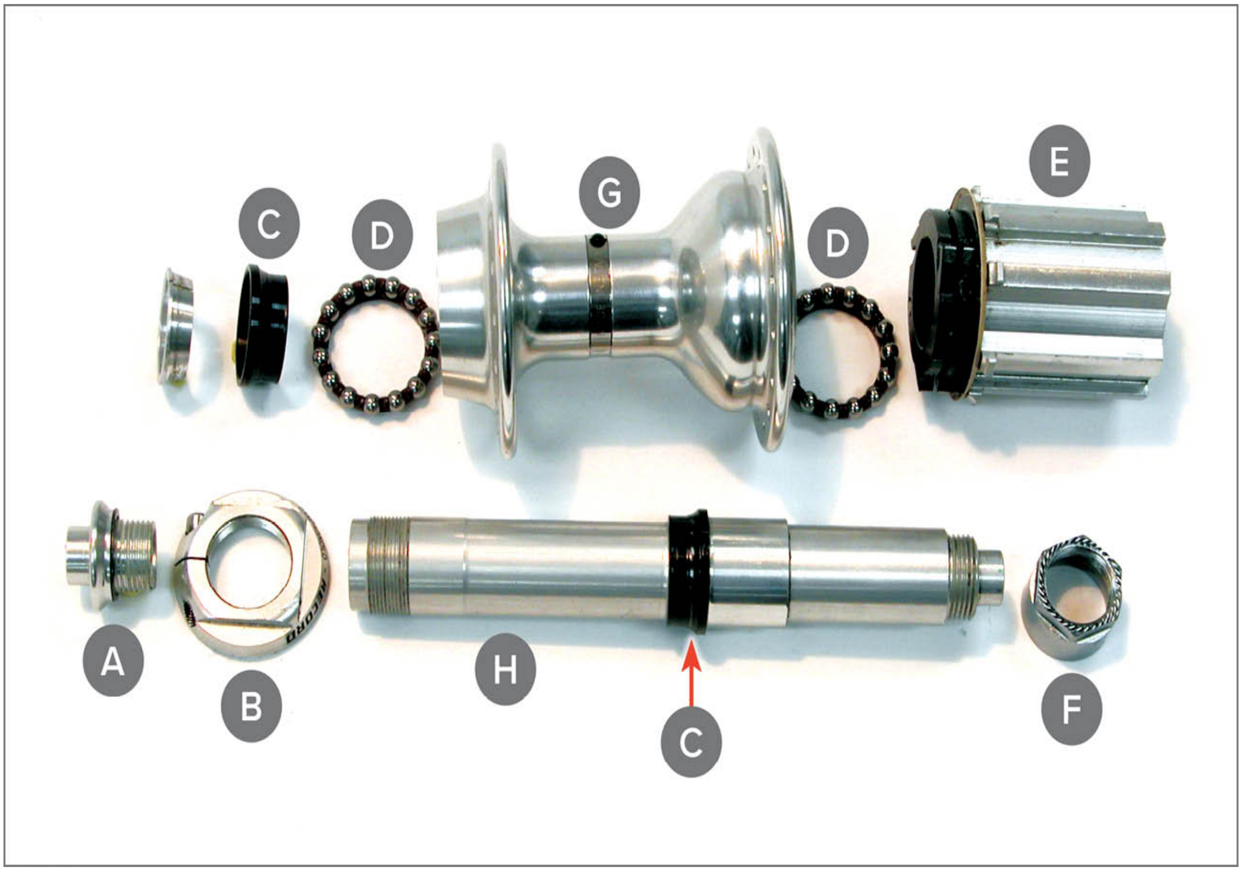


FIGURE 4.15: Component parts of the Campagnolo® Record hub: (A) axle end cap, (B) left-side lockring, (C) cones, (D) ball bearings, (E) freehub, (F) right-side axle nut, (G) hub shell, (H) axle

There are many service features shared between the Campagnolo® and Shimano® oversized hubs. Each uses an oversized aluminum axle with end caps reduced to 10mm. Campagnolo® oversized hubs use unthreaded cones and are similar in concept to threadless headsets. These are locked in place by a sliding compression ring and a lockring with a pinch bolt.

Shimano® uses threaded end caps as the locknut and are removed with hex wrenches. Cones are threaded and are held by the locknut (figure 4.16).

FIGURE: 4.16: Shimano® Dura-Ace® 9000 rear hub threaded cone and axle

Shimano® and Campagnolo® use the cup-and-cone design. The oversized axles do not significantly flex when installed on the bike and the quick-release skewer is closed. The adjustment can be done out of the bike and will be effectively the same as when in the frame.

For Campagnolo® and Shimano® oversized axles service procedures, contact the manufacturer or see the Repair Help section of www.parktool.com.

HUB ADJUSTMENT: SOLID AXLE CUP-AND-CONE

Solid axle hub systems use axle nuts and washers on the outside of the dropouts to hold the wheel in place (figure 4.17). Adjustment of solid axle hub bearings is similar to the hollow axle quick-release type, but there is no need to allow for axle flex. Remove the wheel from the bike. Adjustment for solid axle hubs does not change when mounted in the bike. If no play is present, create play by loosening bearing adjustment. Proceed to adjust tighter in small increments until play is gone. The goal is to find the loosest adjustment that has no play.

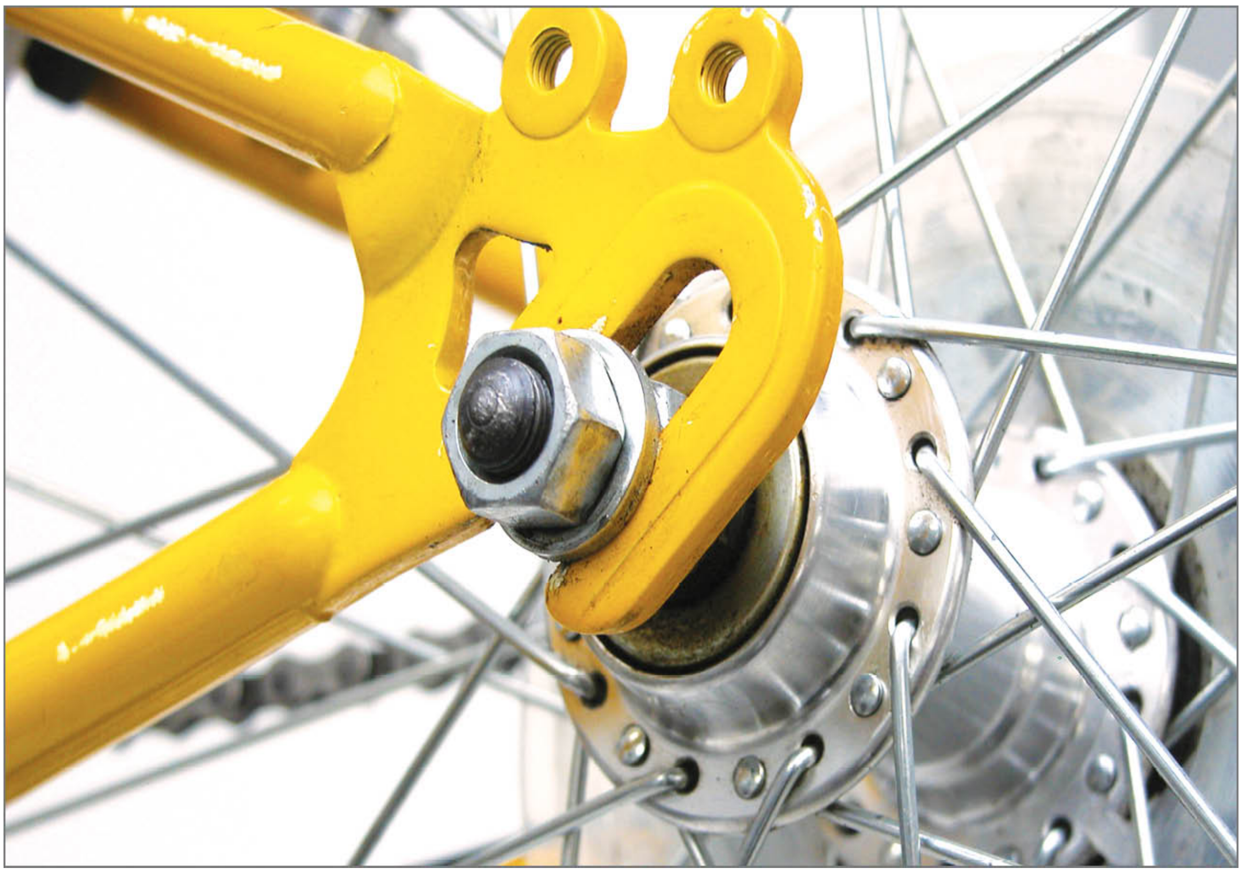


FIGURE 4.17: Solid or non-quick-release axle on derailleur type bike

FREEHUB REMOVAL & INSTALLATION

Hubs designed with a freehub contain a ratcheting mechanism to allow cassette freewheeling. Depending upon the brand and model, the freehub may contain internal parts that eventually wear out or may need lubrication. There are typically no serviceable parts inside most freehubs. Freehubs may be removed on many models for cleaning and relubrication. If this service did not help or solve the freehub problem, the freehub should be replaced as a complete unit.

Removal of freehubs is not a normal part of hub overhaul. Removal procedures vary between hub model and brand. For freehub removal procedures see the repair help section at www.parktool.com.

CARTRIDGE BEARING HUBS

Cartridge-type hubs typically use non-serviceable rolling element bearings, also known as “cartridge bearings.” Round ball bearings are held in a cage between inner and outer rotating races (figure 4.18). Cartridge hubs are generally not serviceable in the sense that they can be taken apart down to the ball bearings, regreased, assembled, and adjusted, as is the case with cup-and-cone hub systems.

FIGURE 4.18: Cutaway of cartridge bearing showing inner races and ball bearings

Although these are also referred to as “sealed bearings,” the seals are simple rubber covers, which can be penetrated by water and dirt. Although the internal parts are not replaceable, if the seal can be lifted off without damage, grease can be cleaned out with solvent, blown dry, and then the bearing packed with new grease (figure 4.19).


FIGURE 4.19: Remove seal carefully from inner edge

When new, cartridge bearings have no play between the inner and outer races. With use the bearing surfaces will wear and eventually develop play. The surfaces can also become pitted, much like any cup-and-cone hub. Once a cartridge bearing surface deteriorates or has play, it will only get worse. New grease will not help such a bearing. The entire cartridge unit should be removed and replaced with a new one.

Cartridge bearing hubs come in many different designs and configurations. This section will discuss basic service concepts that vary with the design of the hub. Details of each brand/model can typically be found at the manufacturer’s website. Additionally, some hub models require proprietary and specialty tools. Service of these hubs is best left to professional mechanics.

Cartridge hub designs typically press the outer race of the cartridge bearing into the hub shell. Bearing removal from the hub shell may involve impact, which can affect the bearing surfaces. If a bearing is being removed, it is assumed it will be replaced with a new bearing and not reused.

For rear hubs, begin service by removing the cassette. If present, remove brake rotors to avoid contamination. During the process, take notes and even take pictures of parts orientation as you work. This can be helpful in getting the hub back together.

Service and disassembly procedures depend upon the hub design. It is necessary to get access to the pressed bearings to remove and replace them.

Two basic cartridge hub designs involve straight axles and sleeved axles. Straight axles match the bearing inside diameter, and pull out of the hub bearings once axle nuts or end caps are removed. Sleeved axles, however, have built-in flanges that sit behind the pressed bearings and cannot be pulled out by hand. A sleeved axle acts effectively as a punch to drive out the bearing from the hub shell.

If there are no obvious external threads, inspect axle end caps for internal hex or external tool fittings or wrench flats. If there are no wrench flats and no internal tool fittings it is likely the caps are pressed in place and can simply be pulled off. Begin by pulling the cap by hand. You can also grab the end cap using inserts such as the Park Tool AV-5 in the jaws of a vise and pull the hub upward (figure 4.20). Using pliers to pull however can leave marring on the cap.

FIGURE 4.20: Use soft jaws in vise to hold end caps while pull up on wheel

Hub designs can also use a pressed cap on one side and a threaded cap on the other. Pull off the cap with no tool fittings and inspect the axle. Hold axle tool fitting while turning the cap (figure 4.21).

FIGURE 4.21: Hold slotted axle on left while turning right end cap to remove

Once left and right-side end caps are removed, for rear hubs pull outward on the freehub body. Work over a table, and pull slowly and watch for any parts that may fall out (figure 4.22).

FIGURE 4.22: Remove freehub by pulling outward

Note orientation of any pawls and springs as the freehub comes off. Again, record notes or take images at this time. Note and record any spacers on the axle behind freehub.

With end caps and freehub removed, attempt to simply pull axle from hub, first from one side, then the other. If the axle does remove, it is likely a sleeved axle. These axles are driven out using a mallet. However, first inspect bearings on both sides. If you can see the outer bearing surface, it can be driven out. For example, if any C-clip over the bearing blocks the view of the outer bearing edge, it must be removed (figure 4.23)


FIGURE 4.23: Inspect for and remove any C-clip using snap ring pliers

For rear hubs, also inspect the drive side and the freehub ratchet system. If the ratchet system is smaller than the outside diameter of the bearing, it will require special tools to remove (figure 4.24). Contact the hub manufacturer for this tool.

FIGURE 4.24: Swiss® ratchet rings require a proprietary tool from the manufacturer for disassembly

For sleeved axles, a direct and firm impact is needed with the plastic head of a hammer to drive the axle and opposite bearing from the hub shell. Begin by impacting the longer axle side to remove the non-drive-side bearing (figure 4.25). Front hubs typically can be driven from either side.

FIGURE 4.25: Drive axle from drive side with a mallet

After the one bearing is removed from the hub, slide bearing off the axle, and use the axle to remove the remaining bearing (figure 4.26).

FIGURE 4.26: Use sleeved axle as a punch to remove second bearing

For hubs using threaded end caps, be aware these can be either left-hand or right-hand threading. If unsure begin assuming it removes counterclockwise. If there is movement but you do not feel a loosening, attempt turning the opposite direction.

After removing either end cap, straight (non-sleeved) axles typically will pull out. With the axle out of the hub shell, bearings are now removable. Use a bearing puller if available. A workaround is to use a punch and hammer from the backside of the bearing to walk it out. Tap first on one side, then tap again 180 degrees across. Repeat tapping back and forth as it walks out of the shell. Repeat on the opposite side (figure 4.27).

FIGURE 4.27: Use punch and hammer to walk bearing out of hub shell by alternating impacts

FREEHUB BEARINGS

The hub design may include cartridge bearings inside the freehub. These can be difficult to remove. If the freehub bearings turn smoothly, simply leave them in place as they are. If the bearings are worn out, begin by finding a way to hold the freehub body. Freehub bodies can be aluminum, so work with care to avoid damage. Hold the body, for example, as you would a bike seat post in the clamp of a repair stand, grabbing the outside in the radius jaws.

As with the hub, you can use a punch and hammer from the backside of the bearing to tap it out. Tap first on one side, then again on the opposite side. Repeat tapping back and forth as it walks out. The second bearing can be driven out using a drift from the backside. Reinstall new cartridge bearings by pressing them in evenly into the freehub body.

ASSEMBLY

Installation of cartridge bearings in the hub shell typically involves an interference fit. Bearings will be slightly larger than the hub shell. A specialty pressing tool is the best option. It is possible to use steel sockets that match the bearing race diameter as drifts (figure 4.28). For example, if the interference fit is on the outer race of the bearing, the driving tool diameter must match the diameter of the outer race of the bearing.

FIGURE 4.28: Installing bearing by socket matching bearing outside diameter

Again, if the bearings were removed, the assumption is they are being replaced.

Bearings used by hub manufacturers vary in outside diameter, inside diameter, and thickness. If two different makes of cartridge bearings match in their specifications they can typically be used without issue.

For assembly, reverse the order from disassembly, referring to any notes or images from disassembly. For sleeved axles, one bearing is first installed, then the axle, and then the bearing is installed. Grease any pressed surfaces to assist pressing.

Bearings are best installed with a special tool set, such as the HBP-1 Hub Bearing Press. Find the drift that closely matches the outside diameter of the bearing being pressed. The HBP-1 can be used to press one bearing at a time, or both bearings together (figure 4.29). Select a drift that closely matches the bearing outside diameter. The axle will act as a guide between the bearings to keep them centered and straight. Because the axle protrudes, use spacers to fit over the axle to allow for pressing.

FIGURE 4.29: Installing bearings with bearing press HBP-1

Freehub pawls or ratchets typically require a light grease or oil. Use lubes such as HPG-1, a lighter viscosity grease. Grease that is too heavy can cause drag in the freehub as it coasts and may cause pawls to stick and not engage while pedalling.

Double-check to be sure all springs and pawls are in place on the freehub.

Engage the freehub over the axle and slide into place inside the hub shell. Rotate the freehub counterclockwise as it is engaged into the hub shell (figure 4.30). If simply rotating the freehub does not engage the pawls, slow the rotation as you push. Use a seal pick to push each pawl that is not engaged as you rotate. This will cause the pawl to fall into the internal ratchet.

FIGURE 4.30: Slide freehub on axle and rotate counterclockwise while engaging into hub shell

Lubricate inside end caps and reinstall caps over axle. Check disassembly notes as caps are likely to be asymmetrical. Match finished hub to notes and images before disassembly. Axle should turn smoothly when rotated.

TABLE 4.2: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Wheel moves laterally back and forth at rim	1. Loose adjustment at hub 2. Loose skewer or thru axle adjustment	1. Tighten bearing adjustment 2. Correctly tighten skewer or thru axle
When spun without brake rub, wheel slows quickly	Hub adjustment too tight	Loosen adjustment
Wheel turns roughly and/or rumbling felt or heard at frame/fork	Bearings badly worn	Replace bearings
Cartridge bearing wearing out quickly	Overly tight preload adjustment	Replace bearings and adjust preload correctly

CHAPTER 5

WHEEL TRUING

Bicycle wheels act as ball bearings between the frame and the ground. Wheels allow the bike to roll forward as we pedal. Straight, round wheels add to the bike's performance. Some adjustment to the wheel runout (true) is possible by making adjustments to tension. Non-serviceable bladed spoke wheels or large carbon disc wheels have no truing adjustment or repair options like traditional wire spoke wheels.

Bicycle wheels are composed of a hoop or rim that is suspended by spokes around the hub. Each spoke is under tension and pulls on a limited section of rim. Spokes coming from the right-side hub flange pull the rim both toward the hub and to the right side. Spokes coming from the left-side hub flange pull the rim toward the hub and to the left side. Spokes are oriented at the rim in a left-right-left-right pattern to counter the pull from each side or flange. Having spokes tight with relatively even tension makes the wheel spin straight. Changes to spoke tension will change the amount of pull on the rim where the spoke attaches and affect its position or "true." The process of changing spoke tension to correct rim runout is called “truing.” Professional mechanics will use tools such as truing stands, centering gauges (dishing tools), spoke wrenches, spoke tension meters, and their experience to adjust spoke tension and produce a durable and strong wheel (figure 5.1).

FIGURE 5.1: Equipment used by professional mechanics

Wheels are under constant stress when used, and occasional truing will keep the rim running straight. Spoke tension is adjusted by tightening or loosening a threaded nut, called the “nipple,” at the end of the spoke. Nipples are turned with a spoke wrench (figure 5.2). Although a common phrase among mechanics is to “tighten the spokes,” it is the nipples that are turned, not the spokes. Turning the nipple changes tension on the spoke, much like any nut or bolt.

FIGURE 5.2: Spoke wrenches are available in different sizes and shapes

Wheels not only help us go, they also help us slow. Caliper rim brakes such as linear pull, cantilever, side pull and dual pivot brakes use the rim sidewall as the braking surface. Brake pad adjustment is difficult and often futile with an out-of-true or wobbly wheel.

WHEEL TRUING OVERVIEW

When truing, it is especially important to use a correctly sized wrench. Spoke nipples are typically made of brass or aluminum, both of which are relatively soft materials. Nipples may be square shaped and come in different sizes. A wrench that is even slightly too large will easily damage the nipple by rounding the corners (figure 5.3). Use a caliper to measure across the nipple flats and purchase the correct size wrench. There is no correlation between spoke diameter and nipple size. See Table 5.1, Spoke Wrench Fit. If you own spoke wrenches of different sizes, use the smallest that will fit, even if it seems to slow down putting the wrench on the nipple (figure 5.4).

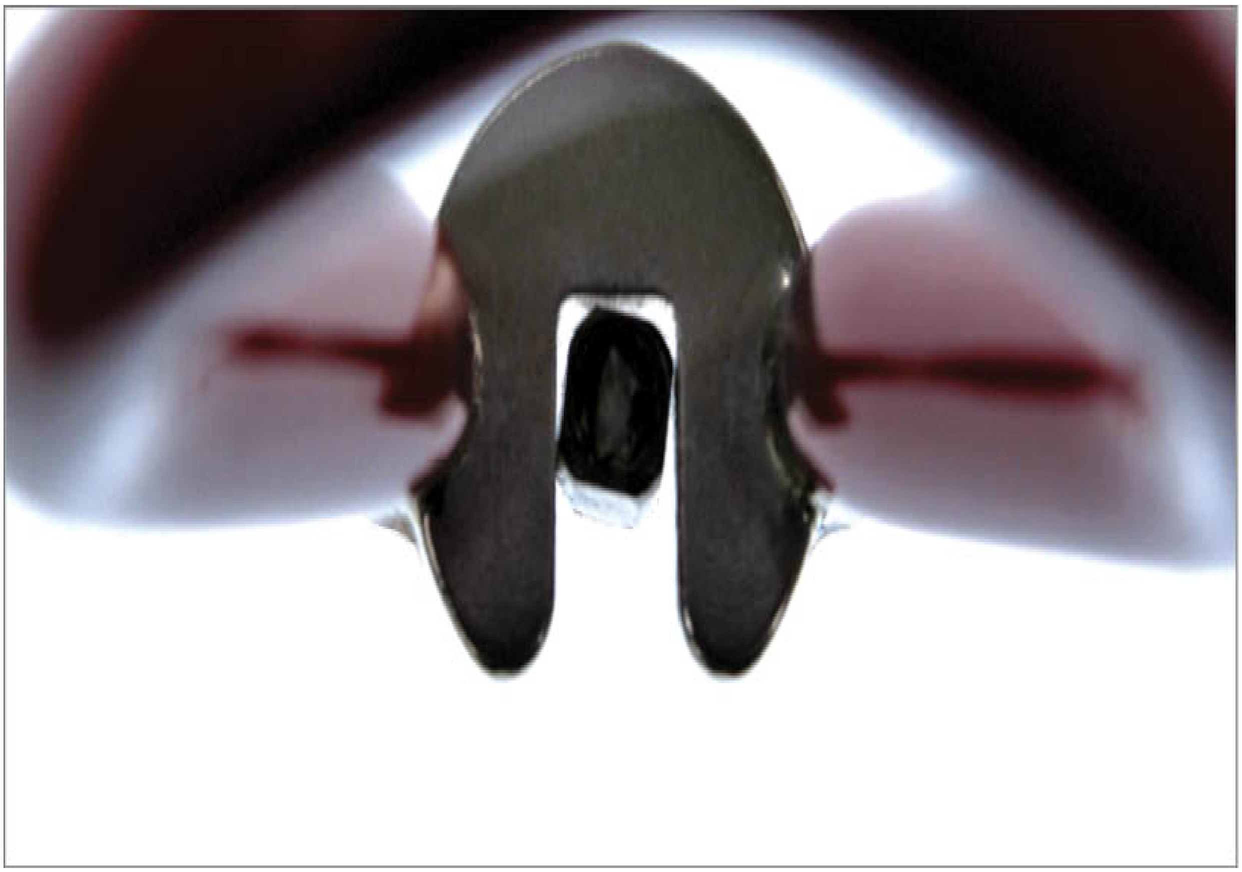


FIGURE 5.3: An oversized wrench for the wrench flats of the nipple

FIGURE 5.4: Properly sized wrench for nipple wrench flats

There are some styles of nipples made with a special pattern or size. In some cases the wrench may be available only from the nipple manufacturer.

There are also some styles of nipples that fit internally, inside the rim. It is necessary to remove the tire and rim strip to access the nipple head in order to fit a tool to the nipple for adjustment (figure 5.5). The internal nipple head may be a 3.2mm square shape, or a hex shape in 3⁄16 inch (4.7mm), 5mm, 5.5mm, or 6mm.

FIGURE 5.5: Truing a rim with internal nipples

Park Tool produces numerous spoke wrench options. If you intend to purchase one wrench, it is best to measure across the nipple flats. If it is a round nipple with splines, count the number of splines as well as measure the outside diameter. See Table 5.1 for sizing detail.

TABLE 5.1: Spoke Wrench Fit

NIPPLE TYPE	SIZE	PARK TOOL WRENCH
Square	3.23mm	SW-0 or SW-20 (black)
Square	3.3mm	SW-1 (green)
Square	3.45mm	SW-2 (red)
Square	4.0mm	SW-3 (blue)
Square	3.75mm	SW-14.5
Square	4.4mm	SW-14.5
Square internal	3.23mm	SW-15 or SW-16
Hex headed internal	3/16 inch (4.7 mm)	SW-16.3
Hex headed internal	5mm	SW-15 or SW-17
Hex headed internal	5.5mm	SW-15 or SW-18
Hex headed internal	6mm	SW-19
External hex	5.5mm	SW-11
External hex	6mm	SW-11
Six-splined round (Mavic®)	5.7mm OD	SW-13
Seven-splined round (Mavic®)	6.4mm OD	SW-12
Six-splined round as grommet for square nipples (Mavic®)	9mm OD	SW-12 or SW-13
Six-splined round (DT Swiss® Tricon)	3.9mm OD	SW-5 (gray)

There are four basic aspects of wheel truing: lateral true, radial true, rim centering over the hub (dish), and spoke tension. A properly trued wheel will have all four aspects adjusted evenly for best performance.

LATERAL TRUE

Also called “lateral runout,” this is the side-to-side rim wobble as the wheel spins (figure 5.6). This aspect is the most critical for rim brake caliper settings. Too much runout will make it difficult to set the rim brake pads without the pads rubbing the rim. Extreme runout problems result in the tire hitting the frame or fork.

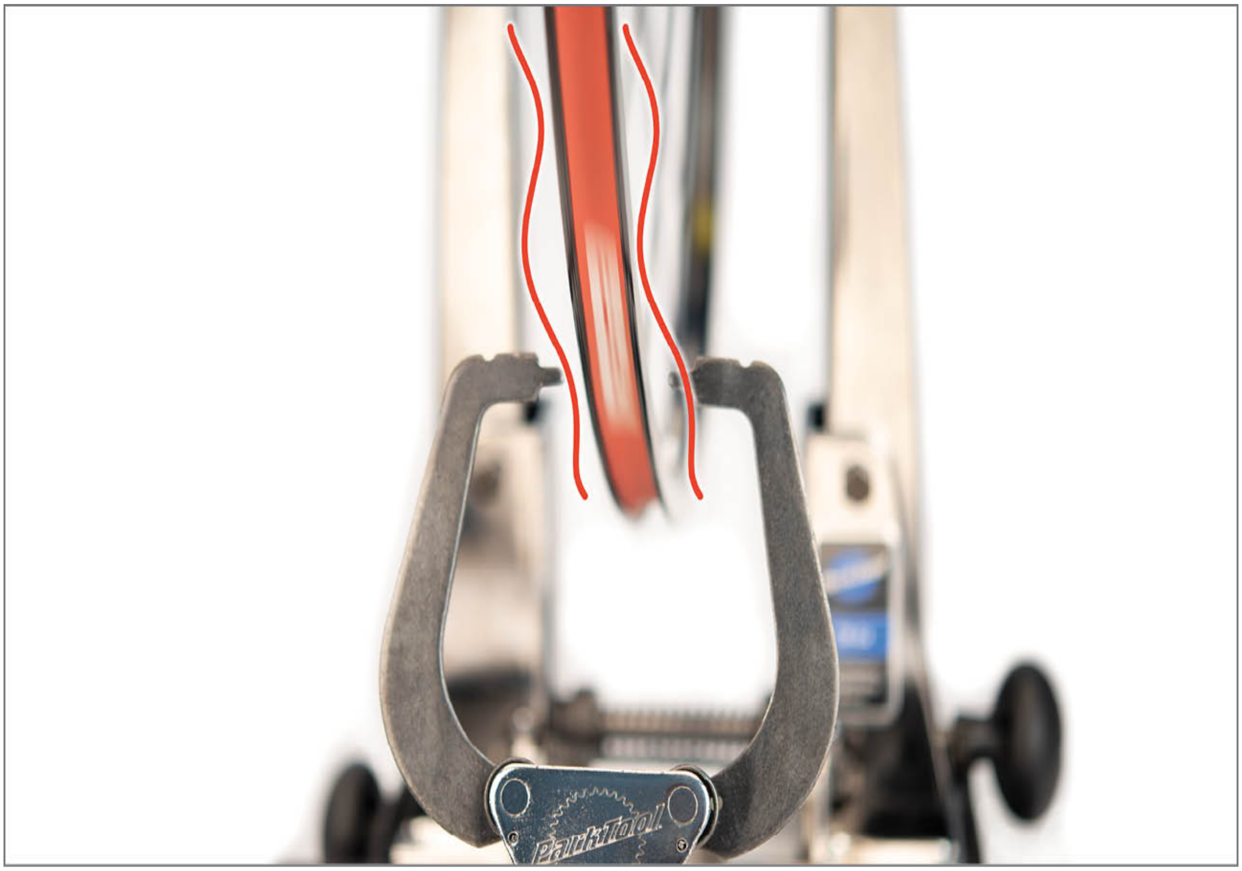


FIGURE 5.6: Lateral runout is side to side movement in a spinning rim

RADIAL TRUE

This is the amount of "vertical runout" or "hop" (figure 5.7). If the wheel becomes out-of-round, it moves or hops up and down with each revolution. In severe cases this will affect brake pad placement and can be felt by the rider as a bump every wheel revolution.

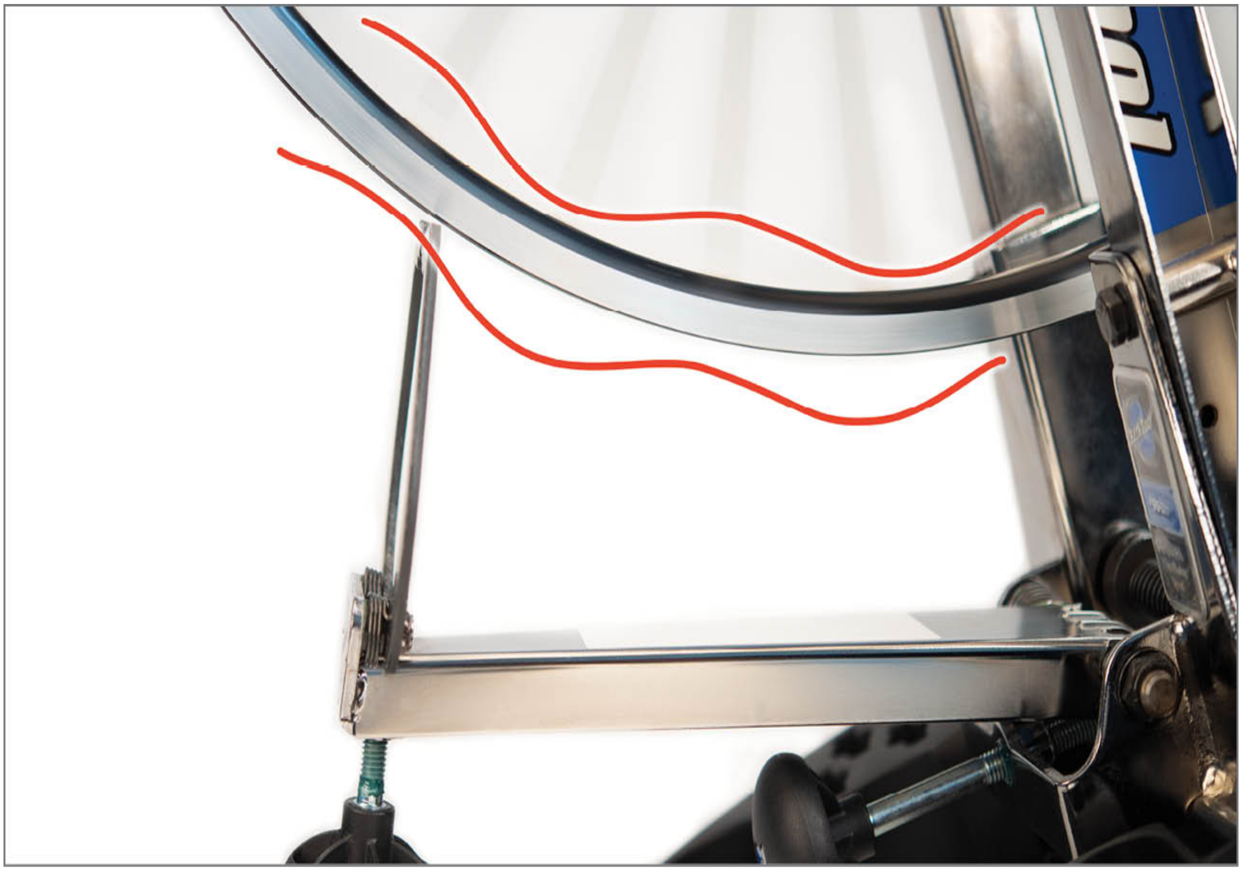


FIGURE 5.7: Radial (round) runout seen as inward and outward motion in the rim

RIM CENTERING (DISH)

Rims should be centered to the middle of the fork or rear frame. If the rim is offset left or right from this, it may be difficult to adjust rim brakes. Severe cases of misalignment can cause handling problems because the front and rear wheel won't track in a straight line (figure 5.8).

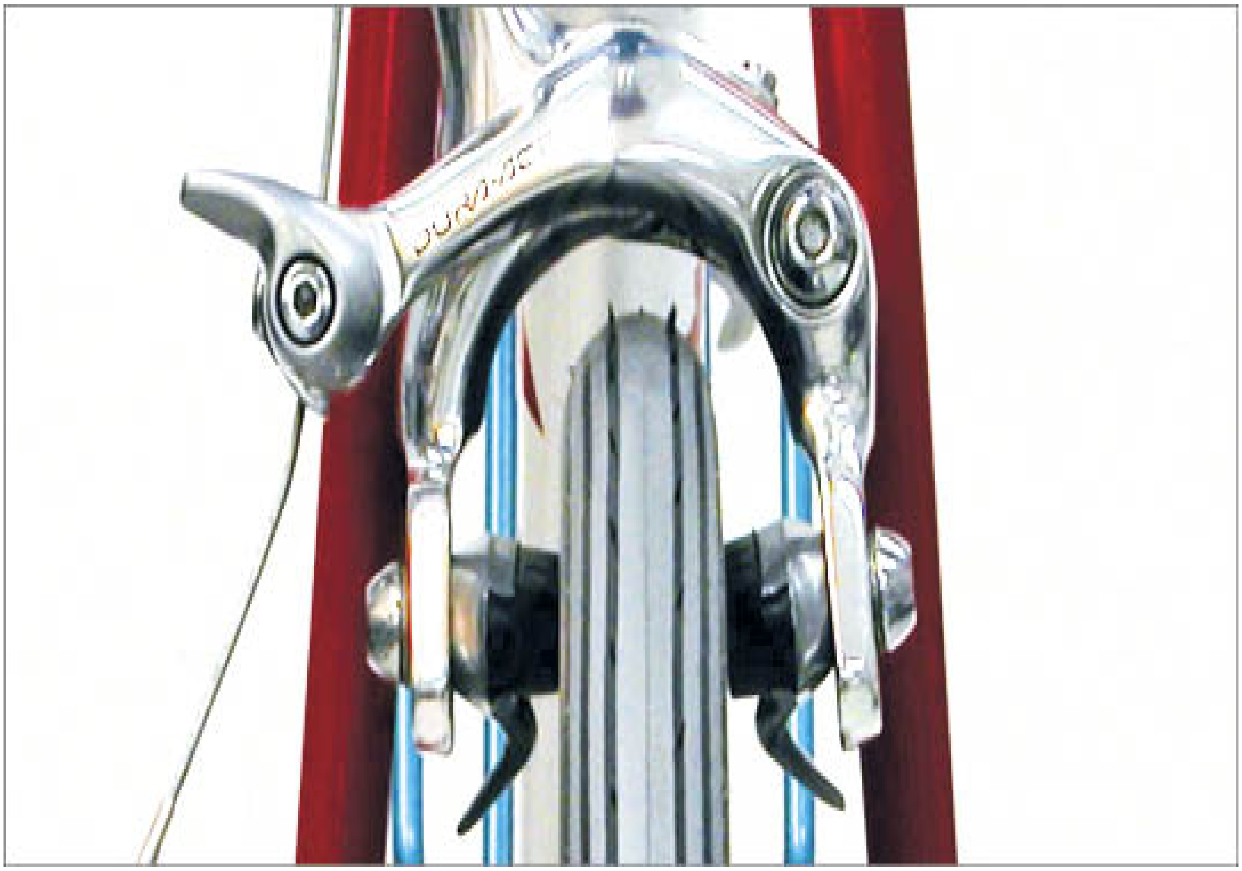


FIGURE 5.8: Center error with wheel sitting too far to right side

TENSION

This is simply spoke tightness. Spokes are tensioned just like other fasteners. Spoke tension is best measured using a tool called a spoke tension meter (tensiometer) such as the Park Tool TM-1, which flexes the spoke using a calibrated spring (figure 5.9). With experience, spoke tension can be roughly estimated by squeezing pairs of spokes and feeling the deflection.

FIGURE 5.9: Spoke tension measurement with a tensiometer

TRUING PROCEDURES

It is useful to use a steady pointer as a reference, such as one found on a truing stand, when sighting rim movement and deviations as the rim turns. Park Tool truing stands allow easier and faster work when truing. The truing stand uses a caliper indicator as a reference to gauge rim runout. If no truing stand is available, it is possible to use anything that will hold the wheel as steady as a truing stand. The bicycle frame or fork itself may also be used. Use the brake pads if there are rim brakes, or use a zip tie to create an indicator as a reference gauge. Secure and snug a zip tie at rim height on each side of the seat stay or fork blade. Cut the zip tie to a length able to touch the rim (figure 5.10).

FIGURE 5.10: Use zip ties for reference indicator if truing stand is unavailable

Before making any adjustments to spoke tension, use a light lubricant to oil the spoke threads and the hole where the nipple exits the rim (figure

5.11). Limit the flow of lubricant, as it only takes a small amount. This will reduce the effort of turning the nipple to tension the spoke. Clean any lubricant from the rim and rim braking surfaces after truing.

FIGURE 5.11: Use gravity to draw down a small drop on thread of spoke and allow it to drip to rim-nipple interface

When truing, it is critical to get the spoke wrench fully engaged on the nipple before turning. A wrench that is only partially engaged may damage the nipple and make further truing difficult. When truing a wheel, the wrench and nipples may be viewed and adjusted upside down. This happens if the wrench and nipple are viewed and adjusted below the axle center. The wrench will appear to the mechanic as turning to the left when tightening the nipple. Do not allow this to confuse you. Keep in mind that the nipple is rotating around the fixed spoke. Imagine a screwdriver at the nipple end and turn it clockwise or counterclockwise as required (figure 5.12).

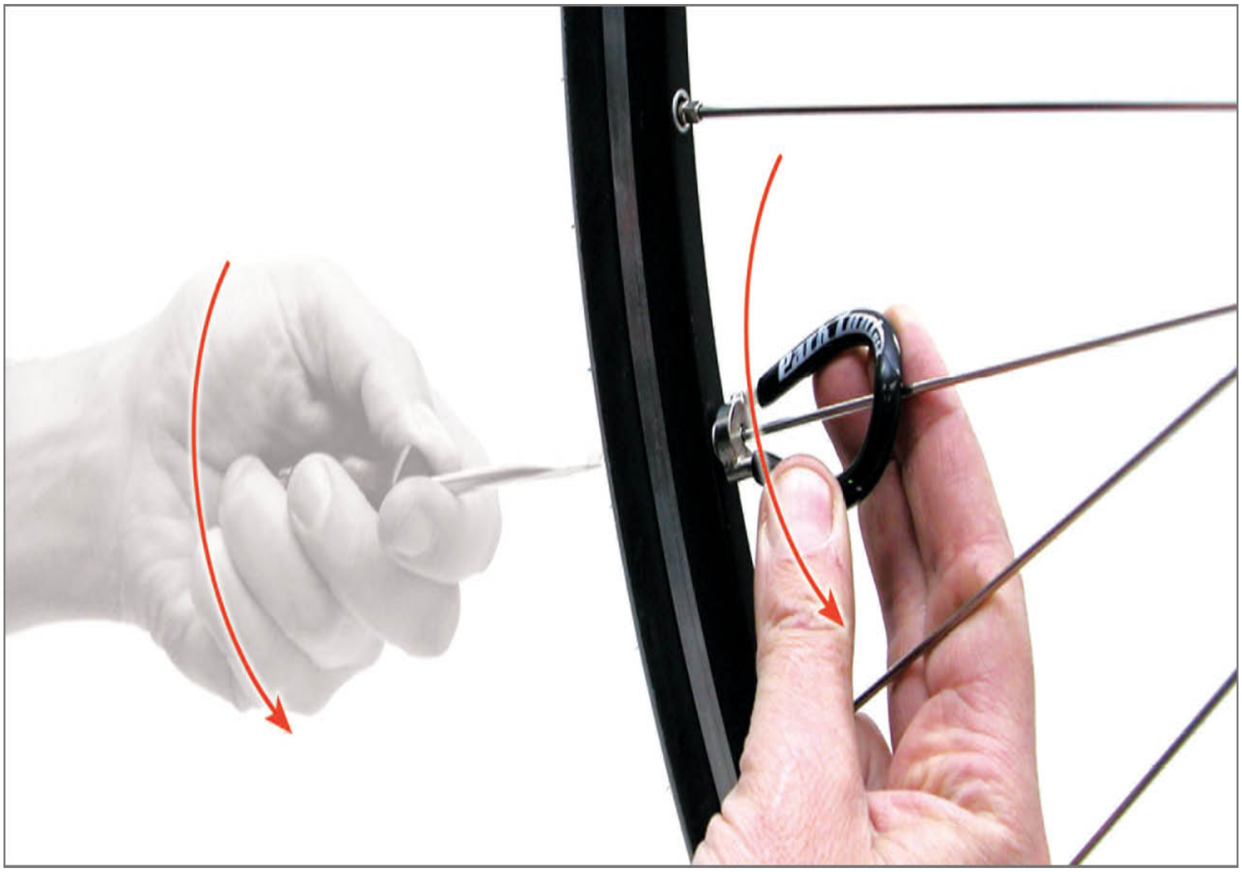


FIGURE 5.12: Visualize turning the wrench as if a screwdriver is turning the nipple

There are some models of wheels where the nipple is located at the hub flange. These wheels true the same as conventional wheels. Tightening a spoke will draw the rim towards the hub flange side where it connects. The threading of the spokes and nipples is still a right-hand thread, and nipples tighten clockwise as seen from the orientation of the nipple.

Bladed or flat spokes add to the complexity of truing. If a bladed spoke is not held while the nipple is turned, the blade may twist until the flat section is at an angle to the front of the bike. Use a pair of small pliers, a small adjustable wrench, or a bladed spoke tool such as the Park Tool BSH-4 Bladed Spoke Holder (figure 5.13) to prevent the spoke from twisting.

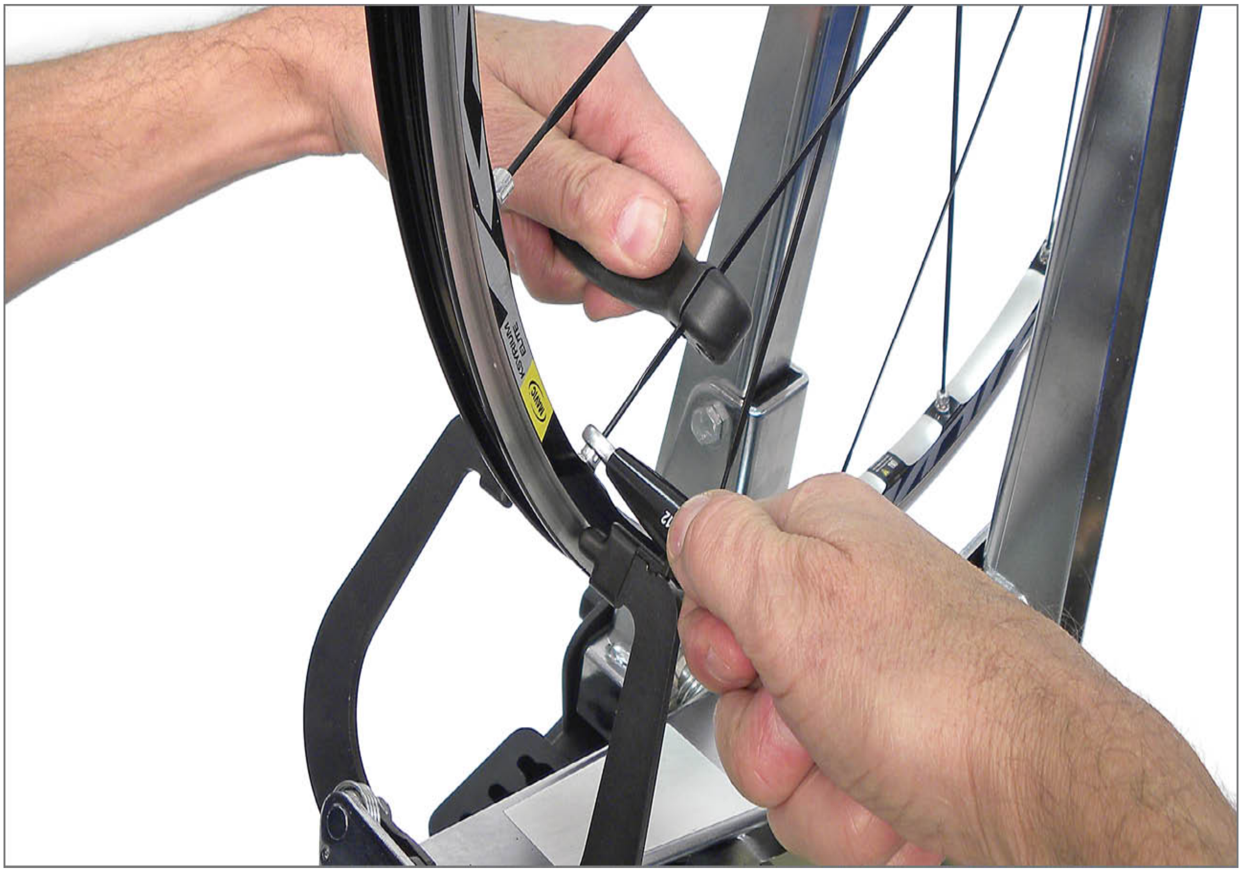


FIGURE 5.13: Use Park Tool BSH-1 to prevent bladed spoke twisting

As spokes are connected from the hub to the rim, they create a pattern, called “lacing.” The common pattern results in a weave effect as spokes from the same flange radiate outward at a tangent. Some spokes radiate clockwise, and a second set radiates counterclockwise. The spokes are joined at the rim with an alternating pattern of left-right-left-right. However this is not the only lacing pattern possible. Spokes can be joined at the rim in a pattern of two right-side spokes, then one left, then two right, etc. Each spoke still pulls on a small section of rim.

Figure 5.14 is a “mechanic’s eye” view of the wheel in a truing stand. The spokes have been labeled and seen here as L3, L4, L5, L6 and L7. These are on the left side of the rim and come from the left-side hub flange. Spokes R3, R4, R5, R6 and R7 are on the right and come from the right-side hub flange. Left-side spokes pull the rim toward the left. Their pulling is offset by the pull of spokes on the right. Each nipple affects a relatively wide area of rim. For example, spoke L4 pulls mainly at the rim nipple hole, but this spoke also affects the rim up to and even past L3 and L5. Turning nipple L4 to increase spoke tension will move that section of rim to the left. Turning nipple R5 to increase tension will move that section of rim to the right. Loosening nipple L4 will also move the rim right because of the constant pull of R5 and R4. While it is possible to manipulate several spokes to correct the same rim error, a person new to truing should consider making one type of adjustment at a time. After some experience, the mechanic can use both tightening and loosening of different spokes in the same correction.

FIGURE 5.14: Use changes in spoke tension to move sections of rim

LATERAL TRUING

Lateral or side-to-side truing is the most commonly required truing procedure. Lateral runout shows up relatively well when viewed from the side, such as at the rim caliper brake pads. Tightening or loosening spokes at a section of rim can change lateral rim movements. Inexperienced mechanics should generally tighten nipples when correcting deviations. Tightening the spoke tension will typically produce more rim movement while making these corrections.

Wheel rims do not need to spin perfectly straight with zero lateral runout in order to be completely serviceable. Most wheels will be adequately true if they wobble laterally less than 1⁄16 inch (1mm) and if the rim does not strike the brake pads. More experienced mechanics may get the lateral tolerance down to 0.5mm or less. While achieving very low runout is enjoyable for some people, it does not necessarily help bike performance.

Procedure for lateral truing:

a. If a truing stand is available, remove wheel from bike. Alternatively, mount wheel in bike and attach zip ties on each side of rim at seat stays or fork blades. If wheel requires extensive truing, remove tire.

b. Place wheel in truing stand. Move indicators close to sidewall of rim.

c. Spin wheel and inspect for left-right deviations.

d. Adjust indicator of truing stand (or zip tie end) so that it lightly touches rim in one area. Work off of either left or right side.

e. Stop wheel where rim and one indicator are closest or touching. This area is the largest lateral deviation of rim runout and should be corrected first. If the area of lateral error appears to be large, select only one spoke at the middle of deviation for the first correction.

f. Rotate rim back and forth past indicator and find center of rim deviation. It is easier to see runout as it moves toward (or rubs) an indicator or it, rather than as a deviation that moves away from an indicator (figure 5.15). Use either a left-side or a right-side indicator.

FIGURE 5.15: Isolate rim lateral deviation

g. If rim deviation moves toward left side, find right flange nipple at rim closest to center of deviation. If rim deviation moves toward right side, find left flange nipple closest to center of deviation.

h. Tightening this spoke will move rim deviation in this section of rim. Tighten selected spoke nipple 1⁄4 to 1⁄2 turn. A 1⁄4 turn is a 90-degree turn of nipple, while a 1⁄2 turn is a 180-degree turn. Spin wheel and check deviation again. It is often necessary to repeat process at one area. Do not tighten more than 1⁄2 turn at a time. It is better to proceed in small increments and to check progress between each nipple tightening by spinning wheel.

i. Locate another side-to-side deviation using indicator. Repeat process of finding center of deviation and correcting deviation by finding and turning nipple from spoke of opposite flange.

j. After making three corrections on one side of rim, switch to other side indicator. This will help maintain previous wheel centering.

k. Continue making corrections. To check tolerance, adjust indicator so it just barely rubs rim in one area. Spin wheel slowly from this point and inspect for largest gap between indicator and rim. This area is worst left-to-right lateral deviation. If this gap appears less than 1mm (approximately thickness of a dime), wheel is adequately trued laterally. In some cases, it will be necessary to continue truing for tighter tolerances.

l. If only lateral true is being adjusted, clean rim braking surface with a solvent such as rubbing alcohol or window cleaner. If frame-mounted zip ties were used as indicators, cut and remove these from frame.

RADIAL TRUING

When viewed squarely from the side, the rotating rim may appear to have sections that move inward and some sections that move outward relative to the hub. This can also be thought of as an up-and-down movement. This radial aspect of the wheel can be affected by spoke tension, again because there is some flex possible in the rim hoop. Sections of rim moving away from the hub are called “high spots.” Sections of rim moving toward the hub are called “low spots” or “flat spots.”

It is easier to see radial errors and easier to make corrections without the tire in place. Truing indicators show error directly off the rim sidewalls. With experience and practice, it is possible to do some radial corrections with the tire in place. This is a useful skill when working with a tubeless tire wheels, or a glued tubular wheel. In these cases, use the rim surface on the inside edge, which is the hub side.

If the tire has been removed, use the indicator on the rim outer perimeter. Move indicator close to the outer edge and spin the rim. As the rim spins move indicator even closer so there is light contact. This is the highest spot relative to the hub.

High spots can be corrected by tightening (shortening) spokes from both flanges in that area to move the affected area toward the hub. In figure 5.16, there is a section of rim moving outward, a high spot, at spokes L3 and R2. Tightening (shortening) these two spokes will move that section inward. If the high area were long, tighten L2, R2, L3 and R3.

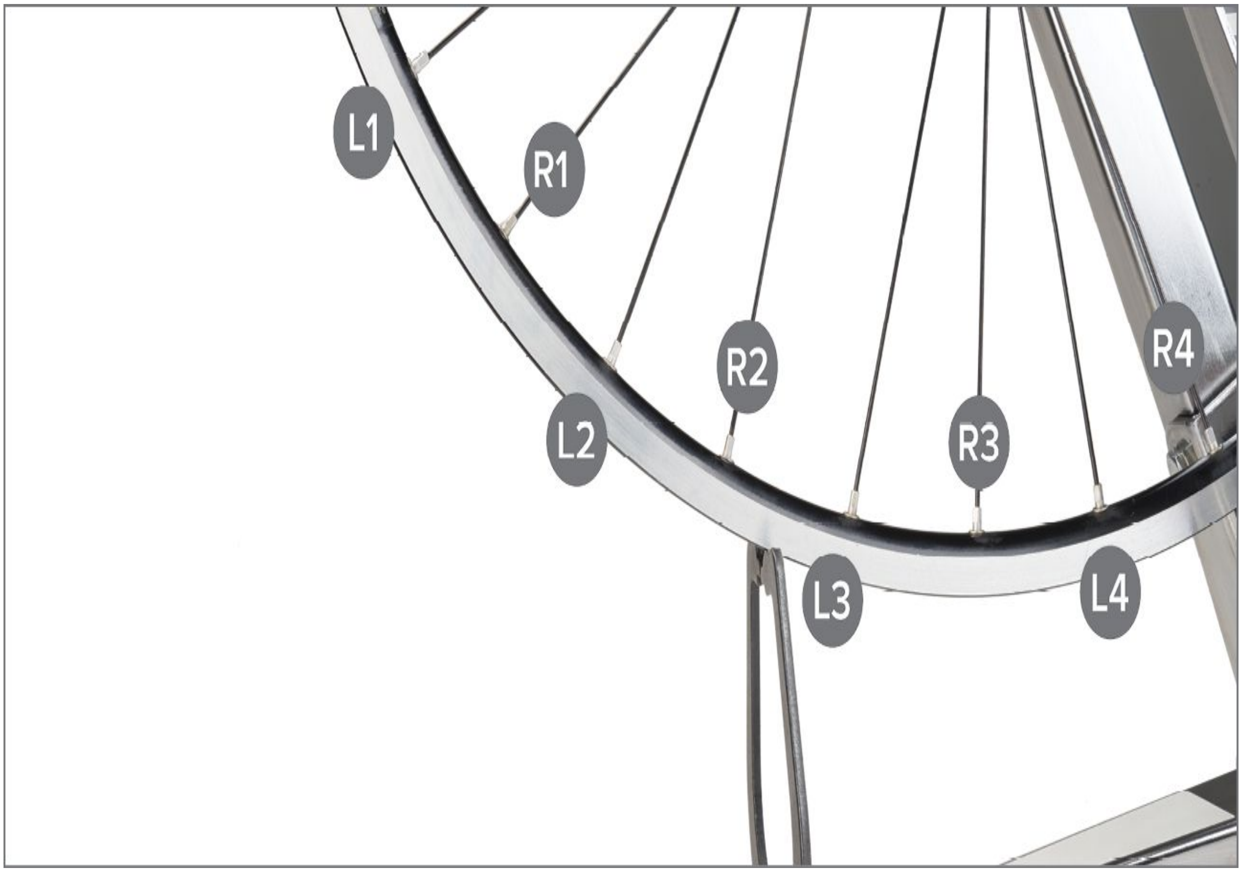


FIGURE 5.16: Correct radial error using both left and right-side spokes

As with low spots, it is typically best to work using pairs of spokes, one from the left side and one from the right side. By working with adjacent left-right spokes there is less of a tendency for the wheel to become laterally out of true. However, always double-check the lateral true after making three or four radial corrections.

In a different example, a section of rim along spokes L5 and R5 is a “low spot” or a “flat spot,” because the rim moves slightly toward the hub as it rotates past the indicators (figure 5.17). Correct this radial issue by again using spokes from both flanges. By loosening (lengthening) spokes L5 and R5, this section of rim will move outward. Because there is tension on the rest of the wheel, this area will tend to move outward. However there are limits on what can be corrected. If there is a flat spot at L5 and R5, and these spokes are found to be already loose compared to the rest of the wheel, it indicates this rim section has been bent inward and not simply flexed inward from differences in spoke tension. The wheel may have struck a hole or rock and the rim has been pushed inward. Loosening spokes in this case is unlikely to have much effect, and the rim will likely need to be replaced to be much better. This type of damage is typically not repairable. Replacement of rim or wheel is recommended. See Chapter 6—Wheel Building or a see a professional mechanic.

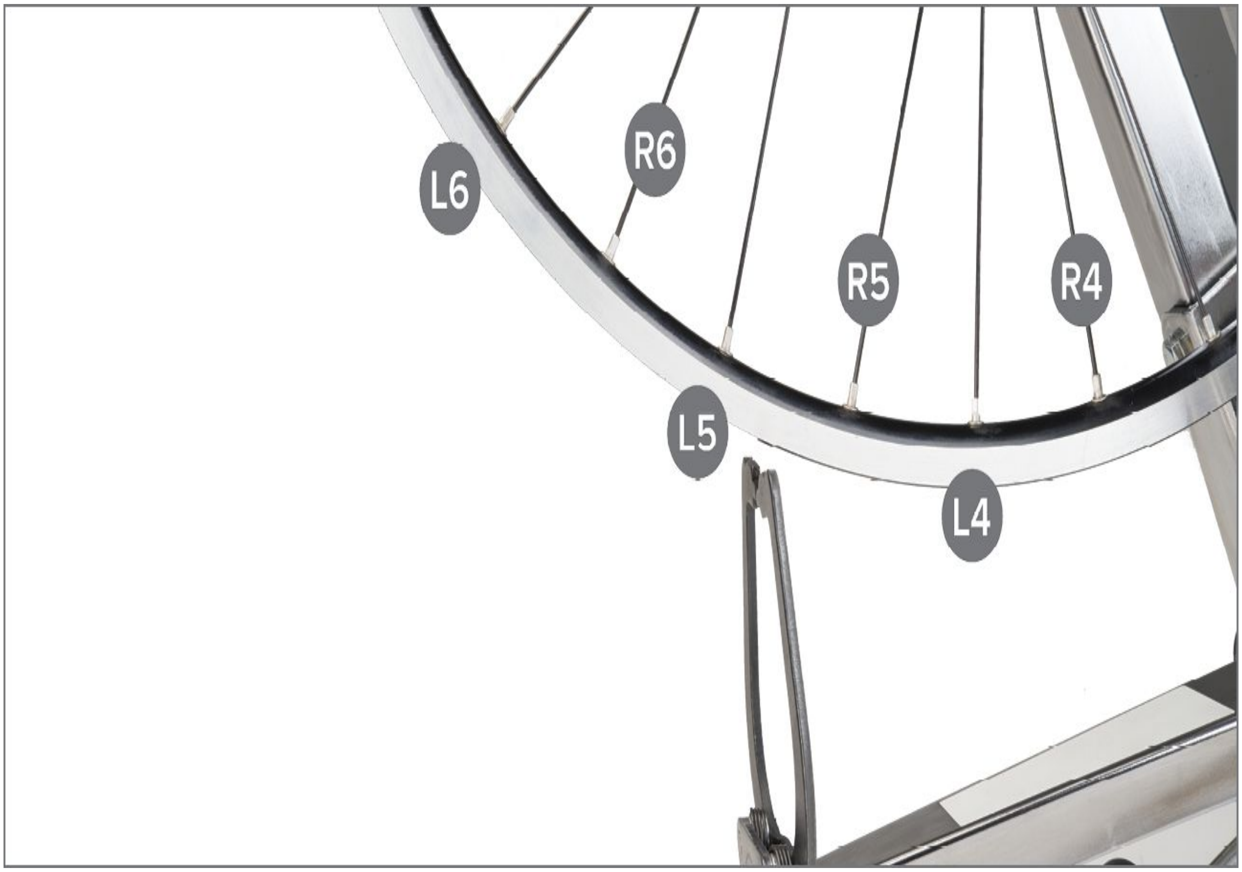


FIGURE 5.17: Correct radial error using both left and right-side spokes

Procedure for radial truing:

a. Remove tire from wheel.
b. Mount wheel in a truing stand or mount wheel in bike frame and attach zip tie indicator to frame. Position zip tie close to outer edge of rim.
c. Bring indicator or zip tie close to outside edge of rim.
d. Spin rim and bring indicator slowly closer to rim until there is a very light rub. This point is the largest high spot or radial deviation away from the hub.
e. Stop rim at light rub. Move rim back and forth through rub and locate

center of deviation. This section of rim needs to move closer to hub (figure 5.18).

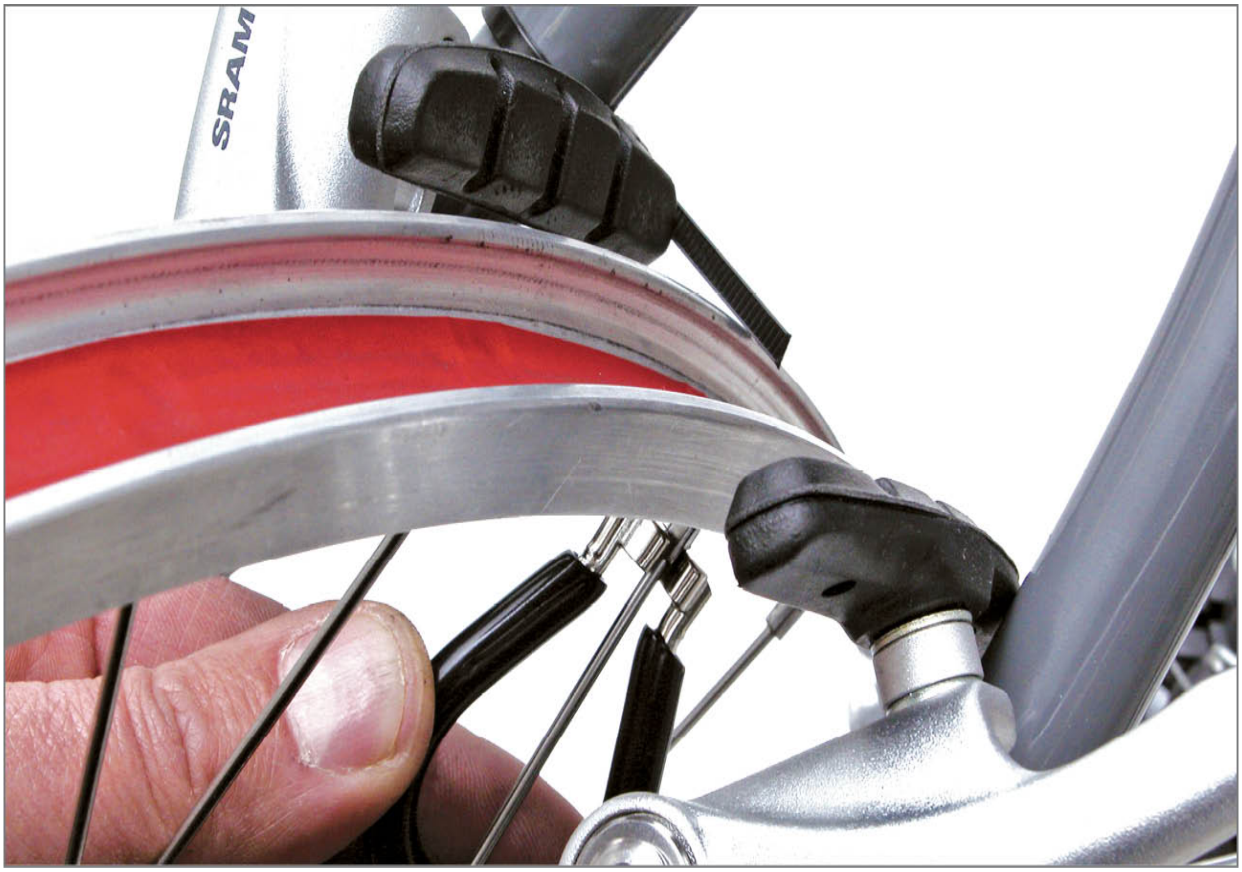


FIGURE 5.18: Isolate radial runout and select left-right pair of spokes to correct

f. Tighten two spokes in middle of deviation. Tighten one left-side and one right-side spoke, each the same amount, beginning with 1⁄2 turn.

g. Rotate rim back and forth through selected area to view impact of your adjustments. Repeat tightening if necessary.

h. Spin wheel and move calipers slightly closer to rim to find next deviation. Correct rub by tightening a left-right pair of spokes at center of rub.

i. After making three radial corrections, stop and double-check lateral true. Correct lateral true as needed before proceeding with further radial adjustments.

j. After making several radial corrections to high spots, rim may show only areas moving toward hub or low spots. It will be necessary to loosen low spot areas. Spin rim and move caliper to create a light continuous scrape. Areas not scraping are low spots and need to move away from hub to be corrected. Isolate center of worst low spot.

k. Loosen two spokes on either side of the center of low spot. Spokes should be adjacent left-side and right-side pairs.

l. Repeat procedure on other low spots. Occasionally check and correct lateral true. Check for acceptable radial tolerance. Adjust indicator so it just barely rubs rim in one area. Spin wheel slowly from this point and inspect for largest gap between indicator and rim. This area is the largest radial deviation. Wheel is adequately trued for round when the deviation from highest to lowest is less than 1mm (1⁄16 inch).

m. Check and correct lateral true as needed.

n. If no other truing is to be done, clean rim’s braking surface with a solvent such as rubbing alcohol or window cleaner. Cut zip ties from frame. Reinstall tire and reinstall wheel in bike.

WHEEL CENTERING (DISHING)

The rim of the wheel should be centered relative to the front fork blades or rear stays. If a wheel is off-center, bike tracking, or handling will be affected, especially when cornering.

Use a ruler and measure from the left and right stay or fork blade to the rim. If distances are equal and the rim looks centered, it is likely adequately centered. If the hub is fully seated in frame/fork, and there is a greater distance from one stay or blade compared to the other, the wheel is off-center, or "misdished."

The rim can be moved relative to the frame center by adjusting spoke length and tension. Remember, spokes from the left flange pull the rim toward the left, while spokes from the right flange pull the rim toward the right. Tightening only left-side spokes evenly will move the rim to the left. Tightening all right-side spokes evenly moves the rim to the right. Alternatively, because there is tension on the rim from both left and right spokes, loosen all left-side spokes to move the rim right. Loosen all right-side spokes to move the rim left.

The most accurate method to check rim centering over a hub is with a centering gauge or "dishing tool," such as the Park Tool WAG-4 or WAG-5 Wheel Dishing Gauge. A dishing tool is always more accurate than a wheel truing stand. The Park Tool WAG-4 comes with two sliding blocks on the feet. These blocks allow the tool to measure off the wheel rim even when a tire is still mounted and inflated.

Procedure for wheel centering with a dishing tool:

a. Note which side of wheel is being checked. In this example, we will assume right side is being checked first and use this as a reference for left side.

b. Place feet of dishing tool on rim and lower sliding indicator until end rests on face of right-side locknut (figure 5.19). Rest indicator on part of hub that will contact frame dropouts.

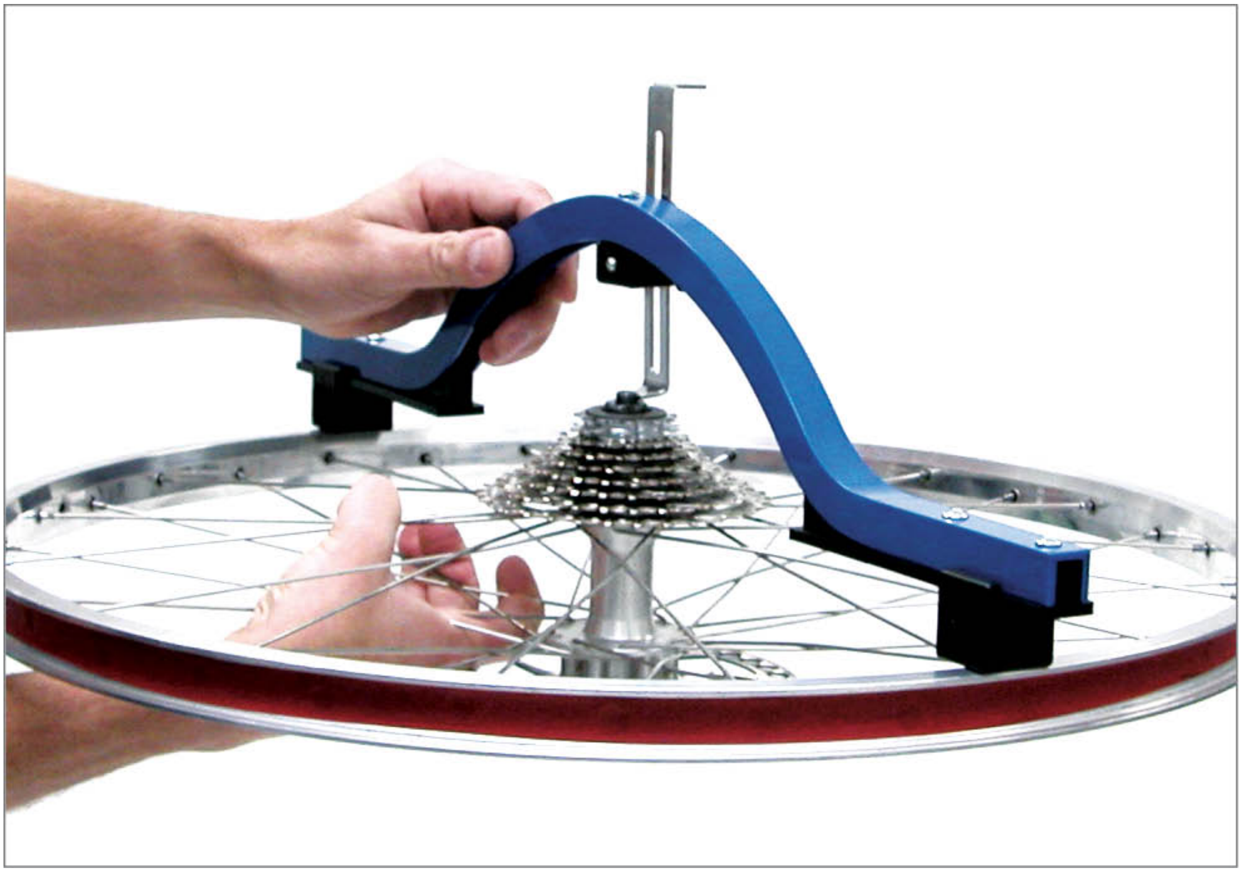


FIGURE 5.19: Set dishing tool to reference right side of wheel

c. Turn wheel over to check left side. Place feet of dishing tool on rim. Note indicator relative to locknut face. There are three possible results:

1. Both feet of dishing tool rest on rim and indicator pointer lightly contacts left locknut face or is within 1mm of it. This rim is adequately centered to locknuts. No correction of centering is required (figure 5.20).

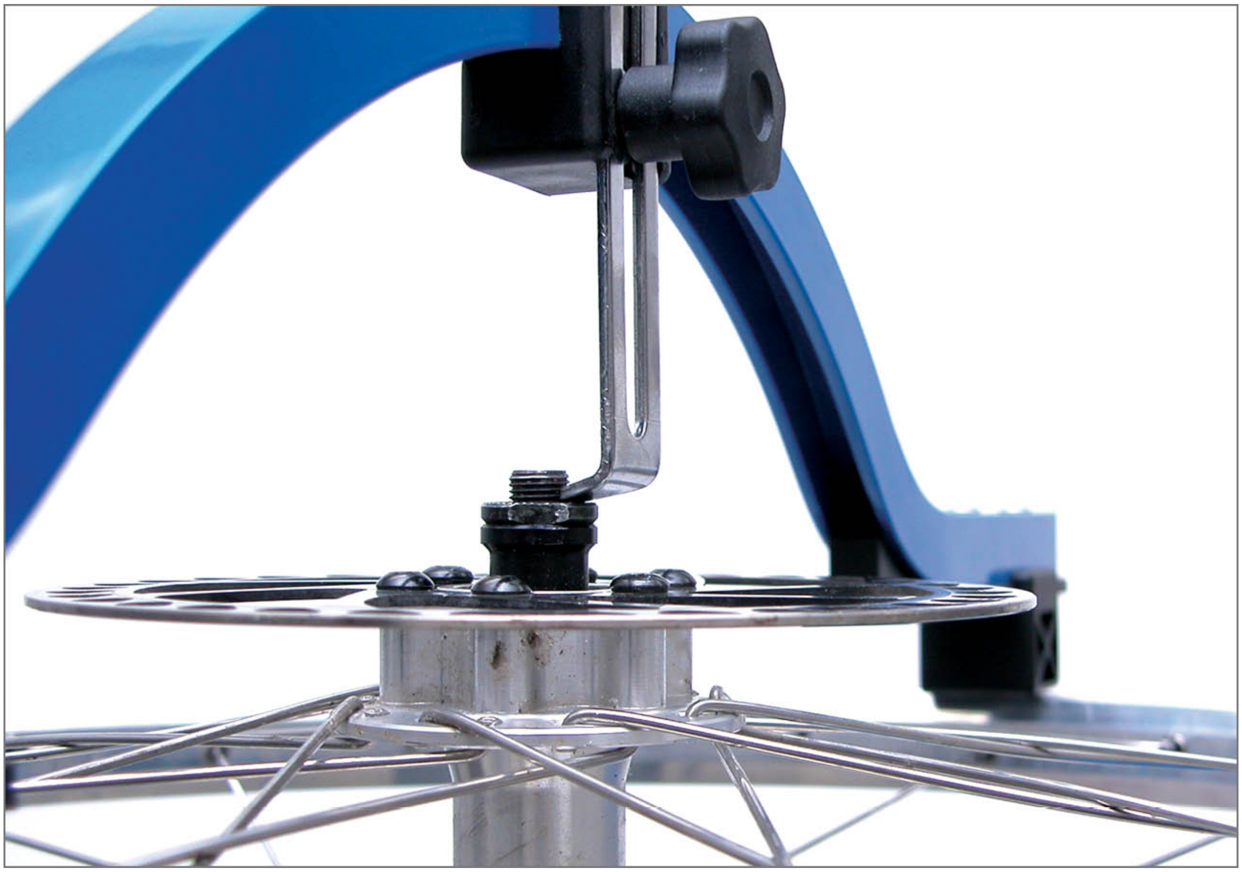


FIGURE 5.20: Three point contact on left indicates rim is well centered

2. Both feet of dishing tool rest on rim, but there is a significant gap between indicator and locknut face (figure 5.21). This indicates the rim is off-center towards the left side. If gap is greater than 1mm, rim should be recentered. In this example, rim should be moved to the right. However, it is less confusing to view any dishing error at rim rather than hub. If after checking wheel there is a gap as described above, reset indicator using left side as the first reference, and then compare this to right side. You will find there is now a gap between rim and one of the dishing tool feet, while indicator rests on locknut face. This method makes it more obvious that rim should be moved towards the tool feet. When viewing a gap between locknut face and dishing tool indicator, the rim is actually pulled away from that locknut face in order to correct the error.

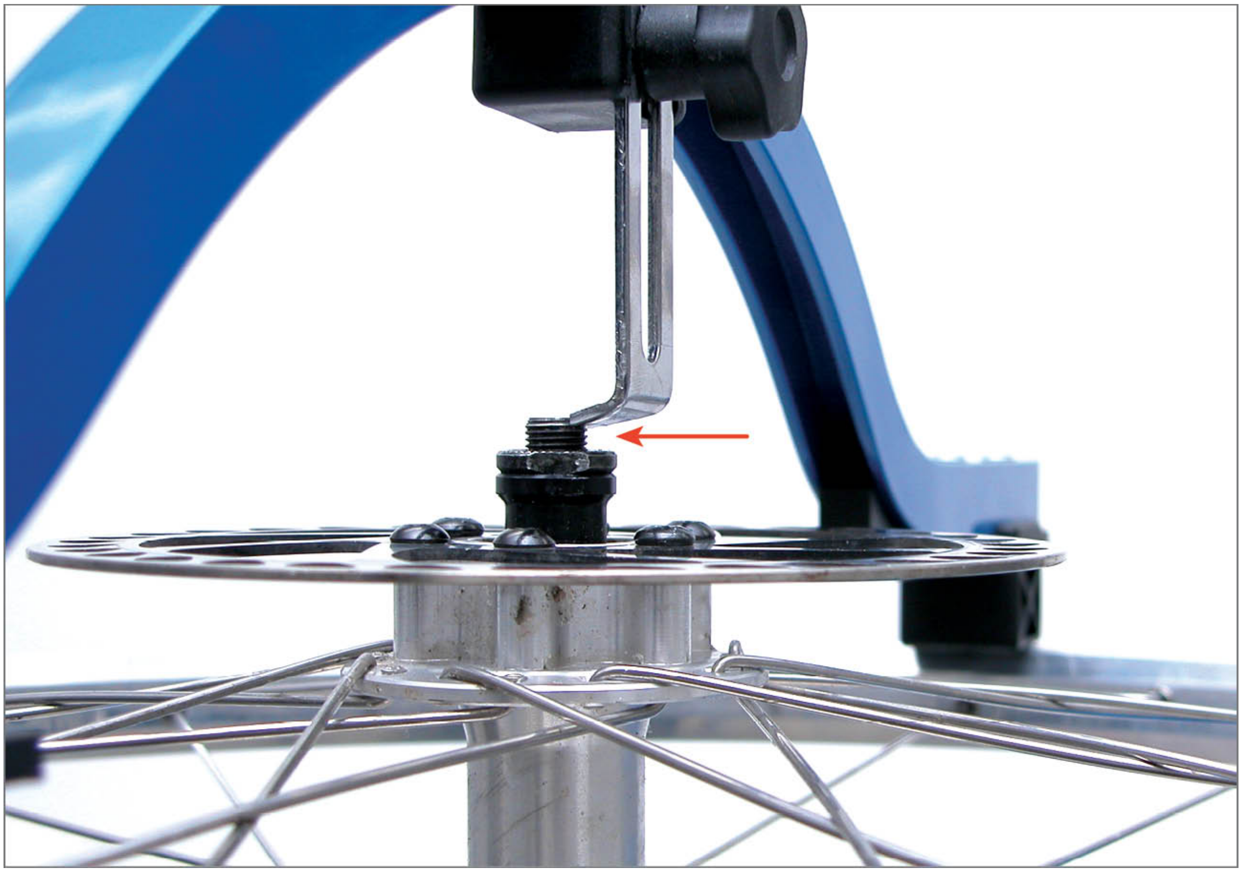


FIGURE 5.21: Gauge indicator showing rim centering error relative to locknut face

3. The indicator is unable to contact the locknut face while both feet are resting on rim. When indicator does contact locknut, only one foot rests on rim, leaving a gap between rim and opposite foot (figure 5.22). This indicates rim is off-center towards the right side. Adjust spoke tension to move rim to left to close gap between dishing foot and rim.

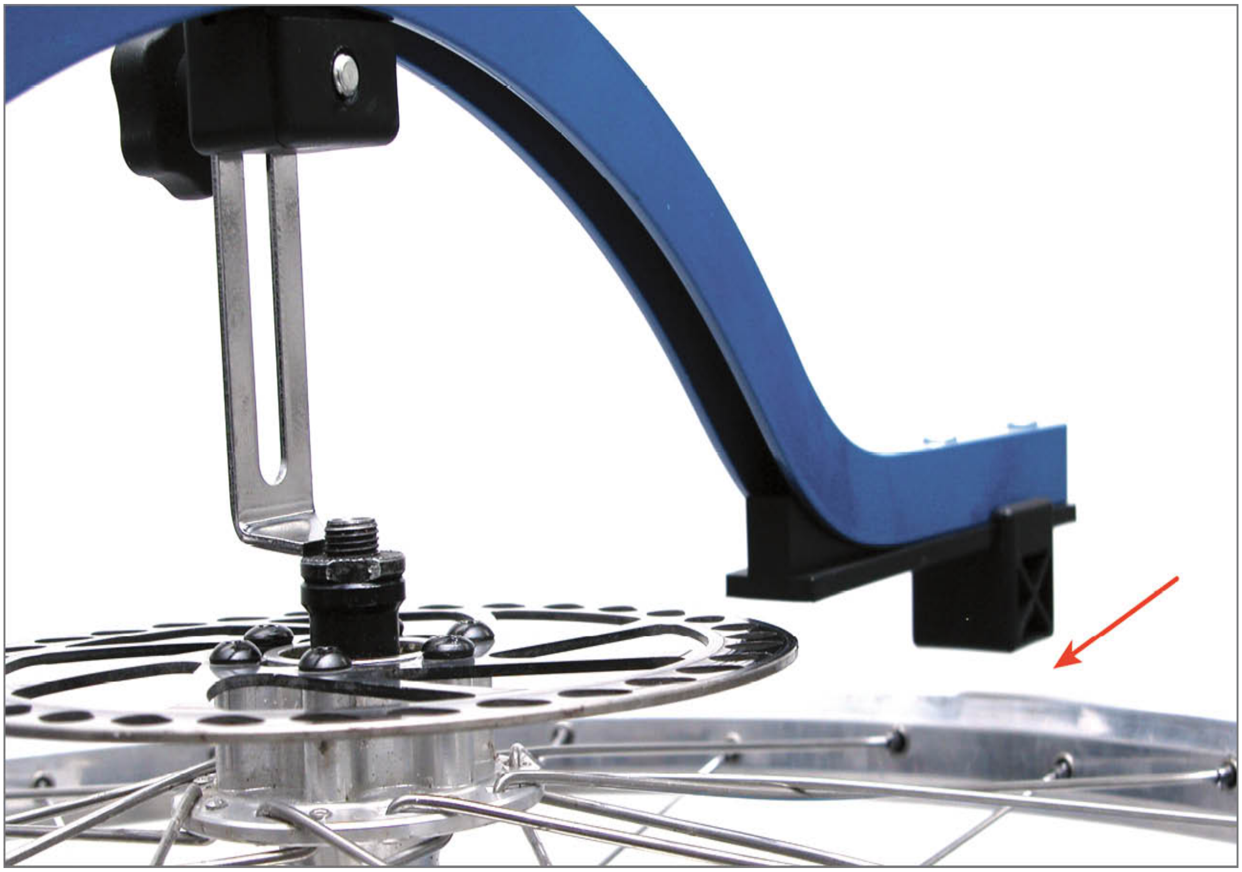


FIGURE 5.22: Gauge indicator showing rim centering error relative to rim contact

d. Correct centering error by tightening spokes connected to flange on same side in which there was a gap between rim and dishing tool foot. Tighten each spoke on that side only 1⁄4 turn. **Note:** A rim is off-center from the bicycle mid-plane by only half the distance between indicator and locknut face. For example, if indicator is 3mm from locknut face, rim is off-center by 1.5mm from mid plane of bike.

e. Double-check and correct lateral true as necessary. The dishing tool’s design assumes rim is laterally true.

f. Use dishing tool and check wheel again, starting with step “a” above. Keep in mind that rim position has changed relative to locknut face of original reference side. Repeat corrections if necessary. When gap between rim and dishing tool is less than 1mm, wheel is adequately centered.

g. If no other truing is to be done, clean rim’s braking surface with a solvent such as rubbing alcohol or window cleaner.

When making corrections to dish, keep in mind that you will also make changes to overall tension. Making corrections by tightening one side will increase overall tension of both sides, while loosening one side will decrease overall tension of both sides. If the wheel overall tension is very tight, make corrections to dish by loosening one side. This drops overall tension while moving the rim to center.

SPOKE TENSION

Consider that spokes are really just long thin bolts with nipples as nuts. These are no different than other fasteners. Like any threaded fastener, there is an acceptable range of tightness, which is called tension. Spoke tension is the amount of force pulling on the spoke. Although spoke tension increases as the nipple is turned and tightened, it is not useful to measure the torque of the nut (nipple) because there are more direct ways to measure spoke tension.

As wheels rotate while you ride, the spokes that are on the bottom, next to the ground, will momentarily lose their tension level then regain tension as they rotate past this low point. This change of tension in each revolution is called a “stress cycle.” Wheels with a relatively low overall spoke tension actually endure a greater swing in tension compared to wheels with greater overall tension. Stress cycles, the loosening and retightening of tension, fatigue the metal and lead to spoke breakage. Wheels with low overall spoke tension will continue to loosen even more as the bike is ridden. This results in shortened spoke life, more spoke failure, and a wheel that requires continuous truing.

While low overall spoke tension results in problems, too much tension can also cause issues. Spokes with too much tension can deform or crack the rim near nipple holes (figure 5.23). Too much tension can also lead to hub flange failure. Spoke nipple wrench flats can become deformed and rounded by forcing the nipple to turn when spoke tension is too high. However, the spoke itself can typically take more stress than the rim, nipple, or hub flange.

FIGURE 5.23: Crack in rim from excessive spoke tension

When adding or subtracting tension, work slowly and in relatively small increments. For example, to add tension to a low-tension wheel, begin with a spoke next to tire valve hole and add only 1⁄4 turn to each spoke. After adding this tension, double-check lateral trueness. It is common to see lateral runout errors develop after adding overall tension. Check out and correct these before rechecking dish and adding more tension. Repeat process until the desired tension is achieved.

It is common for spokes to become twisted along their long axis as nipples are turned. This is called “spoke windup.” To minimize spoke twisting, lubricate the nipples. When truing, you can place a finger on the spoke as you turn the nipple. Significant windup can be felt in the spoke. If you feel this twisting, make slightly more correction than you intend, then rotate the nipple back to help relieve windup. It is common to still end up with some windup in the wheel. The safest method to relieve this torsional stress on the spoke is to simply ride the bike. You may hear an initial “popping” or “pinging” sound while the spokes untwist. In some cases, it will be necessary to true the wheel again laterally.

Spoke tension is best measured with a spoke tension meter (also called a tensiometer), such as the Park Tool TM-1 Tension Meter. It is possible, to some degree, to “feel” the tension by squeezing crossing or parallel spokes. The squeezing technique can, however, be deceiving and inconsistent. The stiffness of rims and thickness of spokes vary widely. A tension meter allows the user to determine both relative spoke tension between spokes and the tension force of each spoke. The TM-1 Spoke Tension Meter is a tool that includes a chart to determine the amount of pulling force, measured in kilograms force (abbreviated as “kgf”). The TM-1 is designed to read tension for many different types of spokes, including titanium, aluminum, and bladed shapes (figure 5.24).

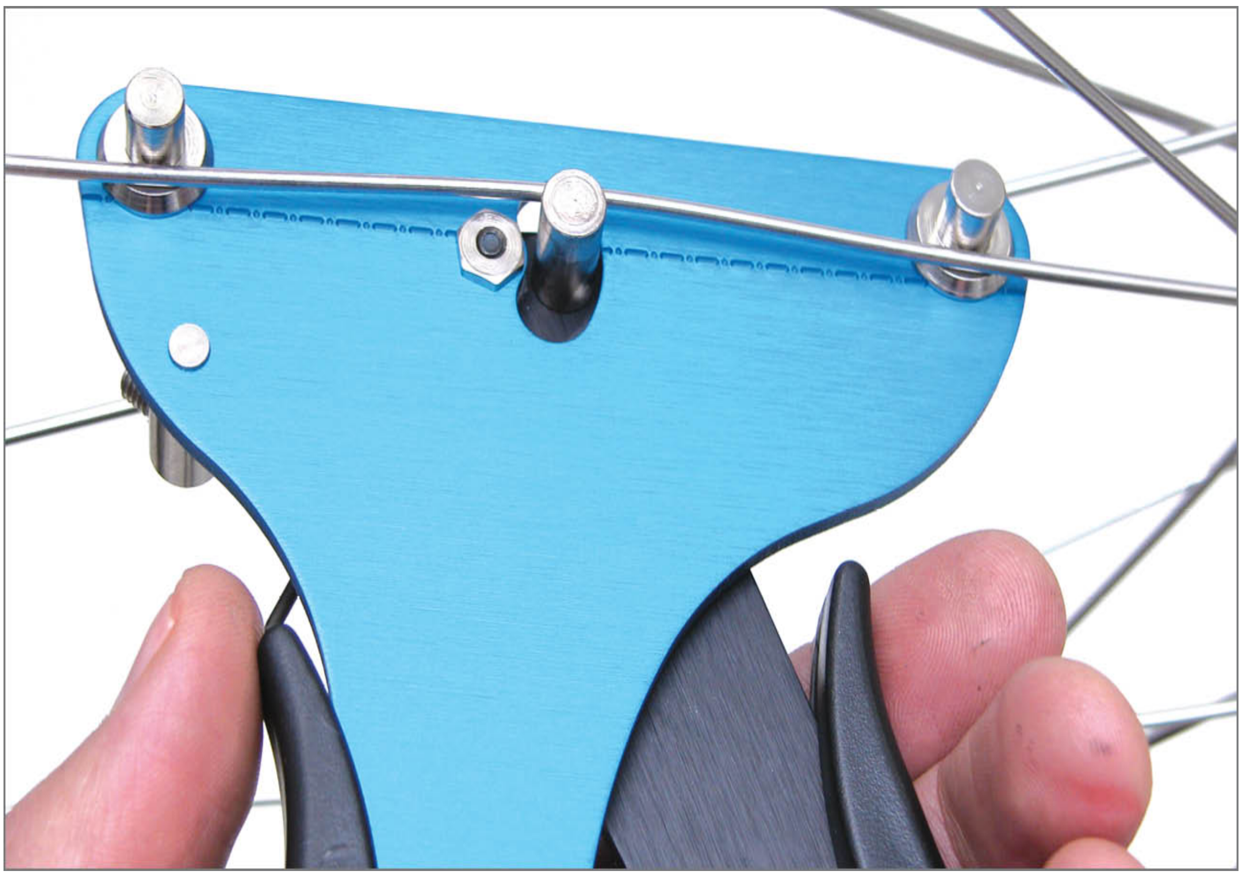


FIGURE 5.24: Tension Meter flexing spoke to determine tension

Rim manufacturers specify tension recommendations from as low as 60kgf to as high as 200kgf. However, 100kgf is a common tension recommendation. It is the rim, not spoke type or diameter, that determines the limits of tension. Generally, the heavier and stronger the rim, the more tension it can handle. A light rim may weigh from 280 grams to 350 grams. A relatively heavy rim may weigh 450 grams or more. Additionally, rim eyelets may help distribute the load on the rim wall. A lack of eyelets on a light rim implies that less spoke tension should be used. There is a wide range of possible tension, and it is always best to consult the rim manufacturer for the most up-to-date specifications.

Manufacturers typically give specifications for the wheel with no tire pressure. Tire pressure will have the effect of lowering tension slightly. Generally, do not try to account for this drop by adding more tension than recommended by the manufacturer. Parts makers list tension for the wheel's tighter side. For rear wheels, this will be the sprocket side or right side. For front wheels with a disc, the tighter side is the disc side. If the flanges are equally spaced from the hub center, then either side can be measured. This is the case for most front wheels made without a disc rotor mount.

The TM-1 Tension Meter includes a Conversion Table that is used to determine the pulling force on the spoke. The tool presses on a spoke to flex it. The tool pointer is used to determine a "deflection reading" (figure 5.25). This reading is used along with the appropriate spoke column to give a reading of the pulling force on the spoke, the spoke tension.

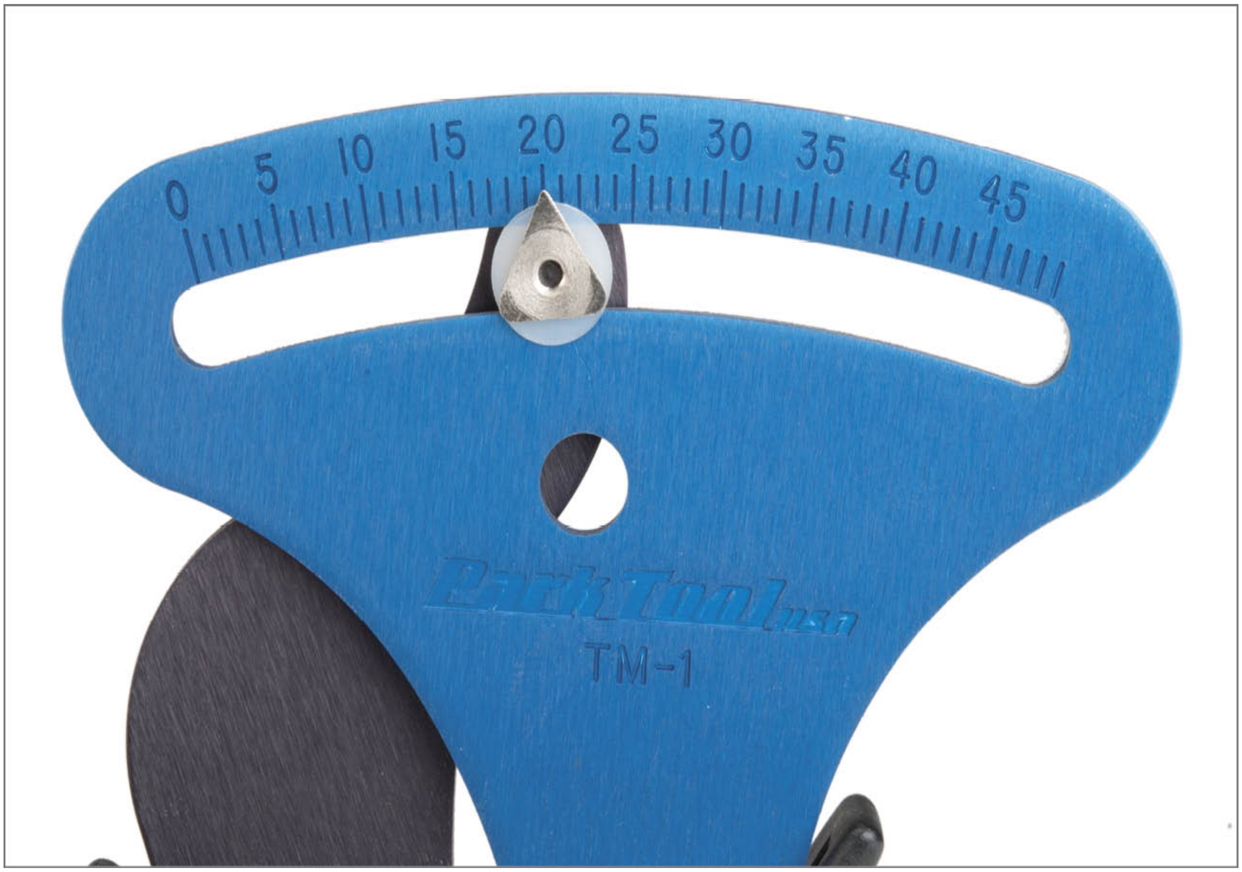


FIGURE 5.25: Deflection reading of 20 on the TM-1. Use Conversion table to determine correlated pulling force.

To use the TM-1 Tension Meter it is necessary to know both the type of material in the spoke and the spoke diameter. Most spokes are steel and many are stainless steel. Stainless steel will usually be very weakly magnetic when tested. Aluminum spokes will have a different feel and look, as will titanium, and are not magnetic.

The tool includes a simple diameter gauge used for round spokes only. The smallest slot the spoke fits into determines the diameter. The diameter at the middle section of the spoke will determine the appropriate column on the Conversion Table. If the spoke ends are butted, the tool is deflecting only the middle, so only consider the spoke middle for the Table. For a bladed spoke, it is necessary to use a measuring caliper to measure the spoke's width and thickness.

Using the Conversion Table, find the column corresponding to the material and spoke diameter being measured. For bladed spokes measure spoke width and thickness. Follow the column down to the row corresponding to the spoke's deflection reading (as determined in step "d" below). The number at this intersection is the actual tension of the spoke in kilograms force (kgf). For bladed steel spokes that are not listed on the Conversion Table, use the online Wheel Tension App at www.parktool.com/wta.

Procedure for tension measurement with TM-1 tensiometer:

a. Determine material and spoke dimension near middle of spoke. Find correct column on Conversion Table included with TM-1.

b. Squeeze TM-1 at handle grips. Place spoke between two fixed posts and moveable post. With butted spokes, position posts so they rest on narrowest portion of each spoke. With aero/bladed spokes, position posts so they rest against wide, flat side of spoke.

c. Gently release handle. Releasing tension rapidly will cause erratic reading results.

d. With TM-1 engaged on spoke, pointer will be pointing to a number on tool's scale. This number is a deflection reading. Use this number on the Conversion Table and find where it meets appropriate spoke column. This number is the tension of the measured spoke.

For the most accurate wheel average measurement, measure all spokes on one side, total the deflection readings, and divide by the number of readings taken. However, only measuring one-quarter of the wheel will give you a good idea of overall tension. If you have a 32-spoke wheel, measure eight spokes and calculate their average tension.

Rear wheels and front rotor disc wheel have hub flanges offset to the frame center. As tension is added by tightening all spokes the same amount it is likely the dish or centering will become slightly off. Be sure to double-check the dish after tension was changed at all spoke nipples.

TENSION RELIEVING OF SPOKES

When truing a wheel, and even after lubricating the nipples, the spokes may still twist or wind up slightly as corrections are made. This can lead to the wheel making “popping” and “pinging” sounds as the wheel is stressed under normal use. The noise comes from the spoke unwinding. This typically goes away in the first few pedal strokes, and riding the bike can be viewed as part of the finishing process of truing. You can also get some twist relieving by squeezing pairs of spokes on either side of the wheel. Grab pairs of spokes and squeeze with force all the way around the wheel and check trueness in that stand.

SPOKE TENSION BALANCE

Spoke tension will vary slightly from spoke to spoke even in a well-trued wheel. It is common for spokes to vary because one spoke shares a zone of influence at the rim with neighboring spokes from the same flange. However, if the spokes can be adjusted so all the spokes of the same flange have close to the same relative tension, the wheel stays true longer. The use of a spoke tension meter will help get spokes closer to the same relative tension. Generally, attempt to get spokes within 20 percent of the average kgf. For example, assume an average right-side tension is 100kgf. Twenty percent of this is a range of 20 kgf. Adjust only right-side spokes that are 80kgf or lower, and spokes that are 120kgf or tighter. With practice and patience, it is possible to get tighter tolerances, however, plus or minus 20 percent provides an acceptable wheel balance for most uses.

On a rear wheel or front disc brake wheel, the tension averages between left flange and right flange spokes will be significantly different, which is normal. Do not attempt to get these two sides to the same tension. The different left-to-right tension accounts for the offset built into the hub.

As you use the TM-1 from spoke to spoke along the same hub flange, notice some spokes from the same flange are tighter relative to others. It is common to see a tight spoke adjacent to relatively loose spoke, both coming from the same flange. You can use a marker to write the reading on the rim for reference. The tighter spoke is pulling more on the rim to keep it straight at a rim section relative to the adjacent lesser tension spoke. The idea of tension balancing is to loosen the tighter spoke a little, then tighten the neighboring spokes on the same flange a little to maintain lateral true. With practice it is possible to make the rim laterally true while keeping the spokes relatively close in tension. This procedure helps produce wheels that stay true over a longer period of use. It also helps maximize spoke life, as the stress of riding is evenly shared between all the spokes in the wheel.

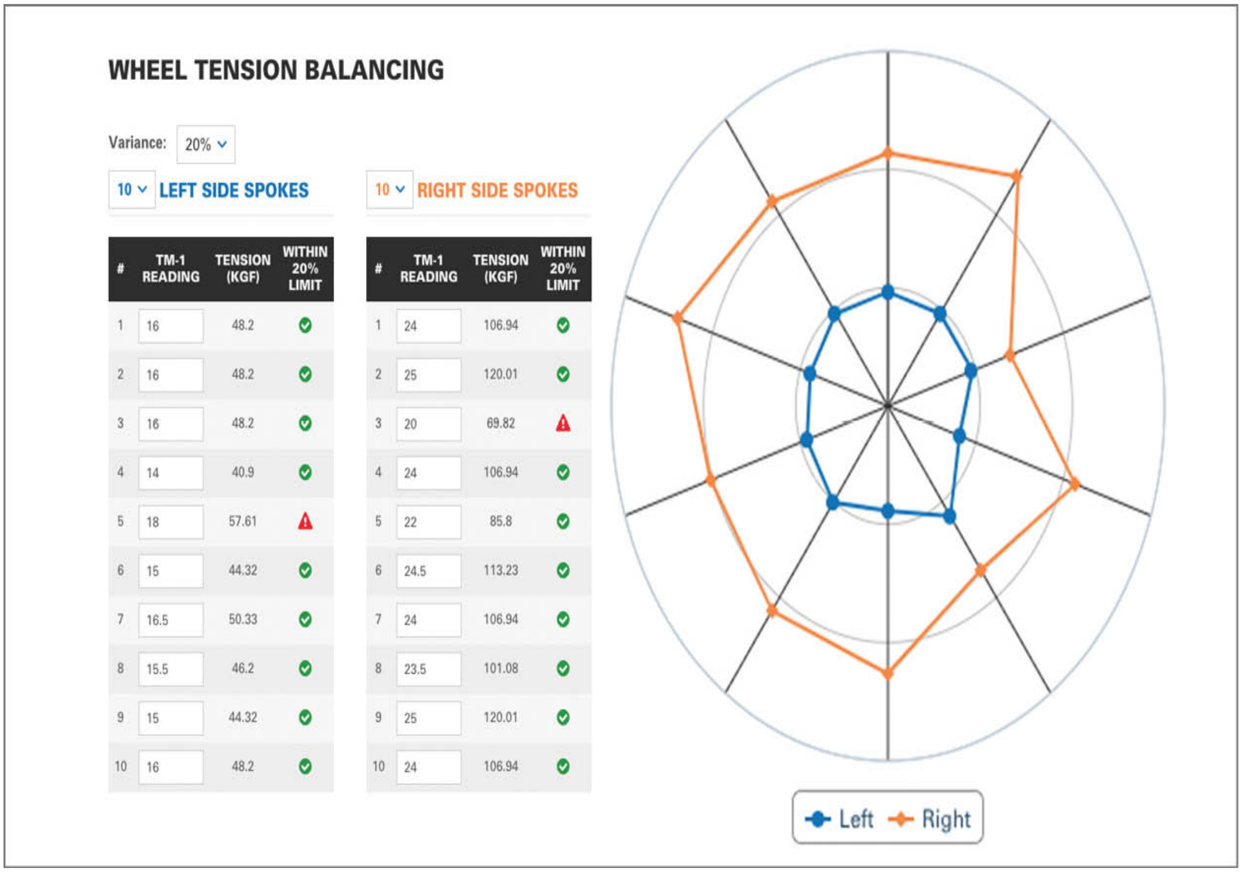
There will be a trade-off between having a “perfectly” laterally true wheel and a wheel that has good tension balance. It may seem both are possible but there are often anomalies in even a new rim that prevent this. Especially with a disc brake wheel, spoke tension balance will take precedence over lateral perfection.

Procedure for tension balancing:

a. Determine average tension in kilograms force (kgf) or Newton Meter (Nm) of spokes on one side of wheel.
b. Multiply this average by 0.8 for the lowest spoke range, and by 1.2 for the highest tension. The resulting two numbers will provide acceptable relative tension range.
c. Use TM-1 to take deflection readings of each individual spoke and use conversion chart to convert readings into individual tension measurements.
d. Determine if individual tension measurements fall within acceptable relative tension range from step 2.
e. Find a relatively tight spoke from one flange. Pair this tight spoke with a same side spoke of lesser tension. Loosen tighter spoke 1⁄8 to 1⁄4 turn. Tighten lower tension spoke approximately the same amount.
f. Check tension of each spoke with TM-1 and note if any progress was made in evening tension between the two.
g. Spin wheel and note lateral error in trueness. Correct any significant error by again using the concept of balance. If there is a choice between tightening or loosening, select based on which will help bring spokes closer to the desired tension.
h. Repeat until spokes on same side flange are within your desired tension range.
i. Repeat process on other flange side.

Another useful technique to estimate relative spoke tension is to pluck spokes like the strings of a musical instrument. You can also use a small hex wrench or a spoke to “thump” the spokes. Two spokes of the same length and same tension should have the same pitch. Like any technique, there are tolerances. This technique does not tell you the absolute pulling force in kgf, but it will point to spokes that are tensioned very differently.

There is an online app at www.parktool.com/wta. This app will create charts of the relative tension to give a visual aid of the spokes that are out of balance (figure 5.26). The data can be saved for future use. Detailed instructions are on the website.



#	TM-1 READING	TENSION (KGF)	WITHIN 20% LIMIT
1	16	48.2	✓
2	16	48.2	✓
3	16	48.2	✓
4	14	40.9	✓
5	18	57.61	⚠
6	15	44.32	✓
7	16.5	50.33	✓
8	15.5	46.2	✓
9	15	44.32	✓
10	16	48.2	✓

#	TM-1 READING	TENSION (KGF)	WITHIN 20% LIMIT
1	24	106.94	✓
2	25	120.01	✓
3	20	69.82	⚠
4	24	106.94	✓
5	22	85.8	✓
6	24.5	113.23	✓
7	24	106.94	✓
8	23.5	101.08	✓
9	25	120.01	✓
10	24	106.94	✓

FIGURE 5.26: Example of WTA spoke tension tables and graphic showing tension imbalances

BROKEN & DAMAGED SPOKE REPLACEMENT

A broken spoke will cause the wheel to come out of true. It may be possible to correct lateral true enough to keep riding until the spoke can be replaced. However, low spoke count wheels (28 spokes or less) may develop substantial lateral runout from a single broken spoke. It may not be possible to correct runout enough to safely finish a ride even by opening the rim brake calipers. Disc hub wheels will allow for more lateral error, but if the tire is striking the frame or fork, it should be trued as well as possible to prevent contact.

To repair a wheel with a broken spoke, begin by inspecting the spoke. If the spoke broke at the hub, and the nipple appears in good shape, the nipple can often be reused. Unthread spoke from nipple. Determine the length of the broken spoke by measuring an adjacent same flange spoke. Use a tape measure to measure from the hub to the point the nipple enters the rim. Typically, from here add approximately 3–4mm. To know the exact length, remove the tire and remove another spoke to measure with a spoke ruler, such as the Park Tool SBC-1 Spoke Ruler.

On rear wheels, remove the rear sprockets to access the hub flange. Feed the new spoke through the hub in the same orientation as the original spoke. The spoke head should similarly face inward or outward in the flange. It may be necessary to flex and bend the spoke, but avoid kinking it (figure 5.27). Inspect another spoke of the same flange and same orientation and follow the same pattern.

FIGURE 5.27: Flex spoke as needed to lace into wheel

When possible, use a spoke tension meter to measure spokes on the same side as the broken spoke and average the readings. Tighten the new spoke until it reaches the average. This will get the wheel close to its previous trueness. Finish truing the wheel with the procedures described above.

WHEEL WEAR, DAMAGE, & REPAIR

Rims may become damaged from impacts, such as hitting rocks, potholes or curbs. Crashing or impacting the side of the rim in a fall can also cause irreparable damage. Truing may afford a limited repair for crashed wheels. Begin by checking relative tension in the damaged area. For example, if a wheel deviates in one section to the right, check left and right-side spoke tension in that area. If the wheel runs to the right even though right-side spokes appear loose and left-side spokes appear tight, the rim metal is bent. This indicates the rim has been deformed beyond the point where spoke tension can repair it (figure 5.28).

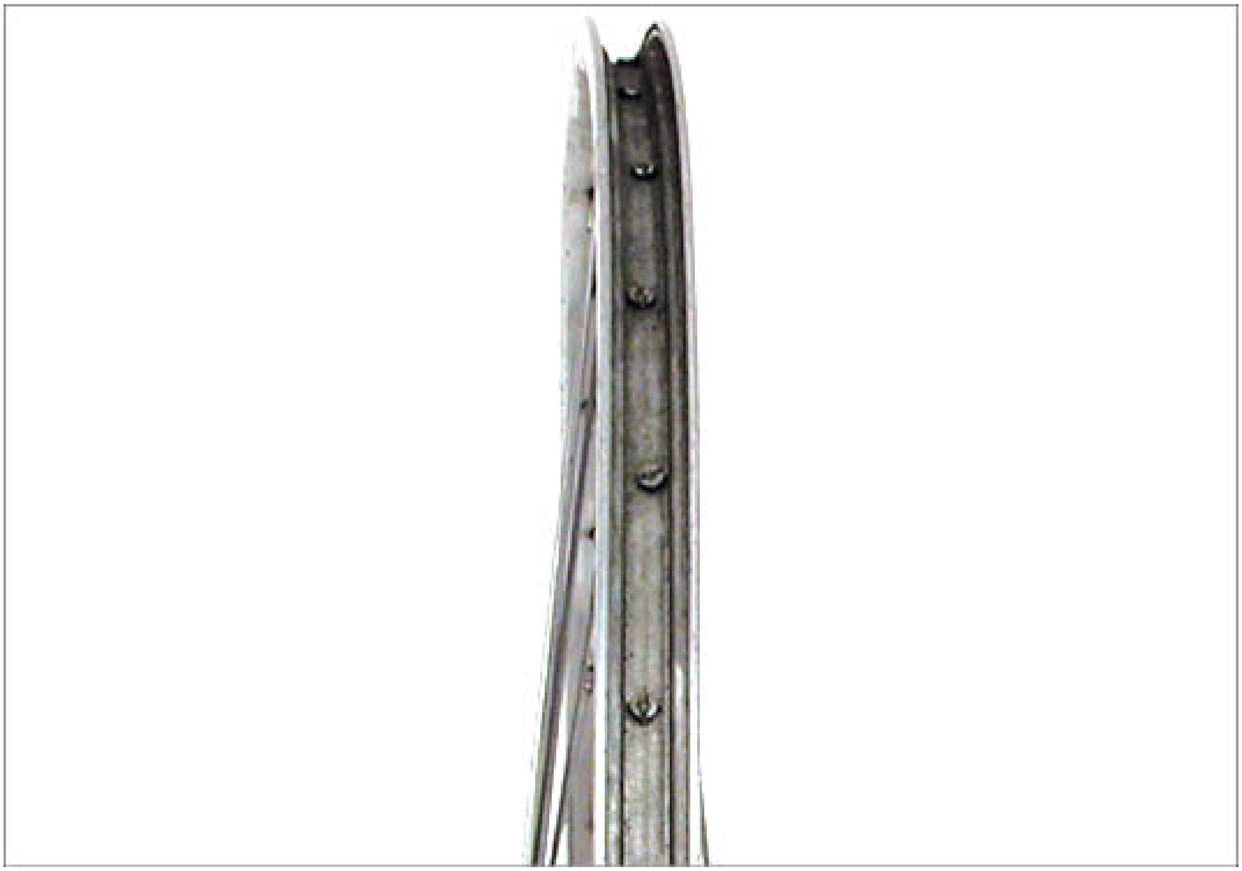


FIGURE 5.28: Wheel rim deformed beyond repair

Bicycle rims may be made from aluminum, carbon fiber or steel. Steel and aluminum are metals that bend under extreme stresses and impacts. Carbon fiber may also fail, but typically will not become permanently deformed until it breaks. A deformed metal rim in theory may seem repairable by simply “bending it back.” However, in practice this rarely works well. The metal hardens when bent and will harden again when rebent back into shape.

Adjusting spoke tension on a wheel with a badly bent rim is unlikely to help, except possibly to get the rider home from a ride. Trying to bash the rim or attempting to rebend the rim back in the problem area is a desperate repair measure. It’s unlikely to help return the wheel to a usable condition. Wheel rims can be replaced, and a new rim is easily laced around the old hub. See a professional mechanic for this service or purchase a new wheel.

On bicycles with rim caliper brakes, brake pads grab and grind rim walls, thinning the metal. The pressurized tire is held in place by the rim sidewalls, which become weakened over time. Thin sidewalls may fail during a ride, causing a tire blowout. Inspect visually, and feel the rim braking surface for a dished, concave surface. If rim appears worn, remove the tire and place a straightedge along the rim surface. Inspect for a gap between straightedge and rim. If the gap is larger than 0.2mm (approximate thickness of a business card), the rim should be replaced (figure 5.29). Modern rims often come with a machined groove as a wear indicator. Replace rim when this groove disappears from rim wear.

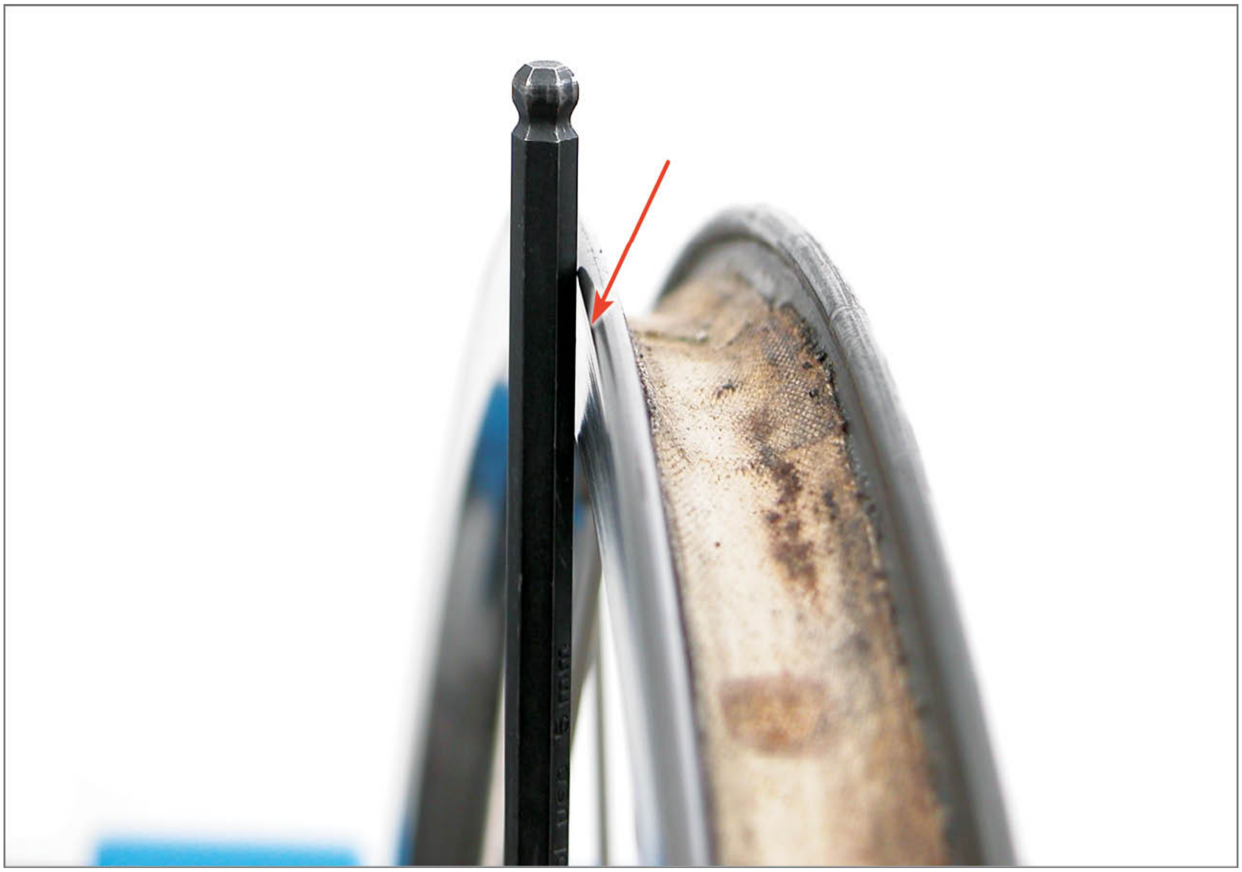


FIGURE 5.29: Rim braking surface worn beyond safe tolerances

TABLE 5.2: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Spinning rim wobbles side to side	Misadjusted spoke tension	True wheel to correct wobble
Rim wobbles when spinning after truing attempted	Rim is bent from impact	Minimize issue by truing, but replace rim or wheel if issue unresolvable
Spoke breaking on relatively new wheel	Spoke fatigued from too low spoke tension	Check and correct spoke tension, increasing tension as needed
Spokes breaking on older wheel	Spokes have reached limit of fatigue life	Replace wheel or relace with new spokes

CHAPTER 6

WHEEL BUILDING

Well-built wheels will provide good service and good performance. Building wheels can be both an enjoyable mechanical process, as well as a challenge. Additionally, understanding and familiarity with the process and procedure of wheel building is useful knowledge for wheel repair and truing.

Although selecting individual components such as hub, rim and spokes for the wheel is important, that topic is too detailed and subjective to be covered in this book. There are many methods and styles to lacing a wheel, this book will review one basic wheel lacing procedure.

SPOKES

Spokes are simply fasteners, much like the nuts and bolts holding together other components on the bike. Spokes fasten the rim to the hub and vice versa. Commonly, spokes are made from steel, but aluminum and composite materials such as carbon fiber are also produced. Steel spokes are typically made from various grades of stainless steel. While stainless steel is shiny and may look like aluminum, it can be differentiated due to being weakly magnetic when tested with a magnet.

Spokes have one end shaped to fit the hub flange. Two possible spoke ends are the straight pull spoke, and the J-bend (figure 6.1). The spokes must match the hub design (figure 6.2 and 6.3).

FIGURE 6.1: Top: straight pull spoke; Bottom: J-bend spoke

FIGURE 6.2: Straight pull spoke in compatible hub

FIGURE 6.3: J-bend spokes in compatible hub

The other end of the spoke is threaded for attachment at the rim with a nut, called the “nipple.” Common spokes use a 2mm round shaft at the end of the spoke that forms 2.2mm x 56tpi threads when rolled through dies. Each complete rotation advances the nipple approximately 0.5mm along the spoke.

Bicycle spokes are available in lengths from under 100mm to over 300mm in one-millimeter increments. Selecting the correct size for the particular build is a crucial step in the building process. When taking measurements and calculations, attempt to maintain accuracy to one-tenth of a millimeter. Rounding to a whole millimeter length is done at the end. Typically, spokes within 2mm of the ideal length should provide no issues or problems when building the wheel. The math of determining the length is best accomplished by using various spoke length calculators available online.

HUB

There are three basic hub measurements and numbers to consider when determining spoke length. These are spoke hole count, flange diameter at the spoke holes, and flange-to-center distance for left and right-side flanges.

The most basic specification is the spoke hole count of the hub, which should match the count of the rim. Do not assume they match when building a wheel; confirm by counting both.

Holes drilled into the hub flanges create a circular pattern. Measure the diameter of this circle by measuring from one spoke hole directly across the flange to the opposite hole. It is easiest to hold a caliper to an outside edge on one side, and to the inside edge of the other. This results in the same measurement as trying to find the center of the small spoke holes (figure 6.4).

FIGURE 6.4: Measure directly opposite spoke holes from inner edge to outer edge

Spoke hole diameter is now a standard 2.5mm. Very large diameter spokes may need larger holes, but the 2.5mm size is assumed for most online spoke calculators.

The distance from each flange to the hub center must also be accounted for. The greater the distance from the flange to the hub center, the longer the spoke needs to be to reach the rim because the rim is centered over the middle of the hub rather than between spoke flanges at the hub. For figuring spoke length, the critical measurement is referred to as “hub flange-to-center” (figure 6.5). Left and right-side measurements will be different for most rear hubs and front disc brake hubs. If differences between sides is great enough, a wheel may need two different spoke lengths to correctly fit left and right flange sides. This is called “differential spoking” and is common on rear wheels with wide freehub spacing and a narrow hub width. 11 or 12-speed road wheels are examples where this may occur. If the left and right flange spoke lengths vary by 2mm or greater, it is recommended to use two different length spokes in the wheel. If they vary by 1mm, use the longer length for both sides.

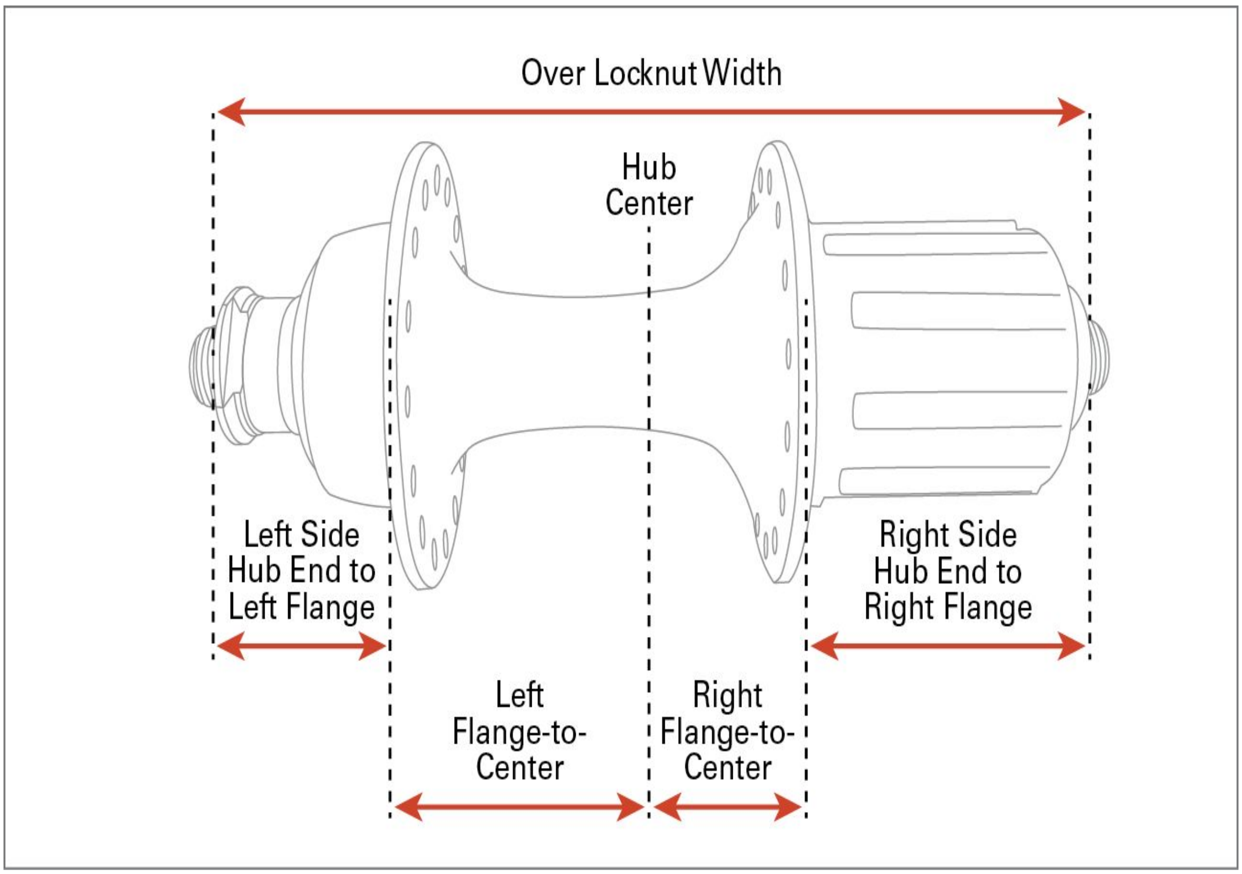


FIGURE 6.5: Hub flange-to-center measurement

Hub flange-to-center is best determined with some simple deduction. Begin by measuring overall hub width. Measure the axle where it contacts the dropouts. For open dropout hubs, measure to locknut face, not to the axle end. Divide overall hub width by two.

Next, measure from each flange to the face of the locknuts or hub end caps. Use a straightedge against the locknut or axle end cap to extend the measuring point of the axle outward parallel to the flange (figure 6.6). Measure approximately at the flange center.

FIGURE 6.6: Extending hub contact face to measure distance to flange

Next, deduct this measurement from one-half hub width for one of the flange-to-center measurements. Repeat process on the other side.

For example, assume the open dropout rear hub in figure 6.7 measures 135mm wide at the locknut faces. The hub center is at 67.5mm from either side. Assume from the left face of locknut to left flange measures 35mm. The left flange-to-center calculation is 67.5mm − 35mm = 32.5mm.

On this same hub, assume the right face of locknut to the right flange distance is 48mm. The right flange-to-center calculation is then 67.5mm − 48mm = 19.5mm.

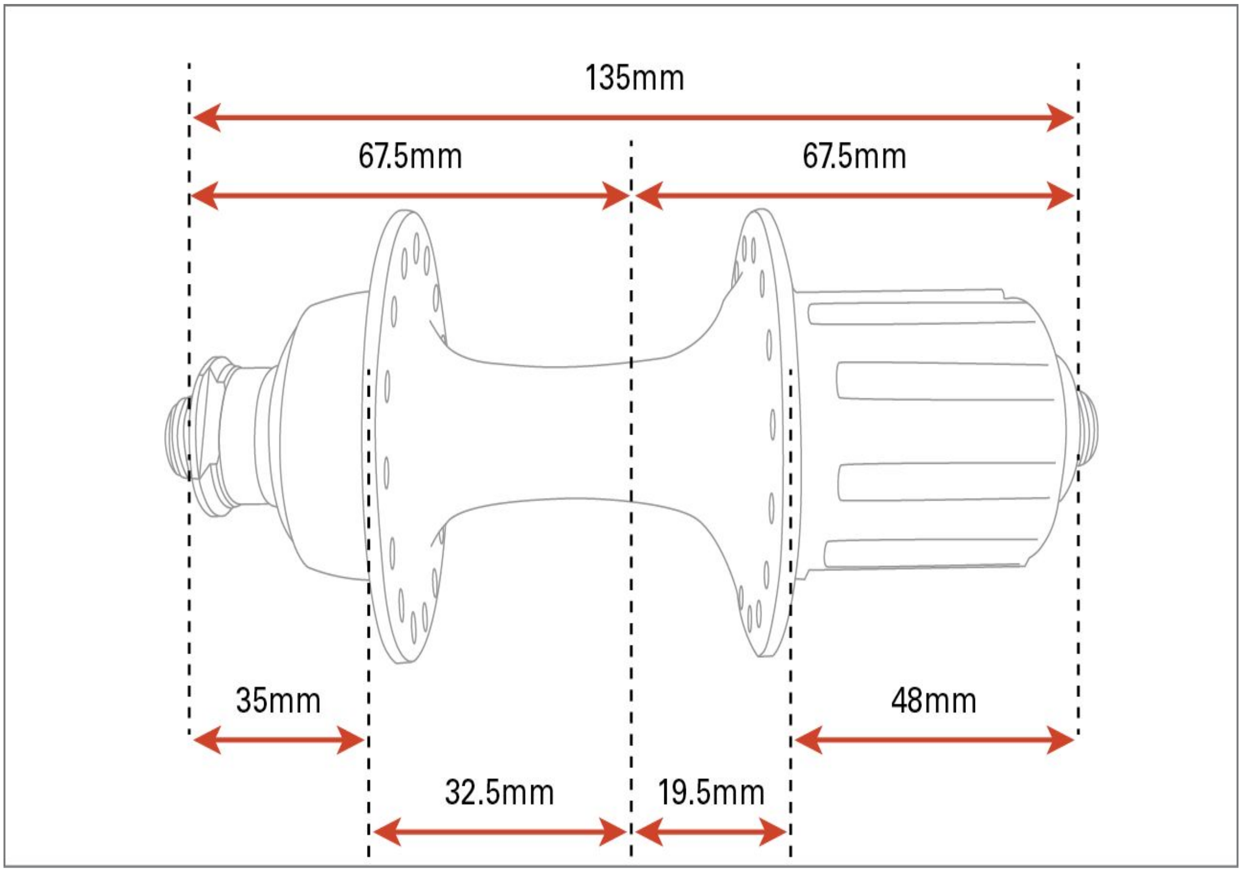


FIGURE 6.7: Example hub measurements

For this example hub, the flange-to-center for the left is 32.5mm, and flange-to-center for right is 19.5mm. The left and right flange are set differently because the right side must have extra space for the sprockets.

An important feature to note regarding hub flanges is that the spoke holes in the left and right flanges are not drilled directly across from one another. Each flange is drilled with a spoke hole that aligns between holes in the opposite flanges (figure 6.8). This offset alignment allows near mirror images of the lacing pattern. When lacing the wheel, it will be necessary to pay attention to this in order to select the correct flange hole.

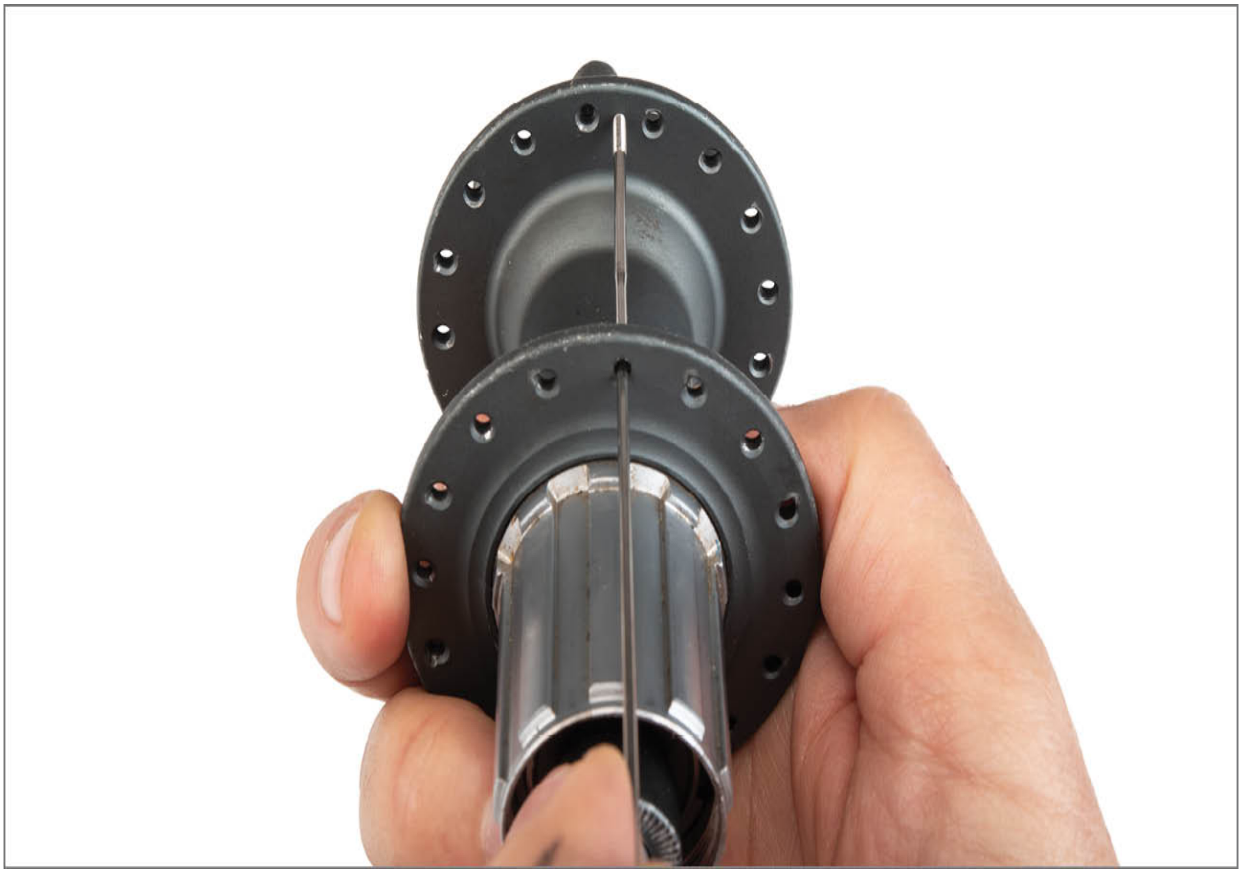


FIGURE 6.8: Hub flange spoke hole alignment is offset left-to-right

RIM

Rims are commonly drilled with spoke holes close to the center of the rim. There may be a slightly staggered left-right-left-right pattern (figure 6.9). In staggered drilling, holes on the rim's right side will go to the right hub flange, and holes on the rim's left side will go to the left hub flange.

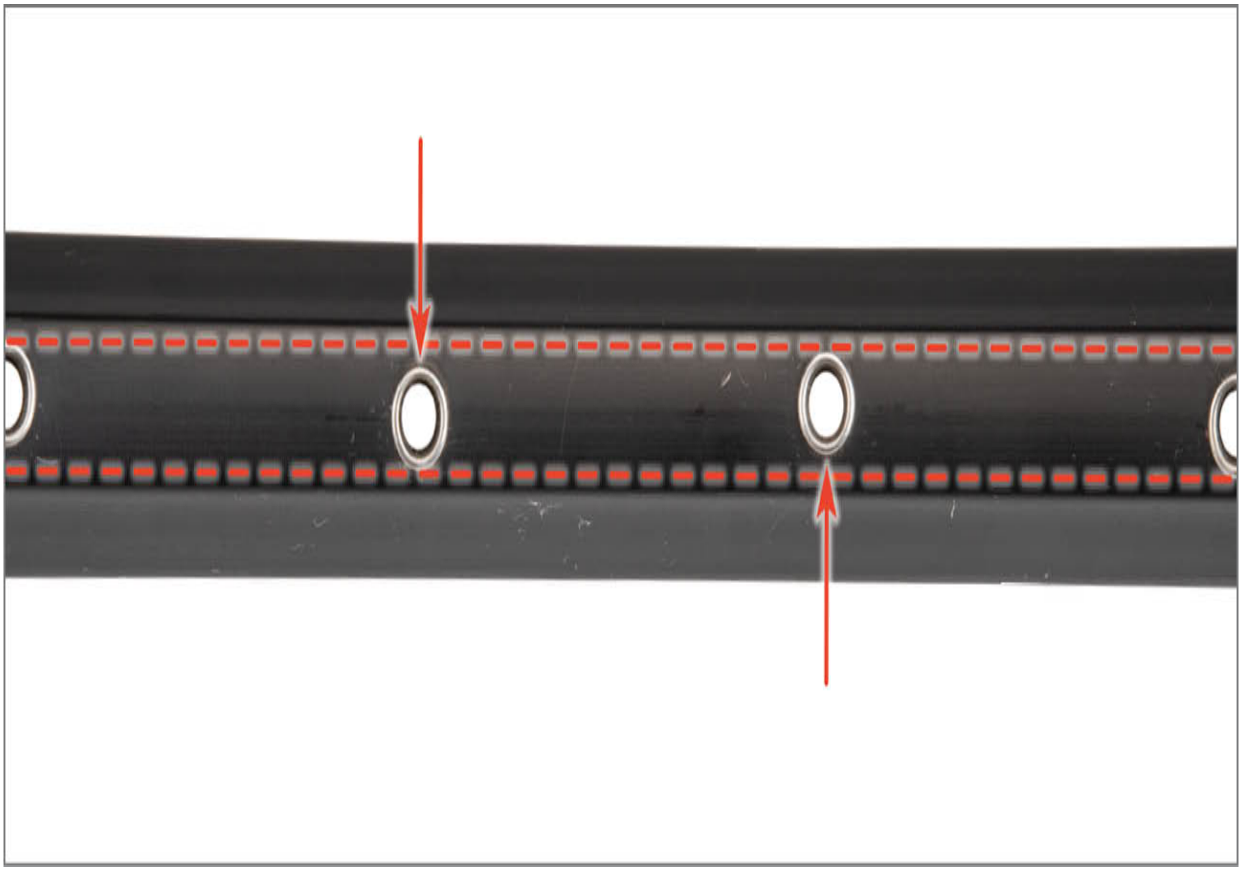


FIGURE 6.9: Subtly staggered drilling in rim

The rim holes may also appear to be in a straight line with no visible offset. In this case, drop a nipple into the rim hole at the 12:00 position and notice if the nipple points straight down, or is slanted to one side or the other of the rim. If the nipple does slant, this dictates the hub flange side for that spoke hole. If the nipple simply points straight, there is not a left-right flange differentiation at the rim.

A feature of some rims is called "asymmetrical drilling." With asymmetrical rims, rim holes are all offset closer to one side of the rim (figure 6.10).

FIGURE 6.10: Asymmetrical rim design to reduce left-to-right spoke tension differences

With an asymmetrical rear rim, the wider section will go to the drive side. For a disc front wheel, the wider offset faces the rotor side. Offset reduces the amount of left-right spoke tension difference needed to center the rim in the bike.

For purposes of wheel building, rim manufacturers specify a measurement number called “Effective Rim Diameter,” or “ERD.” The term ERD is not a very descriptive term because the rim diameter is not part of the consideration. A better term would be “Effective Spoke End Diameter.” This number refers to the point inside the rim where the end of the spoke should ideally sit. From this point across to the same point on the opposite side of the wheel is the rim ERD. Because there is a range of spokes that will allow a good build, the concept of an acceptable ERD is to select adequate spoke length, rather than an “exact” length.

ERD rim specifications can often be looked up on the manufacturer’s website. It is also possible to measure the rim for ERD. This requires a caliper, two nipples and two spokes of known length. **Note:** The spokes are used only as "measuring sticks" and do not need to be the spokes used for the wheel build.

Use a spoke ruler to confirm the length of the spokes. Add the two lengths together and write this number down. Insert one spoke into a rim hole and fully thread a nipple onto the threads. Now begin to unscrew the nipple while sighting into the nipple's end slot. Unthread until the spoke just reaches the slot and stop (figure 6.11). If there is no slot in the nipple, thread spokes flush with the nipple end, and then unthread four turns. Go to the opposite hole directly across the rim and repeat, inserting the spoke and threading nipple using the same procedure.

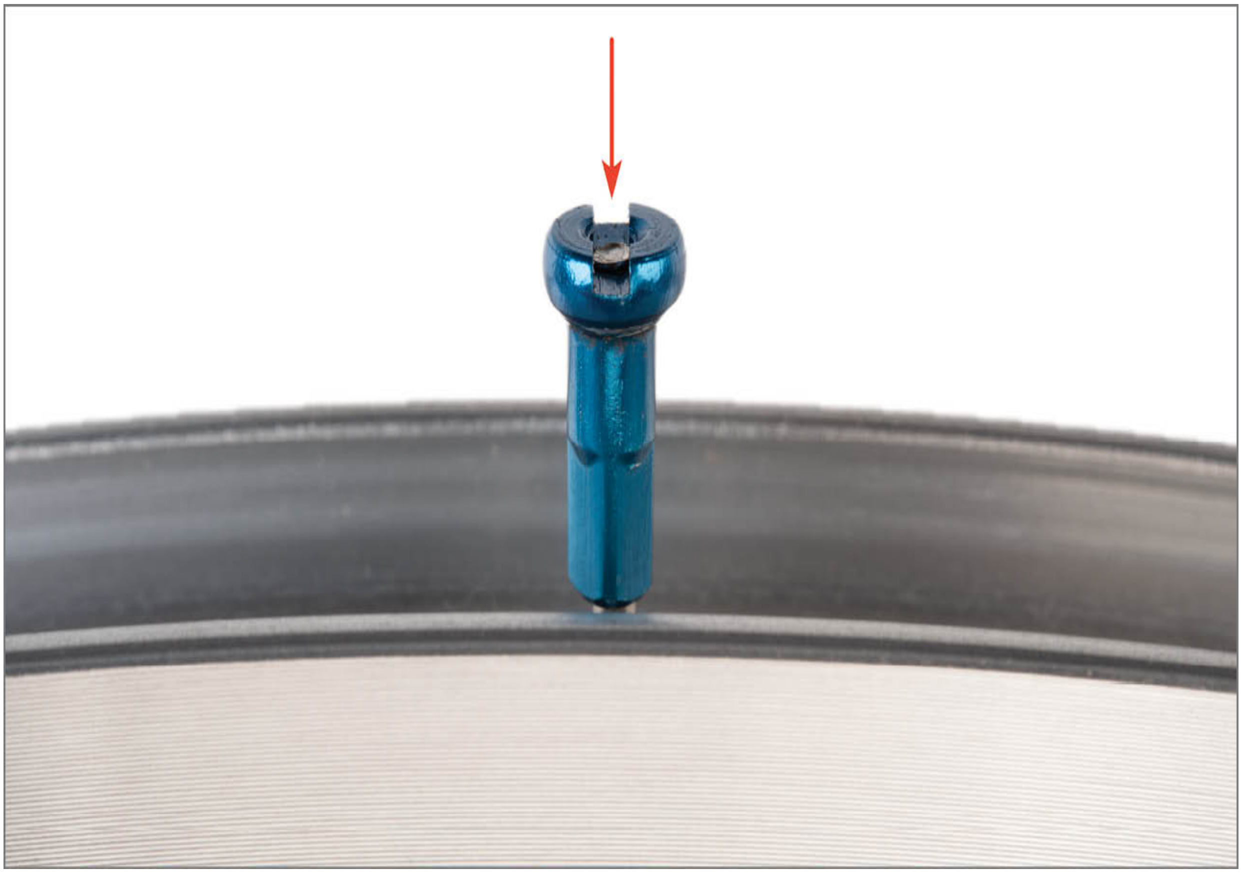


FIGURE 6.11: Thread nipple on until spoke just begins to show in slot

Pull the spokes inward and use the narrow tips of the caliper jaws to measure from inside to inside of each J-bend (figure 6.12). Add this number to the total length of both spokes to arrive at the rim ERD.

FIGURE 6.12: Measure inside J-bend and add to total length of spokes

For example, assume two spokes of 290mm were used to measure. It is 290mm from the inside of the J-bend to the end of the spoke thread. The caliper also measures from inside the J-bend. The ERD would be here 290mm + 290mm + 36.5 = 616.5mm. The 290mm spokes are not intended for this wheel, they are simply known lengths to measure the ERD.

SPOKE CROSS PATTERNS

Spokes connect the hub to the rim in different patterns called the "cross pattern" or "lacing pattern." A cross pattern is the number of times a single spoke crosses over another spoke from the same flange as it travels outward to the rim (figure 6.13). One-half of the spokes from one flange will leave the hub at an angle, and the other half will leave the hub in the opposite directions. This creates the "lacing" pattern. There are options for no-cross (zero-cross), one-cross, two-cross, three-cross, and in some cases four-cross patterns. The shorthand for these patterns is 0X, 1X, 2X, 3X and 4X.

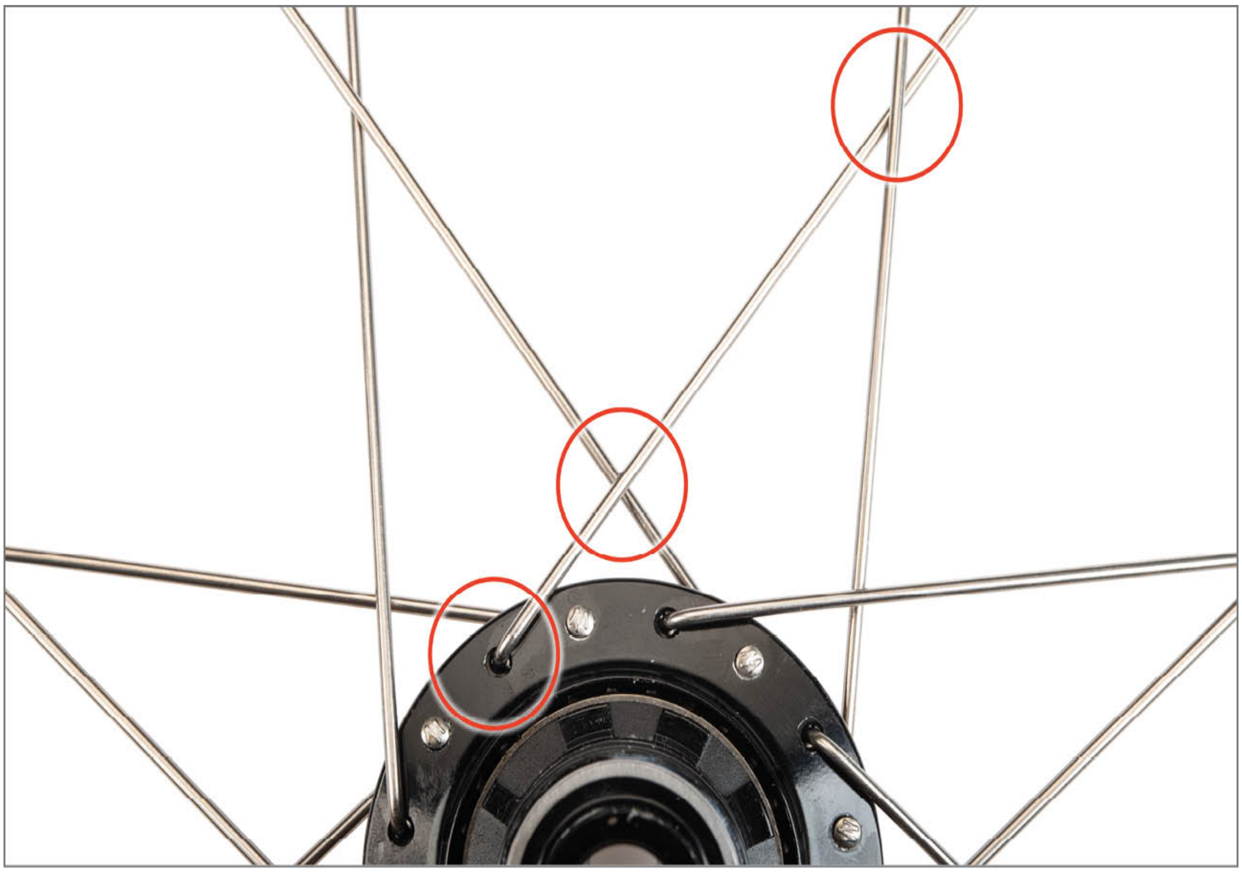


FIGURE 6.13: Count along one spoke as seen at the circles of this 3X pattern

The topic of wheel lacing differences will not be reviewed here at length. If there is no significant torsional or twisting load at the hub, the cross pattern is not particularly important. A front wheel on a rim brake sees no twisting of the hub in rim as the bike is used. A rear wheel does see some torsional load from turning the sprockets and hub under the pedaling force. A disc brake however on either wheel applies a significant torsional stress during a stop. The writing here will assume a 3X pattern for the examples.

The crossing pattern must be decided before selecting the spoke length. Fewer crosses mean a slightly shorter spoke.

Spoke length is a matter of math based on measurements of key components. Use one of the online spoke length calculators, such as the one at www.bikeschool.com. These calculators are basically spreadsheets with math algorithms behind drop boxes. Enter data into the appropriate boxes and proceed to calculate the spoke length. Calculate each flange side separately with its corresponding measurements, rounding to the closest whole millimeter length. Table 6.1 can be used as a worksheet to gather and organize appropriate numbers before entering into online spreadsheet.

TABLE 6.1: Spoke Length Dimensions Worksheet

COMPONENT PROPERTY	FRONT WHEEL	REAR WHEEL
Number of Spokes in hub and rim		
Rim ERD		
Left Side		
Flange diameter		
Flange-to-hub center		
Cross pattern		
Computed spoke length		
Right Side		
Flange diameter		
Flange-to-hub center		
Cross pattern		
Computed spoke length		

WHEEL LACING

Lacing is the procedure for installing the spokes that connect the hub to the rim. Inspect an already built wheel and notice the pattern of spokes as they leave the hub. While there are different systems of lacing possible, this book will teach lacing in four sets. Consider each flange as using two different sets of spokes, making four sets of spokes in the complete wheel.

Before lacing, begin by gathering the rim, spokes of the correct length, nipples, and hub, all at a worktable. If using two different spoke lengths, it can be helpful to make sure the left flange spokes are on your left and the right flange spoke are on your right. If the hub is a rim brake style front hub, pick one side as the right side and mark it with tape or a rubber band for purposes of lacing.

Use colored tape to mark the rim valve hole for quick reference while lacing and truing.

Inspect the rim for any asymmetrical spacing of spoke holes. For asymmetrical rims, the offset faces up for a rear hub, but down for a front disc hub.

Next, inspect rim for a staggered left–right–left drilling pattern. Lay rim flat on a table, with valve hole opposite you. Staggered holes will now be able to be identified as having an up-down-up pattern. If the rim was drilled centered, but the nipples drilled for left–right–left–right direction, identify the upward/downward sets.

FIRST OF FOUR SETS

If using differential spoking, select a right-side spoke. Insert the spoke from the outboard side of any spoke hole on the right-side hub flange. The spoke elbow will be on the inside of the flange and the spoke head will be on the outside.

Using the valve hole as a reference, count to the right to the first upward hole and insert the first spoke (figure 6.14). If rim holes are drilled centered without any staggered pattern, use the second hole to the right of the valve hole and insert the spoke. Thread a nipple, narrow end first, from backside of the rim and engage it a few turns, enough to keep it from falling off. Do not fully thread nipples on or cover all spoke threads, as it will make engaging all spokes difficult as you lace. The first spoke will be referred to moving forward as the “Valve Reference Spoke.” It can be useful to mark it with tape.

FIGURE 6.14: First spoke of the first set in correct staggered hole to right of valve hole

At the flange, counting to the right, skip a hole and insert another spoke into the second spoke hole, again from the outside. At the rim, count four holes from the Valve Reference Spoke to the right and engage the second spoke. Thread on a nipple a few turns to hold it in place. Repeat installing spokes in this pattern, moving clockwise, skipping every other flange hole. Continue installing spokes in every fourth hole moving to the right and insert the spokes into the rim and hold the spokes at the rim by threading on the nipple (figure 6.15). In this example, eight spokes will complete the first set.

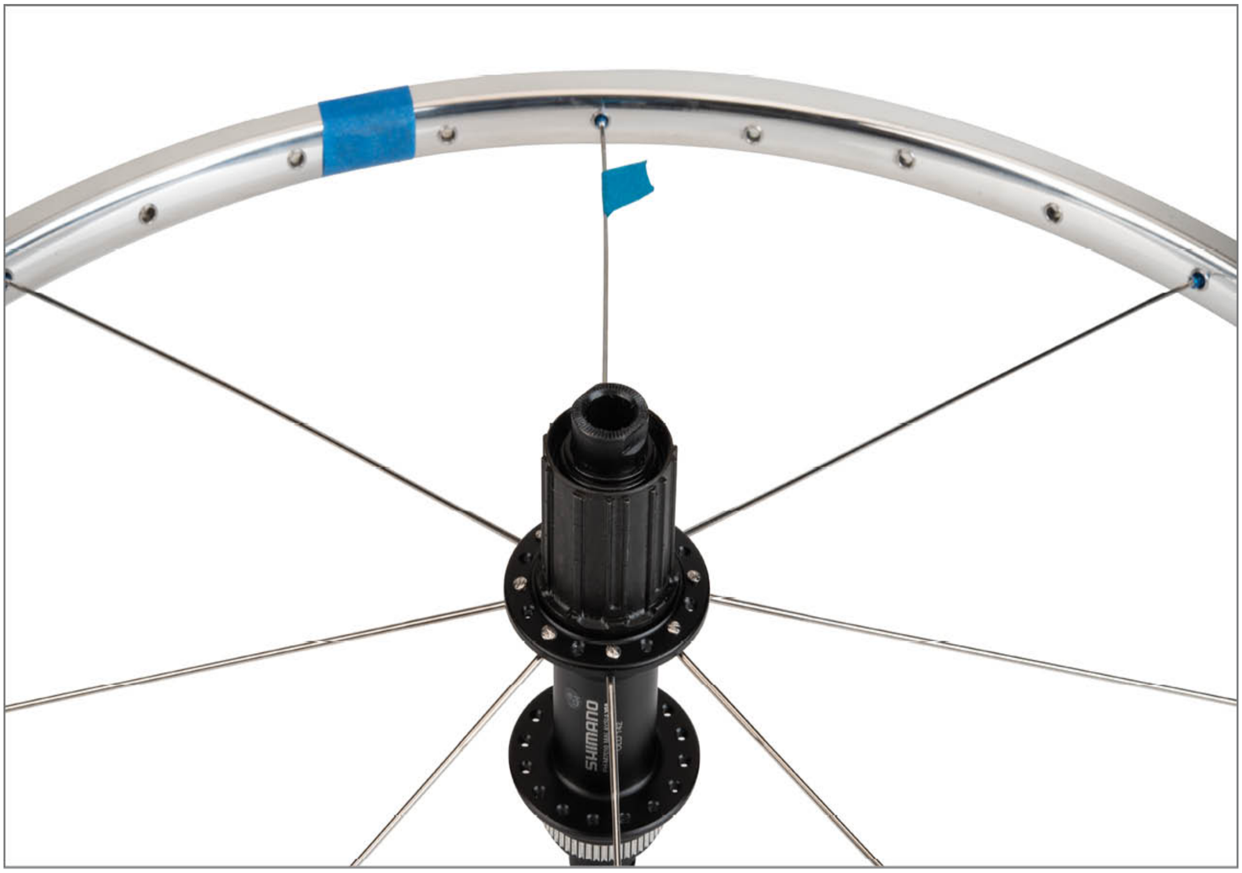


FIGURE 6.15: First set of spokes laced into rim

After completing this first quarter set of spokes, inspect the lacing for errors. Correct any errors.

- There should be three empty rim holes between each spoke.
- Spokes should be in upward holes for staggered rims.
- Every other spoke hole in the right flange should have a spoke head facing up.

SECOND OF FOUR SETS

The first set of spokes should be radiating directly to the rim from the hub. The next set of spokes will engage from the left flange. Selecting the first spoke of the second set is determined by rotating the hub inside the rim.

Turn the wheel over. With the left flange now upward, locate the Valve Reference Spoke. Rotate the hub counterclockwise and notice the Valve Reference Spoke moves away from valve (figure 6.16). This simply makes it easier to get a pump head on the tire valve. If the hub was rotated the opposite direction, the Valve Reference Spoke would move closer to the valve hole. Unwind the hub again so the spokes are again radiating straight.

FIGURE 6.16: Rotate hub to determine direction of first spoke set while viewing valve hole

The first spoke of the left flange will fill the rim hole immediately adjacent to the Valve Reference Spoke, which may be either to its right or left side at the rim. Follow the Valve Reference Spoke back to the right flange. Use a spoke as a pointer from outside of the left flange to find the two spoke holes that are most closely aligned with the Valve Reference Spoke. This is done by inserting the spoke straight from the outside of the left flange until the spoke contacts the inside of the right flange (figure 6.17).

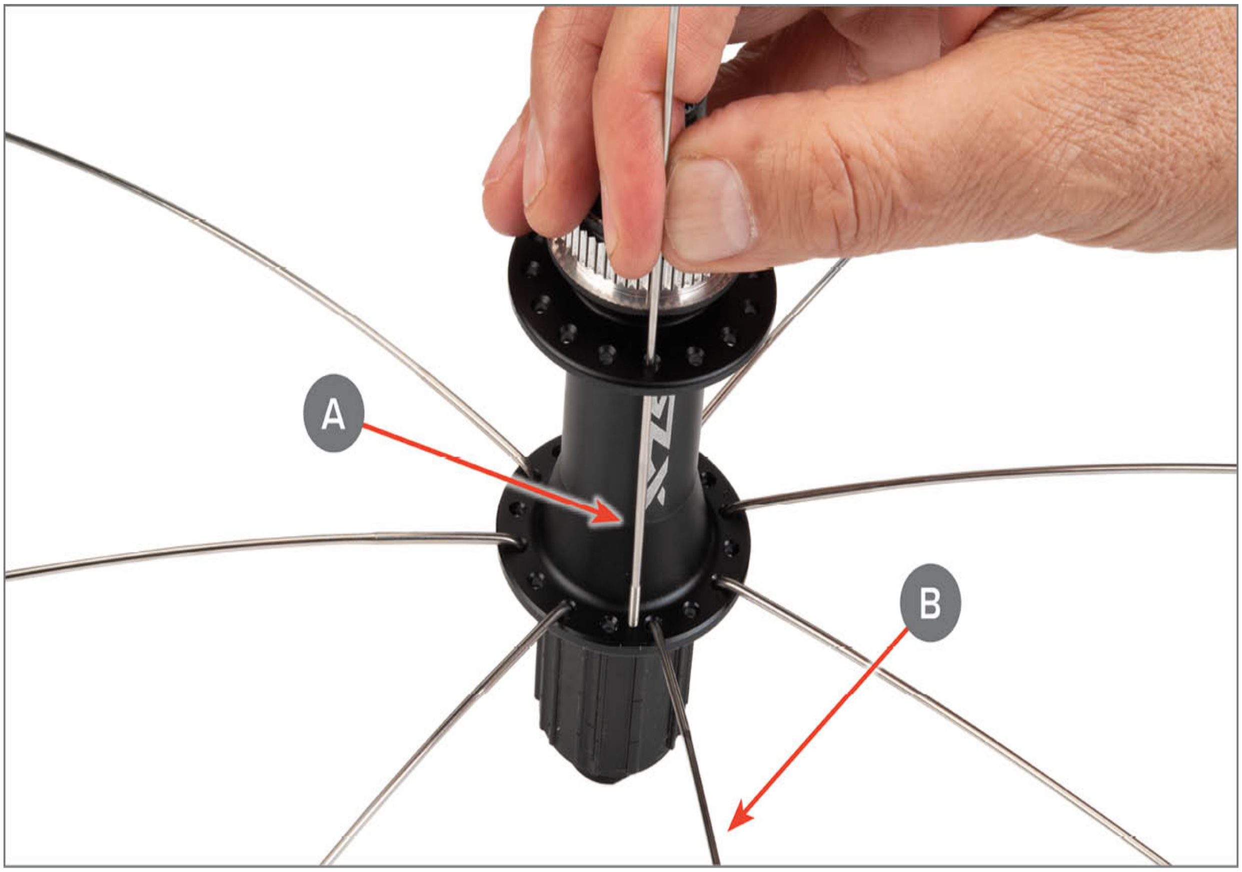


FIGURE 6.17: First spoke of left flange used as straight pointer to select correct left flange hole
(A) First left flange spoke, (B) Valve reference spoke

This hub flange hole is going to fall either to the left or the right of the Valve Reference Spoke. The left flange holes are not directly aligned with the right flange holes, but are offset halfway between. If you are filling a rim hole to the right of the Valve Reference Spoke, select the flange hole to the right of the Valve Reference Spoke. If filling a rim hole to the left of the Valve Reference hole, select the closest flange hole to left (figure 6.18). The head of this spoke will be on the outside of the flange, with the elbows on inside.

FIGURE 6.18: Select hole in left flange relative to Valve Reference Spoke
(A) New spoke starting point, (B) Spoke ending point

Insert the first spoke of the left-side flange into the correct rim hole and thread on a nipple. Counting from this first left-side spoke just installed, skip a hole moving to the right and insert another spoke again from the outside of the flange. From the rim hole just filled, count over to the right to the fourth hole and engage this spoke at the rim with a nipple. There should be no visual crossing over the right flange spokes on this second set. Repeat this process of skipping a left-side flange hole and filling the next, then attaching the spoke at the rim. Continue until there are spokes in every other hole at the left flange and they are attached at the rim (figure 6.19). Spokes should nearly mirror the opposite hub side spokes, being only slightly staggered.

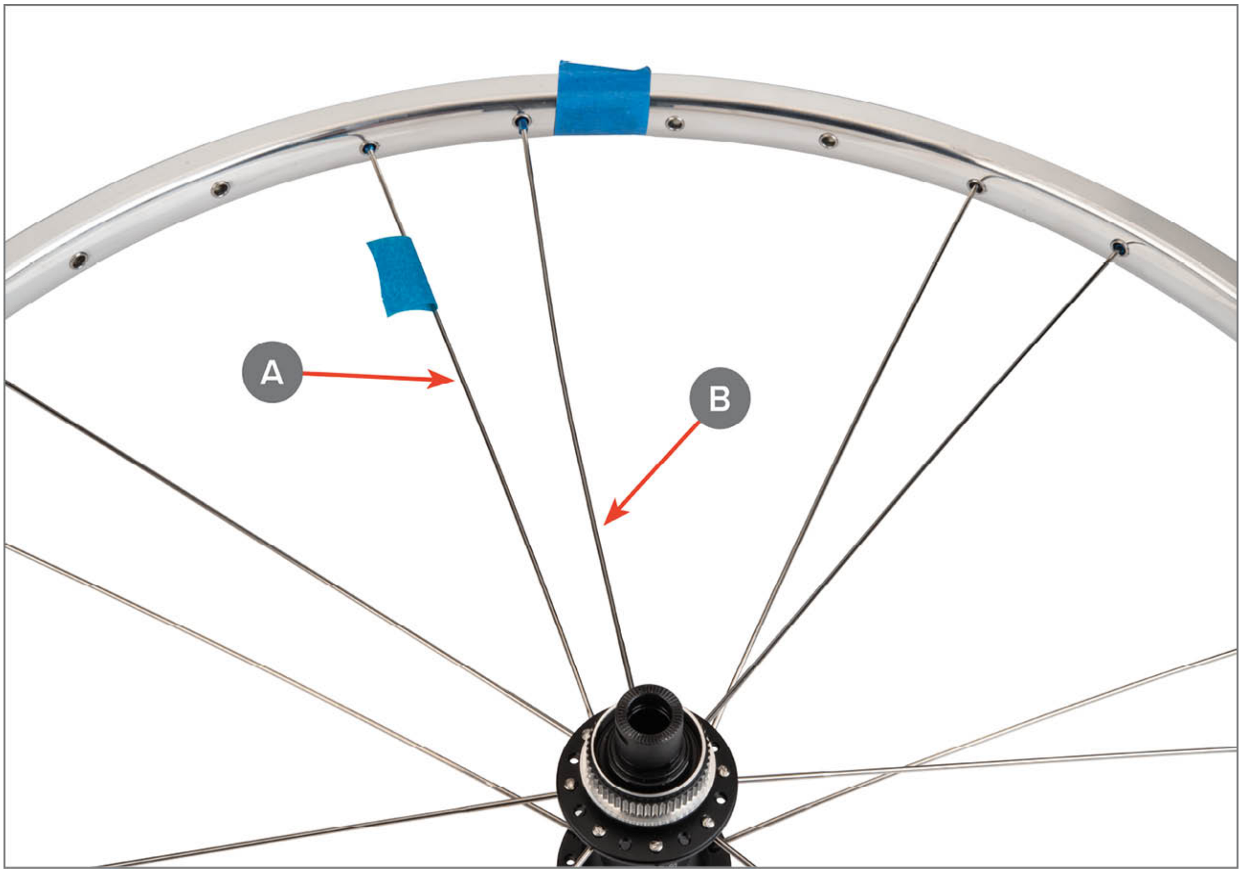


FIGURE 6.19: Left hub flange is half filled with spokes
(A) Valve reference spoke, (B) First spoke from left flange

Check your work at this point. Correct any problems or mistakes.

- The spoke heads should be showing outside the left flange with the elbows inside the flange.
- Every other hole should be filled at the flange.
- At the rim, there should be two adjacent spoke holes filled with two empty holes between.
- Sighting from the left flange, spokes should not visually cross the spokes from the right flange.

THIRD OF FOUR SETS

The third spoke set requires the hub to be rotated inside the rim. At this point, insert one spoke of the correct length through the inside of the right flange in any empty flange hole. The head should be on the inside of the flange and the elbow on the outside.

Hold the rim and notice the location of the valve. Twist the hub either clockwise or counterclockwise and note which rotation moves the Valve Reference Spoke away from valve, giving more clearance.

The third set of spokes will radiate in the opposite direction of the already attached spokes. For example if the first set of spokes are radiating clockwise, this third set will radiate counterclockwise.

A note of caution on this step: watch the nipples at the rim while the hub is rotated. The nipples should be seated inside the rim holes. If nipples are caught on the edge of a rim hole, the hub will not fully rotate. This makes the third spoke set very difficult to install.

With the hub still rotated, grab the first spoke of the third set. Install it in the opposite direction of the attached spokes (figure 6.20). Count the number of times it crosses a spoke from the right flange. This example assumes the wheel is a common three-cross. The first cross to count is actually hidden by the flange.

FIGURE 6.20: Third set spokes will radiate opposite direction of previous spokes

Continue to move this spoke until it has crossed over three spokes from the right flange, including the first spoke at the flange. There will be two empty rim hole choices. Select the empty rim hole next to a spoke from the left flange. The common build uses a pattern of left flange–right flange–left flange–right flange at the rim. Right flange spokes should not be located in adjacent rim holes.

Before engaging the spoke, it is common practice to “interlace” the spoke by crossing under the spoke. Flex the spoke and bend it under this spoke and engage the spoke with a nipple at the rim (figure 6.21).

FIGURE 6.21: Third set spokes are flexed to go under the first set spokes at cross

Insert another spoke from inside the right flange and, again, rotate it in the opposite direction of the first set of spokes. Count over three right flange crosses, and then interlace the spoke under the cross (figure 6.22). Again, select the rim hole adjacent to a spoke from opposite flange. Use a nipple to attach it to rim. Repeat this process until the right flange is filled and the spokes are attached at the rim.

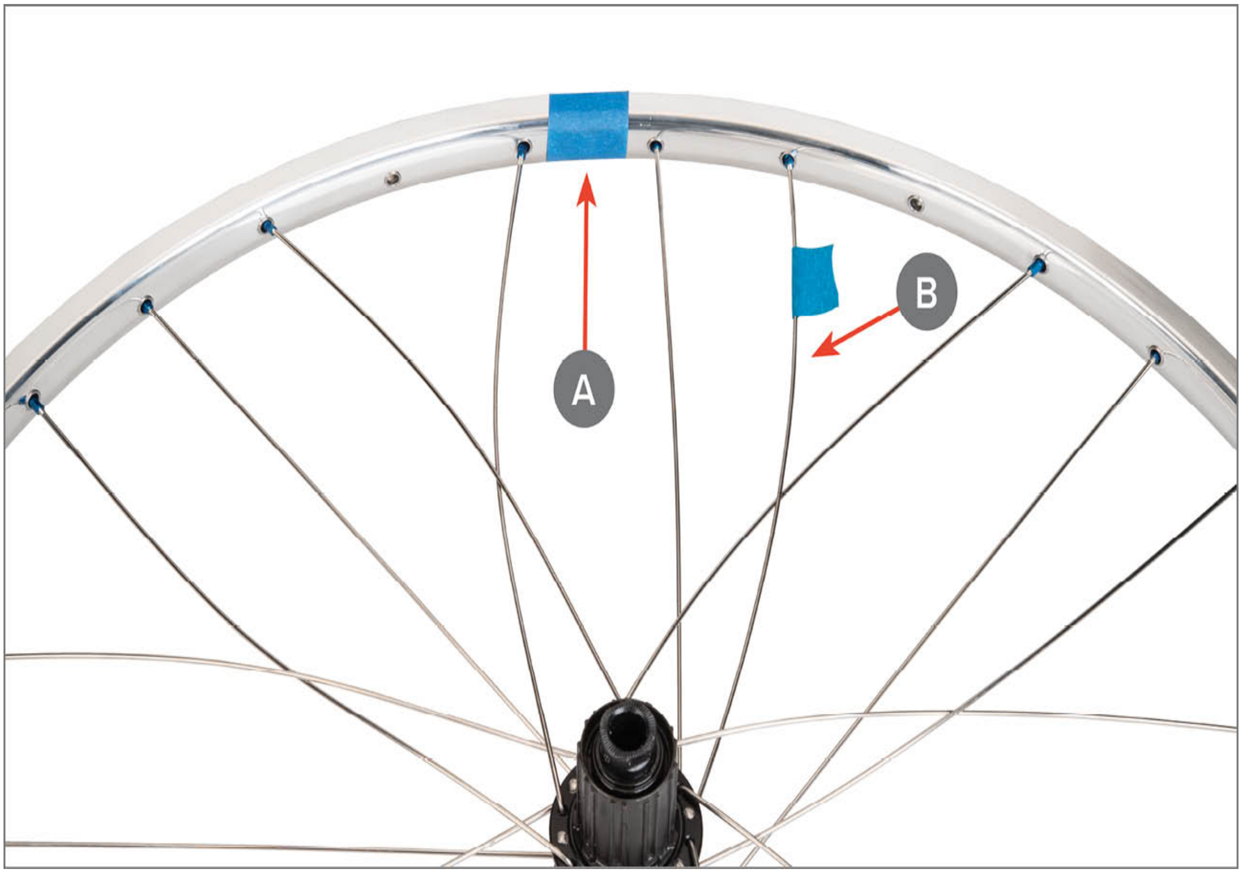


FIGURE 6.22: Third set of laced spokes is complete
(A) Valve, (B) Valve reference spoke

Check this set for mistakes. Make any corrections before continuing.

- There should be one empty hole between sets of three spokes attached at the rim.
- The set of three spokes at the rim should be from the right flange, the left flange, and then the right flange.
- The cross closest to the rim should be interlaced.

FOURTH OF FOUR SETS

The set is the easiest if all steps were checked throughout the build. Insert a left-side spoke through the flange from the inside. Spoke heads should be on the inside and spoke elbows should be on the outside. Move the spoke to radiate from the hub in the opposite direction of other spokes installed in this flange. Count crosses, including at the hub flange, and interlace at the third cross (figure 6.23).

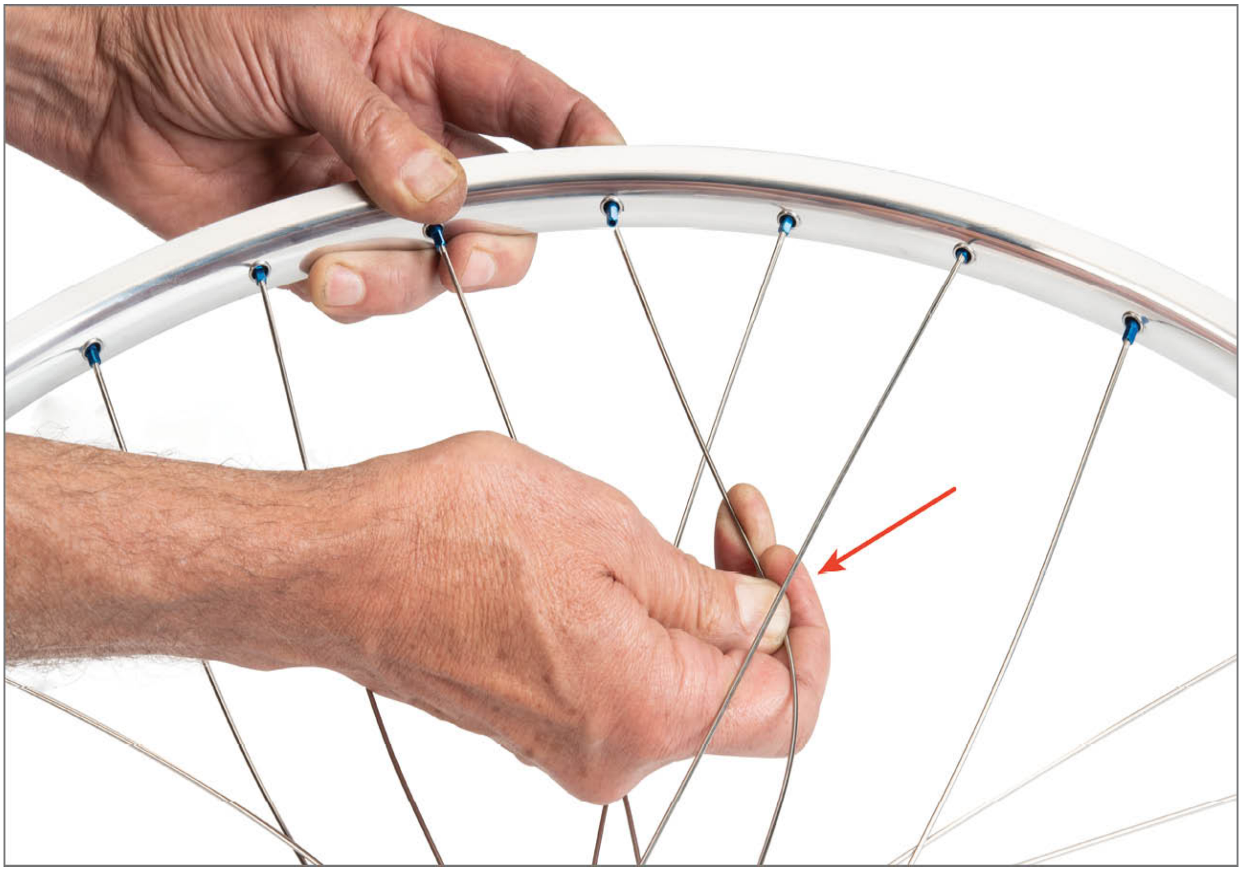


FIGURE 6.23: Spoke is flexed under crossing on way to rim

Repeat until all hub holes and all rim holes are filled with spokes. The final check is to inspect that there is an interlace at the final spoke crossing closest to the rim (figure 6.24).

FIGURE 6.24: Check the set of spokes is interlaced at crossing

BRING WHEEL TO TENSION

Spokes laced into the hub and rim will be very loose. This is a good time to add lubrication to the spoke threads and the nipple-to-rim interface. Use a light lubricant such as a chain lube and put a drop on the spoke threads. Some lubricant will drip off spoke and work its way down to the nipple. Lubrication is important because it will make achieving full tension easier and help prevent corrosion at the thread.

The next step is to consistently even up the amount of threads showing at each nipple. Three threads showing above each nipple should be adequate. For speed, a nipple driver such as the Park Tool ND-1, or a screwdriver can be used from the backside.

If differential spokes were used, evening up the spoke thread at the nipples will also center the rim to some degree. Always start and stop at the valve hole as it provides a good reference point or marker.

If all spokes were the same length on a rear hub or a disc front hub, begin with the same amount of spoke thread showing. If the hub has one side with one flange offset more than the other, turn the side with more offset two complete turns tighter. For rear wheels this is the right side, but for front rotor disc wheels, it is the left. This effectively shortens this side by 1mm.

It is likely spokes are still very loose. Begin to add tension by tightening all spokes in even steps. Add two turns to each spoke nipple. If one spoke feels especially loose do not add more turns. The rim will be out of true at this area later in the process and the spoke will be tightened more at that time.

Do not be in a hurry to reach full tension. Begin at the valve and add one full turn to each nipple. When the spokes are plucked and resonate a low tone, there is enough tension to begin normal truing procedures with lateral, round and dish correction. When the rim has acceptable lateral, round and dish tolerances, again add more tension. Be aware that when all spokes are tightened to add tension, it is common for lateral, round and or dish tolerances to become worse. It takes time and experience to build a wheel, so be patient. Refer back to Truing Procedures for a review of wheel truing and tensioning.

WHEEL TO RIM TRANSFER

Sometimes a relatively new wheel rim gets badly bent from a crash. If the spokes have not been extremely kinked or cut, it is possible to transfer the spokes and the hub to a new rim. Note that spokes will eventually get fatigued and become susceptible to breaking, so spokes with thousands of miles should not be reused. However, if the rim has a bend that cannot be trued, and the wheel has relatively few miles, it is a simple process to rebuild. Begin by removing tire and rim strip of the bent wheel for inspection.

An adequately matched rim with same spoke hole count will be needed. It need not be the exact brand or model but it must have an acceptably close ERD. Look for the damaged rim's manufacturer and model, and search online for the ERD. Find a rim that matches this same ERD.

Inspect the nipples from inside the rim holes. If the spokes were protruding past the nipple end, then a slightly larger ERD of 1–2mm should work. However, if there are threads showing at each nipple below the rim, it indicates the spokes were a bit short, and a 1–2mm smaller ERD should work. If spokes were of a good length, try to match ERD.

Beginning at the valve, loosen all nipples in the old rim 2–4 turns, but do not remove them. Lay the bent wheel on a work table and lay new rim on top, aligning valve hole to valve hole. Using tape, hold old and new rim together in four places.

Next, begin at the valve and loosen the first nipple completely. Pull the spoke from the nipple, and transfer the spoke and nipple upward to the new rim's first hole. Repeat the process of removing a spoke and transferring it upward to the new rim (figure 6.25)

FIGURE 6.25: Transferring spokes after taping rims together

If it is difficult to get the nipple out of the old rim, use a spoke end and thread it into the backside on the nipple. A toothpick or similar device can be also used to hold and control the nipple when removing it from the rim (figure 6.26).

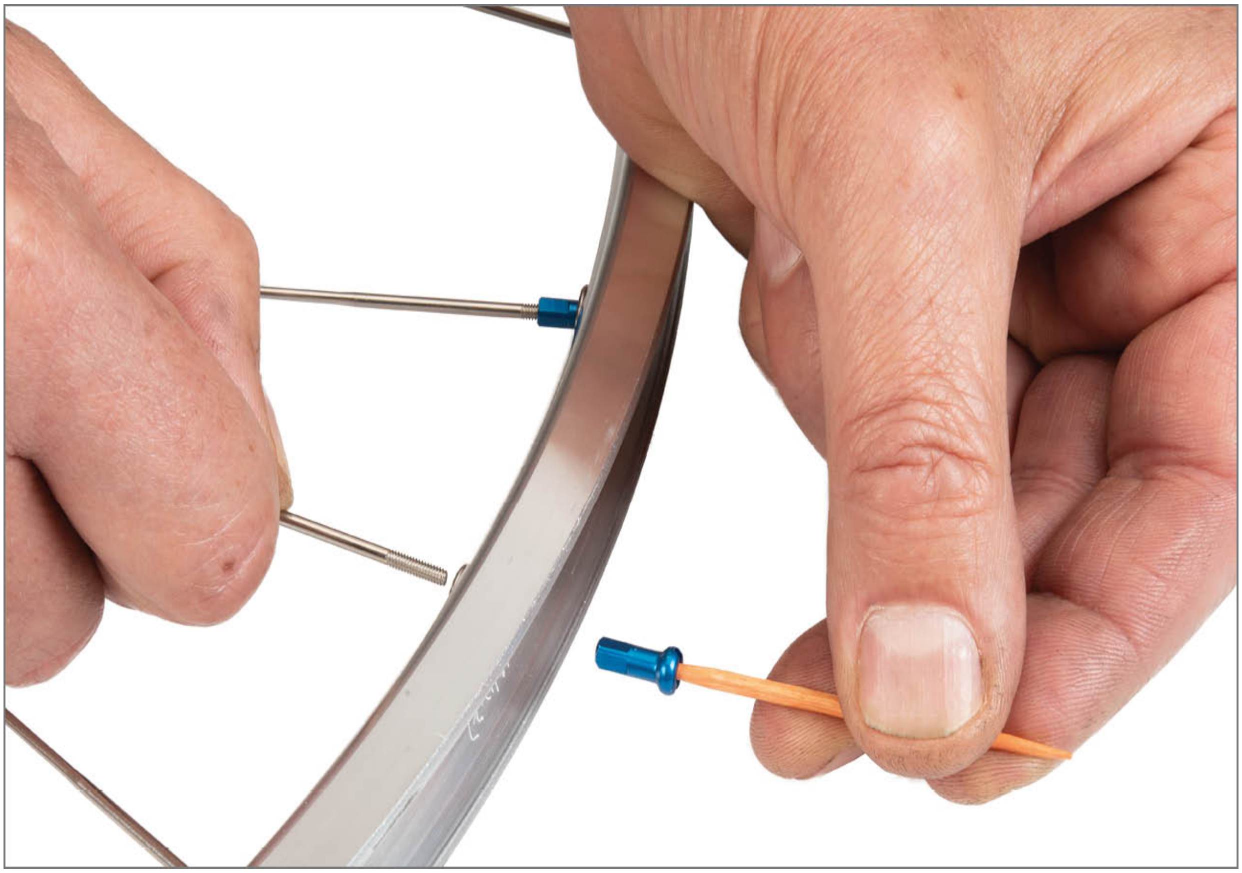


FIGURE 6.26: Use a toothpick to engage nipple

Once all spokes are moved to the new rim, remove the tape, and pull the new rim to tension as if it were a newly built wheel.

CHAPTER 7

CRANKSETS

Cranks are levers that connect the pedals to the bottom bracket spindle. Cranks are fitted with one or more toothed sprockets, referred to as chainrings, that drive the chain. Cranks may be removed to replace the cranks or chainrings, service the bottom bracket bearings, or to better clean the chainrings. Crank systems have become more complex in recent years. The design of the crank system often determines how the bearing system is adjusted. To know the service options you will need to know the type of crank and type of bottom bracket bearing system installed.

CRANK TYPES

Common modern crank designs include “three-piece” and “two-piece” crank systems. The parts of the three-piece crankset are the left crank, the right crank, and the axle spindle (figure 7.1). The spindle is held in position by bearings in the frame. Both cranks must be removed to service or replace the bearings of a three-piece system. Crank bolts secure the left and right cranks to the spindle.

FIGURE 7.1: Three-piece crank components: left crank, spindle, and right crank with chainrings

Two-piece crank designs include systems such as Shimano® Hollowech II®, Campagnolo® Ultra-Torque®, SRAM® DUB® and GXP®, Race Face® X-Type, FSA® MegaEvo®, Rotor® and other similar systems. The spindle is permanently fixed on one crank, making it effectively one piece of the system. The second piece is simply the other crank. The spindle passes through the bearings fitted in the frame. The opposite crank has a fastener system connecting it to the spindle (figure 7.2).

FIGURE 7.2: Two-piece crank components: left crank and right crank with integrated spindle

An older design called the “one-piece” crank was once used on Schwinn and other bikes made in the USA. It is still seen on BMX bikes and some inexpensive bikes. A single S-shaped forged arm is fitted in a large unthreaded shell. Service of one-piece cranks is reviewed at www.parktool.com/repair-help.

In two-piece and three-piece crank systems there are different standards for the spindle-to-crank interface. Many of the newer cranks use proprietary designs and do not interchange between brands or even different models of the same brand. It may be necessary to remove the crank bolt or dust cap to inspect inside to confirm the type of interface.

A tapered square-spindle interface is usually found on less expensive bikes, older bikes, and “classic” bikes (figure 7.3). It is a three-piece crank system, with the spindle ends formed as a square stud made with a slight taper. The spindle fits a corresponding square-tapered hole in the crank. There are two standards for spindle tapers. The JIS standard is used on Shimano® cranks, and many Asian-made cranks. The ISO standard is used on Miche® and Campagnolo® square-spindle cranks. These two standards should not be mixed when choosing spindles or cranks.

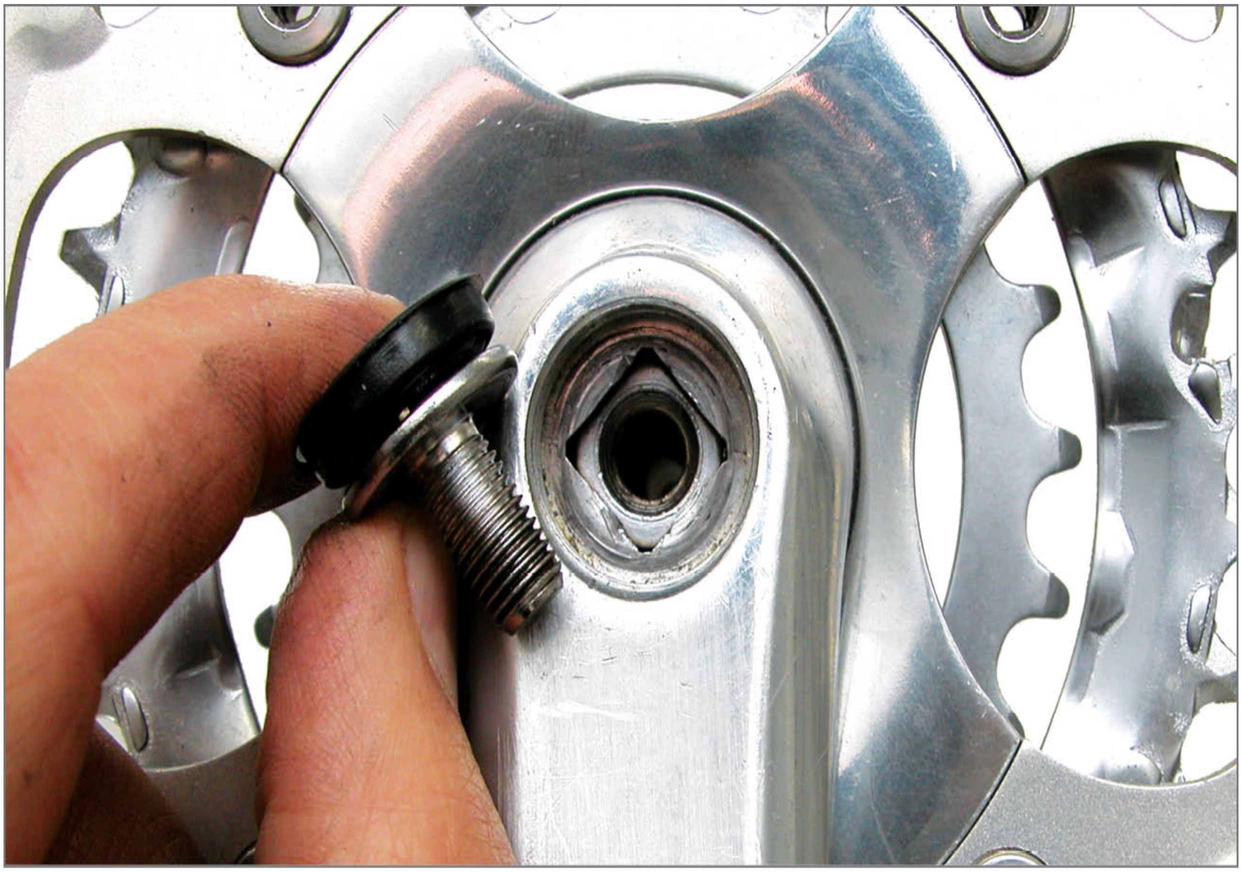


FIGURE 7.3: Square crank hole with square spindle inside

ISIS Drive is a three-piece crank system using a round spindle with splines at the crank spindle interface (figure 7.4). The term ISIS Drive does not refer to a particular brand but to a design standard. Several manufacturers offer cranks in the ISIS Drive standard, and all ISIS Drive cranks and spindles interchange. This system uses a 21mm diameter spindle with 10 splines.

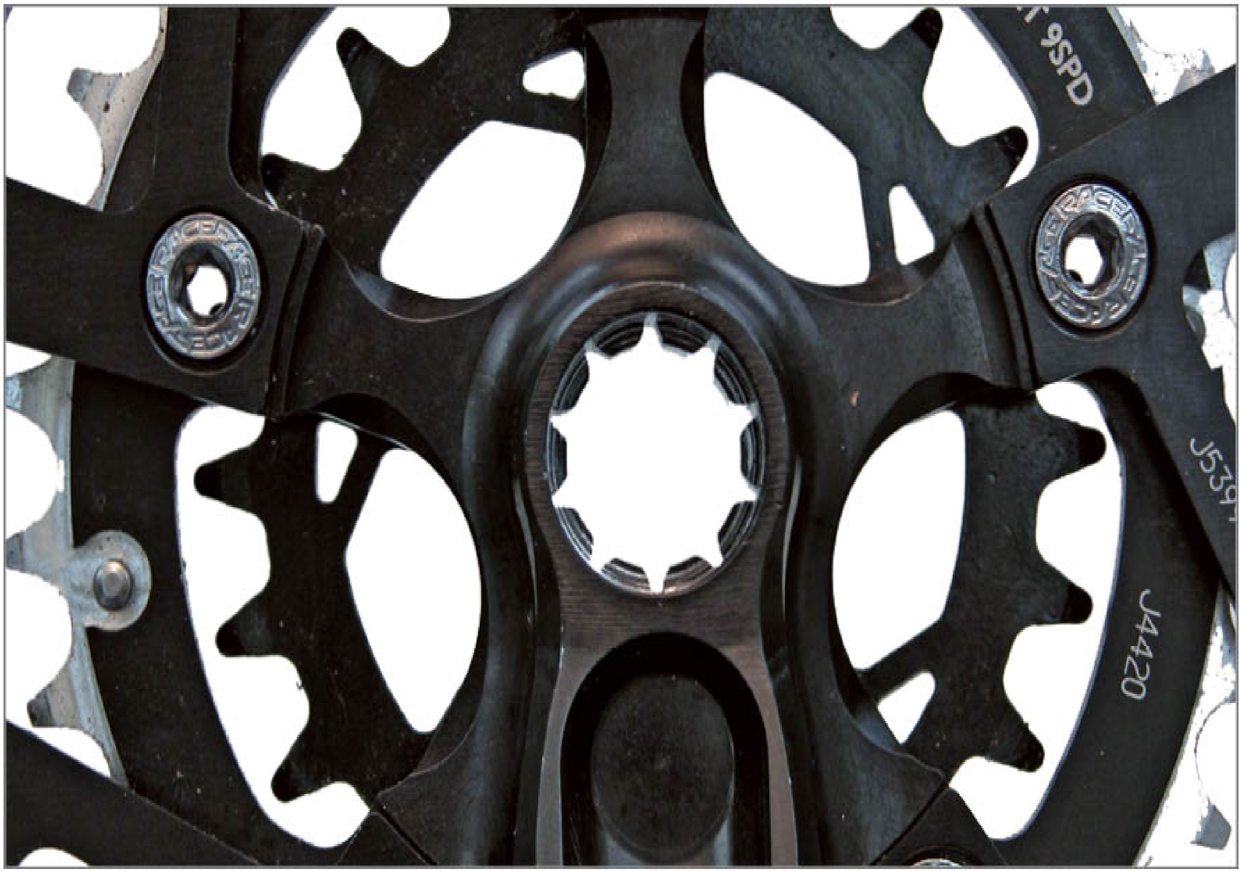


FIGURE 7.4: ISIS Drive crank with 10 splines

Octalink® is a three-piece crank system used in some Shimano® cranks. It uses a round spindle nominally 21mm in diameter but with an eight-splined pattern (figure 7.5). There are two standards in the Shimano® Octalink® system. The original standard is called Octalink® V1, and was used on models BB-7700, 6500, 5500, M950, and M952. The Octalink® V2 fits the BB-ES70/71 and BB-ES50/51. The V2 system uses a thicker and longer spline (approximately 9mm), while the V1 spline is relatively narrower and shorter (approximately 5mm). The V1 and V2 Octalink® standards do not interchange between spindles or cranks. The ISIS Drive and Shimano® Octalink® systems are not interchangeable for cranks or spindles.

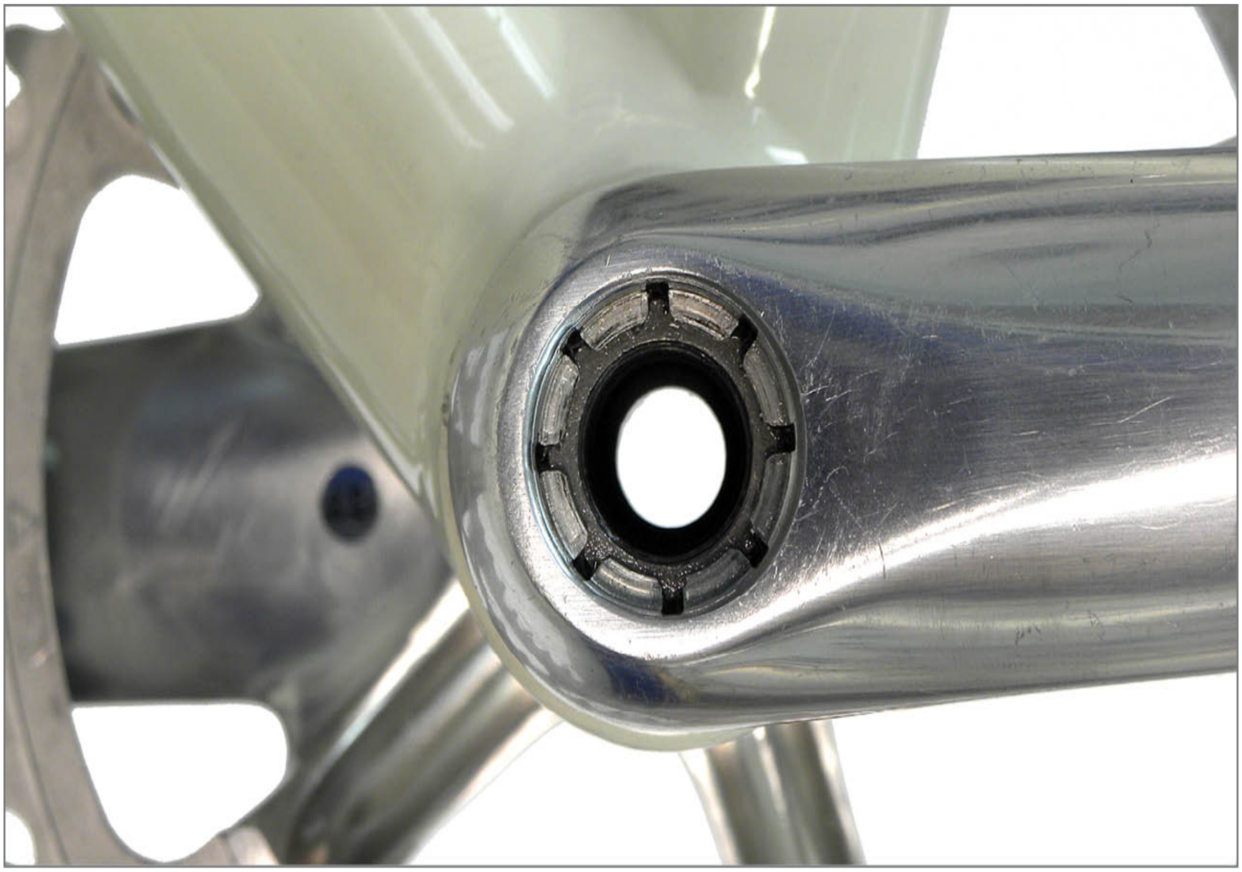


FIGURE 7.5: Shimano® Octalink® crank and spindle interface at the left crank

Power Spline™ crank system is three-piece proprietary design by SRAM® that uses a round spindle crank interface with 12 splines (figure 7.6). A similar system is Power Drive™ by FSA®. Both systems use a sight taper to the splined spindles but the two systems do not interchange.

FIGURE 7.6: SRAM® Power Spline™ and Park Tool CWP-7 Crank Puller

CRANK REMOVAL & INSTALLATION

This section will review crank removal and installation for some common crank systems. There are also proprietary systems that are variations on these designs. When in doubt contact the crank manufacturer for removal procedures.

Removal procedures for two-piece cranks vary with the design and manufacturer. However, some brands and models share design concepts and are removed and installed with similar procedures. Non-permanent arms must be removed first, and then the remaining crank with spindle is pulled from the bike. The spindle may be fixed to either the left or right arm, depending upon the design.

SELF-EXTRACTING CRANK SYSTEMS

Both two-piece and three-piece cranks may be fitted with “self-extracting” or “one-key” release systems. The crank puller is effectively designed and built into the crank (figure 7.7). A threaded extracting cap with a hole in the center takes the place of a crank dust cap and is threaded over the crank bolt to act as bolt-retaining ring. To remove this crank, leave the extracting cap in place. Turn the crank bolt counterclockwise. The crank bolt backs against the extracting cap. As you continue to turn counterclockwise, the crank will be pulled from the spindle.

FIGURE 7.7: Self-extracting crank with hex wrench in place for crank removal

If the extracting cap has been removed, it should be reinstalled and tightened. Self-extracting systems rely on the extracting cap being secure and tight in the crank. The extracting cap should be occasionally checked for tightness (figure 7.8). The thread is normally a right-hand thread. If the cap is a left-hand thread, it is typically marked accordingly and must be tightened counterclockwise.

Extracting cap threading varies with manufacturer. If the extracting cap has a 22mm diameter thread, a crank puller tool such as the Park Tool CWP-7 or CCP-22 can alternatively be used to remove the crank. Extracting caps made in larger thread diameters have no optional crank puller tool available. The manufacturer's extracting cap must be used. Contact the manufacturer if the ring has been lost.

FIGURE 7.8: Check security of extracting cap using a Park Tool SPA-2

Self-extracting systems require extra care when installing the cranks to the spindle. The self-extracting system makes it difficult to see how the crank is fitting onto the splines of the spindle. Cranks and spindles must align and mate properly as the crank is pressed onto the spindle. A forced mismatch can damage the crank. If there is concern about mating the spindle to the crank, remove the extracting cap for a better view of the crank-to-spindle fit, then reinstall cap.

To install self-extracting cranks, inspect both the crank fitting and spindle for the pattern of “tooth” and “groove.” The teeth on the spindle must mate with the grooves (spaces) in the crank fitting (figure 7.9). With crank pointing straight down at a six o’clock position, rotate the spindle so it matches appropriately with the crank fitting. Use the appropriate size hex wrench to rotate crank bolt clockwise. Thread carefully as you maintain alignment. Secure crank bolt fully. Mount the second crank pointing the opposite direction with the same procedure and tighten fully.

FIGURE 7.9: “Teeth” (A) of spindle must align with “grooves” (B) at crank interface

THREE-PIECE CRANKS

Three-piece cranks are identified by each crank having identical bolts or nuts centered to the spindle. The cranks are held secure to the spindle by force from the bolt/nut. To remove the cranks, these bolts or nuts must first be removed. Hex wrench sizes for crank bolts can be 6mm, 8mm, 10mm or 14mm.

If a hex-headed bolt or nut is used, it may be a 14mm, 15mm, or 16mm, depending upon the brand.

Cranks without a self-extracting system require a crank puller to extract arms from the spindle after the crank bolts are removed. Cranks are made with an internal thread fitting to match crank pullers. Crank pullers use a 22mm x 1mm external thread to secure to the crank. Pullers then use a threaded stud to push against the spindle end. The spindle and arm are pulled apart when the puller stud is pressed with force against the spindle.

Park Tool offers different crank puller options depending upon the thread diameter of the crank bolt. The puller stud that pushes on the spindle must be slightly larger than the threaded hole in the spindle end. The Park Tool CCP-44 or CWP-7 offer a puller stud tip of approximately 16mm for the M12 or M14 bolts of the ISIS Drive and Octalink® cranks. The CCP-22 or CWP-7 have a tip of approximately 11mm for the M8 thread of Power Drive™, Power Spline™ and square-spindle systems.

Procedure for crank removal:

a. Shift chain to largest chainring. This helps protects hands from chainring teeth.

b. Remove dust cap (if any) and crank bolt or nut. Remove any washers inside crank that were below bolt/nut.

c. Inspect crank bolt and select correct tool. Cranks with M8 crank bolts use CCP-22 or CWP-7 with small 11mm tip. Larger M12 and M14 bolts use CCP-44 or CWP-7 with larger 16mm tip.

d. Turn driver of puller until it sits recessed in hex fitting of tool. This permits full engagement of 22mm thread into crank.

e. Thread hex fitting of crank puller into crank (figure 7.10). 22mm thread fitting must be fully threaded into crank. Failure to fully engage tool’s threads in crank may result in damage to crank.

FIGURE 7.10: Thread and tighten hex fitting of puller securely into crank threads before extracting crank

f. Turn driver clockwise (figure 7.11). When stud meets spindle, resistance will be felt. Continue threading driver into puller until crank is removed.

FIGURE 7.11: Remove crank from spindle by turning driver of crank remover

g. Unthread crank puller tool from crank and repeat process on other crank.

Three-piece cranks use a bolt or nut that acts as the pressing tool and forces the cranks tight to the spindle end. Bolts or nuts must be tight enough to keep the crank from loosening but not so tight that the crank becomes split or damaged. The bolt/nut may need 25 to 38 Nm (300 to 450 inch-pounds) depending upon brand. Whenever possible, use a torque wrench for this installation. If a crank bolt comes loose or was not properly tightened, the crank hole may become damaged from use. Additionally, the crank can fall off during riding.

Square-tapered spindles are made with a slight slope or taper. This shape creates a wedge as it is driven into the square hole of the crank. Generally this fit is not lubricated. Adequate torque is typically enough to keep cranks from creaking. If a crank creaks even at full torque, remove and grease the pressed surfaces.

Splined-type spindle systems such as ISIS Drive and Octalink® lack the taper of the square spindles. Splines should be well greased before installation.

Procedure for crank installation:

a. Apply grease or anti-seize under head and threads of bolts/nuts.

b. For square-tapered spindle, leave spindle clean of grease. Apply grease (or anti-seize) to spline type spindles.

c. Install right crank onto right side of spindle. Thread in bolt to spindle. Self-extracting models align teeth and grooves of spindle and crank when installing.

d. Tighten bolt fully to manufacturer's specifications. Refer to Appendix C for recommended torques.

e. Align left arm so it points directly opposite right arm. Self-extracting models align teeth and grooves of spindle and crank when installing. Thread bolt into spindle and tighten bolt fully.

f. Grease threads of dust cap (if any), and install snugly.

TWO-PIECE COMPRESSION SLOTTED CRANKS

Shimano® cranks and some models of FSA® cranks use a left crank with a compression slot that is secured by pinch bolts. These systems do not use a conventional crank puller. A threaded adjusting cap is used to bring the arm against the bearings. The cap acts as a bearing adjustment only and does not hold the arm in place.

Procedure for crank removal:

a. Loosen fully any pinch bolts on left-side crank (figure 7.12).

FIGURE 7.12: Loosen both pinch bolts of compression slotted cranks

b. Remove left-side crank adjusting cap turning counterclockwise. Shimano® cranks use an eight-pointed socket fitting. Use Park Tool BBT-9 or BBT-10.2 (figure 7.13). FSA® crank adjusting caps use a 8mm hex wrench.

FIGURE 7.13: Remove crank cap after pinch bolts are loose

c. For Shimano® Hollowtech® II, inspect for a "stop plate" inside left crank slot (figure 7.14). Use a thin screwdriver or hook on the Park Tool BBT-10.2 to lift plate upward. The stop plate acts as a safety redundancy to prevent left crank removal. FSA® has no stop plate.

FIGURE 7.14: Lift stop plate to pull off Shimano® Hollowtech® II crank

d. Pull left crank off spindle by hand. In some cases it may require light tapping with a soft mallet to remove crank if spindle-arm interface is dirty or sticky.

e. Pull right crank and remove it from bike. It may be necessary to use a mallet to tap spindle on the left side.

The left cranks of these crank systems are used to adjust the bottom bracket bearings. The left crank slides along the spindle and is retained and located by tightening an adjusting cap on the crank, much like a threadless headset cap adjusts threadless headset bearings. Bolts in the arm are tightened to keep the arm from falling off and to maintain the bearing adjustment.

Procedure for crank installation:

a. Grease spindle surface and install drive-side crank and spindle from the right side and through both bearings (figure 7.15). If necessary, use a mallet to fully install arm.

FIGURE 7.15: If necessary choke up on mallet handle and tap crank fully into bottom bracket bearing adaptors

b. Grease threads of crank pinch bolts.

c. Place drive-side crank in six o'clock position. Hold left-side crank in twelve o'clock position and press onto spindle using hand pressure. Lift stop plate of Shimano® crank over pinch bolt. Make sure stop plate is engaged over pinch bolt threads after crank is installed.

d. Grease threads of crank adjusting cap and secure gently. For Shimano® use Park Tool BBT-10.2 or BBT-9. For FSA® use an 8mm hex wrench. Cap pushes arm to bearing. Recommended adjusting cap torque is only a very light 0.5 Nm (4 inch-pounds). Crank should not push into bearing with force. Overtightening will cause bearings to drag and wear.

e. Alternate tightening compression bolts slightly on each side, repeatedly going back and forth until both sides are pulled fully and evenly tight (figure 7.16). Recommended torque is 15 Nm.

FIGURE 7.16: Alternate tightening sides until both sides are pulled fully tight

TWO-PIECE CRANKS USING WAVE WASHER

A "wave washer" is a thin piece of spring steel with undulating bends that fits between the crank and the bearing. Curved surfaces of the washer provide preload to the bearings as the washer is flattened. Brands using this include FSA® and SRAM®. The "wave" is compressed as the crank is tightened and prevents lateral motion of the spindle by pressing against the bearings and crank. Preload is basically "self-adjusting" and cannot be fine-tuned. Depending upon the style of crank, the wave washer goes either on the left side or right side of the spindle.

Straight Spindle Cranks

If the spindle is the same diameter across the entire width, the wave washer is fitted to the left side. The left crank uses a self-extracting system and is tightened fully to a dead stop against the end of the splines.

Stepped Spindle Cranks

If the spindle steps down in diameter from the middle to the end, such as the SRAM® GXP® models, the wave washer is fitted to the right side. The GXP® has a 24mm spindle that is reduced to 22mm for the left end. Consequently the right-side bearing has a 24mm diameter and the left side has a 22mm diameter. The inner race of the left bearing is tightened between the stepped shoulder of the spindle and the left crank. The wave washer is fitted to the right side of the spindle to keep the right bearing from moving and to account for any frame shell width inaccuracies.

Procedure for crank removal:

a. Loosen crank bolt in left crank. Do not remove crank extracting cap. Turn bolt counterclockwise to pull crank from spindle.

b. Note orientation of any spacers, seals, or wave washers before removing (figure 7.17).

FIGURE 7.17: Wave washer between crank and bearing

c. Pull crank from right side to remove. Tap spindle end with mallet if necessary to aid removal.
d. Note orientation of any spacers, seals, or wave washers from right-side crank before removing (SRAM®).

Procedure for crank installation:

a. Grease spindle where it inserts into bearings.
b. Grease splines of spindle and grease internal threads of crank.
c. Install any seals, spacers, and wave washers (SRAM®) as appropriate on crank. Install crank and spindle through bottom bracket.
d. Install any spacers, seals, and wave washers (FSA®) on left side.
e. Install and tighten left crank (figure 7.18).

FIGURE 7.18: Tighten crank fully against stop of splined spindle

TWO-PIECE CRANKS: PRELOAD ADJUSTER RING

Bearing preload adjustment can be designed into the left crank, as seen on some models from Shimano®, SRAM® and FSA® and others. Look for a threaded ring on the inboard side of the left crank. Rings may have a split with a set screw to hold the adjustment. Some designs use a simple friction system to hold the adjustment. Preload adjusting rings take up play by pressing gently against the bearing (figure 7.19).

FIGURE 7.19: Use adjuster ring to remove any crank movement relative to bearings

Crank removal is the same as the self-extracting cranks described earlier. After removal of left arm, the setscrew in the ring should be loosened 1⁄2 to one full turn. Turn the ring by hand fully against the crank. This permits correct bearing adjustment during the next installation.

Bearing adjustment is made after the left crank is mounted and fully secured. Turn threaded adjustment ring so it unscrews from the left crank and just begins to contact the bearing. It is only necessary to gently snug the ring against the bearing face. Do not force the ring into the bearing. Tighten the setscrew gently to hold the ring in place (figure 7.20). Spin the crank to test the bearing adjustment, then pull cranks left to right. If there is side-to-side or lateral motion, loosen setscrew and turn ring further toward the bearing 1⁄8 turn. Tighten setscrew and test again for lateral motion. Repeat only if play is still present.

FIGURE 7.20: Tighten set screw to prevent adjusting ring movement

CAMPAGNOLO® AND FULCRUM® ULTRA-TORQUE® CRANKS

Both left and right cranks of the Campagnolo® and Fulcrum® Ultra-Torque® systems are each fitted with one-half of the spindle. Each end of the spindle is machined in a gear shape to mate with the opposite crank. Spindle end teeth engage in the middle of the bottom bracket shell. A bearing is pressed tight to the spindle of each arm. Adaptor cups in the frame act as retainers for the bearings secured on the left and right crank spindles.

Bearing removal and replacement for Ultra-Torque® system requires special tooling. See below for bearing service.

Procedure for crank removal:

a. Use needle nose pliers to remove bearing retaining clip from right-side bearing adaptor (figure 7.21).

FIGURE 7.21: Remove bearing retaining clip from adaptor

b. Use a long 10mm hex wrench to loosen and remove crank bolt from center of spindle (figure 7.22). **Note:** Super Record™ crank uses titanium crank bolt with LEFT-HAND thread and will loosen clockwise. If in doubt, test bolt inside with magnet. Steel bolts loosen counterclockwise.

FIGURE 7.22: Remove crank bolt with 10mm hex key

c. Pull each crank from the bottom bracket.

d. Remove wave washer from left bearing adaptor.

Bearing service for the Ultra-Torque® system is covered in Campagnolo® Ultra-Torque® and Fulcrum® Bearings. Bearing adjustments for this system are part of crank installation from the pressure of the wave washer in the left-side bearing adaptor. The wave washer is a round thin piece of spring steel that has a series of undulating bends. The wave washer is partially compressed and acts as a spring between the arm and bearing and prevents lateral movement of the crank spindle.

Procedure for crank installation:

a. Install wave washer into left bearing adaptor, or place wave washer on left arm.

b. Install right arm through right adaptor. Align left arm opposite of right arm and install through left bearing adaptor (figure 7.23).

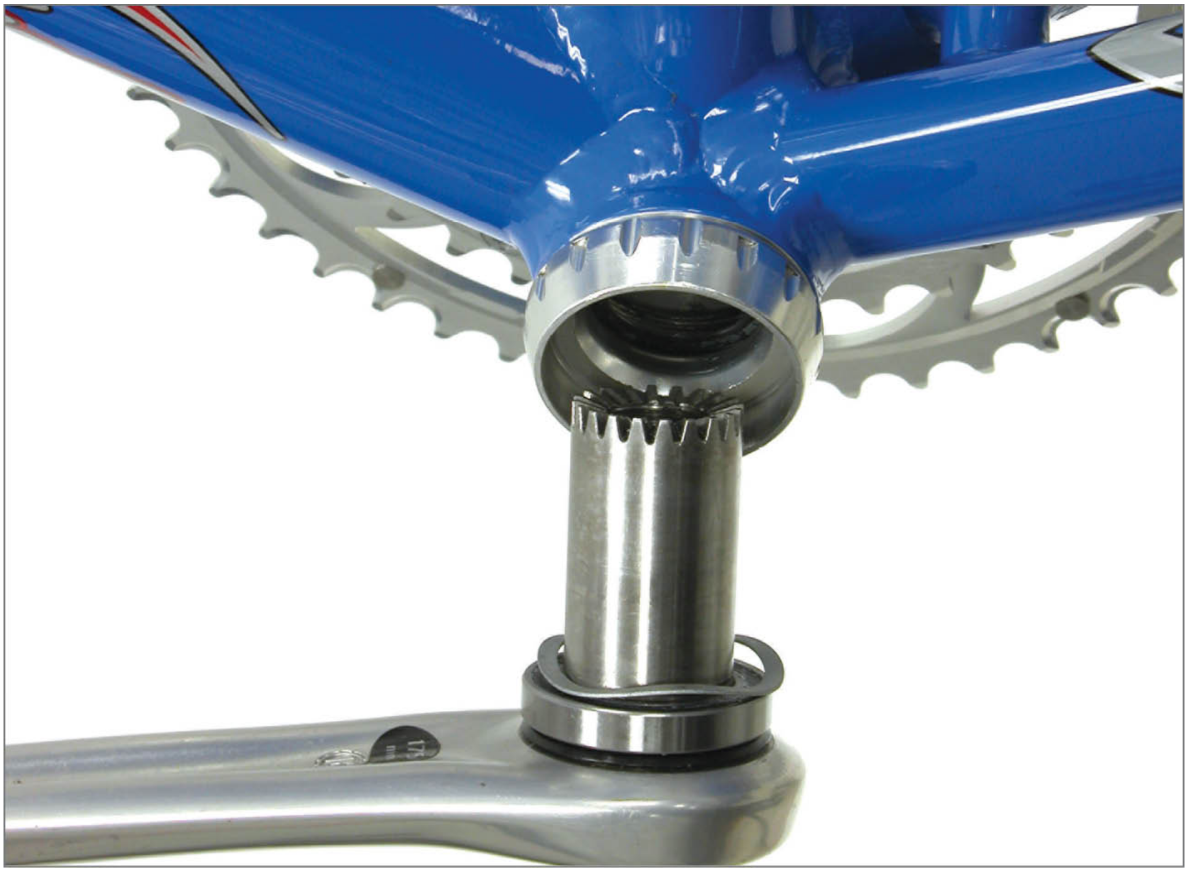


FIGURE 7.23: Install arm and wave washer into left side adaptor

c. Apply grease or anti-seize to threads of crank bolt and install through right-side axle center.

d. Secure bolt fully. Steel bolts tighten clockwise. Titanium bolt tighten counterclockwise.

e. Install bearing retaining clip to right adaptor.

CAMPAGNOLO® POWER TORQUE™ CRANKS

Campagnolo® Power Torque™ system uses a spindle permanently fixed to the right arm. A crank bolt presses the left arm securely to the spindle splines. The Power Torque™ left arm has no threads or fittings designed in the system for crank removal. Because the crank design made no consideration for service and removal, service can be difficult. Gear pullers, such as the Park Tool CBP-8, must be used to remove the left arm. The carbon fiber arms are a different shape compared to the aluminum arms and require a slightly different removal procedure. Bearing service of the Power Torque™ system is covered in Campagnolo® Power Torque® Bearings.

Procedure for crank removal:

a. Remove spring clip from drive-side bearing adaptor (figure 7.24). Crank cannot be removed with this clip in place.

b. Remove crank bolt using a 14mm hex wrench. Inspect inside arm for any washer and remove.

FIGURE 7.24: Remove clip from drive-side adaptor

c. Aluminum arms: Slide plastic molded pad onto crank. Install extension plug into spindle (figure 7.25). Carbon arms: Install fiberboard pad behind arm to minimize scratching and install extension plug (figure 7.26).

FIGURE 7.25: For aluminum crank install molded pad and extension plug

FIGURE 7.26: Fiberboard protection in place on carbon fiber crank

d. Engage puller assembly from CBP-8 bearing puller set. Aluminum crank: caliper arms of puller fit over molded pad. Align puller and use knobs to remove play from puller fingers (figure 7.27). Ends of puller fingers should engage the recess behind mold. There should be no play between fingers and puller body. Carbon crank: insert cardboard protection behind arm and engage puller fingers behind crank. Tighten puller finger knobs to remove play.

FIGURE 7.27: Engage caliper fingers and secure knobs to remove play

e. Tighten driver of puller clockwise to pull arm from spindle (figure 7.28). Remove any seal and wave washer from left side.

FIGURE 7.28: Turn driver of puller clockwise to pull arm from spindle

f. Remove tool from crank. Pull crank to drive side to remove it from bike.

Because of the design limitations of the Power Torque™ system, it can be useful to have an alternative crank removal method. This can be done with impact to the spindle inside the left crank. It will be helpful to fixture the frame close to the bottom bracket or have someone brace the frame during impact. By using the extension plug, the spindle can be pushed to the right and forced out of the left crank. Use care not to miss the plug as you strike with mallet. Keep impact in line with the axis of spindle. Neither bearing is affected by this removal technique.

Alternative procedure for Power Torque™ crank removal using impact:

a. Remove left crank bolt and any washer inside left crank

b. Place the extension plug of Park Tool CBP-8 inside the left crank.

c. Fixture or brace bike frame close to bottom bracket

d. Using a large mallet, strike extension plug directly in line with axis of spindle. Repeatedly strike until spindle is pushed to the right and out of left crank.

e. Remove extension plug and pull crank from bike.

Procedure for crank installation:

a. Install crank through right-side bearing adaptor.

b. Install C-clip into pin-holes of right-side bearing adaptor.

c. Install preload spring and seal cover over left-side bearing.

d. Apply grease or anti-seize to splines inside of crank and to threads of crank bolt.

e. Align crank to point 180 degrees opposite of drive-side arm and install on spline of crank.

f. Install crank bolt and secure.

SPECIALIZED® S-WORKS® CRANKS

Specialized® Bicycle Corporation offers a proprietary crank system designed around the BB30 standard (figure 7.29).

FIGURE 7.29: Specialized® crankset and BB30 bracket shell

Special tools are required to remove the crank. The S-Works® crank design is similar in concept to Campagnolo® Ultra-Torque®.

Procedure for crank removal:

a. Remove dust cover from right-side crank with a 6mm hex wrench.

b. Select the correct bit for the crank bolt. For carbon cranks, use a T45 Torx® bit that is at least 50mm long with a shaft OD no larger than 8mm. For some older models, use a 6mm hex bit at least 50mm long.

c. Insert bit from the right side and fully loosen crank bolt.

d. Pull each crank from bike.

Procedure for crank installation:

a. Grease threads of crank bolt.

b. Insert left and right cranks into bike. Arrange so arms are 180 degrees apart.
c. Thread crank bolt into left crank and secure tight.
d. Install dust cover screw.

The S-Works® crank uses the BB30 bearing system. The bearing adjustment varies with the model of the S-Works®. Some models use a wave washer on the left arm. Other models use an adjustable convex and concave cone washer system lightly pressing against the bearings to remove lateral play. Inspect for three small set screws at the left arm next to the bearing. Use a hex wrench to tighten each the same small amount. Check for lateral play, and continue to tighten each 1⁄4 turn until lateral play is gone.

BOTTOM BRACKET SYSTEM TYPES

The term “bottom bracket” is used to refer to several parts of the bike. The bottom bracket shell of the frame, the bottom bracket bearings and the bottom bracket spindle (axle) are all part of the bottom bracket system.

To determine if the bottom bracket bearings are worn out or have developed play, grab both cranks firmly at the ends, but do not hold at the pedals. Push laterally with one hand and pull laterally with the other hand to force the cranks side to side. Any knocking can be a sign of bearing play. However, play can also come from a loose threaded adaptor in threaded shells, or a poor press fit in a press fit system. For threaded shell bikes, the cranks can be removed and the threaded bearing adaptor checked for tightness. Adjustable bearing systems can be adjusted slightly tighter. For press fit systems, however, it is more common the bearings are simply worn and need replacement.

To determine the wear on the bearing surfaces, drop the chain off the chainrings and arrange it so it does not rub on the crank. Spin the cranks while holding the frame (figure 7.30). Worn bearings will grind, and this can be felt through the frame as a vibration. If in doubt, compare the feeling of an old bottom bracket to that of one on a new bike. There is no repair of a worn bearing other than replacement.

FIGURE 7.30: Spin cranks to feel for grinding on a worn bottom bracket bearing

The bottom bracket shell is part of the frame that houses the bottom bracket bearings and spindle. There are currently multiple bottom bracket shell designs, and the bearing system installed must be compatible with the shell design used. It is necessary to know the bottom bracket system to have the correct tools and parts for service. The brand or model of crank does not necessarily determine the tools or procedures for the bearing service. In some cases you may need to disassemble the cranks to inspect the bottom bracket shell.

Two basic designs for bottom bracket shells are threaded shells and non-threaded shells. There are numerous standards for each.

THREADED STANDARDS

Threaded bottom bracket shells have an internal thread to accept the external thread of the bottom bracket bearing cups or adaptors (figure 7.31). Carbon fiber bikes with a threaded bottom bracket shell use a metal insert for the internal threading. The common bottom bracket shell threading standard is 1.37 in. x 24 tpi. This is also referred to as BSA, English or ISO threading, The left-side (non-drive side) thread is a right-hand threaded, which removes counterclockwise and tightens clockwise. The right-side (drive side) thread is a left-hand threaded. It is installed counterclockwise and is removed clockwise.

FIGURE 7.31: Bottom bracket marking indicating side of bike

A less common threading standard is 36mm x 24 tpi and is referred to as “Italian.” Both drive and non-drive parts are right-hand threaded. Both sides remove counterclockwise and install clockwise. This bottom bracket standard is too large to fit into an English sized frame. An English bottom bracket will simply slide into the larger Italian threading with no thread engagement.

Older thread standards no longer in production include the “French,” “Swiss” and “Witworth.” The French standard uses 35mm x 1 threading, with both left and right side being a right-hand threading. “Swiss” threading is also 35mm x 1mm but the right side is a left-hand threading. “Witworth” threading is 1 3⁄8" x 26 tpi, with right side being a left-hand threading. The ISIS Overdrive standard of 48mm x 1.5mm threading was used on exercise bikes but never became common.

The larger shell of an oversized standard permits larger frame tubing joints to stiffen the frame. Because of this, an industry standard now being advocated is the “T47” standard, using 47mm x 1mm threaded adaptors. Like the English/BSA standard, the right-side thread of the frame is a left-hand thread, and the left side of the frame is a right-hand thread. Although taps are available in the T47 standard, cutting threads into a current PF30/PF46 frame to convert it to the T47 standard is not recommend.

There are numerous frame shell widths in the threaded standards, measured outside to outside of the shell faces. Currently produced widths include 68, 70, 73, 83, 100 and 120mm. The difference between models of replacement systems often becomes simply the length between the outer dust seal between bearing adaptors.

NON-THREADED STANDARDS

Non-threaded bottom bracket shells have a smooth inside bore that house the bearing systems. Non-threaded bottom bracket designs come in several different possible configurations. In addition to matching the bottom bracket shell, the bearing system must be compatible with the crankset. Adaptors allow some interchangeability between standards in bottom bracket bearings and crank standards. The bicycle industry has yet to settle on consistent names for these standards, which adds to confusion when servicing or getting parts. To get acceptable parts, you will need to know the inside diameter of the shell, the shell width, and the spindle diameter of the intended crank. Variations in all three aspects result in a confusing amount of possible choices.

PF41 (also known as BB86, BB89.5, BB92, BB107, BB121, BB132)

The term PF41 refers to "press fit 41mm," which is the nominal diameter of the press fit. Shells of the PF41 have a smooth bore with a nominal 41mm inside diameter. Terms such as BB86, BB89.5, BB92, BB107, BB121, BB132 also use a 41mm diameter fit, but those numbers refer to the nominal width of the shell. Compatible cranks are then designed to fit the width of the bottom bracket shell.

The cartridge bearings of the PF41 system use an adaptor of plastic or aluminum and are pressed into the bottom bracket shell (figure 7.32). Bearing adaptors are made to fit different crank spindle diameters, such as 22/24mm, 24mm, 28.99, and 30mm.

FIGURE 7.32: PF41 (BB86) shell with pressed bearing adaptors

BB90 and BB95

Trek® Bicycle Company uses a proprietary variation of the PF41 system that incorporates the bearing adaptor into the bottom bracket shell of the frame, much like an integrated headset (IS). These are cartridge bearings without an adaptor that simply slip into the frame by hand (figure 7.33). The outer diameter of the bearings is 37mm. Bearings are available for both 24mm and 24/22 spindles. Trek® refers to their system as BB90 (road) and BB95 (mountain).

FIGURE 7.33: BB90 frame shell in a Trek® bottom bracket shell, shown with cartridge bearing

PF42, BB30, BB30a

BB30 is an early industry term that referred to the 30mm diameter of the spindle. Compatible bottom bracket shells have a smooth bore with 41.95mm inside diameter. The PF42 term refers to this nominal pressed diameter. The shell width comes in both 68mm (road) and 73mm (mountain). A cartridge bearing with a 42mm OD is pressed into each side of the frame shell. A common design presses the bearing against an internal bearing-positioning stop such as a C-clip (figure 7.34).

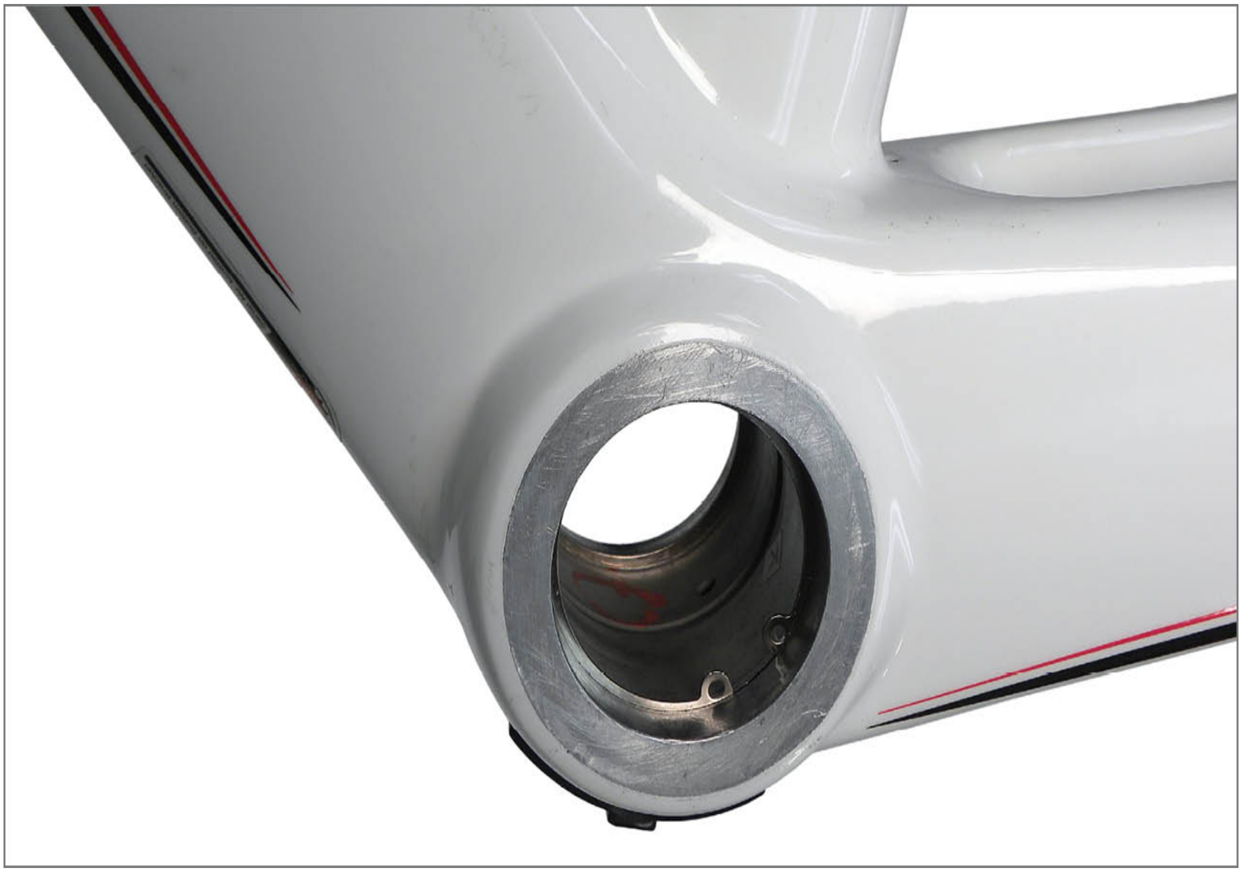


FIGURE 7.34: BB30 shell with C-clip bearing stops in place

The term “BB30a” refers only to an asymmetrical shell design, and does not change the fit of the adaptors to the bike. A BB30a bike will require a BB30a compatible crank.

PF46, PF30, PF30a

PF30 is an early industry name to distinguish this standard from the previous BB30 standard. The frame shell has smooth bore with approximately 46mm inside diameter, making the PF46 a more accurate moniker. The shell widths are 68mm for road bikes and 73mm for mountain bikes. The cartridge bearings of the PF46 system use an adaptor of plastic or aluminum and are pressed into the bottom bracket shell (figure 7.35). Bearing adaptors are made to fit different crank spindle diameters, such as 22/24mm, 24mm, 28.99, and 30mm.

FIGURE 7.35: Left side (non-drive) of PF30 bottom bracket shell seen on full suspension frame

The term “PF30a” refers only to an asymmetrical shell design, and does not change the fit of the adaptors in the bike. A PF30a bike will require a PF30a compatible crank, which is the same as the BB30a crank.

386EVO, 392EVO

386EVO and 392EVO standards are variations on the PF30/PF46. The names come from the frame shell widths of 86mm and 92mm. Crank spindles in the EVO standard are correspondingly longer compared to the BB30 cranks. The inside diameter of the shell is 46mm to accept the same bearing adaptors from the PF30/PF46 bearing systems. Adaptors are available to use the longer 386EVO cranks in the BB30, BB86, BB92, PF30, and threaded bottom bracket shell standards.

BBright™

BBright™ is an asymmetrical variation of the PF30/PF46 system, developed by Cervelo® Bikes. The shell is 79mm wide, with a 46mm ID. Cervelo® offers crank spindles designed specifically for this system, although adaptors are available to use other cranks, such as the 386EVO or the Shimano® Hollowtech® II crank in the BBright™ standard.

BOTTOM BRACKET BEARING SERVICE FOR NON-THREADED SHELLS

Cranks are attached to a spindle or axle, which is supported by the bottom bracket bearings. These bearings rotate during riding and see a lot of load and wear. Bottom bracket bearings are supported by the bottom bracket shell and are usually the lowest point of the bicycle. Any water that gets inside the frame tends to drain to the bottom bracket shell.

Service options and procedures will vary depending on the bearing system in the bike. It is often necessary to know the crank standard used because adaptors may be installed in the bottom bracket shell that allow mixing of shell and crank standards.

Cartridge bearings of these systems can be pressed directly, such as with the BB30 standard, or the bearings may be part of an adaptor that is pressed into the frame. Manufacturers assume that new parts are installed if the old ones are removed. It typically requires impact to remove the parts from the frame. This will not harm the frame but may damage the bearings. Again, the assumption is the parts will be replaced. It can help to fixture the frame, holding it closer to the shell to reduce flex in the tube as the part is struck. However, if a retaining compound was used to install the adaptor, extra effort and special technique may be required. Mild heat such as from a hot air gun or a hair dryer will soften the compound. Even hot water poured on the joint is enough to make a difference.

30MM SPINDLE SYSTEM BEARING REMOVAL

If crank spindle is 30mm, the inside diameter of the bearings system will be 30mm. In pressed systems, use the Park Tool BBT-30.4 to remove the parts.

Procedure for bearing removal:

a. Remove both cranks.

b. Tilt BBT-30.4 tool and guide the foot through one bearing, through shell and engage foot into opposite bearing (figure 7.36). If frame uses C-clips, inspect that foot is not contacting C-clip.

FIGURE 7.36: Engage foot of BBT-30.4 through bearing and push foot to opposite bearing

c. Engage plastic guide bushing of BBT-30.4 into bearing. Guide will keep tool and foot straight as it drives out bearing.

d. Use a hammer and strike end of remover to drive out bearing (figure 7.37). If necessary, rotate tool handle to strike different points on the bearing.

FIGURE 7.37: Strike tool end to drive out bearing from shell

e. After one bearing is removed, remove tool and engage tool from open side of shell. Guide foot to remaining bearing and engage plastic alignment bushing into shell. Strike end of remover and remove second bearing.

An alternative to the BBT-30.4 is the Park Tool RT-1 race tool. The procedure is the same as under DUB™ Bearing adaptor removal below. Another option is careful use of a long punch and hammer Tap from the inside on a bearing edge, then move punch 180 degrees to other side and tap. Walk bearing out this way, working back and forth between sides.

If the frame shell contains C-clips, these may be left in place for the new bearings.

28.99MM SPINDLE SYSTEM (DUB™) BEARING ADAPTOR REMOVAL

SRAM® DUB™ spindles are 28.99mm. Consequently, tools for 30mm spindles do not fit. To remove the pressed DUB™ bearing adaptors use the RT-1 race tool and a hammer.

Procedure for bearing removal:

a. Remove both cranks.

b. Pass the small end of the RT-1 through one bearing adaptor.

c. Pull RT-1 until it clicks into place and engage the backside of one adaptor.

d. Strike RT-1 to remove adaptor (figure 7.38).

FIGURE 7.38: Strike RT-1 to drive press fit SRAM® DUB™ adaptor from shell

e. Reverse RT-1 and remove remaining adaptor.

22/24 AND 24MM SPINDLE SYSTEM BEARING ADAPTOR REMOVAL

Pressed bearing adaptors using the smaller 22 or 24mm ID can be removed with the Park Tool BBT-90.3. Any removal tool must be small enough to pass through the bearing diameter. Although striking the tool may seem stressful to the bike, it is no different from hitting speed bumps in the road.

Procedure for bearing removal:

a. Remove cranks from bike.

b. Pass small end of BBT-90.3 through one bearing adaptor (figure 7.39).

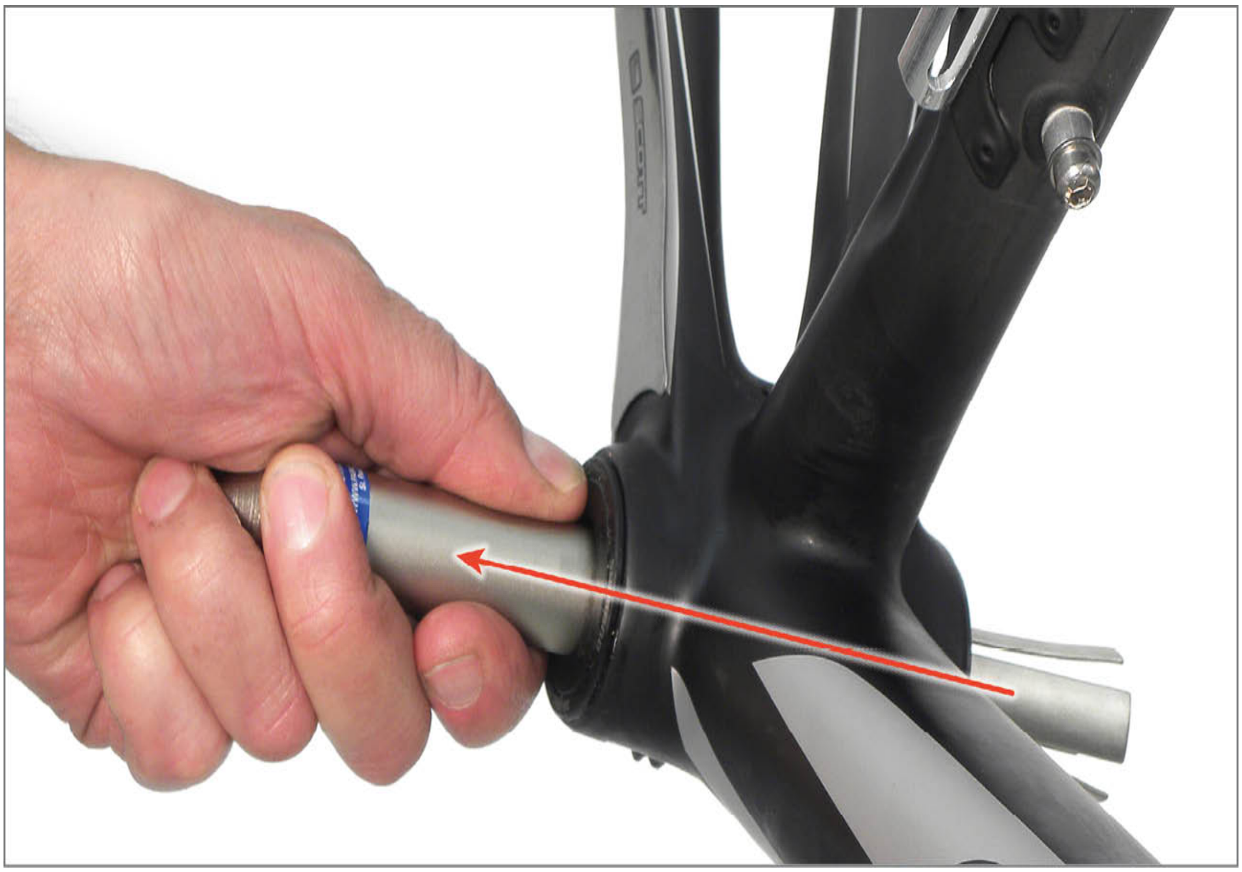


FIGURE 7.39: Pull BBT-90.3 through shell until it engages back of adaptor

c. Pull tool until it clicks into place and engages backside of one adaptor.

d. Strike end of tool with hammer to remove adaptor (figure 7.40).

FIGURE 7.40: Use hammer and BBT-90.3 to drive bearing from bike

e. Reverse tool and pull through remaining adaptor.
f. Strike tool end to remove adaptor.

PRESS FIT BEARING INSTALLATION

Press fit frame shells use a mild interference fit to install the bearing adaptors into the frame shell. Shell inside diameters are typically only 0.05mm less than the outside diameter of the adaptor. If the interference fit is too great, the cartridge bearings are literally squeezed tight, causing them to run roughly and wear out relatively soon. If the interference fit is too small, the bearings are held weakly and may move and creak when ridden.

Should the inside diameter be too small, the bore may be machined by a professional mechanic using frame tools. Should the inside diameter be too large, the press fit will be relatively weak. An option is to use a retaining compound such as Park Tool RC-1. These compounds apply as a liquid to fill gaps in the fit surfaces. The compound hardens and expands as it dries, holding the adaptor tight. Use of compounds may mean extra effort is required to remove the adaptor.

Press fit bearing adaptors are installed similar to pressed headset bearings. If special drifts (bushings) are available, both adaptors can be pressed at the same time. Otherwise press only one adaptor at a time. As a rule, lubricate the adaptor surfaces unless applying a retaining compound. Pressing tools such as a headset press or special bearing presses are used to install the adaptor.

The BB30 bearing outside diameter is 42mm. Frame shells contain snap rings to act as bearing stops. Bearings are recessed below the surface of the frame shell, making it necessary to use drifts slightly smaller than the shell ID. Use the drifts with the Park Tool BBT-30.4. If no drifts are available the old bearings can be used over the new bearings as a work-around to press the bearing below the shell.

The Park Tool BBT-30.4 tool set includes two drifts for the BB30 and PF30 standard. Bearing installation requires a headset press. Drifts help to center and align the bearings during the pressing. A bearing must be pressed until it is recessed into the shell. Pressing with a flat plate will not push bearings to their proper bearing position.

Procedure for BB30 bearing installation:

a. Inspect inside shell for C-clips. Clips should be secure inside groove in bottom bracket shell.

b. Engage drift from BBT-30.4 on each bearing. Drifts will keep bearing aligned during the press (figure 7.41).

FIGURE 7.41: Install press through shell and engage drift into and bearing

c. Insert thread of headset press through drifts, bearings, and shell. Install second nut or stop plate of headset press, trapping bushing and bearings.
d. Turn headset press handle until plates contact bushing, bearings, and shell. Stop occasionally to inspect alignment of bearings into shell (figure 7.42).

FIGURE 7.42: Press bearings with steady pressure from press until dead stop is felt

e. Continue to press bearings until both contact C-clips inside shell.

f. Remove headset press and drifts. Check inside shell for bearing contact at stops.

PF41, PF30, PF46, and many other standards in the press fit designs use adaptors with lips that contact the frame shell. These bearings are stopped by this lip and do not press below the shell surface as do the BB30 bearing systems do. If drifts are available for your standard, such as those from the Park Tool BBT-90.3, use one adaptor per side and press at the same time. Inspect the bearings for LEFT or RIGHT orientation. SRAM® GXP® bearing systems use the smaller ID bearing on the left side of the shell.

Procedure for PF41, PF30 and other lipped bearing installation:

a. Engage one bearing each on a drift. If no drifts available, press one adaptor at a time.

b. Insert thread of headset press through drift, bearing, and shell. Install second nut or stop plate of headset press, trapping bushing and bearings.

c. Turn headset press handle until plates contact bushing, bearings, and shell. Stop occasionally to inspect alignment of bearings into shell (figure 7.43).

FIGURE 7.43: Install headset press through shell and engage bushings and bearings

d. Continue to press adaptor until it has the lip firmly pressed to frame shell face.

e. Remove press and repeat pressing second adaptor.

PRESS FIT ADAPTORS AND CONVERSIONS

Frame shell standards can often be converted to accept different cranks using aftermarket adaptors. Crank performance and fit can vary between designs and brands.

BB30 frame shells may be converted to accept the threaded English/ISO standard with aluminum bushing adaptor from FSA®, SRAM®, and Problem Solvers™. The adaptor contains the internal threading of the English/ISO standard, and is a press fit to BB30 shell using retaining compounds. Conventional threaded bottom bracket bearing adaptors or cups can then be installed. This conversion should be considered semipermanent, as only a professional mechanic should perform removal.

To install this conversion, begin by removing the C-clips from the BB30 frame shell (figure 7.44). Use a small-tipped screwdriver, snap ring pliers, or needle nose pliers.

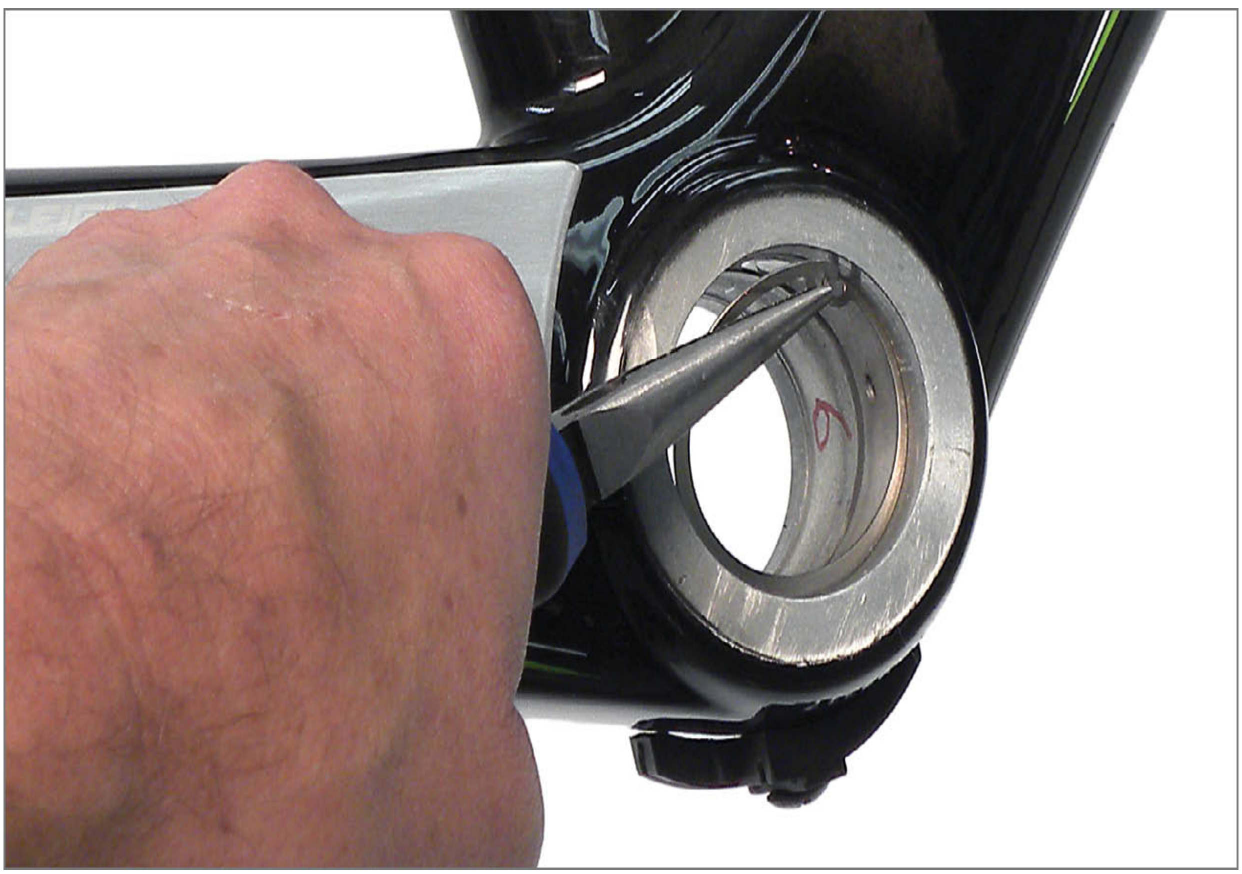


FIGURE 7.44: Remove C-clips bearing stops in shell before installing conversion adaptor

Apply a retaining compound inside the shell. Use a bearing or headset press to press the threaded adaptor into the shell (figure 7.45). Use care to get the left threaded adaptor side on the drive side of the bike.

FIGURE 7.45: Pressing the aluminum conversion sleeve into a BB30 shell

THREAD-THRU BOTTOM BRACKETS

A “thread-thru” bottom bracket is designed for press fit shells. Left-side adaptor connects with threading to the right adaptor. Tightening the two sides together hold the bearing unit secure in the shell, preventing movement or creaking. Tool fittings outside of the adaptor face allow adaptors to be tightened together. Praxis Works®, Enduro®, Rotor® and other companies offer these thread-together adaptors for different frame shell and crank standards. Exact installation procedures vary. Contact the manufacturer for most up to date information (figure 7.46).

FIGURE 7.46: Cutaway of shell during installation of thread-thru bottom bracket

The tool fitting of some thread-thru bottom brackets is very narrow and shallow. In these cases, make sure the tool is pressed firmly to the part as it tightened (figure 7.47).

FIGURE 7.47: Hold tool firmly to bottom bracket tool fittings as it is tightened

CAMPAGNOLO® ULTRA-TORQUE® AND FULCRUM® BEARINGS

Campagnolo® Ultra-Torque® crank bearings are pressed on the spindle section of each crank. Bearings are removed only for replacement. Use the Park Tool CBP-8 Crank and Bearing Tool Set to remove and install these bearings.

Procedure for bearing removal:

a. Remove cranks from bike.

b. Remove C-clip from right-side crank. Use snap ring pliers or a small tipped screwdriver to pry up clip (figure 7.48).

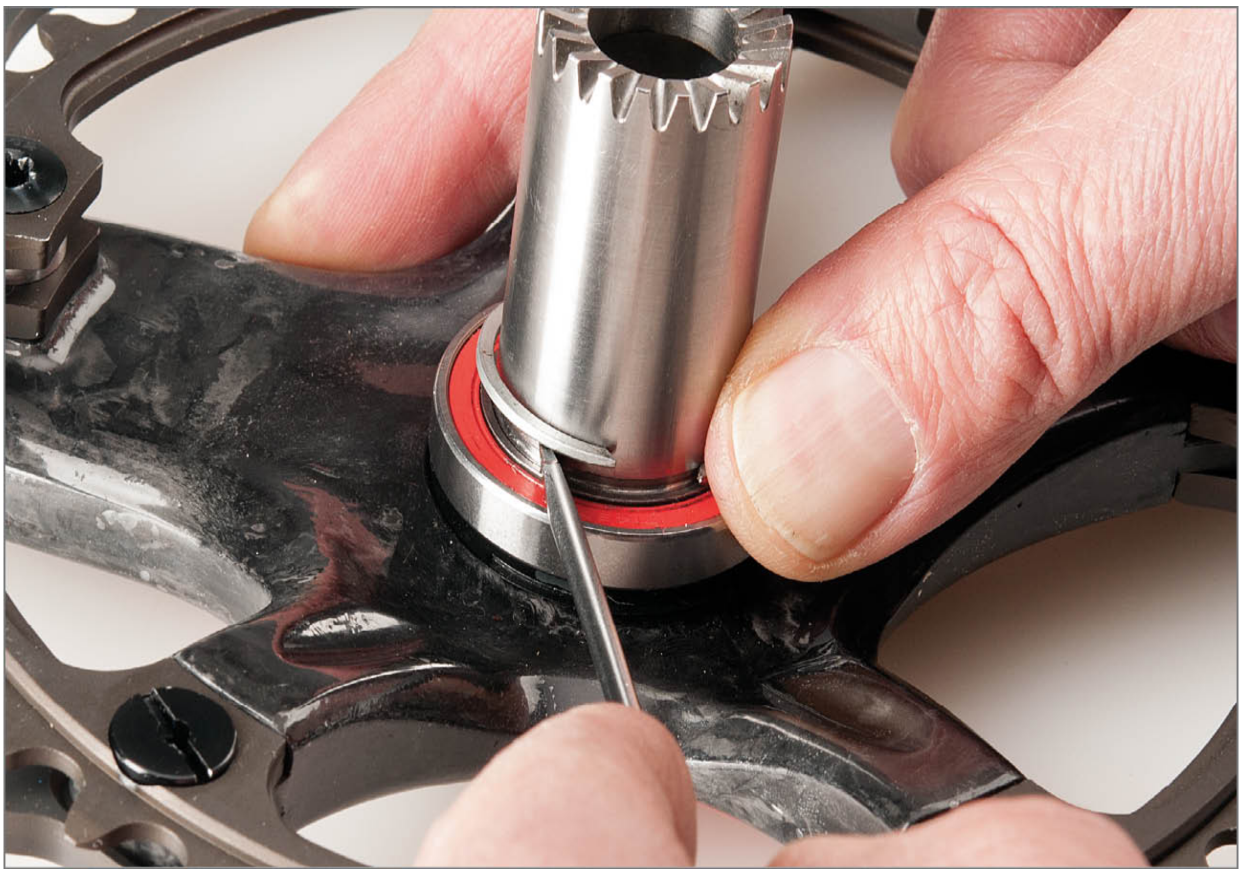


FIGURE 7.48: Remove right-side clip before pulling bearing

c. Arrange bearing puller assembly over spindle. Use side knobs to snug fingers under bearing (figure 7.49).


FIGURE 7.49: Engage puller fingers over bearing and secure knobs

d. Turn handle of puller clockwise to push tool plunger against spindle end. The bearing will be pulled away from crank.

e. Remove tool from crank and repeat process on second crank.

Both crank bearings should be replaced if removed. Do not reuse bearings that were removed. New bearings must be pressed back onto spindle with an interference fit, much like a headset fork crown race.

Procedure for bearing installation:

a. Replace any seals that were removed from crank.

b. Install bearing over spindle.

c. Place crank on wooden bench or other firm non-marring surface. Place driver from Park Tool CPB-8 over spindle and drive bearing downward by striking with a hammer (figure 7.50). Driver is a precise fit to the inner bearing race and will not damage bearing surfaces.

FIGURE 7.50: Drive bearing firmly into place and then install C-clip

d. Engage C-clip over spindle end. Use driver to push bearing down until bearing engages groove in spindle.
e. Repeat installation of bearing on second crank. Install cranks into bike as described in Campagnolo® and Fulcrum® Ultra-Torque® Cranks.

CAMPAGNOLO® POWER TORQUE™ BEARINGS

The right-side bearing for the Power Torque™ is a press fit to the spindle. The left-side bearing is a slip fit to the spindle, but this bearing is pressed tightly to the adaptor or cup. The left-side bearing is replaced together with the adaptor as a unit. The right-side bearing mounted to the spindle can be removed and replaced. Aluminum and carbon cranks share the same service procedure for bearing removal and replacement. Bearing removal requires a bearing puller set such as the Park Tool CBP-8 Crank and Bearing Tool Set.

Procedure for right-side bearing removal:

a. Remove cranks from bike.

b. Use a screwdriver to remove C-clip adjacent to right side. Clip must be removed before bearing can be pulled (figure 7.51).

FIGURE 7.51: Remove right-side C-clip from spindle before pulling bearing

c. Install bearing remover adaptor on crank (figure 7.52). Install adaptor aligned with arm of crank. Push adaptor until fully engaged under bearing.

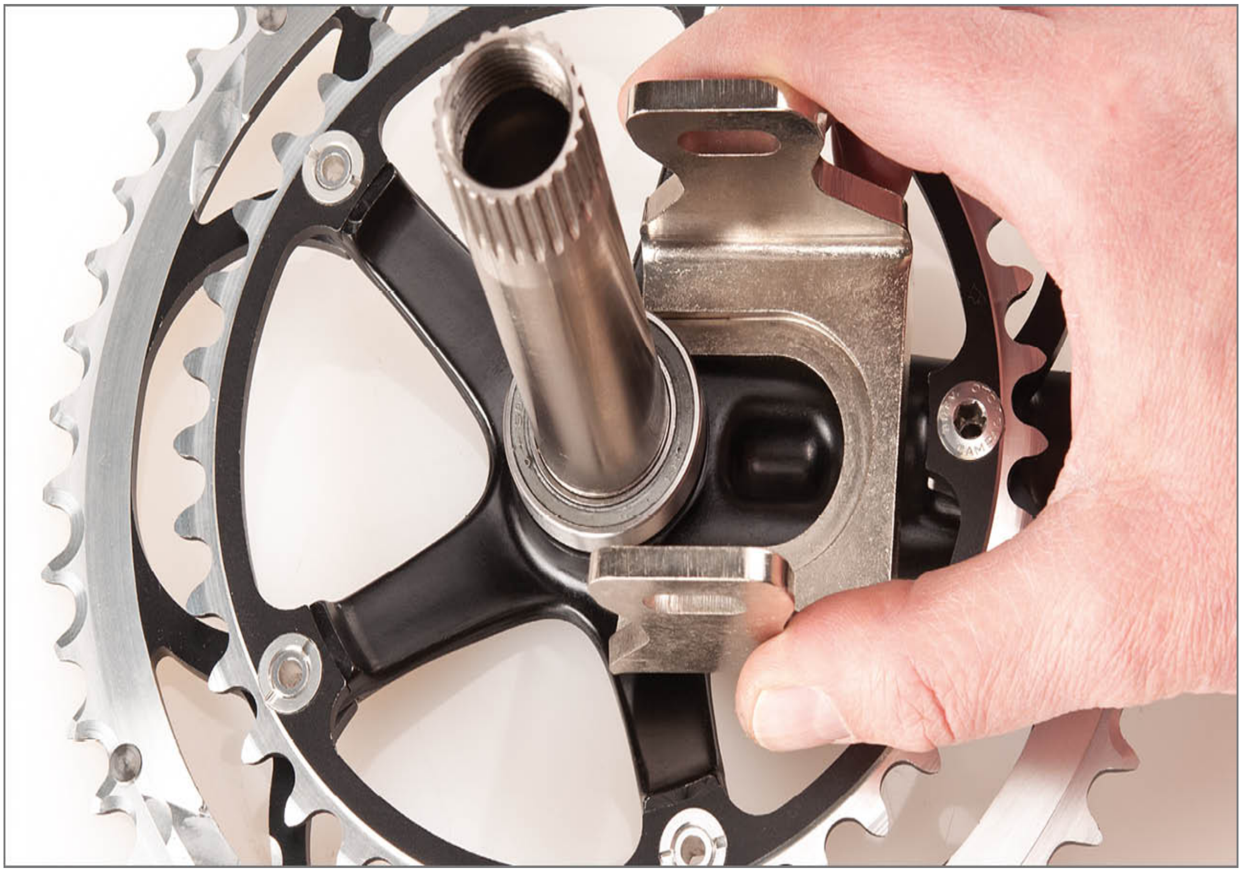


FIGURE 7.52: Install bearing adaptor from direction of crank arm

d. Install puller over spindle end. Engage fingers into arms of adaptors. Adjust knobs of puller to remove play in puller (figure 7.53).

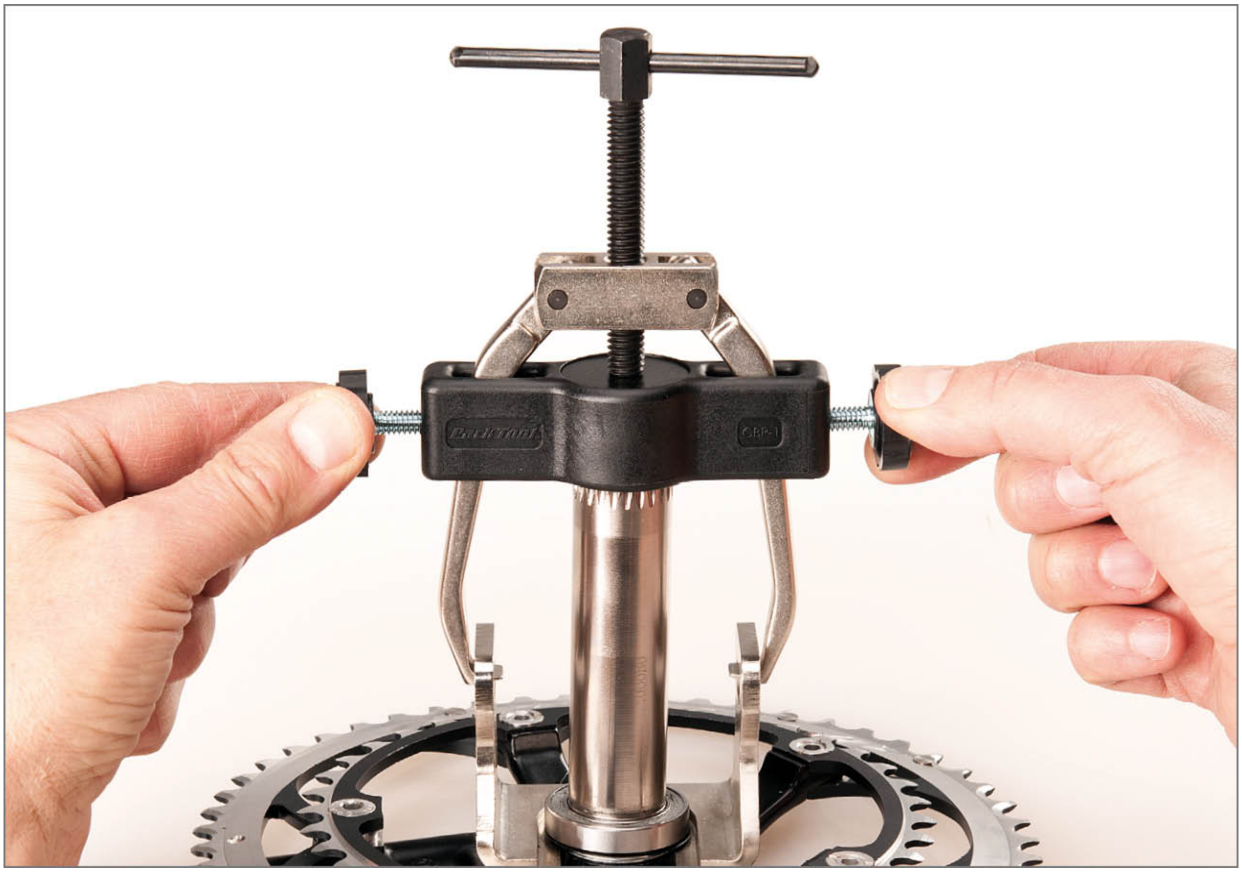


FIGURE 7.53: Engage caliper fingers over bearing and tighten knobs

e. Tighten handle of puller to lift adaptor and bearing from crank. Inspect that puller and adaptor are lifting evenly and not twisting.

Procedure for right-side bearing installation:

a. Install new seal and bearing on crank spindle. Place crank on smooth workbench, and place bearing installer over spindle.

b. Use a hammer and strike bearing installer to drive bearing fully into place (figure 7.54).

FIGURE 7.54: Drive bearing firmly into place and then install C-clip

c. Engage C-clip over spindle end. Use driver to push bearing down until bearing engages groove in spindle.
d. Install crank.

BOTTOM BRACKET BEARING SERVICE FOR THREADED SHELLS

The common bearing system used for three-piece cranks in threaded shells is the "cartridge bearing." Crank spindles are built into the bearings and the unit is held in the frame by threaded adaptors. Cranks attach to the end of the spindles, and consequently the crank must be compatible with the spindle.

In square-spindle types, there are different square spindle lengths available as measured from end to end. The longer the right side of the square-type bottom bracket spindle, the farther the chainrings will sit to the right of the shell. Chainrings may rub against the frame if the right side is too short. There are limits to where the cranks can be positioned in the frame, as described in Chapter 10—Derailleur Systems, Chainline.

Round spindle-end standards for three-piece include Shimano® Octalink®, ISIS Drive, FSA® Power Drive™, and SRAM® Power Spline™ cranks. These spindles are also available in different lengths, measured end to end. When replacing a bottom bracket spindle, measure and duplicate the same length in a new model.

If a bottom bracket bearing adaptor or cup seems to install with excessive force, the shell threads may require tapping (figure 7.55). A professional mechanic will be able to diagnose and repair this problem.

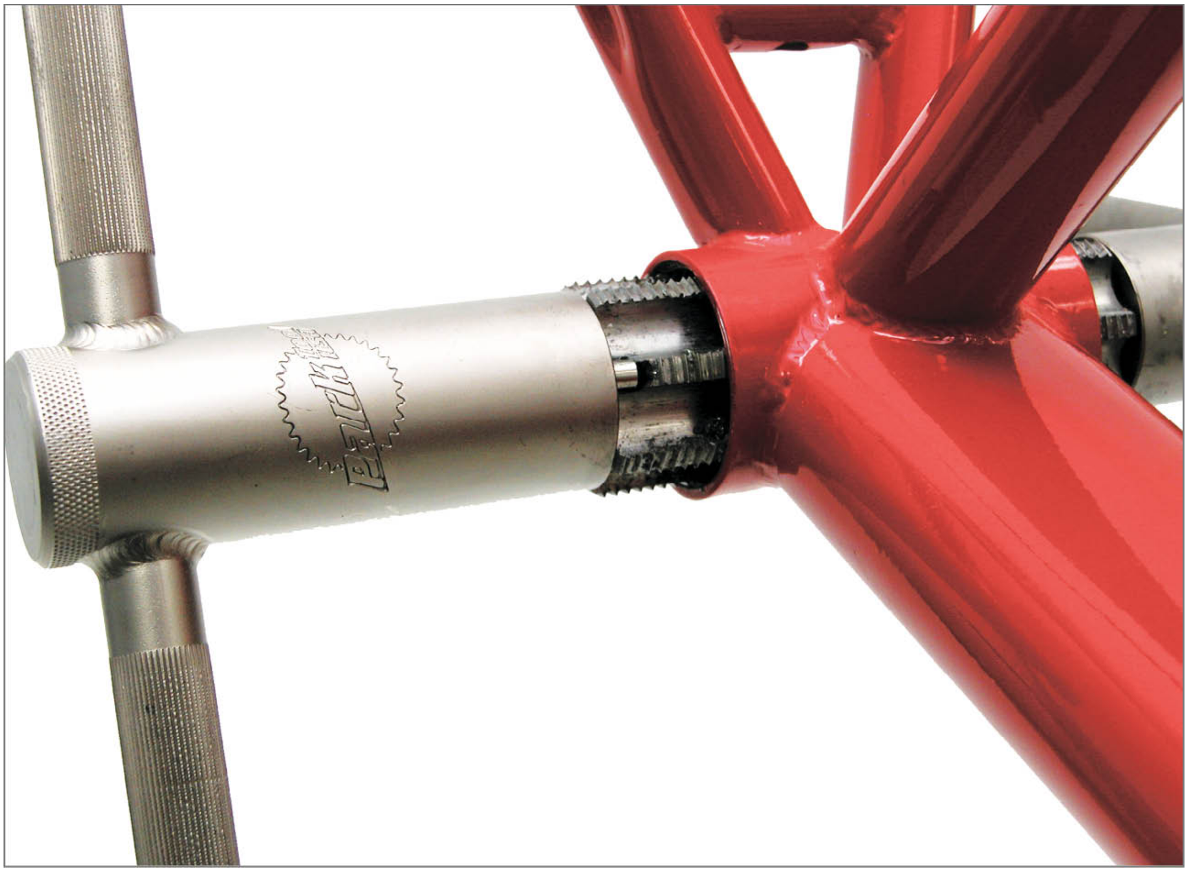


FIGURE 7.55: Tapping a threaded bottom bracket shell to correct threading issues

Bottom bracket bearing adaptors and cups are designed with tool fittings to allow installation and removal. Do not attempt to “fake” the tool by using unusual service techniques, such as trying to tap the bottom bracket out with a punch and hammer. Appendix D outlines the bottom bracket fittings and the Park Tool options for installation and removal.

THREADED EXTERNAL BEARING BOTTOM BRACKETS FOR TWO-PIECE CRANKS

Two-piece crank systems are typically installed into threaded frame shells using “external cartridge bearings.” Bearing adaptors thread inside the shell, but the bearings sit outboard or externally of the shell. The spindle for these systems is part of the crank. Both left and right-side bearing adaptors have holes to accept the crank. Two-piece cranks are designed to match the distance between their bearings when installed in the shell.

Triple chainring crankset bearing adaptors from Shimano®, Race Face®, and FSA® are designed to be spaced 75.5mm apart at the frame shell. These cranks are supplied with three spacers of 2.5mm thickness to locate them relative to the frame and the bearings. Cranksets can be fitted to bikes with a 68mm or 73mm bottom bracket shell width. If the bike uses a front derailleur with a built-in mounting bracket (“E-type”), it is counted as a spacer. Any chain guide mount is also counted toward the width total. See Table 7.1 for arrangement of spacers.

TABLE 7.1: External Bearing Crankset Spacer Arrangement

BB SHELL WIDTH	LEFT SIDE OF BIKE	FRONT DERAILLEUR	RIGHT SIDE OF BIKE
68mm	One 2.5mm spacer	Clamp-on front derailleur	Two 2.5mm spacers
68mm	One 2.5mm spacer	E-type front derailleur	One 2.5mm spacer plus E type bracket
73mm	No spacers	Clamp-on front derailleur	One 2.5mm spacer
73mm	No spacers	E-type front derailleur	E-type bracket

Truvativ® GXP® cranks use spacers under the bearing adaptors. If the shell is 68mm wide, use one of the 2.5mm spacers per side. For 73mm wide shells, no spacers are needed; thread the adaptors directly into the shell.

External bearing system designs for double chainring cranksets (road) from Shimano®, FSA®, and Truvativ® are made for 68mm bottom bracket shells. No extra spacers are required or used for these systems. Bearing adaptors simply thread directly into the shell.

Park Tool makes tools for most bearing adaptors. However, there is no standardization between brands or styles. To identify the tool, it is typically necessary to count the number of tool notches or splines on the adaptor, and measure the outside diameter. See Appendix C for tool options.

Procedure for bearing installation:

a. Prepare bottom bracket shell threads with grease, anti-seize, or a mild threadlocker.

b. If applicable to the component, install the correct number of spacers as described above on bearing adaptor marked with “R” (drive side). Install dust seal on adaptor.

c. Thread drive-side adaptor counterclockwise into right side of bike and secure fully.

d. Install correct spacers as needed on cup marked “L” (non-drive side).

e. Install any dust sleeve onto adaptor, then thread adaptor clockwise into left side (non-drive) of bike and tighten fully as before (figure 7.56). Adaptors are ready for crank installation.

FIGURE 7.56: Install dust sleeve into adaptor and thread adaptor into frame

Removal of threaded bearing adaptors is simply unthreading them from the frame after the crank has been removed. For the common English/ISO frame thread, turn drive-side adaptor clockwise to remove. Turn left-side adaptor counterclockwise to remove.

THREADED CARTRIDGE BOTTOM BRACKETS FOR THREE-PIECE CRANKS

For most brands of three-piece threaded bottom brackets, the entire bottom bracket unit is replaced, including the spindle. Bearing are not removed, regreased and reinstalled. Tool fittings can vary on the three-piece bottom bracket systems. However the most common has fitting diameter of 34mm with 20 splines. Use the Park Tool BBT-22 or BBT-32 Bottom Bracket Tool for installation and removal.

Procedure for bottom bracket removal:

a. Remove both cranks.

b. Insert bottom bracket tool fully into or onto fittings of non-drive adaptor (left side). Hold tool firmly in place while turning counterclockwise to remove adaptor.

c. Insert tool fully into or onto fitting of drive-side (right side) main body. Remove by turning clockwise on English/ISO threaded bikes. For Italian threaded bikes, turn counterclockwise.

d. Pull main body from bike if not already removed.

If the bottom bracket main body and adaptor are difficult to unthread or remove, it can be useful to clamp the tool to these parts. The splines of the main body and adaptor may be shallow, and this technique can prevent the tool from slipping. For hollow spindles, use a quick-release lever to hold the tool firmly in place (figure 7.57). If the spindle is not hollow, use a long 8mm x 1mm bolt of the same thread as the crank bolt.

FIGURE 7.57: Use hub skewer to secure tool snug to fittings of cartridge main body and adaptor

It is common for new cartridge bottom brackets to be marked “Left” and “Right.” These refer to side of bike, not thread direction (figure 7.58). The drive side of the bike is the right side, and the non-drive side is the left side. With the common English/ISO threading, the right side will have left-hand thread direction, and the left will have right-hand thread direction.

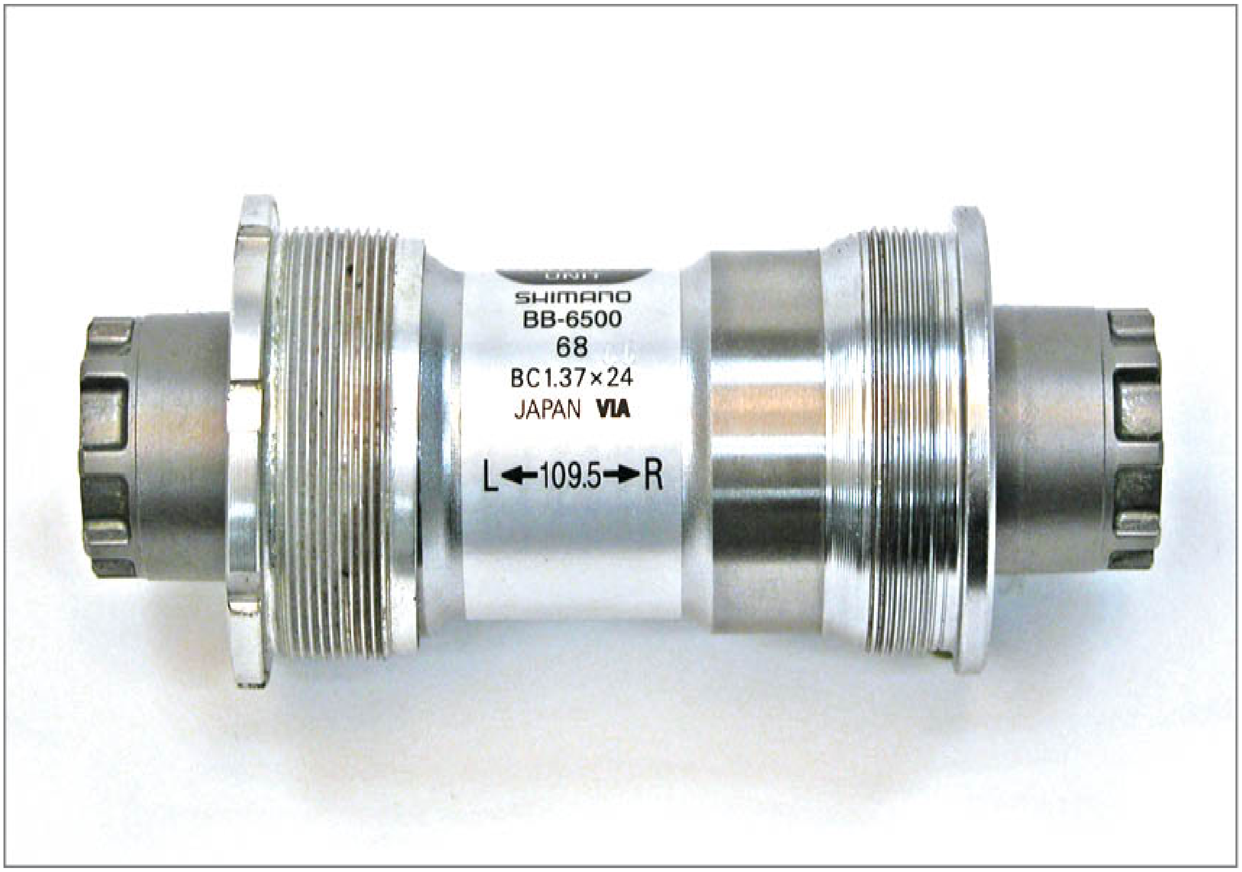


FIGURE 7.58: Bottom bracket marking indicating appropriate side of bike

There are two critical issues regarding thread preparation for bottom brackets. First, the threads need lubrication to pull up fully tight. Second, the threads should be protected from corrosion. Grease will help for both issues, but anti-seize compounds are far more durable and are better at preventing corrosion (figure 7.59). Anti-seize, such as Park Tool ASC-1 Anti-Seize Compound, is especially recommended for titanium and aluminum frames.

FIGURE 7.59: Lubricate threads of the bottom bracket

Another thread option is to use a service removable threadlocker such as Park Tool TLR-1. Place a bead of the threadlocker around the first three or four threads on both sides. Threadlocker will form a seal against water. Use of a threadlocker is especially recommended for Italian-threaded bottom brackets, which tend to loosen during use.

Plastic adaptor threads may be greased or left dry. Do not use threadlocker compounds on plastic as they may cause the plastic to become brittle.

When threading a bottom bracket into the frame, begin turning by hand to feel and avoid cross threading. Look at the opposite side of the bottom bracket shell and keep the spindle centered in the shell. If spindle appears off-center in the shell, it is likely cross-threaded in the frame (figure 7.60).

FIGURE 7.60: If spindle appears off-center in shell, bottom bracket adaptor is cross-threaded

Procedure for bottom bracket installation:

a. Prepare threads of bottom bracket main body and adaptor with grease, anti-seize, or threadlocker.
b. Look on main body and adaptor for “L” and “R” marking. “L” goes to left side of bike and “R” goes to right (drivetrain) side. For common English/ISO threaded bikes, right side (“R”) has a left-hand thread direction. Thread drivetrain side by turning counterclockwise. If bottom bracket has a plastic threaded side and a metal threaded side, install metal threaded side first.
c. Once threads are correctly aligned, thread main body fully into bottom bracket shell using bottom bracket tool.
d. Install threaded adaptor into other side of shell and tighten both sides to manufacturer’s torque (figure 7.61).

FIGURE 7.61: Secure cartridge bottom bracket main body and adaptor with proper torque

THREADED ADJUSTABLE BOTTOM BRACKET BEARINGS

Adjustable bottom bracket designs use convex and concave bearing races opposing one another, trapping the ball bearings between them (figure 7.62). This design can be dismantled, cleaned, regreased, assembled and adjusted. It can be found on some square-spindle bottom brackets and the Shimano® Dura-Ace® 7700 bottom brackets. If the adjustment is too tight, there will be too much pressure on the bearing surfaces. The system will “bind” and quickly wear out. If the adjustment is too loose, there will be movement or “play” between the parts. This causes a knocking in the bearing surfaces, and the surfaces will also wear out prematurely.

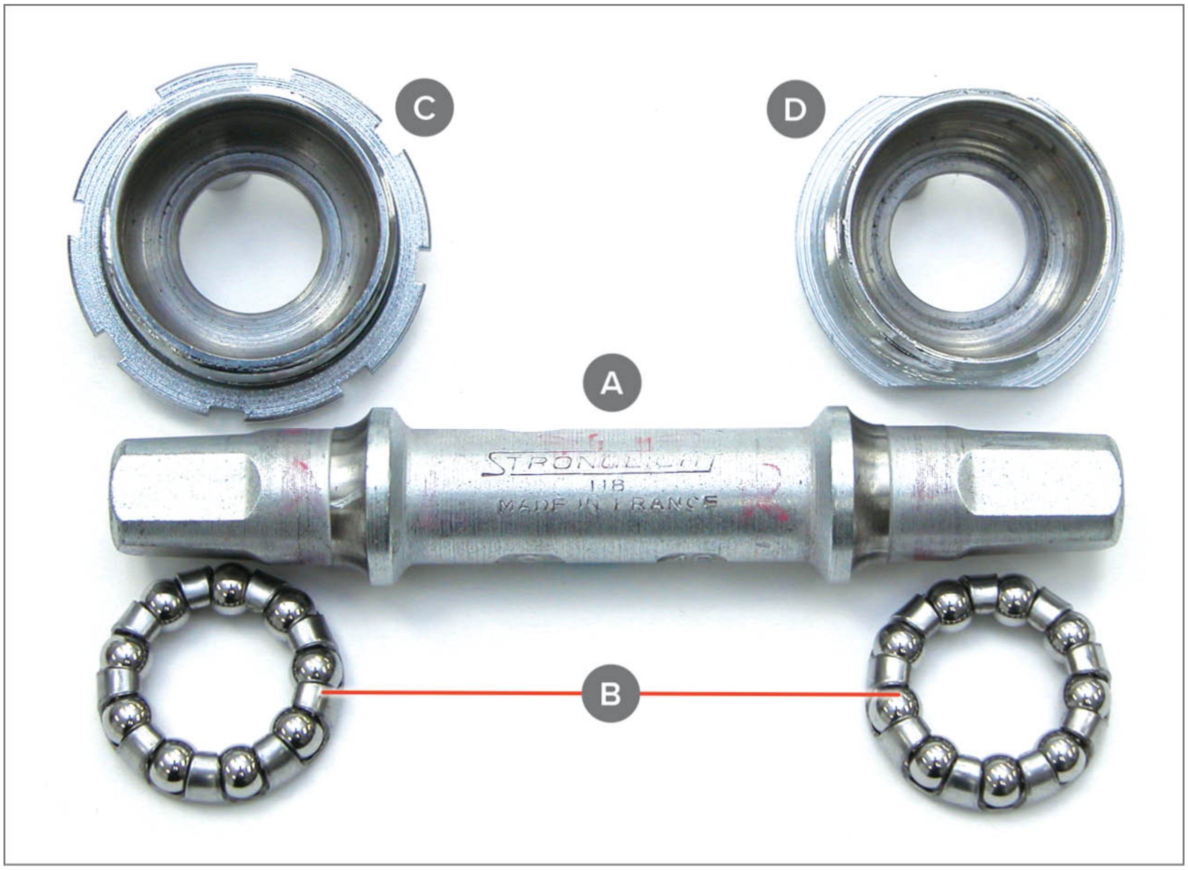


FIGURE 7.62: “Cup-and-cone” design of the adjustable bottom bracket: (A) spindle, (B) bearings, (C) left-side cup and lockring, (D) right-side cup

In adjustable bearing systems the bearing surfaces move on threaded parts. It is normal for threaded parts to have play between internal and external threads. For example, a bearing cup will wiggle in the shell thread until the lockring is tightened down against the frame. Play in the thread is removed when a locking nut or ring is tightened. When checking bearing adjustments, the lockring must be tight. Play felt after the ring is tight will come from the bearing adjustment, not from thread movement.

Bottom Bracket Removal

When dismantling components, it is a good idea to take notes or take pictures of the part's orientation. For a bottom bracket spindle, one side of the spindle may be longer than the other side. Note which side was longer or shorter, and reassemble in the same orientation.

If the bottom bracket is being overhauled, it is optional to remove the fixed side (right-side) cup. Removal makes inspection and cleaning easier. The cup may remain in the frame but will slow the service slightly.

Procedure for bottom bracket disassembly:

a. Remove cranks.
b. Using a lockring spanner, such as the Park Tool HCW-5, loosen and remove left-side lockring.
c. Use a pin spanner, such as the Park Tool SPA-1 or SPA-6 (or other appropriate tool) and remove adjustable cup from left side of bike (figure 7.63).

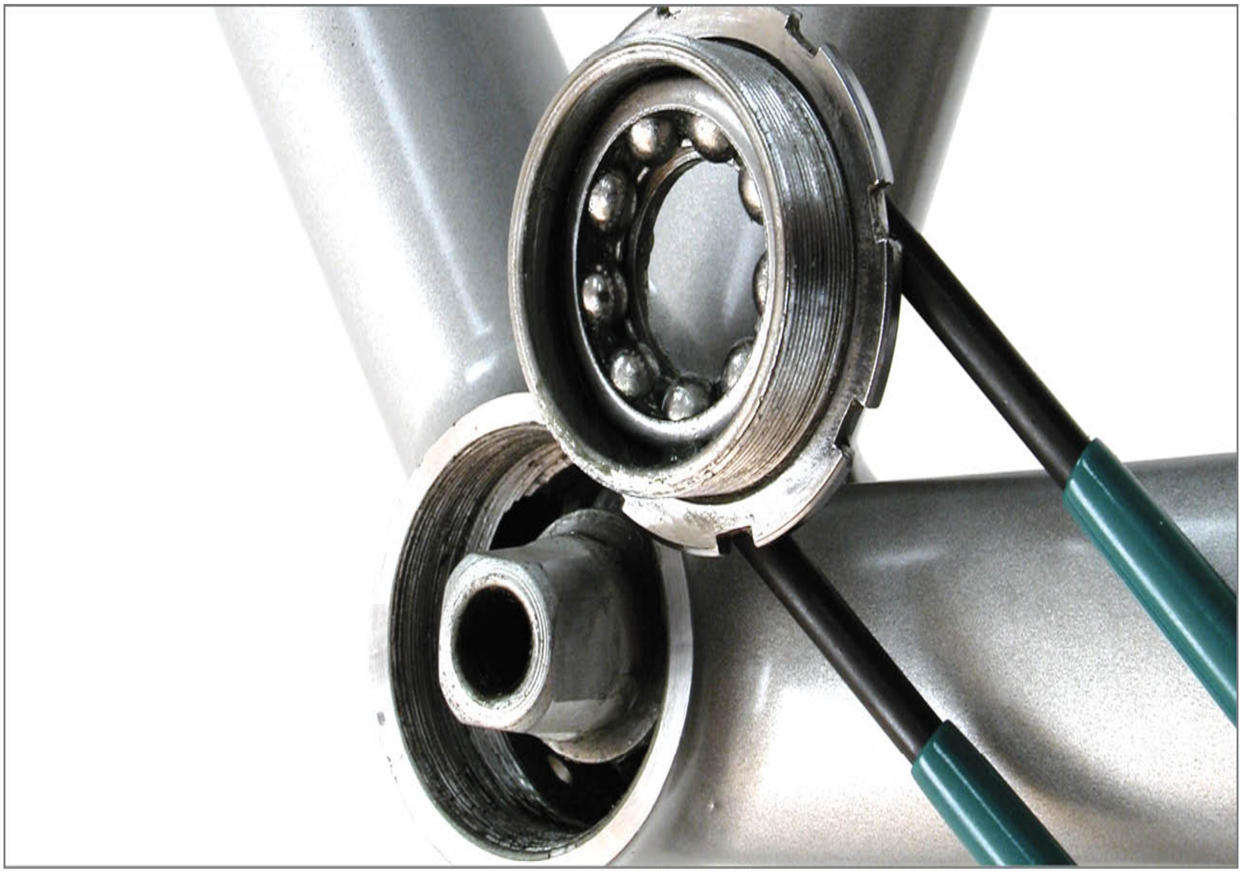


FIGURE 7.63: Remove adjustable cup (left-side) lockring, bearing cup and bearings

d. Remove bearings and spindle. Note and record if right side or left side of spindle seems longer. Note number of bearings if bearings were not caged.
e. Remove any dust sleeve from inside bottom bracket shell.
f. Reach through shell and remove bearings from inside right-side cup. Use a long spoke or other object as necessary.
g. Fixed cups (right-side) are commonly left-hand threaded. If removing for service, use a fixed cup spanner, such as the Park Tool HCW-4, and remove clockwise (for common English/ISO threading).
h. Clean all parts in solvent and dry.
i. Inspect all parts for wear and damage. View cups and spindle races for pitting and other damage. There will likely be a smooth line worn on both cup and spindle. There should not be holes or gouges in either. Use a ballpoint pen to trace bearing path (figure 7.64). Roughness and wear will be felt as ball of pen passes over worn areas. This roughness

will get worse with use. It does not “smooth out” or “break-in” with time. If the ball bearings have a shiny silver color and are smooth, they can be reused. If the bearings appear discolored, they should be replaced. Ball bearings are generally the part of the system to wear out. If the bearings are worn, it is likely that the cups and races are also worn.

FIGURE 7.64: Trace bearing surfaces to feel for roughness and pits

Bottom Bracket Installation

Thread preparation is critical in bottom brackets. Use either grease or anti-seize for cups. Fixed cups (right-side) may also use mild threadlockers rather than lubrication. The common bearing size for square-spindle adjustable bottom brackets is 1⁄4 inch.

Procedure for bottom bracket installation:

a. Prepare threads using grease or anti-seize compound. Right-side (drive-side) cup may use a threadlocker as an option.

b. If removed, install fixed cup (right-side). Even if fixed cup was not removed, check for cup tightness. For ISO/English threading, turn counterclockwise. Secure to a minimum of 360 inch-pounds.

c. Heavily grease bearing cages. Press grease into cage and between bearings.

d. Refer to notes from disassembly and place bearing retainer on fixed cup side (right-side) of spindle. Place open side of bearing cage against cone-shape of spindle. Install spindle through shell and into fixed cup.

e. Install any dust sleeve.

f. Heavily grease second bearing cage and install into adjustable cup (left-side). Place open side of cage towards cone-shape of spindle.

g. Thread adjustable cup (left-side) into place.

h. Install but do not tighten lockring onto adjustable cup.

Bottom Bracket Adjustment

Rotating bearings should be adjusted to be as loose a possible, but without play or knocking. Although the spindle may not feel as subjectively “smooth” and you may like, it should be adjusted to this edge of no play. If the bearing surfaces are worn out, it will not be possible to have a smooth adjustment with no play. Worn bottom bracket parts will need to be replaced.

When beginning a bearing adjustment, start with it loose and then proceed to tighten the adjustment in small increments until the play disappears. This ensures the adjustment is as loose as possible but is without play. In most cases, try to make small changes in increments of 1⁄32 of a complete rotation.

To ensure you are making adjustments in small increments, use a piece of tape as a reference. Use about 2 inches of masking tape and make pen marks on one edge every 3mm. Stick the tape on the left side of the bottom bracket shell so the marks face outward. These will be reference marks when adjusting the bearings and represent the small increments used when turning the adjustable cup (figure 7.65).

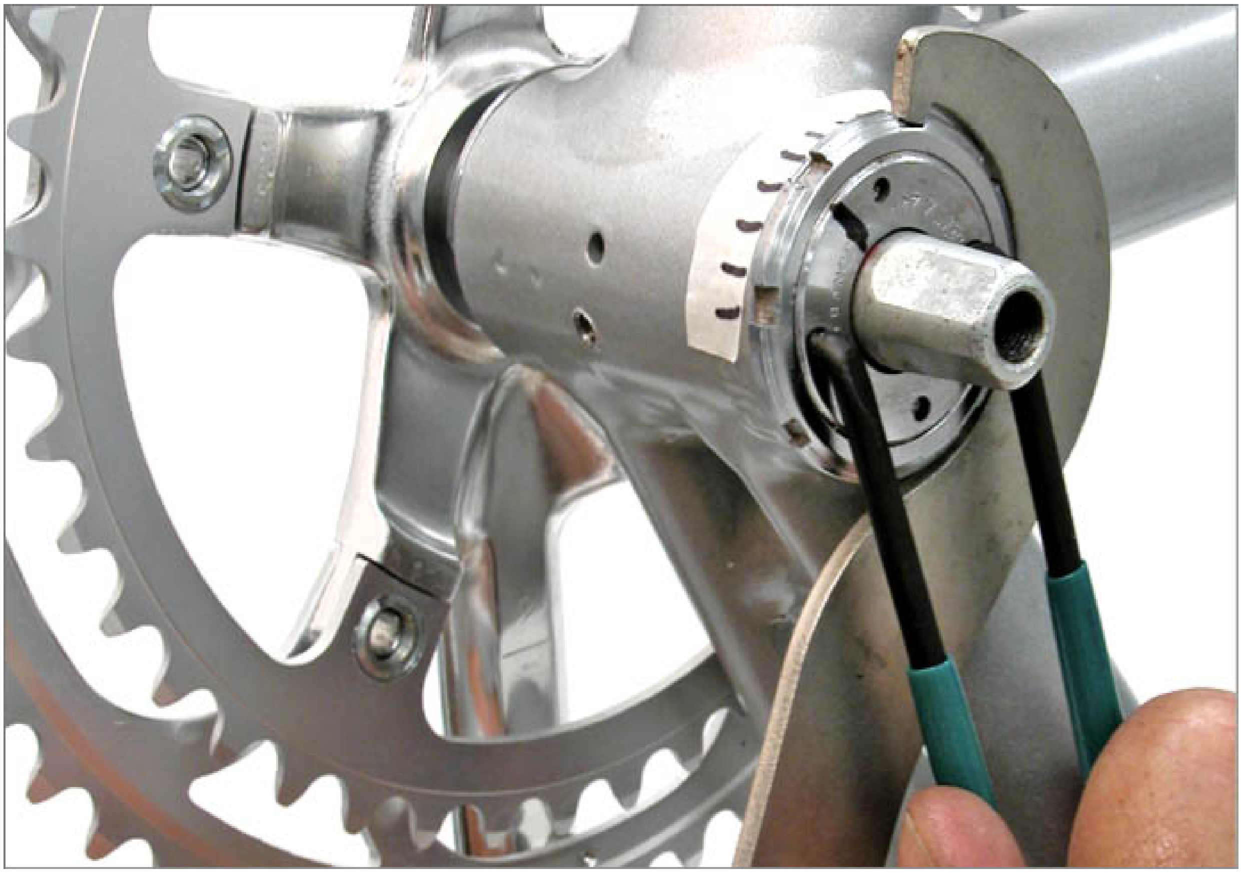


FIGURE 7.65: Use a sticker for reference marks when making small adjustments to the bearing cup

Procedure for bottom bracket bearing adjustment:

a. Reinstall right crank only and tighten crank bolt fully. Crank will be used as a lever to check for play in adjustment.

b. Gently tighten adjustable cup (left-side) clockwise. Turn it just to point you can feel it bump into the ball bearings.

c. Use marker and make a line on cup face. Have a look at reference tape and note which mark aligns with cup reference mark. It is also possible to use a mark already on cup, such as first letter of the manufacturer if cup is stamped.

d. Hold adjustable cup firmly with correct spanner. Using lockring spanner, tighten lockring fully. Locking typically requires 300 to 360 inch-pounds.

e. Check for knocking in spindle. Grab end of right crank and push left to right. Repeat this as you rotate crank all the way around.

f. If there is no play, adjustment may be too tight. Loosen lockring and loosen cup slightly to create play. Secure lockring and check for play.

g. If there is knocking (play), make note of which reference tape mark aligns with cup mark. Loosen lockring counterclockwise. Move adjustable cup clockwise one mark on reference tape. Secure lockring and check for play.

h. Repeat tightening one mark at a time until play disappears, checking for play with right crank in different positions of rotation. When play is not felt at any rotation, adjustment is finished.

i. Use solvent to remove pen mark from cup or frame.

j. Install left-side crank and tighten crank bolt fully.

CHAINRINGS

Chainrings are toothed sprockets attached to the cranks. Cranks may be designed to accept one, two, or three chainrings. Better quality models of cranks are designed so the rings are replaceable. The old ring is removed and a new ring is installed. Different rings may also be fitted if the rider desires a different gear ratio. There are less expensive models of cranks that use chainrings permanently mounted to the crank, which means the entire crankset must be replaced if the rings wear out or are damaged.

For cranks with multiple rings, the chainrings attach to the part of the crank called the “spider.” Spiders may have three, four, five, or six mounting arms. Chainring mounting holes must match the spider mounting holes in order to fit. As the chainrings turn, the mounting bolts trace a circle. The diameter of this circle is called the “bolt circle diameter,” abbreviated as BCD. New chainrings must match both the number of mounting holes and the bolt circle diameter (figure 7.66).

FIGURE 7.66: Bolt circle diameter of a five-arm crank

If there are four, six or eight arms on the crank, measure the bolt circle diameter using opposing chainring bolts. It is easier to measure edge-to-edge on the bolts, rather than center to center.

It is difficult to directly measure the BCD of three-arm or five-arm spiders. Measure one "cord," which is one side of the pentagon created by the bolts (figure 7.67). Measure from bolt to adjacent bolt. Multiply this figure by 1.70 (the mathematical constant for pentagons) to get the bolt circle diameter (BCD). For chainrings with three mounting holes, use 1.155 to find the BCD.

FIGURE 7.67: Measure one cord of pentagon by measuring from bolt-to-bolt

Table 7.2 below lists the bolt-to-bolt (cord) measurements for the common BCD's of three-, four-, and five-bolt chainrings.

TABLE 7.2: Bolt Circle Diameter

BOLT-TO-BOLT MEASUREMENT	BCD	COMMON USE
Three-Arm Cranks		
74.5mm	86mm	3-bolt of FSA® inner and outer
Four-Arm Cranks		
45.3mm	64mm	Inner ring of standard MTB triple
53.7mm	76mm	SRAM® XX1® chainring
56.6mm	80mm	Inner MTB double
62.2mm	88mm	Inner/outer XTR® M985 double ring
72.1mm	102mm	Middle/outer MTB standard
73.6mm	104mm	Middle/outer MTB standard
N/A	110mm	Shimano® 11-speed Dura-Ace®
84.7mm	120mm	Outer, double SRAM®
103.3mm	146mm	Outer XTR® M960
Five-Arm Cranks		
34.3mm	58mm	Inner ring of compact MTB triple
43.5mm	74mm	Inner compact road
53.3mm	92mm	Inner triple Shimano®
55.4mm	94mm	Middle/outer MTB compact
64.7mm	110mm	Middle/outer compact road
76.4mm	130mm	Inner/outer standard road
79.5mm	135mm	Inner/outer Campagnolo® road
84.6mm	144mm	Track

Another system of chainring attachment is called “direct mount” (figure 7.68). The drive-side crank uses a locking system to hold a single chainring direct to the arm. There is not an industry standard for chainring interchangeability or tool fittings for this system.

FIGURE 7.68: Direct mount chainring of a Race Face® crank

For ring replacement, the right crank is removed. The correct tool is engaged and the ring is removed counterclockwise. The old ring is pulled free and a new ring is installed. Some models offer offset rings which will change the chainline relative to the rear sprockets.

The 1X (“one-by”) chainring system uses a single front ring with specially shaped teeth. There may be an alternating tooth profile of narrow-wide, or the teeth may be tall to help prevent the chain from falling off. Although there is not shifting wear on these rings they are susceptible to wear as other front rings. Inspect for bent teeth or wear along the leading edge (figure 7.69).

FIGURE 7.69: New teeth on blue ring compared to worn teeth on black ring

CHAINRING REPLACEMENT WITH MOUNTING ARMS

Replaceable chainrings are held to crank spiders by special fine thread fasteners called “chainring bolts.” These bolts may use a 5mm hex, 6mm hex, or Torx® T30 wrench. Usually, the nut is round and uses a slot to engage a tool instead of external faces. Use a chainring nut wrench, such as the Park Tool CNW-2, to hold the chainring nut while the bolt is turned (figure 7.70). Chainring bolt threads should be lubricated or treated with a mild threadlocker before installing and tightening.

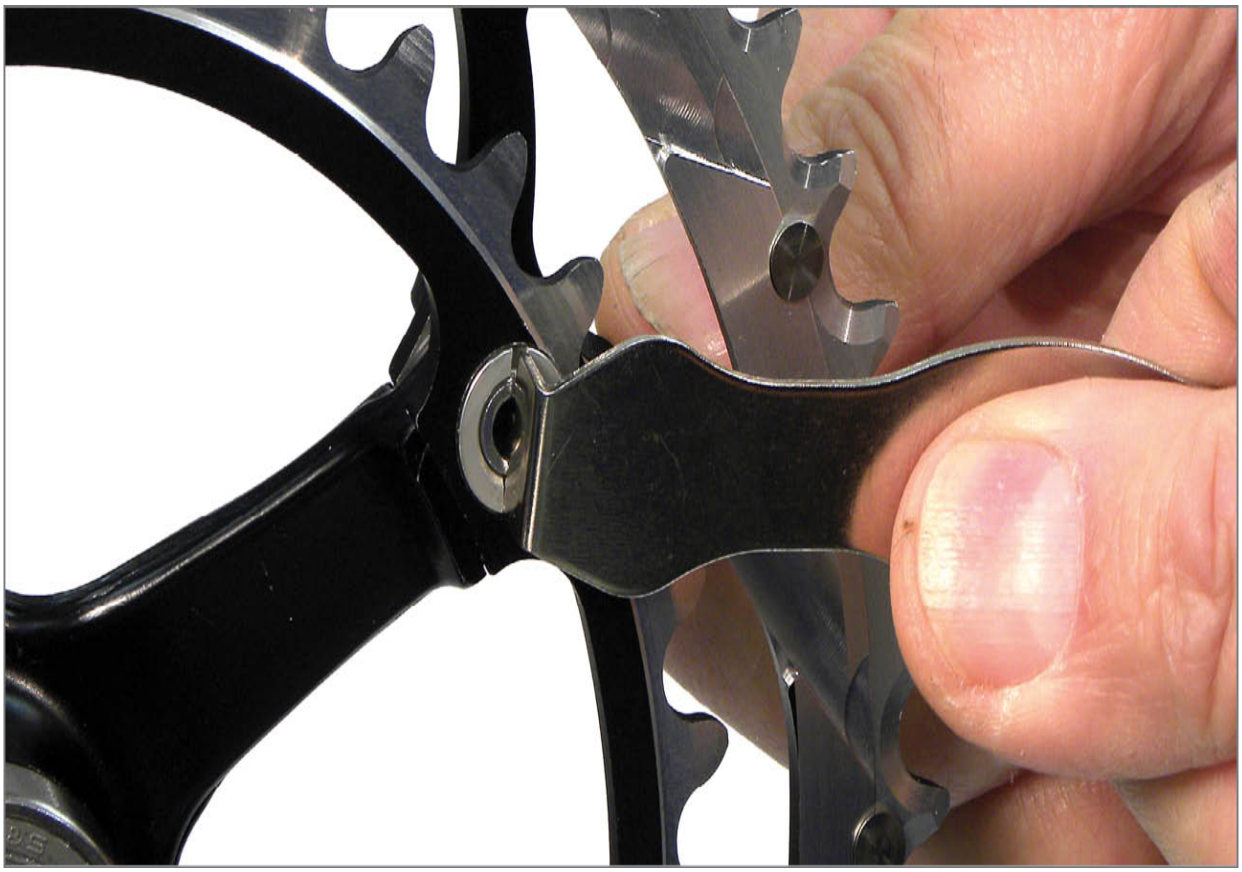


FIGURE 7.70: Use chainring nut wrench behind chainring to hold nut when turning bolt in the front

Chainrings can be designed with specially shaped teeth and “shifting ramps” built into the ring (figure 7.71). Shift pegs may be designed into the ring to help lift chain upward to the large ring. Large chainring teeth may be shortened to allow the chain to disengage and drop inward. Even if two chainrings have the same BCD and same number of teeth, they may not interchange well if one ring lacks these design features.

FIGURE 7.71: Note wear marks as the black anodizing wears off during shift (A) Upshift "pick up pegs" to lift chain to large ring, (B) Down shift ramps

Before removing the old chainrings, pay special attention to how they are oriented on the cranks because of the specially shaped teeth and shifting ramps to assist shifting. These features assist the shifting and are designed to work within a proprietary system. Chainrings must be correctly aligned on the crank to be timed for the shifting feature to work best. Inspect chainrings before removal, and make a note of the location of special ramps or markings (figure 7.72).

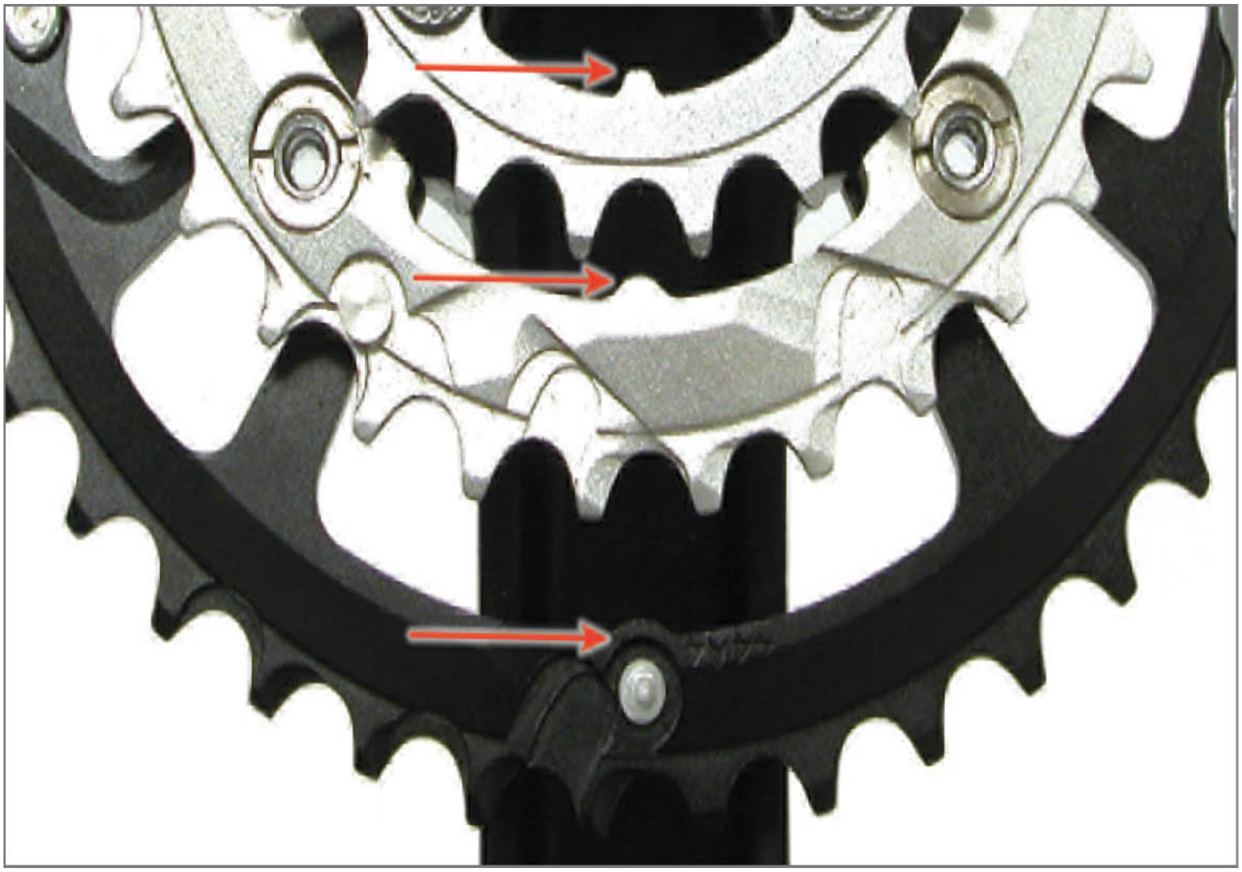


FIGURE 7.72: Inspect for any special marking to indicate chainring orientation relative to crank

CHAINRING WEAR AND DAMAGE

The chainring engages the chain as it turns. The leading or forward part of the chainring tooth takes the load of riding. With use, the teeth wear down, and eventually develop a “hooked” or “shark tooth” shape. Chainring teeth will also wear thin. Shifting ramps cut into the ring will also become worn and dull, which will reduce shifting performance. A worn ring may even skip under the chain when pressure is applied to the pedals. Worn teeth can also grab the chain and pull it upward into the frame, a phenomenon called “chain suck” that jams the chain between chainring and chain stay. Compare old, suspect rings to new ones of the same type (figure 7.73). If there is an obvious difference or if shifting seems to have suffered, replace the chainring.

FIGURE 7.73: An obvious difference between an old ring and new ring

If a tooth bends from impact, it may cause shifting problems. It may be possible to pry it back in line. Use a small adjustable wrench and close the jaws on the bent tooth. Bend the tooth back slowly while checking often so as not to overcorrect. Severely bent teeth may break off. However, even if the tooth breaks the ring may still be usable. Ride the bike after the repair and shift back and forth testing the results. If shifting performance is adequate, the ring is usable.

A bent tooth on the largest ring can be directly gripped by a tool while mounted on the spider for alignment. Bent teeth on the middle or smallest rings are difficult to access with a tool. A bent tooth will typically have been bent inward, towards the bottom bracket. It must be bent back to the outside (away from the bottom bracket). The outer ring usually prevents any tool from working on the tooth while mounted. When necessary, remove the ring from the crank for tooth alignment.

To repair a bent tooth, begin by spinning the rings without the chain in place. Locate which tooth appears bent and mark this tooth on the ring. For small or middle rings, remove the ring from the spider. Use a small adjustable wrench to straighten the tooth. Do not grab the ring itself with the tool, just the tooth. Hold the ring firmly below the wrench and bend the tooth slightly back. Compare the bent tooth to straightness of other teeth (figure 7.74). It may be necessary to remount the ring and try shifting. If the tooth makes a noise when pedaling or has other shifting issues, repeat the repair.

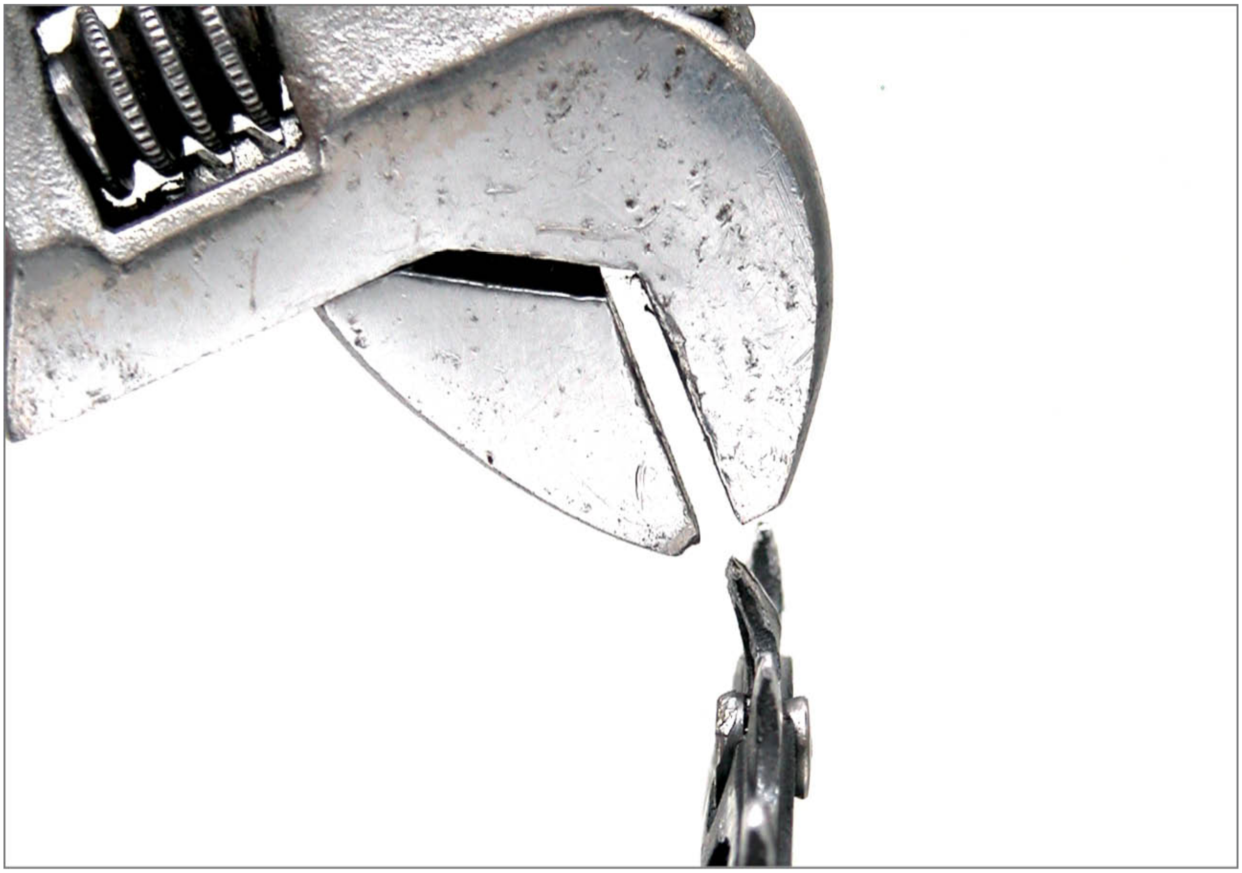


FIGURE 7.74: Sight along the chainring to find any bent teeth

If the chainring is bent, it will appear to wobble from side to side as the cranks turn. Impacts from crashing, impacts from shipping damage, or even damage from falling over and striking something may bend the rings. The bend may be in the ring, or it may be in the mounting arm. If the lateral movement is enough to affect the derailleur setting, it is sometimes possible to rebend rings to improve run-out or wobble. Because a loose chainring mounting bolt causes the ring to appear bent, always begin first by checking the security of the chainring mounting bolts. Use the shaft of a long screwdriver as a lever to straighten a bent chainring. Spin the rings without a chain in place and sight the left-to-right movement. Attempt to leverage the bent section. If there is no improvement after three or four attempts, it is best to replace the ring(s).

If an emergency repair is needed during a ride, you might try to impact the ring. Look for sticks or pieces of wood with a blunt end. Use this as a punch and strike the opposite end with a rock. The ring will never be perfect, but it may get you back from the ride. Four-arm spider rings are especially susceptible to bending under hard use. Again, it is best to replace bent rings rather than repair them.

TABLE 7.3: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Chainrings wobble side to side when spinning	1. Bent chainrings 2. Slight manufacturing defect	Replace chainring
Creaking noise when pedaling	Movement in fitted parts of crankset	1. Check all bolts for proper tightness 2. Loose press fit if PF bottom bracket—reinstall with retaining compound
Cranks turn with a lot of resistance	1. Too much bearing preload 2. Seal dragging on spindle	1. Adjust preload according to system of manufacturer 2. Remove cranks and check arrangement of seals
Crank fell off and will not stay tight even after reinstalling	Crank spindle fitting deformed from riding loose	Replace crank
Play in cartridge bottom bracket bearings	Bearing are worn out	Replace bottom bracket
Noisy bearing when turning cranks, or rumbling felt through frame	Bearing worn out	Replace bottom bracket

CHAPTER 8

CHAINS

The chain transfers motion from the front chainring(s) to the rear sprocket(s). Chains are made of multiple pairs of steel outer plates and inner plates held together by rivets (figure 8.1). A roller separates each pair of inner plates. The rivet is pressed tightly through both outer plates and pivots freely on the inner plates and roller.

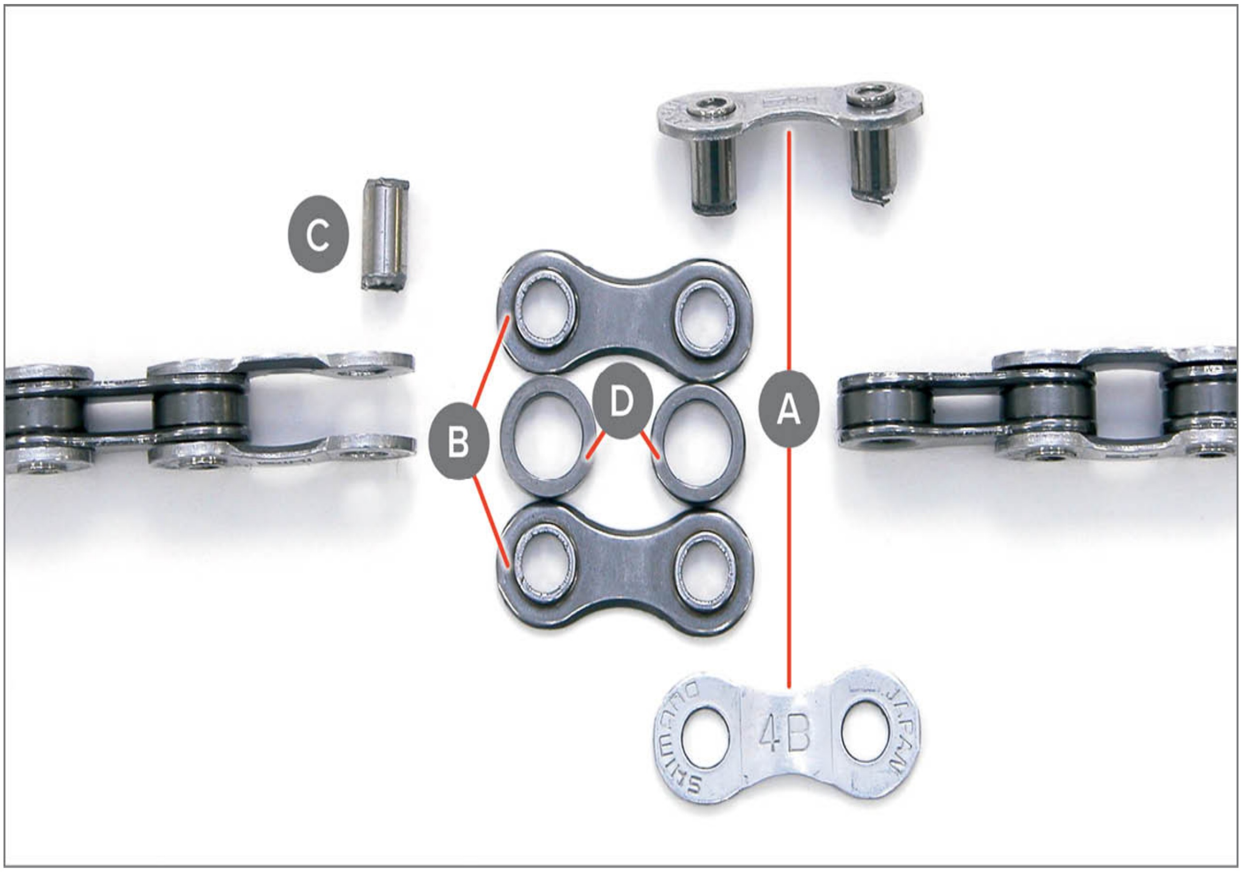


FIGURE 8.1: Component parts of the chain: (A) outer plates, (B) inner plates, (C) rivets, (D) rollers

Chains pass between the right seat stay and right chain stay to form a closed loop. Some chains use either a special connection rivet or a "master link" to close the loop. Also referred to as a quick link, these are specially made outer plates that mate together to hold the chain closed. Older-style chains generally do not use a quick link or a special connection rivet. Instead, the chain's original rivets are pressed out to separate the chain and pressed back in to join the chain back together. This is a weaker system and is not used for any modern drivetrain systems.

Drivetrain manufacturers design the derailleurs, rear sprockets, shifters, and chain to work together as a system. Chains vary in plate design, shape, and width. These differences cause variations in shifting performance between brands and models. Chains should be selected to be brand-compatible with the particular shifting system of the bicycle. Contact chain manufacturers for details on compatibility.

Chain specification is designated by width of the roller and by rivet length. Derailleur bikes use rollers of nominally 3⁄32 inch width. However, the actual roller width varies slightly depending upon the design of the chain and the number of rear sprockets. The 1⁄8 inch roller chains are used on some one-speed bikes, such as coaster bikes and single-speed freewheel bikes.

Chain width measured at the rivet should vary with the number of rear sprockets. The greater the number of rear sprockets, the shorter the rivet tends to be. Approximate chain width measured across the rivets are:

- 12 sprockets—5.4mm
- 11 sprockets — 5.5mm
- 10 sprockets — 6mm
- 9 sprockets — 6.5 to 7mm
- 6, 7, and 8 sprockets — 7mm

Chain pitch is the distance from rivet to rivet and is 0.5 inches for derailleur bike chains. Most all two-sprocket bikes such as BMX and single speed bikes also use this pitch standard.

The roller diameter between brands and models is nominally the same with only slight variations. However, the 12-speed SRAM® RED eTap® AXS® Flattop™ chain has a larger roller unique to their system. Consequently, the 12-speed SRAM® RED eTap® AXS® Flattop™ chains and cassettes are not compatible with other systems. For service work, the Park Tool CT-3.3 Chain Tool is compatible with the 12-speed SRAM® AXS® as well as standard chains.

1⁄8 inch roller width chains are used on some bikes with one rear sprocket, such as coaster bikes, fixed gear bikes and single-speed freewheel bikes. These chains measure approximately 9mm across the rivet, and are not used for multi-speed derailleur systems.

CHAIN SIZING FOR DERAILLEUR BIKES

A chain that is too long or too short may cause shifting and riding problems. A chain that is too long will sag between the derailleur and the chainrings when the bike is in the smallest rear sprocket and the smallest front chainring (figure 8.2). The chain may have low tension in this position, but it should not droop or sag very much between the front and rear sprockets.

FIGURE 8.2: Chain sag in smallest front to smallest rear sprocket position

Another symptom that indicates the chain is too long is the chain contacting itself as it passes by the upper derailleur pulley when the bike is in the smallest rear sprocket and smallest front chainring (figure 8.3).

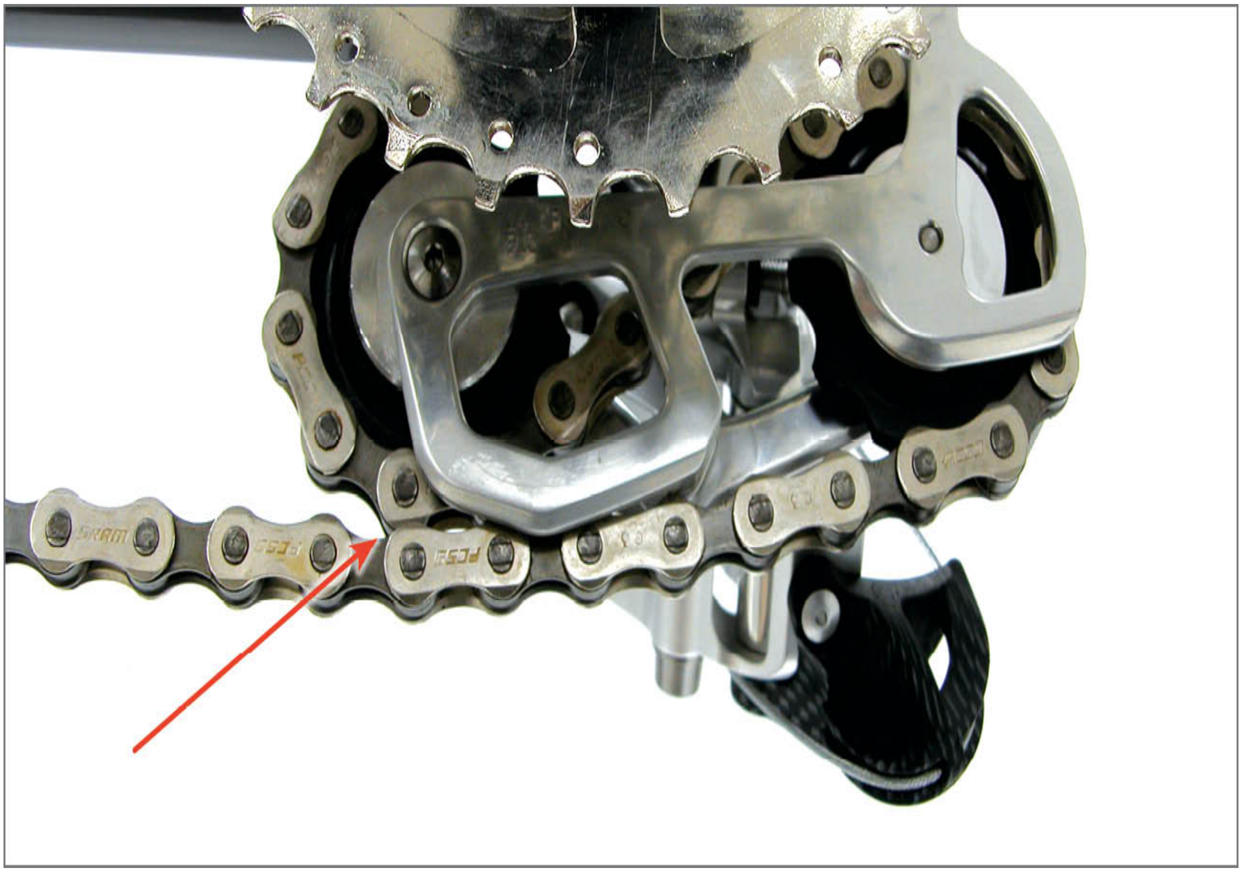


FIGURE 8.3: Chain contact indicating chain is too long

Conversely, there can be problems when the chain is too short. Diagnose a short chain by shifting to the largest chainring and second-largest rear sprocket. Chain tension will normally be tighter in this position. Inspect chain for a double bend (“S” bend) as it passes through the pulley wheels (figure 8.4). Shift slowly and carefully to largest rear sprocket. If chain appears to jam, it is too short. Even if the chain shifts but loses the double bend at the pulley wheels, it is too short (figure 8.5). In extreme cases when the chain is too short, trying to shift to the large rear sprocket and largest front chainring combination may damage the derailleur and/or the derailleur hanger.

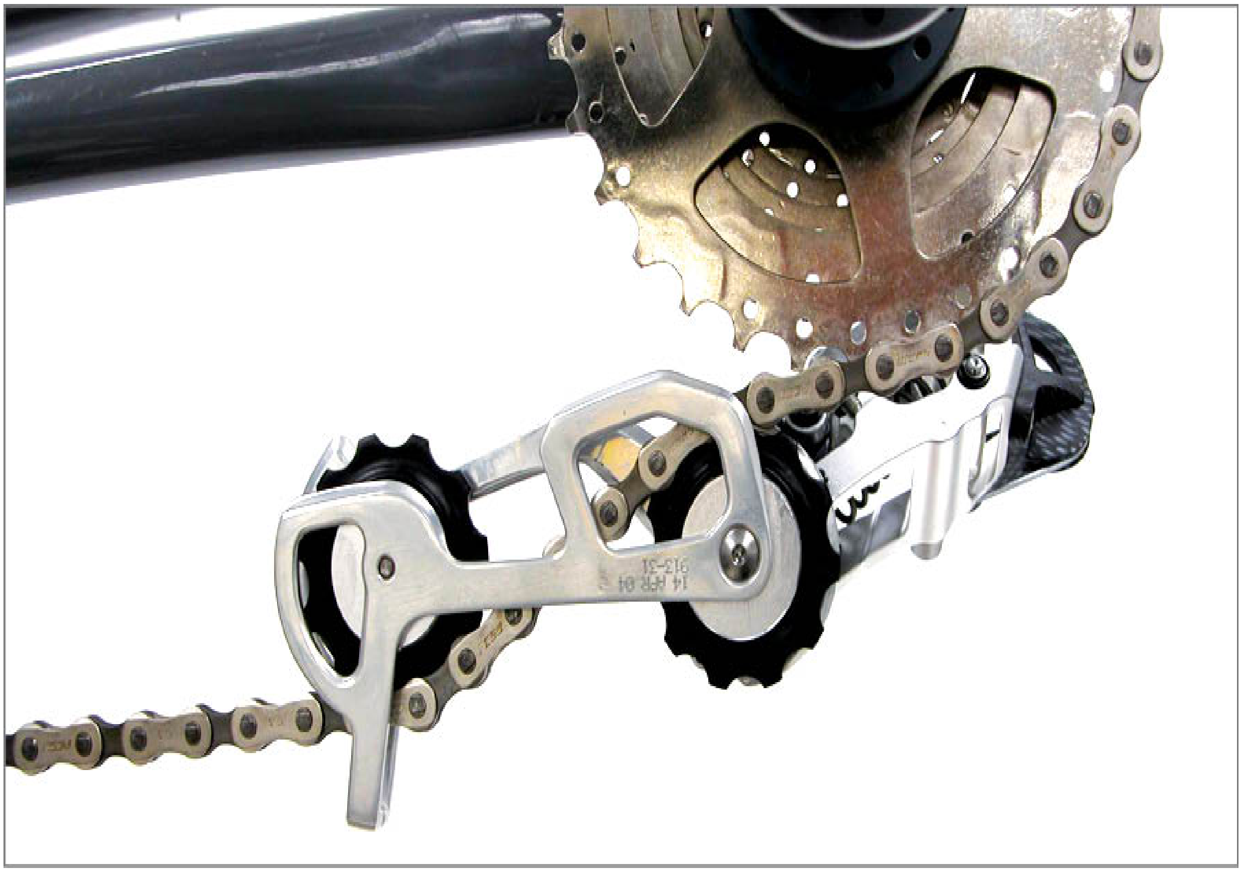


FIGURE 8.4: Double bends at each pulley indicate adequate chain length

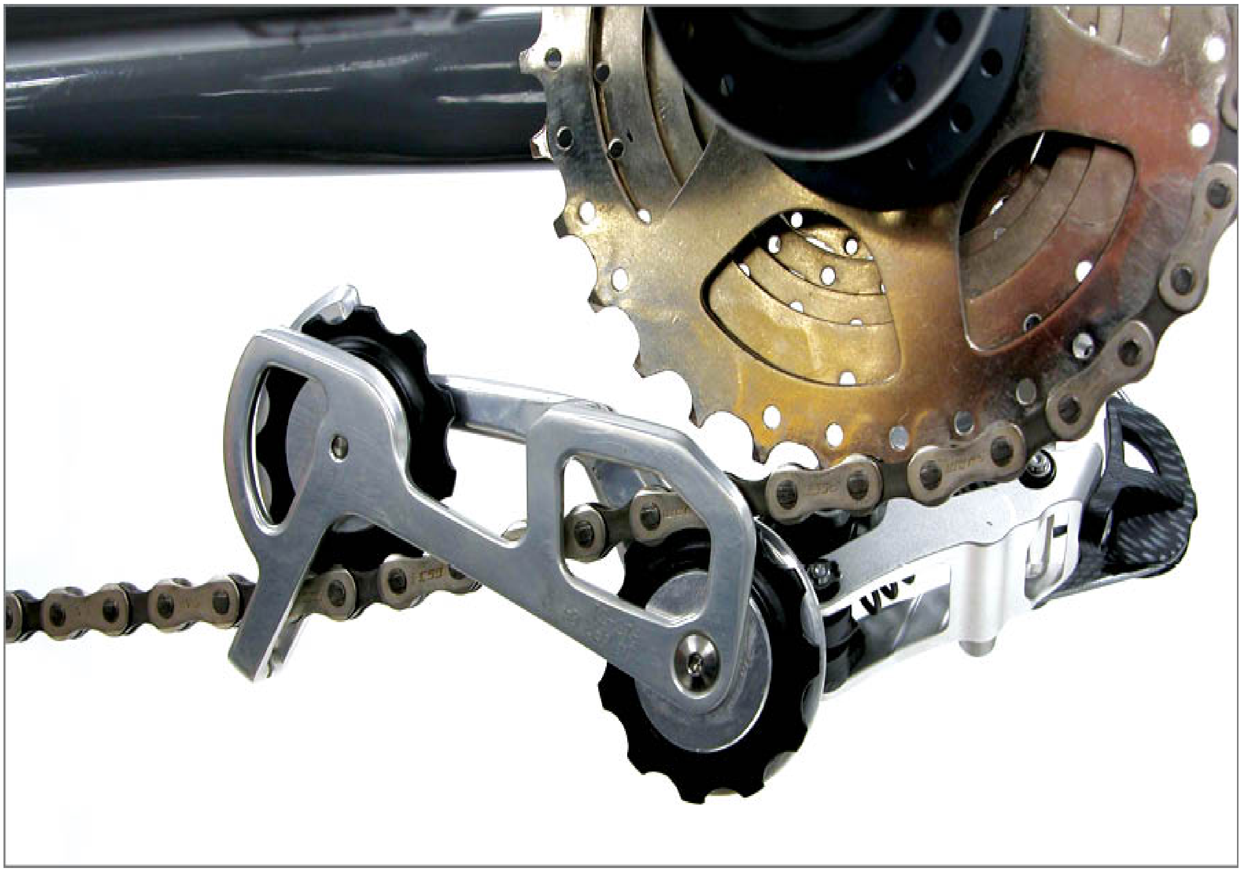


FIGURE 8.5: Too short of chain with no double bends at pulleys

The rear derailleur cage takes up chain slack as the chain is moved between the various front and rear sprocket combinations. Some bicycles are fitted with sprocket combinations and derailleur models that do not allow the derailleur to wrap up the chain slack in every possible gear combination. The sprocket selections in these cases exceed the “Chain Wrap Capacity” of the derailleur.

If the rear derailleur chain wrap capacity does not match or exceed the sprocket range on the bike, the chain length will appear either too long in the smallest sprocket to smallest chainring combination, or too short in the largest sprocket to largest chainring combination. This is seen commonly when a “short cage” derailleur is used on a bike with a wide gear range. When using a derailleur that does not meet the gearing capacity, it will be necessary to avoid certain gear combinations that cause problems in pedaling or shifting. For more discussion of derailleur capacity, see Derailleur Capacity and Maximum Sprocket Size in Chapter 10—Derailleur Systems.

New chains are usually packaged longer than needed for most bicycles.

New chains need to be “cut” (links separated or removed) to fit each bike. Chains are sold in one of two chain end arrangements. Chains using quick links will have both chains as inner plates, and either end may be shortened. If the chain uses a connection rivet, such as Campagnolo® 11 and 12-speed or some Shimano® chains, one end will have a pair outer pair of plates, and the other end with inner plates. To shorten this chain, cut only the end with inner plates.

The chain is sized to the unique gear combination of a particular bike. If the rear cassette will be changed for different rides, be sure to size the chain for the largest rear cassette sprocket of the different options.

To install and size a new chain, a chain tool is required. Chain tools are made up of a driving pin and a system to align and hold the chain roller (figure 8.6). Some models have two chain alignment prongs (cradles). The primary set of locating prongs support the chain for pressing the chain rivet in and out. The tight link prongs are used only for fixing a tight link. Other models, such as the Park Tool CT-4.3 Professional Chain Tool, use a pocket to hold the chain rather than the alignment prong system.

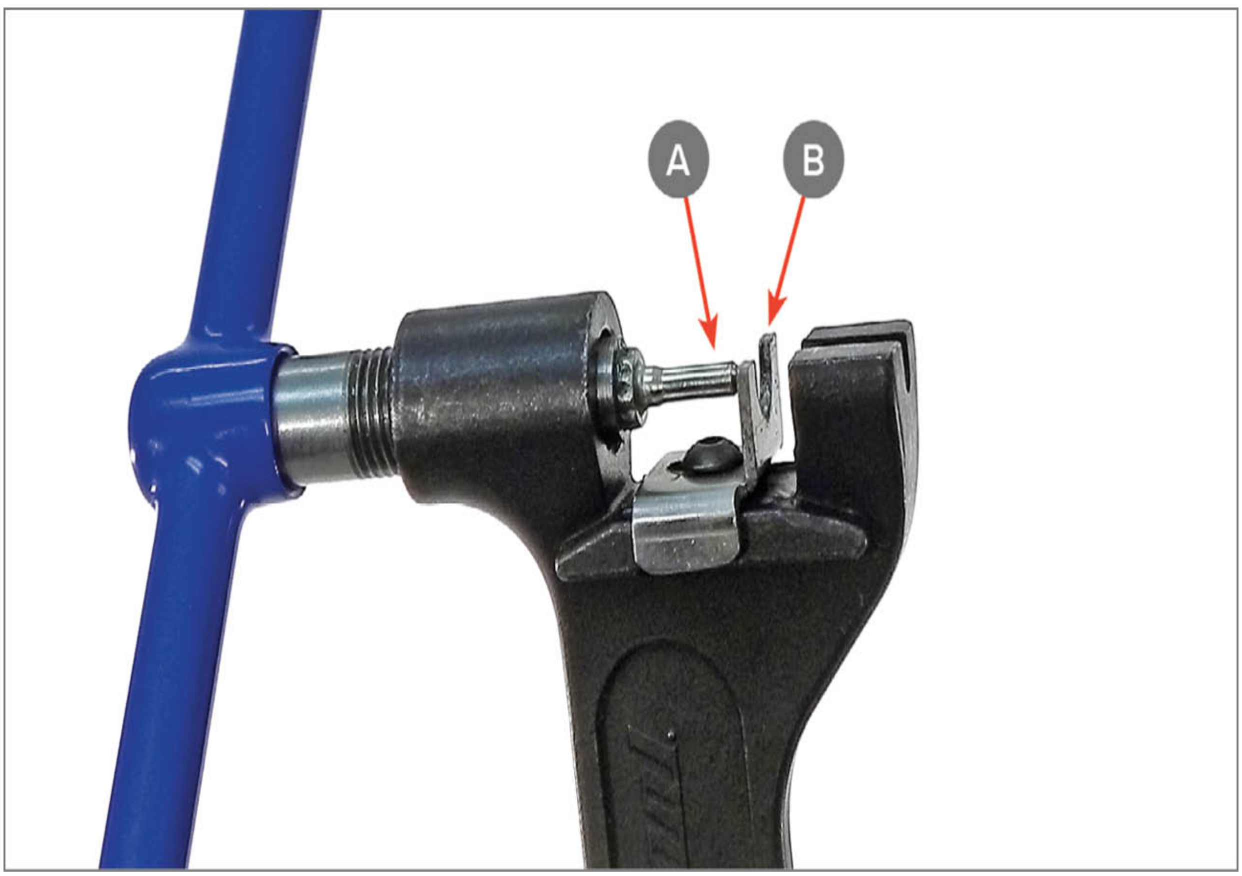


FIGURE 8.6: Park Tool CT-3.3 chain tool (A) driving pin and (B) alignment prongs

Rear suspension bikes may use designs that move the rear hub and sprocket relative to the bottom bracket as the rear suspension compresses. If the pivot of the suspension moves the rear cog further away from the bottom bracket, size the chain to the longest rear-hub-to-bottom-bracket distance. Release shock pressure to fully compress rear suspension before sizing a chain.

If a new chain is being installed and the old chain is the correct length, the new chain may be shortened to match. Test the length of the old chain by shifting to both the largest front and rear sprockets and then the smallest front and rear sprockets. If the chain passes both tests it is an acceptable length. Remove the old chain and lay it on a flat surface with the plates aligned vertically. Pull the chain straight. Lay the new chain next to the old chain in the same fashion, with inner plates of both chains at one end. The new chain may not exactly match rivet to rivet toward the end of the chains. Push the links of the old worn chain together to match up with pins or rivets of the new chain. Account for any quick link by placing it in one end on the new chain. Locate the matching end rivet on the new chain with the rivet on the old chain and cut the new chain.

The procedure below permits the chain to be shifted to the largest front and rear sprockets. It should be assumed someone might shift to this large-large combination. A short chain would jam and potentially cause damage during a shift to this combination. For sizing the chain, do not run the chain through the rear derailleur cage. Extra length is added in the process to account for the cage and pulleys. After cutting, the chain is then routed through the derailleur(s) and joined.

The procedure for sizing chain on 1X ("one-by") systems with a single front chainring is similar to sizing for multiple front rings. The chain is engaged over the only front ring and over the largest rear sprocket. However, only SRAM® 11 and 12-speed systems use an additional four links (four rivets) extra from the shortest possible length. These SRAM® 1X systems have the upper pulley well away from the largest sprocket and require this extra length.

Procedure for derailleur chain sizing:

a. With no chain in place, use shift levers to position the front derailleur over the largest chainring and the rear derailleur under the smallest sprocket.
b. Thread the new chain through the front derailleur (if present), but do not thread the chain through the rear derailleur cage or pulley. Simply wrap the chain around the largest front chainring and around the largest rear sprocket. For quick link chains, install one side of link to simulate full length with quick link.
c. Pull the chain tight and note the rivet closest to where the two ends could be joined (figure 8.7). Keep in mind a chain can be joined only by mating inner and outer plates. If the selected inner and outer sections will not meet, round up and move to the next closest pair that would be possible to join.

FIGURE 8.7: Wrap chain on largest front and rear sprockets without engaging rear derailleur

d. From the closest rivet where it could be joined, count over to add an additional two rivets (figure 8.8). This adds 1 inch to the length to the shortest length from step “c.”

Note: SRAM® 11 and 12-speed systems with the 1X chainring, add two links (two rivets) additional from this point.

FIGURE 8.8: Left: example of one inch added including quick link
Right: one inch added using special connection rivet

e. Cut the chain at this point. Cutting the chain too long will be easier to rectify than cutting it too short. Select the chain side ending with inner plates to cut.

CHAIN SIZING WITH CHAIN RETENTION SYSTEM

Chain retention systems prevent the chain from falling off the front chainrings and are available in single chainring models and double chainring models. The chain passes through pulleys that add to the required chain length. To determine the chain length, route the chain over the largest rear sprocket, the largest front chainring, and through the retention system (figure 8.9). Pull the chain together without routing it through the rear derailleur, as if it were a one-speed, and then add length as described above.

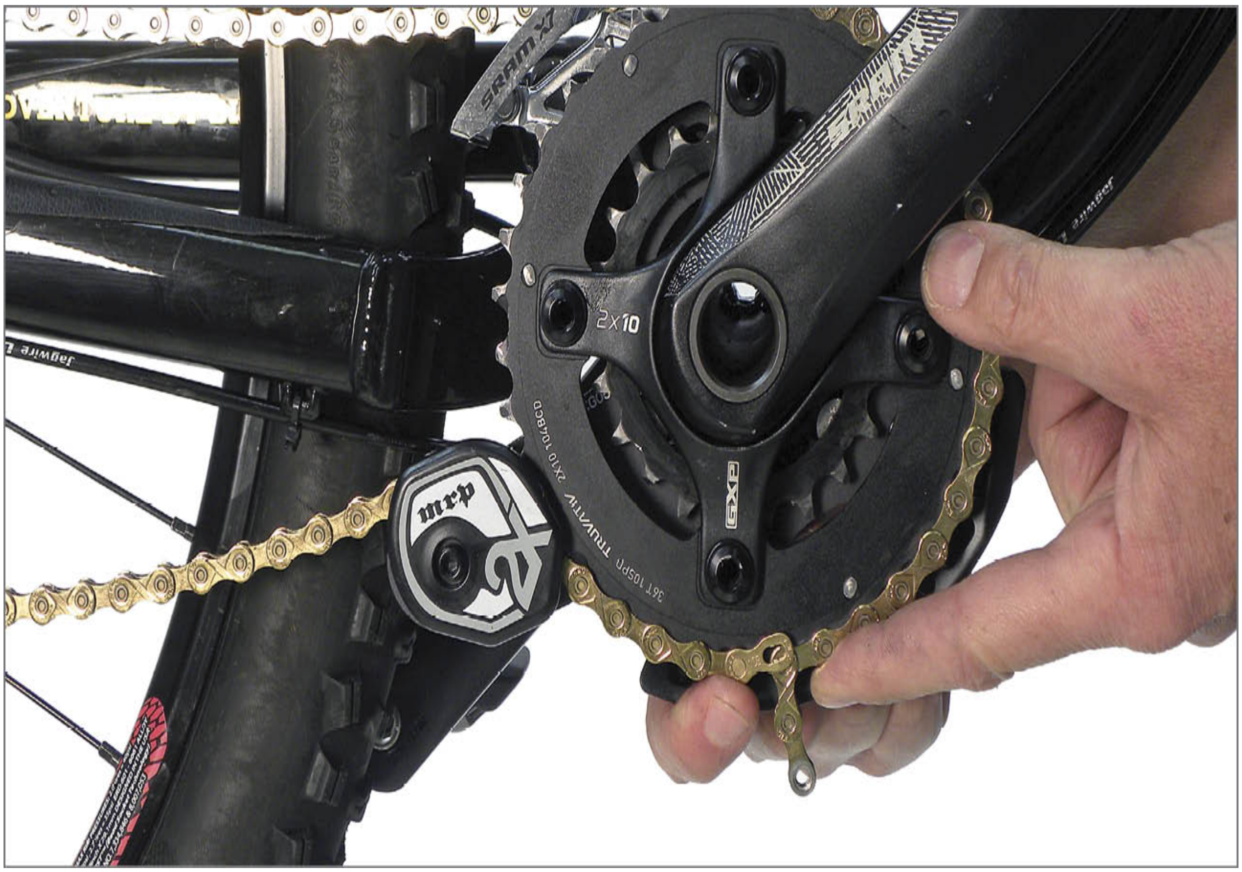


FIGURE 8.9: Engage chain pulley of guide when sizing chain

CHAIN REMOVAL

For modern chains, simply leave the chain installed until it is worn out and then replace it. Removing and reinstalling the chain for frequent cleaning only increases the chance for chain failure. Clean the chain in place on the bike with a chain cleaning system such as the Park Tool CM-5.2 Chain Scrubber.

If the chain is not being reused, it may be cut at any rivet and then removed from the bike. However, if removing and reinstalling the same chain with special connection rivets, such as Shimano® and Campagnolo®, do not select a previously installed connecting rivet. Find a rivet some distance from this original rivet and cut at this point.

For chains that reuse the chain rivet, see Chains With Reusable Rivets in this chapter.

Procedure for chain removal:

a. Shift the bike to the smallest sprockets front and rear.
b. Inspect for a quick link. If present, rotate cranks until link is in the lower section of chain.
c. When possible, drop chain from front chainrings to remove any chain tension.
d. If quick link is present, push both outer plates of quick link toward each other. Squeeze plate together between thumb and fingers while sliding link apart. When available, use quick link pliers such as the Park Tool MLP-1.2. Engage pliers on rollers and squeeze handles of the MLP-1.2 to disengage link (figure 8.10).

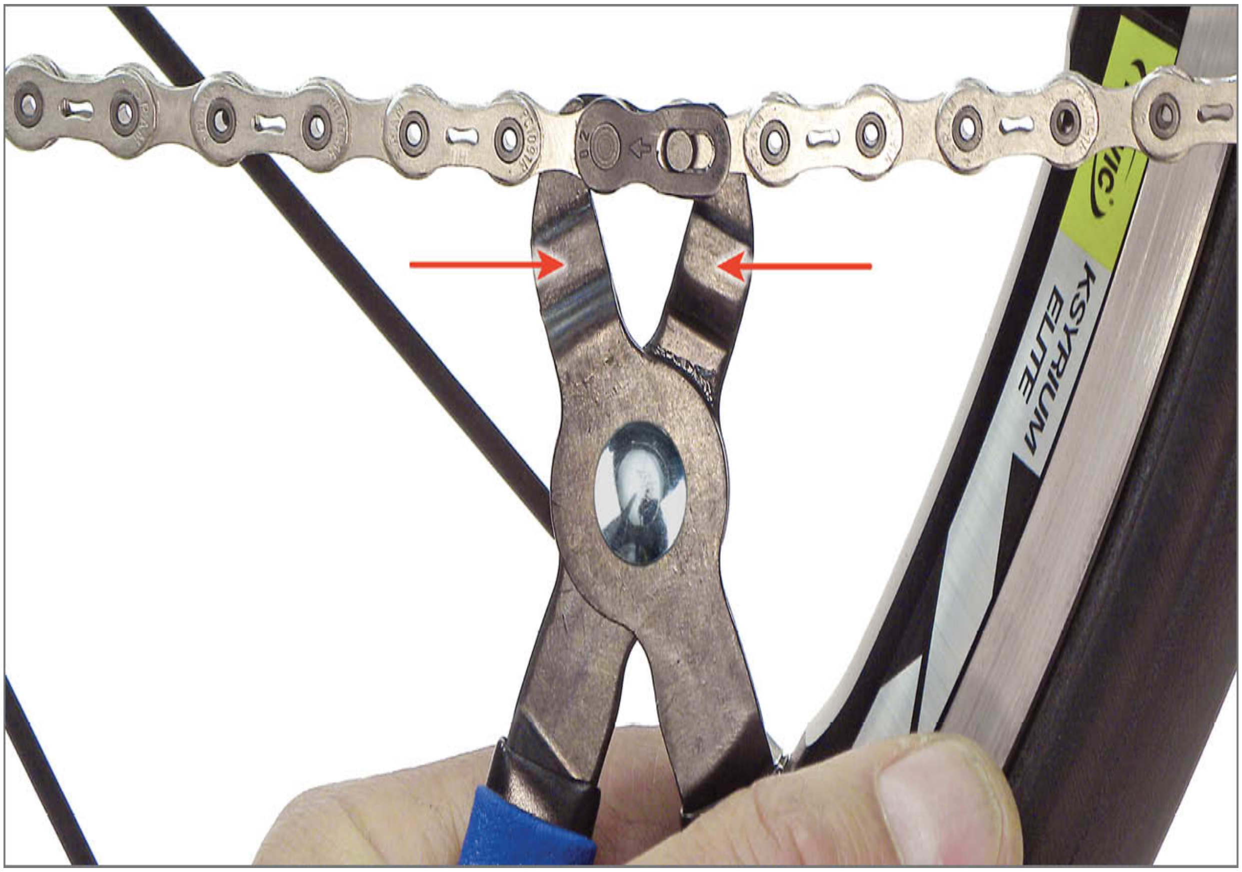


FIGURE 8.10: MLP-1.2 Master Link Pliers disengaging quick link side plates

e. If no quick link is present, select any rivet that is not a special connection rivet. Non-special rivets will appear the same as adjacent rivets.

f. Install chain roller into alignment prong of chain tool and bring driving pin of chain tool into contact with rivet. For CT-4.3, insert chain into pocket.

g. Ensure that chain tool pin is driving in a straight line to chain rivet. Turn handle and drive chain rivet from side plates (figure 8.11).

FIGURE 8.11: Driving chain rivet from chain plates

h. Pull chain through front and rear derailleur cages and remove from bike.

NEW CHAIN INSTALLATION ON DERAILLEUR BIKES

It is necessary to route the correctly sized or cut chain through the front derailleur, rear derailleur, and frame before it is joined. It may be useful to have another derailleur bike on hand as an example of chain routing when attempting this procedure.

After cutting chain to size, cut any zip ties from outer side plates. Feed chain through rear derailleur and front derailleur. Join ends together below chain stays. Any special connection rivet is installed so the rivet is pushed from the outside of the chain toward the inside (figure 8.12). This reduces the chance of the rivet striking the outer chainring when the chain is on the next chainring inward.

FIGURE 8.12: Push connection rivet toward the inside

The Shimano® recommended procedure is to install the chain so the connection rivet of the outer plate leads the plate onto the lower pulley. In other words, when looking at the chain on the lower loop from the drive side, the connection rivet is on the left hole of the outer plate.

Procedure for installation of correctly sized chain:

a. Shift derailleurs over the smallest front and rear sprockets.

b. Inspect chain side plates. If there is printing, lettering, or a logo on one side only, route the chain so writing faces to the right side of the bike, away from the wheel.

c. Beginning at rear derailleur, pass the chain end with outer plates over the top of the lower rear pulley and in front of the upper pulley.

d. Pull the chain behind the rear sprockets, allowing the wheel to spin to get a section of chain to work with.

e. Pass the chain end forward and between the front derailleur cage plates and down onto the smallest front sprocket.

f. Turn crank slowly to gain more slack.

g. Pull chain ends toward one another and join chain according to type or model of chain. If chain tension is making chain difficult to join, drop chain off chainring and onto bottom bracket.

h. Test chain for tight link and repair as necessary.

Chain links are joined by different procedures depending upon the manufacturer. The joining process is critical, and a poorly joined chain is the common cause of a broken chain. Consult the manufacturer’s literature if in doubt.

SHIMANO® CHAINS WITH CONNECTING RIVET

Shimano® produces two styles of chains. Some models come with a quick link system and join like other brands using quick links. Shimano® also produces chains that use a single special connecting rivet to install new chain. For Shimano® chains without quick links, a new connection rivet is required every time a chain is removed and reinstalled. The connecting section of the rivet is nominally 7.8mm (excluding the pilot section). The 9-speed chain uses a silver-colored connecting rivet with a connection section that is nominally 6.7mm. The 10-speed chains use a rivet with two machined lines for identification on the pilot. The connection length of the 10-speed connection rivet is nominally 6mm. The 11-speed chains have a tapered point on the pilot and the connection section is nominally 5.7mm (figure 8.13). These Shimano® connection rivets are not interchangeable between speeds. The Shimano® 12-speed chain has no connecting rivet option, and exclusively uses a quick link.

FIGURE 8.13: Special connecting rivets from Shimano®: (A) 7 or 8-

speed, (B) 9 speed, (C) 10-speed, (D) 11-speed

The connecting rivets for Shimano® chains (and other brands) may actually leave a ring of rivet material on the chain tool driving pin. This ring is the peening from the chain rivet that was driven from the side plates. Do not allow these rings to stack up on the tool because they may interfere with pressing new rivets. Use pliers to remove the old rings (figure 8.14).

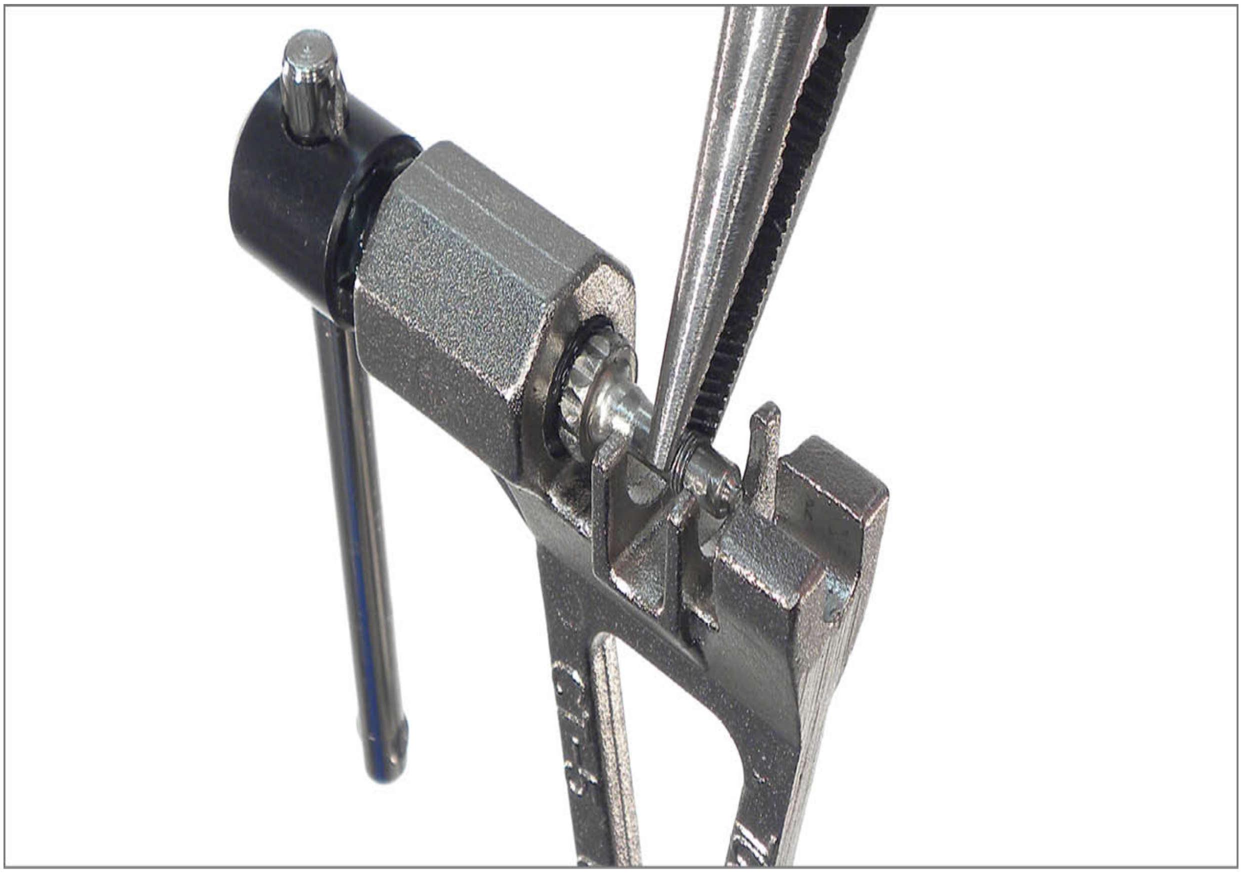


FIGURE 8.14: Remove old remnants of rivets from driving pin of chain tool

Procedure for Shimano® chain installation using connecting rivet:

a. Inspect chain side plates. If there is printing or a logo, route chain so writing faces toward the right. There are asymmetrical chains that require mounting in one direction. Any logo or printed letters face outward toward mechanic on the drive side.

b. Lubricate connecting rivet.

c. Install correct Shimano® connecting rivet, taper end first, into chain outer plate as seen from the mechanic on the drive side (figure 8.15).

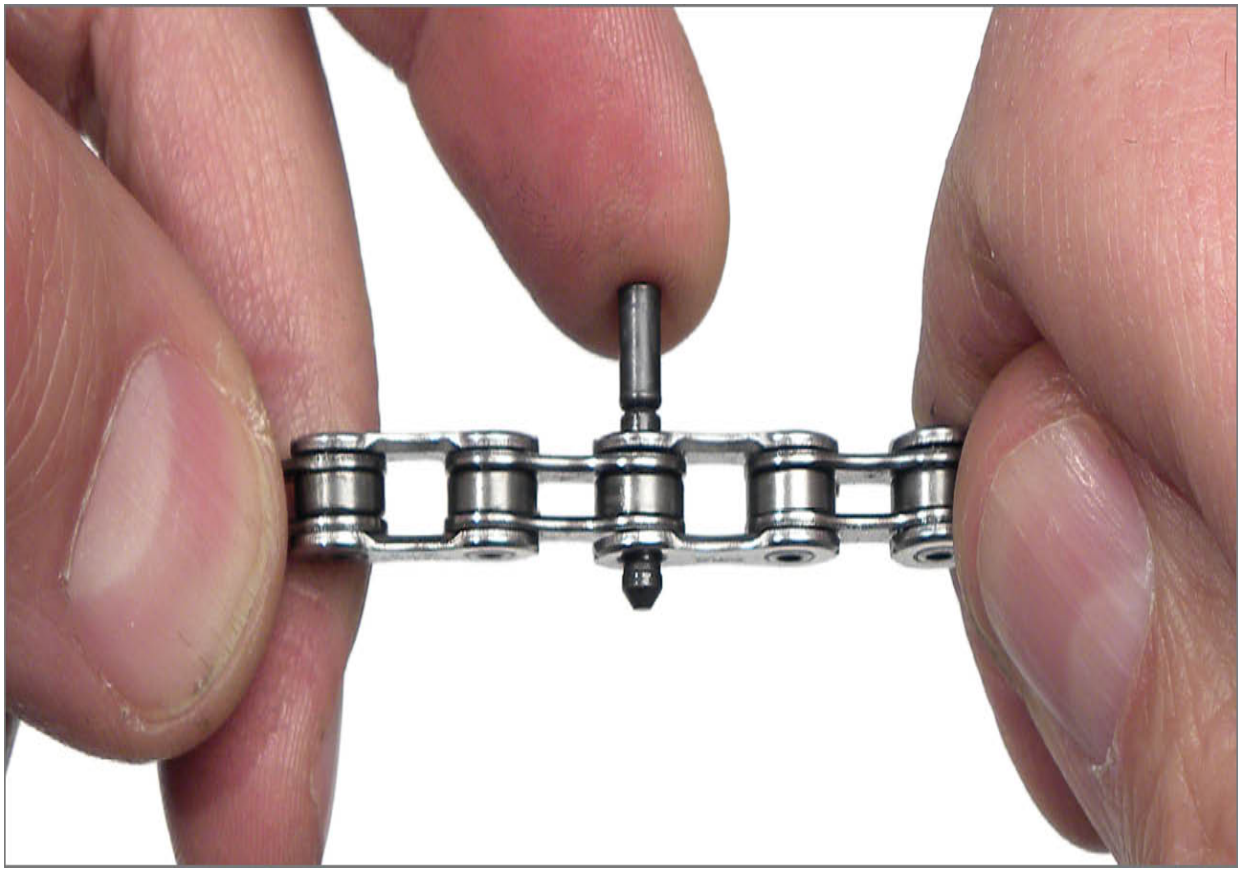


FIGURE 8.15: Insert connecting rivet with tapered end first

d. Unthread chain tool driver and pin into tool body to make room for special connecting chain rivet in alignment prongs of tool.
e. Place chain roller into alignment prongs of chain tool.
f. Drive connecting rivet into chain (figure 8.16). Continue to drive chain tool pin until head of connection rivet appears to protrude the same as adjacent rivets.

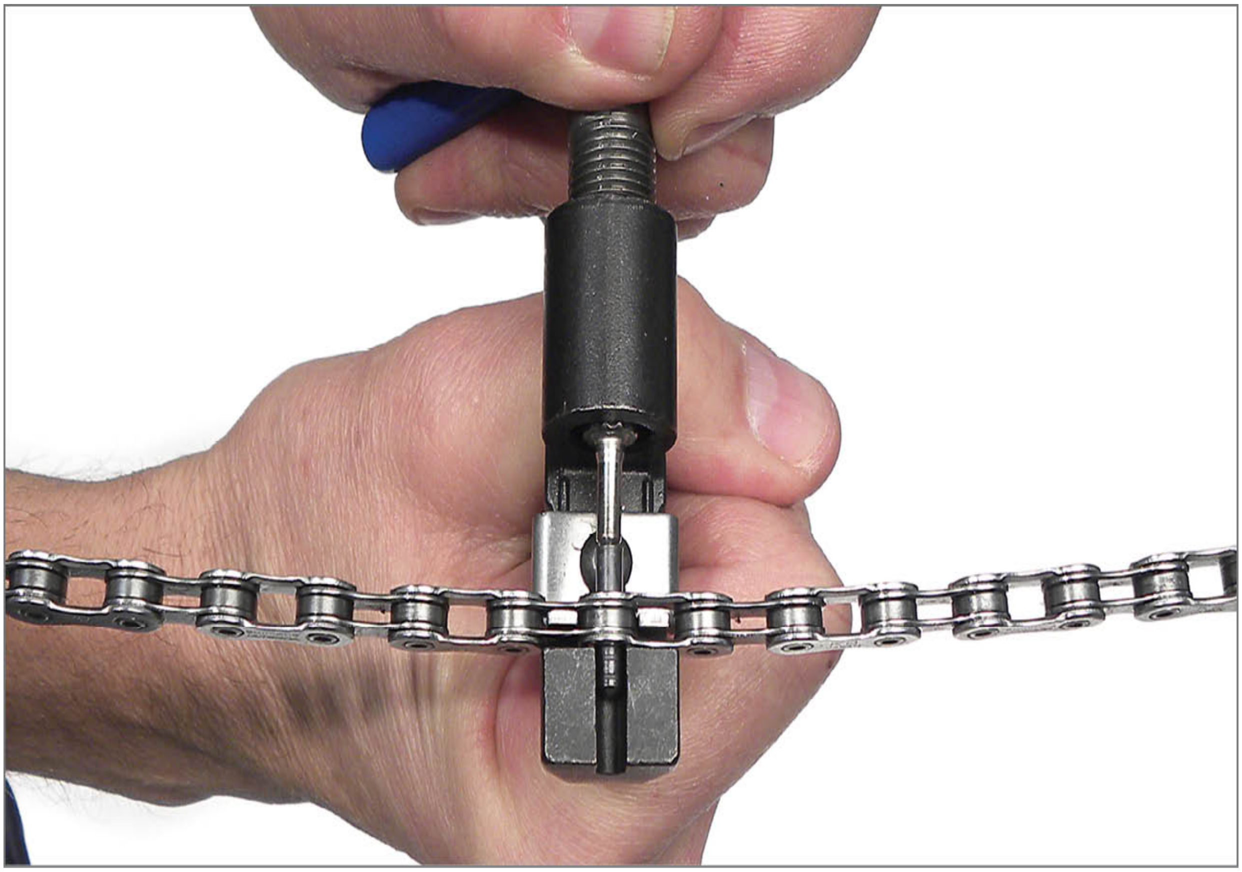


FIGURE 8.16: Drive connecting rivet fully into chain

g. Remove the chain from the tool and inspect the rivet. The non-tapered end of connecting rivet should protrude same as any neighboring rivet. Press further with the chain tool pin if necessary.

h. Break off pilot section of connecting rivet. Use groove of CT-3.3 or CT-5 Chain Tool body, or hole in body of CT-4.3 or CT-6.3, and twist pilot sideways (figure 8.17). Pliers can also be used to break pilot. Inspect rivet again and press further if necessary. Rivet should be centered between outer plates.

FIGURE 8.17: Break off pilot by twisting to the side

i. Inspect for tight links and repair as necessary. Rivet should be centered between outer plates.

A connecting chain rivet is never used again or removed to separate the chain. Reusing the same rivet hole wears plate holes and may weaken the chain and cause it to snap during a ride. Use other original rivets for future chain cutting.

CAMPAGNOLO® 11 AND 12-SPEED CHAINS

Campagnolo® 11 and 12-speed chains have very narrow rollers of nominally 2.0mm width. Use the Park Tool CT-4.3 for work on Campagnolo® 11-speed chains. Do not use the Park Tool CT-5, CT-2, CT-3, or CT-3.3.

The Campagnolo® 11 and 12-speed chains are joined with a special connection rivet called a “coupling pin.” The coupling rivet is used only once for the life of the chain. If the chain is removed for any reason, the original connection rivet should not be selected to press out. The 11-speed chains use a Campagnolo® 11-speed coupling pin, and the 12-speed uses a different coupling pin. Do not interchange the two.

New Campagnolo® 11 and 12-speed chains will have one end with inner plates, and the other end will have outer plates. Shorten new chains from the end with the inner plates. New chains will have a zip tie in the outer plates as a reminder to shorten from the inner plate side.

FIGURE 8.18: Shorten Campagnolo® chains only from side with

inner plates

Procedure for Campagnolo® 11 and 12-speed chain installation:

a. Lubricate coupling rivet and install the tapered end of rivet into chain plates by hand. Pilot will hold chain together while chain tool drives in rivet. Install coupling rivet so it pushes from inside to outside. Handle of chain tool will be on the inside of the bike (figure 8.19).

FIGURE 8.19: Push coupling rivet from the inside toward the outside

b. Use the Park Tool CT-4.3 or appropriate chain tool to drive coupling rivet into side plates. Install and press the coupling rivet fully into the chain plates. Push the rivet from the inside toward the outside (figure 8.20). The coupling rivet has flared sections and these can be felt as you push the rivet fully home. Carefully press coupling rivet until the head of the rivet is flush with the side plate. The pressure on the handle will ease at this point.

FIGURE 8.20: Pressing the Campagnolo® coupling rivet

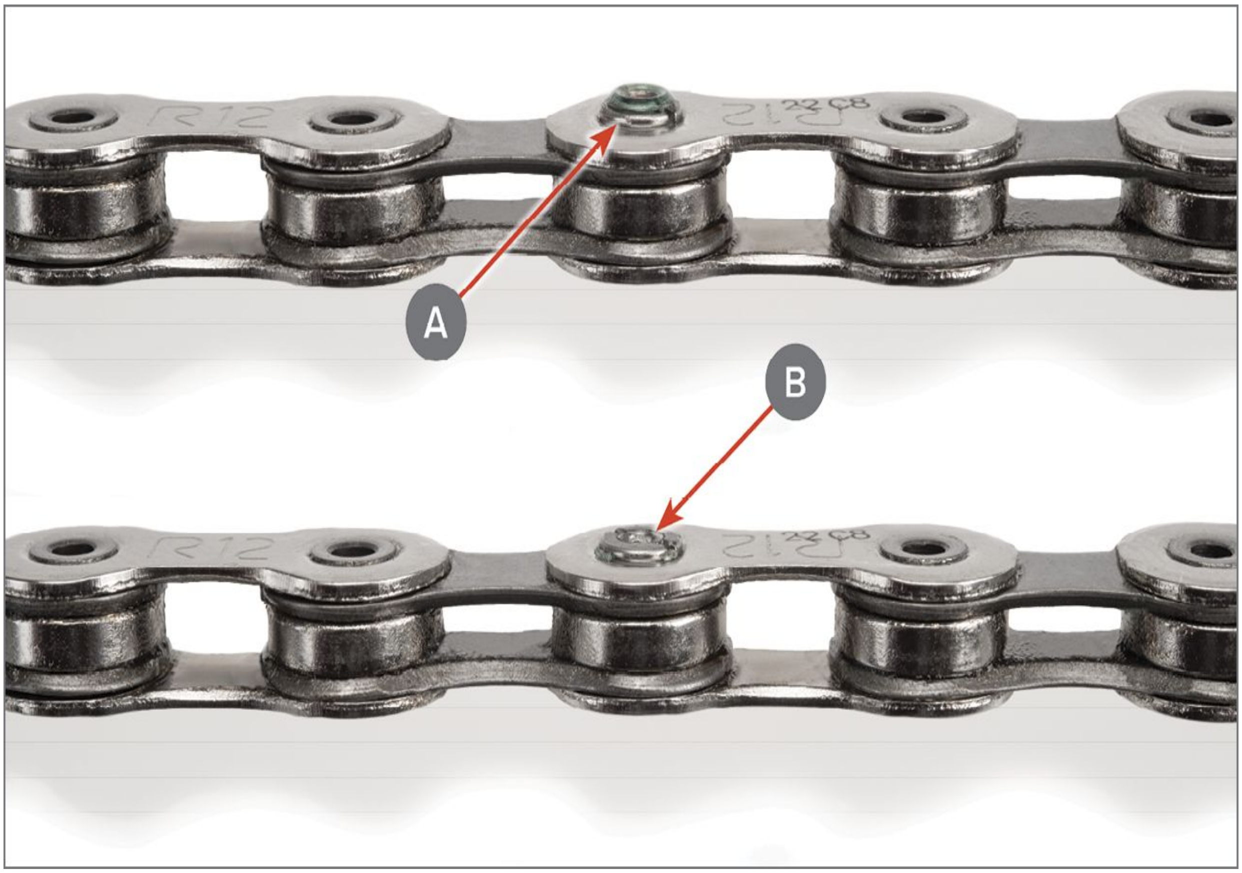
c. Unthread the chain tool handle and remove chain from tool. Inspect the rivet for centering in the chain. Head of rivet should appear to protrude as much as adjacent rivets.
d. Snap off the pilot. Use pliers or hole in body of chain tool. Support backside of chain and place the end of tool over the pilot. Twist horizontally either left or right to snap the pilot.
e. Proceed to setting, or peening, process.

Setting or Peening of 11 or 12-Speed Coupling Rivet

Campagnolo® requires a secondary operation for the coupling rivet after it is installed and the pilot is broken off. The coupling rivet pilot leaves a burr after breaking off. This burr is set or pushed back by a special chain tool against an anvil. Campagnolo's term is "deforming." The purpose is to push on the burr. The rivet should not move relative to the side plates. This is sometimes called "peening," even though there is no change in the rivet diameter. The Park Tool CT-4.3, or similar tool can perform this secondary process.

The CT-4.3 offers an anvil option for pressing the coupling rivet. The CT-4.3 uses an anvil stud that is stored in the handle of the tool. The anvil stud fits into the chain link pocket to provide support for the coupling rivet. The coupling rivet rests against the anvil stud as the driving pin of the tool drives the broken pilot into the rivet (figure 8.21). The anvil features of these tools take the pressure on the driving pin so that only the rivet is feeling the pressure from setting the rivet. The rivet will not move in this process.

FIGURE 8.21: (A) Coupling rivet with pilot removed but before setting
(B) Same rivet after setting with CT-4.3 chain tool



Procedure for setting Campagnolo® 11 or 12-speed coupling rivet:

a. Install chain at coupling rivet into the anvil feature of CT-4.3. Driving pin of chain tool should face broken end of coupling rivet.
b. Turn handle of tool until driving pin just contacts coupling rivet (figure 8.22). From this point, turn handle no more than 1⁄4 turn clockwise.
c. Remove chain from tool and inspect for tight link.

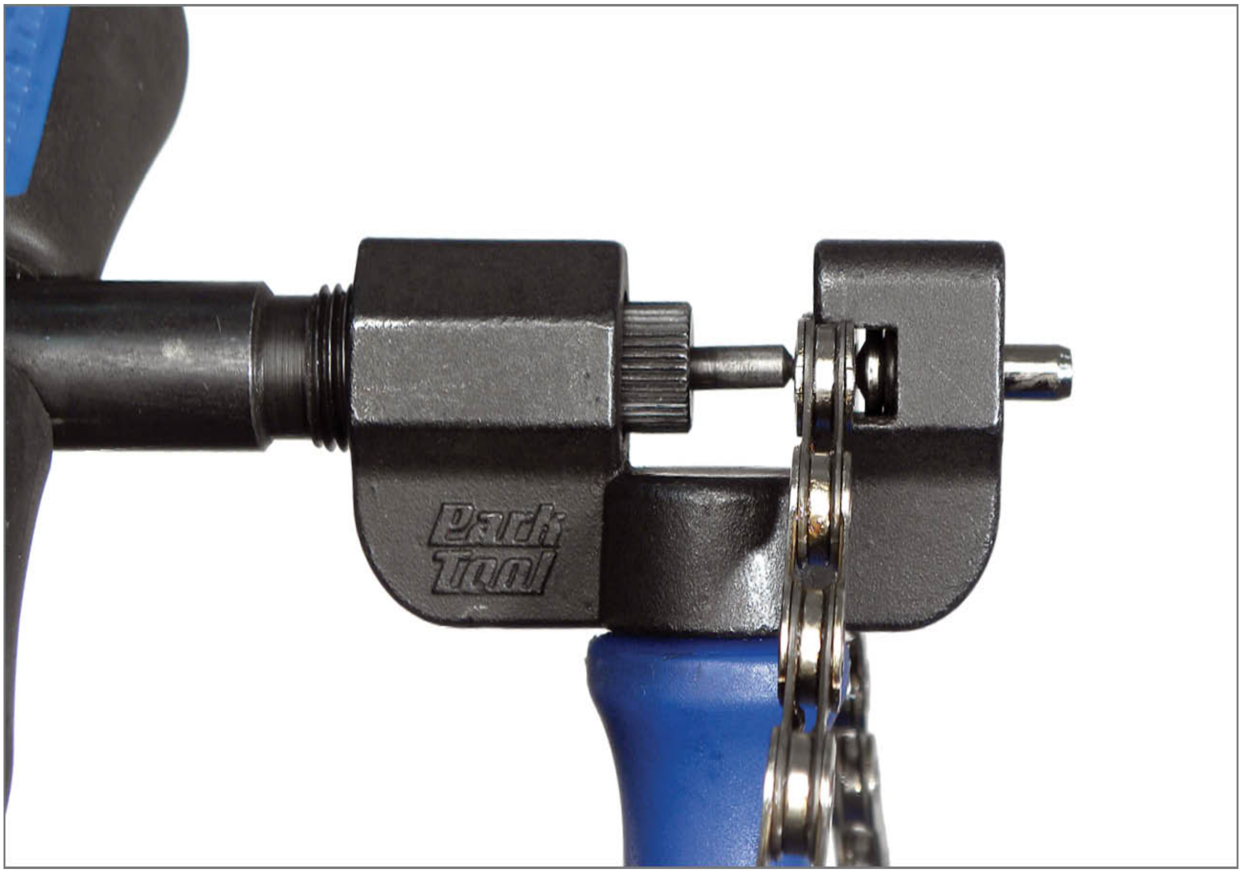


FIGURE 8.22: The CT-4.3 anvil stud in place for the process of setting coupling rivet

CHAINS WITH QUICK LINKS

Several chain manufacturers such as SRAM®, KMC®, Connex®, Shimano®, and others offer a quick link to join the chain, which allows the end of the chain to be joined without a special connecting rivet. Be sure to read the manufacturer's specific directions. Typically, the bicycle chain ends must have inner plates on each end before joining. Neither chain end will present outer plates. The quick link comes as two outer plates joined by a rivet, which then snaps together. Inspect the quick link for any arrows to indicate direction of chain rotation and install accordingly. The arrow will indicate direction as seen from right side of chain. Install one piece of the quick link through one end of the chain. Install the second piece through the other end of the chain but facing the opposite direction (figure 8.23). Engage the two pieces so link rivet mates to link plate hole. Pull chain to lock the link. To fully lock chain, move link to top section between rear sprockets and front chainrings. Hold wheel and press on pedals to lock link. Inspect link to ensure that it is fully engaged. The MLP-1.2 may also be used to lock the quick link.

FIGURE 8.23: Common quick link

Some brands of quick links are reusable, while others must be replaced after each removal. Use a chain tool on the rivet of a non-removable quick link and push it through the outer plate. This will destroy the link. Install a new quick link when installing the chain.

For reusable quick links, drop the chain off the front rings to relax tension. Squeeze the outer plates together. Push one plate forward and one plate backward. This will disengage the two outer plates. Pull plates sideways and remove the quick link pieces from the chain (figure 8.24). Use of the Park Tool MLP-1.2 will speed the process.

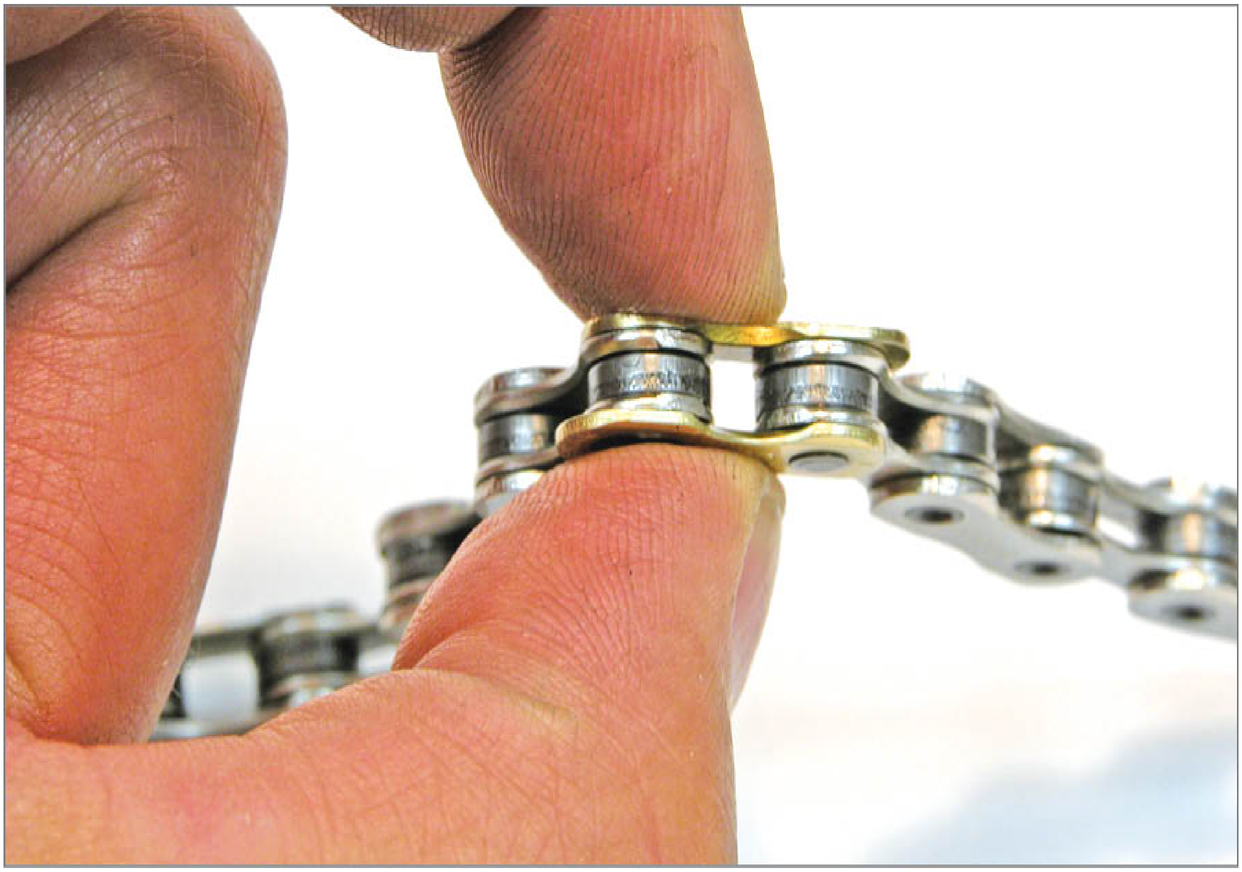


FIGURE 8.24: Push plates in opposite directions to remove

CHAINS WITH REUSABLE RIVETS

There are some less expensive and older brands and models of chains that are serviced by partially pressing out a rivet for the outer plate, then repressing the same rivet to rejoin the chain. Generally, these tend to be only older style chains for 5, 6, or 7 rear sprocket sets, or for two-sprocket bikes (bikes with one sprocket on the rear wheel and one sprocket on the crankset), Check the manufacturer's literature when in doubt.

This is also a technique that can be used in an emergency to join a chain. However, especially on the modern 8 to 12-speed chains, this technique compromises the strength of the chain. The users should be careful not to apply much force, and there is no guarantee the repair might not break.

Procedure for removal of chain with reusable rivets:

a. Place the chain in the chain tool.
b. Drive chain tool pin until it contacts chain rivet.
c. For most chain tool models, turn handle five complete turns (four complete turns for the Park Tool CT-3.3). Use care not to drive out chain rivet.
d. Turn handle counterclockwise to back out chain tool pin from chain. Lift chain out of the tool.
e. Grab chain on either side of protruding rivet. Flex chain toward the protruding chain rivet and pull on chain to separate.
f. If chain does not easily separate, place chain back into chain tool, press rivet slightly, and attempt to pull chain apart as in step "e."

Procedure for installation of chain with reusable rivets:

a. Reinstall chain on bike with protruding rivet facing toward mechanic.
b. Open empty outer plates slightly and insert inner plates. Push inner plates until hole aligns with chain rivet.
c. Back the chain tool pin into tool body to make room for chain rivet.
d. Place roller into alignment prongs with chain rivet facing chain tool pin.
e. Drive chain rivet back into chain. Take care to center rivet exactly between both outer plates. If more chain rivet appears on one side of outer plate than other, push rivet until it is evenly spaced (figure 8.25).
f. Inspect for tight links and repair as necessary.

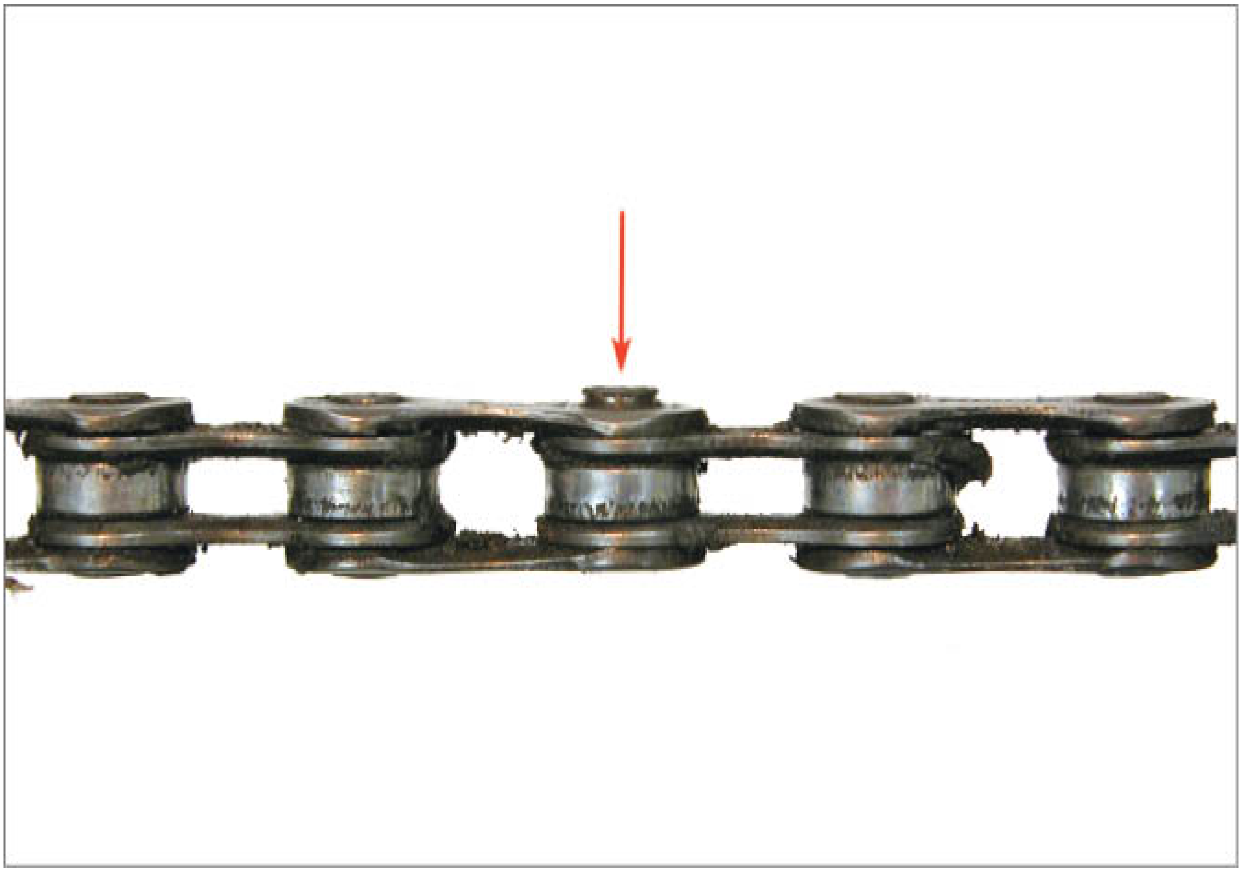


FIGURE 8.25: A poorly centered rivet that will fail under heavy use

TIGHT LINK REPAIR

A tight link occurs when a chain does not pass smoothly through the bends of the rear derailleur. The inner plates and outer plates do not pivot freely around the rivet and feel "tight" when the chain bends. This may be from a lack of lubrication at the offending link or the result of improper chain installation. If the two outer chain plates are pushed tightly against the inner chain plates, the link will tend to hop and skip at the derailleur. If the pressure on the inner plates can be removed, the tight link can be fixed.

To locate a tight link, put the chain in the smallest rear sprocket in back and on the middle ring of a triple crankset or the smallest ring of a double crankset. This relieves tension on the chain and allows problem links to show up. Backpedal slowly by hand and watch chain as it passes through the two pulley wheels of the rear derailleur. Look for popping or jumping of the chain or movement in the derailleur arm. Keep backpedaling slowly. Tight links should show up as they pass by the bends of the lower pulley wheel (figure 8.26).

FIGURE 8.26: Watch for jumping or hopping of chain while backpedalling

Physically stressing and flexing the chain laterally typically repairs tight links. Use care not to bend and deform the plates by using too much force. To avoid damaging your chain, practice on a section of scrap chain.

Locate the tight link as described above. Grab either side of chain with your hands, and place both thumbs at the tight rivet. Pull backward with your fingers, while pressing forward with your thumbs to flex the tight link (figure 8.27). Reverse pressure to flex chain the opposite direction. Press forward with your hands while pressing backward with the index fingers centered on tight rivet. Test link to see if it moves freely and repeat if necessary.

FIGURE 8.27: Grab chain and flex laterally at tight link

CHAIN SIZING AND TENSION ADJUSTMENT FOR TWO-SPROCKET BIKES

Two-sprocket bicycles use a single sprocket, or chainring, at the cranks and a single sprocket at the rear wheel. Two-sprocket bikes include internally-geared hub bikes, one-speed bikes, coaster brake bikes, BMX/Freestyle, and track bikes. These bikes require a shorter chain than derailleur-equipped bicycles.

Typically, two-sprocket bicycles use horizontal dropouts. This allows chain tension to be adjusted by moving the rear sprocket forward or backwards relative to the front sprocket. Dropouts may be either forward or backwards facing (figure 8.28).

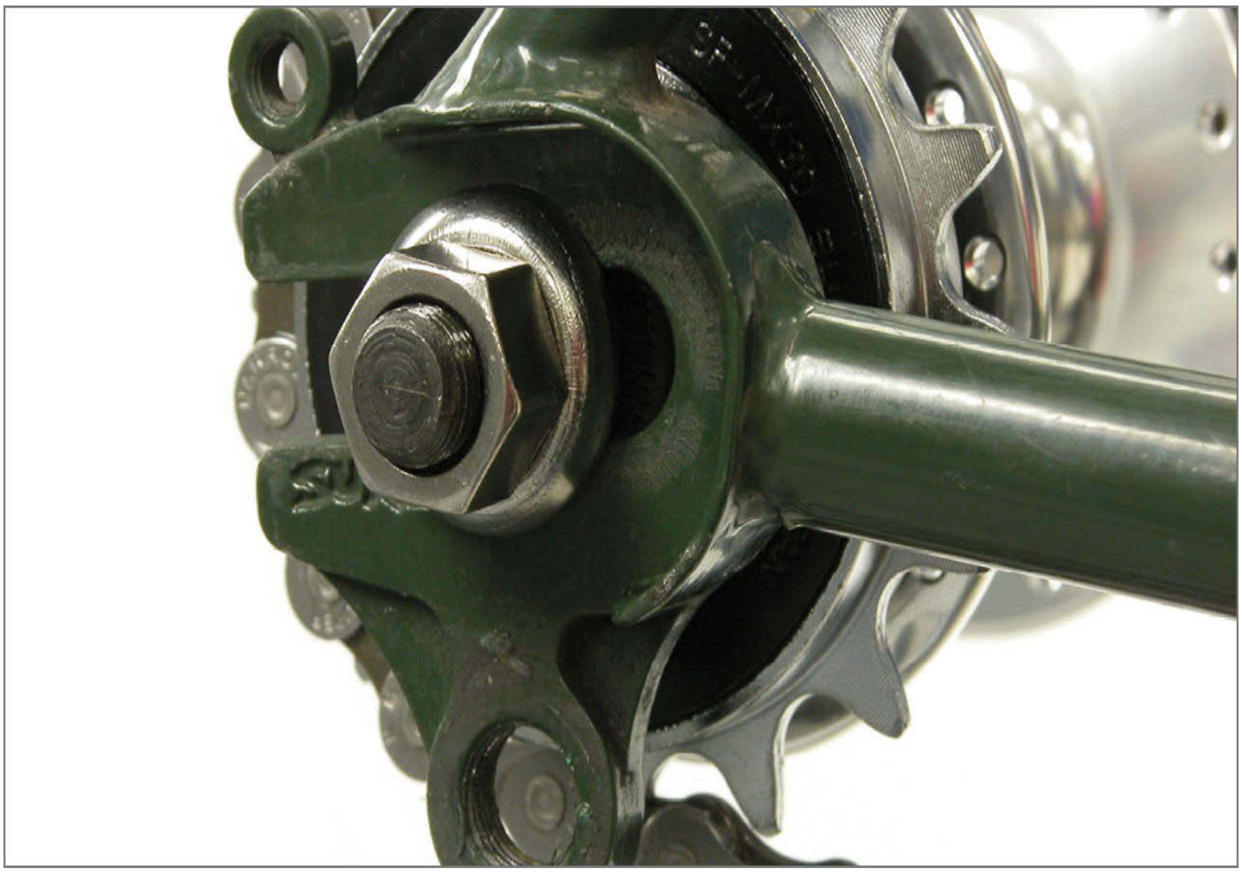


FIGURE 8.28: Horizontal backward facing dropout of a single-speed bike

CHAIN LENGTH SIZING FOR TWO-SPROCKET BIKES

Chain length for bikes without a chain tension device is ideally set to allow the hub axle to sit approximately halfway in the dropouts. Similar to derailleur chains, length is changed in increments of 1 inch. As a rule of thumb, if a chain is lengthened or shortened by 1 inch, it will move the rear axle 1⁄4 to 1⁄2 inch (6–13mm) in the rear dropouts.

Procedure for chain sizing with two-sprocket bikes:

a. Install rear wheel in the bike. For horizontal dropouts, place the axle all the way forward in the dropout slot. With forward facing dropouts, secure the axle nut so they are fully engaged on dropouts but as far forward as possible.

b. Wrap the chain around the front and rear sprockets. The front sprocket can be used to help hold both ends of the chain while determining chain length, as described in the next steps.

c. Place the chain end on the front ring so the chain end will be on the ring about the two or three o'clock position (figure 8.29). Engage any quick link to account for all the links when determining chain length.

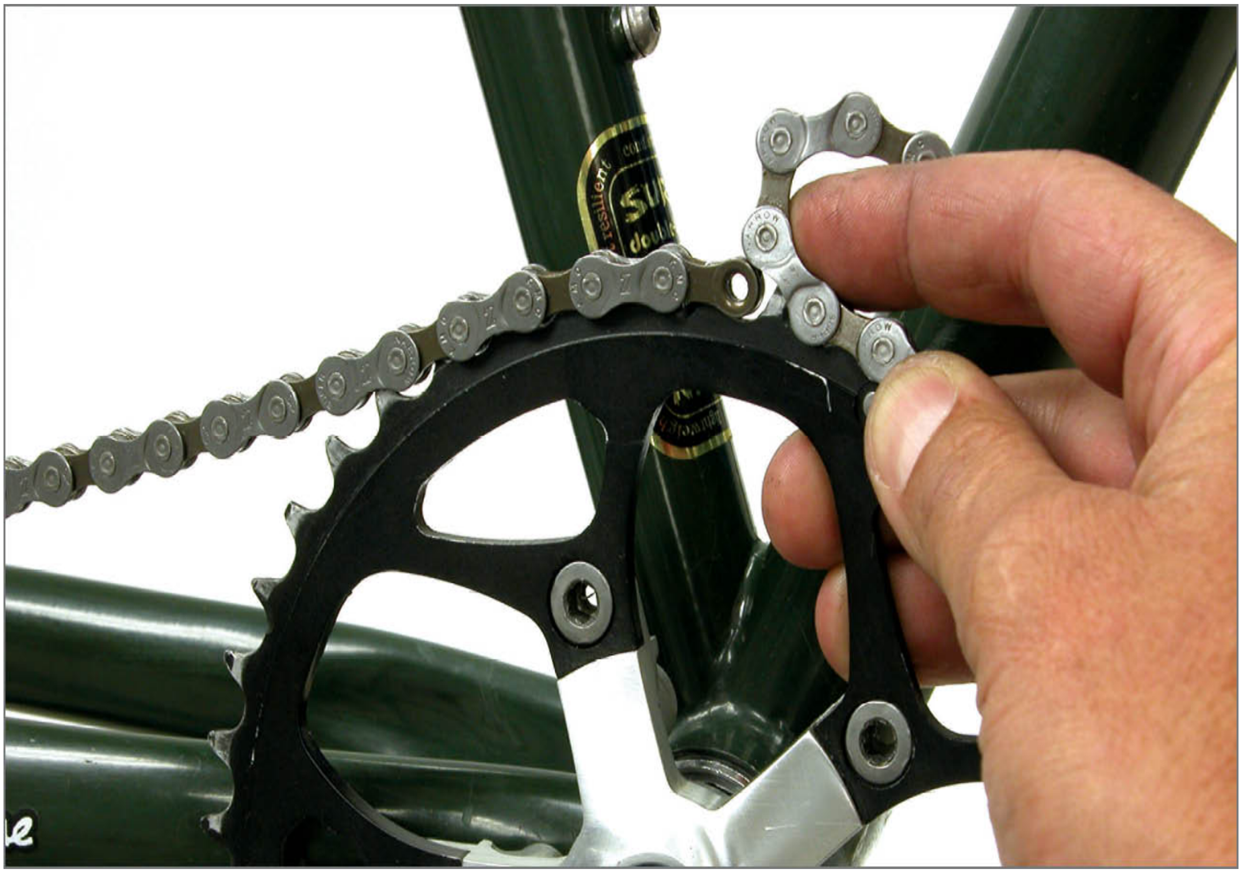


FIGURE 8.29: Use front ring to help hold chain end for sizing

d. Pull the chain snug and find the closest rivet on the lower section that would connect to end coming from the upper section. The outer plate must attach to an inner plate.
e. If the appropriate inner and outer plates of the chain ends are too short to meet, add two rivets (1 inch) to the chain length. If appropriate chain ends meet with no chain slack, add 1 inch to chain length. The chain must have enough slack in this position to allow it to be lifted from front ring.
f. Make note of the appropriate rivet to use in shortening the chain.
g. Remove the rear wheel and shorten the chain accordingly.
h. With chain correctly routed through frame, join ends of chain.
i. Install wheel and confirm that chain length and chain tension are acceptable.

CHAIN TENSION FOR TWO-SPROCKET BIKES

Chain tension on two-sprocket bikes should be set tight enough so that the chain does not come off during use and operates smoothly when pedaled. Bikes without a chain tension idler arm are adjusted by moving the rear hub forward or backward in the dropouts. When checking chain tension, do not touch chain on its inner perimeter. Check tension by touching only the outside loop of the chain to minimize any risk of getting your fingers caught in sprocket teeth.

Procedure for tension adjustment with two-sprocket bikes:

a. Install the rear wheel with chain engaged on both rear and front sprockets.

b. Pull wheel back in dropouts and align wheel centered between chain stays.

c. If the bike uses a coaster brake or a band brake, secure the brake arm to the bike frame.

d. Secure axle nuts or quick-release.

e. Check tension on chain. Touch only outer perimeter of chain loop. Push the chain downward and upward in the middle. There should be approximately 1⁄2 inch (12mm) movement of the chain up and down at a point halfway between front and rear sprockets (figure 8.30).

FIGURE 8.30: Pull up and down at middle of chain to test chain tension

f. To change the tension, loosen the axle nuts and move the wheel forward or backward slightly. Check that rear wheel is centered in frame and resecure axle nuts.

g. Rotate cranks and inspect the chain tension for any tight or loose positions as the crank arms turn. It is not uncommon for sprockets to be out of round. This will result in the chain being tighter at some points of its rotation. After setting chain tension, pedal the bike in a repair stand and check the tension all the way through the crank rotation. If necessary, readjust so there is only 1⁄4 inch (6mm) movement at the tightest point.

h. Test for a loose adjustment. Rotate pedals and push sideways on the chain at a point in between the front and rear sprockets. The chain will make a rattling sound, but it should not derail. If the chain comes off either front or rear sprocket, increase tension by moving the wheel further back.

CHAIN TENSION FOR TWO-SPROCKET BIKES WITH CHAIN TENSION IDLER DEVICE

If the bicycle uses a vertical dropout, it is typically necessary to use an idler wheel as a chain tension device. Vertical dropouts do not permit the adjustments necessary to set chain tension. A chain tensioner is fitted to the derailleur mount and provides a single pulley wheel that will tension the chain (figure 8.31). A common rear derailleur may also be used as a tensioner idler simply by setting the limit screw so the upper pulley is aligned with the single cog.

FIGURE 8.31: Vertical dropout with chain tension device

The chain tension idler arm is similar to the cage of a derailleur. A spring gives tension to the idler pulley, which will take up chain slack. To determine chain length, wrap the chain over front and rear sprockets, and around the pulley. Pull chain tightly to determine shortest possible length and then add 1 inch (two links) of extra chain. Select link and cut chain accordingly.

CHAIN TENSION FOR ECCENTRIC BOTTOM BRACKETS ON TANDEMS AND SINGLE-SPEEDS

Eccentric bottom bracket designs allow the crank to move forward or backward relative to the rear sprocket to adjust chain tension. They are found on the front cranks of tandems and some single-speed bikes. Eccentric bottom brackets use an oversized shell that houses the bottom bracket bearing unit (figure 8.32). The axle is offset from the center of the shell. The crank will move further away from or closer to the rear axle as the eccentric is rotated around in the frame shell. The eccentric is rotated until there is correct chain tension and then locked into position.

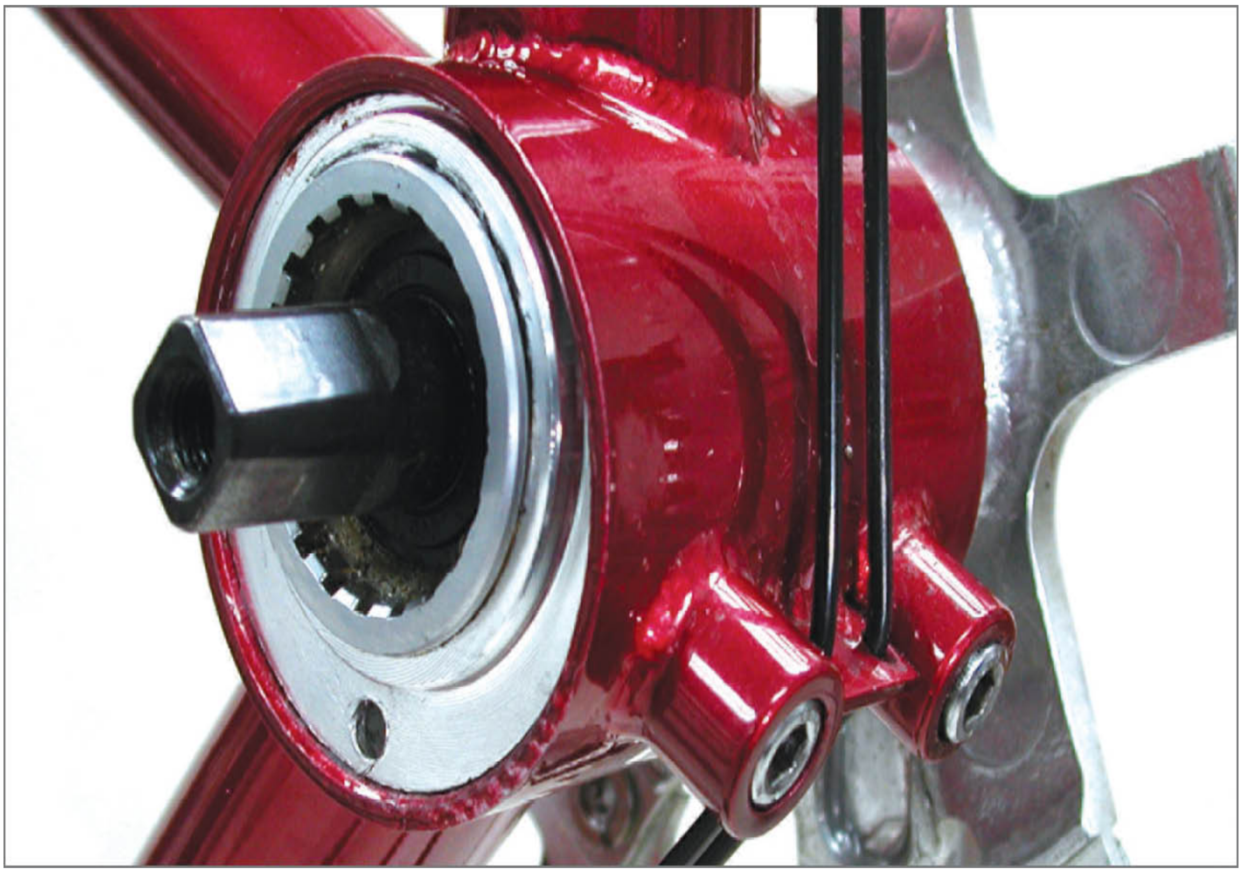


FIGURE 8.32: Eccentric bottom bracket shell with set screw binders

There are several systems of locking the eccentric. The frame shell may be split and held secure with a pinch bolt, similar to stems or seat tube clamping systems. Other designs use a wedge bolt system, similar to wedge-type quill stems. The bolt tightens and the wedge jams inside the frame shell to hold the eccentric. Another option uses set screw fittings welded into the shell.

To set chain tension with eccentric systems begin by loosening the binder on the bottom bracket shell. There will commonly be pinholes for a pin spanner such as the Park Tool SPA-1. Rotate the eccentric in the shell and note changes in chain tension. Tension increases when crank is rotated forward. Set tension so there is approximately 1⁄2 inch (12mm) play in chain when pulled up and down between front and rear sprockets.

CHAIN WEAR AND DAMAGE

The chain is a critical part of bicycle performance and safety. Chain will tend to fail when under load and stress, which is the worst possible time. The common cause of chain failure is a rivet pulled from an outer plate (figure 8.33). This is typically the result of a poorly installed chain. Inspect chains often. Sight the chain from above and look at each rivet for centering in the side plates. If a rivet sticks out of one side plate more than the other links, the suspect link may fail. Also inspect the outer side plates for spreading from the inner plates. Each link should look the same. If a chain becomes jammed during an over shift, it may stress the plates, pulling them apart. This can also result in a twisted link (figure 8.34). Inspect the rollers for any signs of wear (figure 8.35).

FIGURE 8.33: Damaged side plate. Repair on plate is not possible

FIGURE 8.34: Any twist in the chain requires complete chain replacement

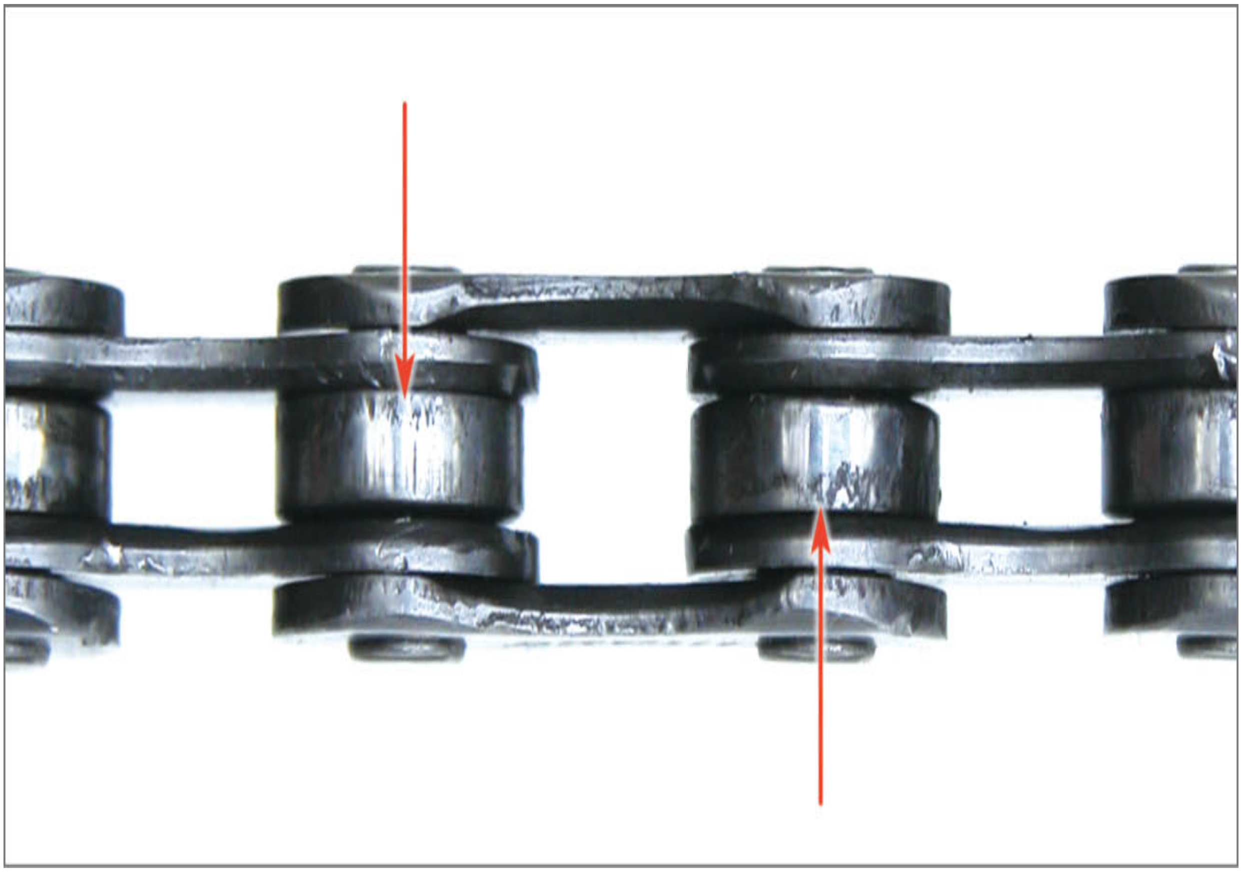


FIGURE 8.35: Rollers showing signs of wear. Replace chain immediately

As the chain is used, wear develops at the rivet and inner plates where it pivots. The play occurs at each link of the chain. The cumulative effect of wear across many links is that the chain appears to "stretch." However, chain plates do not literally stretch and get longer; the wear is in the joint at each rivet. Reversing the chain or flipping the chain around will not add to chain life, as the rivets will still have the same amount of wear.

Figure 8.36 shows a chain and chainring shown under a forward pedaling pressure. A worn chain rides up the chainring profile and will no longer engage between the sprocket teeth. On a rear sprocket, the problem is worse because there may be only two or three teeth engaged. A worn chain may then skip over the rear sprocket under pedaling load.

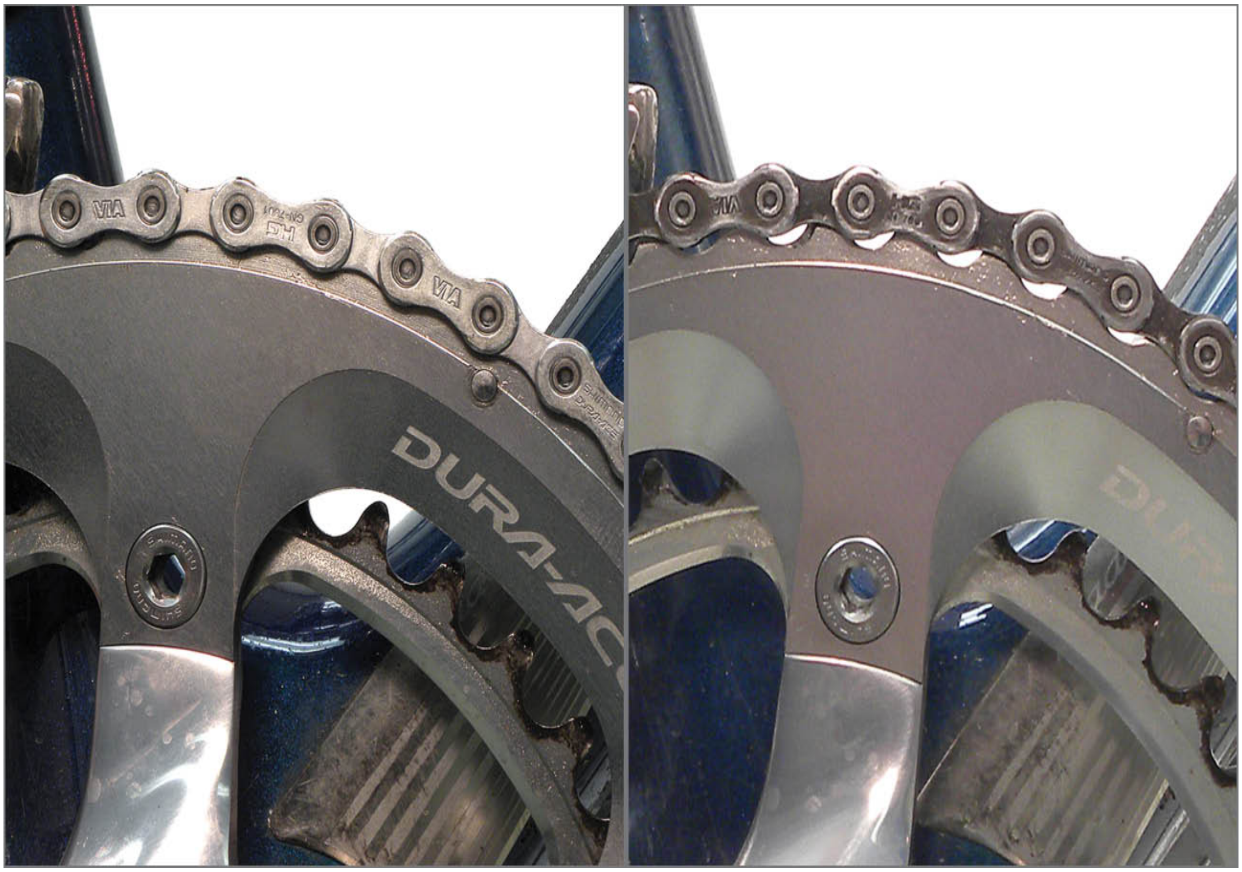


FIGURE 8.36: Left: new chain fully engaging teeth of sprocket
Right: worn chain not sitting fully on sprocket

Bicycle sprocket teeth are cut to fit chains with 1⁄2 inch between each roller and rivet. However, not even brand new bicycle chains measure exactly 1⁄2 inch between rivets. A small amount of play must be included for new chains to bend. As the chain is ridden and it wears, play at each link gets greater, and the distance between each rivet increases. Eventually, the chain rollers no longer sit fully down in the sprocket teeth. The rollers ride up the shoulder of the sprocket teeth. The chain then skips over the teeth, especially when extra force is applied to the pedals, such as when climbing or sprinting. Although chain manufacturers of 10 to 12-speed chains vary, most recommend chains be replaced as the chain reaches 0.5% wear. For systems with a less expensive cassette or freewheel, wear can be extended to 0.75% from the nominal 1⁄2 inch pitch. This wear can be measured with chain measuring tools such as the Park Tool CC-2, CC-4 or CC-3.2 Chain Wear Indicators (figure 8.37). Replacing worn chains will help to get more life out the rear sprockets, which tend to be more expensive. However, even with regular chain replacement, the rear cogs will eventually wear out and require replacement.

FIGURE 8.37: Park Tool CC-3.2 Chain Checker indicating a worn chain

As the bike is ridden, the entire drivetrain will wear. Generally, it is most economical to replace the cheapest item first in order to extend the overall life of the drivetrain. The cheapest component of the drivetrain (the chainrings, chain, and rear sprockets) is the chain, and it also suffers the most wear. Chains and sprockets often wear out together. If a new chain skips over worn rear or front sprockets, then the sprockets must also be replaced.

CHAIN CLEANING

There are more moving parts in the chain than any other part on the bike. Dirt and grit in the chain will wear on the rivets. Cleaning will add life to the chain and improve performance. Before cleaning the chain, brush clean the derailleur pulley wheels. It may be necessary to scrape the sides with a screwdriver if extremely dirty. Scrape rear sprockets with gear comb, such as the Park Tool GSC-1, or the blade of a thin screwdriver. For thorough cleaning, use a rag and pull a section taut to “floss” between sprockets. Also wipe the chainrings before cleaning the chain if they are extremely dirty.

Chain cleaning tools, such as the Park Tool CM-5.2 Cyclone Chain Scrubber, make cleaning the chain easier. Generally, these systems are boxes that hold solvent and brushes. Passing the chain through the brushes and solvent cleans the chain. Follow manufacturer’s directions for use. Expect some spray of dirt and solvent when using any chain cleaner. Using a diluted soap solution for a second scrub will also help the cleaning process. To protect the floor, place a newspaper or drop cloth under the bike. Used as part of a regular cleaning schedule, these systems can add to the life of the chain (figure 8.38).

FIGURE 8.38: Chain cleaning with chain still on bike

If the chain system uses a reusable quick link, it can also be removed and cleaned off the bike. Use a sink, pan, or large can. Remove the chain, grab by one end, and fold once in the middle. Lay the chain on a flat surface and coil the chain with loose ends in middle. Place chain in the pan and cover with solvent. Allow it to soak for some time. Use rubber gloves to protect the hands and work with adequate ventilation. Use a stiff bristle brush and scrub the plates on both sides of the chain. Unfold the chain and scrub downward on rollers and between side plates. Flip chain and scrub other side the same way. Rinse chain in solvent. Remove it from pan and allow solvent to drip off as much as possible. Wipe with rag and allow to completely dry before lubricating. If available, use compressed air to blow-dry the chain, especially between rollers. Wear safety glasses when using compressed air to blow-dry the chain.

Dispose of old solvent properly. Contact your local hazardous waste agency.

CHAIN LUBRICATION

Chain rivets and link pivots require lubrication. The chain rivet and the narrower pair of chain plates rotate when traveling around a sprocket. Lubrication is required only at the rivet, not all over the outer plates. A drip applicator helps avoid applying too much lubrication, which can attract dirt. Proper lubrication will take time and patience. While lubricating, inspect the chain rollers and rivets.

The type of riding and location best determines the type of chain lubrication. If the user is in a generally wet and humid area with a lot of precipitation, select a thicker lubricant that will adhere to the chain. Very dry areas tend to also be dusty, and a thick, heavy lubricant will result in collecting lots of dirt on the chain. A thin lubricant such as “dry” lubricant would do better in these locations. Riding on gravel bike paths also throws more dirt up on the drivetrain.

To properly lubricate a chain, it is best to begin with a clean chain. In any case, wipe chain off with a rag. Inspect chain for a quick link or connecting rivet to act as a reference. Apply a drop of lubricant on each roller and at each side plate at the rivet (figure 8.39). Lubricate each rivet between rear sprockets and front chainring. Turn cranks backwards to advance to the next section of unlubricated chain. Lubricate this section and advance chain again. Continue until each rivet is lubricated once. Avoid over lubricating the chain. Turn pedals to allow lubricant to work into pivots. Wipe outside of chain with a rag to remove excess lubricant. Repeat the process when the chain appears dry or begins to squeak.

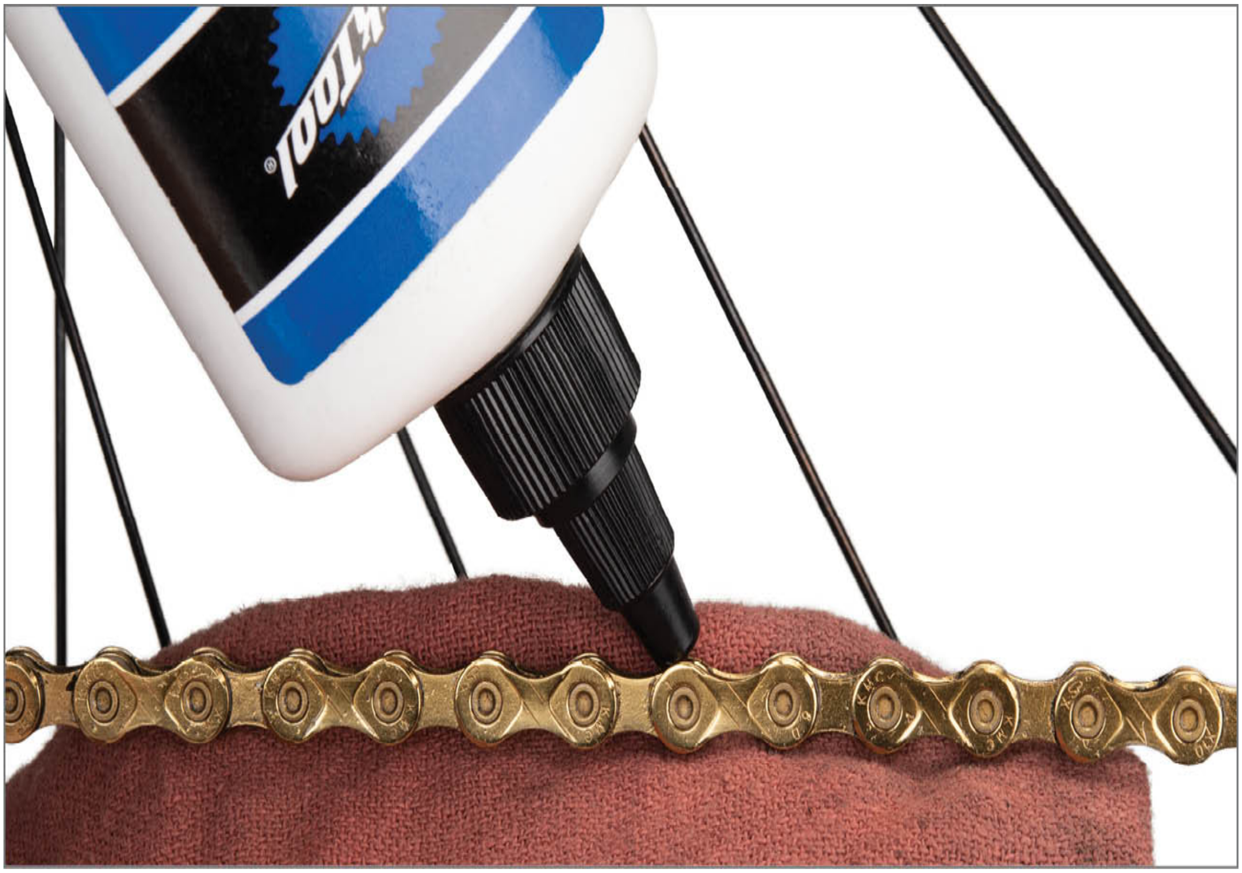


FIGURE 8.39: Lubricate and inspect chain in the same procedure

TABLE 8.1: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Chain has occasional skip at rear sprockets but is not timed to one per pedal stroke	Stiff link in chain	Inspect and locate link. If misshaped, replace chain. If link looks in good condition, lubricate and flex back and forth.
New chain skips on gears when under pressure	Previous sprockets worn to your old chain	Replace rear sprockets
Squeaking sound from back when pedalling	Lack of chain lubricant	Lubricate chain
Chain broke under load of riding	Broken link	Replace chain, as repairing old chain is still likely to fail again

CHAPTER 9

PEDALS

Pedals are the mechanisms attached to the ends of cranks. Pedals come in a variety of designs for specialty uses. “Platform” pedals are a simple flat pedal and may be used with any recreational street shoe. Toe clips can be added to many of these types of pedals, acting as cages to help retain the foot to the pedal. “Clipless” pedals require shoes fitted with special cleats. Clipless pedals use retention mechanisms that attach the cleats to the pedals. Lightly lubricate clipless pedals at the cleat engagement pivot points. Occasionally check the security of all threaded fasteners on the pedal cage and body.

PEDAL REMOVAL

Pedals are removed from the cranks to service axle bearings, pack the bike for shipment, or change pedals. Most pedals have narrow wrench flats on the axles, adjacent to the crank. The standard pedal wrench size is 15mm. While pedal wrenches appear to be similar to cone wrenches, use a proper pedal wrench—not a cone wrench—for narrow wrench flats on a pedal. A pedal requires much greater tightening torque than a cone wrench can deliver. Use of the wrong wrench may damage both pedal and wrench. Pedals may also feature a hex fitting at the end of the spindle behind the cranks (figure 9.1). Use a long-handled hex wrench for removal and installation. When working on pedals, rotate the bike in a repair stand to find good leverage.

FIGURE 9.1: Pedal wrench fitting behind crank at end of pedal axle

The right-side (drive-side) pedal uses a right-hand thread. It removes counterclockwise and installs clockwise. The left-side (non-drive-side) pedal uses a left-hand thread. It removes clockwise and installs counterclockwise.

This thread difference prevents the pedals from becoming loose as they rotate. As pedals turn during riding, the bearings on the pedal body reverse the direction of load on the spindle. Pedals are commonly marked with an "R" on the right-side pedal and an "L" on the left-side pedal. Left pedals may also have "hash marks" on the spindle to mark it as different from the right. It is also possible to view the thread angle to determine which is the left threaded and right threaded pedal.

Procedure for pedal removal:

a. Mount bike in repair stand and shift chain to largest chainring. This helps protect against cuts from chainring teeth.

b. Rotate bike until right pedal is easily accessed. Reach over or through frame as necessary for best leverage.

c. Place wrench securely onto pedal wrench flats. For hex wrenches, fully secure wrench into back of pedal. Reposition wrench until crank and wrench form an angle of 90 degrees or less. Use opposite crank for extra leverage. Correct mechanical advantage is critical on pedals, which are often overly tight. When possible, grab opposite crank for second lever.

d. Turn pedal wrench counterclockwise (as seen from right side of bike) to remove right pedal. Use care not to cut hand on crank or chainring. Note that pedaling forward while wrench engages pedal flats will loosen pedal on both right and left side (figure 9.2).

FIGURE 9.2: Pedal in a forward direction to remove pedal from cranks

e. Remove right pedal completely from crank. Inspect for any pedal washer on crank or pedal spindle.
f. Rotate bike as necessary until left pedal is easily accessed.
g. Engage pedal wrench onto left pedal and grab right crank for second lever. Position wrench and crank for good mechanical advantage.
h. Turn pedal wrench clockwise (as seen from right side of bike) to remove left pedal or turn crank so pedal is pedaling forward.
i. Remove left pedal completely from crank. Inspect for any pedal washer on crank or pedal spindle.

PEDAL INSTALLATION

The common pedal thread for aluminum cranks is 9⁄16 inch x 20 tpi. Pedal threads on steel one-piece cranks are 1⁄2 inch x 20 tpi. Pedal threads tend to be made of bearing-hard steel and are relatively difficult to damage. However, minor pedal thread damage may be repaired with a thread file.

Pedal threads can damage aluminum threads of the crank if threads are misaligned. Start initial threading with only your fingers to avoid forcing the pedal into the crank threads. Using a pedal wrench to start the thread will not allow the feel necessary to detect cross threading.

Some cranks require the use of a “pedal washer.” This is a thin washer to protect the crank. These are especially useful to prevent gouging carbon fiber cranks. The washer will have a low profile and is placed between the pedal and crank (figure 9.3).

FIGURE 9.3: Pedal washer for carbon fiber crank

Pedals are secured to a relatively high torque range, approximately 34Nm

(300 inch-pounds). As an example of effort on the wrench, assume the wrench is grabbed 8 inches (20cm) from the pedal. It would require an effort of approximately 35 pounds (16kg) force to achieve proper torque. Grease or anti-seize compound on threads is recommended to prevent pedal thread corrosion and seizing to the crank arm.

Procedure for pedal installation:

a. Identify right and left pedals. Look for “L” or “R” marking on pedal axle or wrench flats. If no “L” or “R” marking is seen, use pedal thread direction to identify pedals. Left-threaded pedals (threads sloping upward to left) fit the left crank. Right-threaded pedals (threads sloping upward to the right) fit right crank.

b. Apply grease or anti-seize compound to threads of both pedals. Install pedal washer if appropriate.

c. Thread right-side pedal into right crank using only your fingers to avoid cross threading.

d. Engage pedal wrench to flats (or inside hex fitting) and fully thread pedal into arm. For pedals with external wrench flats, hold wrench with one hand while holding pedal with other. Rotate crank and pedal assembly backward to install quickly.

e. Arrange pedal and crank for best mechanical advantage. Use opposite arm as second lever (figure 9.4).

f. Tighten right pedal fully.

FIGURE 9.4: Good mechanical advantage for securing pedals

g. Repeat for left pedal by threading pedal counterclockwise to install.

h. Fully secure left pedal. For pedals with external wrench flats, hold wrench with one hand while holding pedal with other. Rotate cranks and pedal assembly backward to install quickly.

Another way to visualize pedal installation with the wrench is to consider pedals turning backward. With wrench installed and held on the pedal, if cranks were rotated backwards, the pedal will be tightened into the arm.

DAMAGE TO CRANK PEDAL THREADS

If crank threads are damaged, the pedal may be difficult to install. To repair thread, use an appropriately sized tap (either 9⁄16 inch x 20 tpi or 1⁄2 inch x 20 tpi) and chase threads in the crank. Begin tap from backside of crank to use undamaged threads for best alignment.

If a pedal has come loose and fallen out, the outer thread of the crank hole may be mangled and damaged. Use a pedal tap to align thread. However, a tap will not restore metal that has been removed or torn away. If threads are questionable, install and tighten the pedal. If the pedal pulls up properly at full torque, it will be usable.

If pedal threads in the crank are too damaged for a tap repair, they still may be repairable using a thread insert system. Solid aluminum cranks may be repaired by being drilled or tapped to a larger thread. A special bushing is then installed with an internal 9⁄16 inch thread. This repair is best left to professional mechanics. If the arm is carbon fiber or is a hollow aluminum design, this repair may not be possible. Because cranks are available individually as a replacement part, replacement of the arm is often the less expensive option.

PEDAL BEARING SERVICE

Bearing systems in pedals are similar to other rotational bike bearings. The axle is attached to the crank and rotates inside the pedal body. Bearing service is possible on some brands and models, but others are simply thrown away when bearings become excessively worn.

The procedure for bearing service varies between pedal brands and is reviewed at www.parktool.com/repair-help.

TABLE 9.1: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Pedals will not remove from crank	1. Pedals are simply tight 2. Turning thread the wrong direction	1. Find better wrench placement for better mechanical advantage. 2. Turn wrench according the pedal thread direction. Right side loosen CCW. Left side loosen CW.
Pedals difficult or impossible to thread into crank	1. Pedals are side specific 2. Pedals are cross-threaded 3. Wrong thread for crank	1. Check pedals are on correct side for thread 2. Use better alignment into crank 3. Check thread compatibility
Clipless shoes will not release from clipless pedal	1. Cleat bolts loose 2. Cleat very worn	1. Pry shoe free from pedal and tighten cleat bolts 2. Pry shoe free and replace worn cleats

CHAPTER 10

DERAILLEUR SYSTEMS

Derailleurs are mechanisms that move the chain from sprocket to sprocket on the rear wheel, or at the front chainrings for multiple ring cranksets. They allow the cyclist to use different sprocket combinations for low gear ratios when going uphill and high gear ratios when going downhill. A derailleur pushes or “derails” the chain to move it from one sprocket to another. The mechanical derailleur system consists of the shift levers, cable housing, derailleur cable, and the derailleur. Some derailleurs systems are now electrically controlled and are reviewed in Chapter 11—Electronic Derailleurs. All derailleur systems require occasional maintenance, adjustment, and parts replacement.

Some shift levers use a dial showing the cyclist reference numbers for gears. These are arbitrary numbers and do not represent the order of gear ratios in the shifting sequence. For example, the number “6” showing on a lever dial does not mean the sixth gear out of the total number of ratios available. These reference numbers will not be used here. This chapter will use the terms “inner” and “outer” sprockets, as well as “smallest” and “largest” sprocket. The rear cog closest to the spokes is the “innermost” cog, and the smallest cog nearest the rear dropout is the “outermost” cog. For chainrings, the largest chainring is the outermost ring, and the smallest chainring is the innermost ring. The “middle” chainring on a triple crankset is the one between the inner and outer rings.

CABLE SYSTEM

The connection between the shift lever and the derailleur is the cable system. The cable system consists of an inner derailleur cable, an outer derailleur housing, and derailleur housing end caps. The housing is the casing that routes the derailleur cable from the shift lever to the frame and then eventually to the derailleur. Motion of the derailleur cable causes the derailleur to move. Dirty, rusty, or worn derailleur cables and housing will not consistently and effectively transfer the shift lever motion to the derailleur because of friction inside the housing.

Derailleur cable housing for index shifting bikes is called “compressionless” derailleur housing. Compressionless housing is stiffer than brake housing and provides better shifting performance, even for non-indexing “friction” shifting systems. The derailleur cable runs inside a plastic liner, which is surrounded by support wires that run longitudinally with the cable (figure 10.1). Compressionless housing is available in a 4mm or 5mm outside diameter. Housing end caps must be compatible with the diameter housing to fit snugly over the housing.

FIGURE 10.1: Compressionless derailleur housing with outer plastic cover cutaway showing inner support wires

“Braided” or “woven” housing may be used for both brake and derailleur housing (figure 10.2). The outer support wires are woven in a mesh around the liner.

FIGURE 10.2: Braided housing usable for shift or brake housing

A third housing option is “articulated housing,” which uses small metal segments strung together like beads over a liner (figure 10.3). Articulated housing can be effective when tight bends in the housing are required. With articulated housing, there is very little flex along the length of the housing.

FIGURE 10.3: Articulated housing on a rear derailleur

Compressionless and woven derailleur housing should be cut with proper bicycle cable cutters. Bicycle cable cutter jaws surround the cut and shear the multiple strands of compressionless housing, woven housing, brake cable, or derailleur cable, causing less fraying. Firmly hold the housing or cable adjacent to cutting point. Hold housing or cable squarely with the cutting jaws and squeeze the handle (figure 10.4). Cutting may slightly deform the housing end. Use the reforming jaws section of the Park Tool CN-10 Professional Cable and Housing Cutter and gently reshape the housing (figure 10.5). If the housing liner is pinched closed, open the liner with a sharp pointed object, such as a seal pick or safety pin.

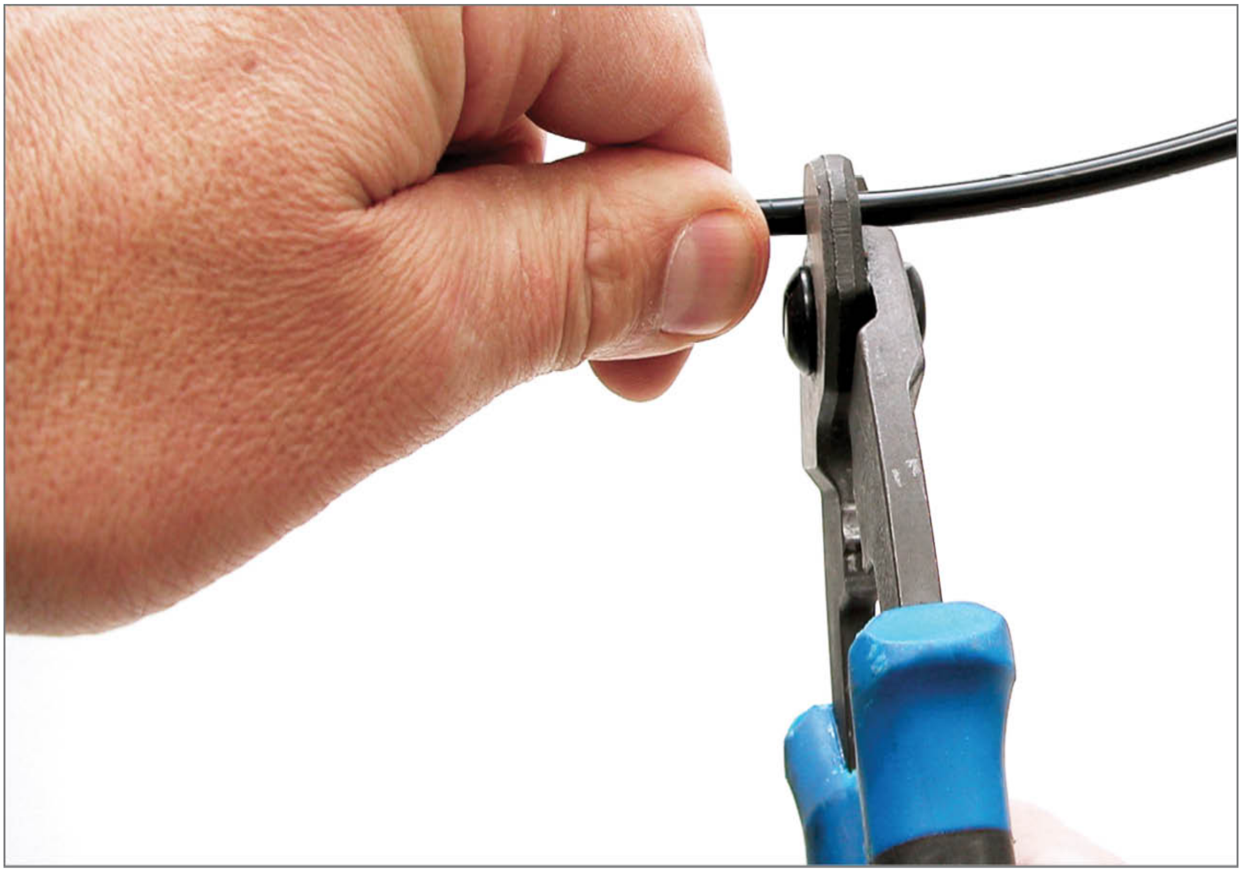


FIGURE 10.4: Hold compressionless housing square to jaws of cable cutter

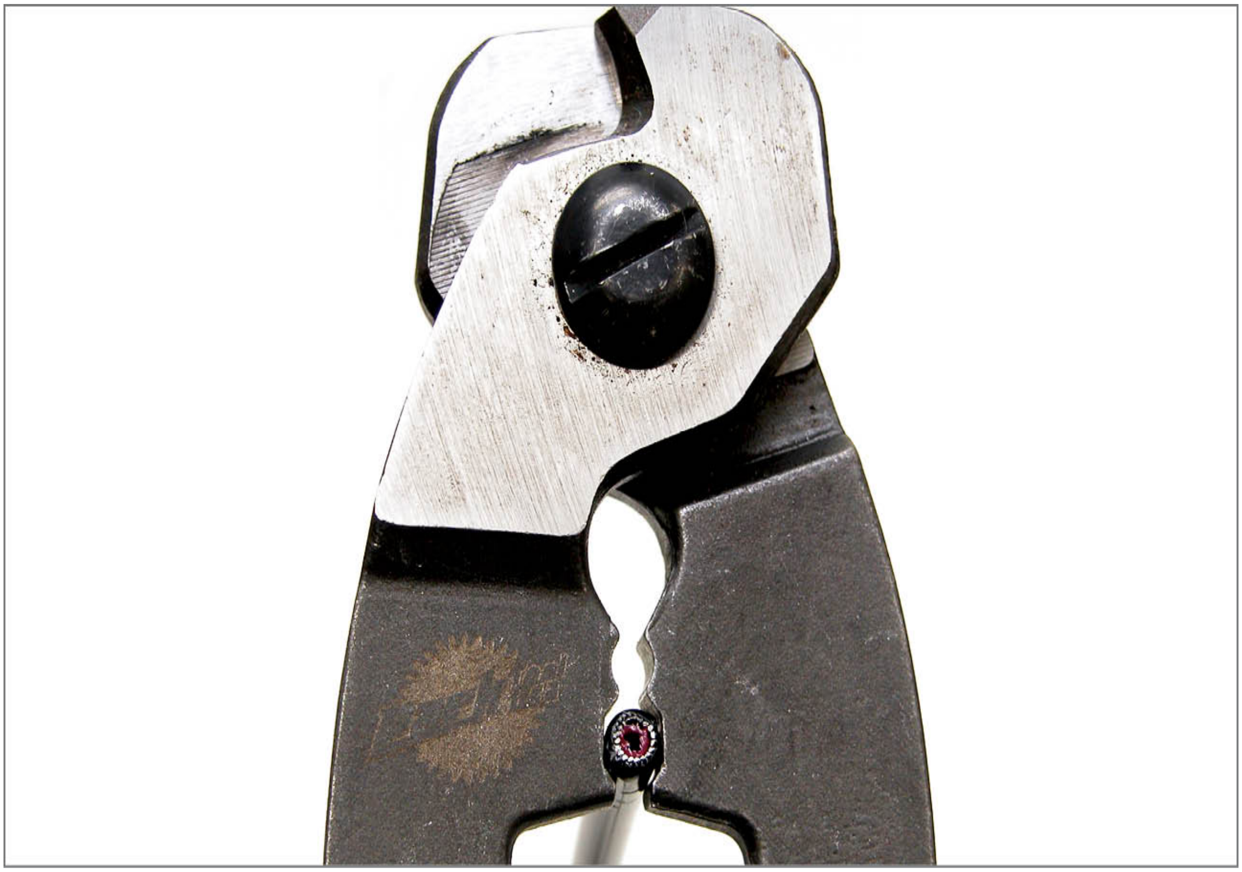


FIGURE 10.5: Reshape compressionless housing after cutting

Common derailleur cable is 1.2mm in diameter with a small cylindrical head at one end, which is about 4.3mm in diameter (figure 10.6). However, Campagnolo shift levers use a slightly smaller cable end of 4mm. Do not use the common 4.3mm cable end in Campagnolo levers, or the cable end may become stuck in the shifter. The lever moves the cable end carrier, or cable end socket, which pulls on the cable end. High quality derailleur cables have a smooth outer finish to reduce drag in the derailleur housing. Note: A derailleur cable should never be used as a brake cable.

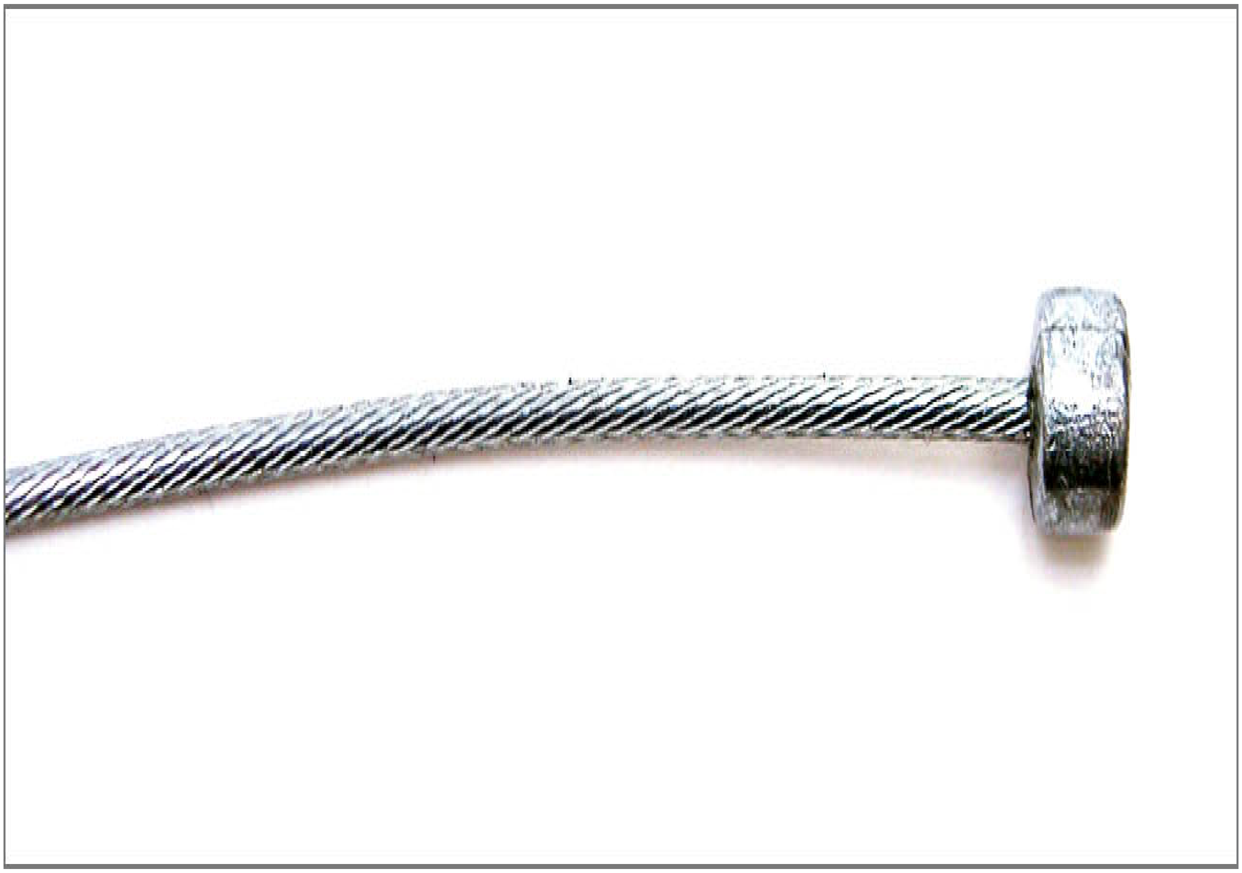


FIGURE 10.6: Derailleur cable with head

If the derailleur cable is partially cut anywhere from use or damage between the lever and the cable pinch bolt, it should be replaced. Even the failure of a single strand of cable will eventually lead to a cable break (figure 10.7).

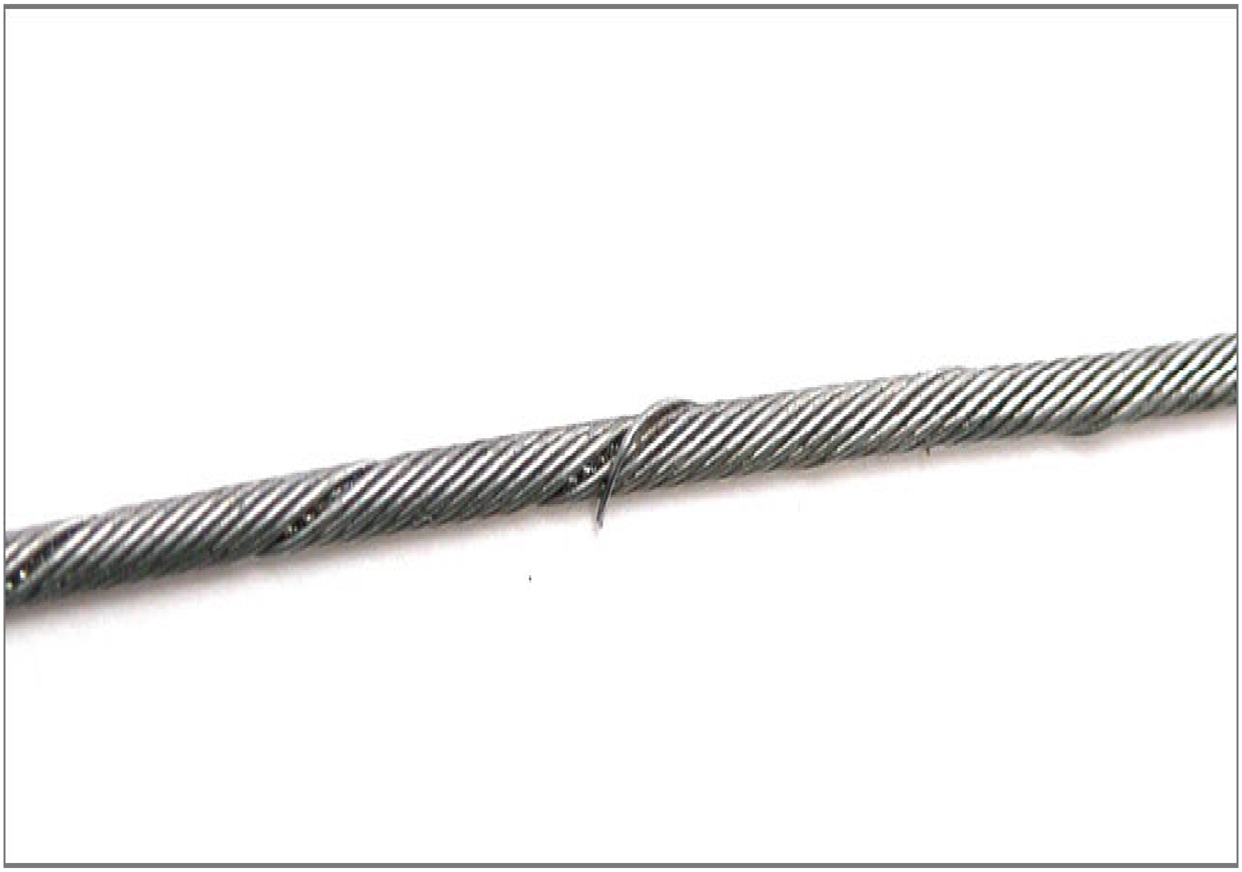


FIGURE 10.7: Inspect and replace cables with cut or broken wires

CABLE HOUSING LENGTH AND ROUTING

The cable and housing must travel from the front shift levers to the corresponding derailleur. It is useful to look at the previous routing, but do not assume it is correct. Appropriate derailleur housing lengths will help ensure that the bike shifts well. Generally, derailleur housing should be as short as possible yet still approach the derailleur housing stops in the frame, adjusting barrel, shift lever, and derailleur in a straight line. If the housing is too long and forces the cable to pass through excessive housing, it will add friction.

If the housing is too short and creates kinks, it will also cause excessive friction. Short housing will also bend or twist the end cap as it sits in the adjusting barrel (figure 10.8). Properly sized housing will enter the derailleur in a straight line and will not bend the end cap (figure 10.9).

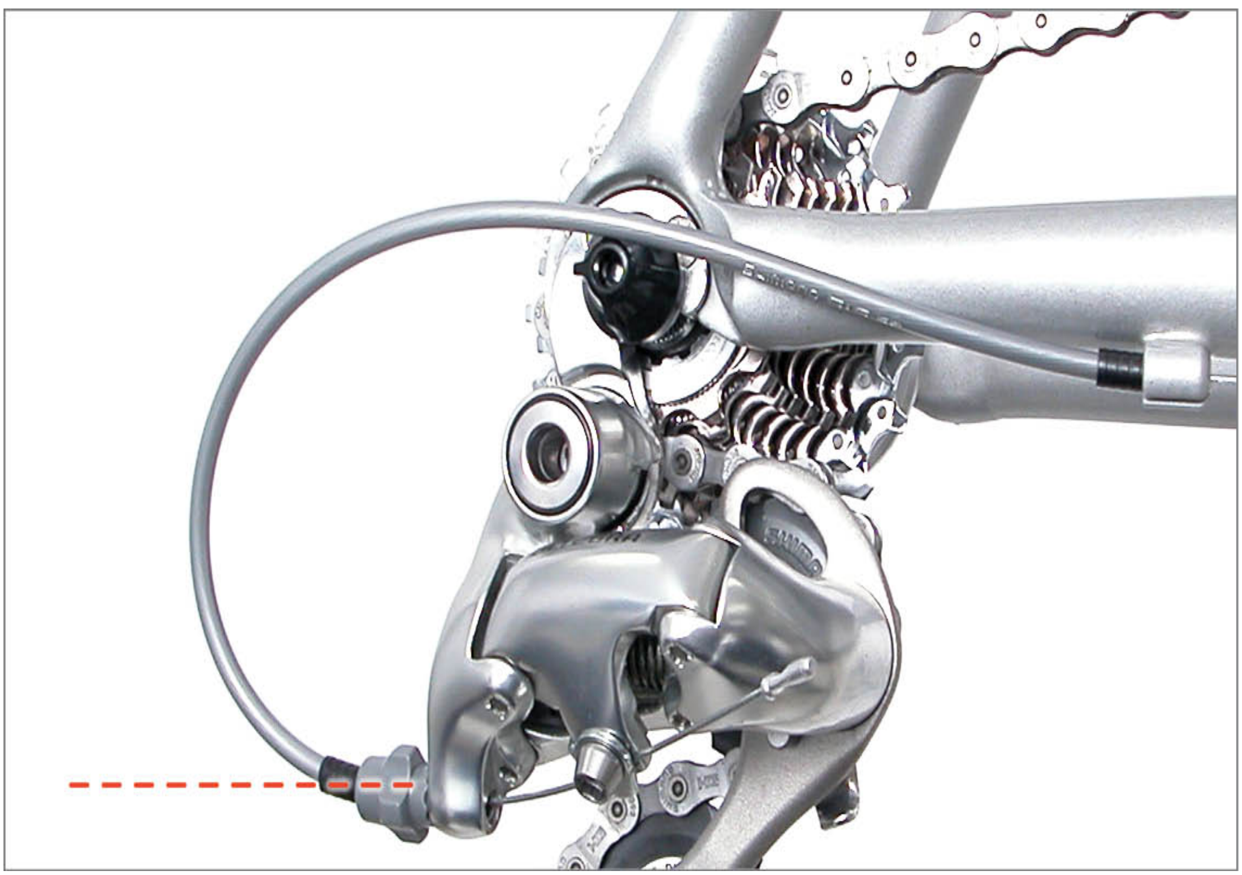


FIGURE 10.8: Housing does not enter adjusting barrel in a straight line, indicating it is too short

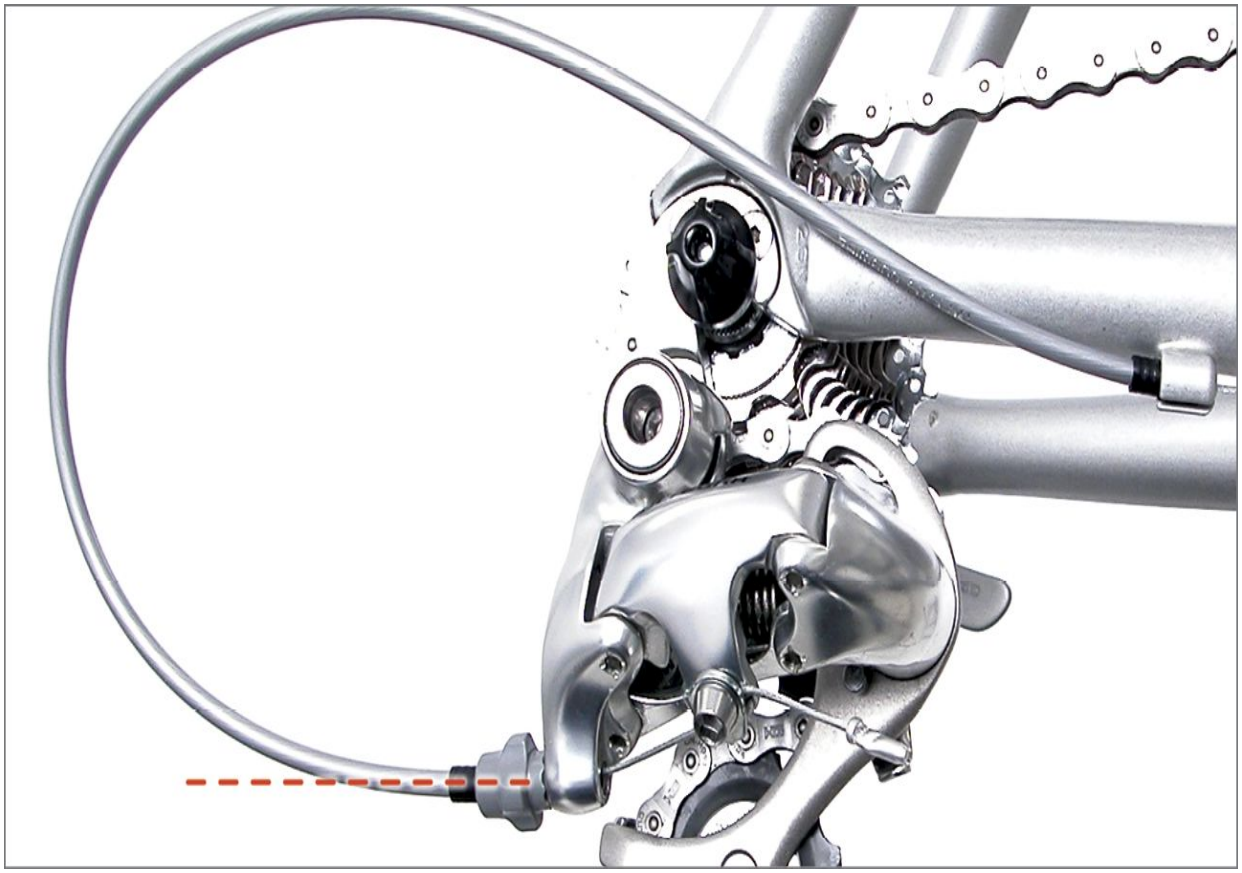


FIGURE 10.9: Housing entering adjusting barrel in a straight line

On some bicycles, the front housing loops from the shift levers to the frame may be purposely switched from left to right-side housing stops to improve the routing. The left shifter housing is passed to the right-side stop and vice versa. This is called “crossing over” (figure 10.10). The derailleur cable must then cross back over in order to arrive at the corresponding derailleur. Crossing over may in some cases reduce bends in the housing by creating a straighter line for the housing. This can also help eliminate housing rub on the frame. Crossing over, however, will not work well on all bikes. If the cable rubs on a frame tube, such as the down tube, or if there are severe bends resulting in other parts of the system, do not cross over. It is both common and acceptable for the derailleur cables to lightly touch when crossing back.

FIGURE 10.10: Shift housing routed to cross over from levers to housing stops. Notice cable must again cross back under down tube.

CABLE LUBRICATION

Dirt, corrosion, or rust in the cable systems will cause drag as the cables move through the housing, resulting in poor shifting. If the system uses housing stops along the frame, the cables can often be wiped clean and relubricated without taking them off the bike. Shift the rear derailleur to the sprocket with the tightest derailleur cable tension. Stop rotating the cranks and release derailleur cable tension by shifting the lever as if shifting to the other extreme sprocket. Do not rotate the cranks. Push the derailleur body to the outside to further release tension for extra slack on the derailleur cable. Pull housing ends from guides and stops (figure 10.11). Wipe derailleur cable clean and apply light lubricant. If wiping does not remove rust, the derailleur cable should be replaced. Push derailleur again to release tension in order to replace the housing in the stops. Rotate the cranks to shift the derailleur. Double-check that the housing is fully inserted into all stops.

FIGURE 10.11: Remove housing from frame stops to clean and lubricate

Some bicycle designs route the housing internally through the frame tubing (figure 10.12). Better bike designs use an inner guide to route the derailleur cable and/or housing in and out of the frame. If there is no guide inside, it can be difficult to get the housing through the frame. Feed the housing through one end and then use a stiff wire, such as a spoke, to help catch and guide the housing out the frame hole at the other end. To replace housing that is already in place, feed a derailleur cable into the back end of the housing and out the front. Pull the housing from the frame while leaving the derailleur cable in place to act as a guide when installing the new piece. Feed the derailleur cable into the new housing and push the new housing along the cable into the frame.

FIGURE 10.12: Internal routing for shift and brake housing

SHIFT LEVERS

Shift levers are designed with a socket or carrier inside the lever to hold the cable head (figure 10.13). The shift lever moves the carrier or socket and pulls the derailleur cable, which will move the derailleur. Indexing shift levers use a dwell system of "clicks" or stops at predetermined positions to align the derailleur pulleys and chain to the sprockets.

FIGURE 10.13: Shift lever cable carrier

Some bicycles use a friction shift lever system where the lever has no preset stops. Cyclists must listen and feel when the derailleur has reached correct alignment under the appropriate sprocket to properly engage the sprocket and prevent excessive chain noise from misalignment.

Shift levers with indexing features must be compatible with the derailleur, cassette, and crankset. The spacing between rear cogs will vary with the number of cogs. As the number of cassette cogs increases, the spacing between cogs narrows, and the shifter must pull the corresponding correct amount of cable. Cog spacing can also vary between different manufacturers. There is no comprehensive table of interchangeable systems. In some cases, it may not be possible to know if different models/brands are compatible until they are installed, adjusted, and test ridden.

Some models of front derailleur shifters allow for “half-clicks” and allow the front derailleur to be “trimmed.” This slight movement of the cage is used to prevent rubbing when the chain moves left to right on the rear sprocket combinations. Not all gear combinations are usable even with a trim feature because the chain may rub against the chainrings and not the front derailleur cage. In these cases, simply avoid using that gear combination.

The type and design of shift lever varies with the handlebars or bike it is intended to fit. Flat bar shifters are designed for 22mm diameter handlebar ends. Road brake/shift levers are designed for the larger 23.5mm diameter curved drop handlebars.

For shift cable installation and removal, all shift lever models and brands should be set so the cable is in the slackest or most relaxed position. The cable tension will typically be lowest when the derailleurs are set to the smallest sprockets front and rear.

FLAT BAR TRIGGER SHIFTERS

Shimano® and SRAM® have numerous models and generations of trigger-type shifters, some of which share the same bar mounting and cable installation features. If the lever is integrated with the brake, alignment preference should be given to the brake lever. Set levers at approximately a 45-degree downward slope from horizontal using the mounting bolt. Some models of shifters also include a separate shift lever lateral positioning option.

Inspect the lever and follow a line from the cable housing, looking for a screw head or cover where the cable head might exit. Shift the lever so the cable is in the most relaxed position with no tension. Remove the screw. Detach cable from derailleur anchor bolt and push the cable head out of the lever.

Feed the new cable through hole and out adjusting barrel. It can be difficult to find the hole for the cable, and it can be helpful to shine a flashlight through the adjusting barrel (figure 10.14). Aim for the light source as you feed the cable end through.

After new cable is installed, test by pulling on cable with one hand while working shift lever with the other hand. The cable should pull and release as the lever is worked. If the cable fails to move, the head is incorrectly installed. If the cable moves when lever is pulled, reinstall cover screw or plug.

FIGURE 10.14: Use flashlight to help find route for cable end

The SRAM® trigger shifters such as the current “X” series (X7, X9, X0®, XX and XX1®) use a plastic or carbon fiber cover over the cable access hole. It may be difficult or impossible to remove the cable access cover with the shifter in place on the handlebars. These shifter models may be unbolted from clamps or from the brake lever mounts. When necessary, remove the shifter from the bracket to get the cover off and install a new cable.

Inspect the shifter for the type of cover. Some models (X9, X7) use a rubber cover over the cable end. Lift up the end of the cover to expose the cable end (figure 10.15). Feed out and in through this hole. Replace the rubber cover and reinstall the shifter to the handlebar mount.

FIGURE 10.15: Pull up on rubber cover to expose cable access hole

For SRAM® trigger shifters using a carbon fiber or plastic plate, again, remove the lever from the handlebar. Inspect for a fastener in the middle of the cover. Remove the nut counterclockwise relative to the plate. The cable end carrier is under shifter return spring or plate. Use a small-tipped screwdriver or seal pick to carefully lift cable end while pushing on cable (figure 10.16).

FIGURE 10.16: Carefully lift cable head from socket

Installation of the cable is the reverse process. It can help to slightly bend the end of the cable to help feed it through cable carrier. Removing the adjusting barrel provides a large hole for cable to pass. Pull cable into place and check that the spring was not displaced. Reinstall adjusting barrel and cover plate.

TWIST GRIP SHIFTERS

Twist grip shifters mount to flat or upright handlebars. The twist grip body can be rotated around the handlebars. Twist grip shifters mount to the handlebar between the brake levers and bar grips. Check that shifters do not interfere with brake levers when brake levers are squeezed with maximum force. Look for a set screw that locks the lever to the handlebars (figure 10.17). Use a hex wrench to loosen the screw and rotate shifter body so cable housing follows a smooth line to the frame stop.

FIGURE 10.17: Location of setscrew in SRAM® twist grip shifter

There have been different generations of twist grip shift levers, and installation of the derailleur cable can vary. A common style has an access hole with a plastic or rubber cover. Shift the lever to the most relaxed derailleur cable position and remove the cover. Detach the derailleur cable from the derailleur and then push the derailleur cable toward the lever. Some models may have a small set screw over the derailleur cable end. Use a hex wrench to remove this screw. Other models use a small clip to hold the derailleur cable end. Use a small screwdriver to pry back the clip and then push the cable to remove it from the lever (figure 10.18).

FIGURE 10.18: Use small screwdriver to access and remove cable end

The SRAM® XX1® twist grip has a cable access hole below a plastic cover. Shift the derailleur to the smallest sprocket and unbolt the cable from the derailleur. Loosen the brake lever clamp to move the brake lever inwards to allow room for removal of the retaining ring and cover. Use a 3mm hex wrench to loosen the retaining ring and pull it away from the shifter. Pull the shrouding away from the lever to expose the cable end (figure 10.19). Push the cable from the adjusting barrel side to free the cable end from the lever.

FIGURE 10.19: Remove SRAM® XX1® twist grip retaining ring and shrouding to expose cable end

After installing a new cable, reinstall the shrouding. Push retaining ring back into place and secure. Move brake lever back to original position and secure.

ABOVE-THE-BAR SHIFTERS

The above-the-bar shifters (also called “thumb shifters”) are designed for upright handlebars. Placement should be close to the grip, and the body of the shifter should point downward at a slight angle (figure 10.20).

FIGURE 10.20: Above-the-bar shift lever

The derailleur cable is simply fed through a hole in the shift lever and then through the housing to the derailleur.

DROP BAR INTEGRATED BRAKE / SHIFT LEVERS

Several manufacturers offer drop bar levers combine shifting and braking into the same lever system. Brake lever placement will determine how the shift levers are aligned (figure 10.21).

FIGURE 10.21: Align brake/shift levers relative to lower section of drop handlebars

Shimano® shifters have two different shift cable routing styles. One design routes the shift cable and housing inward from the front of the lever body to the housing stops on the frame. The housing is not run under the handlebar tape but loops in front of the head tube. For this style, feed the cut end of the cable through the socket from the outboard side (figure 10.22). Pull cable fully through until the head engages inside the socket.

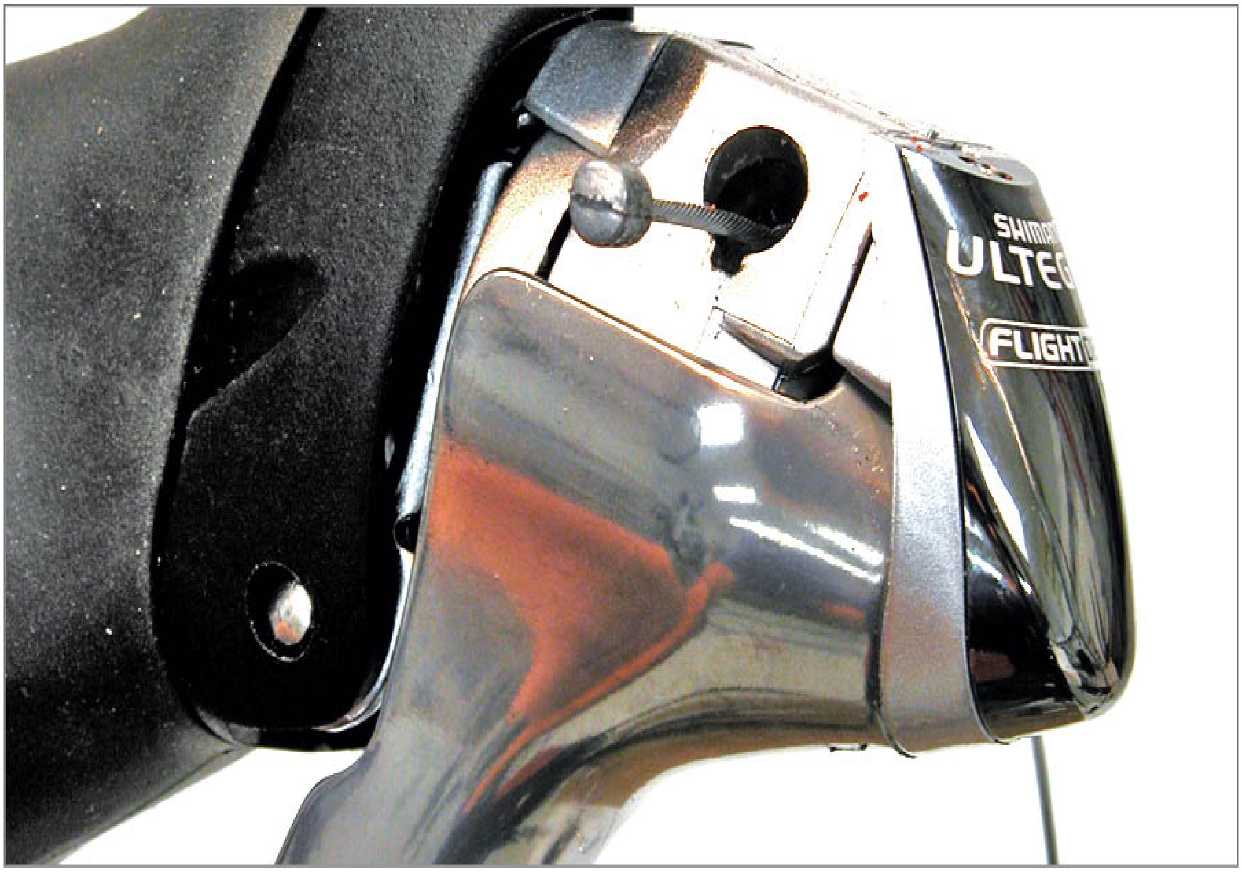


FIGURE 10.22: Feed cable through socket at top of lever

Shimano® also uses designs that run the shift housing under the bar tape to the back of the lever body. Pull the rubber brake lever hood forward to expose the cable entry under the lever body. The cable feeds upward through this hole and exits out the back of the body into the shift housing (figure 10.23).

FIGURE 10.23: Cable access hole located under the lever body

The Shimano® Dura-Ace® ST-9000 is a mechanical 11-speed shift/brake lever. A plastic cover on the inboard side of the lever covers the cable entrance. Pull the brake lever hood forward to expose the cable access cover. Pull the housing from the lever and remove the inboard cable cover by pulling the exposed cable inward and forward (figure 10.24). Push the cable from the inboard side outward. The cable end must exit from the larger opening out the outboard side. Pull on the cable end to remove.

FIGURE 10.24: Use cable to pull open cable access cover

As with all shifters, to install a new cable the lever must be in the smallest sprocket position. Pull back on the lever hood to expose the cable entrance on the outboard side of the body. If still in place, remove the plastic cover on the inboard side of the lever. Feed the cable end through the upper hole and in a straight line through the lever body (figure 10.25). The cable head should be bent downward to fit through the larger hole in the access slot into the cable carrier.

FIGURE 10.25: Install cable from inside face of lever and up through the top of lever body

For Campagnolo® Ergopower® levers, pull the rubber lever hood forward to expose the cable anchor under the lever body. Feed derailleur cable upward through anchor and out the top of the lever (figure 10.26). Housing and end cap enter lever from the top and run underneath the handlebar tape.

FIGURE 10.26: Cable access is under lever body

For SRAM® Double Tap levers, the cables install from the inside face of the lever body. Pull cover back on lower portion of lever to expose wire access hole. The wire must make a relatively quick 90-degree turn from entering horizontal to exit vertical. It can be useful to give the cable a slight curve by bending it (figure 10.27). It is best to use new shift wires or to solder the end of used wires. Freshly cut wires may have difficulty making the bend.

FIGURE 10.27: Cable access is from the inside of lever body and cable exit hole is on upper side of body

DOWN TUBE SHIFTERS

Down tube shifters are mounted on the down tube of the bicycle frame and were once common on road bikes (figure 10.28). The frame will have a fitting for the levers. There is no positioning adjustment for these levers. The cut end of derailleur cable is fed through a hole in the lever and is routed down below the bottom bracket to the appropriate derailleur.

FIGURE 10.28: Typical down tube shifters

BAR END SHIFTERS

Bar end shifters are fitted into the ends of drop style handlebars or to the end of “aero” handlebars (figure 10.29). These levers secure inside the ends of the bars in place of end caps. The derailleur housing is then routed along the handlebar underneath the bar tape or, in some cases, through the bar itself. The derailleur cable is fed through a hole in the lever and through the housing.

FIGURE 10.29: Bar end shifter on an aero handlebar set

FRONT DERAILLEUR

Front derailleurs are used on bikes with two or three front chainrings. A cage surrounds the chain and shoves it off one chainring and onto another. A derailleur cable pulls the derailleur linkage to move the cage left to right across the chainrings. A spring in the derailleur linkage returns the cage when the derailleur cable is relaxed. A properly adjusted front derailleur should shift the chain between all front chainrings but should not throw the chain off the chainrings.

The basic adjustments for the front derailleur are the height, rotation, limit screw settings, and index setting. Most models and brands share many of these adjustment features, but there are some exceptions covered at the end of this section.

DERAILLEUR DESIGN

There are several possible systems to mount the front derailleur to the frame. The common system is a clamp that is sized for the seat tube diameter. Clamp sizes are available in 28.6mm, 31.8mm, and 35mm diameters. Some derailleur models are sized for large tubing and use shims to accommodate smaller sized seat tubes.

The Shimano® "E-plate" front derailleur models use a plate that mounts over the bottom bracket shell and is held by threaded bottom bracket adaptors or by a threaded fitting at the shell (figure 10.30). The derailleur is fixed in both height and rotation settings. The only adjustment is with limit screw settings. The E-plate must be used with compatible chainring spacing, chainring sizes, and chainline.

FIGURE 10.30: E-plate front derailleur mount

The Shimano® FD-9000 front derailleur has special adjustment procedures and is reviewed later in this chapter.

A common road bike mounting system is referred to as a “braze-on.” A concave bracket is mounted to the seat tube and allows limited height and rotational settings. This may be welded (“brazed”) to steel frames but is riveted, bolted, or glued to aluminum or carbon fiber tubing. The braze-on compatible front derailleur body is made with a convex radius to fit the concave braze-on. Clamp-on brackets with the braze-on fitting are available for seat tubes without braze-on mounts (figure 10.31).

FIGURE 10.31: Clamp-on adaptor for a “braze-on” type front derailleur

The “direct mount” system is an MTB mounting system similar to the road bike braze-on. The derailleur bolts directly to a special fitting on the seat tube (figure 10.32). Height adjustment is possible on this system, but there is typically no allowance to adjust the rotational position of the direct mounts. It is assumed the frame manufacturer has determined acceptable derailleur rotation.

FIGURE 10.32: Direct mount derailleur with single bolt (A) for adjusting cage height above rings

The front derailleur design will vary with the crank style used. Triple cranksets have a wide spread of chainring sizes and use a cage with a relatively wide inner plate. This type of derailleur is called a “deep cage” derailleur. Road bikes tend to have two front chainrings that are relatively closer together in size and do not require a wide plate. These derailleurs are called “shallow cage” (figure 10.33). Consult a professional mechanic for the correct design for your bike.

FIGURE 10.33: Top: shallow cage design Bottom: deep cage design

Front derailleur cages are moved by a parallelogram in a linkage system that allows the sides of the cage to remain parallel to the chainring as it moves laterally. There are three basic linkage designs: the “bottom swing,” “top swing” and “side swing.” These designs differ in placement of the parallelogram in relation to the derailleur clamp or bracket attachment to the frame. Another variation is the pull direction of the cable. If the cable is routed from the top along the seat tube, it is a “top pull.” If the cable is routed upward from the bottom bracket the derailleur is a “bottom pull.”

Bottom swing derailleurs are designed so the parallelogram attaches and swings below the clamp (figures 10.34 and 10.35). The frame clamp will end up higher on the seat tube as compared to a top swing derailleur.

FIGURE 10.34: Bottom swing design with bottom pull cable

FIGURE 10.35: Bottom swing design with top pull cable

Top swing derailleurs attach with the parallelogram swinging above the frame clamp or bracket (figures 10.36 and 10.37). Top swing derailleur clamps will end up lower on the seat tube as compared to bottom swing derailleurs. Some bike frames will only allow the mounting of a top swing derailleur because of a water bottle fitting or suspension fittings on the seat tube.

FIGURE 10.36: Top swing cage design with bottom cable pull

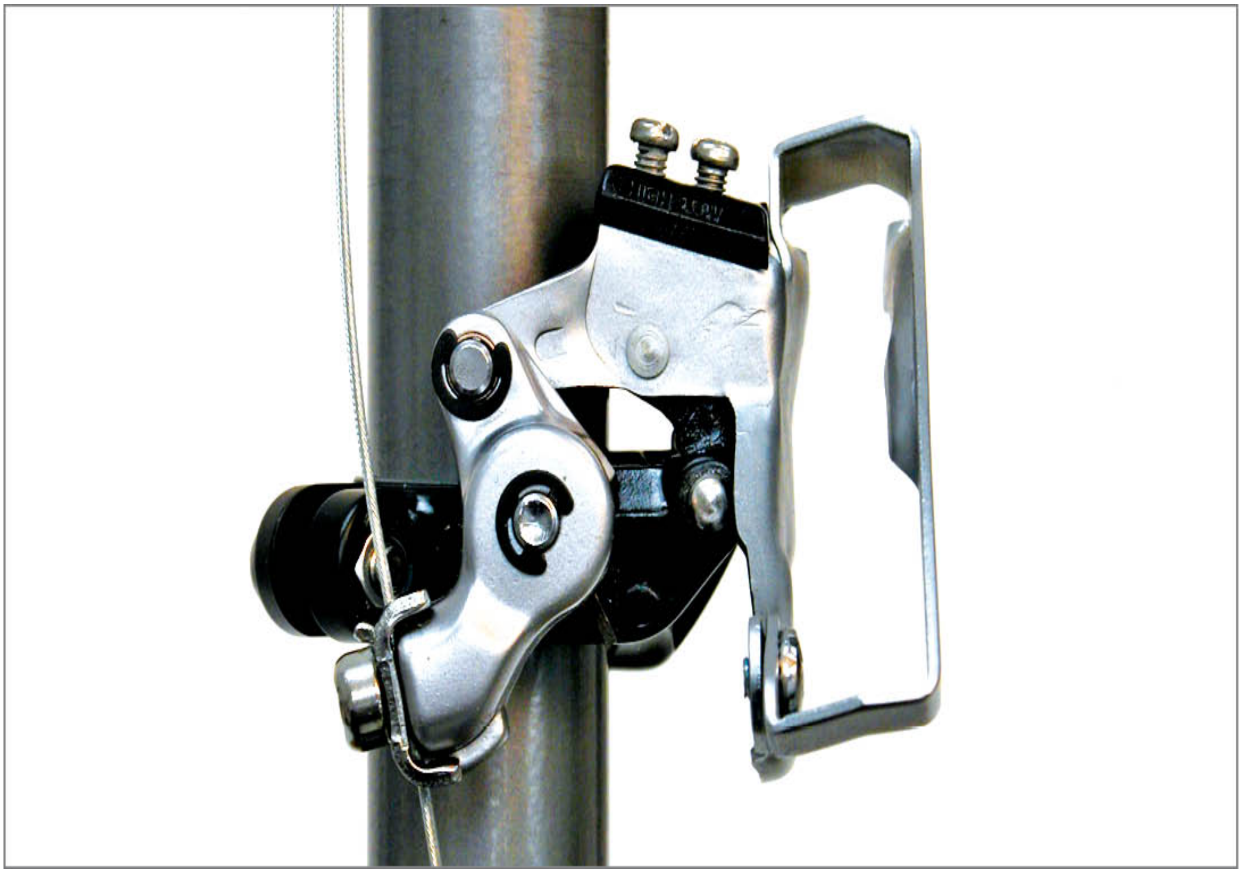


FIGURE 10.37: Top swing cage with top pull cable

FIGURE 10.38: Cable attachment design allowing for either top or bottom cable pull

There are also derailleur models that will function with either the cable pulling from the top or pulling from the bottom by rerouting the cable at the derailleur (figure 10.38).

The “side swing” derailleur linkage moves horizontally as the cage moves outward. The shift housing and cable enter at the front of the body (figure 10.39). The cable pulls the cage outward, and the return spring pulls the cage inward. This design provides more clearance behind the mechanism for tighter tire clearances. Alignment and limit screw concepts are the same as other front derailleurs.

FIGURE 10.39: Side swing design front derailleur

DERAILLEUR CABLE ATTACHMENT

The derailleur cable attaches to the front derailleur at the fixing or pinch bolt mechanism. Unthread the bolt and look for a groove in either the fixing washer or derailleur arm. The derailleur cable will lay in this notch (figure 10.40). Inspect the mechanism and keep the cable aligned with the groove. There may also be a tab on the washer used to prevent it from rotating.

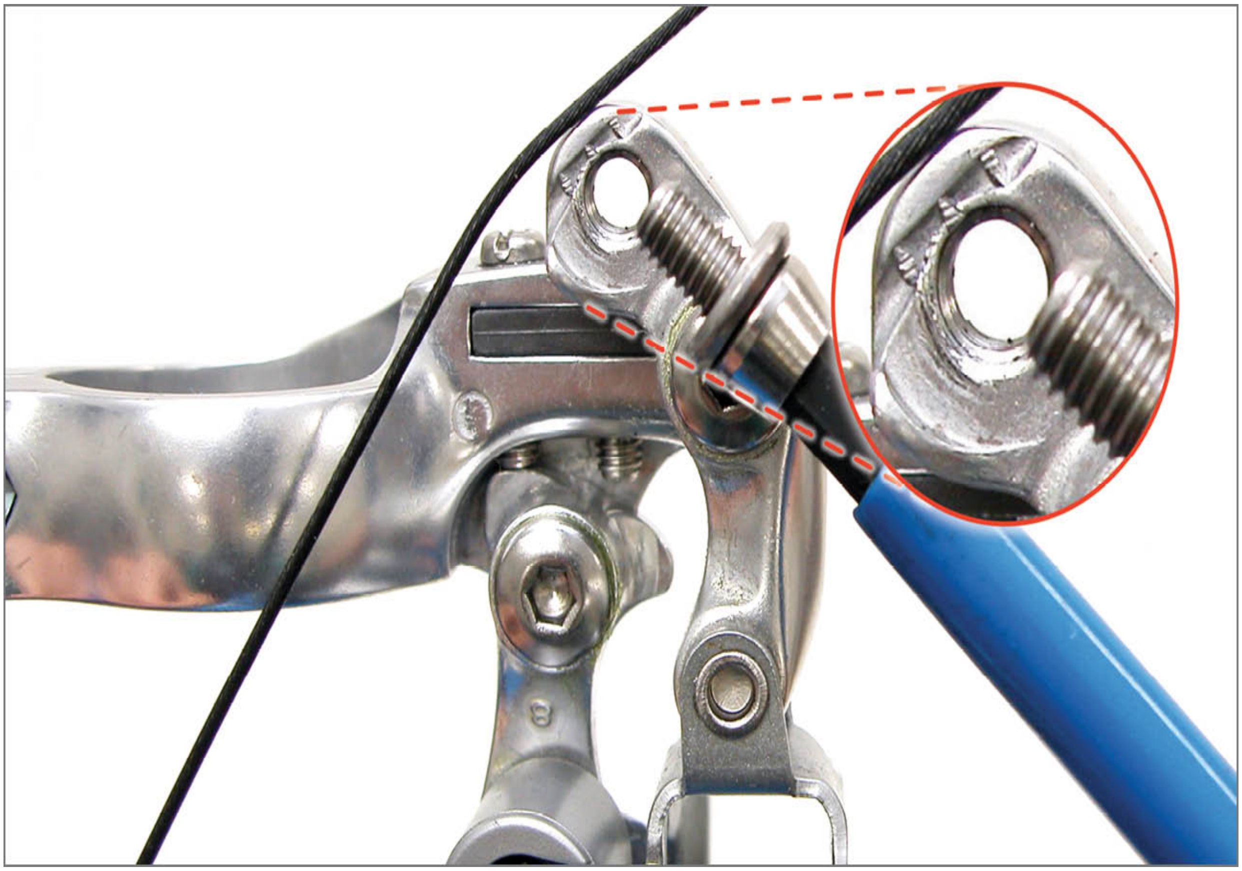


FIGURE 10.40: Derailleur cable routing through groove under cable fixing washer

While the fixing bolt is loose, lubricate the threads. Pull the derailleur cable snug and secure the bolt. The typical torque for the pinch bolt is approximately 4Nm (35 inch-pounds). The derailleur cable should be flattened where it is pinched.

HEIGHT ADJUSTMENT

If the derailleur cage is too far above the large chainring, it will shift poorly. If the derailleur is too low, it may scrape against the chainrings and jam the chain when shifting. The proper height can be set with or without the derailleur cable attached. Derailleurs mounted to “E-plates” or direct mount systems normally do not allow height adjustment.

Procedure for front derailleur height adjustment:

a. Pull front derailleur cage plate until it is directly over outer chainring teeth. Either use the cable or pull directly on the cage.

b. The gap between the teeth of the outer chainring and the lower edge of the outer cage plate should be 1–2mm or about the thickness of a U.S. penny. Using the penny as a feeler gauge, fit it between the chainring teeth and the cage plate. It should just barely fit (figure 10.41).

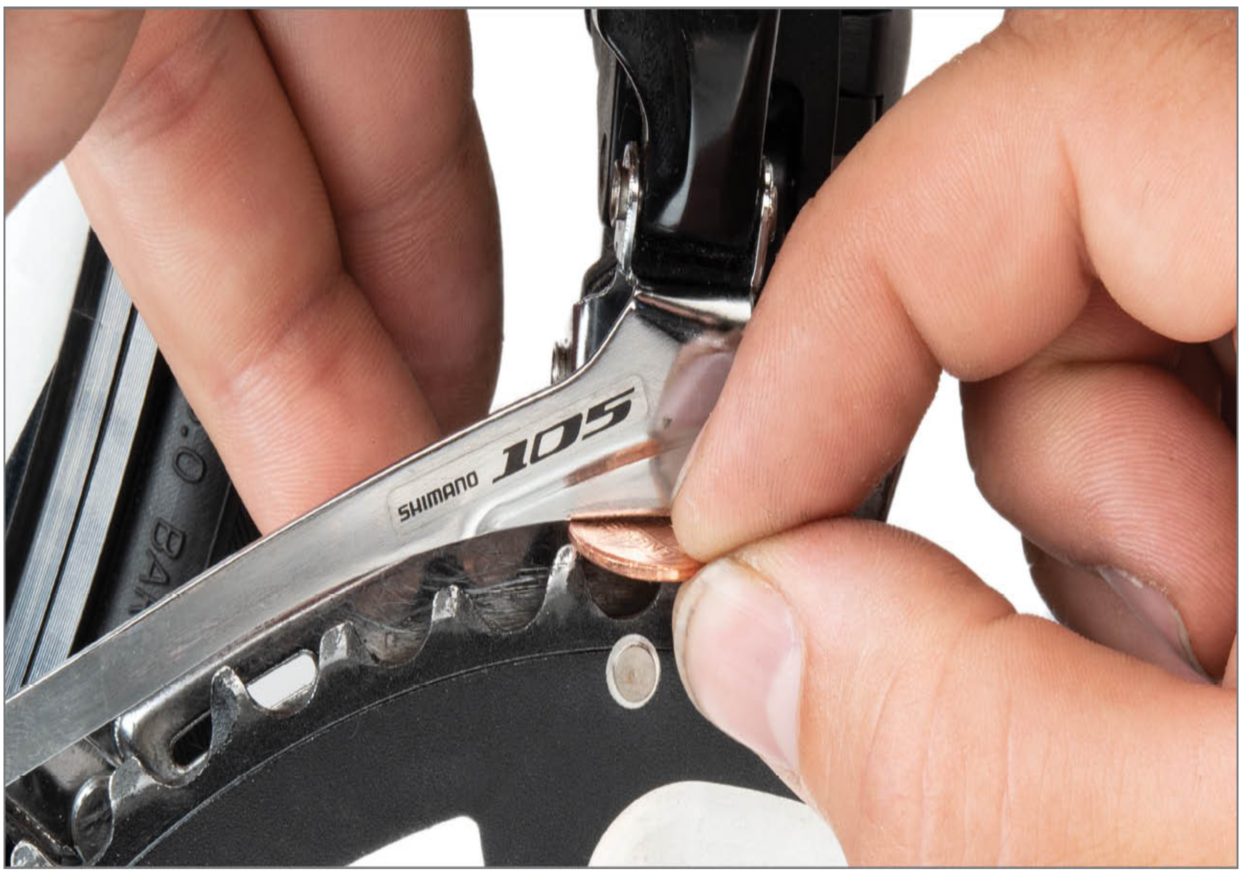


FIGURE 10.41: Set height for 1–2mm clearance at closest point between cage and teeth

c. Inspect angle of outer derailleur cage relative to the chainring. Cage plate should be approximately parallel to ring at this time.

d. To change cage height in most front derailleurs, release derailleur cable tension completely by shifting to the innermost chainring. Any cable tension will pull the derailleur downward and make height difficult to set.

e. Front derailleur clamps typically leave a mark on the frame, which is useful as a reference when changing height. Loosen the derailleur mounting bolt and change derailleur height. Use care to keep cage parallel to chainring. Tighten mounting bolt. Move the outer cage plate over outer chainring and check height again.

f. Repeat process until cage plate height is 1–2mm above outer chainring. For triple chainring bikes, inspect that the inner derailleur cage plate is not striking the middle ring. It may be necessary to raise the derailleur above the 1–2mm height recommendation.

If the derailleur cannot be set to an acceptable height, it may be incompatible with the front chainring sizing. Additionally, the frame may not permit an ideal setting, or there may be a chain guard that prevents a lower setting (figure 10.42).

FIGURE 10.42: Chain guards can sometimes prevent good derailleur height

ROTATIONAL ADJUSTMENT

Generally, the front derailleur cage should be aligned parallel to the chain. Because the chain angle moves when the rear derailleur is shifted left and right, use the outermost (smallest) rear sprocket when checking the cage rotation. If the derailleur cage is rotated too far from parallel it may shift poorly or rub on the chain after the shift is completed. Keeping the cage and chain parallel will minimize the risk of the chain jumping off the outermost chainring. If the cage is not parallel, there will be a relatively large gap at either the back or the front end of the cage. Then the derailleur may overshift the chain past the chainring (figures 10.43 and 10.44).

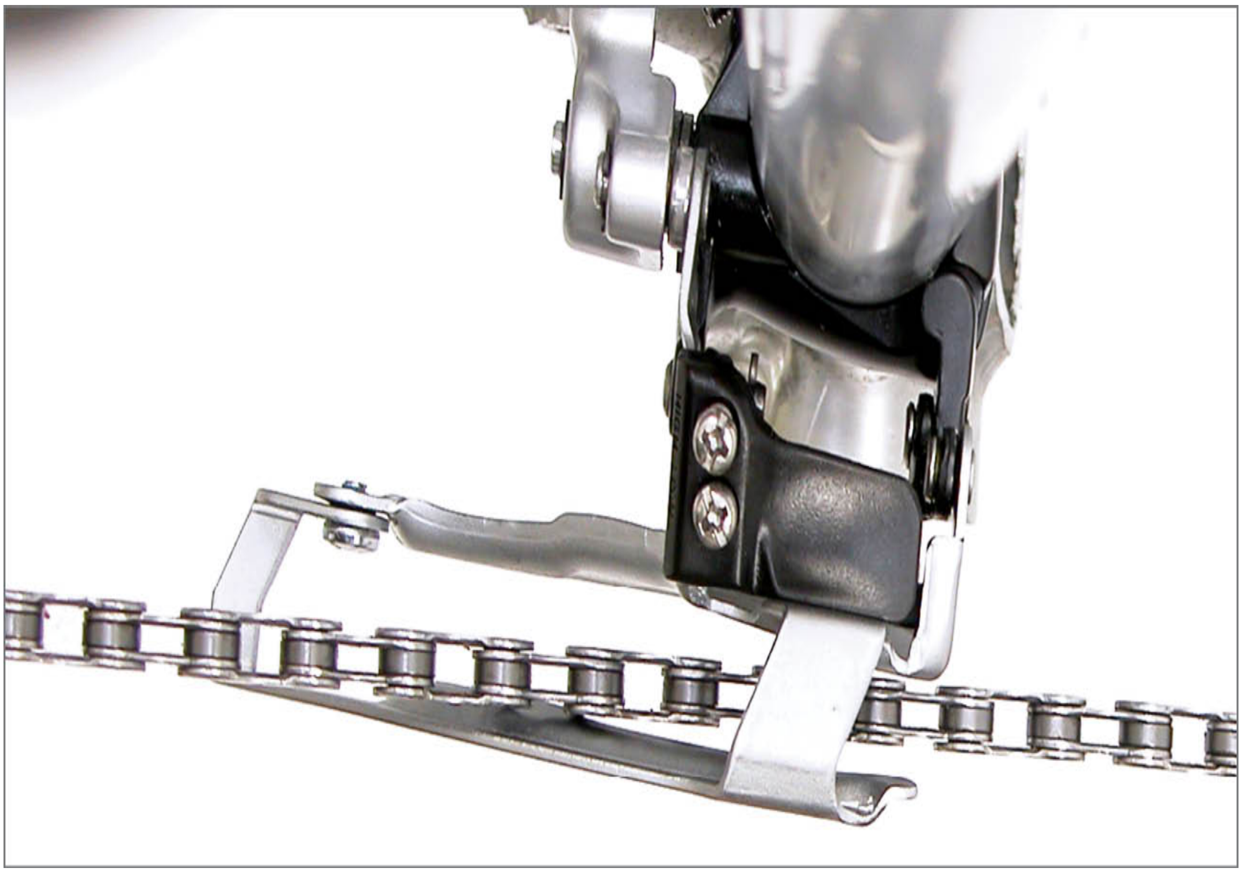


FIGURE 10.43: Cage rotated too far clockwise. Notice rear end of cage is inward compared to chain.

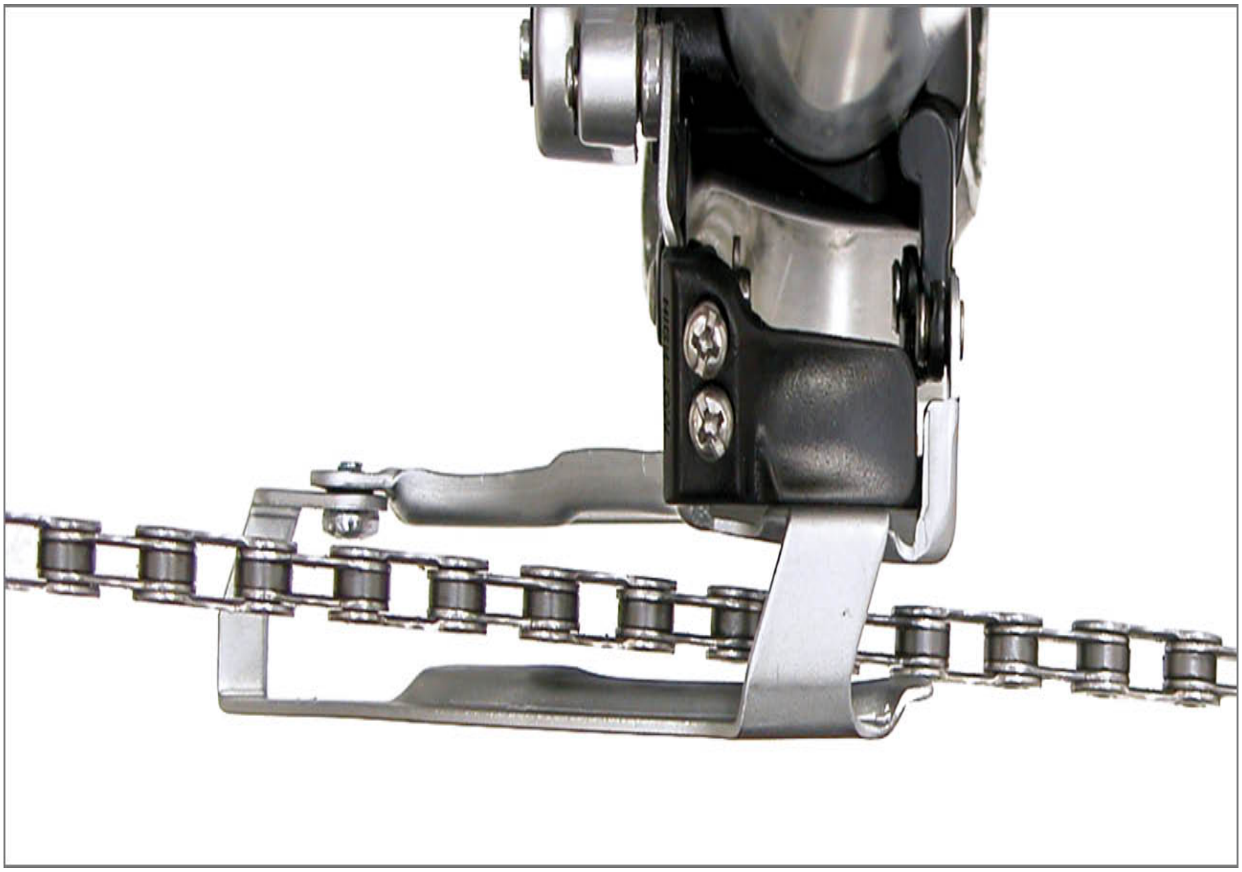


FIGURE 10.44: Cage rotated too far counterclockwise. Notice rear end of cage is outward compared to chain.

Clamp mounted and braze-on mounted derailleurs permit a rotational adjustment. However, the E-plate or direct mounted derailleurs do not permit a rotational adjustment.

The derailleur should be moved to the largest chainring when inspecting rotation. The cable may be attached to allow the cage to be pulled over for inspection. However, to adjust the rotation it is necessary to loosen the clamp bolt. A cable pulling on the cage may change the height. To prevent this, release cable tension and move the cage inward before making adjustments.

Procedure for front derailleur rotation adjustment:

a. Shift chain to outermost chainring and outermost rear sprocket.

b. Sight chain and cage from directly above chainrings. Consider the chain as representing a straight line. Compare this line to the outer derailleur cage plate. Outer cage plate and chain should be parallel (figure 10.45).

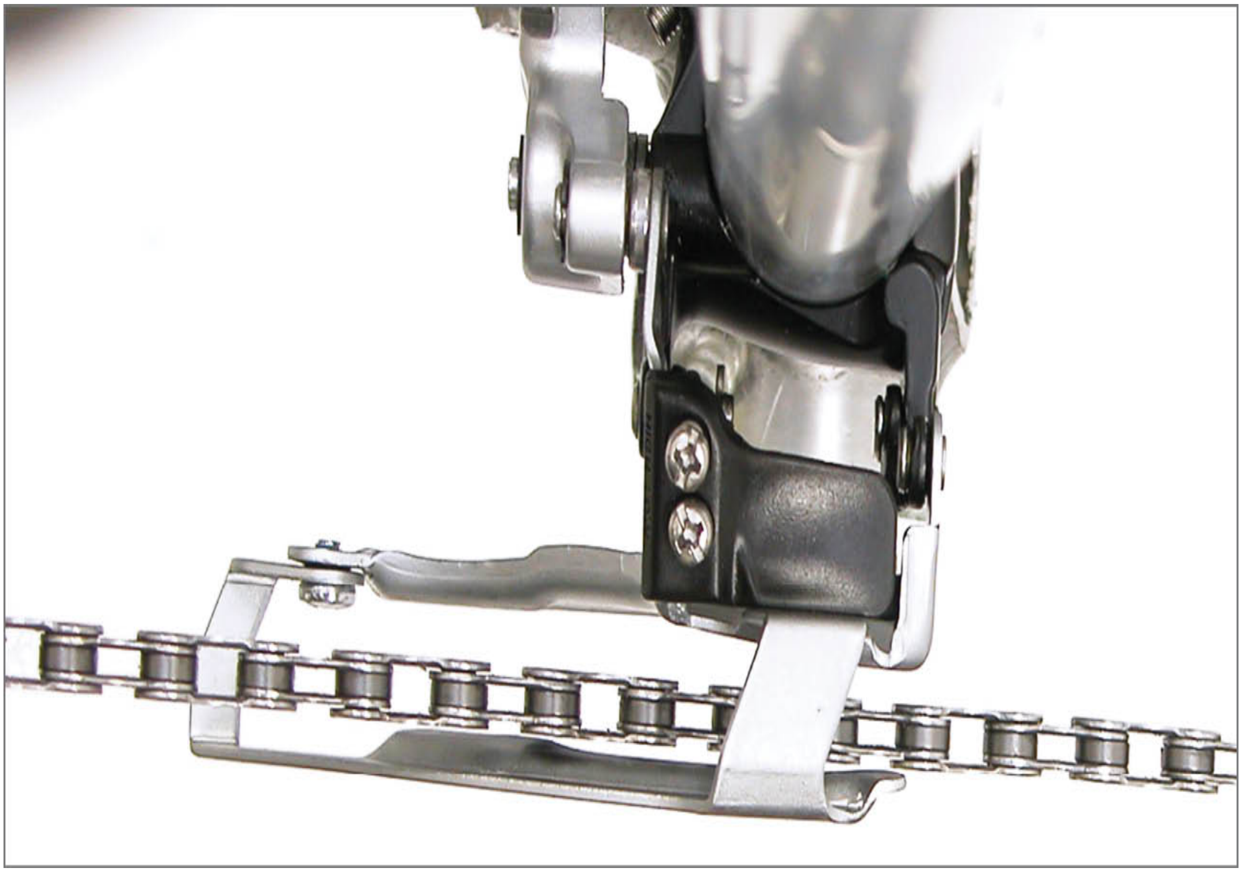


FIGURE 10.45: Acceptable derailleur cage rotation with outer cage parallel to chain

c. If the derailleur cage must be rotated, note direction of desired rotation.

d. For most derailleurs, release derailleur cable tension by shifting to the innermost chainring.

e. Many clamps leave a slight marking on the frame. Use a pencil to make two reference marks on the frame, one for height and a second, vertical mark to reference rotation. Use the marks to avoid inadvertently changing height.

f. Loosen mounting bolt and slightly rotate in correct direction. Use care not to change height. Tighten clamp bolt.

g. Shift to outer chainring and observe rotation alignment.

h. Repeat adjustment if necessary until cage is adequately parallel to ring.

The procedure above usually creates the best front derailleur alignment. However, there are situations where it is necessary to deviate slightly from parallel. For example, after properly setting the limit screws, a derailleur may seem slow when shifting inward. It may benefit from having the cage rotated slightly clockwise. This moves the back end of the cage closer to the chain if viewed from above and this position can help push the chain inward to the next sprocket. Recheck both limit screw settings any time height or rotation is changed.

The SRAM® Red with “Yaw Front” system does not align parallel to the chainrings when the cage is inward over the small ring. As the cage moves outward it rotates or “yaws” to become parallel. Check proper rotation of this model by pulling the cage over the large ring and sighting two alignment marks at the front and back of the cage directly over the largest ring (figure 10.46).

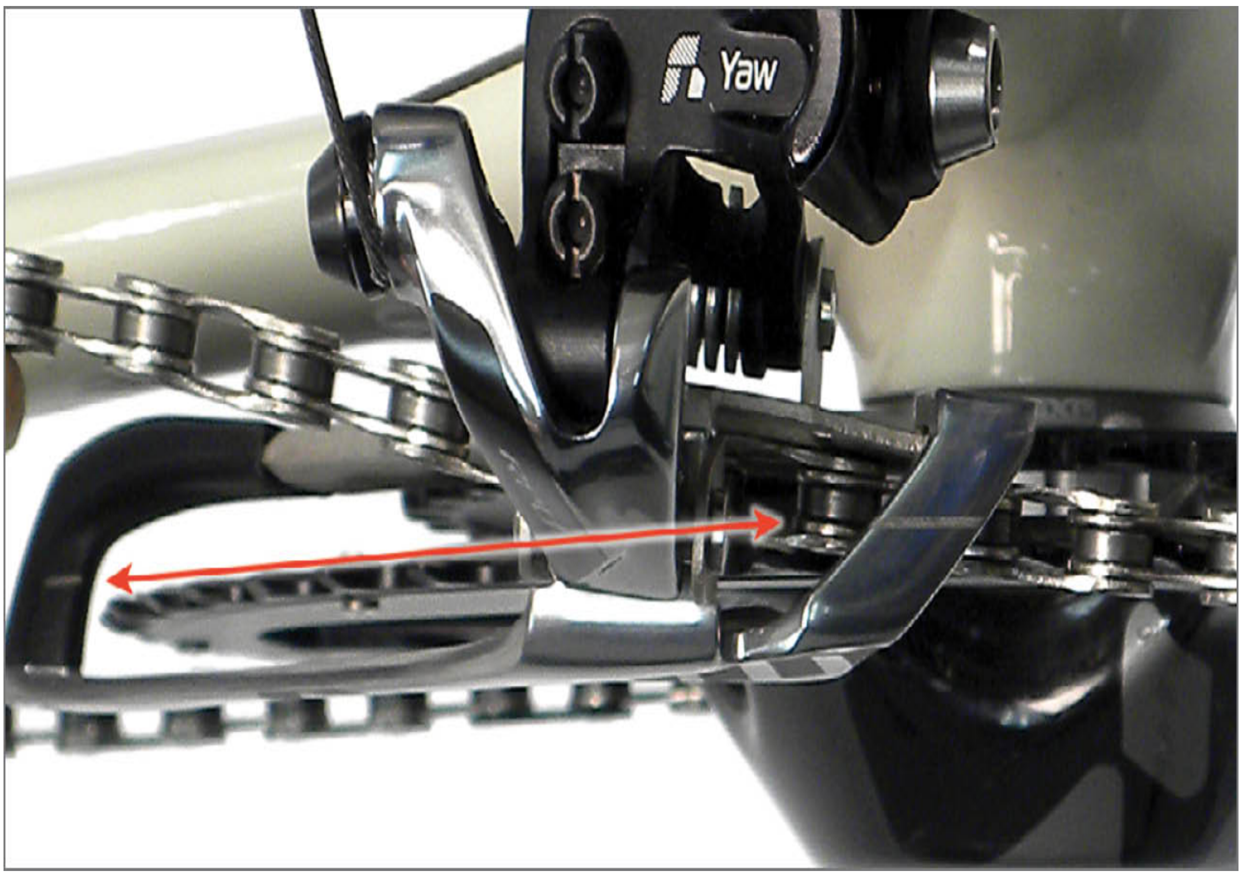


FIGURE 10.46: SRAM® Red front derailleur uses alignment marks on cage to align with largest chainring

LIMIT SCREW ADJUSTMENT

Limit screws are marked “L” and “H” (figure 10.47) and used to stop the travel of the front derailleur cage by striking the moving linkage system. The L-limit screw will stop the inward motion of the derailleur toward the smallest chainring or “low” front gear, and the H-limit screw will stop the outward motion of the derailleur toward the largest chainring or “high” front gear. The L-limit screw also keeps the chain from falling off the smallest ring onto the bottom bracket. Similarly, the H-limit screw keeps the chain from falling off the outside of the largest sprocket. Adjust limit screws before setting index shifting with cable adjustment settings. The screws use a nyloc fitting to prevent them from moving after adjustment. If the screws seem to move too easily, remove the screw and apply a mild threadlocker. Do not lubricate the screws.

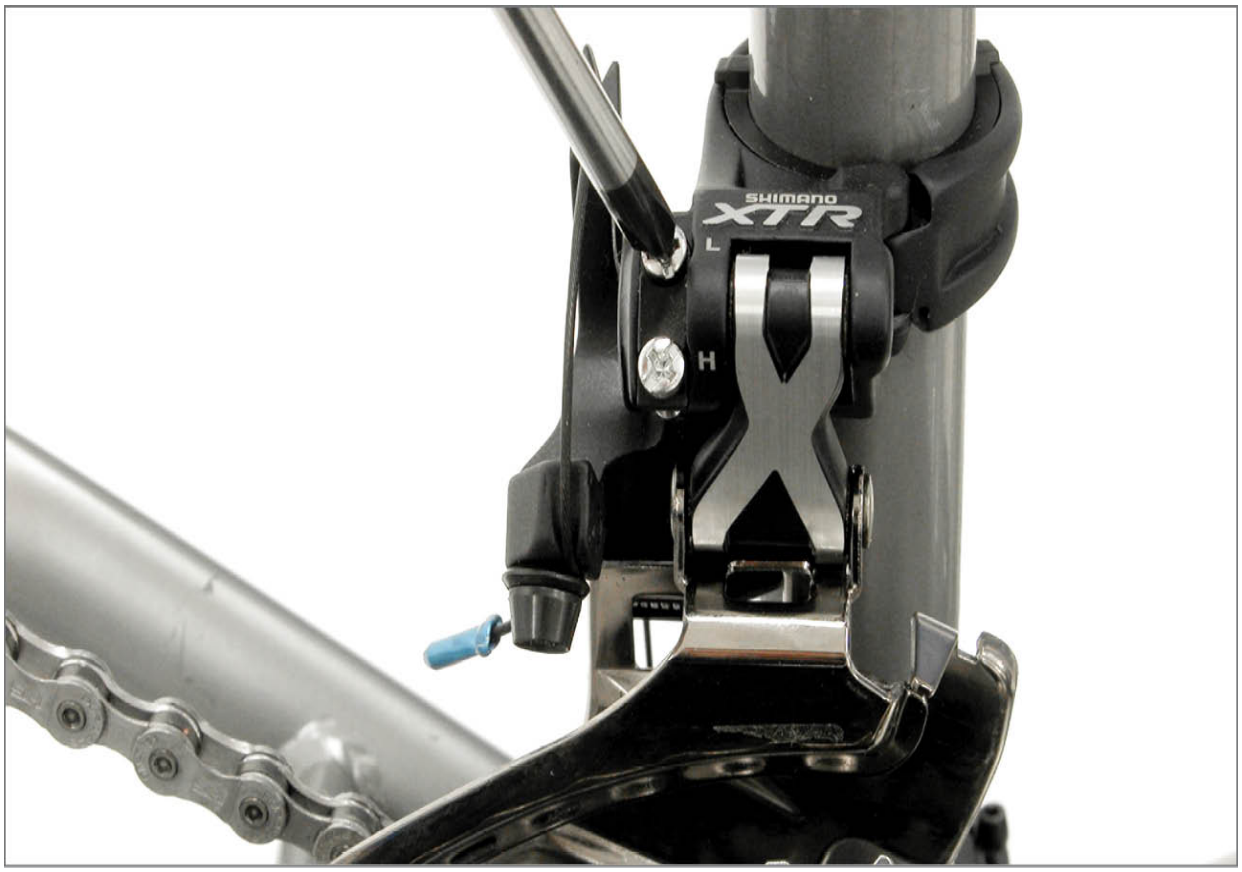


FIGURE 10.47: Location of limit screws

L-Limit Screw

When adjusting the front derailleur L-limit screw, it is important the derailleur rest on the L-screw stop when the cable is slack. If the derailleur cable is pulling too much, it may prevent the derailleur resting on the L-screw stop. The procedure here will purposely slacken the cable so a proper adjustment can be made.

Procedure for L-limit screw adjustment:

a. Shift chain to innermost rear sprocket and innermost front chainring. Inspect derailleur for mark indicating “L” screw.

b. Check front derailleur cable tension. It should be fairly loose at this time. If derailleur cable is taut, turn adjusting barrel clockwise into lever to provide slack. If adjusting barrel is already fully turned into the housing, loosen the derailleur cable pinch bolt, slacken the derailleur cable and retighten the bolt.

c. Sight the gap between the chain and inner cage plate. Only a small gap of 0.5–1mm should be visible at the point where the two might touch (figure 10.48).

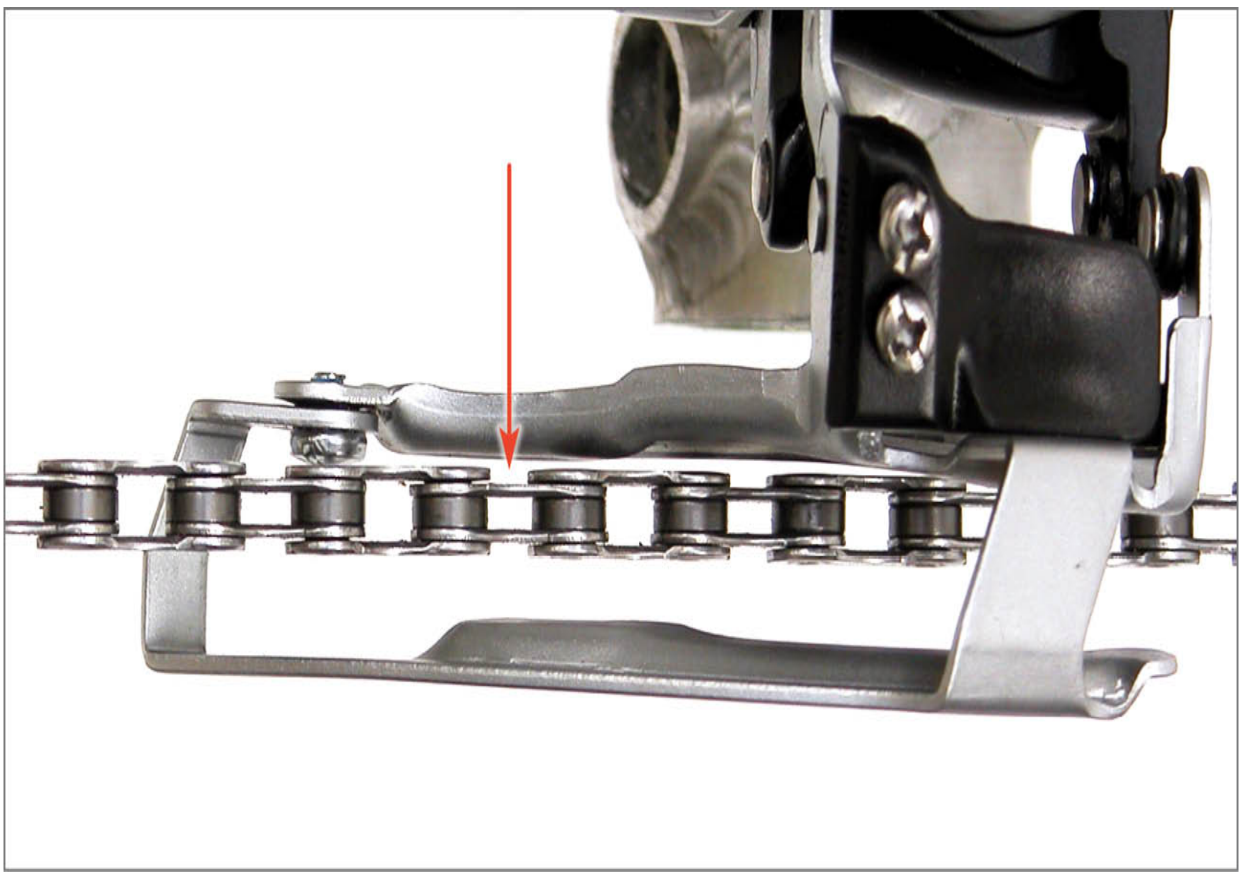


FIGURE 10.48: Sight gap between chain and inner derailleur cage

plate

d. Rotate the cranks slowly and continue to sight gap. Set clearance at narrowest or tightest point in the chainring rotation. Rotate the cranks and check that chain is not rubbing cage while chainrings and chain turn.
   1. If there is no gap and chain is rubbing cage, loosen L-limit screw 1⁄8 turn (counterclockwise). Inspect for gap again and repeat until slight gap appears.
   2. If the gap appears larger than 1mm tighten the L-limit screw 1⁄8 turn until the gap closes to 1mm.

e. Test the shift by shifting chain to next chainring and then shift back to the innermost chainring. If chain shifts quickly to the smallest ring, limit screw setting is adequate. The outward shift away from the smallest ring is not determined by the L-screw. A poor outward shift will be adjusted during the index or cable tension setting.

f. If the shift to the smallest ring from the next ring is slow (requires more than one crankset revolution to initiate shift), turn L-limit screw counterclockwise 1⁄8 turn and repeat test. Repeat 1⁄8 turn increments until shifting is adequate. The gap will open wider than the 1mm target but will still be as small as possible with adequate shifting.

g. If chain is shifting beyond the inner chainring and falls off the chainring, the gap may be too large or cage alignment may be off. Tighten L-limit screw 1⁄8 turn and check shift again. If chain ends up rubbing inner cage of derailleur yet still drops off inner chainring when shifting, other problems such as chainline or derailleur rotation exist.

H-Limit Screw

Setting the H-limit can be confusing because the spring in the derailleur body is constantly pulling the derailleur inward. The cable pulls against the spring to move the cage outward to shift. The H-limit screw should be set to stop the cage so it still allows a quick shift to the largest chainring, yet not allow the chain to go beyond the largest ring.

During the L-limit screw setting the cable was purposely slackened. When adjusting the H-limit screw adjustment, take out slack by turning the adjusting barrels outward. During checks of cage clearance and during shifting in the process maintain pressure on the shift lever to ensure the derailleur is pressing against the H-limit screw.

Procedure for H-limit screw adjustment:

a. If the adjusting barrel was turned in to slacken the cable for the L-limit adjustment, turn barrel outward.

b. Shift to outermost sprocket in rear and outermost front chainring. If the lever will not move the cage to the outer ring, return shifter to inner ring position. Loosen cable pinch bolt and pull slack from the cable. Retighten pinch bolt. Try shift again.

c. If the chain did not shift to the outer ring while maintaining pressure on the shifter, the H-limit may be too tight. Loosen the H-limit 1⁄4 turn and try the shift again.

d. If the chain did shift to the outer ring, maintain pressure on the shifter and inspect the gap between chain and outer cage plate. Alternatively pull on cable (figure 10.49). Only a small gap should be visible, approximately 0.5mm to 1mm. Rotate the crank slowly and continue to sight this gap. Set clearance at tightest point in chainring rotation (figure 10.50).

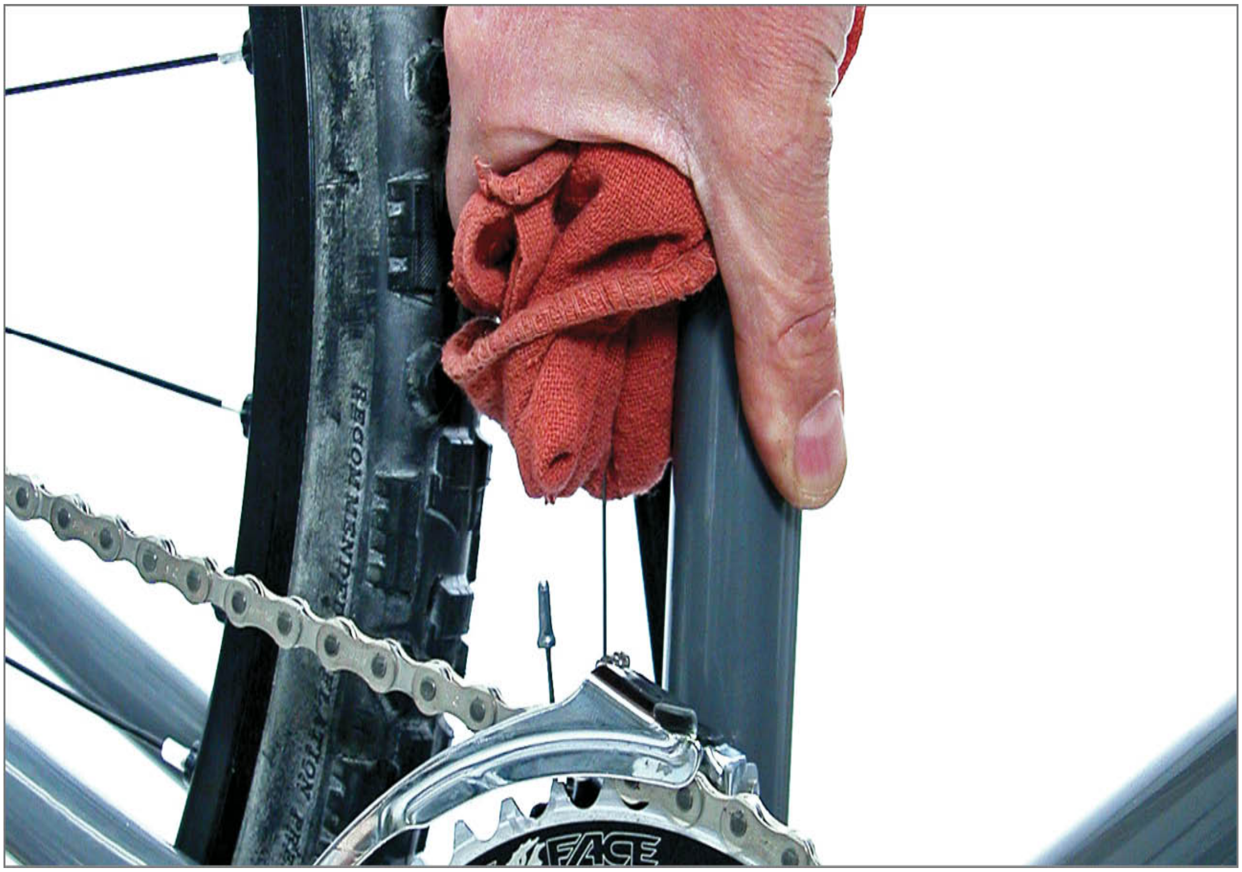


FIGURE 10.49: Pull cable by hand or lever to force derailleur to limit screw

FIGURE 10.50: View gap at closest point between chain and derailleur cage

e. If chain is rubbing outer cage, loosen H-limit screw 1⁄8 turn. Again, maintain pressure on the shift lever. Continue to loosen a small amount and press on lever to see any change in clearance.

f. If the chain has a large gap over 1mm, tighten H-limit screw repeatedly until chain does rub cage. Then loosen H-limit screw 1⁄8 turn and check as in step "d."

g. After adjusting the H-limit screw, test shift to the large chainring. Shift derailleur from small or middle chainring to largest ring. Again, maintain pressure on lever during shift. If shifting is slow, loosen H-limit screw 1⁄8 turn and repeat test. If chain shifts over the outside of the large chainring, tighten H-limit screw 1⁄8 turn and test shift again.

h. If chain ends up rubbing outer cage of derailleur yet still drops off outer chainring when shifting, other problems such as chainline or derailleur rotation exist.

FRONT INDEX ADJUSTMENT: THREE-CHAINRING BIKES

A front derailleur shift lever may have an index setting. If the shift lever has three distinctive stops or clicks, it is indexing. If the front shift lever is a friction type without any clicks, there is no index setting. If the front shift lever has multiple clicks, such as some twist grip style shifters, it is shifted similar to friction levers. The user simply selects the shifter position so there is no chain rub at the front derailleur. Set front indexing only after completing limit screw settings.

Turning the adjusting barrels at the shift lever, frame, or derailleur performs the index setting. Turning the adjusting barrel counterclockwise (unthreading) effectively lengthens the housing, and this moves the cage outward, but only between the L-limit and H-limit settings. Bike mechanics may say this “tightens” the index setting, but it is only moving the position of the cage. Turning the adjusting barrel clockwise (threading it into the shifter/frame/derailleur) effectively shortens the housing, and is said to “loosen” the setting. This positions the derailleur cage more inward compared to before the adjustment.

Procedure for index shifting adjustment:

a. Shift chain to middle chainring in the front and innermost rear sprocket.

b. View gap between inner cage plate and chain. Gap should be as small as possible without rubbing chain. To reduce gap, turn the adjusting barrel outward (counterclockwise). Check gap again and repeat as necessary.

c. If chain is rubbing cage at the inner plate, turn adjusting barrel clockwise to move cage inward.

d. If adjusting barrel is all the way in or out and no adjustment is possible, reset derailleur cable tension. Shift to innermost chainring and loosen derailleur cable pinch bolt. Turn the adjusting barrel all the way clockwise and then back out 2–3 turns. Pull derailleur cable with a fourth hand tool and tighten pinch bolt. Repeat index adjustment procedure.

e. Test by shifting front derailleur to all three front chainrings.

FRONT INDEX ADJUSTMENT: TWO-CHAINRING BIKES

If the shift lever has distinctive stops or clicks for each chainring, it is indexing. If the front shift lever is a friction type without any clicks, there is no index setting. For friction systems, the cyclist moves the shift lever as needed to shift between sprockets. The cyclist then adjusts the cage side to side by moving the lever to avoid any chain rubbing against the front derailleur cage.

Set the indexing feature only after checking and setting the limit screws. If the limit screws were initially set to allow no chain rub, the index feature should also produce no chain rub. Some shifters permit trim of the front cage. This is a half-click that moves the cage slightly over and is used when the chain is moved left or right from different gear selections at the rear cogs.

Procedure for index shifting adjustment:

a. Shift chain to outer chainring in the front and outermost rear sprocket.

b. View gap between outer cage plate and chain.

c. If outer cage plate clears the chain, index setting is adequate.

d. If plate is rubbing chain, increase derailleur cable tension by turning adjusting barrel counterclockwise and check again.

e. If adjusting barrel is all the way in or out and no adjustment is possible, reset derailleur cable tension. Shift to innermost chainring and loosen derailleur cable pinch bolt. Turn the adjusting barrel all the way clockwise and then back out two to three turns. Pull the derailleur cable with a fourth hand tool and tighten pinch bolt. Repeat index adjustment procedure.

f. Test shift front derailleur between front chainrings.

SHIMANO® TOGGLE FRONT DERAILLEURS

The Shimano® "toggle" design front derailleurs such as the FR-R9100, FD-8500 and FD-5801 have unique features in the set up and adjustment.

Similar to the Shimano® FD-9000 and FD-4700 "long arm" road derailleur systems, the derailleur body contains a "support bolt" to push against the frame and brace the derailleur. The screw pushes against a metal plate called the backing plate adhered to the frame behind the derailleur body. To adjust the support screw, align the body with the cage slightly inward at the back end. Snug the screw against the plate to push cage parallel to biggest chainring (figure 10.51).

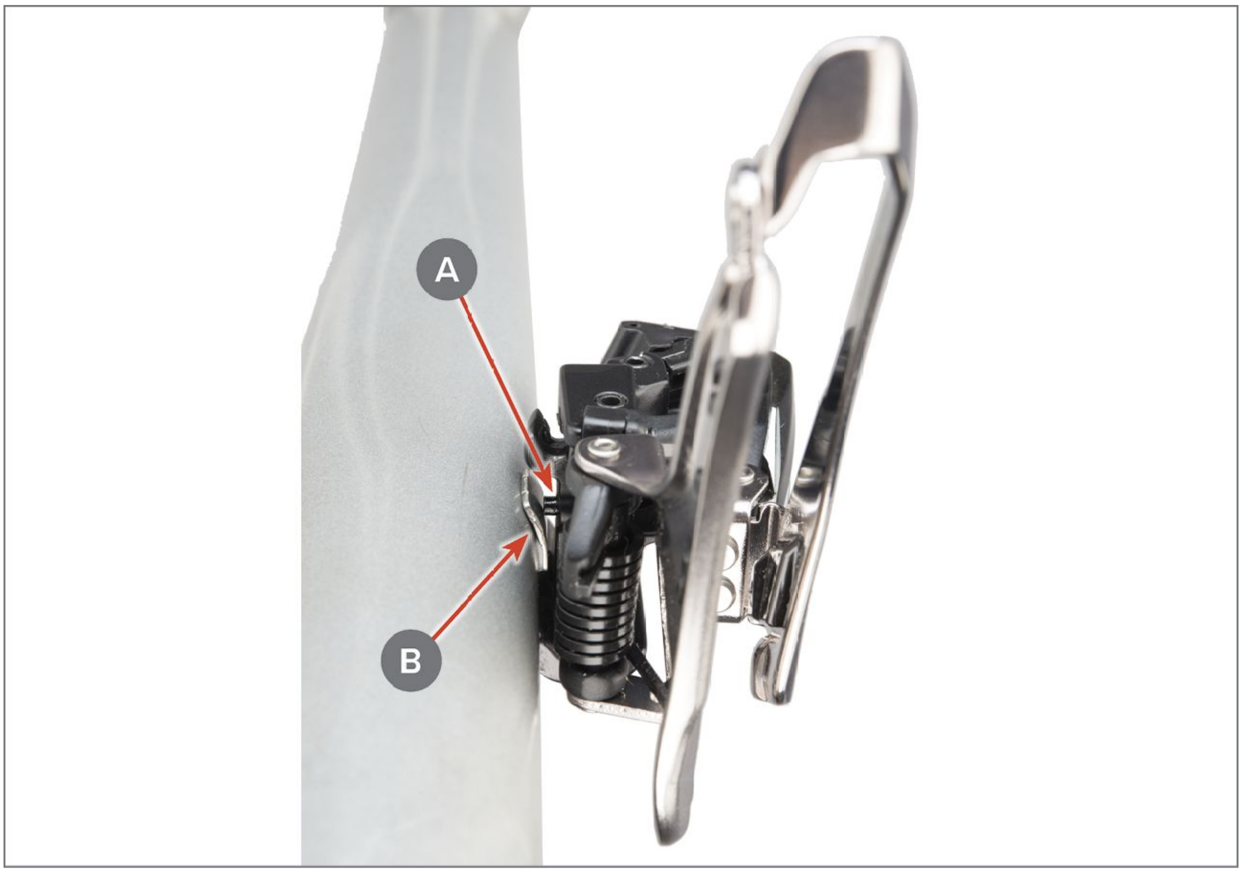


FIGURE 10.51: Support bolt (A) pushing against backing plate (B) to brace the front derailleur

The L-limit screw adjusts like a traditional four-bar linkage front derailleur. However, the H-limit screw moves the cage linkage independently of cable pull to correctly position the cage over the largest ring. Turning the screw does not change the pull of the cable. Turning the H-screw clockwise moves the cage outward, and turning it counterclockwise moves the cage inward (figure 10.52).

FIGURE 10.52: The Shimano® toggle design front derailleur and H-limit screw

To adjust the H-screw, put the chain in the smallest rear cog. Put the chain in the largest chainring using the shift lever, pushing all the way to the stop. Use the H-screw to set gap of no more than 0.5mm from the outer cage to the chain. Set the L-screw with the chain in the largest rear cog and small front chainring. Set gap between inner cage and chain to 0–0.5mm.

The cable setting is used for the shift lever trim feature and is done at the derailleur body, not at an adjusting barrel on the housing. The cable pinch bolt mechanism rotates to draw up slack when the cable adjustment screw is tightened (figure 10.53).

FIGURE 10.53: Turn adjustment screw to rotate the cable pinch bolt system and control cable slack

Shift the chain to the largest chainring in front and largest rear sprocket. Push the shift lever lightly to trim position and move cage inward slightly to the H-trim position. Use cable setting screw to just clear inner cage of derailleur from chain.

SHIMANO® LONG ARM DUAL CABLE MOUNT FRONT DERAILLEUR

The Shimano® front derailleurs such as the FD-9000 and FD-4700 have unique features that require special considerations during installation and adjustment. The front derailleur cable-fixing plate has two positions to allow for changes in leverage of the cable pull. The two options change the mechanical advantage of the cable pull during the shift. Frames vary in how the cable is fed to the derailleur, and this angle changes the amount of effective cable pull on the long arm (figure 10.54).

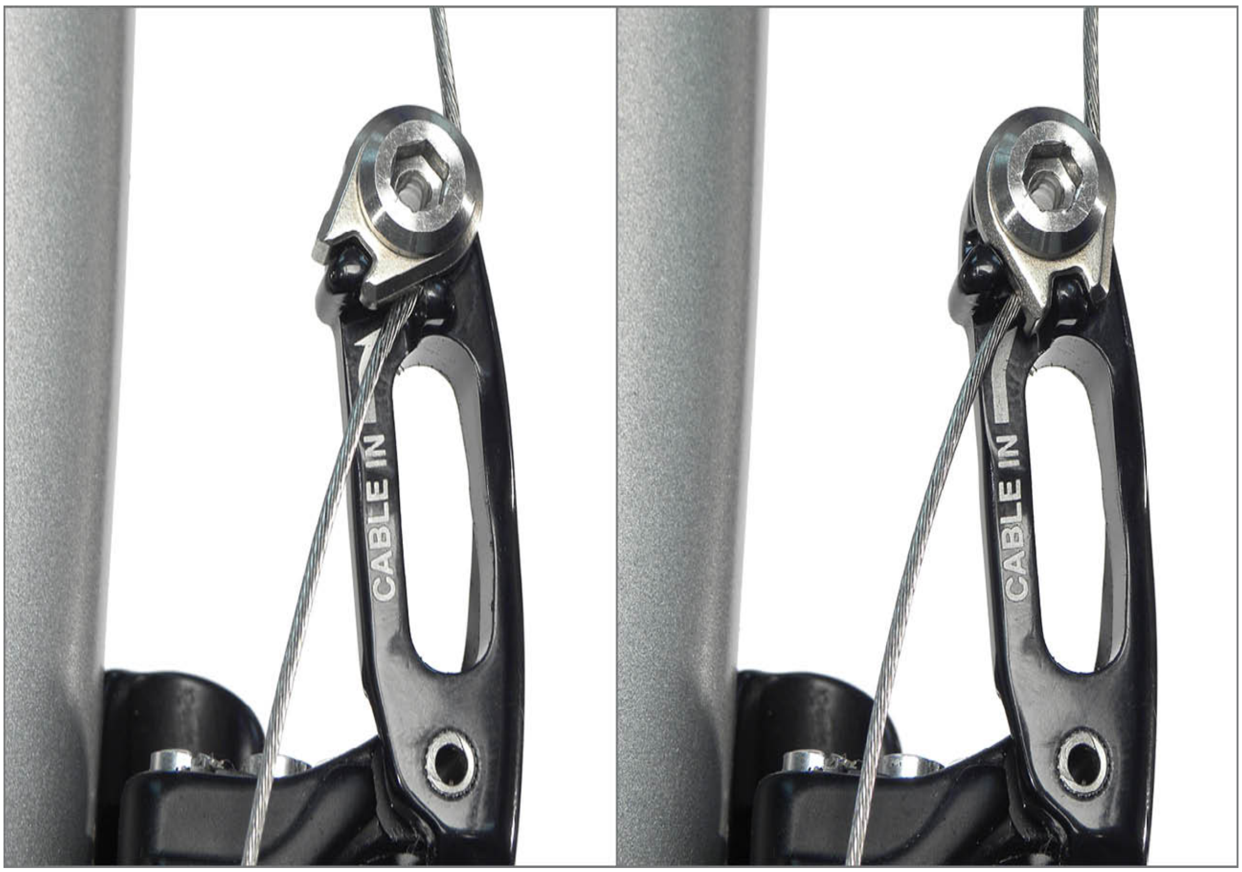


FIGURE 10.54: The two routing options at the notched washer

Like other derailleurs, the outer cage should be set for 1–3mm above the largest chainring. Set the cage parallel to the largest chainring using the support screw as with the Toggle style derailleurs.

Although Shimano® offers the TL-FD68 cable routing tool to assist in determining which pinch bolt routing option to use, the most common is with the washer in the “on” position, or rotated to the right.

If your choice of routing options was wrong, the derailleur will not index or trim properly. Loosen the cable mounting bolt and remove cable. Rotate washer to other position and attach cable.

FRONT DERAILLEUR PERFORMANCE

There are limits to the performance of a front derailleur. There may be certain gear combinations that simply do not work well or cause problems. For example, when the bike is used with the smallest front chainring and the smallest rear sprocket, the chain may rub against an adjacent chainring or the front derailleur. This is called “cross-chaining.” As a simple rule, if a gear combination causes a rubbing problem, avoid that gear. If there is no rubbing, the gear is considered usable.

Another chain rub problem can occur when pedaling in the largest front chainring and the smallest rear sprocket. Very hard pedaling will flex the frame slightly with each stroke, which may cause a chain to rub on the front derailleur cage, even for properly adjusted derailleurs. Loosening the H-limit screw and then tightening the index setting cable tension will move the front cage out more. This may stop the rubbing, but it may also cause the chain to shift over the largest chainring and come off. If all aspects of front derailleur adjustments are correct on this bike, the rider is simply exceeding the engineering and design limits of the machine.

REAR DERAILLEUR

Rear derailleurs push or "derail" the chain from one rear sprocket and move it to another. The chain feeds through two pulleys held by a cage. The upper derailleur pulley, also referred to as the "G-pulley" or "guide pulley," moves the chain from sprocket to sprocket. The cage is adjusted so the G-pulley aligns under the rear cog as selected by the shift lever.

The derailleur body is fitted with a spring that is pulled tightly or released by the derailleur cable. Pulling the cable at the shift lever effectively shortens the cable and moves the derailleur cage and guide pulley toward larger sprockets, while tightening the return spring. When the shift lever feeds out cable (relaxing cable tension), the return spring moves the body and pulley outward toward smaller cogs. Useful terms for parts of the rear derailleur are illustrated in figure 10.55.

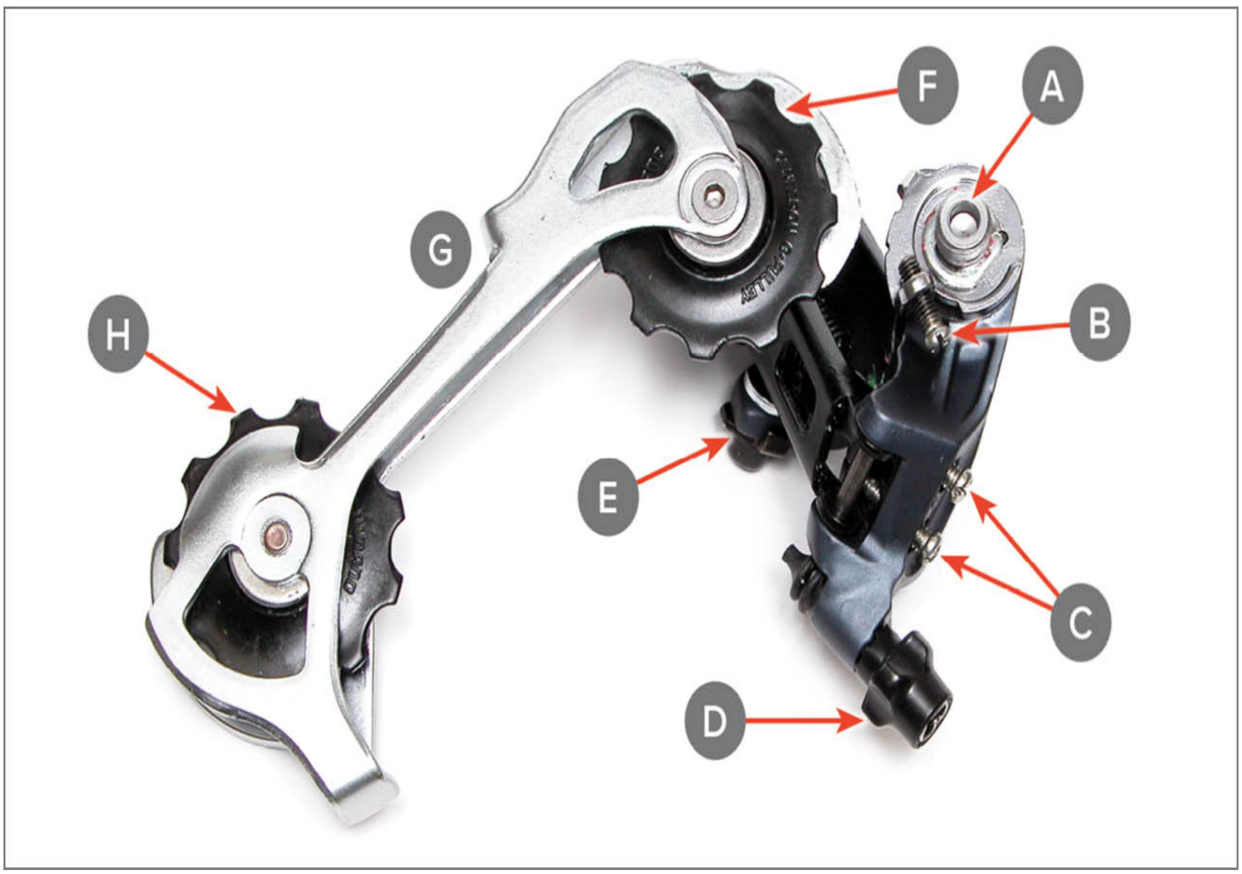


FIGURE 10.55: Derailleur component parts: (A) mounting bolt, (B) body or B-screw, (C) limit screws, (D) adjusting barrel, (E) cable pinch bolt, (F) upper pulley or G-pulley, (G) pulley cage, (H) lower

pulley or T-pulley

DERAILLEUR CAPACITY AND MAXIMUM SPROCKET SIZE

The rear derailleur is usually selected to be compatible with sprocket sizing and spacing used on the bicycle. Derailleurs are made with specifications for the maximum sprocket size and the total capacity. The maximum sprocket size is the largest rear sprocket the derailleur will accept. For example, a bike with a 32-tooth rear sprocket should use a rear derailleur with a maximum sprocket size of at least 32.

The total derailleur capacity refers to the derailleur's ability to take up chain slack as the derailleur shifts between different gear combinations. The capacity requirements of the bicycle are determined by the front and rear sprocket sizes. To calculate this capacity, the difference between the smallest and largest chainring sizes is added to the difference between the smallest and largest sprockets of the rear sprockets. For example, if a bike has a front crankset with 22-32-46 tooth chainrings, the spread between the front extremes is 24 teeth. If the rear sprocket sizing is 13-14-15-17-19-21-23-26-30 teeth, the spread is 17 teeth. The total capacity requirements are then 17 plus 24, or a total of 41. A derailleur rated for a total capacity of 41 or greater would take up the slack for any gear combination. However, this does not mean that every gear combination will work well, only that the derailleur will take up the chain slack.

If the bike uses only one front chainring, capacity is simply the difference between the smallest and largest rear sprocket. A 12-speed rear cassette with 10-50 teeth would require a capacity of 40.

Bikes are sometimes fitted with derailleurs that do not take up chain slack in every gear combination. In the multiple chainring example above, if the bicycle is fitted with a derailleur with a rated capacity of 33, the derailleur will not be able to take up the slack in all gear combinations. The chain will hang slack when it is on the inner front chainring and in the 13, 14, 15, 17, or 19 rear sprockets. If the chain were shortened to accommodate these gear combinations, it would be too short when the bike is in the 46-tooth front chainring and the several of the larger sprockets in the back. When sizing a chain with a derailleur that violates the total capacity needs of the bike, it is best to use the sizing method in Chapter 8—Chains. This will allow shifting to largest rear and front sprockets, but the chain will hang slack in some small front chainring and small rear sprocket combinations. It will be necessary to avoid those gear combinations that cause problems in pedaling or shifting or to replace the derailleur with a model of greater total capacity.

Check with derailleur manufacturer for specifications on maximum sprocket size and total capacity. As a general rule, total capacity increases as the derailleur cage gets longer, and the distance between pulley wheels increases. Short cage derailleurs, those with approximately 50mm between pulley wheels, will have a capacity of about 29 teeth. Medium cage derailleurs (approximately 73mm) will have a capacity of approximately 33 teeth. Long cage derailleurs (approximately 85mm) will have a capacity of approximately 45 teeth.

DERAILLEUR INSTALLATION

The rear derailleur attaches to the frame at a fitting called the derailleur hanger. The hanger has a tab that acts as a stop for derailleur rotation (figure 10.56). Grease the bolt before installing. When installing the derailleur, use care that any stop screw or plate on the derailleur clears the hanger tab. Hold the derailleur clockwise from its “normal” position while engaging the thread. The torque for the mounting bolt is modest (Appendix C). Test that the derailleur is freely pivoting on the hanger.

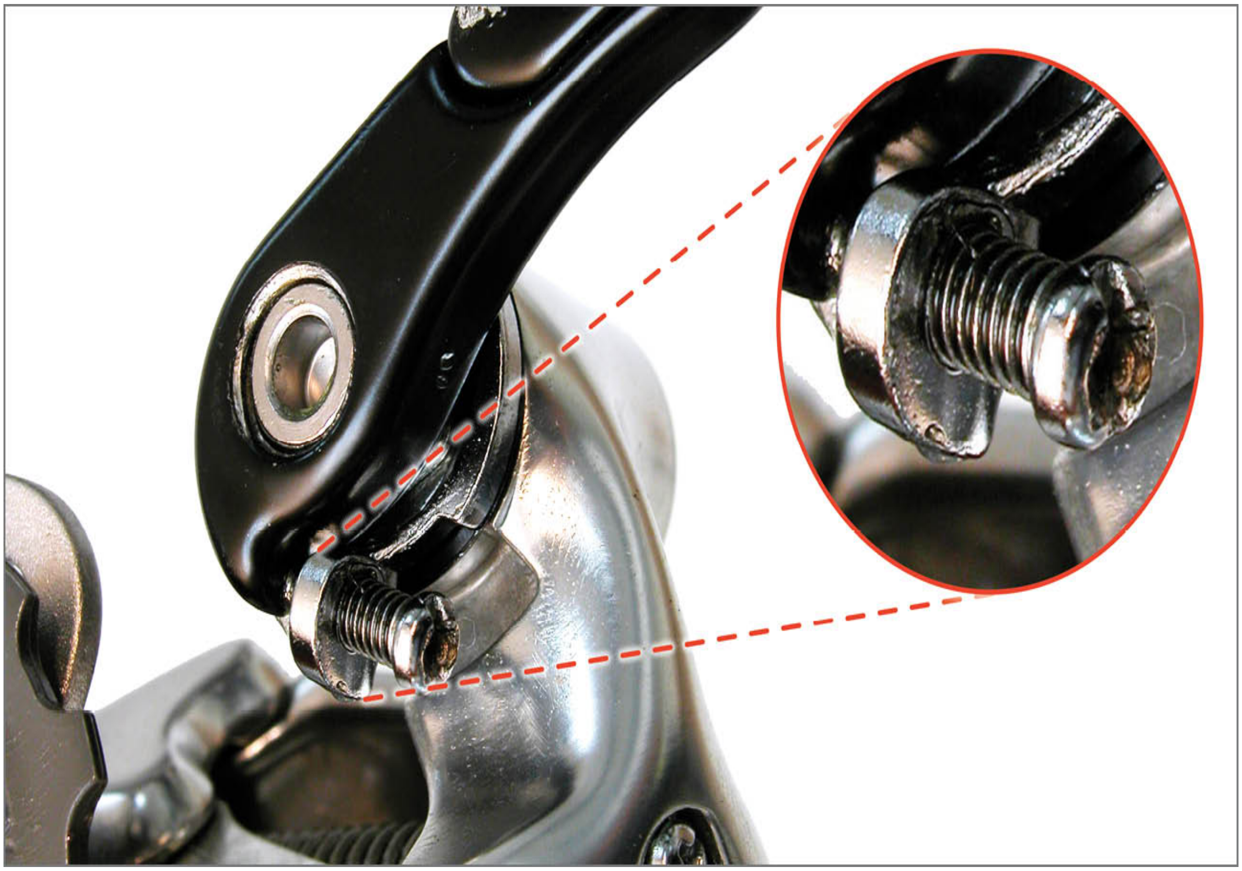


FIGURE 10.56: Frame hanger tab and derailleur stop screw

DERAILLEUR CABLE ATTACHMENT

The derailleur cable attaches to the rear derailleur at the pinch bolt mechanism. The derailleur cable is flattened by a plate and bolt (figure 10.57). Unthread the bolt and look for a groove in either the plate or derailleur arm. The derailleur cable will lie in this depression or notch. Inspect the groove and keep the derailleur cable in line with it. There may also be a tab system. The tab is used to prevent the washer from rotating. The derailleur cable is not usually routed around the tab.

FIGURE 10.57: Derailleur cable routing through pinch mechanism

While the bolt is loose, take the opportunity to lubricate the threads. Pull the derailleur cable snug and secure the bolt. The derailleur cable will be flattened where it is pinched.

LIMIT SCREW ADJUSTMENT

The inward and outward travel of the rear derailleur cage and pulleys is limited using the derailleur limit screws. Limit screws will strike and stop the derailleur linkage as it articulates through its motions. The limit screws are usually marked “H” and “L.” The H-limit screw sets the outermost limit of the derailleur, and the L-limit screw sets the innermost limit. The location of limit screws on the derailleur body may vary between manufacturers. For some models you may need to inspect the linkage and determine which screw is the H-screw or L-screw. Find the end of the screw and note if it rests on part of the parallelogram as it moves (figure 10.58).

FIGURE 10.58: Inspect end of limit screw to determine which limit it control

Properly set, the derailleur will stop on both the extreme outward sprocket (the smallest in size) and the extreme innermost sprocket (the largest in size). The limit screws, however, do not control the derailleur on any of the sprockets between the two extremes. The sprockets between the extremes are set to the clicks (dwell) in the shift lever by using the adjusting barrel during indexing adjustments.

It is normal for a chain to make some noise during a shift. The shift may appear subjectively “noisy,” “loud,” or “rough.” Factors like the type and design of the chain or sprocket, the wear on each, and the amount and type of lubrication will affect the noise a chain makes during shifting. The limit screws do nothing to affect the noise during the shift between the two extreme sprockets.

The adjustment procedure below begins with setting the H-limit screw, then adjusts the index setting with adjusting barrels, then proceeds to set the L-limit setting, and concludes by checking the B-screw.

H-Limit Screw

When setting limit screws, it can be confusing to determine what is controlled by the shift lever and cable settings, and what is controlled by the limit screw. The pull or release of the cable moves the pulleys and derailleur, but the limit screws determine where it will stop. When adjusting the H-limit screw, there are two aspects that are important. First, pay attention to the outward shift from the second smallest sprocket to the outermost sprocket. Next, notice how the chain rides on the outermost sprocket as you pedal. Do not be concerned, however, when adjusting the limit screw to how the chain rides when it is on the second sprocket. That is a function of derailleur cable pull, not limit screw settings. Cable pull controls the indexing and shifting to inner cogs, but the H-limit screw controls only the chain position on the outermost sprocket.

Procedure for H-limit screw adjustment:

a. Shift chain to outermost (largest) chainring. Shift chain to outermost rear sprocket (smallest sprocket). Even if you’re already on the smallest cog, keep clicking until there are no more clicks. This makes certain the shifter is fully actuated outward.

b. Check tension on rear derailleur cable. If derailleur cable appears to have any tension, it may interfere with the H-limit screw setting. Turn adjusting barrel clockwise to slacken cable and eliminate derailleur cable tension.

c. Rotate the cranks at a quick cadence, approximately 60 rpm or more.

Shift the derailleur one sprocket inward and then shift derailleur back to outermost sprocket. Note how it shifted. Even if it takes two clicks at the shifter, move the chain to the next cog and then out.

d. If the shift appears acceptable, tighten H-limit screw 1⁄4 turn clockwise and repeat shifting to the second sprocket only. Continue to test shift, tightening H-limit screw by 1⁄4 turn increments. When the outward shift becomes slow, hesitant, or simply no longer shifts outward, the adjustment screw is too tight. Another symptom of a too tight H-limit screw is when the chain is on the smallest sprocket but makes a rattle from rubbing the second sprocket inward. Look under the rear sprockets where the chain meets the sprockets (figure 10.59). The chain will be seen rubbing against the next sprocket inward and making an excessive rattling noise.

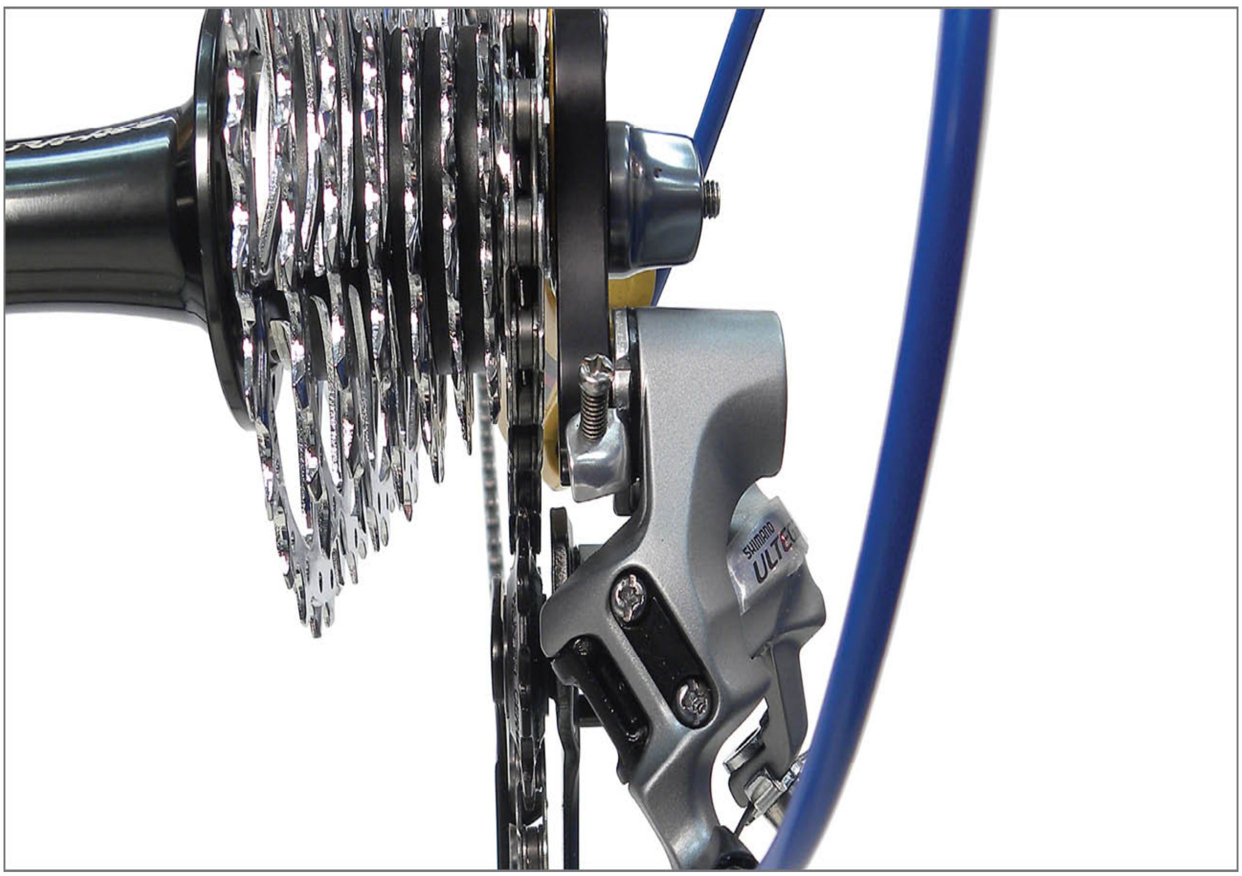


FIGURE 10.59: Inspect the H-limit by view behind and under the rear cogs

e. When symptoms of a too tight H-limit screw have appeared, loosen H-limit screw 1⁄4 turn and check shift again. Repeat process of shifting and correcting by 1⁄4 turn increments. When too tight symptoms disappear, H-limit screw is at tightest acceptable setting. There is no need to loosen further, the H-limit screw setting is done.

Index Adjustment

Indexing is adjusted next because the shifter must work properly for the G-pulley to reach the inner sprocket.

The indexing procedure here assumes that there are no unusual problems, such as bent derailleurs, bent derailleur hangers, or excess derailleur cable friction from dirt in the housing. Additionally, it is assumed the shift levers and drivetrain components are from the same manufacturer, as mixing brands of components within the drivetrain may result in less than optimal shifting.

Indexing shift levers use “dwell,” which is a hesitation or “click” in the lever rotation. These hesitations are calculated to match the movements of the derailleur and the spacing in the rear sprockets. The design of some derailleur and shift lever brands requires a little more push (or twist) of the lever to complete the shift. The amount of extra push or twist is not consistent between manufacturers and each rider must learn the particular attributes of his or her system. In other words, an index lever may, in some cases, need to be “finessed” to shift properly, and this finesse must be learned by the user.

Adjusting barrels may be located either at the rear derailleur, the shift lever or both. These are used to effectively shorten or lengthen cable length to adjust the rear indexing. For conventional derailleurs, turning the adjusting barrel counterclockwise moves the rear derailleur guide pulley (G-pulley) toward the spokes. Traditional bicycle mechanic talk is that this “tightens” the index setting. However, it is not like tuning a guitar with tension that changes the performance. Adjusting the cable at the adjusting barrel moves the set of index clicks at the shifter to align with the rear cassette cogs.

Turning the adjusting barrel clockwise allows the spring in the derailleur to pull the guide pulley outward (toward the dropout). The derailleur adjusting barrel settings will not stop the derailleur at its extreme limits. Again, the H-limit and L-limit screws stop the derailleur at its outermost and innermost settings.

Although there is a range of adjusting barrel settings that will adequately shift the derailleur, the procedure here is to find the one setting that removes the most slack ("tightens") from the cable so it will allow good shifting to all the gears normally used. This setting is then the longest lasting indexing adjustment because the cable system tends to wear and settle in with use. To find this setting, begin by purposely making the G-pulley adjustment too far inward by removing cable slack, and then turn the adjusting barrel inward incrementally to move the G-pulley outward.

There are two basic symptoms of a "too tight" derailleur cable: a rattling noise from the chain rubbing against the next sprocket inward or a slow or hesitant outward shift.

It is important understand there is a normal noise from the chain riding on the sprocket, and this is useful for setting indexing tension. For any given bike, there is a "base level" of noise from the chain as it passes over the sprocket teeth. To demonstrate the "base level" noise, shift the bike to the second sprocket by manually pulling the derailleur cable. Continue to rotate the cranks and move the derailleur cable slightly to hear changes in the level of noise. The quietest level of noise may be considered the base or normal level for that bike. When the derailleur pulley wheel is out of alignment, the chain may make excessive noise beyond this level.

Procedure for rear index setting adjustment:

a. Set H-limit screw, if not already done.

b. Rotating the cranks, shift chain to outermost rear sprocket (smallest). Shift chain to outermost (largest) chainring in front for multiple chainring bikes.

c. Test initial derailleur cable tension. Rotate the cranks at a normal cadence and shift rear derailleur with ONLY ONE click on lever. Use care to move lever only to the second position. If derailleur moves one sprocket inward, it has a basic setting. Proceed to step "e" below.

d. If derailleur fails to shift one sprocket with one derailleur shift (click), the derailleur cable may be too slack. Return shifter to the outer position. Turn adjusting barrel fully into derailleur body (or shift lever) then turn counterclockwise two turns to allow for index adjustments. Loosen derailleur cable pinch bolt and gently pull on derailleur cable with fourth hand tool or pliers to remove slack (figure 10.60). Tighten derailleur cable pinch bolt. Attempt shift again. If derailleur will not shift one sprocket after removing slack, return lever back to outermost sprocket position and increase derailleur cable tension by turning adjusting barrel counterclockwise one-half turn and attempt shift again.

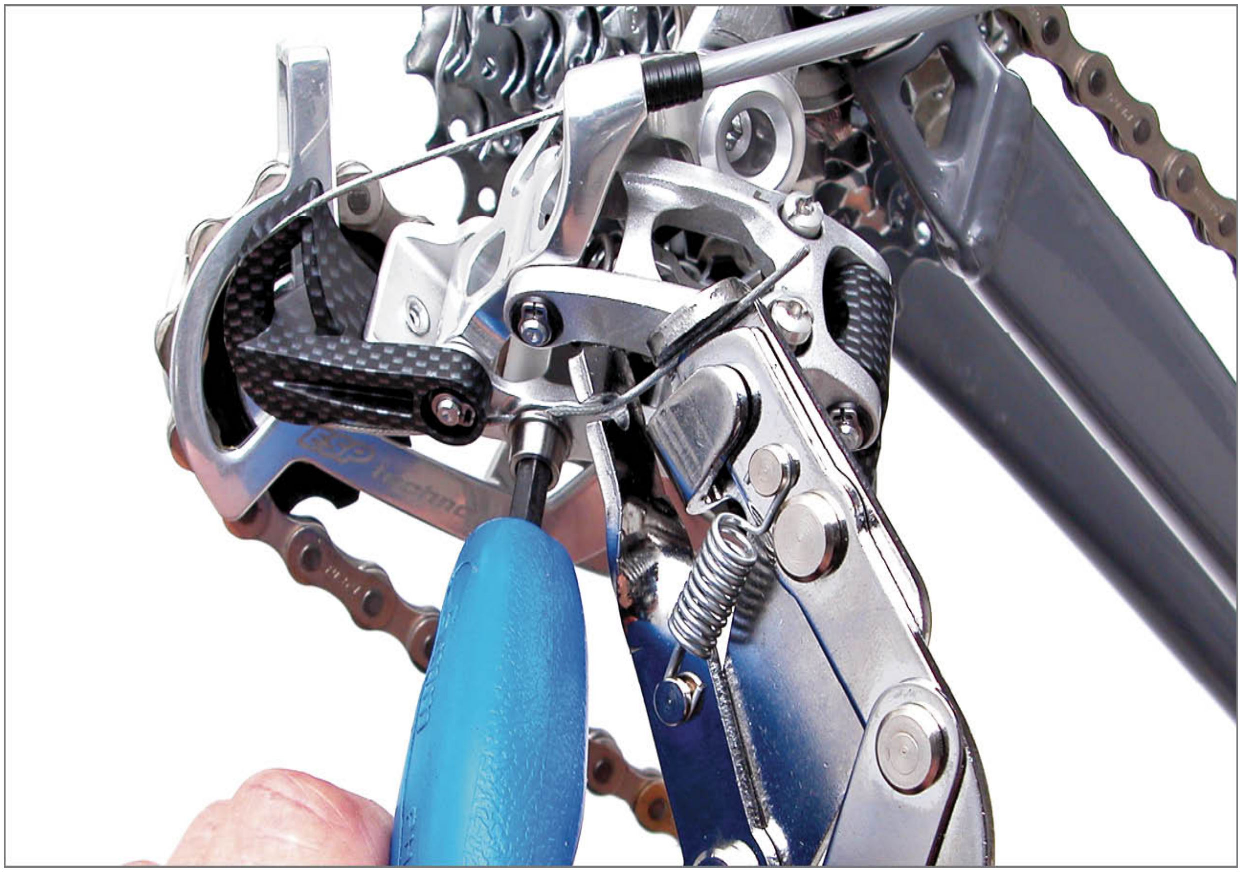


FIGURE 10.60: Pull excessive slack from cable at pinch bolt

e. Once the derailleur has shifted inward one position with one click at the shifter, proceed to shift to other rear sprockets. However, do not shift to largest sprocket. That will be done during the L-limit screw setting, done after indexing.

f. To find the longest lasting index setting, purposely increase cable tension by turning adjusting barrel counterclockwise until a definite rattling is heard. Rattle is from the chain scraping against the next sprocket. Inspect by sighting from under the rear sprockets (figure 10.61).

FIGURE 10.61: Chain positioned too far inward resulting in a rattle against sprocket

g. Once a too-tight symptom is achieved, turn adjusting barrel 1⁄4 turn clockwise to move G-pulley outward. Test shifting and again look for symptom of G-pulley being too far inward. Continue turning adjusting barrel 1⁄4 turn clockwise at a time until rattle disappears (figure 10.62).

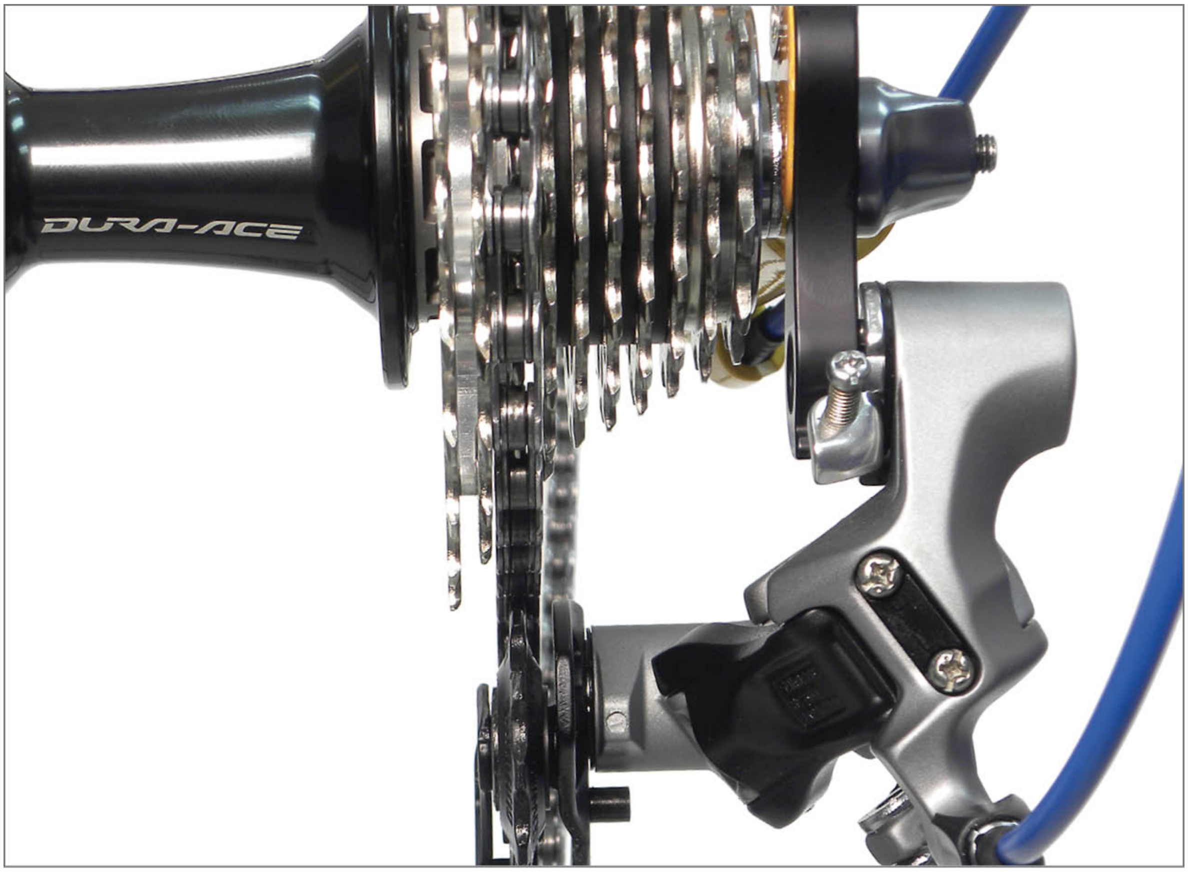


FIGURE 10.62: Index setting adjusted so chain rides under sprockets

h. Shift derailleur one sprocket inward at a time, listening for signs of rattle. Turn adjusting barrel ¼ turn clockwise to eliminate rattle. Note: Do not attempt to shift to largest rear sprocket while the chain is in the largest front sprocket. This gear is normally not used and adjusting tension to this shift may compromise other commonly used gears.
i. Shift to innermost (smallest) chainring and check shifting again. If no rattling is present, index adjustment is done. Proceed to L-limit screw setting.

L-Limit Screw

The L-limit screw is set after the indexing is properly adjusted. This will allow the cable to fully pull the derailleur to the largest sprocket. The L-limit screw adjustment acts to stop the derailleur from moving inward (toward the spokes). The L-screw adjustment should allow the pulley wheels to shift the chain to the innermost sprocket, but not off the sprocket into the spokes. To find this, purposely tighten the L-screw until there are symptoms of it being too tight, then begin loosening 1⁄4 turn until proper shifting to the largest sprocket appears. Be concerned only with the inward shift from the second-to-innermost sprocket to the innermost sprocket. Additionally, notice how the chain rides on the innermost sprocket once it makes the shift.

There is an exception to the procedure below. SRAM® 1X 11 and 12-speed systems use large inner sprockets with a wide-thin tooth pattern. It can occur that the chain appears to be riding up and off the teeth. This is due to the timing of the chain on the sprocket as the shifter is pushed. This occurs only in a repair stand because there is no load on the chain to settle it back down to the sprocket. When you are riding the bike, this phenomenon does not occur because the load on the chain settles to the correct timing of the largest sprocket teeth.

Procedure for L-limit screw adjustment:

a. With the index properly adjusted, shift bike to middle chainring of three chainring bikes or smaller chainring of double chainring bikes.

b. Using the shift lever, rotate the cranks and shift to second to largest rear cog.

c. If the chain shifts to the largest cog, find the ideal L-limit by tightening the screw 1⁄2 turn and attempting the shift again. If the chain shifts well in a tighter L-limit setting, tight again 1⁄2 turn and test the shift. Tighten until there are clear symptoms of a too tight L-limit screw, such as the chain not making the shift to the largest sprocket or making excessive noise when on the largest cog. If the chain did not make the shift to the largest cog initially, it was too tight already.

d. Loosen the screw 1⁄4 turn and try the shift again. When the chains make the shift, inspect how the chain rides on the cog. Loosen only what is necessary to make it ride quietly on the largest sprocket.

e. As a test of the L-limit screw, stop pedaling and put extra pressure on the shifter with the chain on the largest cog. Watch at the rear derailleur—the cage should not move inward. The linkage should be stopped just at this largest sprocket.

B-Screw Adjustment

After setting the L-screw, check the “B-screw” for an adequate setting. The B-screw controls the derailleur body angle, hence the name. Adjust the distance between pulley and sprocket when the chain is on the smallest sprocket in front and on the largest sprocket in back. This places the upper pulley and largest rear sprocket at their closest point.

For the common Shimano® and SRAM® derailleurs the B-screw is located behind the derailleur's upper mounting bolt (figure 10.63).

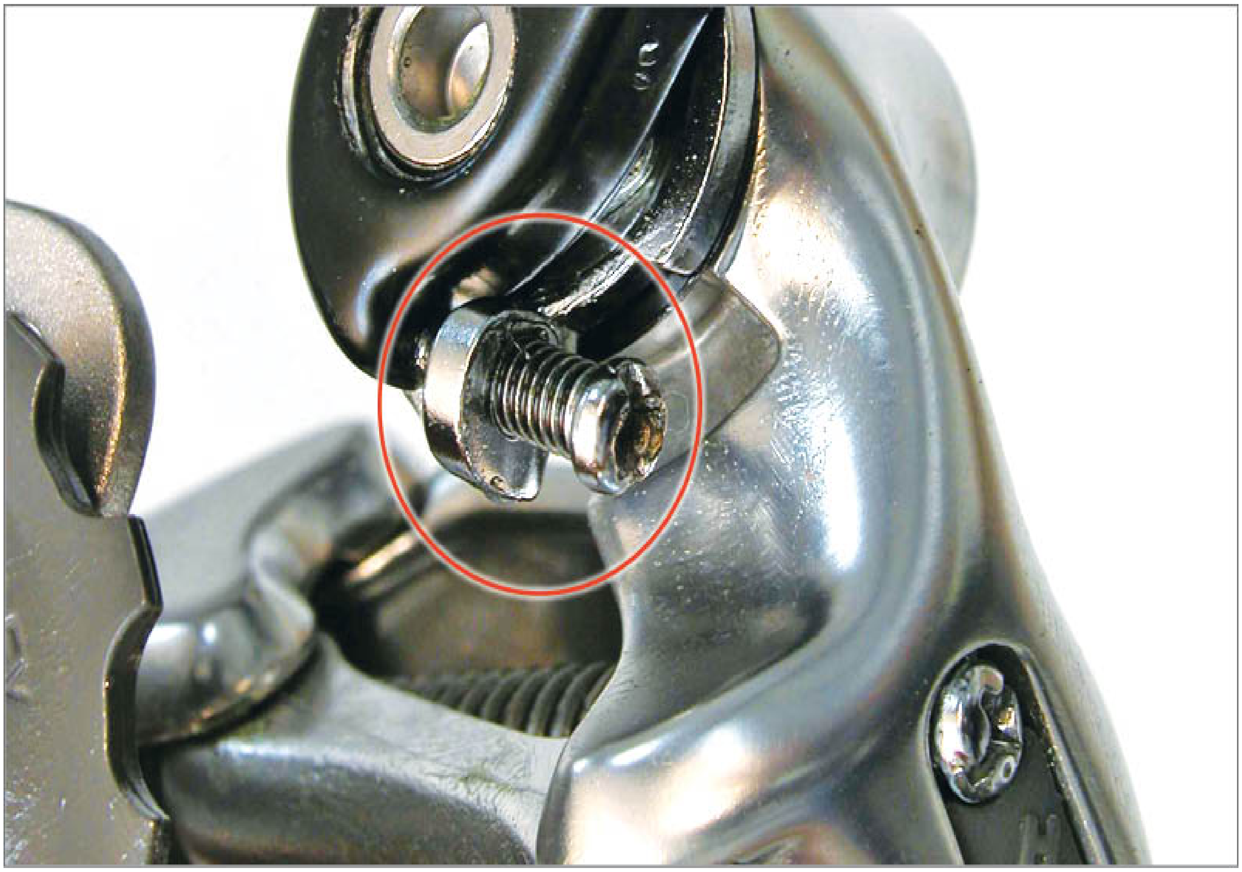


FIGURE 10.63: Location of B-screw

Shift to the innermost sprocket and the smallest front ring of multiple ring cranks. Rotate and view the upper pulley relative to the largest sprocket. If the pulley is rubbing against the sprocket, tighten the B-screw to increase upper pivot spring tension, which pulls the pulley back and away from the sprocket. Generally, there should be a gap of 7–8mm between the upper pulley and sprocket. If the gap is large, loosen the screw. Rotate the cranks backwards to double-check for rubbing. Besides a rumbling noise when the pedals are turned, the derailleur may hang up as it attempts to shift off the largest cog to the smaller cogs.

If the G-pulley is set back too far, there may be imprecise shifting between cogs. The pulley is too far away to effectively move the chain.

SRAM® and some models of Shimano® derailleurs do not use a spring in the upper mounting bolt. A screw behind the upper mounting bolt adjusts the distance from the upper pulley to the largest sprocket. Adjust so there is approximately a 6mm (1⁄4 inch) gap between the pulley and largest sprocket. Use a 6mm hex wrench to estimate this gap (figure 10.64). Tighten the B-screw to pull the body back, and increase the distance between sprocket and pulley. Loosen the screw to decrease gap size.

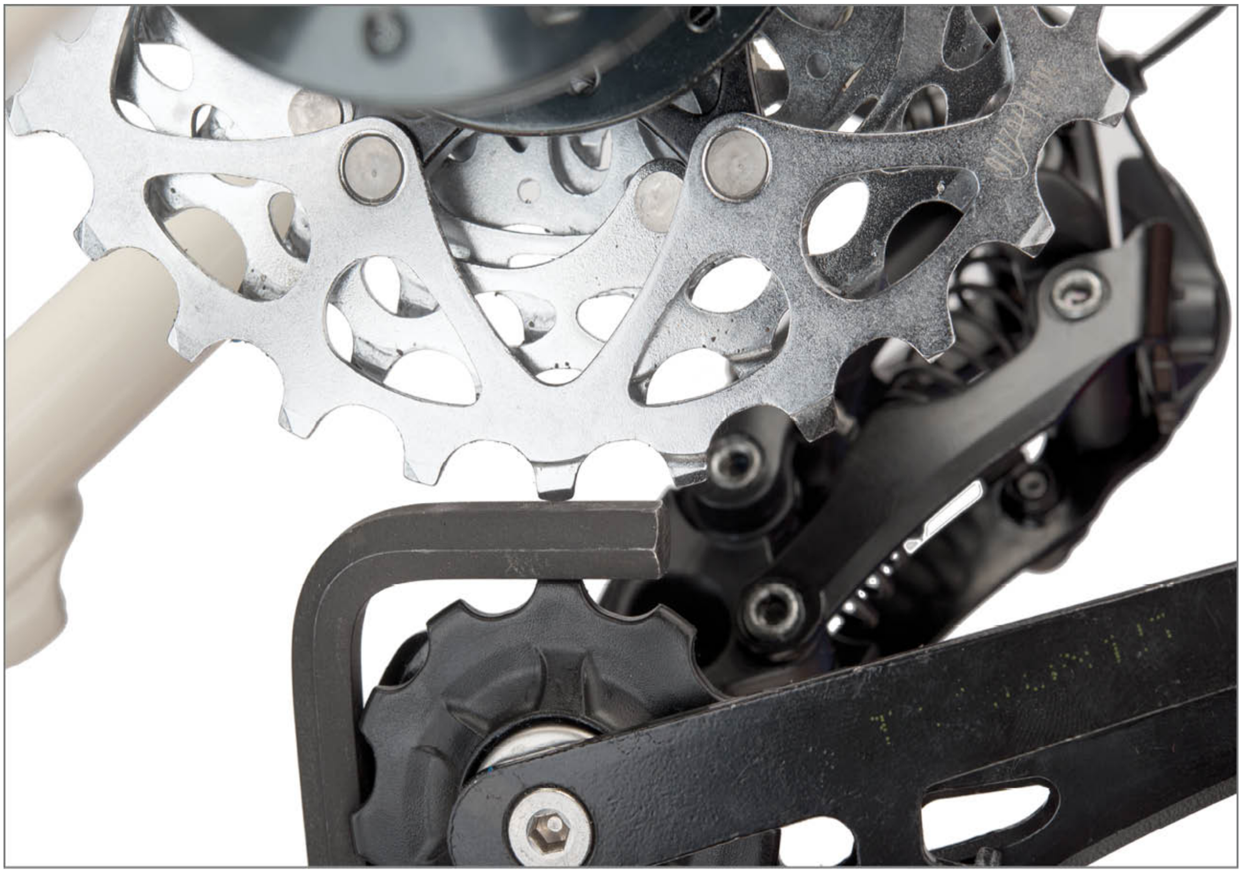


FIGURE 10.64: SRAM® and Shimano® Shadow setting for the upper pulley to largest cog

SRAM® 11 and 12-speed off-road derailleurs should be set with a large B-gap of at least 16mm (figure 10.65).

FIGURE 10.65: Set gap between G-pulley and largest sprocket

CLUTCH SYSTEM REAR DERAILLEURS

Shimano®, SRAM®, Box® and MicroShift® have rear derailleurs available with a clutch system in the pulley cage. In a traditional rear derailleur, the pulleys are mounted to a cage that pivots on the derailleur body. A spring in the body applies tension to the low pulley, pulling it backward. If the bike hits a bump, the weight of the chain will force the pulley forward, and the chain will bounce up and down. This often results in the chain slapping the chain stay and can also result the chain coming off the chainrings.

A clutch system in the lower pivot provides resistance to forward movement of the lower pulley to help maintain chain tension during bumps. The cage is free to pull back on the pulley from the clutch design. This reduces chain slap and helps maintain the chain on the chainrings.

Clutch system derailleurs make removing and installing the rear wheel more difficult. The Shimano® Shadow Plus® RD design includes a lever at the lower pivot which disengages the clutch. The up position on the lever is the “on” or working position. Pulling the lever down disengages the clutch for the “off” position (figure 10.66).

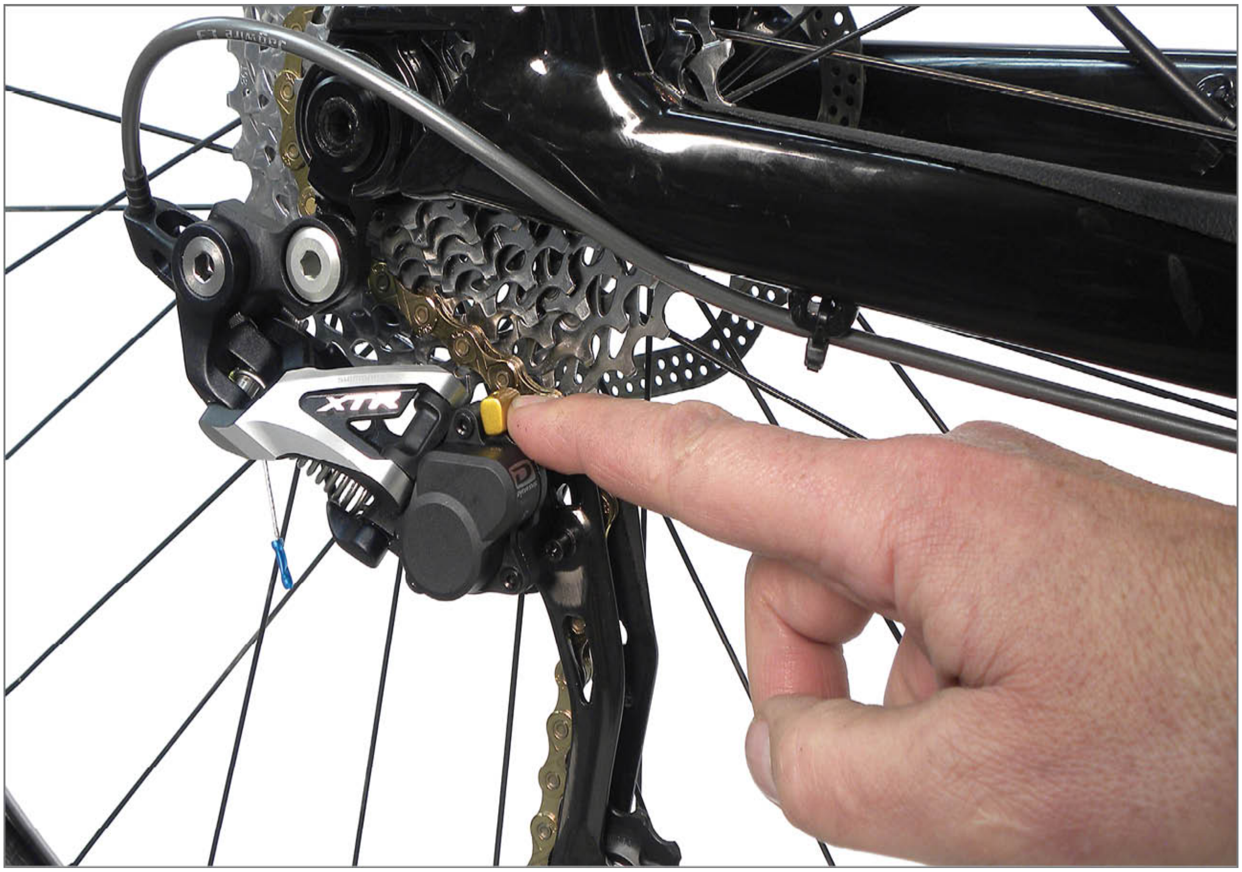


FIGURE 10.66: Push “on-off” lever upward to return derailleur to clutch operation mode

SRAM® and Box® model derailleur clutches are always engaged—there is not an on–off lever. MicroShift® models have a switch for on-off clutch engagement. The clutch type systems are adjusted the same for limit screws and indexing. These systems typically do require more force to move the shift lever.

CHAINLINE

Chainline is the relation of the front and rear sprockets to the center plane of the bicycle (figure 10.67). The bike center plane is an imaginary plane running from front to rear through the middle of the bike. As an example, a front crankset and/or front derailleur might be designed to have a chainline of 50mm. The front derailleur would then work best when the middle of the chainrings are 50mm from the bike centerline.

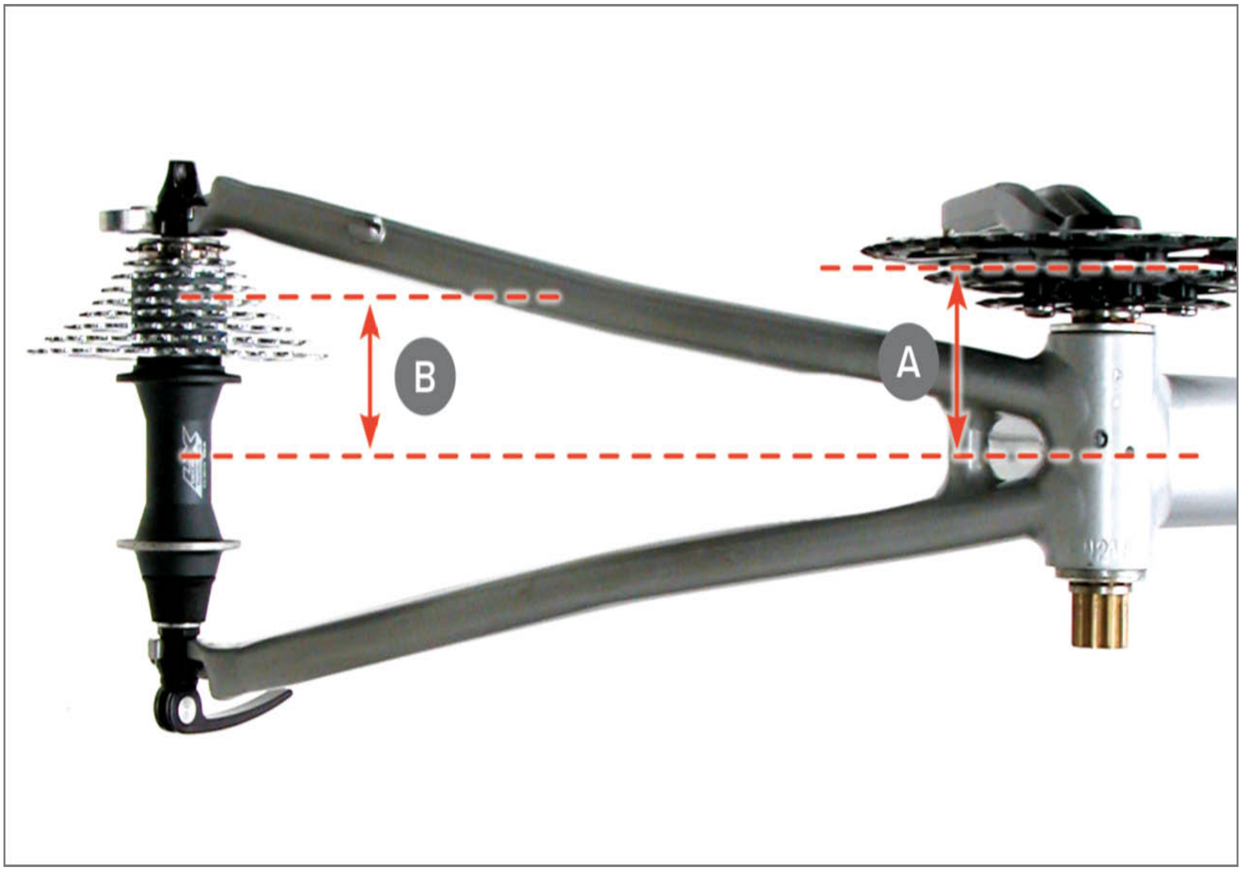


FIGURE 10.67: Chainline in relationship to the bike mid plane: (A) distance from middle of front chainrings to mid plane, (B) distance from middle of rear sprockets to mid plane

Chainline can also refer to the relative position of the front and rear sprockets to each other without regard to the bike centerline. This is called "effective chainline." Effective chainline is simply the difference between "A" and "B," but distance "A" is not always designed to be equal to "B." For example, with most three-chainring bikes, the middle of nine rear sprockets will be approximately 45mm from the bicycle mid plane or distance “B.” The manufacturer’s specified chainline of triple cranksets ranges from 47mm to 50mm, distance “A.” In this case, the front chainrings are not designed to align directly with the middle of the rear sprockets.

Drivetrain manufacturers generally do not consider all gear combinations to be usable. For example, a “27-speed” bike has three chainrings in front and nine sprockets in the rear for a total of 27 gears. There are likely to be several gear combinations that are exact or very close duplicates. It is also likely that the chain will rub the side of the middle chainring when the chain is on the smallest sprocket in front and possibly two or three of the smallest sprockets in back. This is simply the limitation of the design. If the front crankset were moved outward until there was no rubbing in these combinations, there would likely be other shifting problems in other gear combinations, such as the largest chainring and several of the inner rear sprockets.

Sprocket combinations that should be avoided are termed “cross-chaining.” Drivetrain manufacturers vary on exactly which combinations should not be used. Generally, it is assumed that the smallest front chainring and smallest rear sprocket will not be used, nor will the largest rear sprocket in combination with the largest front chainring. As a practical matter, each bike may be different as to which exact gear combinations are unusable.

As a rule of thumb, if the bicycle shifts well, the chainline should be considered adequate. However, chainline adjustment may be needed if:

- Chain jumps off large chainring when front derailleur is correctly adjusted for height, rotation, and limit screw settings.
- Chain rides off lower derailleur pulley teeth when derailleur or derailleur hanger is not bent.
- Chain rattles on inner faces of front chainrings in what should be usable gears.
- Chain derails off inner chainring when front derailleur is correctly adjusted for height, rotation, and limit screw settings.
- Front derailleur cannot be adjusted to stop overshifts while still allowing good shifting.

Moving the front chainrings can make changes to chainline. For the three-piece cranks, there may be different bottom bracket spindle widths available to move the chainring inward or outward. Shorter spindles locate the chainrings inward, and longer spindles locate the chainrings outward.

On some models, a thin spacer can be placed under the right-side cup or bearing adaptor of the bottom bracket to move the chainrings outward. There are limits to this, however, because it results in less thread engagement for the right-side cup. There are also limits to moving a derailleur inward, toward the bike mid plane. The chainrings may end up rubbing the frame. Additionally, the front derailleur may not work well with the front chainrings too close to the frame.

Two-piece cranks offer little opportunity to change the chainline. If the bike uses threaded bearing adaptors with spacers under each side, these can be moved between sides to allow some chainline changes in the rings.

Chainline manipulation with rear sprockets is also limited. The freehub mechanism cannot be moved laterally on the hub shell. If the hub uses a threaded axle, spacers may sometimes be moved under the cone locknut to shift the rear sprocket positions. If spacers are moved from the right side to the left side, double-check that the chain will not strike the frame when on the smallest rear cog. It is important not to change the fit of the hub into the frame. Any change of axle spacing will also change the centering of the wheel rim over the hub. Double-check and correct dish if the spacers were manipulated.

Modern bicycles are designed for forward pedaling. There are times, such as when preventing the inside pedal from striking a tight corner, when a cyclist may want to pedal backwards briefly. When pedaling forward, the chain is guided to the rear sprocket by the upper derailleur pulley, which is very close to the sprockets. When a cyclist backpedals, the chain is guided to the rear sprocket by the front chainrings, which are relatively far away. The chain may disengage or become jammed when it is backpedaled because the front chainrings cannot keep the chain guided straight to the sprocket. Disengagement is likely to be worse in gear combinations where the chainline is offset the greatest. It may be possible to minimize backpedaling problems by changing chainline, but again, this may result in other problems.

DERAILLEUR HANGER ALIGNMENT & REPAIR

The rear derailleur is mounted to the bike at the derailleur hanger. The hanger should be aligned parallel to the rear sprockets. A bent or misaligned derailleur hanger will result in poor shifting performance (figure 10.68). The derailleur hanger can become bent when the bike is crashed, bumped with force, or if something, such as a stick, becomes caught in the derailleur when riding. A misaligned hanger may also just be a manufacturer oversight on a new bike.

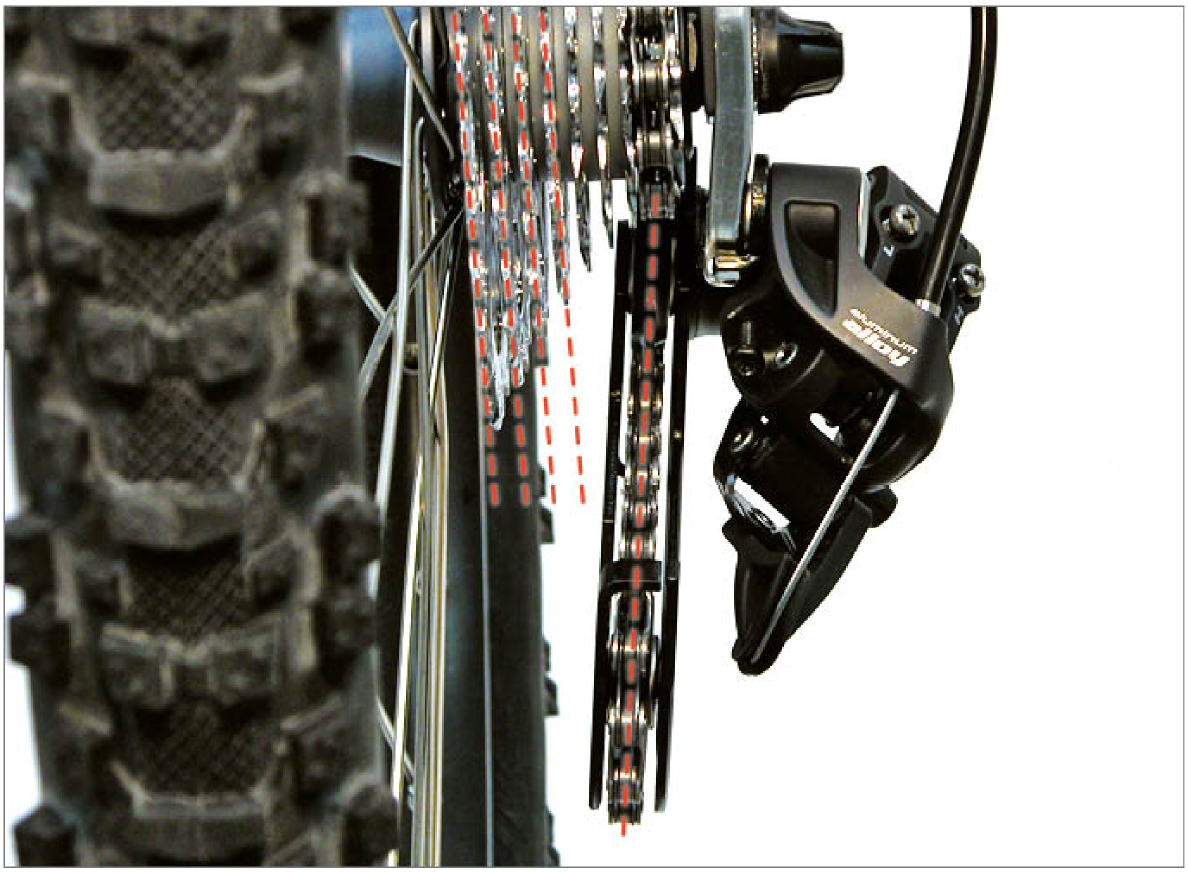


FIGURE 10.68: Bent hanger from impact to rear derailleur

Many hangers can be bent, aligned, rebent, and realigned repeatedly. This is because there is very little stress from riding the bike or shifting gears. As a rule of thumb, if a hanger survives a repair by bending, it will survive the riding.

To check alignment and repair the derailleur hanger, use a derailleur hanger alignment gauge, such as the Park Tool DAG-2.2 Derailleur Hanger

Alignment Gauge. The tool extends the plane of the hanger and compares it to the rim. If the hanger is aligned to a wheel rim, it will allow the derailleur pulleys to be aligned to the rear sprockets.

Bikes may use a bolt-on or replaceable hanger (figure 10.69). These hanger styles are also repairable and can be bent and rebent for proper alignment. Even newly installed hangers should be checked for proper alignment. Before checking alignment on replaceable hangers, double-check the tightness of fasteners connecting them to the frame.

FIGURE 10.69: Replaceable type derailleur hangers should be checked for proper alignment

Procedure for derailleur hanger alignment:

a. Mount the bike in a repair stand. Level the bike in the stand, as if it were on flat ground.
b. Check that the rear wheel is mounted straight in the frame.
c. Remove rear derailleur from hanger. Derailleur may simply hang from derailleur cable and housing during hanger alignment. Note: If this is

an electric shifting rear derailleur use care not to damage the wire.

d. Install DAG-2.2 into hanger and tighten handle. If the DAG-2.2 does not thread easily into the derailleur hanger, chase and clean the threads using a tap as necessary. Do not use the DAG-2.2 threads as a “chaser” of bad derailleur hanger threads.

e. Rotate the arm toward the left side of the rim at the nine o’clock position. Rotate the tire valve to the same position. Use the valve on the rim as a constant reference point when checking the hanger (figure 10.70). By checking the same point on the rim, wheel trueness or dish will not affect alignment.

FIGURE 10.70: Set DAG-2.2 gauge to reference rim at the nine o’clock position

f. Loosen the sliding gauge knob and move the pointer to contact the rim, then secure the knob.

g. Push gauge bracket toward hub before rotating arm. This prevents pointer from being forced against rim.

h. Rotate DAG-2.2 and rim valve 180 degrees to the three o’clock position. Slide pointer toward rim to same point near valve.

i. There are three possible results:

1. The pointer barely touches the rim or has a small gap less than 3mm. In this case, hanger is aligned horizontally.
2. The pointer is away from the rim some distance (figure 10.71). The hanger is misaligned. If the distance is greater than 3mm, the hanger will need realignment. Use a 3mm hex wrench to gauge the gap.

FIGURE 10.71: Gauge indicating misaligned hanger

3. The pointer strikes inside the rim, which indicates a misaligned hanger (figure 10.72). It is easier to determine the error by seeing the gap between the rim and pointer. Reset tool to contact rim at the three o’clock position and rotate back to the nine o’clock position. There will be a gap between the rim and the pointer.

FIGURE 10.72: Reset gauge if it falls inside rim

j. Bend the derailleur hanger a small amount using the arm of the DAG-2.2. Then recheck both sides. Reset pointer and remeasure gap. Generally, it is best to bend with the DAG-2.2 arm next to the chain stay (figure 10.73). This allows you to use the stay for leverage and to control the amount of bending either inward or out.

FIGURE 10.73: Use frame to leverage and control bending of hanger

k. Repeat bending and checking until the gap is less than 4mm. A 4mm gap at the rim means the hanger is off less than a millimeter at the sprockets, where the derailleur actually shifts. Use a 4mm hex wrench as a “go/no-go” gauge.

l. When the horizontal positions are aligned, move on to check the six o’clock and twelve o’clock position. Set gauge to the six o’clock position, and then check at the twelve o’clock position.

m. Rotate DAG-2.2 and rim valve 180 degrees. If gap exceeds the 4mm tolerance, bend accordingly in small increments, rechecking and resetting the pointer (figure 10.74). When the gap is less than 4mm, keep the same setting and check at the nine o’clock position. When three points that are 90 degrees apart are within 4mm, hanger is aligned.

FIGURE 10.74: Use a 4mm hex wrench as a go/no-go gauge when checking tolerance

n. Remove the tool and reinstall the derailleur.

o. Check settings on both limit screws and check index settings.

The Shimano® Shadow rear derailleurs use an extra“B-link” attaching the derailleur main body to bikes using a traditional hanger. This B-link effectively creates two attachment points. After checking the derailleur hanger, reattach the derailleur. Remove the main derailleur body from the B-link and use the DAG-2.2 to double-check the B-link alignment (figure 10.75). It can occur the frame derailleur hanger is aligned but the derailleur body is not because the B-link was not aligned.

FIGURE 10.75: Check alignment of the B-link for best derailleur alignment

The threads of the derailleur hanger are commonly 10mm x 1mm. Campagnolo uses threads that are 10mm x 26tpi, which can effectively interchange with the 10mm x 1mm thread without issue. If the derailleur installs with difficulty, the threads of the hanger should be tapped. As a test of thread acceptability, fully tighten the derailleur. If the derailleur bolt does not strip, the hanger is usable. If the threads strip and fail, it is possible for a professional mechanic to install a coil thread or a T-nut repair system (figure 10.76). These repairs work well when properly done and allow the bike to be used normally.

FIGURE 10.76: T-nut thread repair of a stripped hanger

DERAILLEUR WEAR & SERVICE

Both front and rear derailleurs will eventually wear out with use. Play and excess movement develop at the pivots. Grab the lower cage of a rear derailleur and pull left to right to test play. It may help to compare the play in the old derailleur to new models. Replace the derailleur when the cage at the lower pulley has more than a 1⁄8 inch (3mm) movement.

The chain travels over the pulleys and pulley teeth, which causes wear. Worn pulley wheels will not engage well with the chain (figure 10.77). The pulley wheels can usually be replaced.

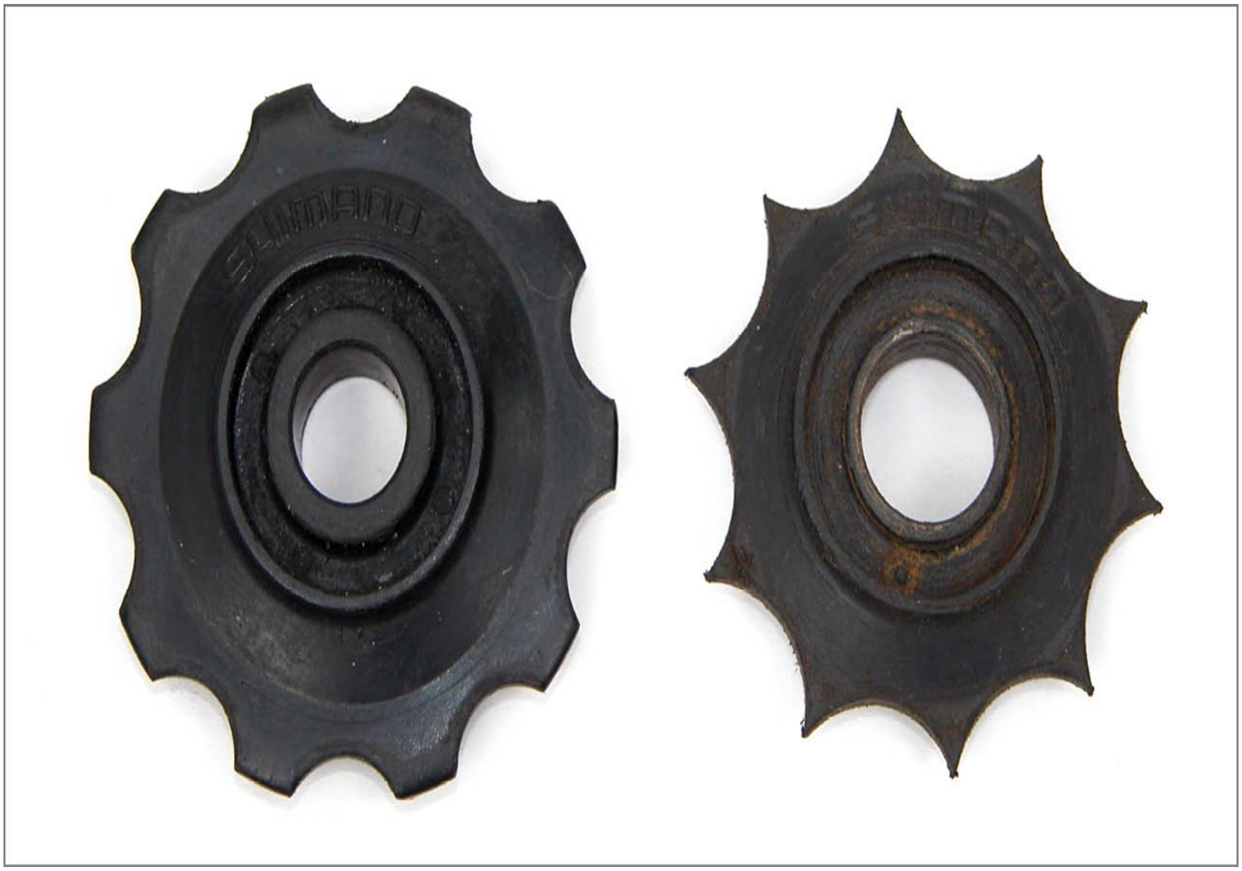


FIGURE 10.77: Unworn pulley wheel on left and extremely worn pulley wheel on right

The rear derailleur can be brushed off and lightly scrubbed with soap or solvent. Use care not to get solvent in the upper and lower pivots. Solvent in the cage pivots will ruin the grease inside. It is also possible to disassemble, clean, and reassemble some rear derailleurs. Overhaul of the rear derailleur is not discussed in this book.

The front derailleur can be flushed with degreaser, dried, and relubricated at the spring and all pivot points with a light lubricant. The pivots of the cage will eventually develop play and slop with enough use. Grab the back end of the derailleur and pull from side to side. Compare the old derailleur to the movement on a new derailleur. The cage may also be gouged or damaged from dragging on a chain. Front derailleurs typically have no replaceable parts and, when the derailleur wears out, should be replaced as a unit.

TABLE 10.1: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Chain skips in all gear combinations	Poor indexing adjustment	Readjust indexing
Shifting is slow or hesitant for either inward or outward shifts	Friction in the cable system	Lubricate and/or replace cable and housing
Shifting is slow or hesitant on inward shifts	Poor indexing adjustment with cable tension too loose (Rapid Rise™ likely too tight)	Increase cable tension (Rapid Rise™ decrease cable tension)
Shifting is slow or hesitant on outward shifts	Poor indexing adjustment with cable tension too tight (Rapid Rise™ likely too loose)	Decrease cable tension (Rapid Rise™ increase cable tension)
Chain skips under pressure in only 1, 2, or 3 rear sprockets	Sprockets and chain may be worn out	Inspect and replace sprockets and chain
Chain shifts off largest front chainring	Front H-limit screw too loose, or rotation of cage is off	Inspect and correct cage rotation as necessary Check H-limit screw setting
Chain shifts off smallest front chainring	Front L-limit screw too loose, or rotation of cage is off	Inspect and correct cage rotation as necessary Check L-limit screw setting
Chain shifts slowly or not at all to largest front chainring	Front derailleur cable tension too loose, H-limit screw too tight, and/or rotation of cage is off	Check front index setting Check derailleur rotation and H-limit screw setting
Chain shifts slowly or not at all to smallest front chainring	Front derailleur cable tension too tight, and/or L-limit screw too tight, and/or rotation of cage is off	Check front index setting Check derailleur rotation and L-limit screw setting
Chain shifts well to largest front chainring but outer cage rubs after shift is completed	Front derailleur cable tension too loose	Increase front derailleur cable tension
Chain skips under load at front chainrings	Front chainrings worn	Replace chainrings

CHAPTER 11

ELECTRONIC DERAILLEUR SYSTEMS

Electronic derailleurs use on-board batteries to power servo motors housed in the front or rear derailleur linkage. Motors move the derailleurs and push the chain to the appropriate sprockets. A switch in the shift lever activates the motor to move the derailleur cages inward or outward. There are manufacturers using both wireless and wired systems to interface with the shifters. “Indexing” features are controlled by microprocessors located inside the components. Manufacturers commonly have downloadable apps to help tune and track the system. The apps are often able to change features and operating system functions.

SHIMANO® DI2® ELECTRONIC INTELLIGENT SYSTEM

The Shimano Di2® electronic shifting system is available in road and off-road groups. Shifting and adjustment are similar for both types of groups.

LEVERS

Left and right integrated road shift/brake levers contain two electronic switches each (figure 11.1). The “X” switch on the side of the lever blade is used for shifting to larger sized sprockets. The “Y” switch is located behind the brake lever blade, and permits shifting the chain to smaller sprockets.

FIGURE 11.1: X and Y switches located on a drop brake lever

Mountain bike Di2® systems use flat bar shifters (figure 11.2). These clamp to the bar like mechanical shifters. The wire is routed from the lever to the front junction box. It is possible to use only the right shifter to control both the rear and front derailleur by using the system’s software to determine the next shift.

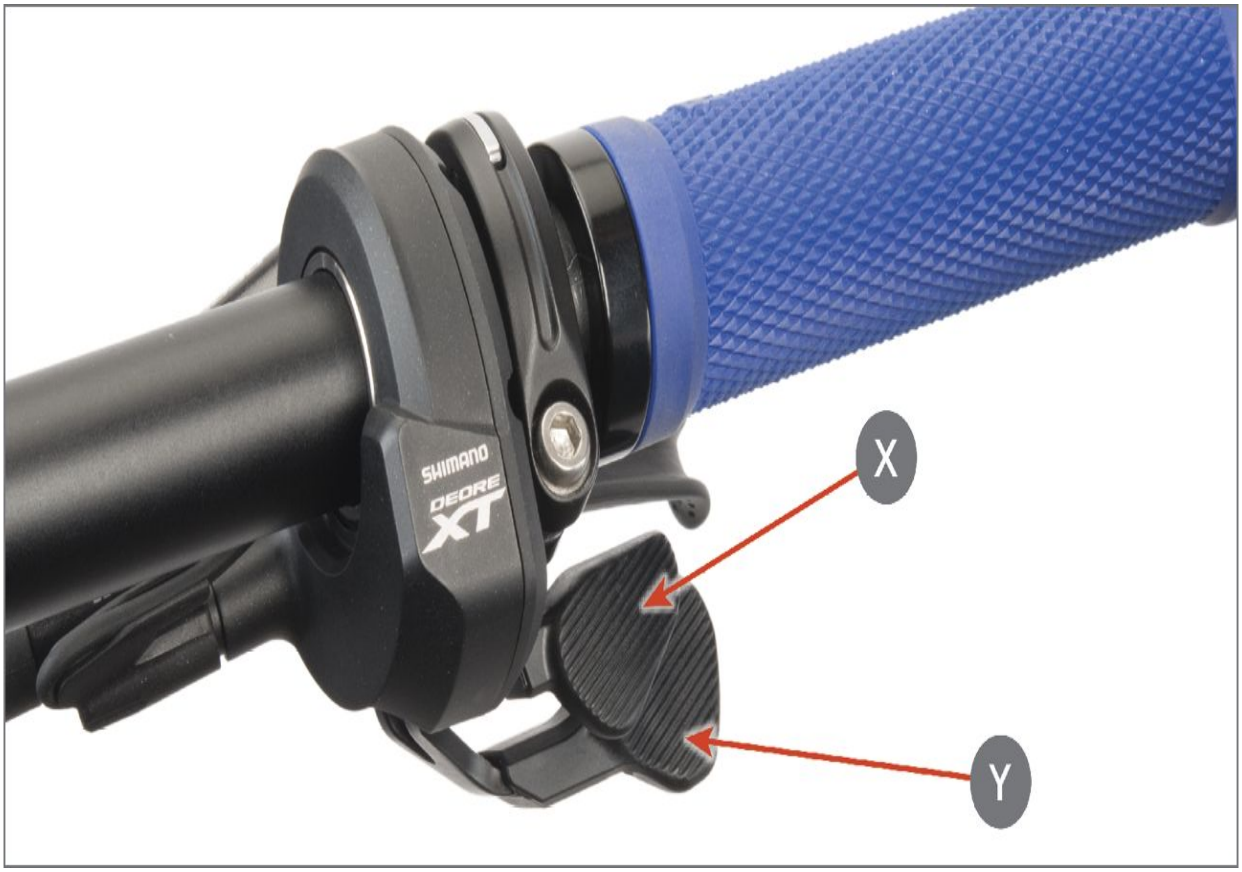


FIGURE 11.2: Flat bar shifter with X and Y shifters

Electrical shift wires plug into sockets at each lever and run to the front "junction box" (figure 11.3). This junction box is typically located near the stem and is used for fine-tuning shifting of both derailleurs and for checking battery charge. A single wire runs from the front junction box to the rear junction box.

FIGURE 11.3: Front junction box secured below stem

The mountain bike Di2® junction box mounts on the handlebars and displays the current gear, battery life, and shifting mode selected (figure 11.4)

FIGURE 11.4: MTB Di2 junction box with display of gear, mode and battery life

The rear junction is typically inside the frame tube and connects wires from the battery as well as the front and rear derailleur (figure 11.5).

FIGURE 11.5: Internally installed junction box

Electrical shift wires are small and should be handled with care. When installing or removing wires from their plugs, it is recommended you use the Shimano® TL-EW02 tool. This tool has a pronged fork end for plug removal and a socket end for plug installation (figure 11.6).

FIGURE 11.6: Use Shimano’s special wire tool for plugging and unplugging wire in shift levers

Inspect shift wire routing. Secure any loose wire that may snag on protruding objects with small zip ties or tape. Handlebars must be free to rotate fully to the left and right without binding wires. However, excessive wire slack may lead to the wire being caught, pulled, or damaged.

BATTERY

A lithium ion battery powers the motors in the derailleurs. Batteries may be housed either internally, such as inside the seat post or steering column (figure 11.7), or externally, such as on the down tube or below the bottom bracket.

FIGURE 11.7: Internal battery installed inside seat post

Shimano® offers a charger that will plug into the front junction box. Locate the side plug door, and lift from the lower edge to plug in the charger. External batteries are removed for charging with a special charging unit.

The battery charge duration will vary according to riding conditions, number of shifts, and battery age. However, anticipate approximately 1,600 kilometers between charges for a battery in good condition. Extreme cold may shorten battery charge life. Allow for at least 90 minutes of charging time for a full charge.

The battery charge level may be checked at the junction box using the shift lever switches. For either front or rear shift levers, begin first by shifting to the smallest sprocket. Press and hold Y-switch for approximately two seconds until front junction indicator light comes on (figure 11.8). The light will change with the battery charge. See table 11.1.

TABLE 11.1: Di2® Battery Indicator Light

INDICATOR LIGHT	APPROXIMATE BATTERY LEVEL
Solid Green	>75%
Blinking Green	75-50%
Solid Red	49-25%
Blinking Red	24-1%
None	None

FIGURE 11.8: Press Y-switch and watch for lights at junction box

If you will not be riding the bike for a long period of time, such as 2 months or more, remove the battery from the bike and occasionally recharge the battery fully.

FRONT DERAILLEUR

The front derailleur mounts similar to mechanical models. There are limit screws and a rotation adjustment for road models (figure 11.9). Direct mount models have no rotation setting.

FIGURE 11.9: Front derailleur and adjustment screws: (A) rotation adjustment screw, (B) H-adjustment screw, (C) height adjustment screw

The front derailleur cage can be safely pulled manually to the outside to assist in setting its height over the largest ring. Set clearance to approximately 2mm over the largest chainring teeth. For “braze-on” derailleurs, set cage rotation using the “support screw” to set cage rotation (figure 11.10). The screw pushes against a protective pad on the frame and this flexes the cage outward as seen from the rear of the bike.

FIGURE 11.10: Support screw location for setting cage angle with braze-on derailleur mount

Procedure for front derailleur adjustment:

a. Set L-limit screw. Shift to smallest front chainring and largest rear cog. This will automatically trim front cage inward.

b. Turn L-limit screw clockwise to move cage outward until inner cage of derailleur begins to contact chain, and then loosen until there is a slight gap between chain and inner cage of no more than 0.5mm.

c. Set H-limit screw. Shift rear derailleur to smallest cog, and shift front derailleur to largest chainring.

d. Turn H-limit screw clockwise to move cage outwards. Turn H-limit screw counterclockwise to move cage inward. Set derailleur so there is a slight gap between outer cage and outer plate of chain of no more than 1mm (figure 11.11).

FIGURE 11.11: Slight gap from chain to cage while setting H-limit screw

e. For MTB Di2 front derailleurs, loosen the cage fixing bolt in front of the derailleur and make adjustments at the H-limit screw. Adjust for at most 0.5mm clearance between chain and outer cage (figure 11.12).

FIGURE 11.12: Position front derailleur to 0.5mm gap after unlocking cage fixing bolt in front

f. Test shifting performance. If shifting is slow or hesitant, double check height, rotation and limit screw settings.

REAR DERAILLEUR

The rear derailleur attaches to the derailleur hanger like any mechanical derailleur. It is important for electronic shifting systems that the hanger be parallel to the sprockets. Check hanger alignment with the Park Tool DAG-2.2 Derailleur Hanger Alignment Gauge.

Derailleur indexing is unique for Di2® systems. On a traditional mechanical derailleur, indexing is set using the barrel adjuster, which effectively lengthens or shortens the housing. This moves the upper guide pulley slightly left or right under the sprockets, and then holds that relative position for all indexing shifts in the normal shifting mode.

On Di2® systems, the indexing process begins by entering adjustment mode, which is done by pressing the button on the front junction box. In adjustment mode, the switches on the rear shifter are used to move the guide pulley into position—the X-switch moves the guide pulley inward approximately 0.2mm, and the Y-switch moves the pulley outward the same amount. The switches are used to position the derailleur underneath the sprockets.

The rear Di2® derailleur motor is designed to move the derailleur cage and guide pulley and to stop underneath the desired sprocket. The derailleur also uses the H-limit and L-limit screws to help prevent any overshift beyond the cassette cogs. These screws are the same as the ones found on a mechanical derailleur—the H-limit screw stops pulley movement beyond the smallest sprocket, and the L-limit screw stops pulley movement beyond the largest sprocket.

The B-screw (body screw) setting is the same as on a mechanical unit. Increase or decrease tension as needed until the upper pulley is close to the largest rear sprocket when the chain is on the smallest front ring. Backpedal and inspect for contact between upper pulley and chain. If there is contact, tighten B-screw until it stops.

Procedure for rear derailleur adjustment:

a. Shift rear derailleur to one of the middle cogs (figure 11.13).

FIGURE 11.13: Shift to middle cogs to adjust rear derailleur

b. Push button at front junction box to enter adjustment mode. Look for red adjustment light to illuminate (figure 11.14). For MTB Di2®, press and hold button to enter the adjustment mode (figure 11.15). The system will stay in adjustment mode for approximately 60 seconds. (**Note:** pressing button for several seconds will reset derailleur from "safe mode" and will make an audible beep when completed.)

FIGURE 11.14: Press and release button at junction box to enter Adjustment Mode

FIGURE 11.15: Press and release shift mode button on MTB Di2® to enter

c. Pedal bike and sight upper pulley relative to cog. Press X-lever continuously to move pulley inward until you hear a noise from chain rubbing next inward sprocket (figure 11.16). This signifies that the pulley is too far inward. Press Y-lever approximately four times or until chain noise is quiet and no longer rubbing next inward cog.

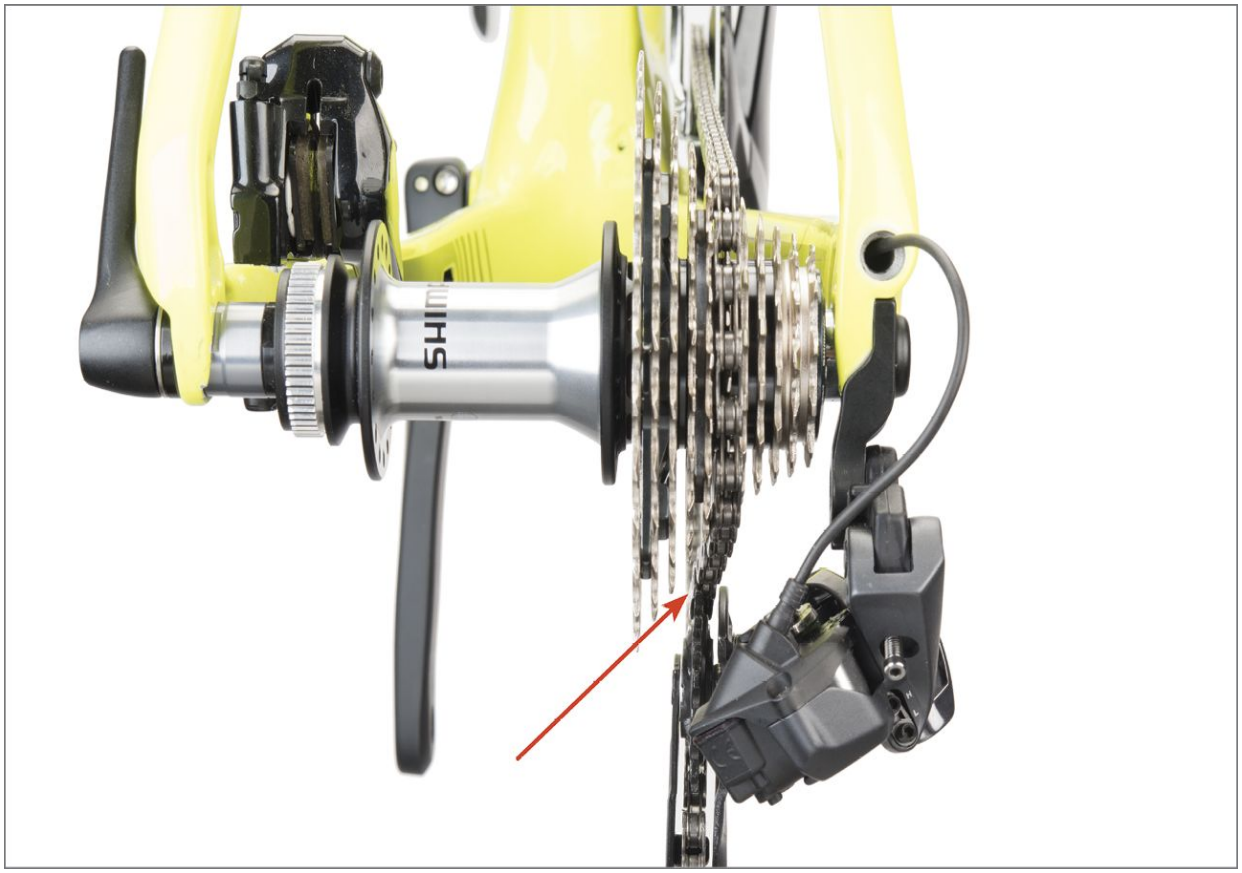


FIGURE 11.16: Use adjustment mode to intentionally move cage too far inward, then move back outward until quiet

d. Press button on front junction box to lock adjustment setting and to return bike to shift mode. Test all other rear sprockets. Return to adjustment mode if necessary to fine-tune a particular gear. Similar to mechanical systems, it is often necessary to fine-tune in several positions to find a setting that works in all gear combinations.

e. Set L-limit screw. Shift derailleur to largest sprocket. Look under derailleur and tighten limit screw to contact linkage in this position (figure 11.17). Test adjustment by shifting between two largest sprockets. If chain is slow to shift to largest cog, or chain will not stay on largest cog, loosen L-limit screw 1⁄4 turn and test again.

FIGURE 11.17: Tighten L-limit screw until lightly contacting linkage

f. Set H-limit screw. Shift to smallest sprocket. Sighting under derailleur body, tighten H-limit screw until it contacts linkage, and then loosen 1⁄2 turn counterclockwise. This loose H-limit setting allows for a slight overshift, which is designed into the system. Test shift by pedaling and shifting between two outermost cogs.

Di2® for off-road uses many of the same adjustment procedures. The shift pattern and sequence can be changed using the display screen as well as with the Di2® app. In adjustment mode the derailleur cage can be moved inward or outward 16 “micro adjustments.” This is the analog of turning the mechanical adjusting barrel. When in adjustment mode the micro adjustment numbers are given on the screen. When a front Di2® derailleur is used, the left shifter can be eliminated because the software running the shifting sequence will decide when small and large front rings are used.

DI2® CRASH FEATURE

The rear Di2® derailleur has a built-in protection feature to help in case of a crash. During an impact, the connection between solenoid motor and parallelogram opens, and the rear derailleur will no longer operate. This is designed to help protect the system when the bicycle falls over. To reset the system, press the button on the front junction box for at least five seconds to reconnect the solenoid to the parallelogram. Double check shifting and fine-tune the derailleur, using adjustment mode as necessary. If the adjustment has significantly changed, it is an indication the hanger may have been bent. Check alignment with Park Tool DAG-2.2 Derailleur Hanger Alignment Gauge.

SRAM® ETAP®

The SRAM® eTap® electronic shifting system uses wireless technology to communicate between all drivetrain components. Shifters use replaceable Li-Ion button batteries, while the front and rear shifter uses rechargeable batteries to power the shift motors. The derailleur contains an accelerometer to “wake up” the system when the bike begins moving. There is no “on-off” button.

It is important to note that neither the front or rear derailleur should be manually pushed or forced to move to different gears. Use only the function buttons or shifters to move them.

The components must be paired to communicate and work with one another. A new bike will already have the components paired. Replacement components however will need to be paired. See the repair help section of www.parktool.com.

LEVERS

eTap® shift/brake levers mount like other brake levers. There is a CR2032 Li-Ion battery under a cover on the inner face of the lever body which is held on by three screws. Pull rubber hood backward from front to expose and remove the forward screw. Then pull the hood forward to remove two rear screws.

Lift off cover to remove and replace battery (figure 11.18).

Replace cover and screws. Changing battery does not affect pairing to the components.

FIGURE 11.18: Battery is under the cover on inside of lever body

There is a shifting paddle on each lever. The right lever paddle moves the rear derailleur outward to the smaller cogs. The left paddle moves the rear derailleur inward to the larger cogs. The front derailleur moves between the two front rings when both left and right paddles are pushed simultaneously.

On the inward face of each paddle is a small function button and indicator light (figure 11.19). These are used when setting up and tuning the system. Each derailleur also has a function button and a light that indicates when it is receiving a shift message.

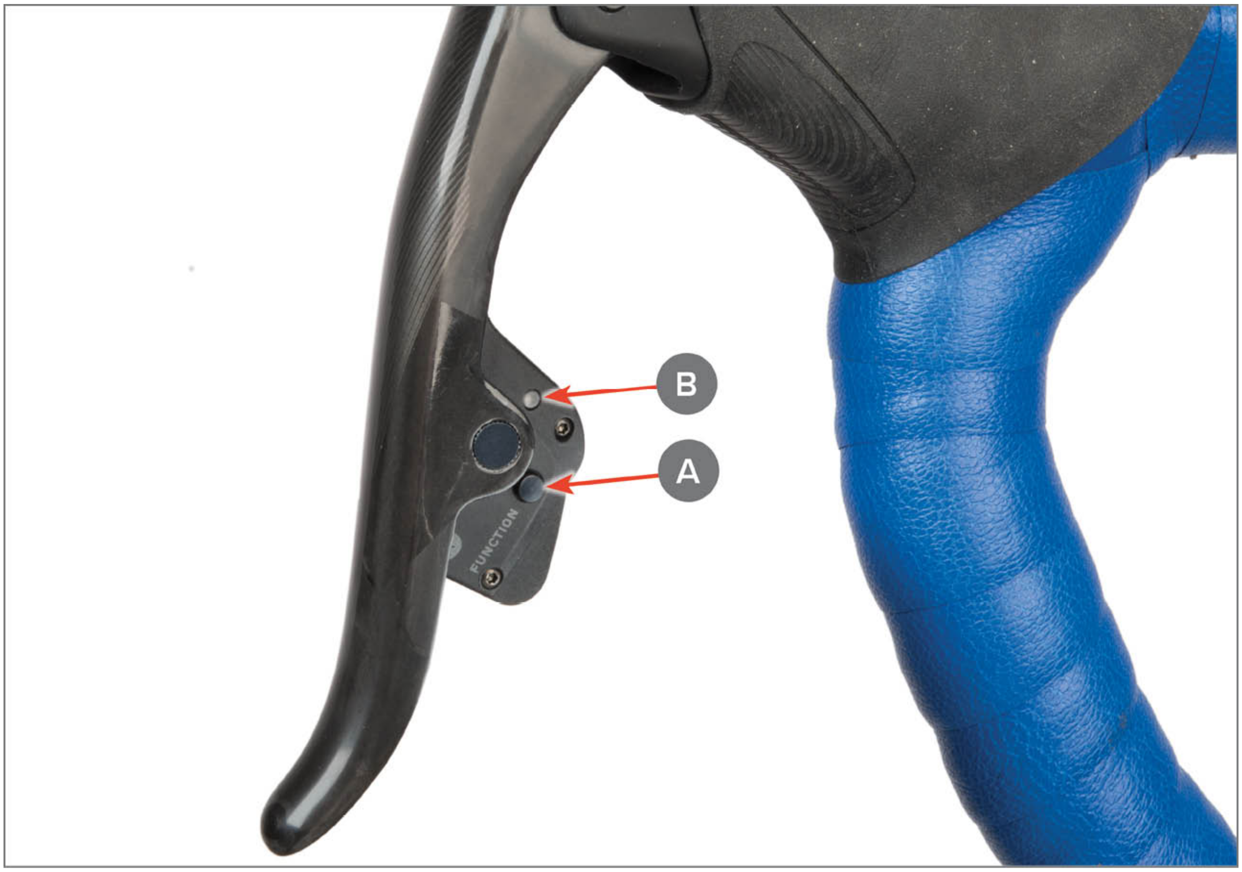


FIGURE 11.19: Function button (A) and indicator button (B)

BATTERIES

The front and rear derailleur motors both require a battery pack. The front and rear batteries are interchangeable – if one battery runs out of charge while on a ride, you may try switching batteries front to rear, or carry a spare charged battery (figure 11.20).

FIGURE 11.20: Battery attachment to rear derailleur

To check the battery charge, push the function button on the respective derailleur, illuminating the indicator light for 1–2 seconds. The light will change with the battery charge. See table 11.2.

TABLE 11.2: eTap® Battery Indicator Light

INDICATOR LIGHT	APPROXIMATE BATTERY LIFE (HRS.)
Rear Derailleur	
Green	15–60
Red	6–15
Blinking Red	<6
Front Derailleur	
Green	22–90
Red	9–22
Blinking Red	<9

To remove either battery, hold it in place while lifting the battery latch on top of the battery. Remove the battery, install in the eTap® charger. Reverse the process to reinstall the battery.

FRONT DERAILLEUR

Pushing both the left and right shift paddles inward at the same time shifts the front derailleur. This is practically impossible to do when pedaling in a repair stand. To shift the front derailleur while in a repair stand, push the function button on the front derailleur body (figure 11.21).

FIGURE 11.21: Use function button on front derailleur body while working on bike in repair stand

The front derailleur is aligned and adjusted while over the largest chainring. Height is set similarly to other front derailleurs, with about 1–2mm over teeth. There are rotational alignment marks on the front and back of the cage to align it parallel to the largest ring. The derailleur motion is similar to the SRAM® Yaw™ system.

To set the H-limit screw, the cage must be in the outer ring, otherwise damage to the derailleur can occur. eTap® front derailleur limit screws are better thought of as "cage positioning screws," as there is no spring tension in the system. The upper screw positions the cage for the large ring, and the lower screw is for the inner ring (figure 11.22).

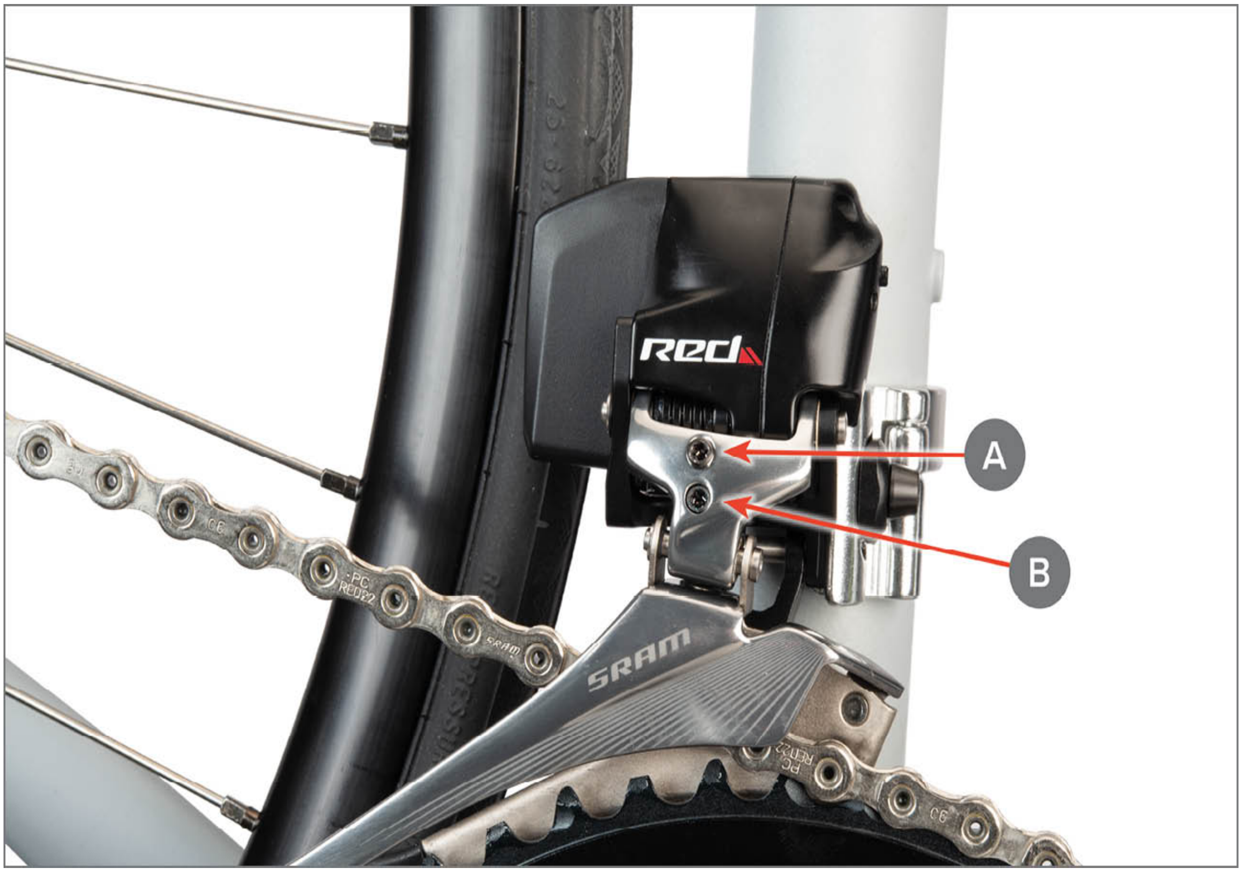


FIGURE 11.22: Cage position screws in front derailleur: H-Limit (A) and L-Limit (B)

Procedure for front derailleur adjustment:

a. With the chain in the smallest rear cog, shift to the largest ring. Inspect gap between outer cage and chain.
b. Use upper cage positioning screw and turn it clockwise to move cage inward. Turn screw counterclockwise to move cage outward. Adjust until cage-to-chain gap is close to 0.5mm.
c. Next, use the function button on front derailleur body to shift the chain to the smaller front ring. Use the shift lever and move the chain to the largest rear cog.
d. Use the lower cage positioning screw to set a gap of 0.5–1mm between inner cage and chain. Turn screw clockwise to move cage outward, and counterclockwise to move cage inward.

There is no manual adjustment for trim on the front derailleur using shifters. This is done automatically by the microprocessor depending on the rear sprocket selected.

REAR DERAILLEUR

Adjustment to the rear derailleur is done by putting the shift lever in "adjust" mode by pushing and holding the function button on the paddle. The left paddle function button will micro-adjust the guide pulley outward (away from the spokes), while the right paddle will micro-adjust the guide pulley inward.

Procedure for rear derailleur adjustment:

a. Begin with chain in either the highest or lowest rear cog. Similar to cable-actuated systems, make sure to click the shifter a few extra times to verify that the shifter and derailleur positions match.

b. Sight that the guide pulley is directly under the sprocket. If it is clearly not aligned, adjustment is necessary.

c. To micro-adjust pulley, push and hold the function button on the appropriate paddle. Notice a light will come on at the paddle next to the function button.

d. Continue to hold the function button while pushing the paddle at least four clicks. Watch at the rear derailleur for a light to come on, indicating that the rear derailleur got the message to micro-adjust. Each micro-adjustment click moves the pulley approximately 0.2mm. There are more than 20 clicks in each gear position, which will allow pulley to move across more than sprocket-to-sprocket spacing.

e. Release the function button and test the adjustment by shifting back and forth to and from the nearest cog. If the chain is rattling against the next largest cog, the pulley should be brought out slightly to quiet the noise. Use the right paddle and function button to bring the pulley slightly outward and quiet the noise.

f. Release the function button and test this setting in other gears. Shift up and down between the largest and smallest cogs while you listen and look for symptoms of indexing problems. Make further adjustments as necessary.

The rear derailleur has limit screws similar to a cable-actuated system. With the chain on the innermost cog, tighten the L-limit to lightly contact the linkage (figure 11.23).

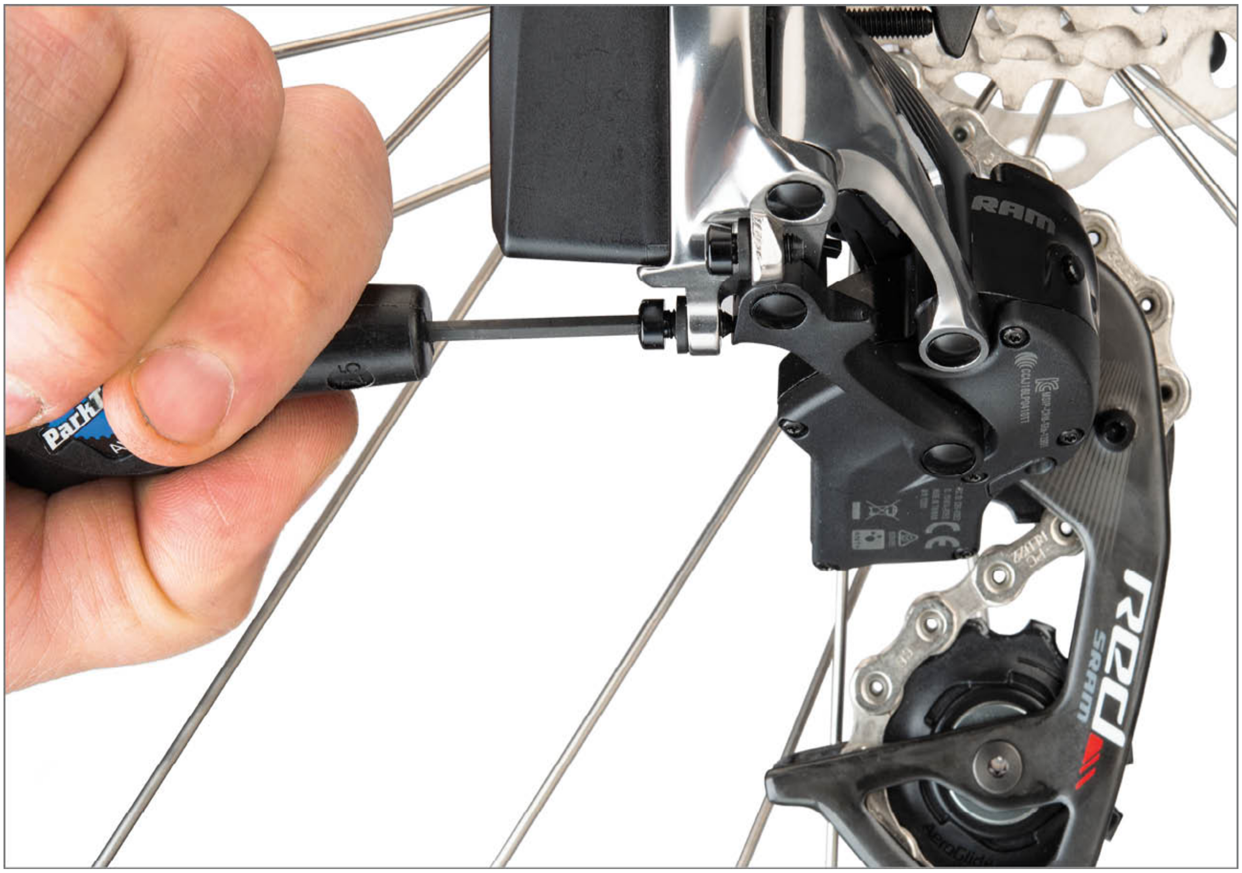


FIGURE 11.23: Tighten the L-limit screw while on the largest cog

Shift the derailleur outward to the smallest sprocket and tighten the H-limit until light contact at the linkage.

FSA® K-FORCE® WE®

FSA® electronic shifting uses a combination of wired and wireless communication between components. Both shift levers communicate wirelessly to a microprocessor housed in the front derailleur. A Li-Ion battery housed inside the seat post powers the shift by a wire connection to the derailleurs. The wire also allows for communication from the microprocessor to the rear derailleur. The system must be turned on in order to shift. The system will also turn off automatically if no shifting occurs. The default shutoff time is one hour if no shifting occurs, but this can be changed using the K-Force® WE® app available at www.fullspeedahead.com. The app also covers common troubleshooting issues.

LEVERS

Brake levers mount to the handlebars, similarly to other road levers. Brake lever blades have paddle-like switches to operate the derailleurs. The default factory setting uses the right lever to control the rear derailleur shifting and the left lever for the front. For the rear shifter, pushing the lower portion of the paddle moves derailleur outward to smaller sized cogs. Pushing the upper portion of the paddle moves the derailleur inward to larger cogs. For the front shifter, pushing the lower portion of the paddle moves the derailleur inward to the smaller chainring (figure 11.24). Pushing the upper portion of the paddle moves the derailleur to the large chainring. However, the K-Force® WE® app permits the user to change shift sides and paddle direction. The procedures here assume the factory setting. If you have changed from the default setting, use whichever paddle moves the rear derailleur for adjustments.

FIGURE 11.24: Rear derailleur inward and outward portion of shift paddles

A button battery (size #CR2032) is housed in each lever body. The battery is used only when the shift paddles are pressed. To change the battery, rotate the bike upside down and pull the rubber cover forward to expose the battery cover. Use a small #0 cross tip screwdriver to remove holding screw. Pull cover from the front, lifting it back and upward to expose the battery (figure 11.25)

FIGURE 11.25: Battery cover below shift lever body

Use care not to drop the screw or the small reset button stud in the cover. A seal pick or small straight blade screwdriver can carefully pry out the battery. Install a new battery and replace the cover with reset button stud and screw in place.

BATTERY

The derailleur battery inserts into the seat post, which is then installed into the seat tube. There are two identical protruding wires from the end of post, with either plug going to either derailleur. A fully charged battery should between 4–6,000 kilometers of riding. The charge can be checked using the K-Force® WE® app or on the indicator lights on the front derailleur. Press the ON button and hold until both indicator lights flash. Watch rear indicator light as it flashes. See table 11.3.

TABLE 11.3: K-Force® WE® Battery Indicator Light

INDICATOR LIGHT	APPROXIMATE BATTERY LEVEL
Blue	>75%
Green	75-50%
Yellow	50-25%
Blinking Red	<25%

To charge the battery, first make sure the system is turned off. Use a hex wrench and loosen the wire plug pinch screw before disconnecting the derailleur wire. Grab the plug—not the wire—and pull upward. Plug end wire into the K-Force® WE® charging unit. A green light on the charger unit indicates charge is complete.

FRONT DERAILLEUR

The front derailleur mounts similarly to conventional derailleurs for height and rotation. The front derailleur wire plugs into the body and is also held with a pinch screw.

There are two buttons on the front derailleur body. Above each button is an indicator light. The front button is the power button. Press and hold front button until both indicator lights flash and turn momentarily blue. The rear indicator light will occasionally flash to let you know the power is on and the bike is ready to ride.

The rear button is for SET mode and is used to tune shifters to front and rear derailleurs (figure 11.26). Limit adjustment on the front derailleur is done electronically as part of the adjustment procedure.

FIGURE 11.26: Power button and indicator buttons

REAR DERAILLEUR

The rear derailleur is installed like a conventional derailleur. The shift wire plugs into the body, and is held in by a pinch screw (figure 11.27). Always loosen this screw before attempting to pull the plug.

FIGURE 11.27: Rear wire plug pinch screw

DERAILLEUR ADJUSTMENT

The system can be adjusted after levers and derailleurs are "paired." This sets up communication between the shifters and microprocessor. If respective shifters move their derailleurs, it has already been paired. Pairing is only needed on a new aftermarket installation or if a lever is being replaced. Pairing is reviewed at www.parktool.com and is not covered here. Changing the shift lever battery does not affect the pairing.

Derailleurs are adjusted using the SET mode to create an "index cable adjustment" mode analogous to mechanical systems. This is a micro-adjust system where the rear shifter paddle moves the derailleur in small increments. It is important to understand the rear shift lever paddles are used to make micro-adjust movements at either front or rear derailleurs.

The chain must be in the sixth cassette sprocket for any front or rear micro-adjustment. The microprocessor will make adjustments to other positions based on this one setting being properly set. Even front derailleur limits are set with the chain on this sixth cog. The microprocessor will move the cage accordingly as the chain is shifted in the rear.

Procedure for front derailleur adjustment:

a. Turn system on using POWER button.
b. Shift rear derailleur to sixth sprocket.
c. Shift front derailleur to small chainring.
d. Push and hold SET button for approximately two seconds, until both lights flash green. Both derailleurs are now in SET mode until processor is informed which one you are working on.
e. Inform processor of front derailleur adjustments by pushing front shifter once. Push paddle side to keep derailleur in small ring.
Note: Fine-tuning of front derailleur is done at rear shift paddle. Do not use front shifter attempting to fine-tune front derailleur cage position.
f. Using rear shifter paddles, adjust front cage so inner face of chain clears inner front derailleur cage by 0.5–1mm.
g. Still in SET mode, use front shifter paddle to move chain to largest chainring.
h. Return again to rear shifter paddles and adjust so that outer cage clears outer plates of chain by 05.–1mm.
i. Push and hold SET button until both lights flash. This saves and locks

settings for front derailleur.

j. Pedal and test shift.

The front derailleur has no limit screw setting, but relies on the microprocessor to stop it.

Procedure for rear derailleur adjustment:

a. Turn system ON.

b. Shift chain to smallest chainring.

c. Use rear shift paddle to move chain to sixth sprocket (counting from smallest cog). If chain will not reach sixth cog, proceed to SET mode and use micro-adjust to reach sixth sprocket.

d. Enter SET mode by pushing SET button on front derailleur for approximately 2 seconds. Both lights will flash green.

e. Press paddle on rear shifter to enter rear derailleur micro-adjustment mode.

f. Continue to use rear shift lever paddles to fine-tune guide pulley inward or outward as necessary until pulley is directly under sixth cog. Pedal to test for any excessive chain rattling noise against seventh cog.

g. Press SET button to exit adjustment mode to save and lock this setting for rear derailleur.

REAR DERAILLEUR LIMIT SCREWS

The limit screws act as a safety stop for the chain striking the wheel, spoke or frame (figure 11.28). These limits are set after index adjustment and are set to act against any over shift of the chain.

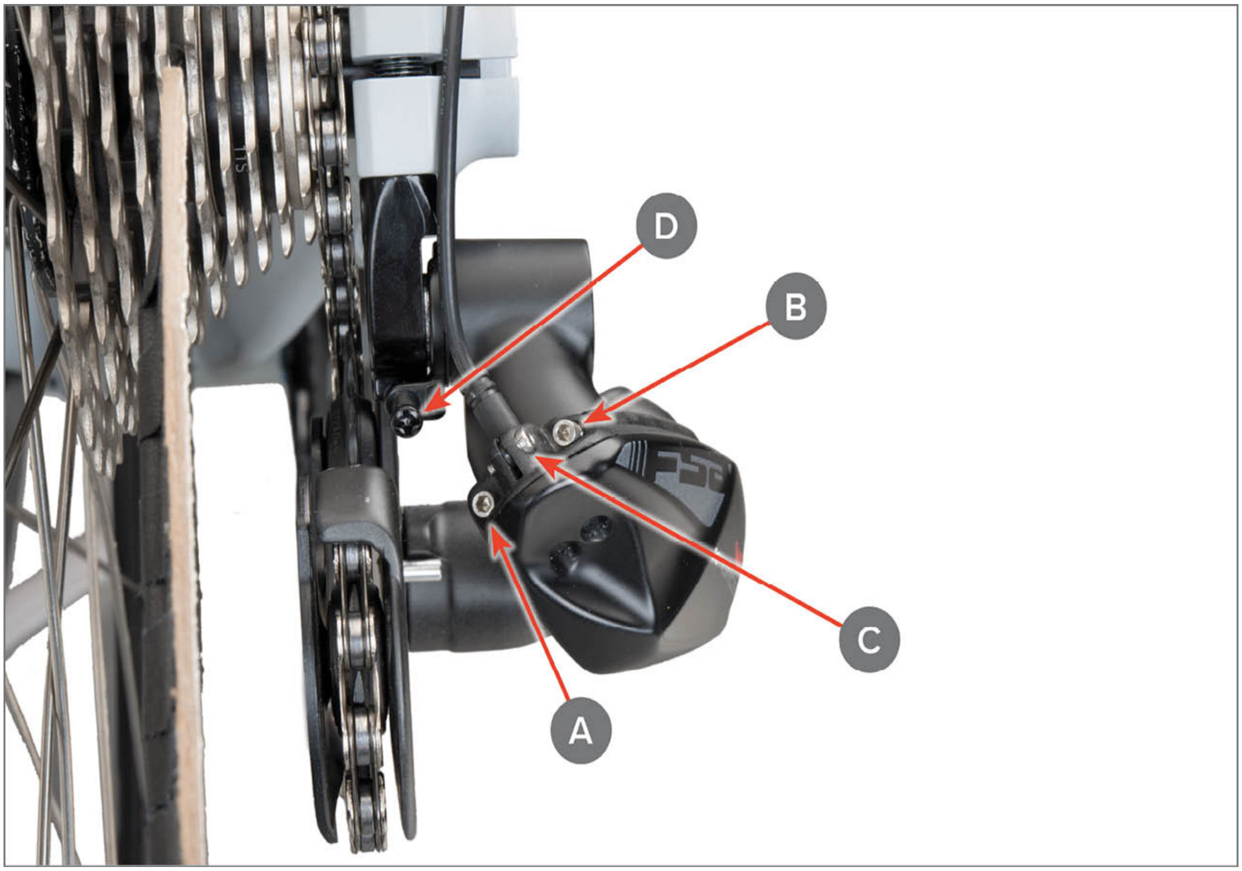


FIGURE 11.28: (A) H-limit screw, (B) L-limit screw, (C) Wire pinch screw, (D) B-screw

Procedure for rear limit screw adjustment:

a. Shift rear derailleur to smallest sprocket and locate H-limit screw. Turn screw clockwise until you feel it contact derailleur linkage, or if you see the cage begin to move inward. Loosen screw 1⁄2 turn at this point.

b. Shift rear derailleur to largest rear sprocket to set L-limit screw. Turn screw clockwise until you feel it contact derailleur linkage, or if you see cage begin to move outward. Loosen screw 1⁄2 turn at this point.

c. Test shift to inner and outermost cogs.

B-SCREW

The B-screw of the K-Force® WE® is adjusted similar to other systems. The upper pulley should be close to the largest rear sprocket, but not so close that it rubs against the sprocket.

TROUBLESHOOTING

Troubleshooting electronic shifting varies greatly between manufacturers. Check with the manufacturer of your system for troubleshooting help.

CHAPTER 12

INTERNAL GEAR SYSTEMS

Internally-geared hubs allow for different gear ratio selections without a derailleur system. These hubs contain a series of gears inside the hub shell that act as a transmission. A center gear, called the “sun gear,” is fixed to the axle and engages the outer gears, which are known as “planetary gears.” All planetary gears are engaged into the “planet carrier” which drives the hub shell. Different planetary gears engage or disengage the sun gear for a particular gear ratio. Internally-geared hubs use a special keyed washer and axles with flats that prevent the axle from rotating in the dropout (figure 12.1).

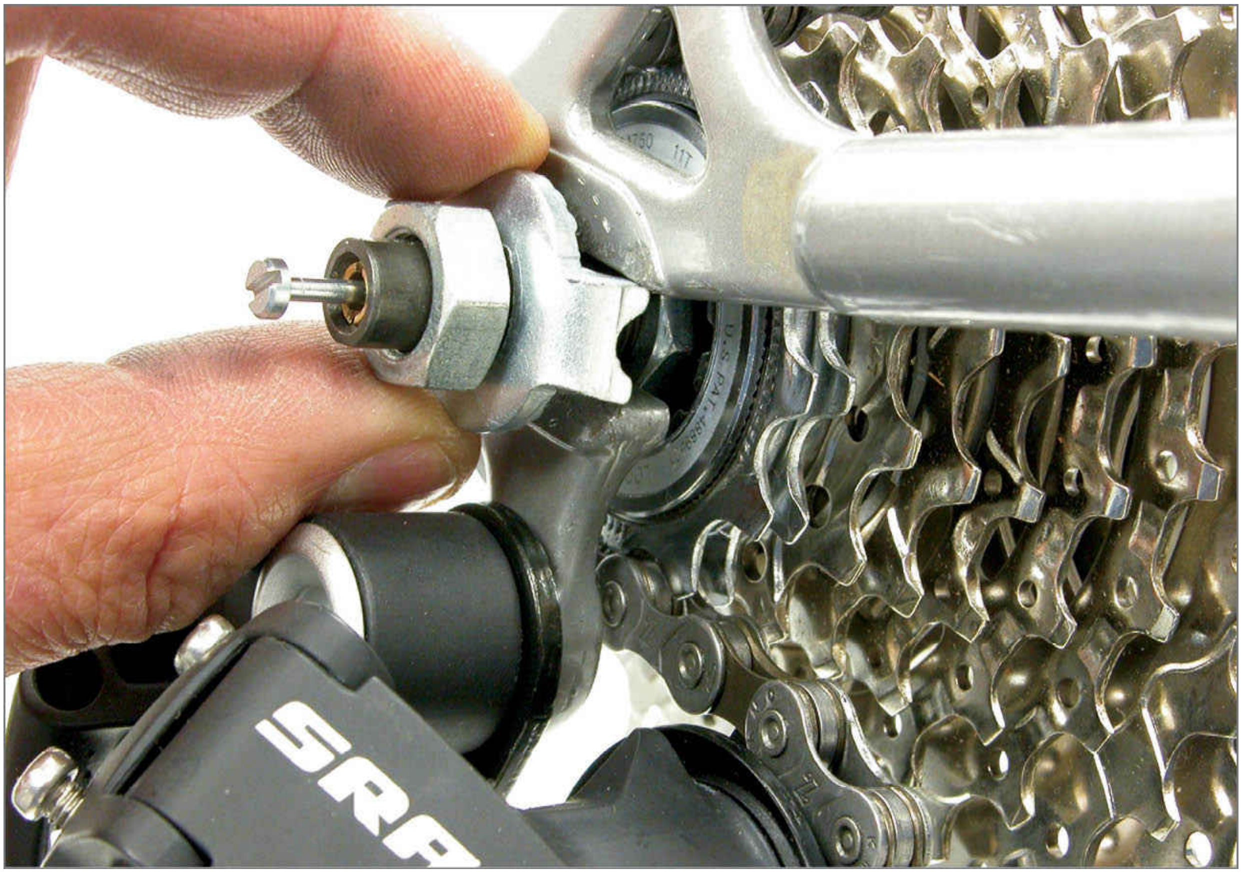


FIGURE 12.1: Keyed washer to prevent axle rotation

Examples of wheel installation, cable attachment, and gear adjustment are reviewed here. Internal hub service is best left to professional mechanics.

Internally-geared hubs use one of the middle gears as the “neutral” gear. This gear provides 100% of the front ring-to-rear cog ratio, resulting in the same mechanical advantage as if the bike were a simple single speed. Gears on either side of this neutral gear will either reduce or increase the gear ratio. For example, the first gear of SRAM® DualDrive™ hubs reduce the gear to 73% of the middle position, and third gear increases it to 136% of the middle position.

SRAM® DUALDRIVE™

The SRAM® DualDrive™ hub offers three internal gear choices. The hub is also fitted with a freehub and cassette, which is shifted by a derailleur. The internal hub gears can be viewed as a replacement for a three-chainring front derailleur system.

Internal hub gears are shifted via a small rod on the right side of the axle. The shift rod attaches to a "Clickbox," which pulls the shifting rod, engaging different combinations of planetary gears inside the hub. The wheel can be removed to service the tire and tube, and the cable can be replaced.

Procedure for wheel removal:

a. Shift internal shift lever to lowest gear (to left). Shift external derailleur to smallest rear cog on derailleur.
b. Push button on Clickbox downward to release box from shifting rod. Pull box off of right-side axle (figure 12.2).

FIGURE 12.2: Remove Clickbox to access axle nuts

c. Loosen left and right axle nuts. Shifting rod may remain in right side of axle, but use care not to bend or damage rod.

d. Remove wheel from bike.

Procedure for wheel installation:

a. Install wheel in frame and align. Use care to position special alignment washer in frame dropout.

b. Secure axle nuts fully.

c. If shifting rod was removed, reinstall and gently secure with screwdriver.

d. Push button downward on Clickbox and install Clickbox on axle by pushing it against axle nut.

e. Push Clickbox button from below to engage lever arm onto shifting rod. Test by pulling gently on Clickbox away from hub to ensure it is seated on axle threads.

The rear derailleur is adjusted the same as you would any other derailleur system. See Chapter 10—Derailleur Systems, for rear derailleur adjustments.

The internal gears of the DualDrive™ are adjusted by changes in cable tension at the shift lever. To adjust the three internal gears, shift to the middle position. Inspect the window of the Clickbox for a solid yellow mark and a yellow box. Use the barrel adjusters to change the cable setting so that the yellow mark is aligned with the box (figure 12.3). Test the adjustment by shifting to all three possible positions.

FIGURE 12.3: Adjust cable tension until yellow mark is aligned between lines

DualDrive™ systems have two cables at the shift lever. One cable shifts the derailleur. A second cable shifts the rod at the Clickbox.

Procedure for derailleur shift cable replacement:

a. The derailleur cable can be accessed through a ring-cover on the side of the shifter, which is held on by a screw. Disconnect cable from the rear derailleur and remove ring-cover at the lever.

b. Pull cover outward to expose cable end and push out old shift cable.

c. Lubricate new cable and install through same hole as old cable.

d. Replace cover onto lever, reinstall screw, and secure.

e. Feed cable through housing to derailleur.

f. Reconnect cable, trim excess length, and adjust indexing.

Procedure for internal shift cable replacement:

a. Remove Clickbox as described in wheel removal above.

b. Remove back end of Clickbox. Hold main body and push downward on corner end of Clickbox (figure 12.4).

FIGURE 12.4: Hold Clickbox and pry corner down and away

c. Loosen cable pinch bolt inside Clickbox and pull cable from Clickbox.
d. At shift lever, remove cover over internal shift cable (figure 12.5).

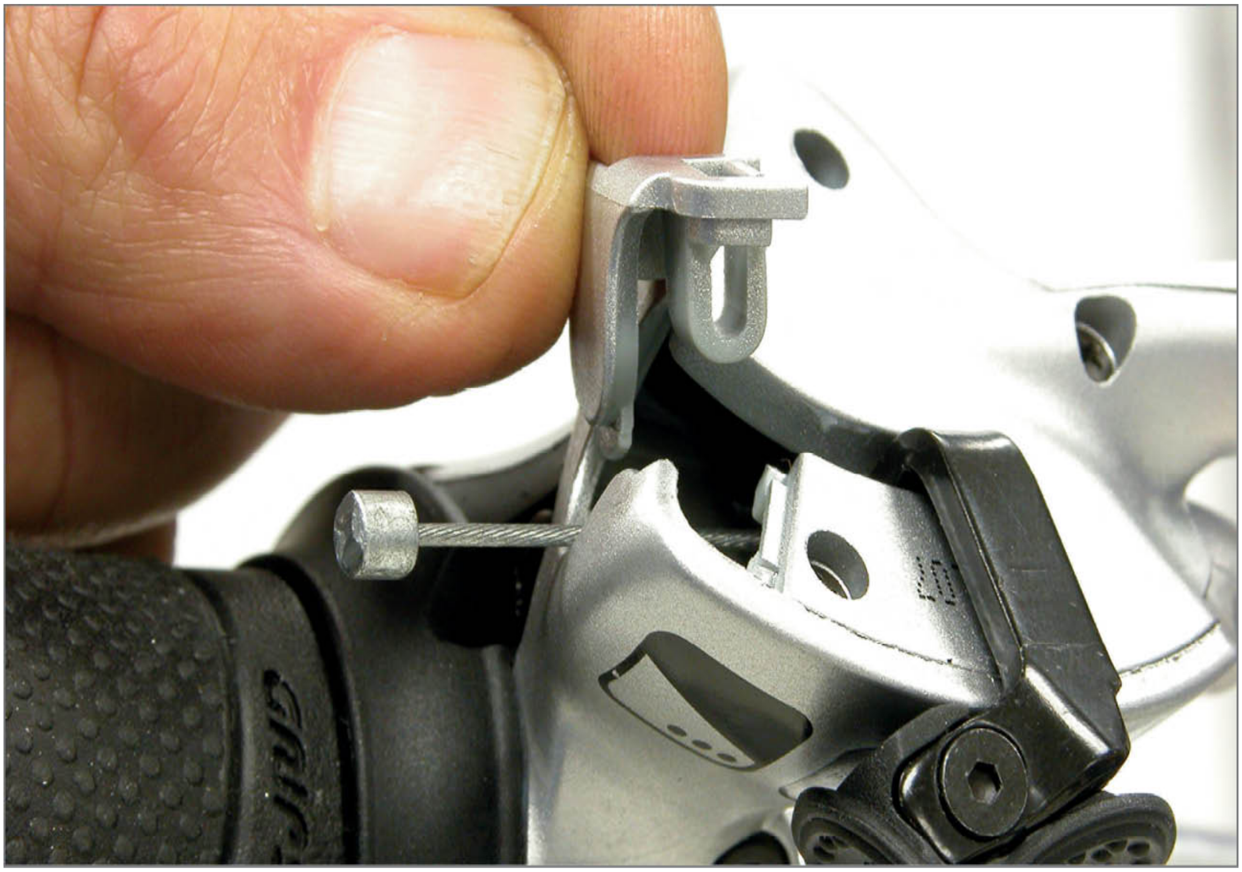


FIGURE 12.5: Remove and install cable at shift lever

e. Push old cable from lever. Lubricate and install new cable and route though lever and housing back to Clickbox. Thread barrel adjuster fully into Clickbox.

f. Thread cable into pinch bolt mechanism. Push Clickbox onto housing end cap, while pulling back on lever. Secure pinch bolt (figure 12.6).


FIGURE 12.6: Pull cable snug and secure pinch bolt

SRAM® I-MOTION® 9

The I-Motion® 9 hub offers nine different gear ratios. The sixth position is used for adjusting hub gears. It is necessary to detach the shift cable when removing the wheel.

Procedure for wheel removal:

a. Turn shifter to first gear.
b. Slide quick-disconnect sleeve on connecting tube and slide it away from hub.
c. Pull connecting tube down and away from hub fitting (figure 12.7).

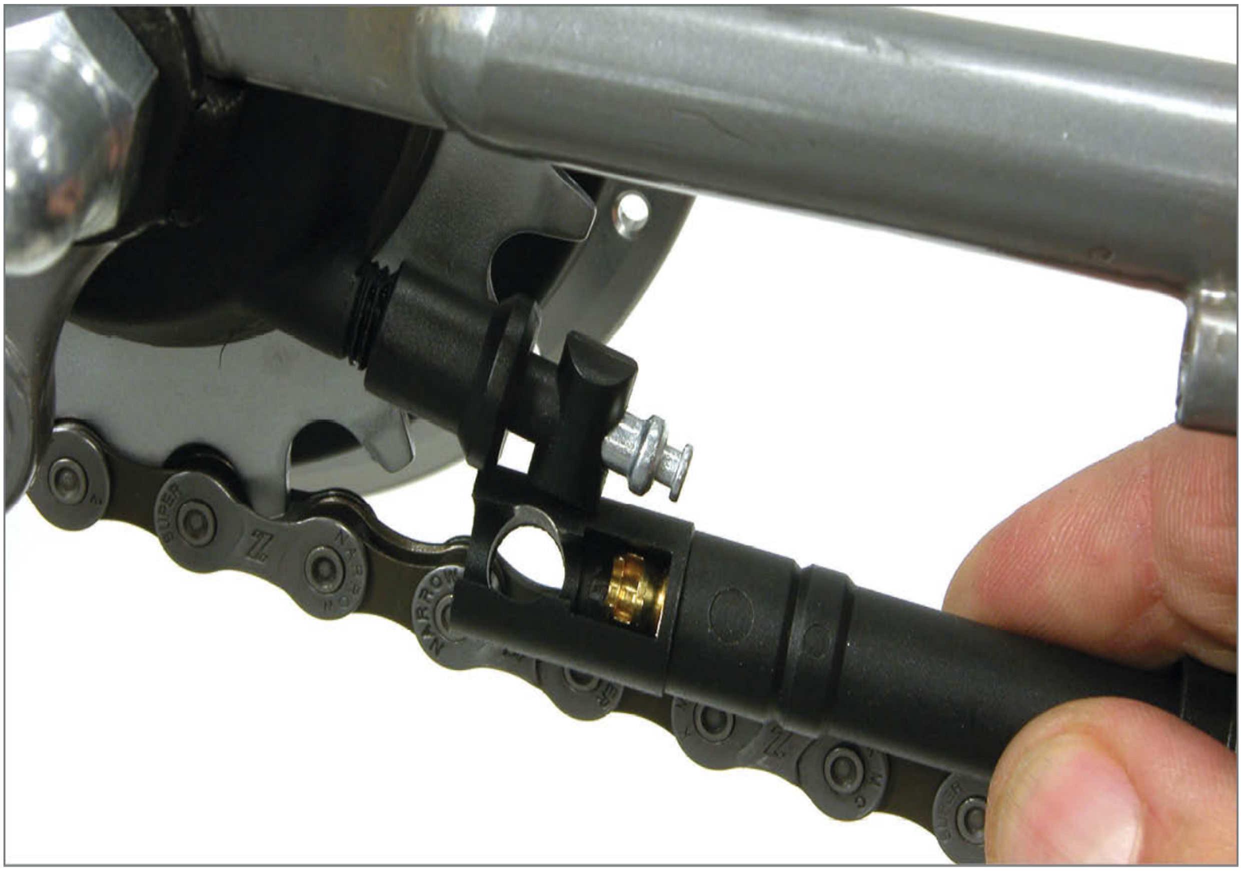


FIGURE 12.7: Remove connecting tube

d. Loosen axle nuts. Remove coaster arm locking bolt if applicable.
e. Remove wheel.

Procedure for wheel installation:

a. Install washers with serrations toward frame. Washer lugs must fit into dropouts to prevent axle rotation.

b. Tighten axle nuts—first on drive side, then non-drive. Check and correct chain tension as necessary.
c. Install and secure coaster arm locking bolt if applicable.
d. Move shifter to first gear.
e. Open quick disconnect sleeve and connect catch to shifting stud at hub.

Procedure for gear adjustment:

a. Shift bike to seventh gear, then shift to sixth gear.
b. Look for red and yellow marks in window on right side of hub.
c. Use barrel adjuster at connecting tube to adjust cable tension until yellow marker on moving indicator aligns with red marker of hub (figure 12.8).

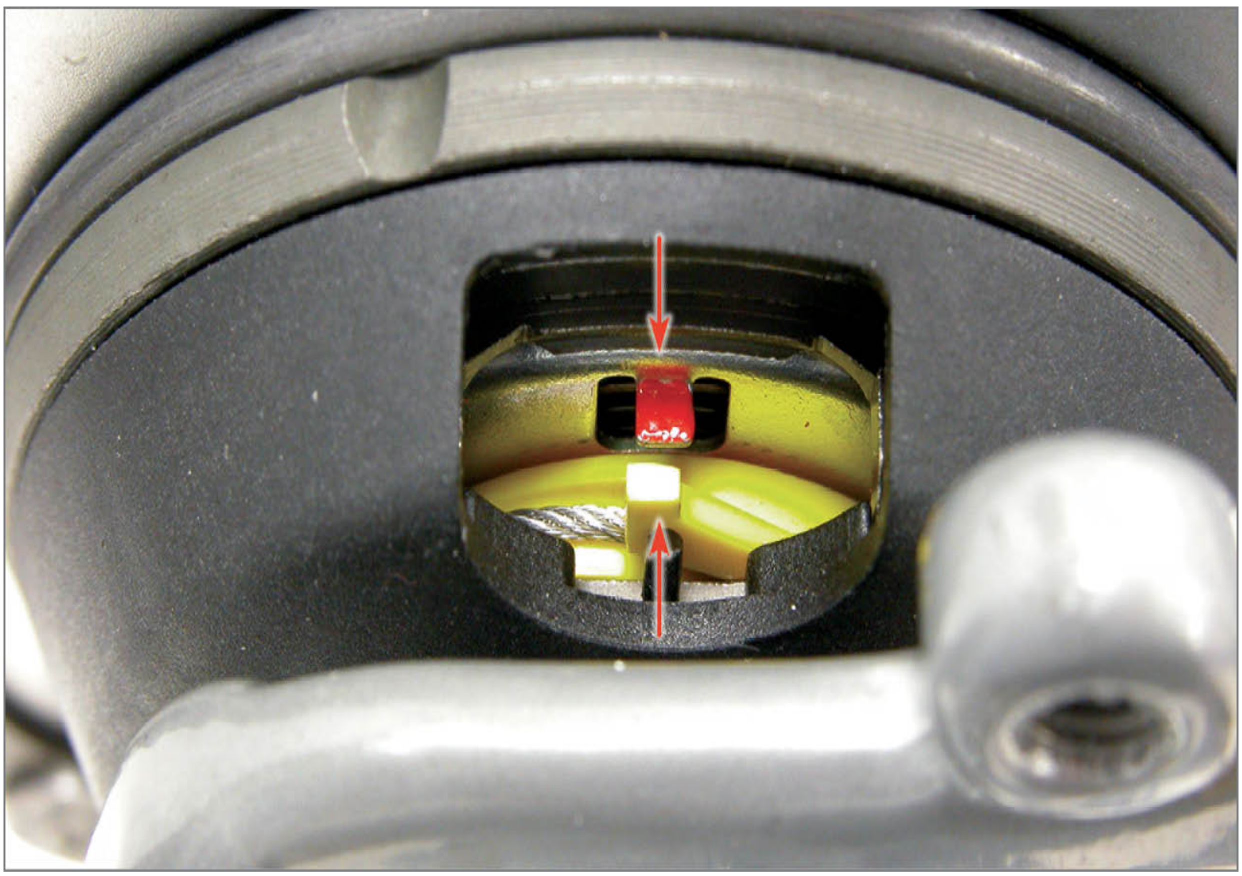


FIGURE 12.8: Align marks through window to adjust gears

d. Test gears by shifting through gear range.

Procedure for cable replacement:

a. Shift to first gear.
b. Remove quick-disconnect sleeve from hub.

c. To remove old cable, pull at connecting tube away from housing and cut cable.
d. Remove barrel adjuster from connecting tube.
e. Remove coil spring, remaining shift wire, and connection nipple from connecting tube. Loosen set screw in connection nipple and remove old cable.
f. Using a small flat-bladed screwdriver or utility pick, remove cable cap from shift lever. You may need the screwdriver to also help pull the head of cable out. Push cable while engaging cable end with tip of screwdriver (figure 12.9).

FIGURE 12.9: Remove cable from shifter

g. Install new cable through shift lever. It can be helpful to slightly bend end of new wire to feed it through bend in lever.
h. Route new cable through housing. Ensure all end caps are fully pressed onto housing.
i. With shift lever in first gear and housing fully seated, cut cable a

distance of 105mm (4 1⁄8 inches) past housing end cap.

j. Install barrel adjuster and coil spring over wire.

k. Carefully compress coil spring over cable and install connection nipple onto end of cable. Secure set screw to hold cable (figure 12.10).

FIGURE 12.10: Secure shift wire set screw

l. Install connection nipple and cable into connecting tube. The asymmetrical shape of nipple will fit tube in only one orientation. Nipple should be visible at end of tube with open end facing hub connection stud.

m. Thread barrel adjuster fully onto connecting tube.

n. Install quick-disconnect sleeve to hub and adjust hub gears as described above.

SHIMANO® NEXUS® INTER-7, NEXUS® INTER-8, & ALFINE® HUBS

Nexus® Inter-7, Nexus® Inter-8, and Alfine® hubs use a “cassette joint” on the right side to actuate gears. When installing the wheel, it may be easier to work with the bike upside down. This allows use of two hands to manipulate parts.

Procedure for wheel removal:

a. Shift lever to first gear on indicator.

b. Remove housing from housing stop at hub cassette joint. Pull at housing end and disengage from housing stop (figure 12.11).

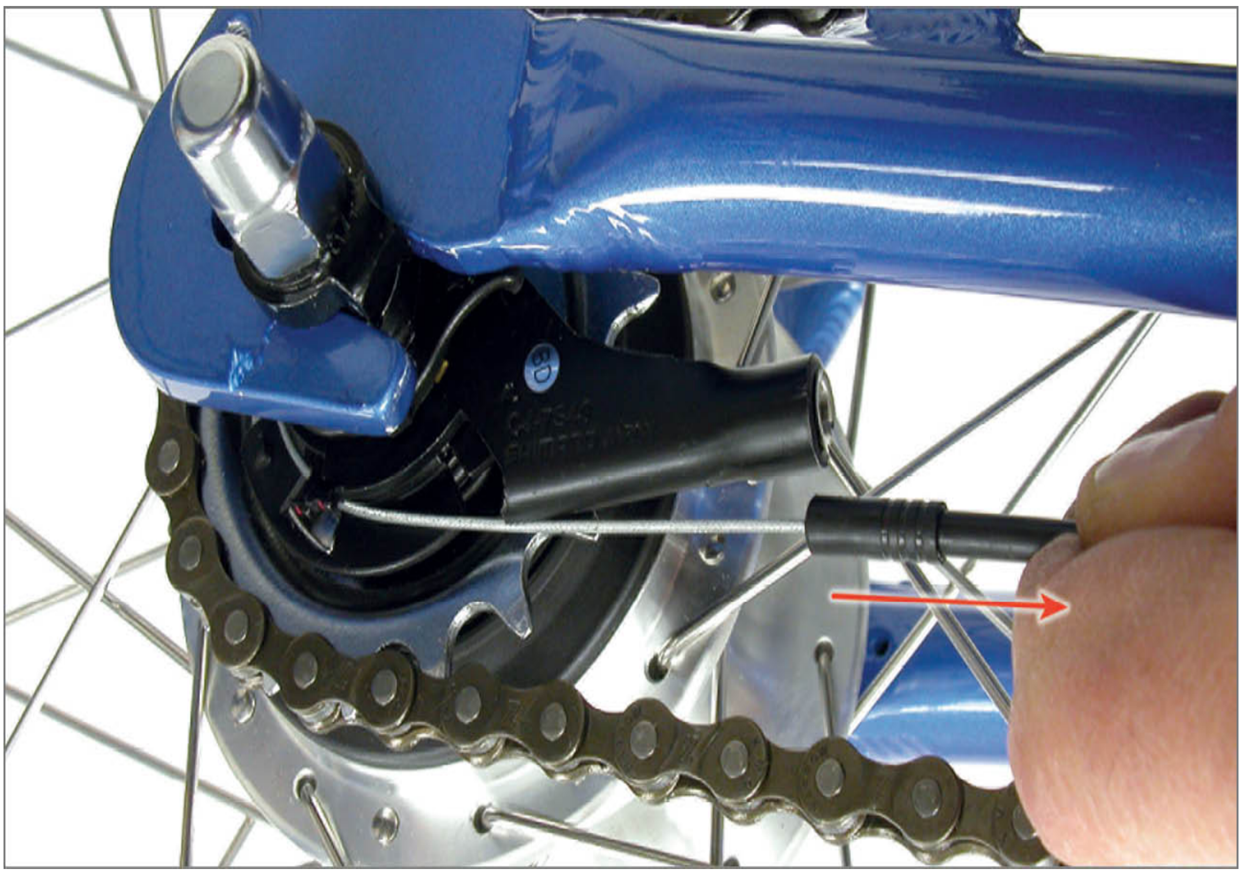


FIGURE 12.11: Release cable from housing stop to detach anchor from cassette joint

c. Detach cable anchor from cassette joint. Rotate anchor and lift it from hook in joint.

d. Loosen axle nuts and remove wheel. Cassette joint consists of three pieces and is held to hub by a lockring. Cassette joints may stay together for wheel service. Turning the lockring lever counterclockwise releases joint. To install joint, align the series of yellow dots on the assembly. Turn lockring clockwise 45 degrees to lock cassette joint (figure 12.12).

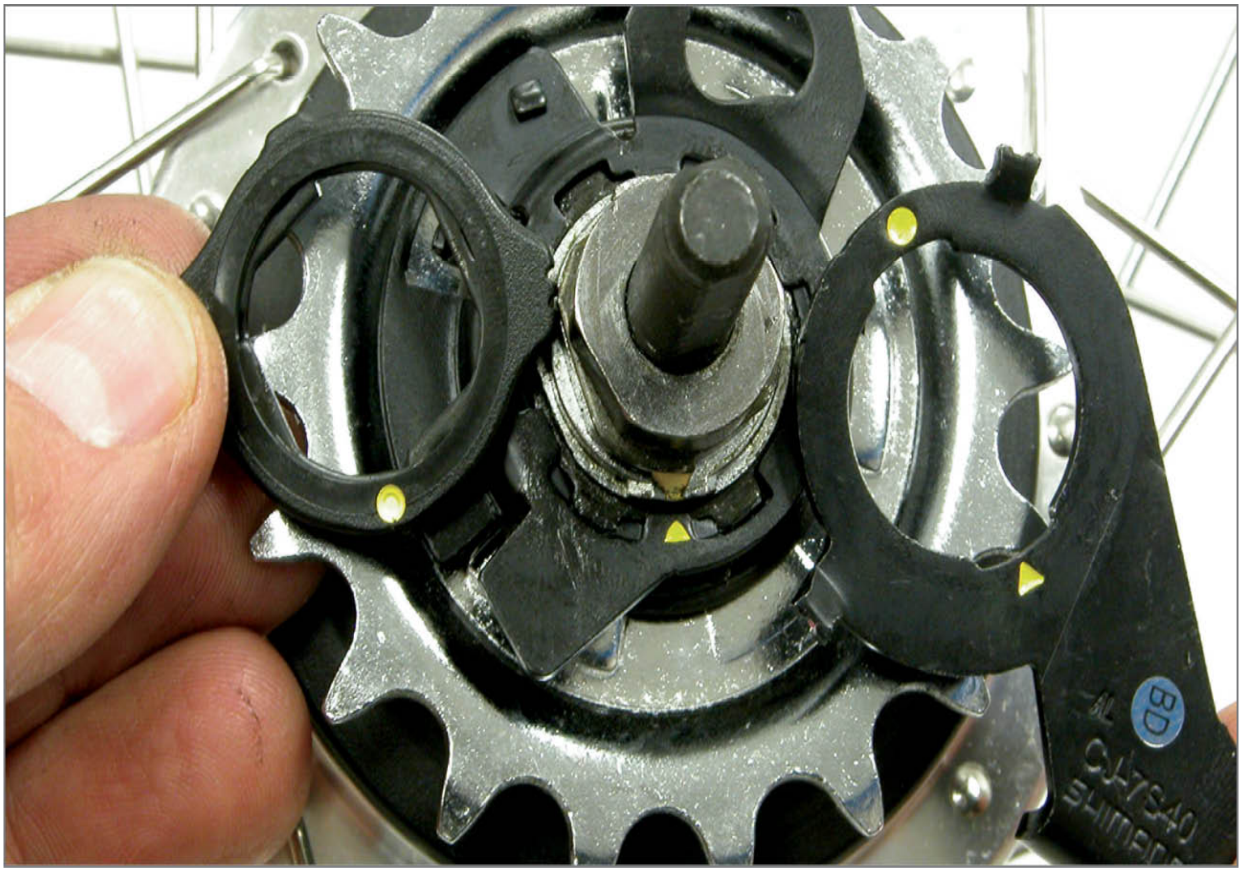


FIGURE 12.12: Cassette joint of Inter hub system

Procedure for wheel installation:

a. The hub axle uses special keyed washers to prevent axle from rotating in dropouts under load. Align cable housing stop of cassette joint so it points toward shift cable.

b. For hub models with coaster or band brakes, secure left-side braking arm to frame.

c. Install wheel and adjust chain tension as on a single-speed system.

The most common shifter for Inter hub systems is the Revoshift® shifter.

Procedure for cable replacement:

a. Remove cover screw and lift cover from lever body.

b. Turn shifter to gear seven or eight—whichever allows better access to cable end.
c. Push on exposed cable adjacent to barrel adjuster to gain cable slack. Use a small flat-blade screwdriver or utility pick to remove cable end from lever (figure 12.13).

FIGURE 12.13: Shift cable attachment in Revoshift® lever

d. Install new cable through barrel adjuster and back into cable end anchor. Install cover and cover screw and shift to first gear.
e. Route shift cable through housing to rear hub. A pinch bolt mechanism is used to attach cable anchor to cassette joint. Pull firmly on cable to ensure it is seated in housing stops.
f. Back out barrel adjuster approximately two turns from full engagement to allow for future adjustment.
g. Secure pinch mechanism so there is a distance of approximately 100mm (4 inches) from end cap to center of bolt (figure 12.14). Secure nut; cable will flatten at pinch mechanism.

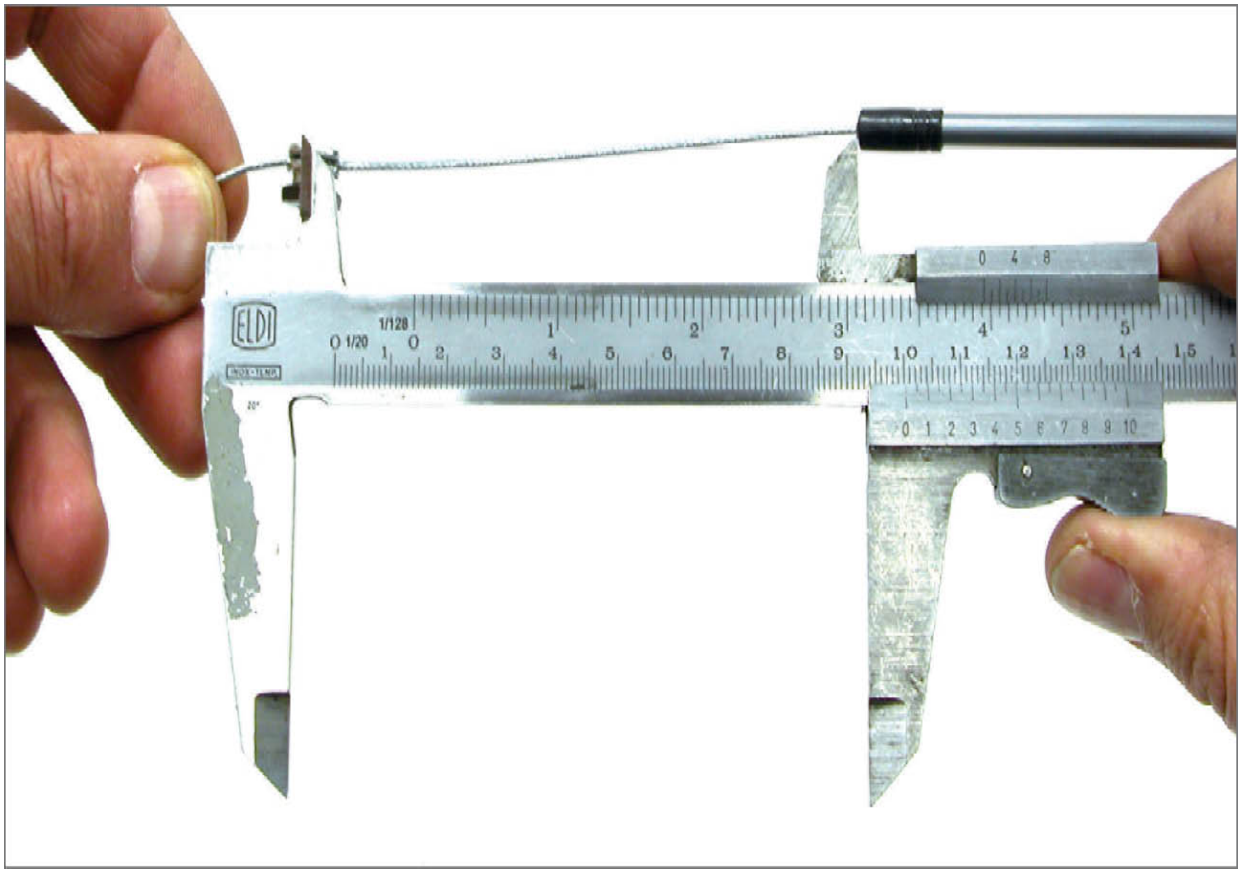


FIGURE 12.14: Measure approximately 100mm between end cap and center of pinch bolt

Gears are adjusted by alignment marks on cassette joint. Marks are visible both from above and below bike.

Procedure for gear adjustment:

a. If not already done, tighten cable anchor bolt onto cassette joint (figure 12.15).

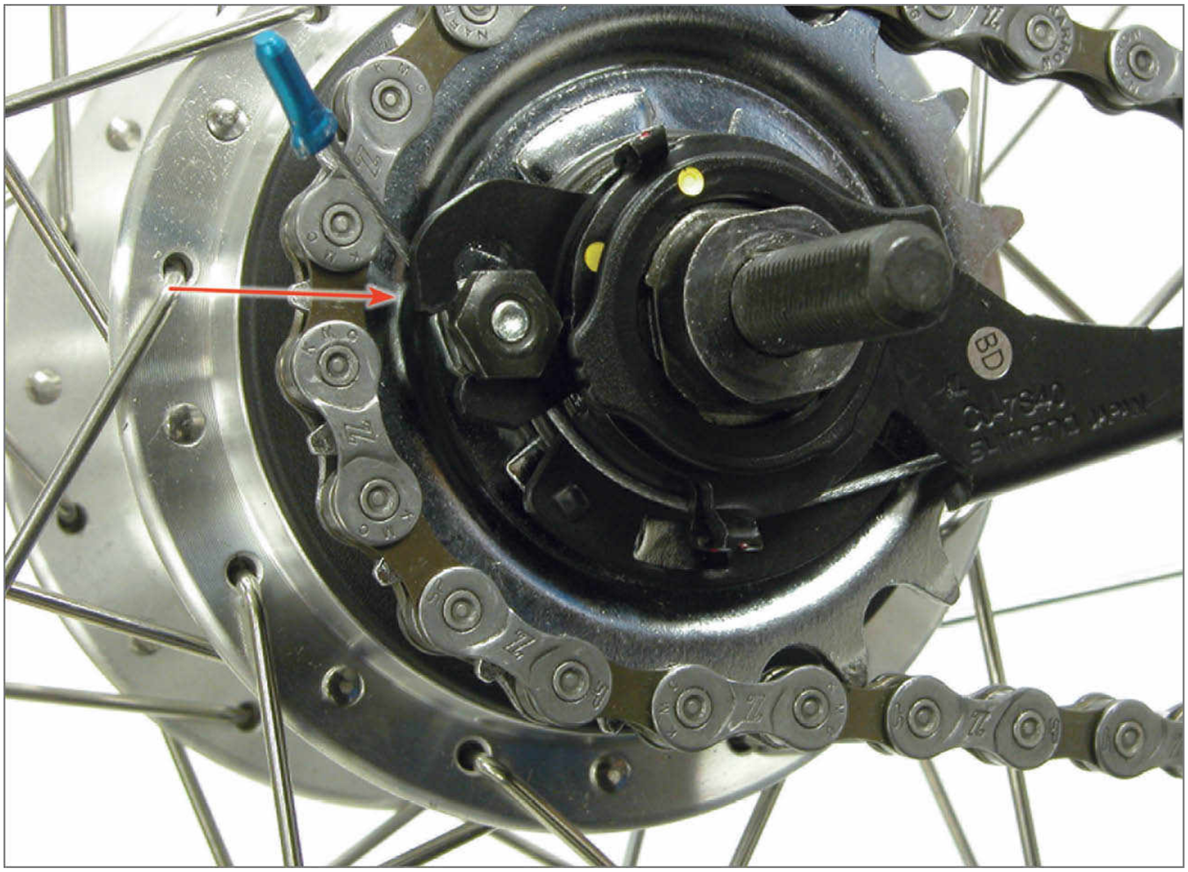


FIGURE 12.15: Engage pinch bolt onto cassette joint

b. For Inter-7 and Inter-8 hubs and shifters, shift to fourth gear position. For Alfine® 11-speed, shift to sixth position.
c. Use barrel adjust to align red marks on cassette joint (figure 12.16). Shift all gears after adjustment.

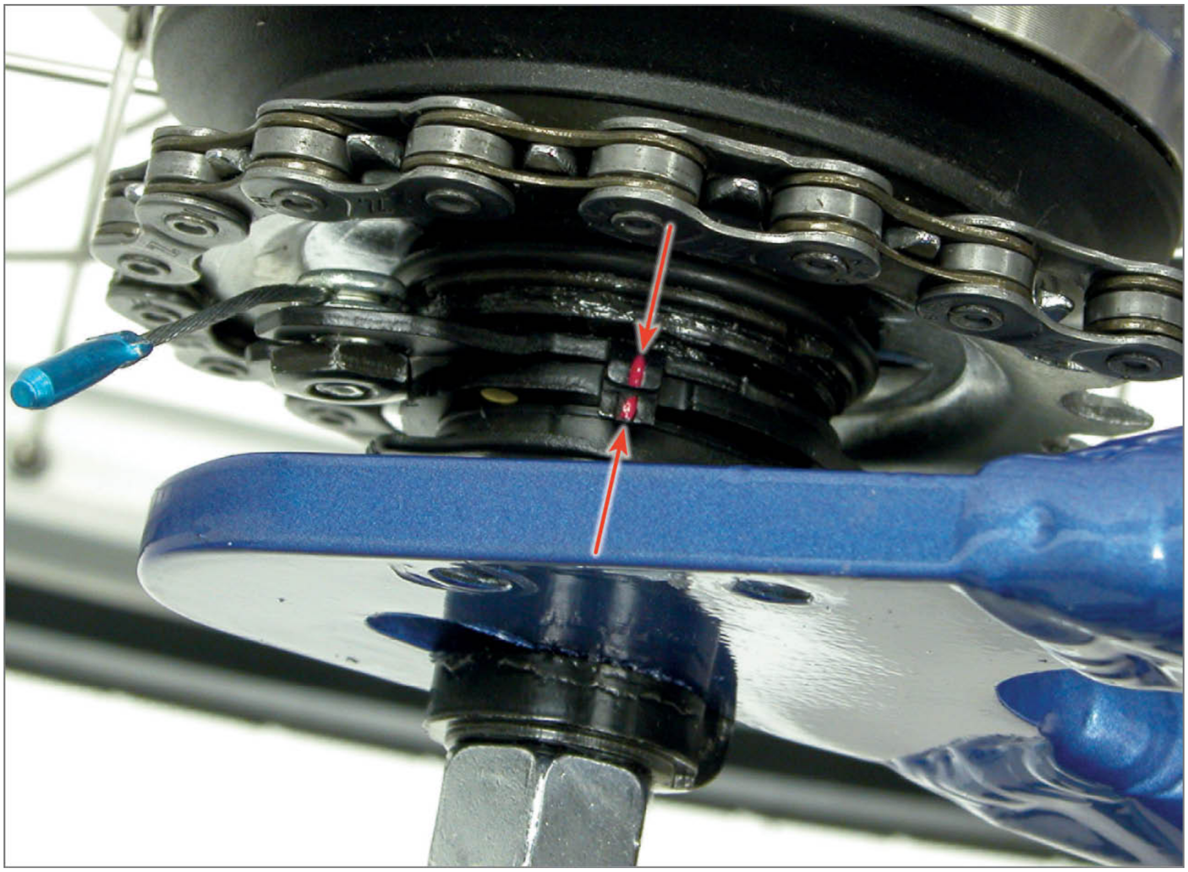


FIGURE 12.16: Align shifting adjustment marks at joint

CHAPTER 13

CALIPER DISC BRAKE SYSTEMS

Disc brake bikes use a caliper mounted near the fork or frame dropout ends, and a rotor disc mounted to the hub. Disc brakes can be designed into most any bikes, including MTB bikes, road bikes, cyclocross bikes, hybrid bikes, E-bikes, three-wheeled bikes, BMX bikes, and recumbent bikes. However, if brake mounts were not originally fitted to the bike, disc brakes cannot be added on. Disc brakes can be effective in wet weather where mud, dirt, and water are a concern in braking.

Brake pads are housed in the caliper and are forced against the rotor, which slows the bike by converting the bike speed into heat. Allow the rotor and caliper to cool before touching. The rotors are made of machined steel, and the edges can be sharp. Always stop the wheel before touching or working on the calipers and rotors. Try your best not to touch the rotors, as your fingers have oils on them and can add to their contamination.

CALIPER TYPES

Disc brake systems can be either mechanical or hydraulic. Mechanical systems use calipers that are cable actuated, similar to rim caliper brakes, using brake housing and an inner brake cable pulled by the brake lever (figure 13.1).

FIGURE 13.1: Front mechanical caliper brake

Hydraulic caliper systems use sealed hydraulic hose and pistons to move the brake pads (figure 13.2). Brake fluid travels from a piston at the lever to pistons behind the brake pads, which in turn push against the rotor. The brake lever piston is referred to as the “primary piston” and the pistons in the caliper body are the “secondary pistons.” The brake system relies on the entire system being sealed and free of air bubbles when the lever is pulled.

FIGURE 13.2: Hydraulic brake with hydraulic tubing fitted to caliper

There are now three possible frame mounting standards to secure calipers to the frame and fork. These are the International Standard (IS), Post Mount (PM), and Flat Mount (FM).

The International Standard (IS) uses two non threaded mounting tabs spaced at 51mm on frame or fork (figure 13.3). Older calipers were designed to bolt directly to these mounts. However, IS mounts are now primarily used to hold adaptors that allow for Post Mount style calipers. These adaptors are available in different sizes to allow for use of different size rotors.

FIGURE 13.3: International Standard (IS) mounting system holding a caliper mounted to a Post Mount (PM) adaptor

Post Mount (PM) compatible frames or forks allows PM calipers to be directly mounted without the use of an adaptor bracket (figure 13.4). The mounting holes are spaced 74mm apart with internal threading for M6 bolts. PM adaptor brackets act as spacers to raise the caliper body, allowing the use of larger rotor sizes. Consult frame or fork manufacturer if an adaptor is required.

FIGURE 13.4: Post Mount (PM) system on compatible fork

The Flat Mount (FM) brake caliper standard is designed to be more compact. The rear mounting system is integrated directly into the chain stay. Two bolts pass through oval shaped holes in the chain stay and thread into an the FM caliper body or an adaptor hold the caliper. The oval shape holes allow for lateral caliper body positioning over the rotor (figure 13.5)

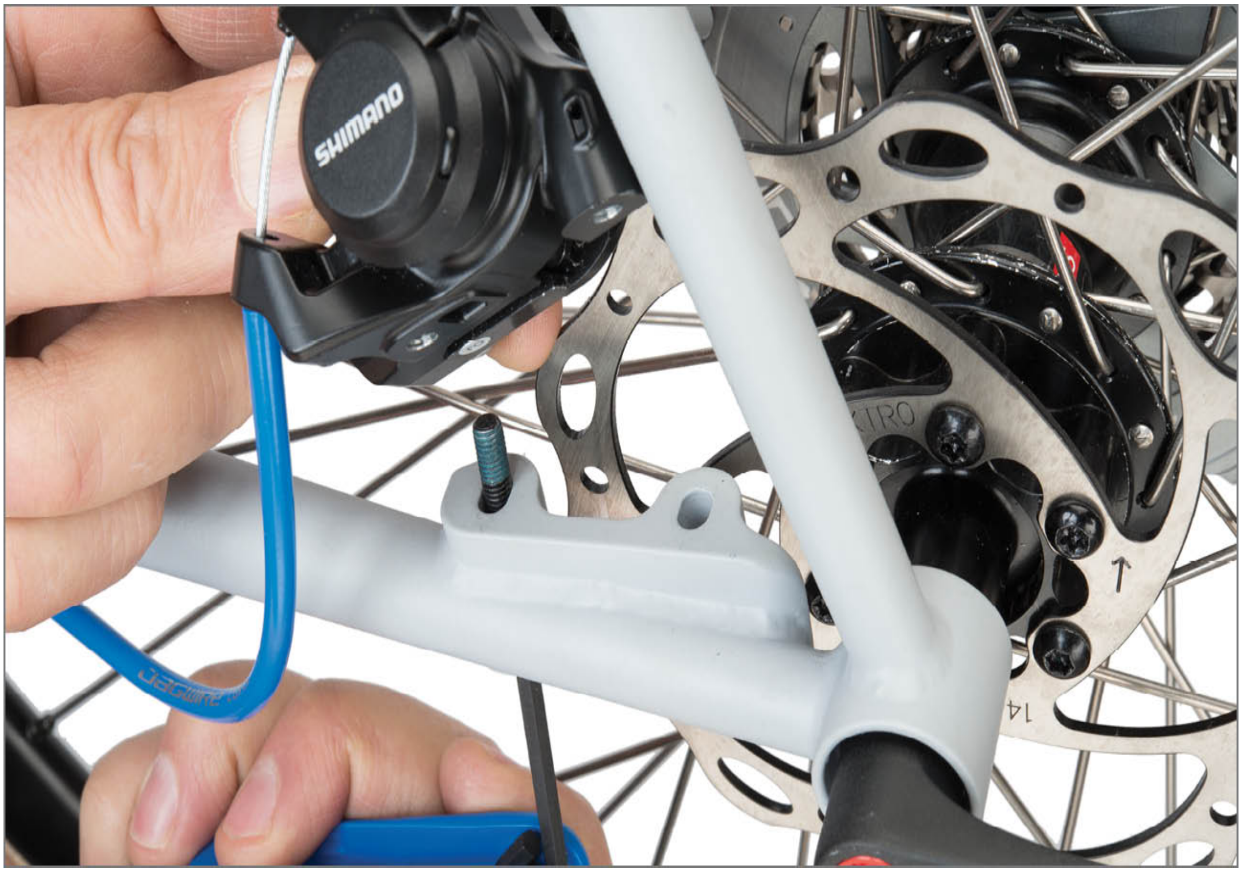


FIGURE 13.5: Rear Flat Mount brake standard

Compatible FM forks are made with internal threads to hold the front brake adaptor. The flat mount caliper bolts to the adaptor, and the adaptor is then bolted to the fork. Oval holes in the bracket allow for lateral caliper positioning (figure 13.6). Front and rear FM mounts use M5 threaded fasteners.

FIGURE 13.6: Front fork Flat Mount brake standard

BRAKE PADS

Each brake manufacturer designs pads to fit their particular caliper body. Pads do not interchange between most brands or even models within a brand. However, there are aftermarket pad manufacturers making pads for many different models.

Brake pads thin with use as they rub and wear against the rotor under the pressure of braking. Pads should never be worn down to where the metal back plate is showing or contacts the rotor. Typically, replace pads as they reach about 1mm pad material thickness, not counting backing plate. Contact brake manufacturer for their specifications.

Pad material of synthetic, non-synthetic and sintered metal is bonded directly to a back plate of either steel or aluminum. Basic styles are referred to as “resin” and “metal,” also called “sintered metal.” Generally, resin materials offer the user more modulation and tend to squeal less. However, these pads tend to also wear more quickly. The harder metal or semimetallic pads will longer, especially in wet and muddy conditions (figure 13.7), but also tend to be noisier. Check the brake rotor before selecting pads. Some rotors are designed for resin pads only and this will be printed on the rotor. Resin-only rotors will not function well with the harder metallic pads.

FIGURE 13.7: (A) Semimetallic disc brake pad, (B) Resin disc brake pad

Keep pads free of oils, and grease. Contaminated pads should be replaced. A light sanding with very fine emery cloth can help to clean marginally dirty pads. Remove pads from caliper body. Lay abrasive paper on a flat surface and rub pad back and forth lightly to remove grit. Use isopropyl alcohol or acetone when cleaning dirt or oils from rotor surface. Do not use a solvent or cleaner that contains oils or leaves an oily residue.

BRAKE PAD REMOVAL AND REPLACEMENT

Caliper brakes will have a system in place such as a spring to move the pads away from the rotor as the brake cylinders are released (figure 13.8). This spring does not literally push the cylinder wider; it simply moves the pads off the rotor. Note orientation of any spring as old pads are removed. As always, take images for future reference as you work.

FIGURE 13.8: Return spring positioned between pads

For mechanical caliper pad replacement, begin by dialing back any pad adjustment screw to make room for newer, thicker pads. For hydraulic calipers, pads can be removed first, but caliper pistons need to be "reset" or pushed back into the caliper before new pads are installed.

Begin pad removal by getting the bike in a repair stand and removing the wheel. Pads will have a variety of pad retaining systems built into the body. A common system is the pad-fixing bolt or pin through the caliper body and pad backing plates. Inspect caliper body for a screw or a cotter pin. A screw may have a retaining clip acting as a safety; remove this clip before unscrewing (figure 13.9).

FIGURE 13.9: Remove bolt clip and unthread pad-fixing bolt

If a cotter pin is used as a retaining pin it should be straightened using needle nose pliers, and then pulled from the body (figure 13.10).

FIGURE 13.10: Straighten cotter pin before pulling from body

Inspect caliper body to see which way to push pads for removal. Some models remove upward, away from the rotor, and others remove downward. The caliper body opening with a large opening is the direction of removal.

Another system of pad retention is an internal clip system inside the caliper body. Hayes® brake pads are one example of pads held to pistons with spring clip (figure 13.11). If there are tabs at end of pads, use these to pull pad from caliper using your fingers or pliers.

FIGURE 13.11: Use pliers to remove Hayes® pads with spring clip

Another design option is a magnetic system to hold pads. Push pads inward to free and pull to remove (figure 13.12).

FIGURE 13.12: Remove magnetically held pads by pushing them out of caliper body

PAD INSTALLATION

Pad installation is for the most part the opposite procedure of removal. Pads may not be symmetrical, inspect for “inner” and “outer,” or “left” and “right” markings. Some models use a return spring between pads, typically sandwiched between pads before installing. It may take a few attempts to successfully install new pads even for experienced mechanics.

For hydraulic brake systems, push each piston back into its respective caliper body side. USE CARE WHEN SEATING PISTONS. Unless there is a stud for clip-type pads, push at the center of the piston using a plastic lever, such as a thin tire lever or a padded cone wrench. If the piston has a stud for the pad clip, use a small box end wrench that will fit around the stud to push it back.

Again, for mechanical caliper brakes, dial any pad adjustment screw counter clockwise to retract pads from rotor before installing new pads (figure 13.13).

FIGURE 13.13: Dial mechanical caliper pad adjustment screws

counter clockwise

Reinstall and secure any pad-fixing bolt and any bolt clip. If it was a cotter pin retainer, install pin and bend longer end of the pin end upwards 90 degrees. Install wheel. Mechanical calipers will need to be reset with new pads and usually realigned to the rotor. For hydraulic calipers, squeeze lever repeatedly. This advances pistons and pads to rotor. Inspect alignment and realign if pads are rubbing rotor.

DISC BRAKE ROTORS

Disc brake compatible hubs are designed to hold and secure the rotor disc. The common system uses six bolts on a flange built into the hub shell. Rotor-mounting bolts are M5 threading and typically use a Torx® T-25 size wrench (figure 13.14). Secure rotor bolts to manufacturer's torque specifications. When mounting rotors look for rotational direction arrows indicating mounting orientation. If there is writing on one side of the rotor that side will face outward toward the mechanic.

FIGURE 13.14: Secure rotor bolts using T25 driver

A "center-lock" hub is designed with splined fittings to accept rotors made with a matching internal pattern. The rotor is held tight with a lockring. Some lockrings use the same tool fitting as cassette lockrings with 12 internal notches. Use the Park Tool FR-5 series. It is common on thru axle hubs to see a larger lockring with 16 external notches (figure 13.15). Use the Park Tool BBT-9 or BBT-69.2.

FIGURE 13.15: Center-lock rotor on thru axle hub using BBT-9

The rotor diameter needs to be compatible with the brake mount so the pads strike the rotor correctly. Rotors are available in many sizes including outside diameters of 140, 145, 152, 160, 180, 183, 185, 200, and 203mm. A larger rotor provides more leverage during braking, which results in a more powerful brake. Frame and fork design will limit the rotor size options. It is possible on some frames/fork to change rotor diameter by also changing the caliper mounting adaptor bracket. Different rotors brands can typically interchange between caliper brands assuming the replacement rotor is a compatible diameter.

Braking during the ride grinds and thins rotors, which must eventually be replaced. A common manufacturer’s replacement thickness is a minimum of 1.6mm. Measure caliper thickness at the braking surface and replace before it reaches this minimal tolerance. To gauge wear without a caliper, replace rotor if it has developed an obvious step at the braking surface where it has contacted the pads (figure 13.16).

FIGURE 13.16: An obvious step in braking surface from pad wear requires rotor replacement

Rotors may become bent or warped with use and abuse. Some rebending for alignment may be possible. The Park Tool DT-2 Rotor Truing Fork allows rotor rebending (figure 13.17). Write a number on each rotor arm to better track the repair progress. Mount the bike in a repair stand and spin the wheel. Watch for a lateral wobble (run-out) at the caliper pads or hold the DT-2 close to rotor as a truing indicator. Stop the wheel where it rubs and note location and direction of rub. Also note your reference number on the rotor arm. Move rotor out of the caliper body to permit bending, and use the DT-2 or adjustable wrench to bend this area slightly. Spin the wheel and check the rotor again. Repeat as necessary. If rotor true does not improve after several attempts, replace the rotor.

FIGURE 13.17: Move area to be rebent away from caliper body before bending rotor left or right

New rotors and new pads should be “burned in.” The heat of burn-in helps remove solvents and any residue from pads and rotors. Pad material is also transferred to the rotor face. To burn-in a new rotor, begin by cleaning it with alcohol or acetone. Under clean and dry conditions ride the bike at speed on flat pavement and apply brakes with force, as in a “panic stop,” but do not skid the tires and do not stop the bike completely. Again, bring the bike up to speed and repeat this hard slowing about ten times for each brake (figure 13.18).

FIGURE 13.18: Typical rotor showing burned in effects

HYDRAULIC BRAKE SYSTEMS

Mechanical cable systems have flex in both the cable and housing, and this prevents full transfer of force from pulling the lever down to the brake pads pushing on the rotor. Because hydraulic fluid does not compress or flex under stress, hydraulic systems are considered more efficient and provide higher performance compared to mechanical systems.

Hydraulic systems should be inspected at all fittings and hose connections for leakage and seepage on a regular basis. Leaking at any fitting will eventually lead to brake failure.

HYDRAULIC BRAKE LEVERS

Hydraulic brake levers contain a piston called the "primary piston." When the lever is pulled, the primary piston pushes brake fluid down sealed hydraulic hose to a pair of "secondary pistons" inside the caliper body, and these push against the brake pads. A spring inside the brake lever body pushes back the primary piston when the lever is released. This pulls fluid from back behind the caliper pistons to move pads away from the rotor face.

The pads will press and rub against the rotor, resulting in heat as the bike slows. The heat is dissipated at the rotor but some heat will also transfer to the pads and pistons and eventually to the fluid, which can cause the fluid to expand. Hydraulic disc systems use a reservoir system that contains a bladder to allow for the expansion of brake fluid (figure 13.19). The primary piston is sealed from the reservoir when the lever is pulled, but it opens to the reservoir when the lever is fully open.

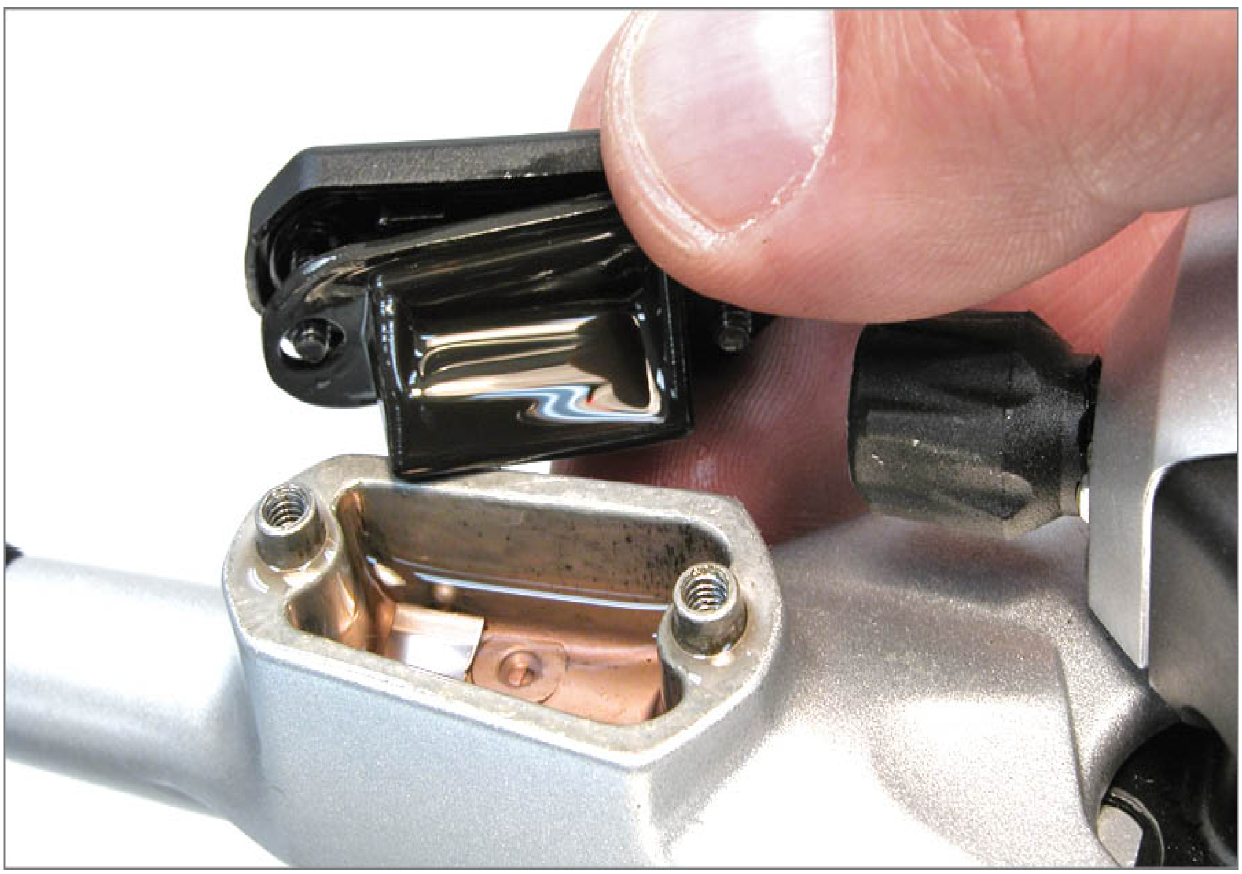


FIGURE 13.19: Reservoir and bladder at brake lever

Hydraulic brake levers are positioned on handlebars similar to conventional or non-hydraulic levers. The lever reach from bar to lever is adjusted with a screw either behind or in front of the lever (figure 13.20). Turning the reach screw moves the lever relative to the handlebars. The reach adjustment screw does not move the pistons closer to the rotors. Set lever reach for rider preference.

FIGURE 13.20: Brake lever reach adjustment screw on a Shimano® lever

Some models of hydraulic brake calipers and levers can be rebuilt with new seals at the primary and secondary pistons. This is more commonly required for DOT brake systems, and this work is best left to professional mechanics.

Hydraulic Brake Caliper Alignment

There are tight tolerances between pad and rotor in a working brake. Because the pads are hidden inside caliper body, it can be difficult and awkward to view caliper-to-rotor alignment. Work in well-lit areas. It can also help to place white paper, or equivalent, behind the area you are viewing. Shine a flashlight on the paper to backlight the pad and rotor (figure 13.21).

FIGURE 13.21: Use white background to help view caliper alignment to rotor

Disc pads are designed to strike the rotor face flat or squarely. Inspect old pads when removed. If pads are worn unevenly, it may be a sign that the caliper is misaligned to the rotor (figure 13.22).

FIGURE 13.22: Pad above is new, while used pad below shows signs of misalignment of caliper to rotor

Caliper brake bodies commonly have a lateral adjustment and allow adjustment of front and back edges of pads to the rotor. The top and bottom edges of the pad should also strike the rotor flat. Depending upon design of the caliper, proper alignment will rely on the machining of the caliper mounts relative to the rotor. If no caliper mounting adjustment will stop pad rubbing and allow pads to strike the rotor flush, the frame fork mounts may require machining (“facing”). Consult a professional mechanic.

There are some brake models using a pair of conical spacers above and below the caliper body mount. These “cup-and-cone” spacers help with perpendicular alignment. Because the brake caliper must be designed with extra spacer height, you cannot add these spacers to a caliper not designed to accept them. Avid® refers to this as a CPS mounting system.

The procedure to align the caliper to the rotor assumes the rotor is spinning with very little lateral error or wobble. Correct rotor errors before aligning the caliper. Another potential issue for hydraulic brakes is excessive seal drag between the caliper piston and hydraulic seal. Too much drag will not provide enough space between pads after the lever is released. Caliper body piston service is best left to professionals.

Procedure for hydraulic caliper alignment:

a. Loosen both caliper-mounting bolts. Check that caliper moves easily side to side on mounts.

b. Pull brake lever repeatedly to move caliper pistons against rotor. Maintain pressure at lever. This will move caliper body to align over rotor. Use a toe strap to hold lever if you cannot reach mounting bolts while holding lever pressure (figure 13.23). Snug caliper mounting bolts while maintaining pressure.

FIGURE 13.23: Hold lever to maintain pad pressure

c. Release lever and inspect this initial pad alignment. Spin wheel and watch for any contact. Pads may also make scraping noise if rubbing the rotor. Ideally, pads should retract to clear rotor with no rubbing. Fine-tune pad alignment by loosening one mounting bolt while keeping the other bolt only snug. This will allow you to push the caliper while pivoting off snug bolt (figure 13.24).

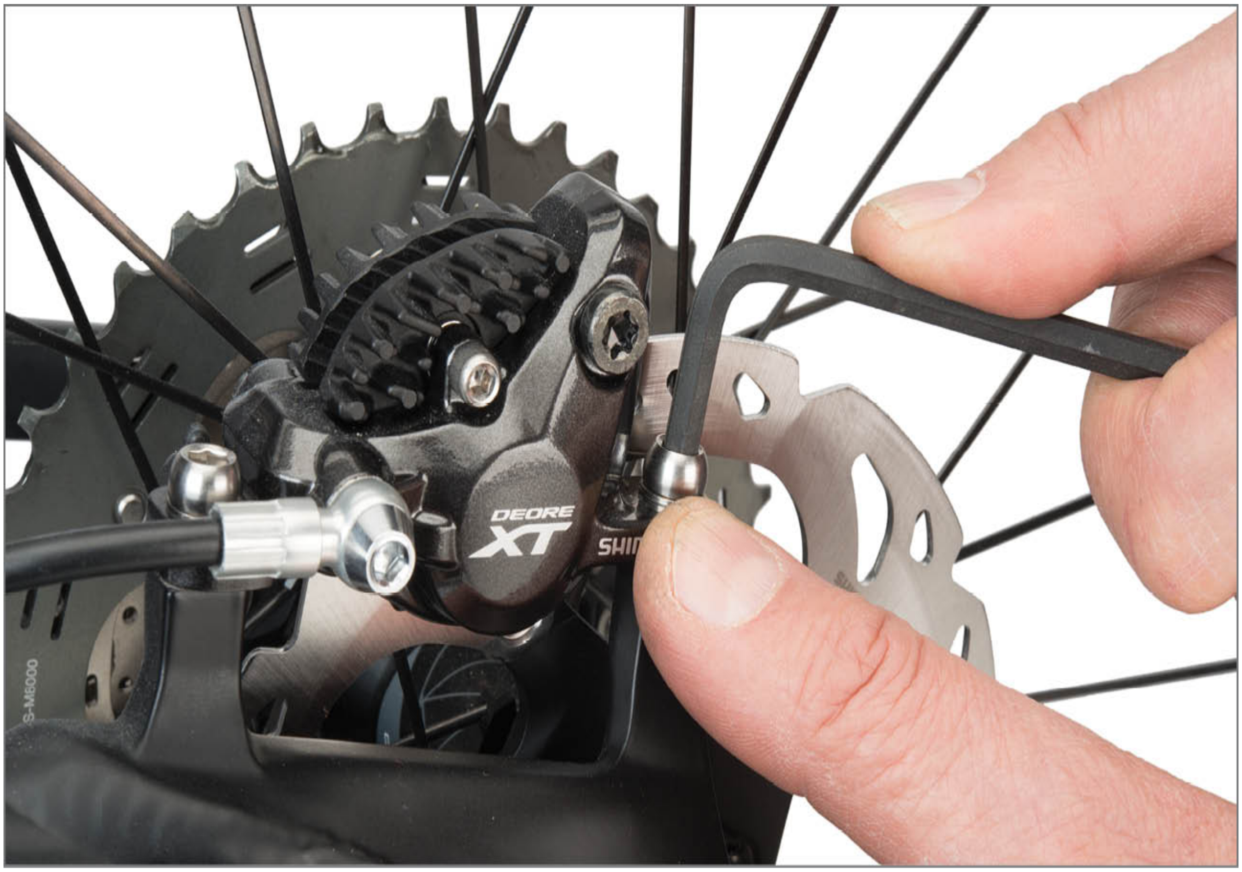


FIGURE 13.24: Align caliper pad to rotor and then tighten caliper-mounting bolts

d. Fully secure caliper-mounting bolts, typically 6–8Nm.

When a hydraulic brake lever is pulled, both the outer and inner pistons of hydraulic calipers are designed to move toward the rotor the same distance, and at the same time. However, because of small differences in seals, pistons, and caliper bodies, it may be that one pad strikes the rotor first. This is not a problem because no significant pressure will be applied until second pad reaches the rotor. One pad and piston may not retract as fully as the other into the caliper body when the brake lever is released. Consider this retracted position as its “neutral” or resting position. Use the neutral pad position when aligning the caliper body laterally over rotor, instead of trying to adjust the caliper so the pads hit the rotor at the same time. In some cases, however, a light rubbing may occur no matter the adjustment. This should not affect performance and can typically be ignored.

HYDRAULIC BRAKE FLUID SERVICE

With use, dirt and moisture will creep past seals to contaminate brake fluid. Hydraulic systems need occasional change fluid and bleeding with new fluid even if braking is good and there is no air in the system. An adequate fluid change interval by bleeding is typically once a year.

In hydraulic systems, it is important that there is no air in between the caliper pistons and the primary piston. Air bubbles will compress and cause the brake to feel soft when the lever is pulled with force (figure 13.25).

FIGURE 13.25: Air bubble seen inside clear model of brake lever

To determine if there are air bubbles in the system, grab and pull the lever with force. There will always be some flex in the lever but it should come to a firm stop when the pistons are pushing against the rotor and before the lever hits the bar. A system with air inside will feel soft or "spongy" as the air bubbles compress when the lever is pulled. Test both brakes to see if they feel the same. If one feels firm, and the other "spongy," a bleed is in order.

It is critical to use the correct type of fluid when servicing brake system. Some manufacturers specify proprietary mineral fluids, while others use various automotive DOT brake fluid. The DOT fluid and Mineral oils should never be mixed. Using an incompatible fluid can cause seals to fail and result in brake failure. Bleeding tools and syringes for mineral fluid should never be used for DOT fluid and vice-versa.

Automotive fluids are DOT (Department of Transportation) approved and are generally polyglycol fluids. The DOT fluids have different ratings, such as 3, 4, 4.1 or 5 or 5.1. Contact brake manufacturer for specific recommendation. DOT brake fluids are caustic and toxic. Work with care to avoid fluid contact with the outside of lever or caliper, bike, and your skin. When available, use protective gloves, such as Park Tool MG-2 Mechanic Gloves. During any work with hydraulic fluid, clean spills on the bike, caliper, or lever with a rag and isopropyl alcohol, or soapy water. DOT hydraulic fluids can damage paint finish.

The procedures to service brake fluid system varies between manufacturers. There may also be different techniques for the same model. In all hydraulic brakes, the concept is to inject new fluid and remove any air bubbles inside the system.

There are usually three parts of a bleeding procedure. First is bleeding the brake caliper body, followed by bleeding the hydraulic hose. Last is removing any air from the brake lever. When in doubt, check with manufacturers for their service recommendations.

The required service tools for brake bleeding can vary with each brand. The basic component parts of a bleed kit are: a sealed plastic bottle or syringe to pump fluid into the system, a mechanism or system to catch waste fluid as it exits, and tubing and threaded fittings to attach hoses to caliper and levers. Acceptable syringes are also available from pet supply retailers and farm & ranch suppliers. However, if the system requires threaded fittings, these are often proprietary and it is best to use the manufacturer’s bleed kit. When servicing hydraulic brakes, work in clean conditions. Use care to keep hydraulic pieces, such as the bladder, bleed port screws, and any fittings clean and away from dirt or moisture.

SHIMANO® HYDRAULIC BRAKES

There have been multiple styles of Shimano® hydraulic brake systems. All use Shimano's® proprietary mineral fluid. Shimano® offers bleed kits for their brakes based on two different systems. An older Shimano® style uses a removable reservoir cover at the brake lever. There will be no bleed port screw in the lever on these models. Procedures for this reservoir cover style are covered at www.parktool.com. The contemporary Shimano® style uses a special "funnel" system to bleed, using Shimano® part number DISC-BP. This cup or funnel fits into the bleed port at the lever. Road hydraulic levers use the "funnel" system of bleeding, but only the older MTB levers use the removable reservoir cap design. The road levers require an extension to the DISC-BP funnel.

The funnel cup acts as a temporary fluid "reservoir." The system begins first with fluid pushed up from the caliper to the funnel. Then excess fluid is allowed to drain downward and out the caliper bleed nipple. Lastly, the caliper bleed nipple is closed and the lever is rotated fore and aft to ensure any bubbles trapped inside find a way out. The road version and MTB version of braking systems share the same basic bleeding procedures.

For purposes of bleeding, the lever reach should be moved outward as much as it is allowed. Use the reach adjustment screw to bring lever away from grip if it was adjusted inward. This ensures the piston is not blocking the bleeding port.

Procedure for Shimano® Funnel bleed:

a. Mount bike in repair stand and remove wheel. Rotate bike so there is always an uphill slope to brake hose.
b. Fill a syringe near full with Shimano® brake fluid.
c. Remove pads from caliper.
d. Pressing evenly on piston surface, moving each piston back into its respective side (figure 13.26).

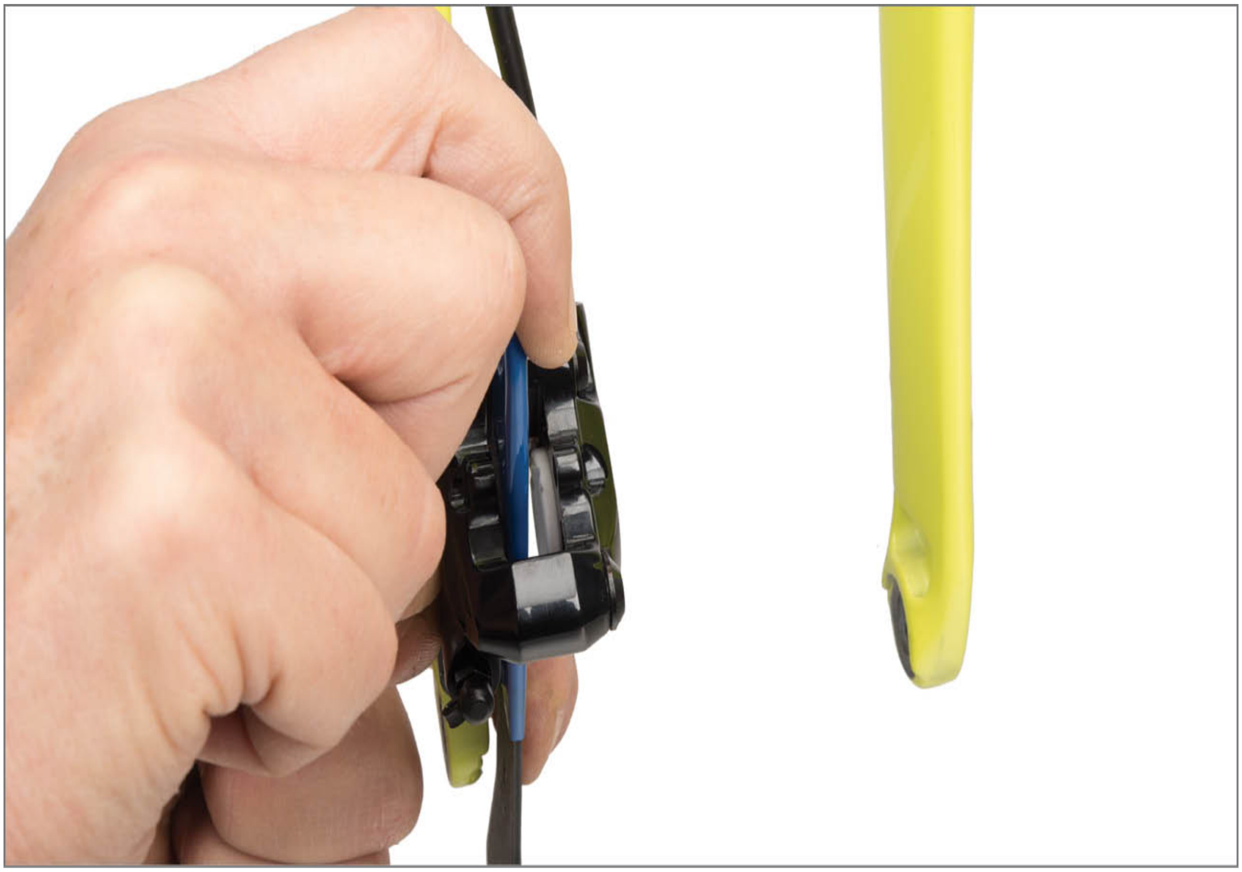


FIGURE 13.26: Push pistons back into relative sides of brake body

e. Install Shimano® bleed block (figure 13.27). Substitute a clean and hard material that matches the width between pistons to keep piston from moving inward. For example, a hex wrench of matching width.

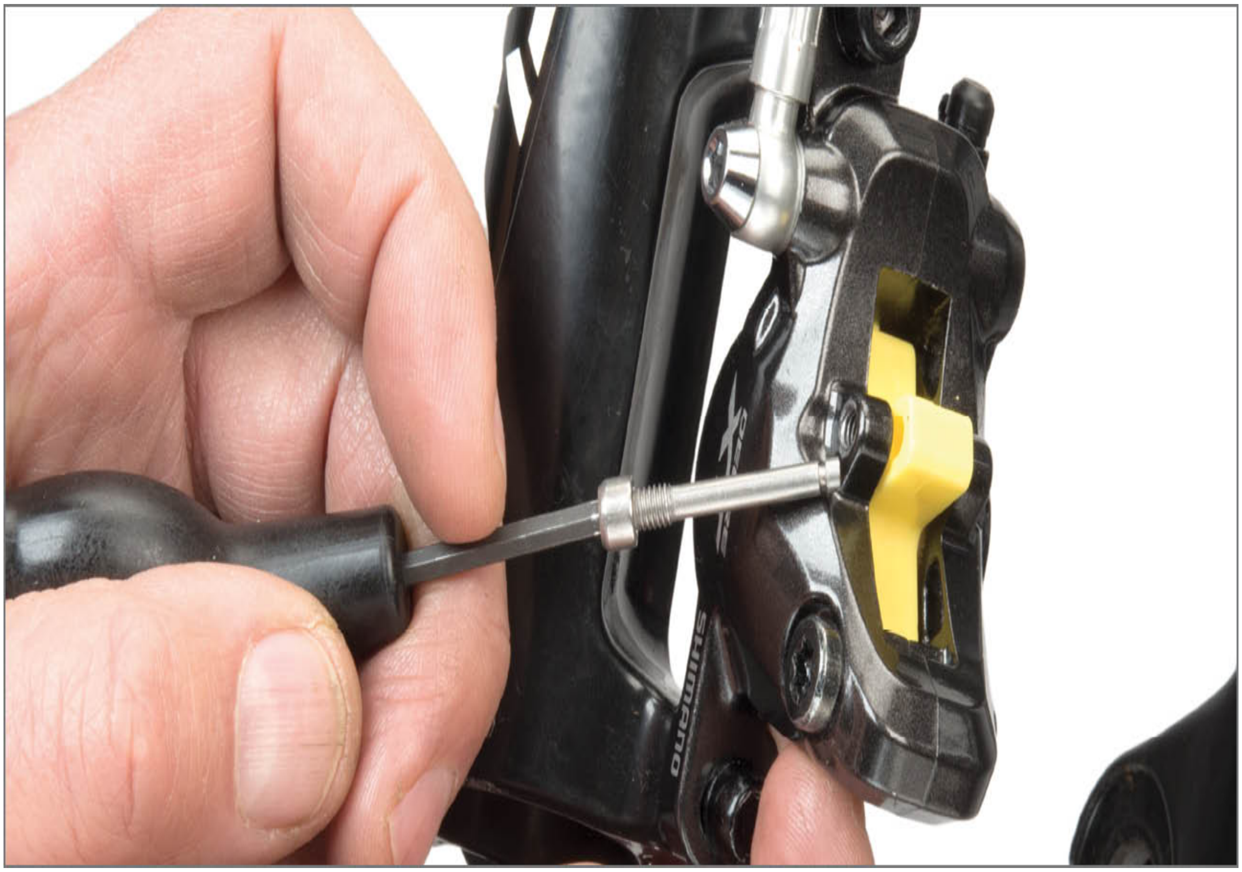


FIGURE 13.27: Install brake bleed blocks

f. Locate and remove brake lever bleed port screw and O-ring. For upright bar levers this screw is on top of lever (figure 13.28). For road levers, look under brake lever hood. The road levers require a funnel extension. Expect some mineral oil to weep out of the hole, take precautions to protect bar tape (figure 13.29).

FIGURE 13.28: Bleed port screw on upright bar lever

FIGURE 13.29: Bleed port and extension on drop bar lever

g. Thread on Shimano® Funnel DISC-BP into bleed opening in lever or onto extension. Remove plunger from funnel.
h. Viewing bike directly from side, take note of vertical alignment of funnel. For MTB levers, loosen lever clamp and rotate for funnel so that it is approximately 45 degrees back from vertical (figure 13.30). For road levers loosen handlebar binder bolts and rotate bars to achieve 45-degree alignment from vertical (figure 13.31).

Di2® CAUTION: if bike uses internally mounted shifting wires through handlebars and stem, do not rotate bars. Rotate entire bike as necessary to change funnel tilt.

FIGURE 13.30: Rotate brake lever so funnel is 45 degrees from vertical

FIGURE 13.31: Rotate so funnel is 45 degrees from vertical

i. Locate caliper bleed nipple and remove cover. Engage tubing from syringe over nipple (figure 13.32). Some bleed nipples are internal to the caliper body (figure 13.33).

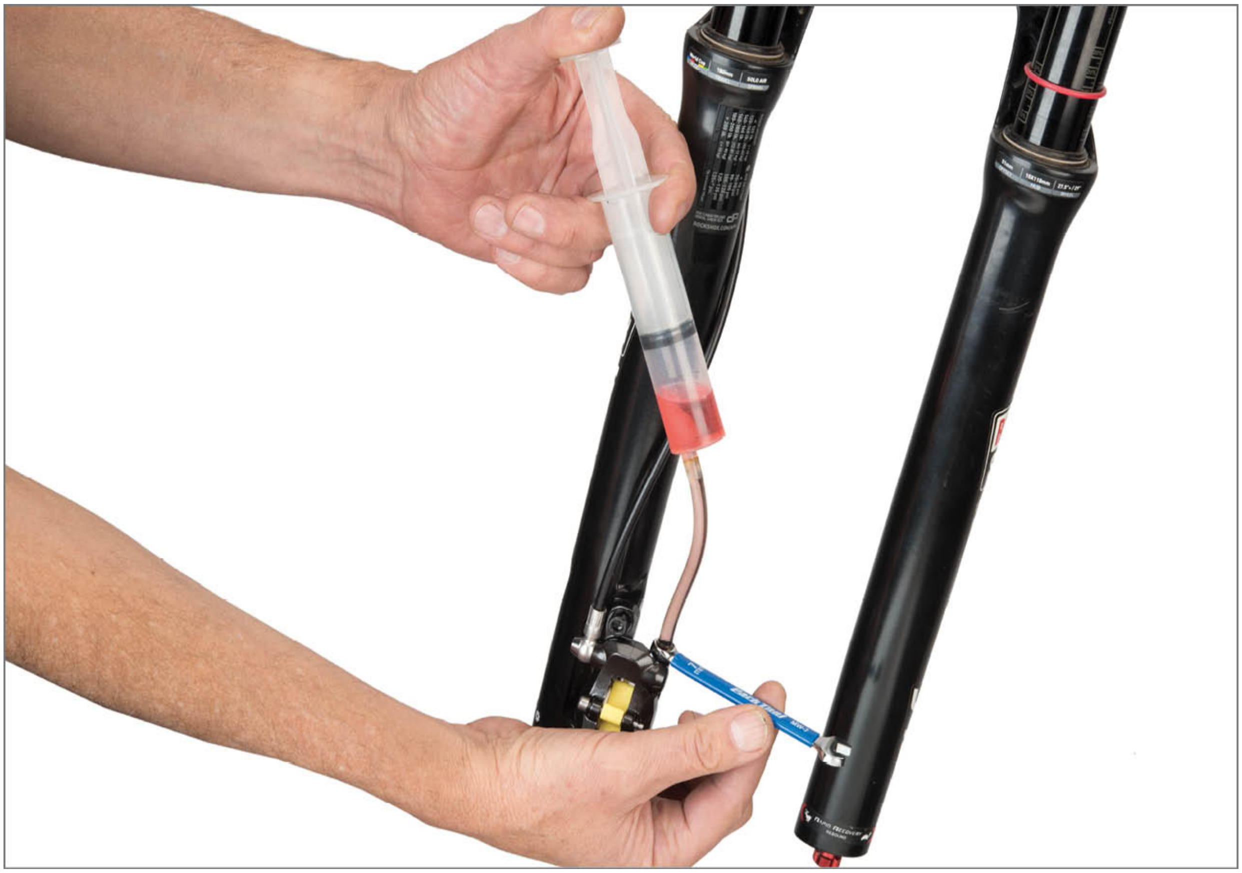


FIGURE 13.32: External caliper bleed nipple opened with wrench

FIGURE 13.33: Internal caliper bleed nipple open with hex key

j. Open nipple by loosening 1⁄2 turn. External nipples loosen with 7mm box wrench. Internal nipple set screws loosen with 3mm hex wrench.

k. Hold syringe with plunger vertical to prevent air bubbles from reaching caliper. Push most of syringe fluid into caliper but do not allow any air from syringe to enter caliper. New fluid and air bubbles will travel upward to lever and exit at funnel.

l. Close caliper bleed nipple or set screw and remove bleed syringe from brake caliper nipple.

m. Install a section of hose with waste collection bag or waste bottle over caliper bleed nipple (figure 13.34).

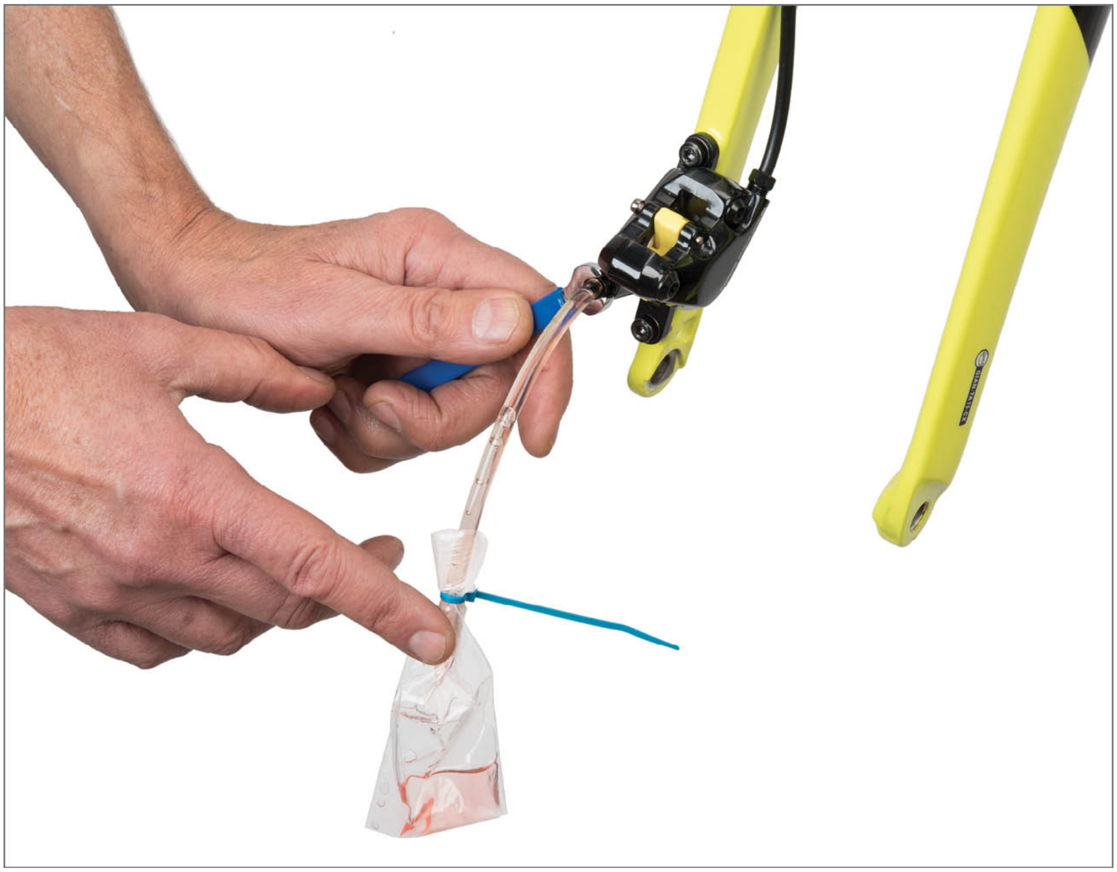


FIGURE 13.34: Attach waste collection bag to bleed fluid out of caliper

n. Check that funnel is more than ½ full. Add fluid if necessary. If clean, use fluid to bleed back down line. If dirty, use plug and unscrew funnel, disposing of fluid. Reinstall and refill. Loosen caliper bleed nipple or set screw allowing fluid from funnel to drain down and out through waste tubing. Squeeze lever gently to start fluid flow.

o. Tap along length of hydraulic tubing to encourage any bubbles to dislodge. **Caution:** Inspect at funnel to see it does not come close to draining fluid to empty (figure 13.35). Leave funnel approximately ¼ full. Close caliper bleed nipple or set screw. Refill funnel as necessary

FIGURE 13.35: Inspect at lever and fill cup before it fully drains

p. Pull lever to apply pressure to pistons. If you cannot reach bar and caliper simultaneously, hold lever to bar with strap or zip tie.

q. Quickly open and close caliper bleed nipple once. Pressure will be lost at lever. Remove strap and repump level until it again feels firm. Repeat one more cycle of opening and closing caliper bleed nipple. Remove strap from lever.

r. Check that lever is free of air by repeatedly squeezing lever while inspecting inside funnel for any bubbles (figure 13.36).

FIGURE 13.36: Inspect for bubbles inside funnel

s. The funnel should now be rotated 45 degrees forward from horizontal. Rotate either brake lever, handlebars, or bike as necessary.
t. Again, repeat squeezing lever while inspecting inside funnel for any bubbles.
u. When no bubbles are appearing from either tilted funnel position, rotate lever, handlebars, or bike until funnel is vertical. Plug funnel and remove from lever, checking that funnel O-ring is with funnel.
v. Install lever bleed screw with O-ring and secure.
w. Return lever or bars to riding position and secure.
x. Remove brake block and clean all levers and calipers with alcohol. On road bikes, expect to clean brake fluid from inside rubber hood using alcohol.
y. Install brake pads, retaining pin, retaining pin clip, and wheel. Recenter brakes a necessary.

MAGURA® HYDRAULIC CALIPER BRAKES

The Magura® hydraulic disc calipers use a proprietary mineral oil called "Magura Royal Blood™." Do not use DOT fluids for brake fluid.

The Magura® caliper brakes bleed from the caliper upward to the lever. Magura® offers a bleed kit with a two-syringe system. The first syringe uses flexible tubing with a proprietary barbed fitting to push fluid from the caliper to the lever. A second syringe is used for fluid collected at the lever bleed port ("EBT™ screw).

Procedure for bleeding caliper:

a. Mount bike in repair stand and remove wheel of brake being bled.

b. Set pistons back into caliper body using Park Tool PP-1.2 Piston Press, or a plastic tire lever.

c. Remove pads from caliper to avoid oil contamination.

d. For front fork calipers, rotate bike so caliper mounting tabs are vertical. For rear brake, unbolt caliper brake from frame and allow caliper to hang vertically. This places caliper bleed port screw in its most vertical position.

e. Install a Magura® transfer block inside caliper. Substitute a 10mm hex wrench for this block. Hold block in place with a rubber band or zip tie as necessary. This prevents any movement of piston during bleed.

f. Prepare injection syringe with mineral oil. Pull 25cc to 30cc of brake fluid into syringe, then hold syringe vertically with fitting upward to allow air to escape. Push plunger slowly until only fluid remains in syringe.

g. Remove caliper bleed port screw from caliper. Thread and secure barbed fitting of syringe filled with fluid.

h. Remove bleed port screw (EBT™ screw) from brake lever using T25 Torx® driver. Pull plunger from second syringe and insert syringe without plunger into brake lever port (figure 13.37). Open syringe will act as a brake fluid catch during bleed.

FIGURE 13.37: Install syringe into bleed port at lever

i. Push fluid syringe at caliper until nearly empty (figure 13.38). Do not fully empty syringe as this may introduce air into system. Watch for bubbles appearing in fluid at lever in open syringe, indicating air is leaving the system.

FIGURE 13.38: Push fluid from caliper upward to lever

j. Pull backward on caliper syringe slowly to draw a vacuum in brake system (figure 13.39). This helps remove any internal air bubbles. Partially squeeze and quickly release lever to encourage any bubble to dislodge and leave system. Do not completely drain syringe at brake lever.

FIGURE 13.39: Alternatively push and pull at syringe to remove air from caliper

k. Push fluid back through system a second time from caliper syringe toward lever.
l. Pull back one time on syringe at caliper to draw a vacuum. Do not completely drain fluid from syringe at lever.
m. Remove syringe at lever. Use a rag to catch fluid as syringe is pulled. Install bleed port screw (EBT™) at lever and secure.
n. Unthread syringe fitting from caliper and install caliper bleed port screw.
o. Wipe caliper and lever clean of fluid using alcohol.
p. Remove block from caliper. Install pads and pad screw.
q. Install wheel and pull lever to move pads to rotor.
r. Lever should feel firm when pulled repeatedly with force. Repeat bleed as necessary.

HAYES® HYDRAULIC CALIPER BRAKES

Hayes® offers brakes in both mineral oil and hydraulic brakes using DOT 3 or DOT 4 brake fluid. Never attempt to mix tools or fluids. These procedures are written for models using DOT fluid. The brakes bleed from caliper upward, and excess fluid exits at lever. Hayes® bleed kit includes bleed fittings for the lever, small pieces of plastic tubing, and a squeeze bottle. The bottle permits fluid to be pushed into the system, and then to be sucked back out. This system of pressure followed by a vacuum helps to clear the system of air. A syringe can be substituted, but it is necessary to occasionally pull back on the plunger to flush the system of air. It is necessary to rig a bleed waste fluid collection bottle at the lever to catch DOT fluid.

HAYES® BLEEDING

Hayes® bleed kit contains a bottle for fluid input and tubing with threaded fittings to fit various brake lever models. Find an empty bottle or can to collect waste fluid. A bent spoke and zip ties can be used to hang bottle from handlebars during your work. Before beginning bleed process, fill bleed bottle approximately half with Hayes® brake fluid. Attach tubing onto filling bottle spout. It can be useful to use a small zip tie to help secure tubing to bottle spout. Cut bleed hose short to maintain control of bottle during bleed.

Procedure to bleed caliper:

a. Remove wheel and remove brake pads to avoid contamination.

b. Rotate bike and or bars as necessary so there is an upward flow from caliper to lever bleed screw at lever. Remove caliper from frame if necessary.

c. Inspect lever for bleed screw. Loosen and rotate lever on bar as necessary until screw points directly upward to assist any air bubbles to escape. Leave lever clamp bolts loose enough to rotate lever.

d. Remove bleed screw from lever and insert bleed hose fitting. Arrange bleed hose and waste bottle to catch fluid. Use rags around lever to prevent fluid from getting on frame or other components.

e. Hayes® caliper brakes require pads be removed before setting pistons. Use box end of an 8, 9 or 10mm wrench over stud in piston and push each piston fully into caliper body (figure 13.40).

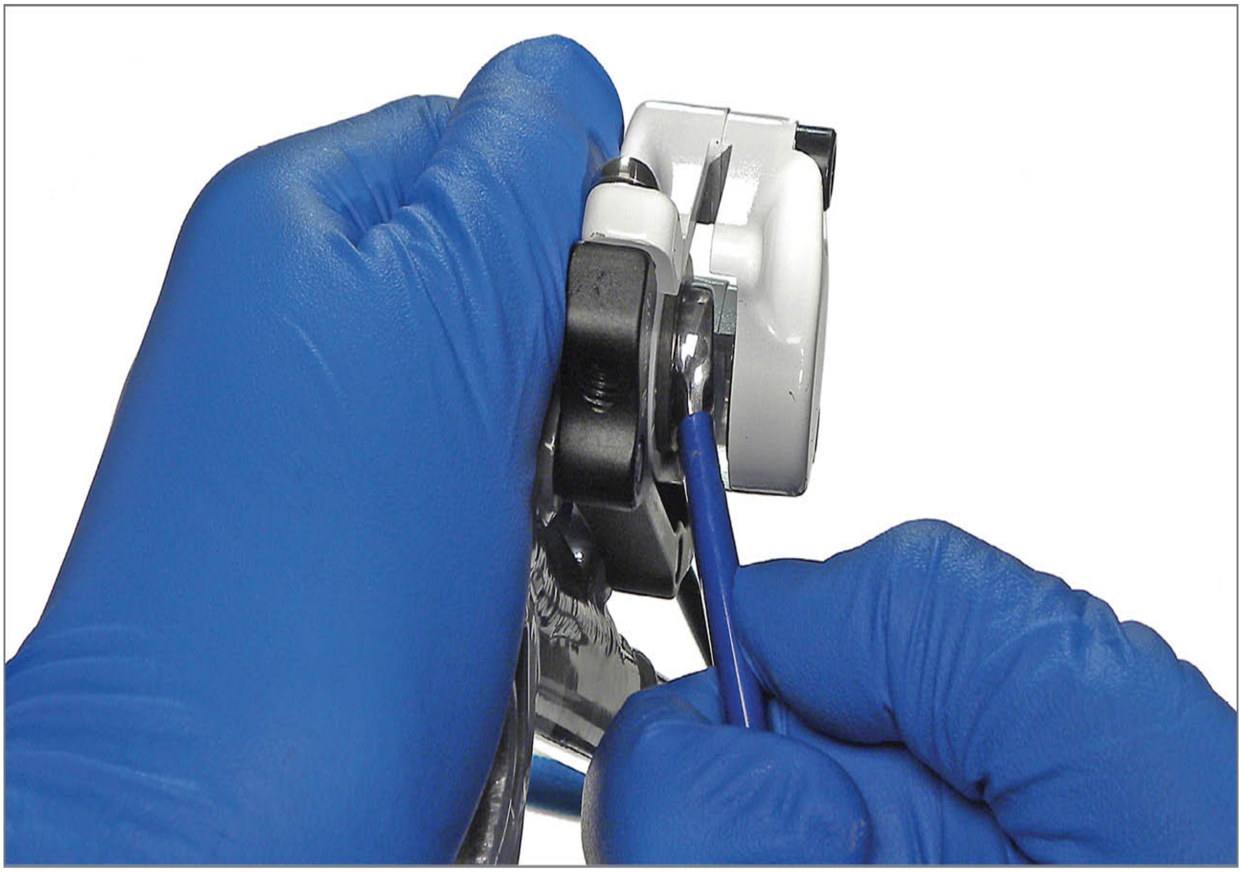


FIGURE 13.40: Push piston back using box end of wrench placed over piston stud

f. Locate bleed nipple on caliper body and remove rubber cover. Use a 6mm box end wrench and fit over bleed nipple.

g. Attach tube from brake fluid squeeze bottle to bleed nipple. Loosen bleed nipple 1⁄4 turn. Squeeze bottle firmly for approximately five seconds to force fluid into caliper and out lever bleed port. Relax bottle to draw any air out of caliper body. Continue to alternate between squeezing bottle for five seconds and releasing bottle until no air bubbles come back out of caliper (figure 13.41). If using a syringe, push fluid in, then draw back slightly to draw out any air from caliper.

FIGURE 13.41: Alternately squeeze and release bottle to draw out bubbles from caliper

h. When no more air bubbles appear to exit at caliper, continue to squeeze and release bottle while inspecting exit tubing at lever. Snap lever closed and open to encourage any trapped air to exit (figure 13.42).

FIGURE 13.42: Pull slightly on lever and allow it to snap forward to release bubbles

i. Rotate lever on bar slightly upwards while continuing to push fluid through system. Next rotate lever slightly downward and repeat. Continue until fluid exiting lever appears clear with no bubbles.
j. Close bleed nipple at caliper. Remove caliper bottle carefully and avoid dripping fluid on bike or parts. Clean any spills immediately with soapy water or isopropyl alcohol.
k. Remove exit hose from lever. Install and secure lever bleed-screw. Return lever to normal position and secure. Clean any spilled fluid all parts with soapy water or isopropyl alcohol.
l. Remove piston block and install brake pads.
m. Install wheel and rotor and test lever. Lever will feel loose for a few pumps until pistons move toward rotor. Lever should then feel firm when pulled with force.

SRAM® AND AVID® HYDRAULIC CALIPER BRAKES

SRAM® produces brakes under the SRAM® and Avid® labels. Both use only a DOT 4 or DOT 5.1 fluids. Do not use a mineral oil in this system. Models share the same concept and procedures for bleeding. It is recommended to use a SRAM/Avid® bleed kit with their hydraulic brakes. It includes two syringes with special threaded fittings, a bottle of DOT fluid, and an 8mm crow's foot with 3⁄8" drive. Store syringes with tubing clamps open. Syringes push the fluid back and forth between calipers to remove and internal air bubbles. There are some models using "Bleeding Edge™" technology and require a special caliper attachment.

Before beginning the bleeding procedure, prepare two syringes. Open tubing clamp on the syringe and fill one syringe about three-quarters full with DOT 5.1 fluid. Hold syringe with tubing upward tapping the side to free any bubble. Push syringe to purge any air out of syringe and close syringe clip. Repeat process on second syringe but fill only 1⁄4 full.

Procedure for bleeding:

a. Remove wheel from bike and remove pads. Install brake block. Substitute a 10mm wide block such as a hex key if necessary.

b. Check reach adjustment. Levers set for a long reach may have reservoir closed and will not permit bleeding. For flat bar lever, measure from center of handlebars to end of brake lever tip for no more than 80mm (figure 13.43).

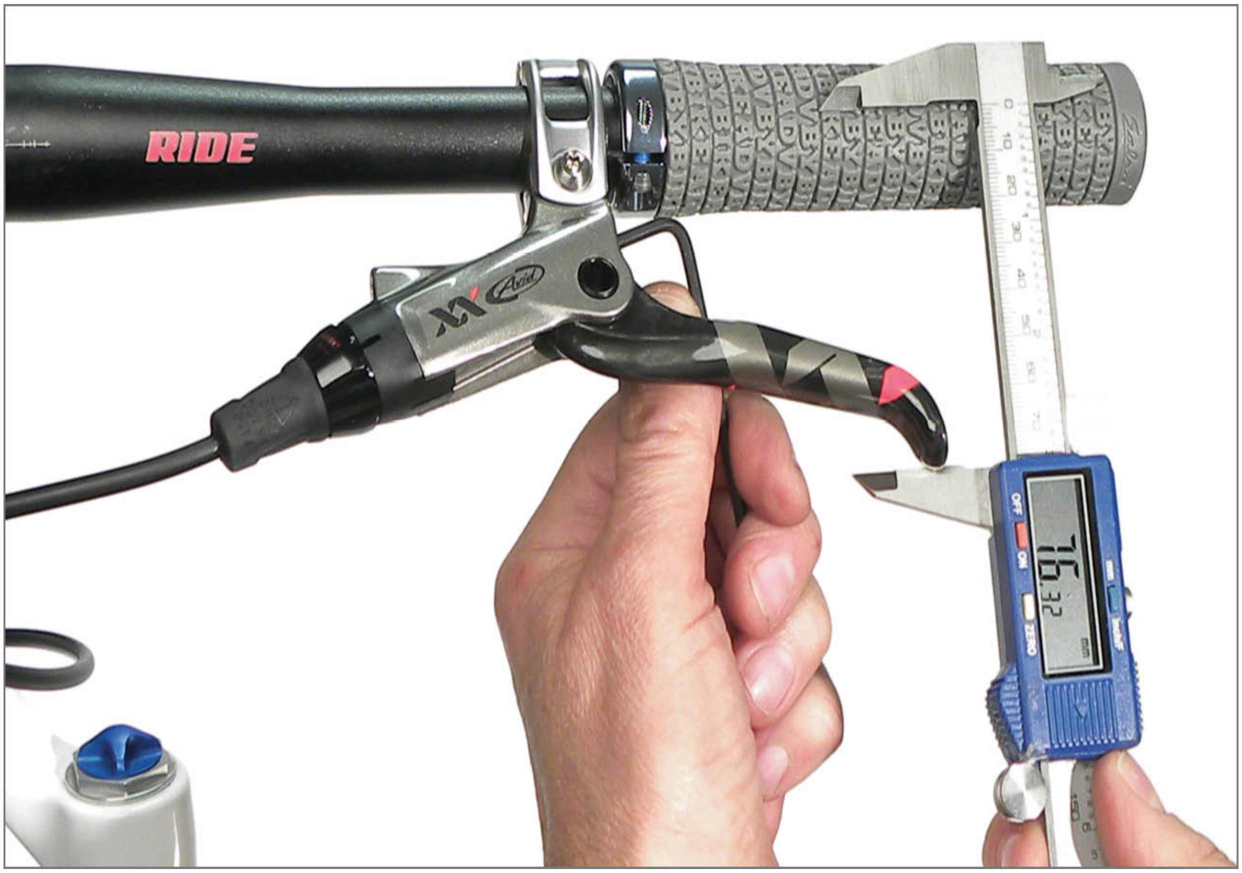


FIGURE 13.43: Adjust reach screw until lever end is no more than 80mm from bar center

c. For road levers, turn reach adjustment knob counterclockwise until lever is fully outward (figure 13.44).

FIGURE 13.44: Turn road lever reach adjustment knob counterclockwise

d. If present on flat bar levers, set volume of caliper system with adjusting knobs. Right-hand lever: turn knob completely counterclockwise, then back until bleed screw is upward. Left-hand lever: turn knob completely clockwise, then back counterclockwise one turn (figure 13.45).

FIGURE 13.45: Adjust contact adjusting knobs

e. Rotate bike and brake levers as necessary so there is an upward flow from caliper to lever bleed screw. For flat bar brakes, loosen lever bolts just enough to allow you to rotate levers to different angles. For road levers, rotate bars as necessary (figure 13.46).

FIGURE 13.46: Rotate complete bike as necessary to achieve upward flow from caliper to lever bleed port

f. Remove bleed-port screw at caliper body using a T10 Torx® driver (figure 13.47).

FIGURE 13.47: Remove bleed port screw at caliper

g. Syringe that is more full is secured to caliper bleed-port. Double-check it is free of bubbles, and leave tubing clip closed. **Note:** “Bleeding Edge™” attachments are reviewed later.

h. Remove bleed port screw from brake lever (figure 13.48). Thread in less full syringe (figure 13.49).

FIGURE 13.48: Open bleed port at brake lever after protecting area with rag

FIGURE 13.49: Thread in syringe at caliper

i. Open tubing clamp clips on both syringes. Hold lower syringe upright to help prevent any air from entering caliper body (figure 13.50). Push lower syringe plunger to move fluid through system and out at lever syringe (figure 13.51). Inspect for air bubbles. Inspect for dirty or contaminated fluid. Push lower syringe plunger until at least empty of fluid, but do not fully empty syringe.

FIGURE 13.50: Push fluid through caliper toward brake lever

FIGURE 13.51: Fluid from lower syringe accepted by syringe at lever

j. Close tubing clip on lever syringe. Leave caliper syringe tubing clip open.

k. Pull brake lever to handlebars and secure to bar with toe strap or rubber band (figure 13.52).

FIGURE 13.52: Pull and hold lever to handlebars after closing lever syringe clip

l. At lower caliper syringe, push plunger gently to pressurize system, and then pull back on plunger. Repeat this process 3 or 4 times to pressurize and then apply a vacuum to caliper (figure 13.53). Inspect for any air coming back up into syringe. Leave caliper syringe open.

FIGURE 13.53: Pull back on plunger to create vacuum at caliper

m. Remove strap holding lever, but keep lever to bar by hand pressure (13.54). Push caliper syringe plunger and allow lever to slowly return to relaxed position as fluid is pushed at caliper.

FIGURE 13.54: Release brake lever slowly while pushing caliper syringe

n. Close tubing clip at caliper syringe. Unthread caliper syringe and reinstall bleed port screw. Clean off any fluid with alcohol or soapy water.

o. Open tubing clamp of syringe at lever. Pull back on plunger to create a vacuum, then push plunger. Pull lever slightly and allow it to snap back to help purge any bubble remaining in lever body (figure 13.55). Repeat this process ten times, or until no more bubbles appear in tubing.

FIGURE 13.55: Push and pull repeatedly at lever to clear lever of air

p. Push plunger gently as lever syringe is unthreaded from lever. Remove syringe and install bleed port screw. Clean up any spilled fluid with alcohol or soapy water.

q. Test brake bleed by pulling firmly on lever. Lever should have a firm feel.

r. Install pads and install wheel.

s. Pull lever to bring pistons to rotor. Lever should feel firm when pulled with force. Repeat bleed if necessary. Empty syringes into appropriate container and store syringes with clamps open.

SRAM® offers some caliper bodies with “Bleeding Edge™” technology to make an easier caliper bleed attachment to the syringe. The bleeding process is similar other SRAM® calipers with two syringes. However, SRAM® offers a proprietary syringe fitting that acts as both the hex key to open and close the bleed valve, as well as bleeding portal (figure 13.56).

FIGURE 13.56: Bleeding Edge™ attachment for specific brake calipers

For Bleeding Edge™ calipers, there is a rubber cover over the bleed port. After removing the cover insert syringe with Bleeding Edge™ fitting into hole and push until you feel it click into place. Turn Bleeding Edge™ knob counterclockwise 1⁄2 turn. If the Bleeding Edge™ knob will not loosen the port, remove fitting and loosen screw slightly with a 4mm hex (figure 13.57).

FIGURE 13.57: Bleeding Edge™ brake ready for bleed

Fill syringe with Bleeding Edge™ fitting only 1⁄4 full. Fill second syringe without Bleeding Edge™ fitting over 1⁄2 full. With Bleeding Edge™ calipers, the fuller syringe is secured at the brake lever, and fluid is initially pushed downward toward and out the caliper to syringe with Bleeding Edge™ fitting.

TEKTRO® HYDRAULIC BRAKES

Tektro® offers several brake models and all share common bleeding procedures. Tektro® uses a mineral oil as brake fluid. Never use a DOT fluid or syringes used for DOT fluid with this system. Tektro® bleed kits includes a syringe to push fluid from caliper to lever. The fluid exits at a port screw at the lever. Tektro® provides a hollow M6 threaded fitting on a hole for waste fluid to cleanly exit. Flexible tubing that is 3⁄16" diameter can be substituted for the threaded fitting, however, expect some spillage of fluid at the lever. The caliper fitting uses 1⁄4" tubing.

While the system can be bled with brake pads in place, it is best to remove pads to avoid any chance of contamination with brake fluid.

Procedure to bleed Tektro® caliper brakes:

a. Hold bike in repair stand and rotate bike so there is an uphill path from caliper body to lever. Remove wheel and remove brake pads from caliper.

b. Rotate brake lever so lever reservoir is parallel with ground (figure 13.58). Use split below reservoir lid as a reference line when aligning. Aligning level will put port screw at the highest point.

FIGURE 13.58: Adjust lever so reservoir cap is flat to ground

c. Remove bleed port screw from top of reservoir lid using a T15 driver (figure 13.59).

FIGURE 13.59: Remove bleed port screw

d. Attach bleed tubing to lever reservoir lid. Tektro® bleed fitting will screw into lever (figure 13.60). Alternatively, insert 3⁄16" tubing into hole. Place other end of waste tubing into a bottle or can fitted to hang off handlebars.

FIGURE 13.60: Brake fluid will bleed into waste bottle

e. Attach hose to syringe and fill syringe with approximately 15ml of mineral based brake fluid. **Note:** excess hose at syringe makes bleeding difficult. Trim hose to about 3–4cm in length. Fill syringe at least half full of fluid

f. Caliper has a bleed screw fitting that uses a 7mm wrench. Place box end of a 7mm wrench over fitting and then attach syringe hose. Hold syringe upward to allow any small bubbles in syringe to float to top.

g. Open bleed fitting counterclockwise 1⁄8 to 1⁄4 turn and press syringe to flow brake fluid upward to lever and waste bottle. Push slowly and evenly. Keep syringe upright to prevent any bubbles in syringe from entering caliper (figure 13.61).

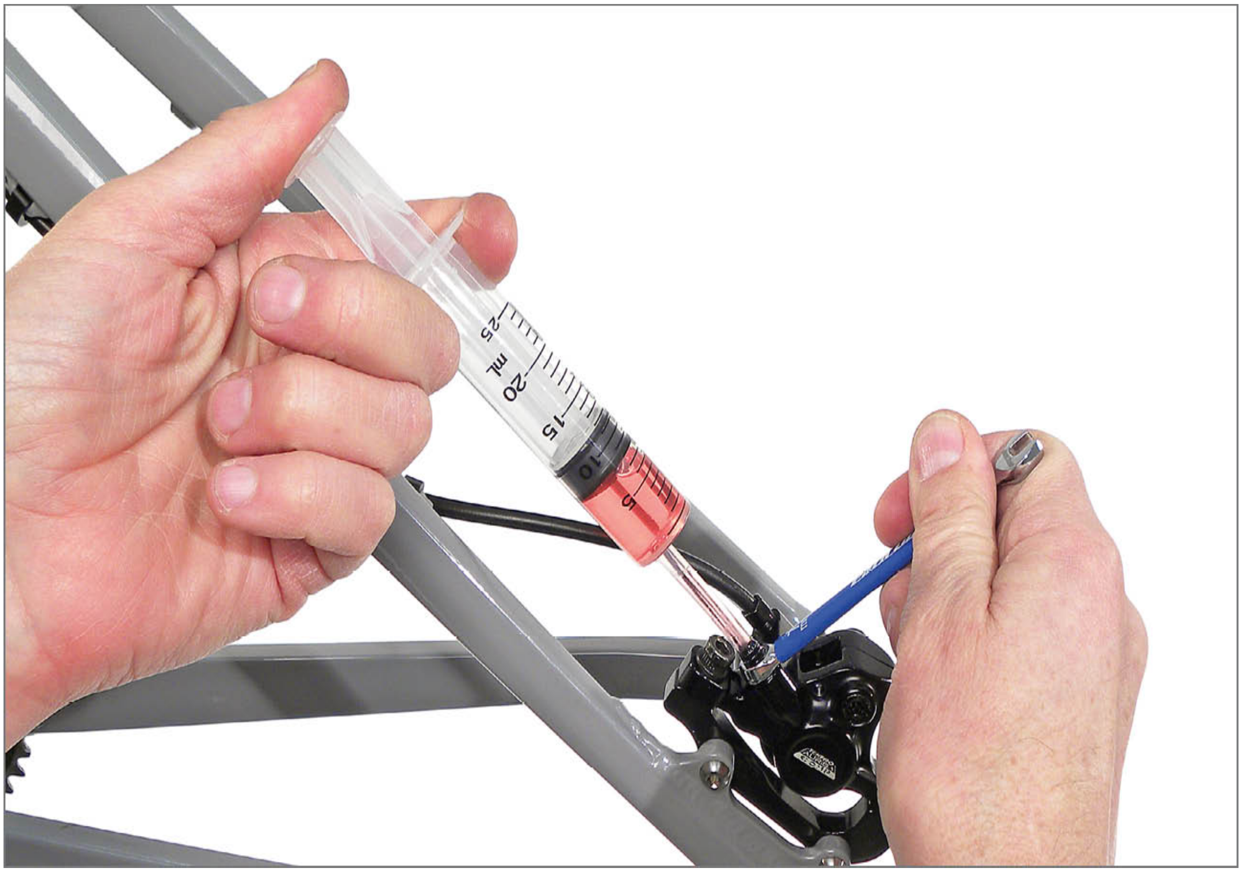


FIGURE 13.61: Push fluid after opening up bleed nipple

h. Continue pushing until syringe is near empty. Watch at exit hose for any signs of air bubbles, debris or discolored fluid (figure 13.62).

FIGURE 13.62: Push fluid upward into bottle after opening up bleed nipple

i. Retighten bleed fitting at caliper body. Secure fitting to equivalent of 4–7Nm. Remove syringe from bleed nipple. Replace any rubber cover on bleed nipple.

j. Remove bleed hose from lever. Drip a drop or two of fluid into hole at reservoir cover and install screw. Secure to snug only to 2–4Nm.

k. Clean any excess fluid on caliper or lever with isopropyl alcohol or soapy water.

l. Reinstall brake pads. Reinstall wheel and test caliper brake.

The first pull at the lever may depress more as the pads move to the rotor. Repeated pulling should feel firm with no softness. Any air in the hose will show as a mushy feeling in the lever pull.

MECHANICAL DISC CALIPER SYSTEMS

A wire brake cable pulled from brake levers operates mechanical disc calipers. The brake cable is fixed to a lever arm on the caliper body. The arm is rotated to push brake pad(s) to the rotor. The most common mechanical design moves only pad, with the other pad fixed in the caliper body. The rotor is simply flexed by the moving pad until it contacts non-moving pad. This system does not harm or stress the rotor.

A less common design uses double lever arms at the caliper with both pads move to the rotor (figure 13.63). The adjustment procedures vary depending upon design.

FIGURE 13.63: The double lever arm design moving both pads to the rotor

Mechanical calipers typically operate with wider clearances between pads and rotor. Because there is flex in housing and brake cable, mechanical caliper brakes are not as efficient as hydraulic systems. These brakes will produce heat like hydraulic caliper brakes when the bike is slowed. As with all disc brake systems, stop the wheel before getting into the parts to adjust.

The caliper design must also be compatible with the brake lever design. Flat handlebar disc brake bikes tend to use long travel levers and should use a compatible long travel caliper. Drop handlebar levers tend to be short travel levers and should specifically use calipers designed for less cable pull. Mixing between standards changes mechanical advantage and this reduces brake performance.

An important design difference between mechanical caliper disc brakes and rim caliper brakes is the adjustment as pad material wears away. With rim brakes, the cable-adjusting barrel pulls both arms and pads closer to the rim. However, with caliper disc brakes as pads wear the barrel adjuster should not be used. Caliper disc brake pads need to be brought closer to the rotor by using pad adjusting screws at the caliper body. Disc caliper lever arms require a full range of travel to be effective (image 13.64). Using a barrel adjuster to move pads inward puts the lever arm in a weaker position for applying pad pressure. Mechanical caliper pads should be readjusted close to the caliper body as they wear thinner without using the barrel adjuster.

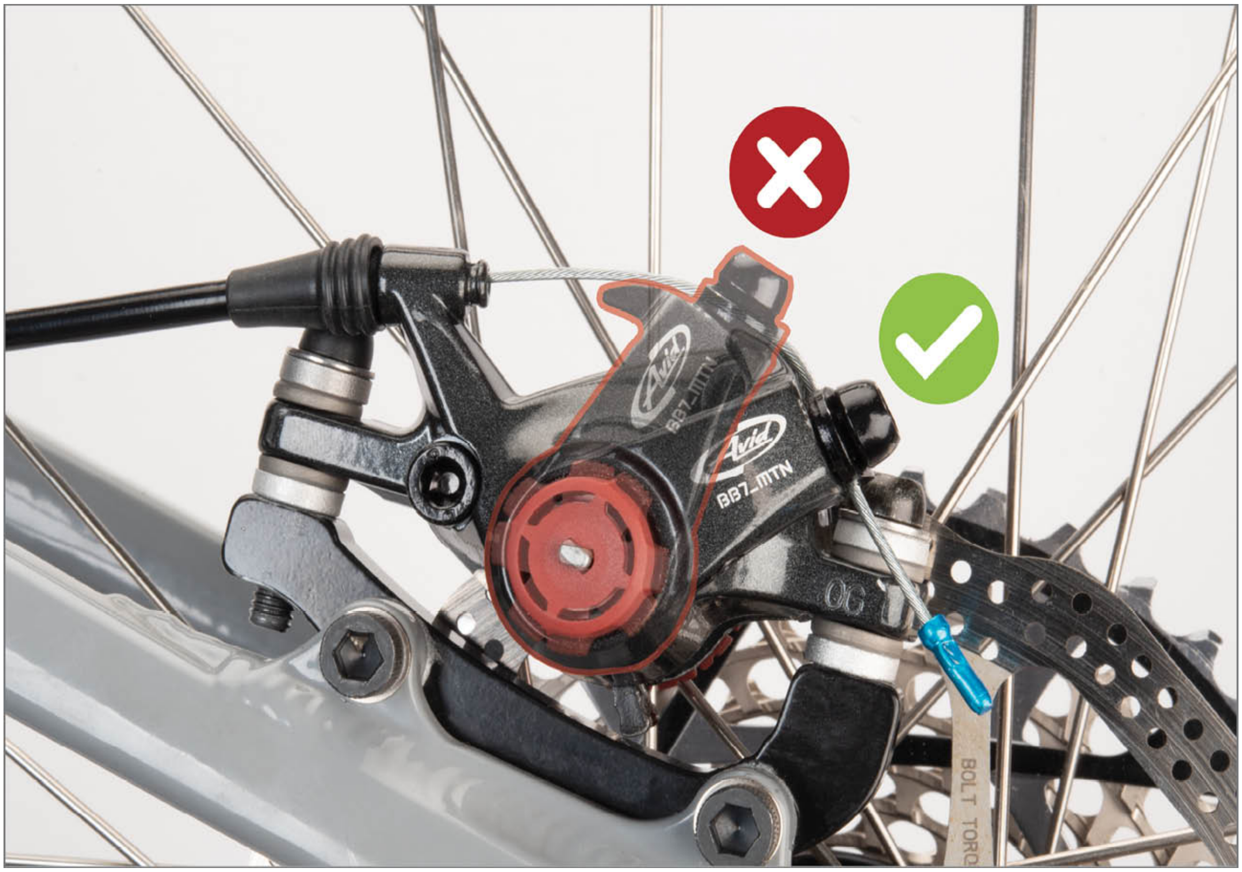


FIGURE 13.64: With brake lever open, caliper arm must start in back position

The lever arm on the caliper should be fully back or relaxed when setting pads. Loosen cable pinch bolt at caliper arm or turn barrel adjust inward to confirm arm is fully back.

Calipers designed with one moving pad normally have an adjusting knob or screw for the non-moving pad to be moved in or out relative to the rotor. The moving pad will have no pad adjustment screw, and this pad pushes the rotor over to the fixed pad when the cable is pulled. The non-moving pad is moved closer to the rotor by adjusting the caliper body over relative to the rotor.

Procedure to align mechanical disc calipers with one moving pad with one adjustable pad adjusting screw:

a. Loosen both caliper-mounting bolts to permit free lateral movement of caliper body.

b. Turn adjusting pad screw fully inward, then back 1⁄4 turn (figure 13.65)

FIGURE 13.65: Use adjusting pad screw to move pad to rotor

c. Pull and hold brake lever firmly
d. Snug each mounting bolt. Final tightening will be after pads are aligned.
e. Release lever and spin wheel to inspect pad position.
f. If adjustable pad side is rubbing, loosen screw and check rub again.
g. If non-adjustable pad is rubbing, loosen one mounting bolt, push caliper body slightly to align, and repeat process on other mounting bolt.
h. When pads are not rubbing, secure mounting bolts fully.
i. Test brake by pulling lever. Adjust feel by adjusting pad screw in or out, and again checking for rub.

As pads wear and thin on this caliper design do not use the adjusting barrel to draw pads closer to rotor. This places the lever arm in a poor working position. It is necessary to reposition fixed pad closer to rotor by moving caliper body at mounting bolts. Move the adjustable side pad by tightening pad adjusting screw.

The one-moving pad calipers are also available with adjustable pad screws for each pad. Inspect each side of caliper body for hex key fittings or knobs that will turn by hand (figure 13.66).

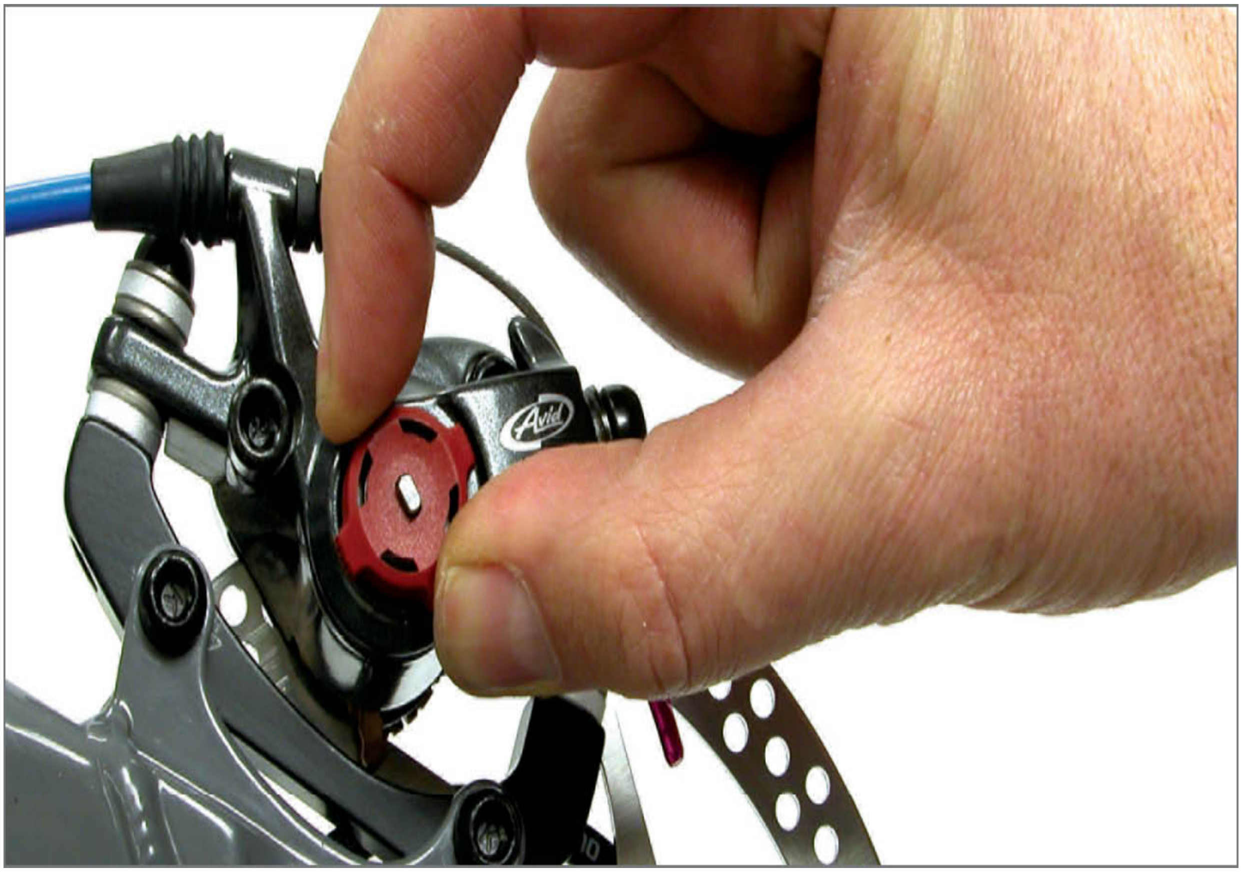


FIGURE 13.66: Pad adjusting screw turned by hand

Procedure to align mechanical disc calipers—one moving pad and two adjustable pad screws:

a. Loosen both caliper-mounting bolts so caliper can freely move laterally.
b. Check that both pad adjusting knobs or screws are turned fully counterclockwise.
c. Turn outer pad adjusting screw fully counterclockwise, then back clockwise 1 full turn. This permits fine tuning of pad setting.
d. Turn inner pad adjusting screw fully clockwise to lock pad against rotor. This aligns caliper body and pads to rotor face.
e. Snug each caliper-mounting bolt.
f. Loosen each pad adjusting know or screws 1⁄4.
g. Spin wheel and inspect pad alignment. If one side rubs, loosen adjustment slightly (figure 13.67).

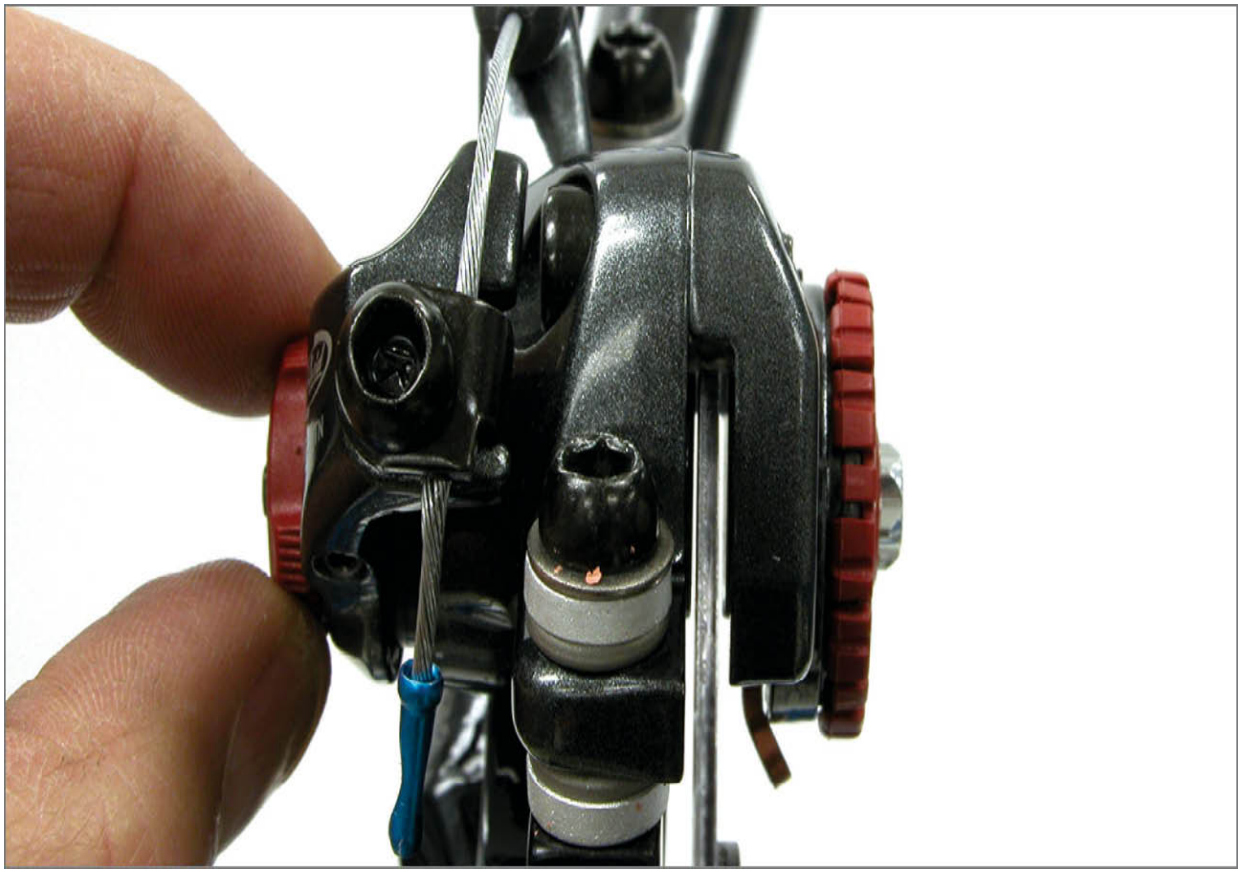


FIGURE 13.67: Adjust each knob so pads do not rub rotor

h. Fully tighten mounting bolts.

i. Squeeze lever to test caliper brake. If lever pulls to bar, tighten each pad screw slightly and test feel again. If lever pull is too tight, turn each pad adjusting screw counterclockwise slightly and check again at lever.

Calipers with a lever arm on each side of the caliper body move both pads toward the rotor. These designs will have pad adjusting screws on each side. As pads wear, use both adjusting screws to move pads closer to the rotor.

Procedure to align mechanical disc calipers—two moving pads:

a. Loosen caliper mounting bolts.

b. Alternating between each side, turn each 1⁄4 turn until pads lock against rotor (figure 13.68).

c. Snug each mounting bolt.

d. Loosen each pad adjusting screw 1⁄4–1⁄2 turn and spin wheel to inspect pad alignment.

e. Pull lever and adjust feel by either tightening or loosening each side 1⁄4 turn at a time.

f. If pads need further alignment, loose one mounting bolt at a time and push caliper body.
g. When pads do not rub, fully secure mounting bolts.

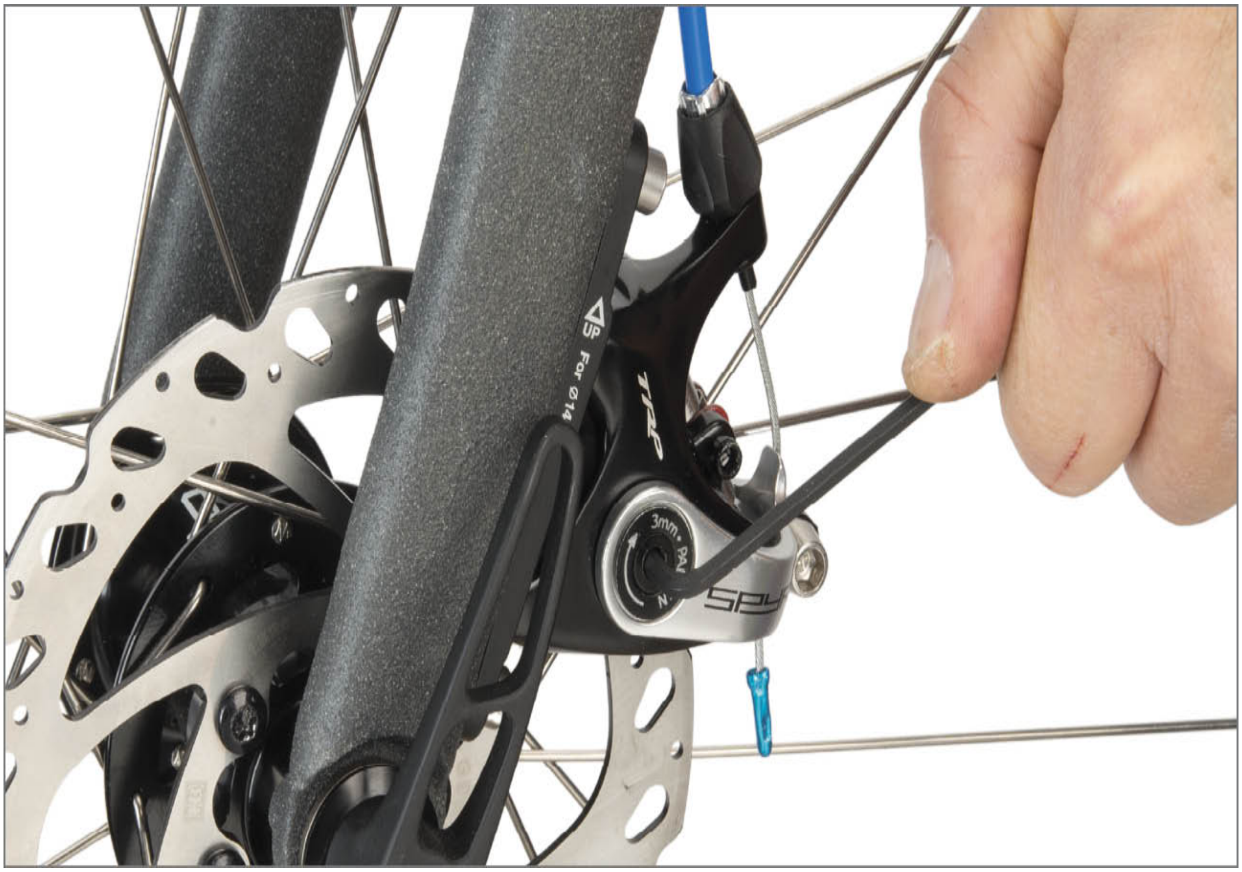


FIGURE 13.68: Adjust both pads evenly until pressing against rotor

TABLE 13.1 Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Mechanical disc brakes are rubbing	1. Your wheel may not be all the way in the dropout 2. Rotor is bent 3. Caliper body misaligned	1. Seat your wheel all the way in the dropout 2. Align rotor by bending or replace rotor 3. Realign caliper
With hydraulic system, after wheel removal, wheel is difficult to get back in bike	When rotor was out of caliper, lever was inadvertently squeezed drawing in pads	Press pads back into caliper body and reinstall wheel
Pads rubbing rotor after open dropout type wheel was removed and reinstalled	Wheel was reinstalled in dropouts differently	Loosen skewer, check wheel is fully seated, and check for rub. Realign caliper to new wheel fixturing
On hydraulic brakes lever goes all the way to the bar	1. Brake system has air in the lines or caliper 2. Fluid has leaked from system	1. Check your brake pads for wear and bleed the brake system 2. Inspect for fluid showing at all joints and/or pistons Take to professional for parts replacement as necessary
Squealing disc brakes upon slowing	1. Contaminated pads and/or rotor 2. Glazed pads or rotor	1. Pad replacement preferred; Clean rotor with alcohol 2. Sand pad surface to remove glazing; Clean rotor and test

CHAPTER 14

CALIPER RIM BRAKE SYSTEMS

Caliper rim brakes are mechanisms attached to the frame and fork that apply pressure to the wheel rim. The caliper rim brake system includes the brake lever, cable and housing, brake caliper, brake pads, and the braking surface of the wheel rim.

Our hand force squeezing at the lever is multiplied, leveraged, to pull the brake cable. This pulling force is transferred to the brake calipers, the pads, and eventually to the rim to slow the bike. It is a common error for newer riders to want an overly tight brake setting. Rim brake calipers generally should not be set so tight that a mere touch of the lever results in the pads striking the rim. Hand muscles are not in a good position to apply power to a hand lever when the pads are set too tightly at the rim.

Keep in mind that braking systems provide more than an emergency stop. Properly adjusted brakes give the user subtle control and modulation of speed and bike handling. Many small details affect the control of the bike, including lever placement, cable system installation, and brake pad alignment.

Hub coaster brakes, “U-brakes” and center pull rim calipers are not reviewed here. However, information on these systems can be found in the repair help section at www.parktool.com. Disc brake systems use a rotor attached to the hub and a caliper attached to the frame or fork near the hub. These are discussed in Chapter 13—Caliper Disc Brake Systems.

BRAKE LEVERS

Brake levers are fitted to handlebars with a clamp. Two basic lever types are upright bar brake levers and drop bar brake levers. Shift levers can also be designed into the brake lever.

UPRIGHT HANDLEBAR BRAKE LEVERS

Upright compatible brake levers are designed for a 22.2mm handlebar end diameter. Position upright handlebars brake levers so they are easy and comfortable to reach. Levers will also move laterally along the handlebars. They are commonly positioned close to the grips and outboard of separate any clamp type shift levers.

Upright handlebars (flat bar) brake levers should be rotated so they are aligned with the rider's arms as the rider sits on the saddle and holds the bar grips. A common standard is to set the lever at 45 degrees downward slope from horizontal (figure 14.1). This avoids excessively bending the wrist to apply the brakes. Brake levers may be rotated on the bar by loosening the clamp-fixing bolt.

FIGURE 14.1: Rotate levers for comfortable reach

Upright bar levers commonly have a set screw for adjusting the lever reach. Reach is the distance from the bar to the lever end. Lever reach is set according to the rider’s hand size and riding style. Tighten the set screw to bring the lever toward the grip to accommodate smaller hands or shorter fingers. Changing this setting will cause a change in the brake cable adjustment and the two must be adjusted together.

Upright bar levers typically allow for easy installation of cable ends into the lever cable anchor. Pull the lever and inspect for the cable anchor, which is typically a hole for the cable end with a slot for the cable to exit to the cable housing. Inspect also for slots in the adjusting barrel and lockring. Align slots and then slip the cable end into the anchor hole. Engage the brake cable between the slots in the barrel adjuster (figure 14.2).

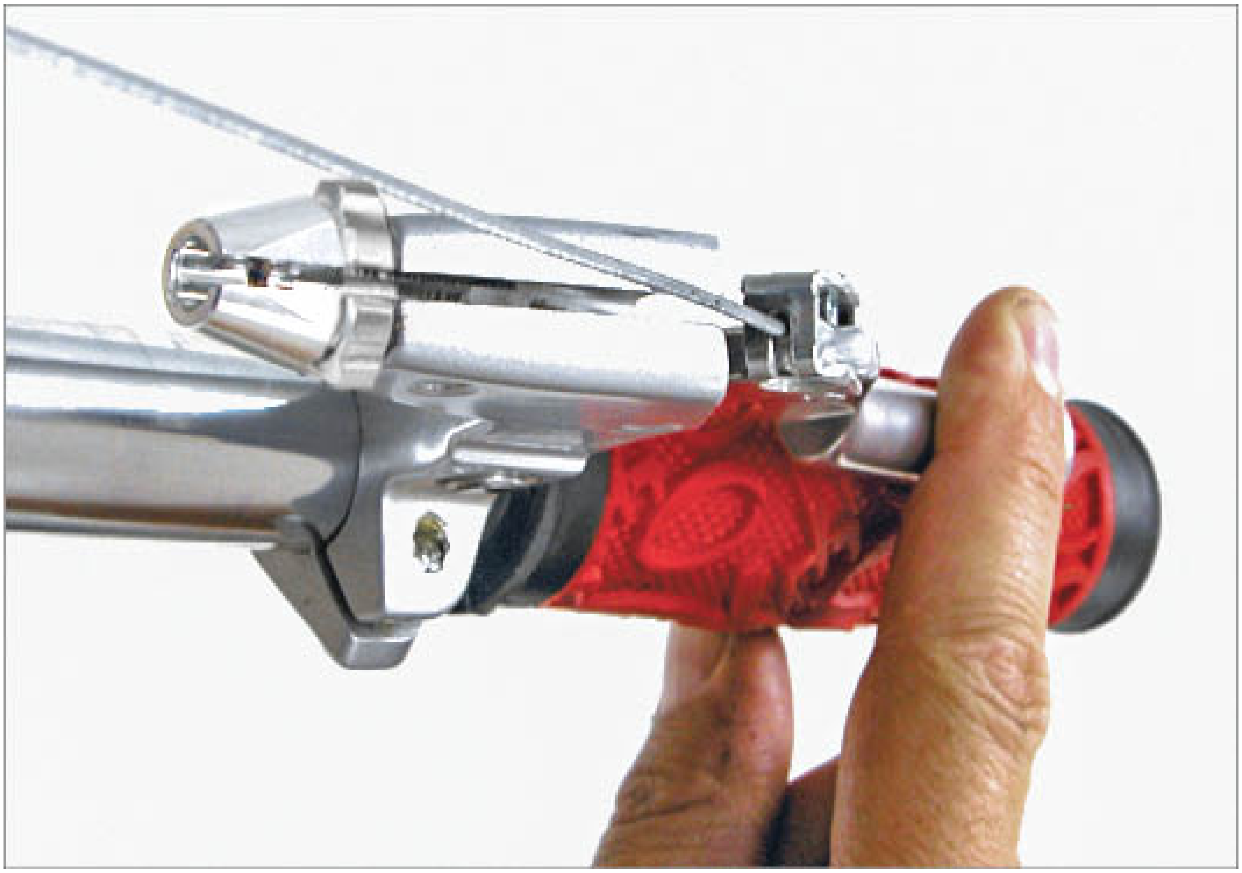


FIGURE 14.2: Use slots in lever body to engage and disengage cable end

Brake levers are designed to pull a certain amount of brake cable as the lever is squeezed. The distance from the lever pivot to the cable head pivot determines the amount of brake cable pulled. Linear pull or “long pull” brake calipers require more cable be pulled by the lever, and compatible brake levers will have a greater distance between cable end and lever pivot (approximately 30mm or more). Cantilever, dual pivot, and side pull brake calipers generally require a relatively shorter distance (29mm or less) and use “short pull” levers. Switching levers or calipers between “Long Pull” and “Short Pull” systems changes the mechanical advantage of the caliper and that changes braking power from the original design.

DROP BAR BRAKE LEVERS

Drop bar brake levers may be moved up or down the curve of the bar for easier reach. Moving the lever down makes for an easier reach while riding in the drops. Moving upward allows for an easier reach when riding the top portion of the bars. Handlebar tape must be removed to move levers up or down.

Drop bar brake levers usually use a metal strap to pull the brake lever body tight to the handlebars. The handlebar diameter of drop bars is 23.4mm, compared to the 22.2mm diameter of flat bars. Consequently, brake levers are not compatible between flat bars and drop bars.

The bolt or nut to tighten the brake lever strap may be inside the lever body or hidden under the rubber hood covering of the body. It may be necessary to pull the rubber hood up in order to insert a wrench when tightening the strap (figure 14.3). Drop bar brake levers should be tight to the handlebars. The user effectively uses the lever bodies as “bar extensions” when riding on the tops of the levers. If the levers were to move during use, it could result in a crash. Levers should feel firm to the bar and not move even when excessive force is applied.

FIGURE 14.3: Adjust lever height along hook of drop bar

The cable anchor in the lever is designed to hold the brake cable end. Pull the brake lever fully down and inspect inside. The anchor will have a socket fitting for the cable. The common aero-style lever will have a hole in the lever for the cable end (figure 14.4). Feed the cut end of the cable into the socket first and route it out the back of the lever body. Pull the cable and check that the end is fully seated into the anchor. The brake housing is fitted through the back of the lever body.

FIGURE 14.4: Insert brake cable from front of lever

CABLE SYSTEM

The cable system is made of the brake cable and cable housing, connecting the brake lever to the caliper. Brake cables are made of multiple strands of wire and a metal fitting called a “cable end” that is fitted in the lever. Brake cables are often sold with two different ends, and the type of cable end not required is cut off. The brake cable end sits in the brake lever, and the other end of the cable is bolted to the caliper arm. Upright bar levers use a round, disc-shaped end about 7mm (9⁄32 inch) in diameter. Drop bar levers use a “mushroom” or “teardrop” shaped end (figure 14.5). Brake cables have a minimum diameter of 1.5mm (1⁄16 inch), which is larger and stronger than derailleur cables.

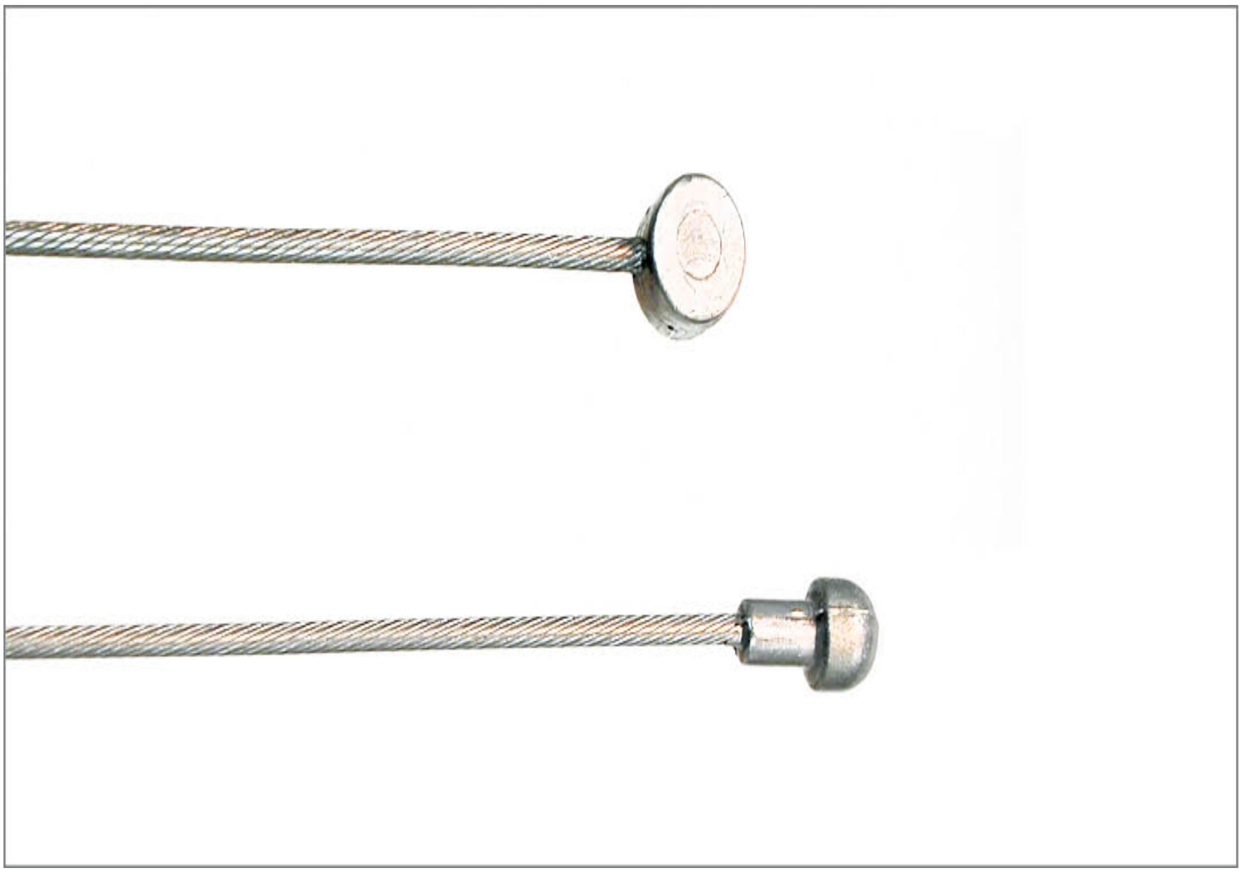


FIGURE 14.5: Top: brake cable end for upright bar lever
Bottom: brake cable end for drop bar lever

Brake housing connects brake levers to the caliper and allows the cable to bend around corners and account for swinging handlebars as it travels to the caliper. “Wound-type” brake housing is made of a plastic liner tube around which support wire is wound like a coil. It is then covered by plastic to help prevent rust (figure 14.6). Wound housing differs from the “compressionless” shift cable housing used on derailleur systems. Compressionless shift housing will not hold up to the higher stresses of braking and should not be used for braking systems.

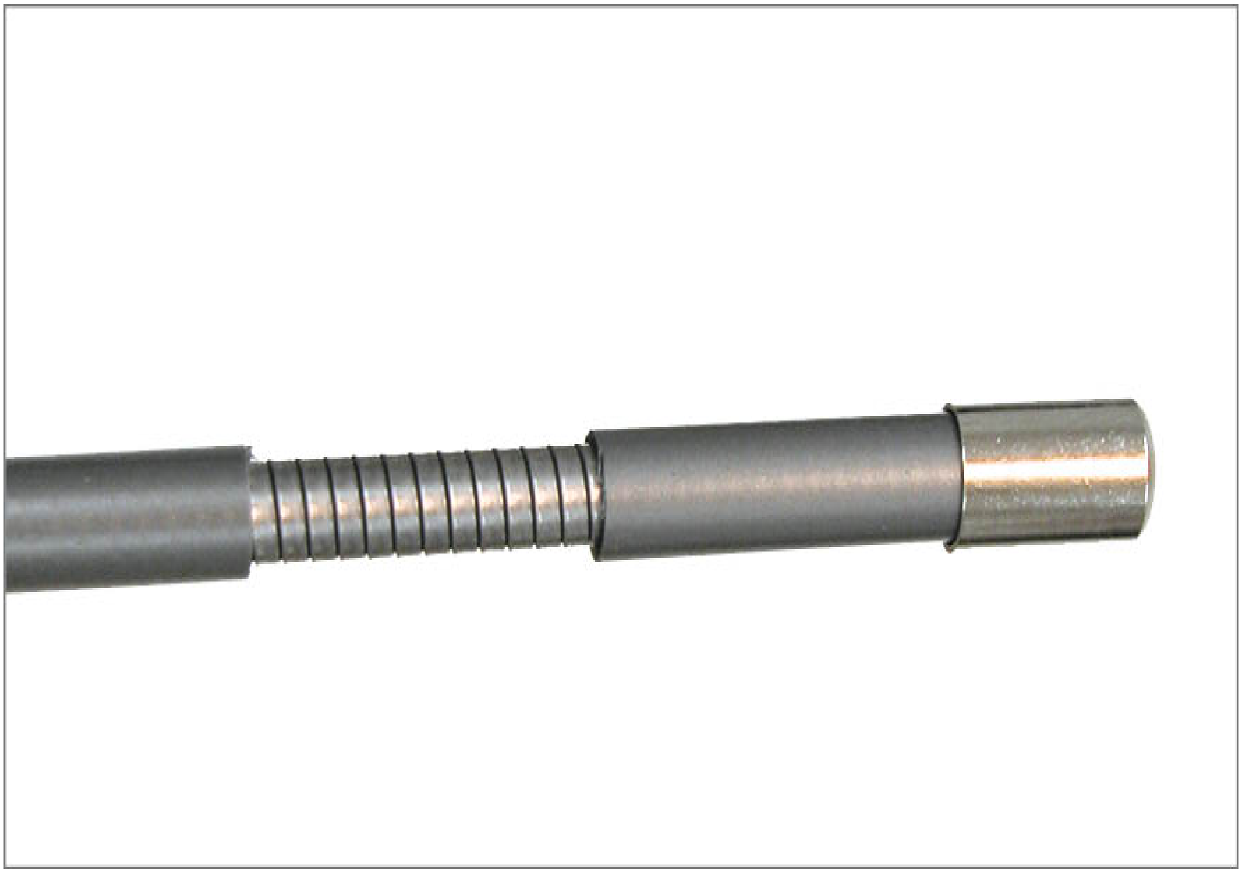


FIGURE 14.6: Common brake housing, cut away to show inner support coiled wire

“Braided” or “woven” housing is acceptable for either brake or indexing shift housing (figure 14.7). The outer support wires are woven in a mesh around the liner. This housing is especially effective on systems that seem to have excessive amounts of flex from coiled housing. Housing flex is felt as “sponginess” or “softness” in the lever pull.

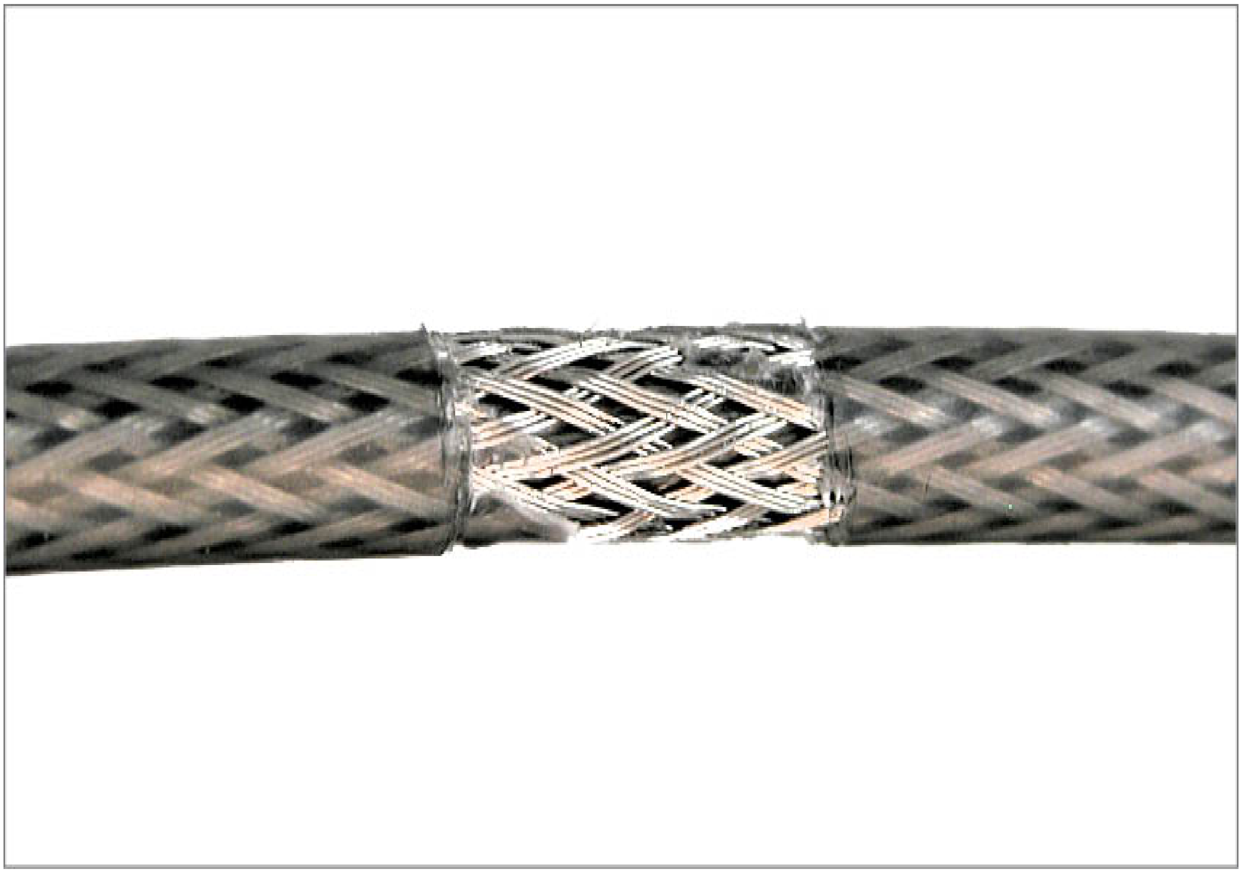


FIGURE 14.7: Braided or woven housing

"Articulated housing" uses small tubular segments strung together over a plastic liner (figure 14.8). Articulated housing may be used for both brake housing and indexing shift housing. The pieces of housing are strung together over a liner, much like beaded string, for correct length.

FIGURE 14.8: Articulated housing used for both braking and shifting

Replace housing if it has become twisted, rusty, split, or if it is too short. It is a good idea to replace housing if it is simply old, as there is a plastic tube inside the wound housing which becomes dirty and worn with use.

CABLE HOUSING LENGTH

When replacing housing, consider housing length. Generally, housing should be as short as possible yet still enter straight into housing stops (figure 14.9). If housing is too long, it will bend past an imaginary line created by the housing stop (figure 14.10). If it is too short, it will create kinks or severe bends. If it is likely the stem and bars might be raised in the future, leave the housing somewhat longer than the ideal length at brake levers.

FIGURE 14.9: Housing enters stop in a straight line, indicating a good length

FIGURE 14.10: Housing passes housing stop, indication housing is too long

If the old housing was an acceptable length, cut new housing to the same length. If in doubt, cut housing longer and insert into stops, then inspect and cut shorter as required. For wound brake housing, cut with diagonal pliers (preferred) or with cable cutters. Bend brake housing where you wish to cut to open the wound coil (figure 14.11).

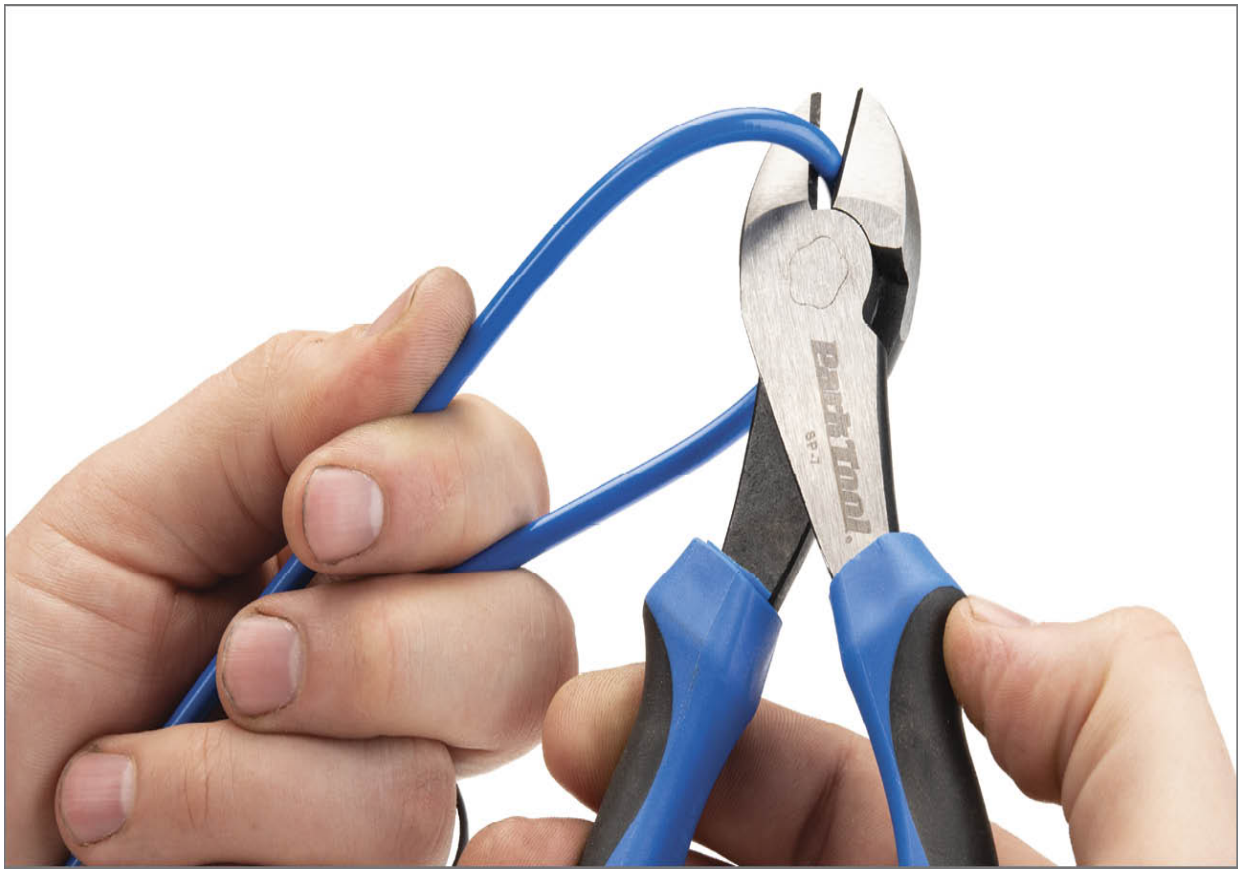


FIGURE 14.11: Flex the wound housing to open coils for side cutters

Wound housing is made of a single coiled wire. Cutting this wire tends to leave a sharp end or burr. The burr should be filed or ground smooth so the housing end is perpendicular to the length of housing (figure 14.12).

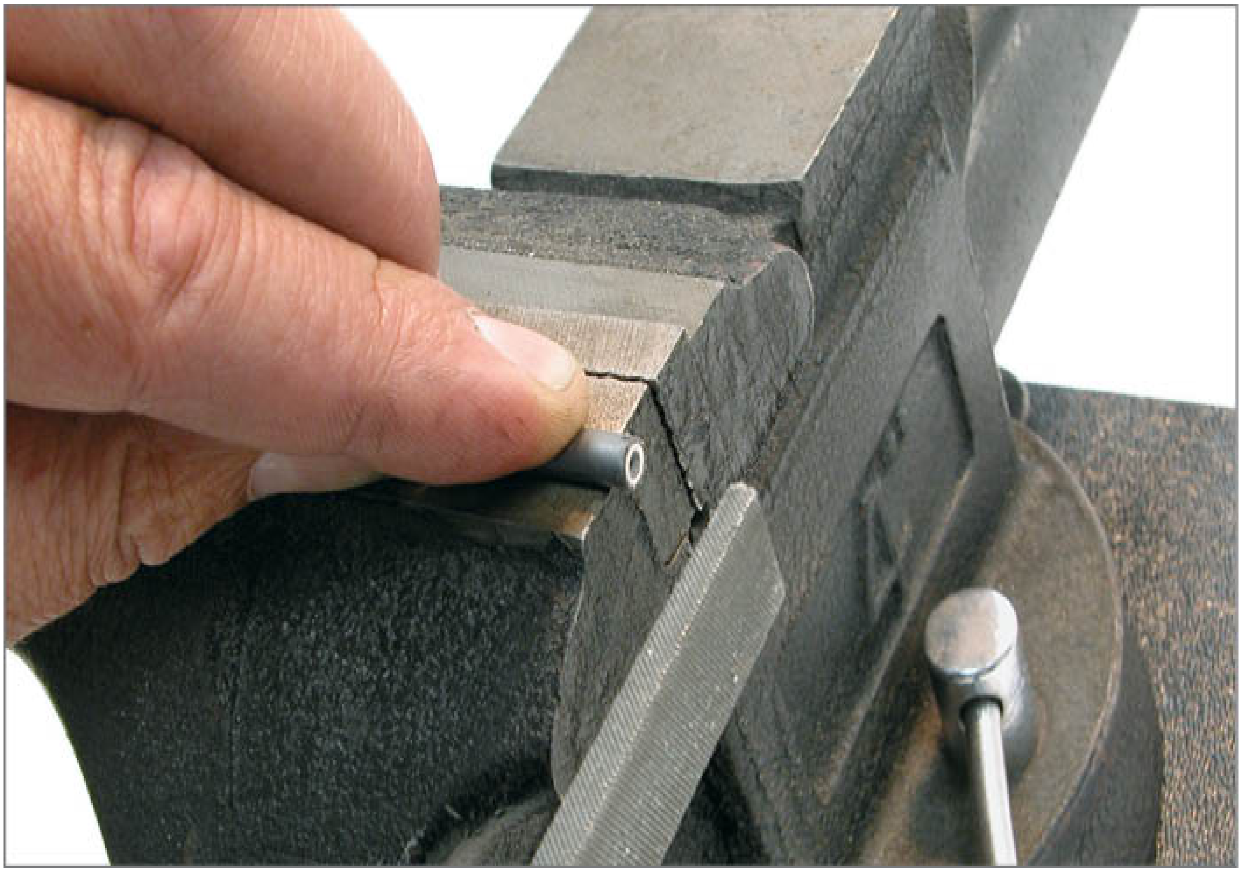


FIGURE 14.12: File wound coil housing to eliminate burr

Woven or braided housing is best cut with cable cutters, as is compressionless shift housing. However, articulated housing is shortened similar to shortening a beaded string. Pieces are removed and the inner plastic liner cut with scissors.

Housing end caps should be used whenever they fit. End caps will only improve the fit into a cable stop. However, if an end cap will not fit into a brake cable stop, the cap is not necessary. End caps are available in different designs (figure 14.13). The end diameters vary to better mate with frame fittings, and some may have extensions for protective liners.

FIGURE 14.13: Various style of housing end caps

After a brake cable is installed and brakes are adjusted, excess cable should be cut using a cable cutter, such as the Park Tool CN-10. The cutting jaws surround the cut, and shear the wires. Leave approximately 3–4cm (1.5–2 inches) wire length past the pinch bolt. After cutting the brake cable, use a cable end cap crimped to the end to prevent fraying (figure 14.14).

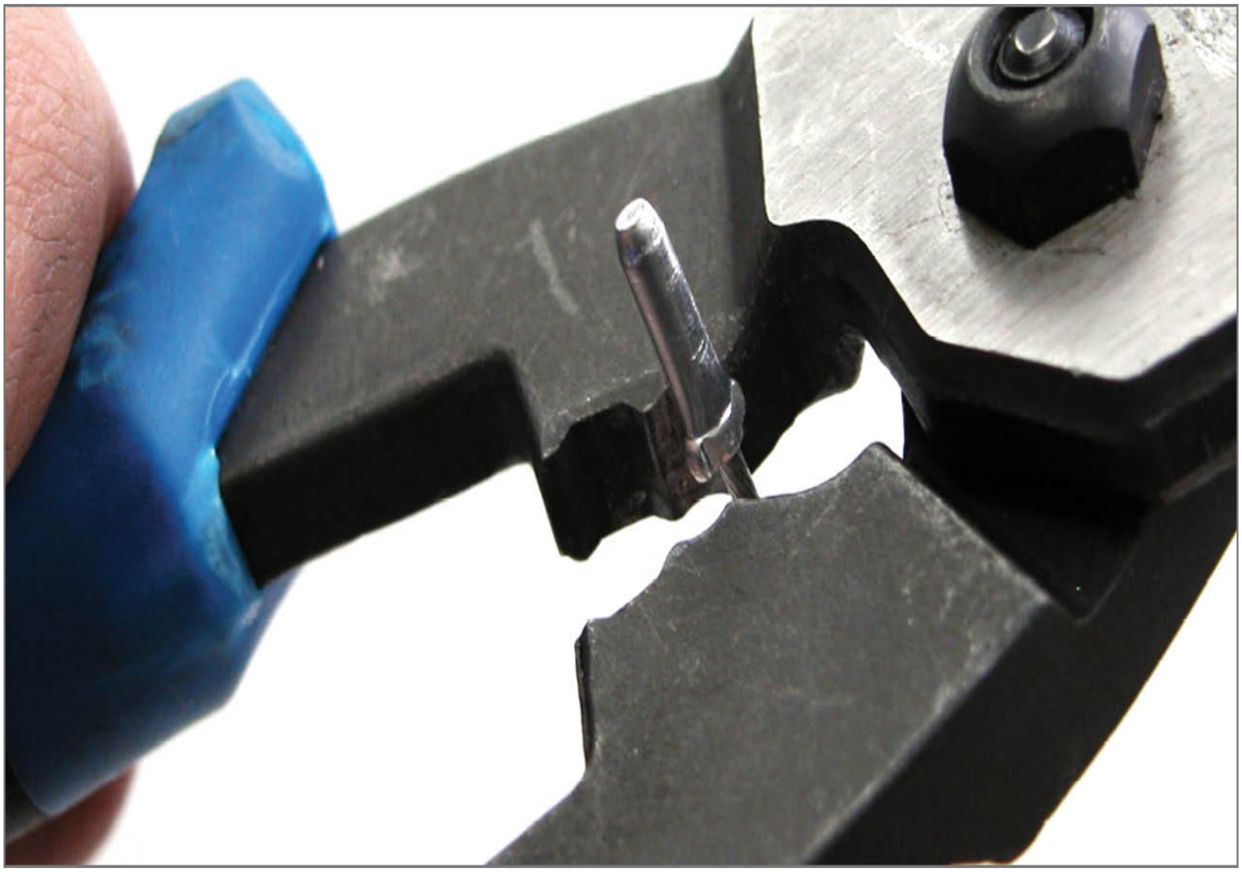


FIGURE 14.14: Use cable end cap to prevent fraying of wires

The brake cable is fixed to the rim caliper arm by a plate and bolt. The brake cable is pulled with great force by the hand lever and must not slip in the pinch bolt. The brake cable will flatten and deform with proper torque on the pinch bolt (figure 14.15).

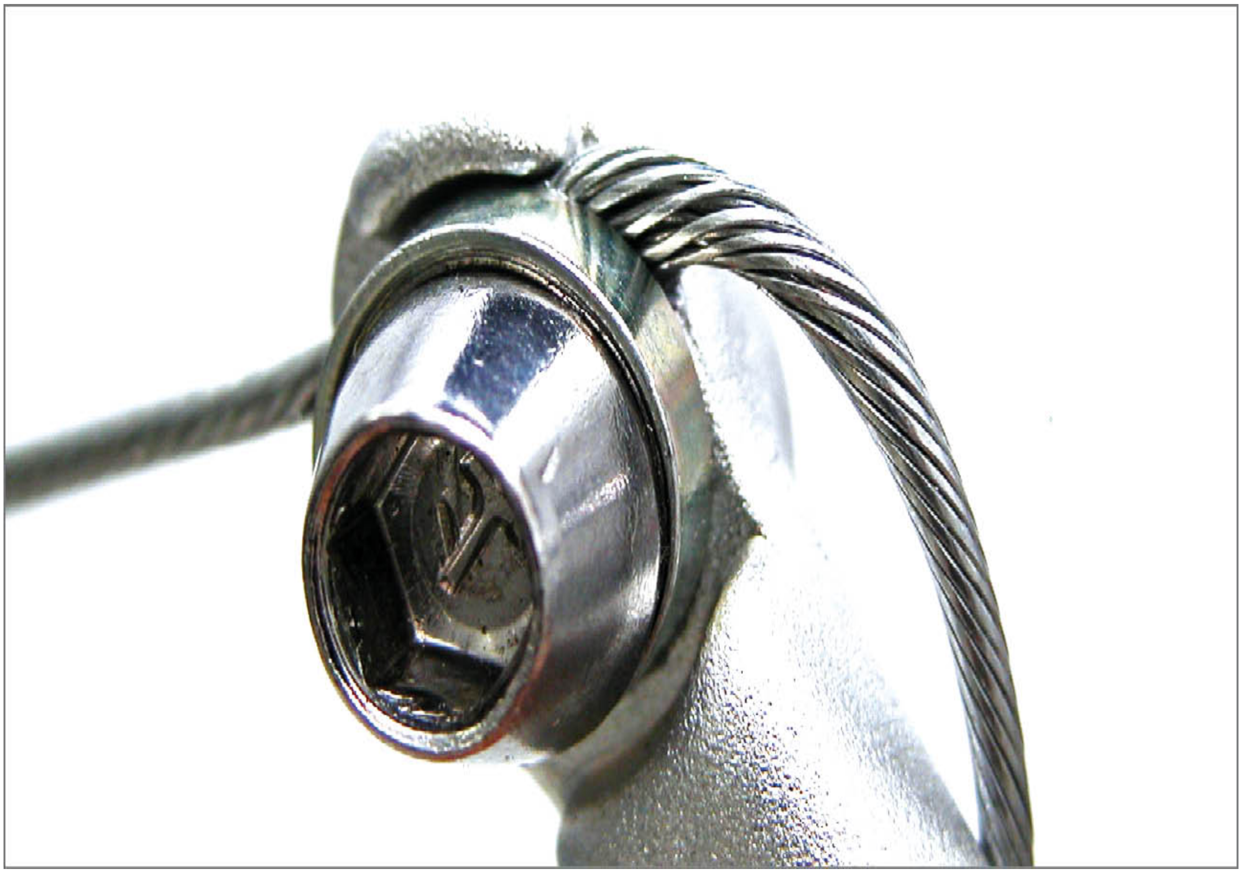


FIGURE 14.15: Pinch bolt will flatten the cable

Brake housing is often routed through a “barrel adjuster,” fitted either at the brake lever or at the caliper arm (figure 14.16). This is a hollow threaded bolt that is turned in or out to effectively shorten or lengthen the housing. Unscrewing the barrel out of the lever body or caliper will effectively lengthen the housing and draw the brake pads closer to the rim. Screwing the barrel into the lever body or caliper arm will shorten the housing and allow the pads to come away from the rim.

FIGURE 14.16: Adjusting barrel to control cable slack

If the brake cable is frayed or sliced anywhere between the lever and the cable pinch bolt at the derailleur, it should be replaced. Even the failure of a single strand of wire will eventually lead to a complete cable break (figure 14.17).

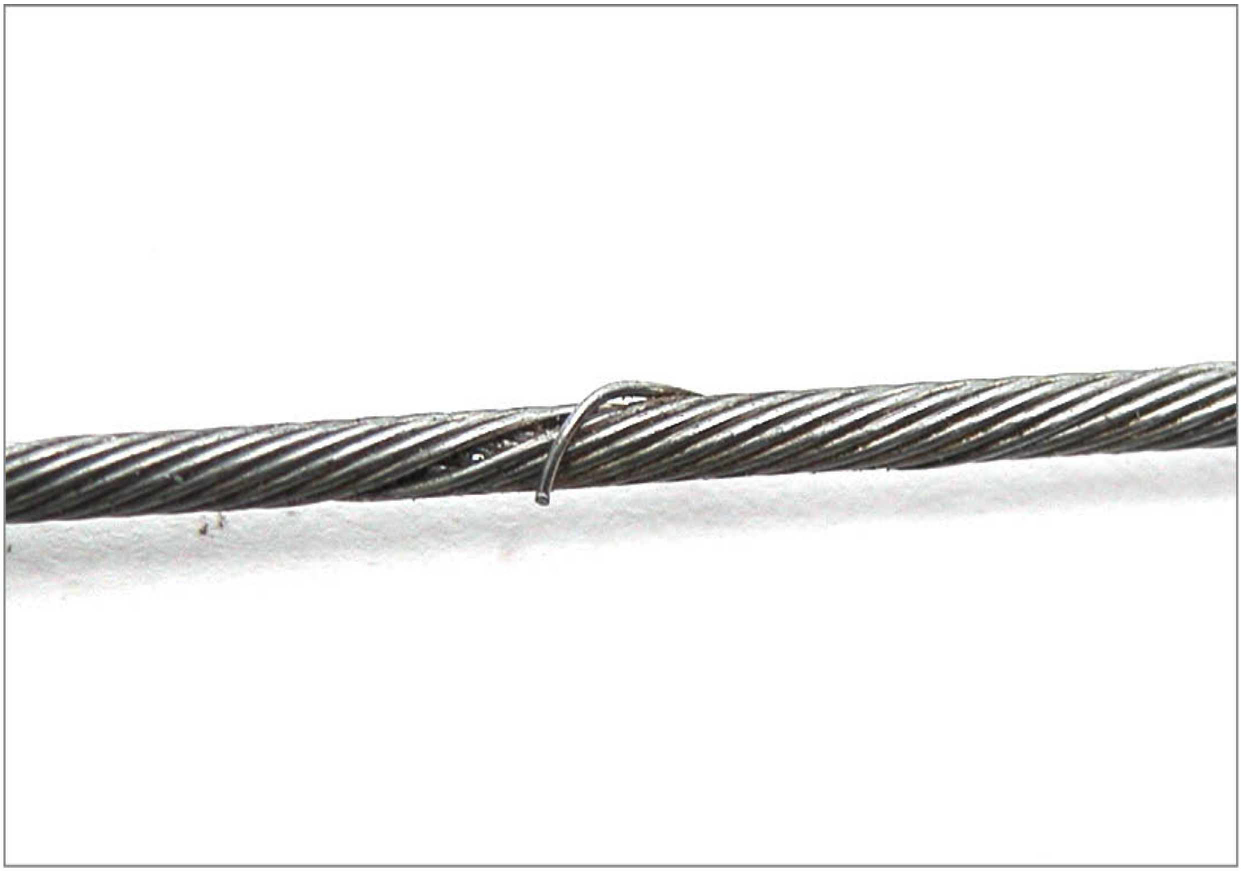


FIGURE 14.17: Inspect and replace cable with broken wires

CABLE LUBRICATION

To prevent rust and to ensure smooth operation, apply a light lubricant to the brake cable where it passes through the housing. If the frame housing stops have a split, the housing and brake cable can be released from the stops for easier lubrication.

Release brake caliper quick-release to relax cable tension. Pull housing back and out of the stop. Slide housing back to expose cable. Wipe cable clean with a rag and lubricate. Reinstall housing into the stops. Close the caliper quick-release.

If removing the housing from the stops is not possible, rotate bike so lubrication can be dripped down brake cable into the housing. Some housing systems use an external liner to cover the entire length of cable from lever to caliper. Do not lubricate cables in these systems.

CALIPER RIM BRAKES

Note: When rim calipers are discussed in this chapter, "right" and "left" will be from the mechanic's point of view, not the rider's point of view. In other words, the left caliper arm of the front brake is the right one as seen when standing in front the bike. The left caliper arm of the rear brake is the one on the left side of the bike while standing behind the bike.

The design of the brake caliper will determine how the brake pads are adjusted. Most caliper arms swing the pad on an arc as it approaches the rim. Certain caliper types swing the pad downward as it moves toward the rim. Other types move the pad upward as it moves. Before adjusting the pads, begin by determining the basic type of caliper used. Move the caliper arm and watch how the pads move toward the rim (figure 14.18).

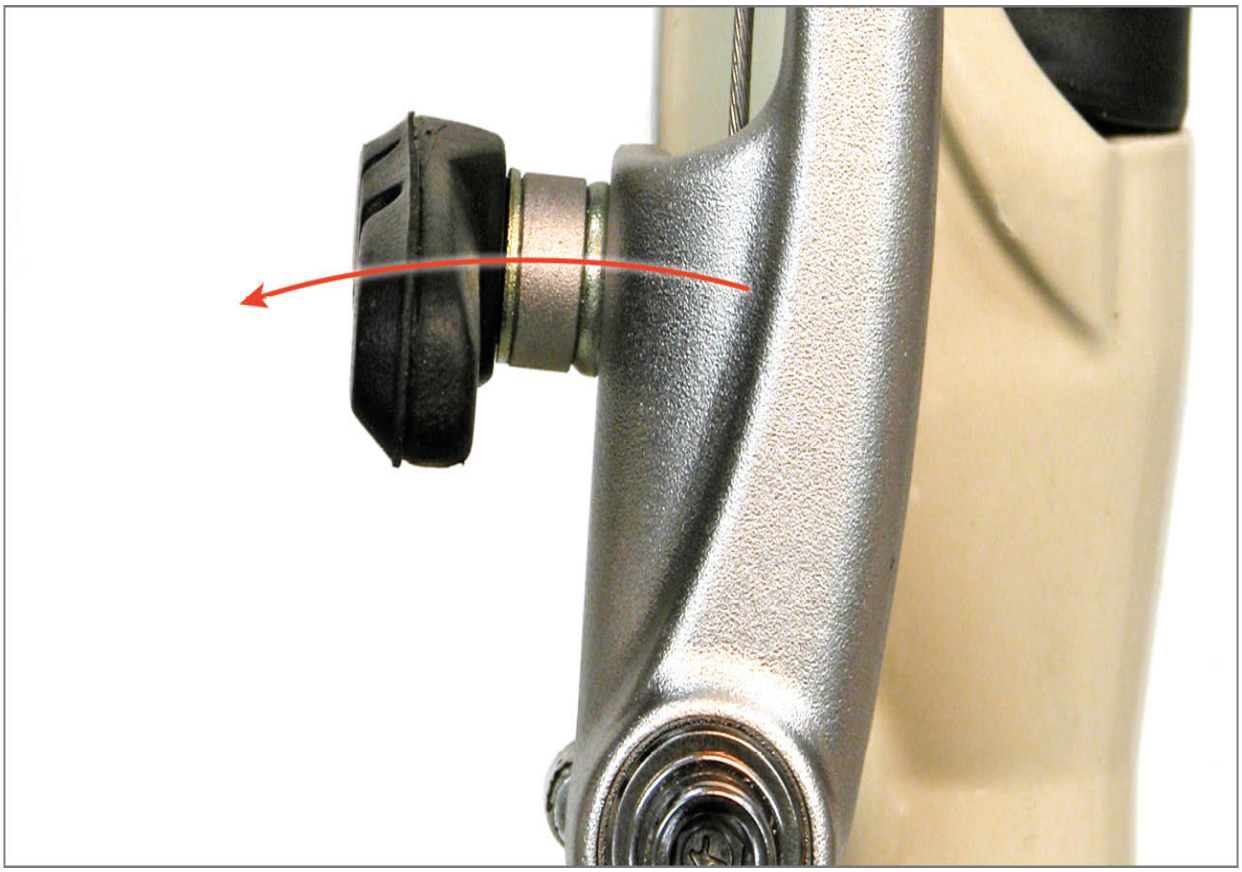


FIGURE 14.18: This pad moves in a downward arc as it swings toward the rim

BRAKE PADS

Brake pads wear with use and will require replacement. Some pads are made with a "wear line," which indicates needed replacement. Age will also harden pad material and make it less effective. It is not uncommon for small amounts of aluminum from the rim-braking surface to become embedded in the pad. Inspect brake pad and remove pieces of grit and foreign material as necessary using a pick or small screwdriver. Pads that are aligned too low on a rim, toward the hub, will develop a lip or edge. This lip makes correct alignment impossible (figure 14.19).

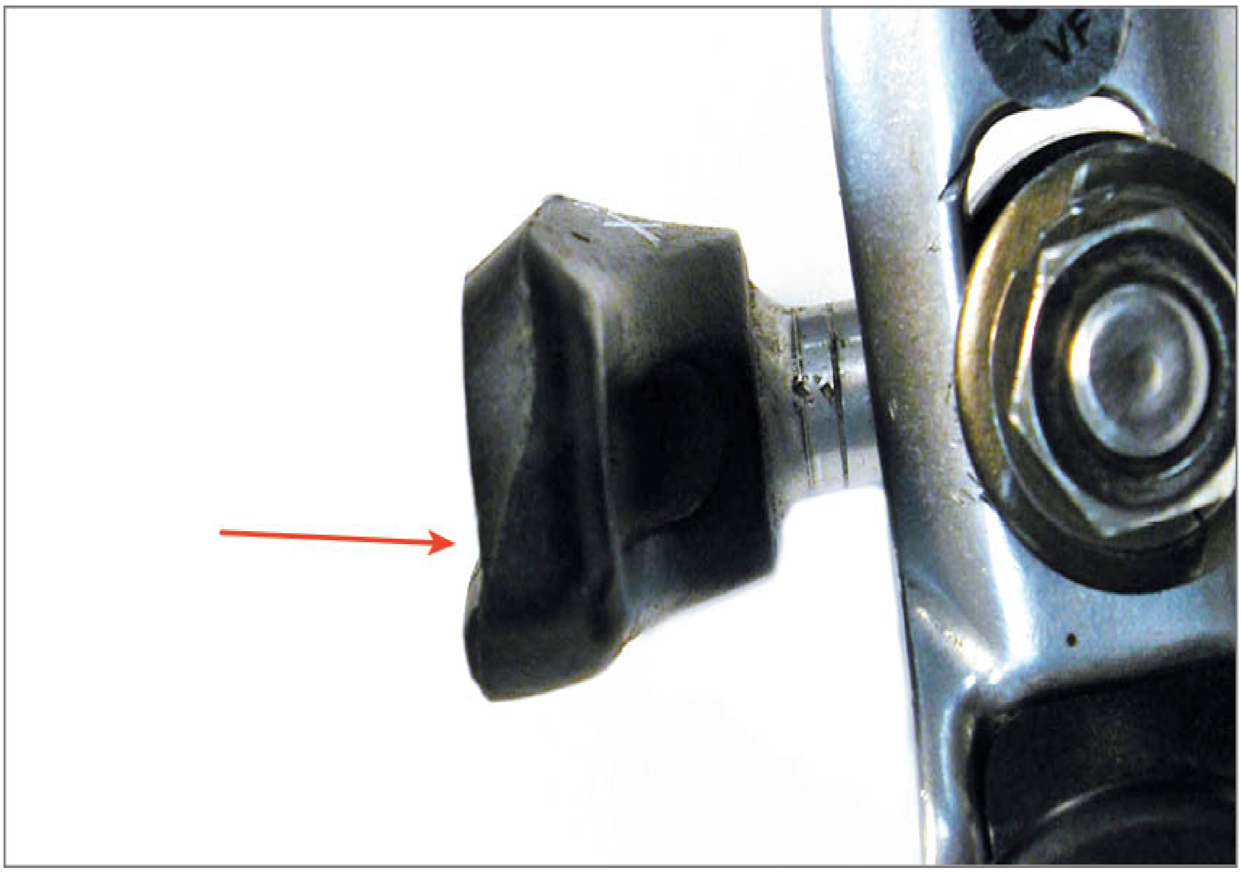


FIGURE 14.19: Worn pad showing signs of low placement on rim braking surface

Replacement brake pads should be compatible with the type of caliper. There are aftermarket pads available for all-around use, as well as pads specifically for wet conditions or specific rim compounds. Choose a pad set that meets the user's needs. A relatively soft pad, for example, will generally give high performance but will wear quickly.

Brake pads may be replaced as an entire unit with the pad material, pad holder, and fastener in one piece. Some brake pad systems use a "cartridge pad" holder that allows for the pad material to be replaced. The pad holder and fastener are reused in these systems. To replace cartridge pads, inspect for and remove any screw or clip retaining the pad. Pull on the pad backwards, away from the rim rotation direction (figure 14.20). Install the new pad by pushing it into holder and reinstalling any retaining screw or clip.

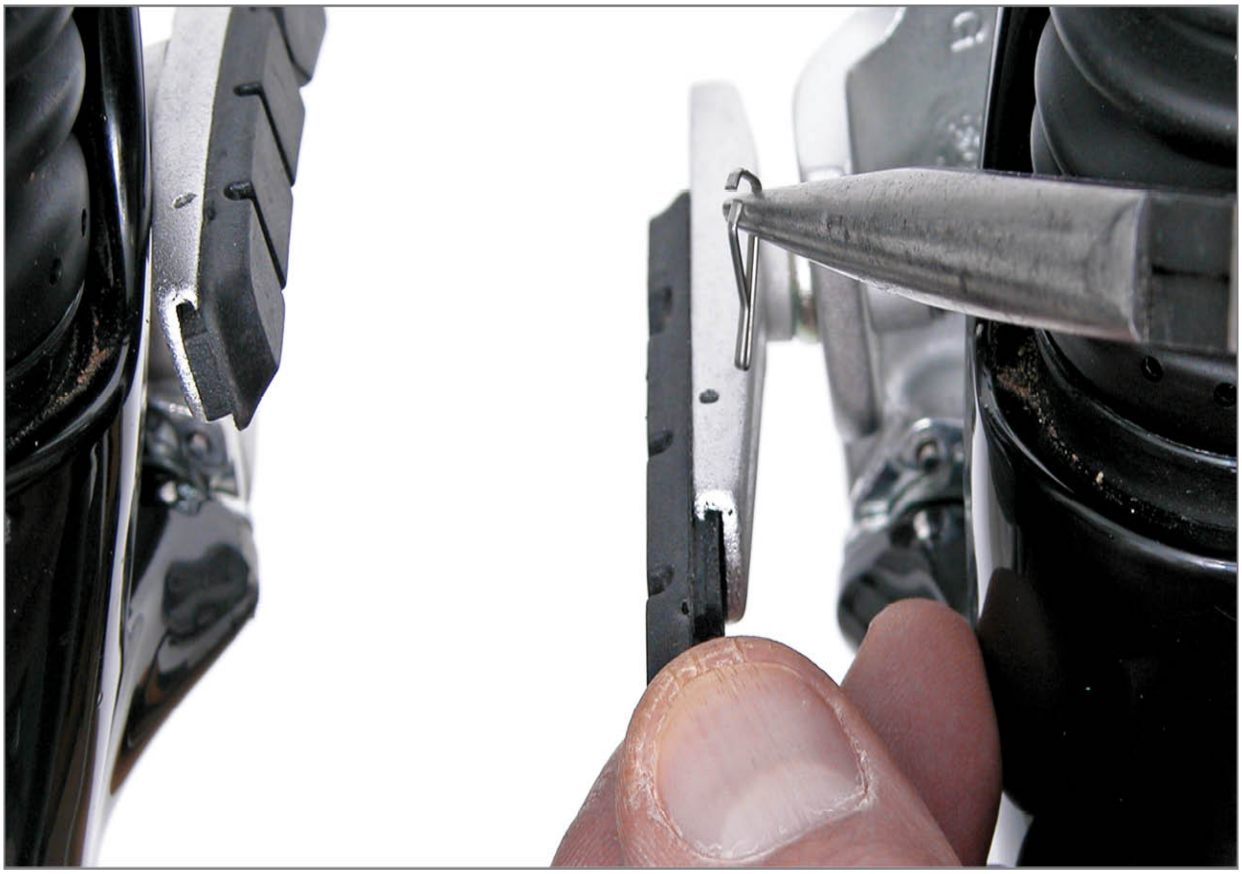


FIGURE 14.20: Pull cartridge pad toward back to remove pad from holder

It is common for some cantilever and linear-pull caliper brake pads to have mounting studs placed off-center, so one end of the pad appears longer (figure 14.21). Look for manufacturer's marking for direction of rim rotation or marking for "front" or "back" pad.

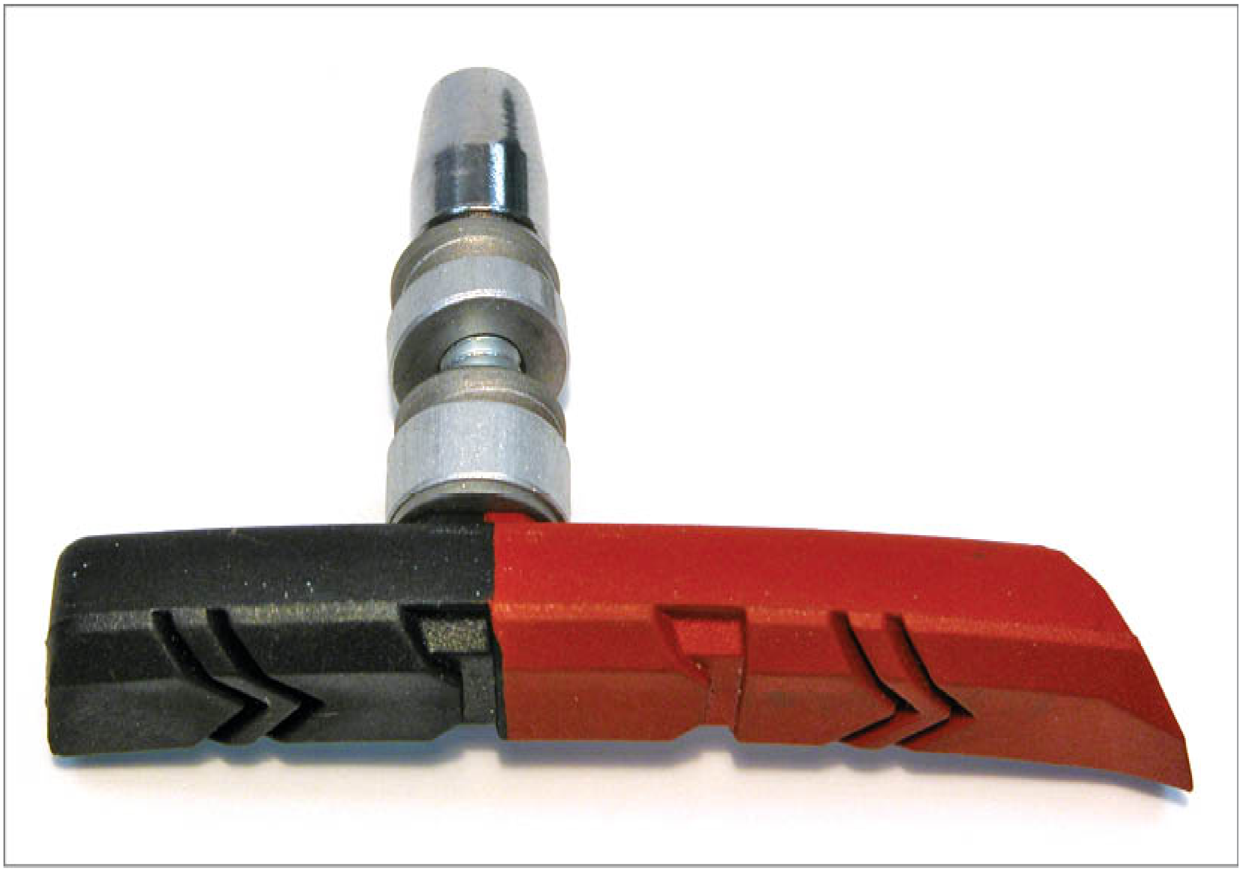


FIGURE 14.21: Off-center brake pad mounting stud

Brake Pad Alignment

Rim caliper pad adjustments depend upon the wheel being centered in the frame. A misaligned wheel will affect both pad centering and pad placement on the rim, and it is important that the wheel be centered before beginning pad adjustments (figure 14.22).

FIGURE 14.22: Misaligned wheel off-set to mechanic's left side

A wheel can be misaligned from simply being placed in the frame incorrectly. Loosen quick-release or axle nuts and pull wheel fully into dropouts. It is also possible the wheel rim is not properly centered over the hub. As a test, flip the wheel around left to right and inspect again. If the centering is good, wheel centering will look the same either way. A wheel may be purposely "misdished" to correct for minor frame or fork misalignment. It is also possible the frame or fork was made with the left and right dropouts at slightly different heights.

An effective solution for an off-center fork or frame is simply to hold the wheel centered when installing it, and then close the skewer tightly (or tighten axle nuts) to hold the wheel in place. Some frames have dropouts that have enough material to allow filing to effectively raise one dropout. Consult a professional mechanic.

Brake pads are mounted to the caliper arms and are adjustable in several directions. There are four basic aspects to pad alignment: vertical height alignment, tangential alignment, vertical face alignment, and pad toe. Not every brand or model of brake caliper has every adjustment, and sometimes it is necessary to compromise when setting pads.

Vertical Height Alignment

This is alignment up and down relative to the rim braking surface, which is the flat vertical section of rim. View caliper face-on and move arms to the rim while watching the pads. If the pads move downward on an arc, set pads near the upper edge of rim-braking surface (figure 14.23). If the pads travel upward toward the rim, set pads near lower edge of rim-braking surface. As brake pads wear, they get thinner and tend to move further upward or downward along their arc. Do not set pads so high that they strike the tire at any time or so low that they are below the braking surface.

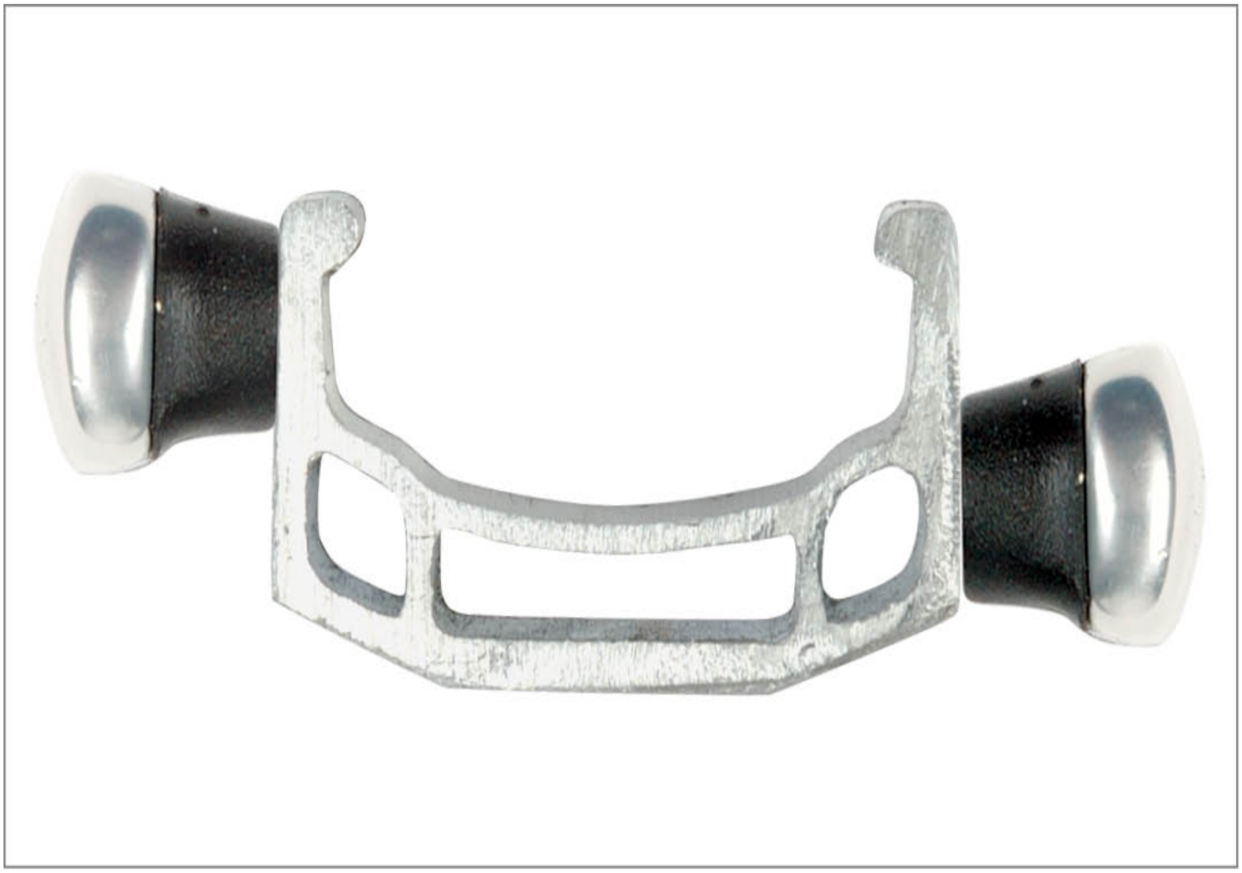


FIGURE 14.23: Pad of left set to top of rim braking surface, while pad on right set to bottom of rim braking surface

Tangential Alignment

This is alignment of the pad tilt viewed from the side. The front and back of the pad should be even on the rim. One side should not be higher or lower than the other side (figure 14.24). Use care when tightening pad fixing bolt and hold brake pad to keep it from rotating.

FIGURE 14.24: Top pad showing proper tangent alignment to rim with front and back of pad square to rim. Lower pad showing improperly set pad with front and back of pad not square.

Vertical Face Alignment

This is alignment of the brake pad face relative to the rim's vertical surface. The vertical face of the pad should be set parallel to the face of the braking surface as it strikes the rim (figure 14.25). Most cantilever and linear pull calipers have an adjustment for vertical face alignment. Many side-pull and dual pivot caliper pads do not allow for vertical alignment. These pads will simply wear in with use or they can be sanded or filed to shape.

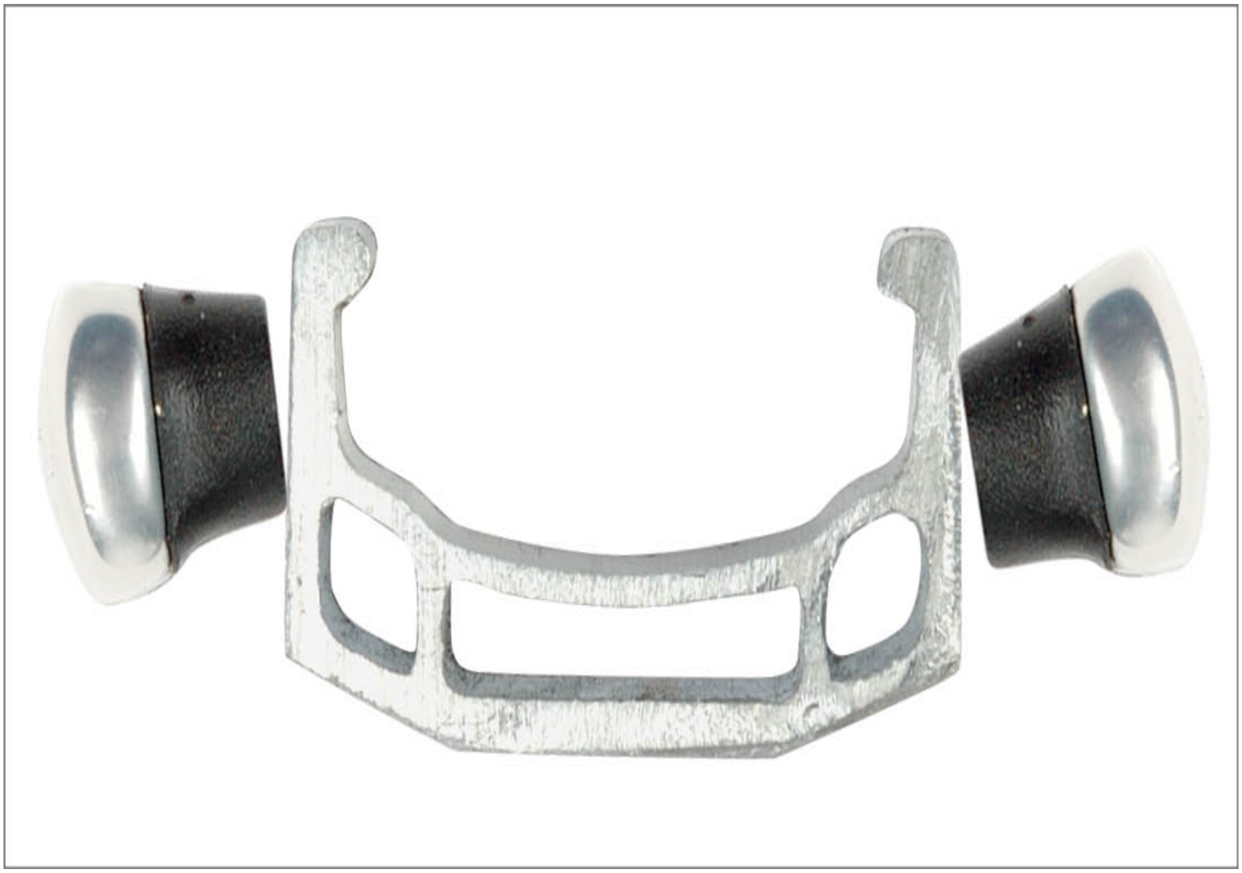


FIGURE 14.25: Vertical faces of both pad showing misalignment to rim braking surface

Pad Toe

This is the alignment of the pad angle as it touches the rim, viewed from above the brake. Toe, often called “toe-in” or “toeing,” refers to setting the pad so its front or leading edge strikes first, with a slight gap of 0.25mm to 1mm at the back or trailing edge of the pad (figure 14.26). Toe helps to reduce “squeal” during braking.

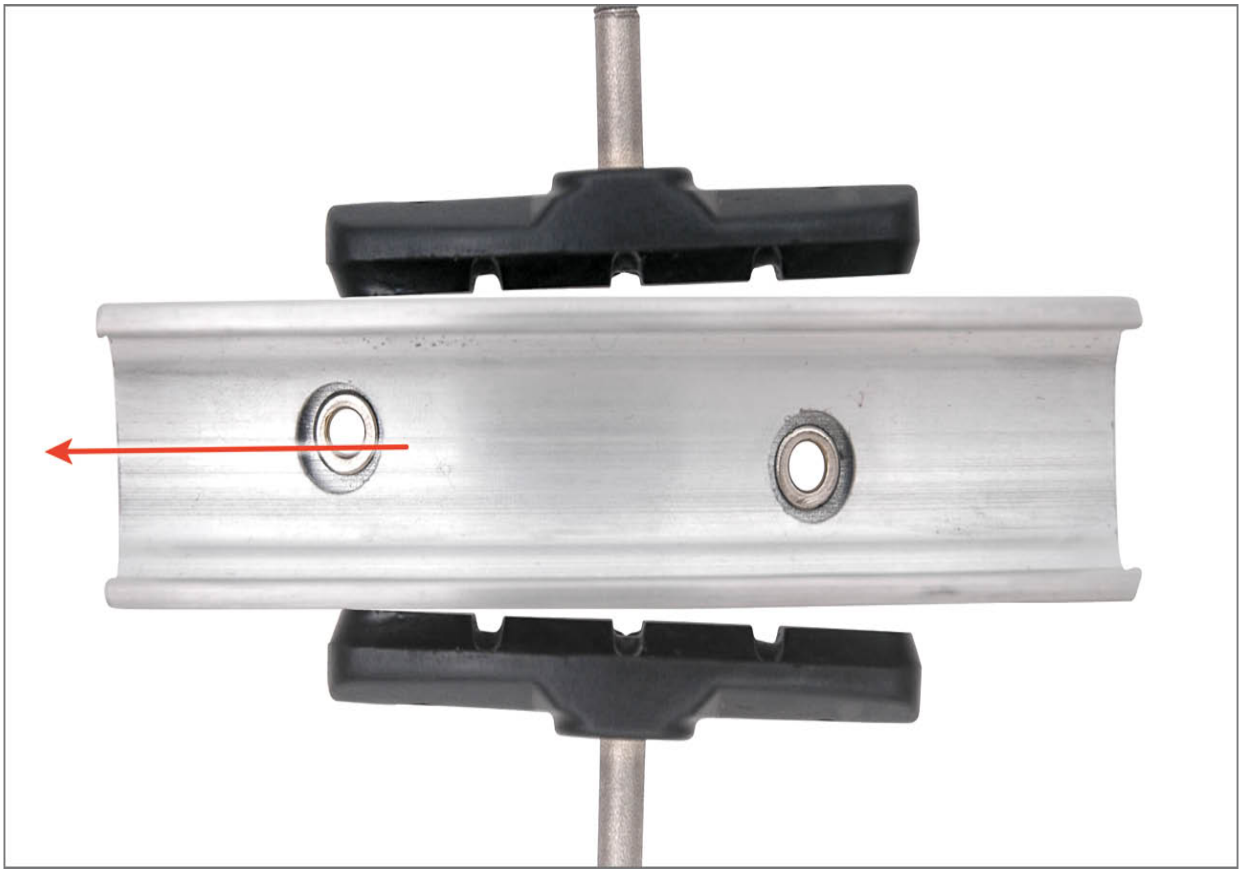


FIGURE 14.26: Toe set with contact at front edge of rim rotation and gap at back

Caliper arms have play in the pivots. Additionally, brake calipers flex with the spinning wheel movement when the brake is applied. This creates a back and forth “slip and stick” phenomenon as the pads are first pulled forward and then spring backward. The effect is much like that of a bow on a violin string. The result is “harmonic resonance” or “squealing” sometimes heard during braking. Caliper systems that are more rigid tend to flex less and that results in less audible squealing. Generally, less toe angle is better than more for brake performance. Too much toe angle will exacerbate brake caliper flex without providing braking force to the pads.

Some brake pad systems allow toe adjustment in the pad fixing bolt. Side pull and dual pivot caliper arms can sometimes be bent slightly for pad toe. However, if the caliper arm is relatively thick, they should not be bent. Toe may be cut into the pad with a file. It is simplest to first test ride and see if toe is even required.

LINEAR PULL CALIPER ADJUSTMENT

Both linear pull and cantilever caliper arms attach to separate frame or fork pivots located below the rim surface on either side of the wheel. Pivot studs are commonly bolted to the frame or fork. For steel frames and forks, the studs may be "brazed-on" to the tubing. Studs are nominally 16mm long and 8mm in diameter, with an internal thread for a M6 mounting bolt. Grease the surface of the studs before installing the calipers. The cantilever should pivot freely when the mounting bolts are secure. Overtightening may damage stud fittings and cause the caliper to stick.

There may be several spring hole options in the brake caliper as well as in frame braze-ons (figure 14.27). Mount left and right caliper springs into mirror image holes. Spring hole options allow changes in spring tension. Generally, select the middle option and move both sides symmetrically if changing tension.

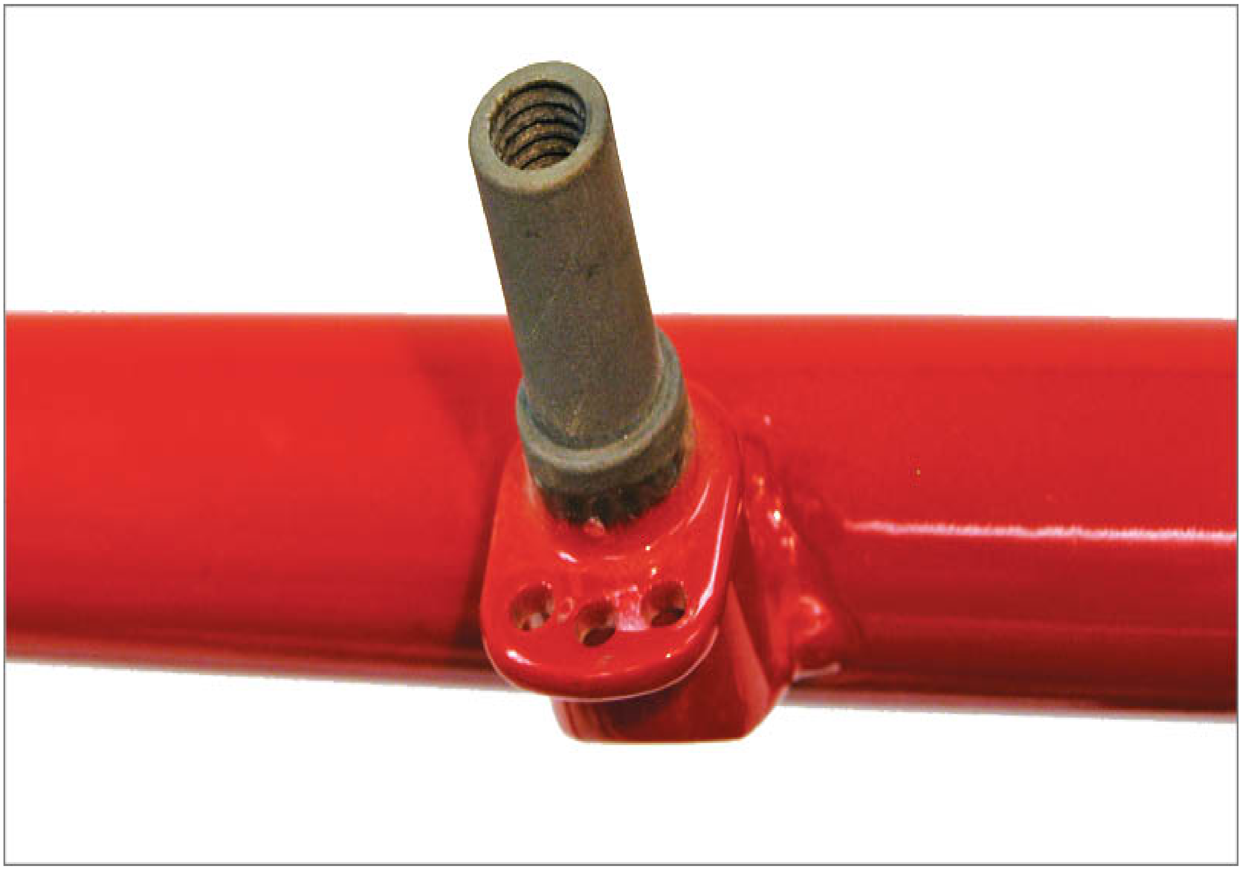


FIGURE 14.27: Brake caliper mounting stud with spring mounting holes for linear pull or cantilever-style brake arms

Linear pull brakes share many similarities with cantilever brake designs. Caliper arms pivot on frame or fork-mounted studs at one end and are pulled by the brake cable at the other end (figure 14.28). However, there is no straddle wire as with cantilevers. The primary cable from the brake lever passes through a metal cable housing stop called a “noodle.” The noodle is fitted to a carrier on one arm, and the cable attaches by a bolt to the second arm. Pulling the brake lever pulls the arms together and forces the pads onto the rim braking surface.

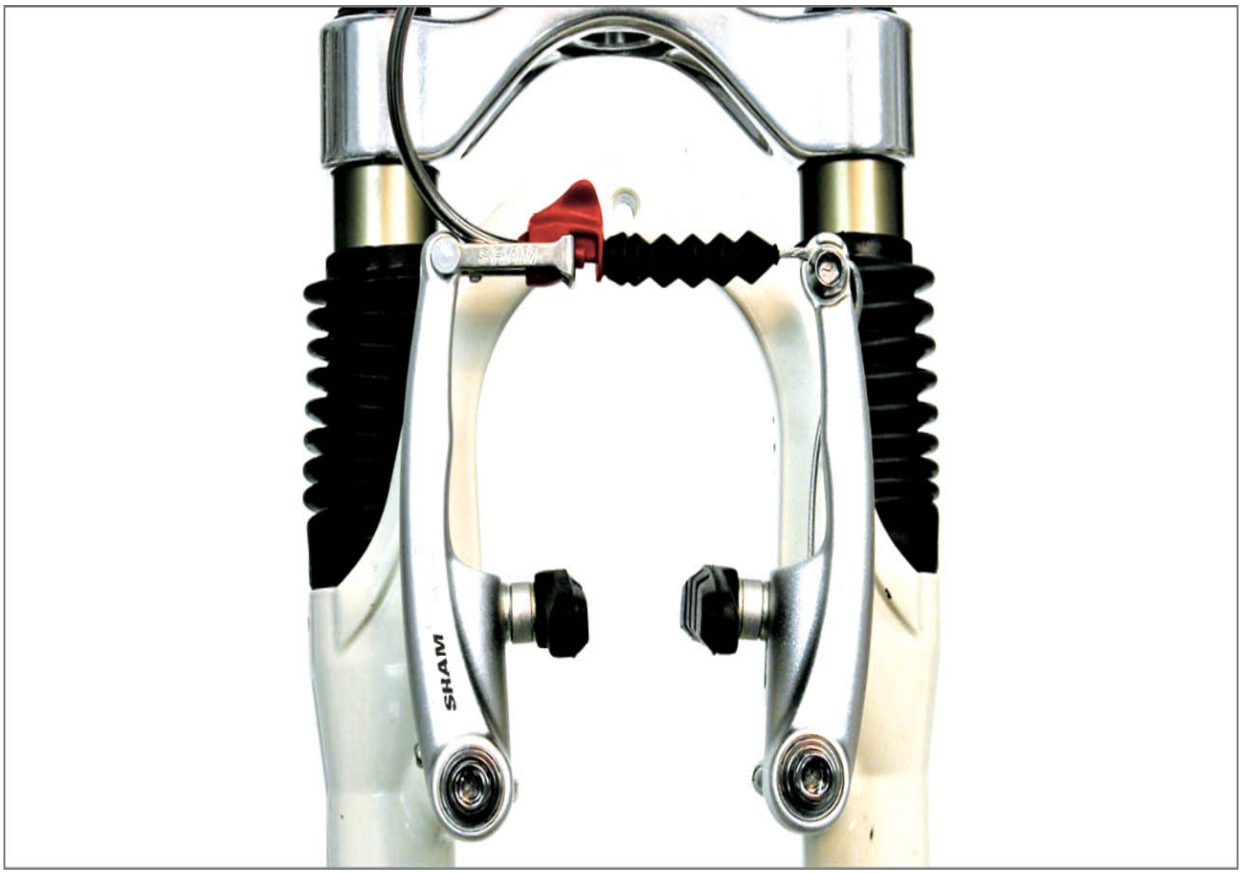


FIGURE 14.28: Linear pull caliper brake

Linear pull calipers and cantilever calipers move brake pads in an arc moving downward toward the low side of the rim. Pads should be set high vertically on the rim but without interfering with the tire. Pad height will lower as pad face wears.

Linear pull calipers, like cantilevers, attach to the frame or fork at braze-ons. Grease the outer surface of each braze-on before installing the calipers. Secure mounting bolts. The caliper arm should pivot freely. Over tightening may damage the fitting and cause the caliper to stick.

Most models of linear pull calipers use a threaded stud brake pad. A threaded bolt is fixed into the pad. The bolt is positioned to the caliper arm by a series of convex and concave spacers. This “ball and socket” system allows the bolt and pad to move in the caliper arm for toe and vertical face alignment (figure 14.29). To change pad angle, loosen nut/bolt, and move pad to desired position. Hold pad while securing nut/bolt.

FIGURE 14.29: Ball and socket spacer system of threaded brake pad

Wide rims versus narrow rims may require different liner-pull pad spacer arrangement. Changes to spacers permit changes to the angle of arms as they contact rim. Push both arms together until pads are touching rim and view caliper arms from the front. Arms should be relatively close to parallel with one another. If arms are forming a wide “V,” swap wide spacers inside caliper for narrower spacers outside caliper. Conversely, if arms tilt inward, swap narrow spacers inside calipers for wider spacers outside calipers (figure 14.30). The convex surface of one spacer must always face a concave surface on the other spacer.

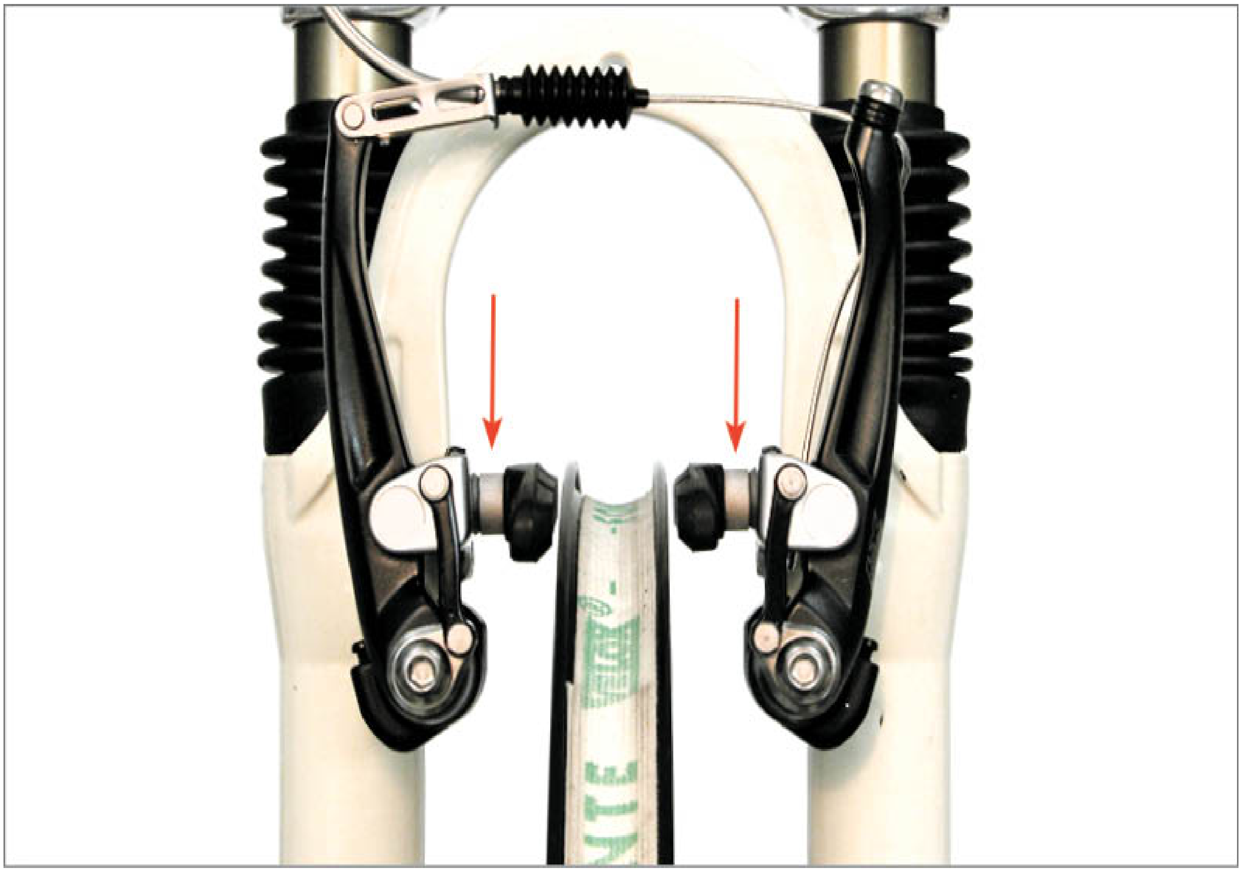


FIGURE 14.30: Move wide spacer to outboard side of calipers to change caliper arms

Procedure for linear pull caliper and pad adjustment:

a. Attach brake cable to brake lever and feed through barrel adjuster and housing. Feed cable through frame fittings, through “noodle,” and through protective rubber boot, if available. Finally, feed brake cable through pinch mechanism.

b. Check barrel adjuster position. Unscrew barrel adjuster two turns from fully threaded into lever body.

c. Push both arms together until pads are touching rim and inspect caliper arms. Arms should be close to parallel with one another. Move spacers as necessary to position arms as described above.

d. Adjust one pad position relative to rim at a time. Loosen pad nut/bolt and lubricate curved spacers and thread. Install rubber band shim at back edge of pad (figure 14.31). This creates a temporary shim to add toe to back edge of pad.

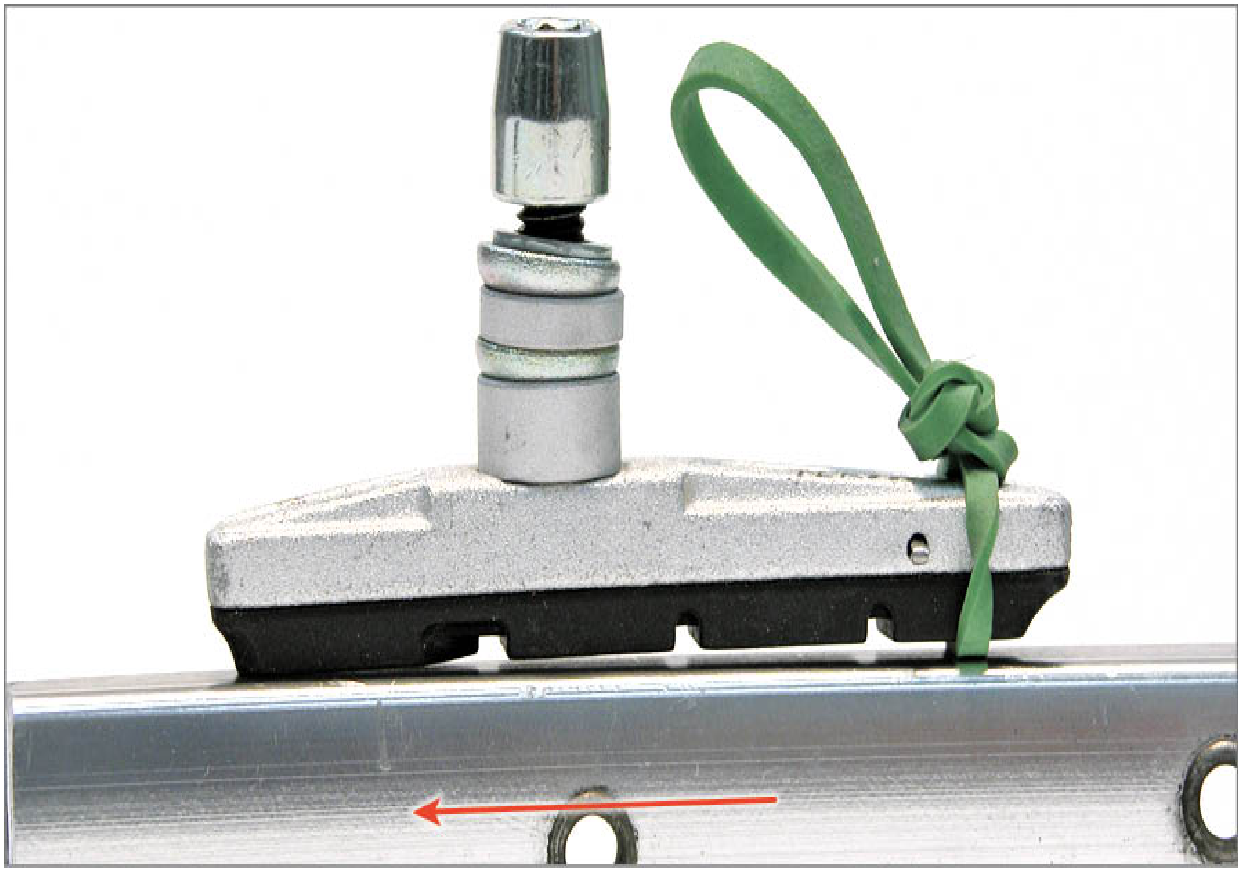


FIGURE 14.31: Use rubber band as a shim to create toe in ball and socket threaded stud pads

e. Push caliper arm to rim and view pad alignment. If practical, unhook spring from arm to make alignment easier. Set pads for correct position relative to rim in four basic alignments:

Height: with pad close to top edge of braking surface.

Tangent: with front and back edge even to rim.

Vertical face: with pad face and rim parallel.

Toe: with slight gap at trailing edge of pad. A rubber band can act as a shim to hold back of pad out slightly.

f. Tighten pad nut and remove rubber band. Inspect pad alignment again.

g. Repeat pad adjustment on other side of caliper.

h. Pull cable slack through pinch bolt mechanism. Do not pull cable overly tight if using a fourth hand tool such as the Park Tool BT-2. Secure cable pinch bolt fully. Cable should flatten when pinch bolt is tight.

i. Squeeze lever hard several times to test pinch mechanism and to settle cable and housing. Set pad clearance at lever for rider preference by using barrel adjuster. If barrel adjuster is screwed all the way into lever body and brake lever is still too tight, loosen brake cable pinch bolt and allow slack to feed through pinch plate. Tighten pinch bolt and test again and adjust as necessary.

j. Inspect pad centering to rim. Use set screw on sides of caliper to center pads to rim. Tighten set screw on arm with pad that is closest to rim (figure 14.32).

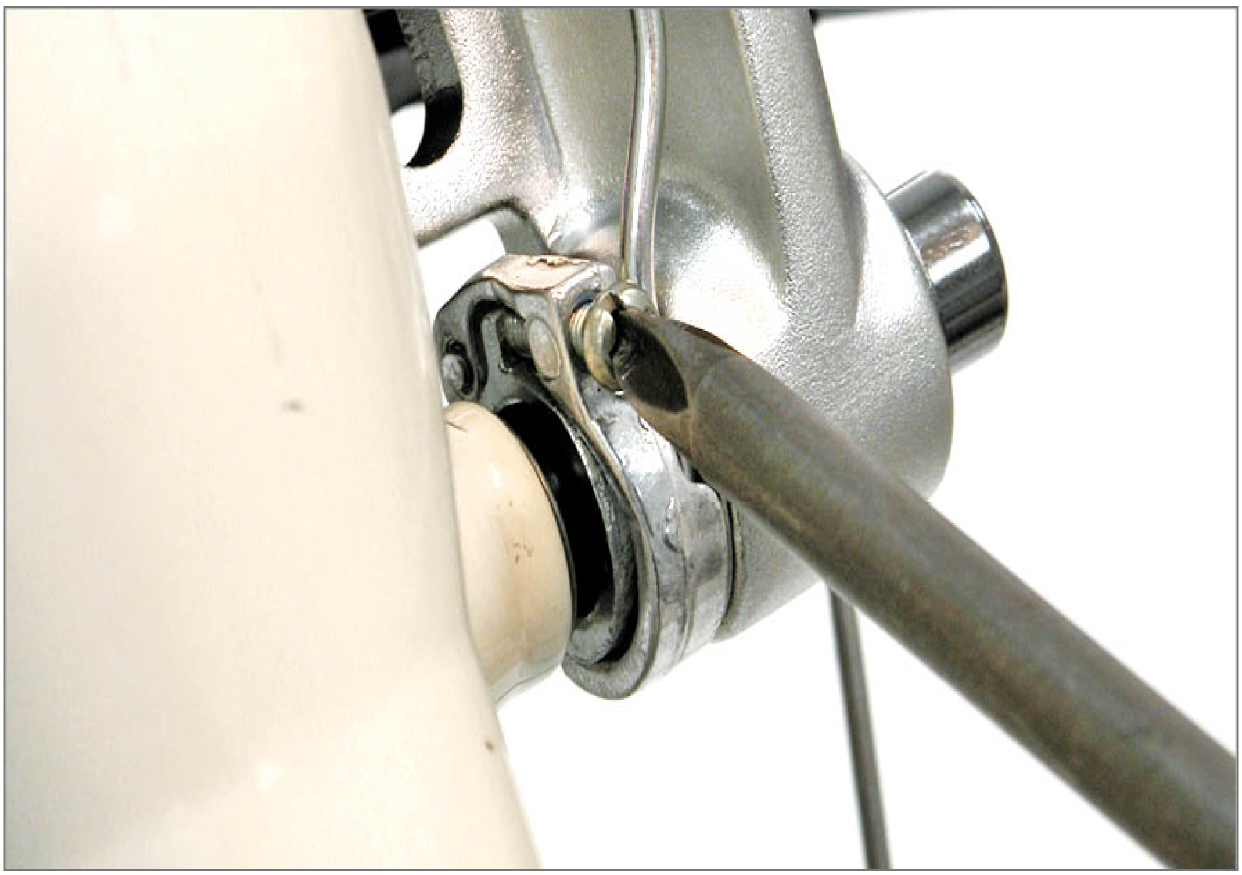


FIGURE 14.32: Use screw to change spring tension when centering pads to rim

k. Inspect to ensure that pads are not rubbing tire. Adjust if necessary.

If linear pull calipers use smooth stud brake pads, the procedure is similar to cantilever calipers. A smooth stud caliper pad has no threads. The smooth section of the stud passes through a hole in the bolt head and is held secured by tightening a nut. Adjust cable tension to set arms close to parallel and then adjust pads. Use barrel adjuster to back pads off rim for clearance.

CANTILEVER CALIPER ADJUSTMENT

Cantilever calipers may be found on mountain bikes, cyclocross bikes and touring bikes. Cantilever caliper pads move downward on an arc as they travel to the rim (figure 14.33). Because of the downward arc, pads should be set high vertically on the rim but without interfering with the tire. Pad height will lower as pad face wears and the caliper arms get closer to the lower edge (or hub side) of the rim.

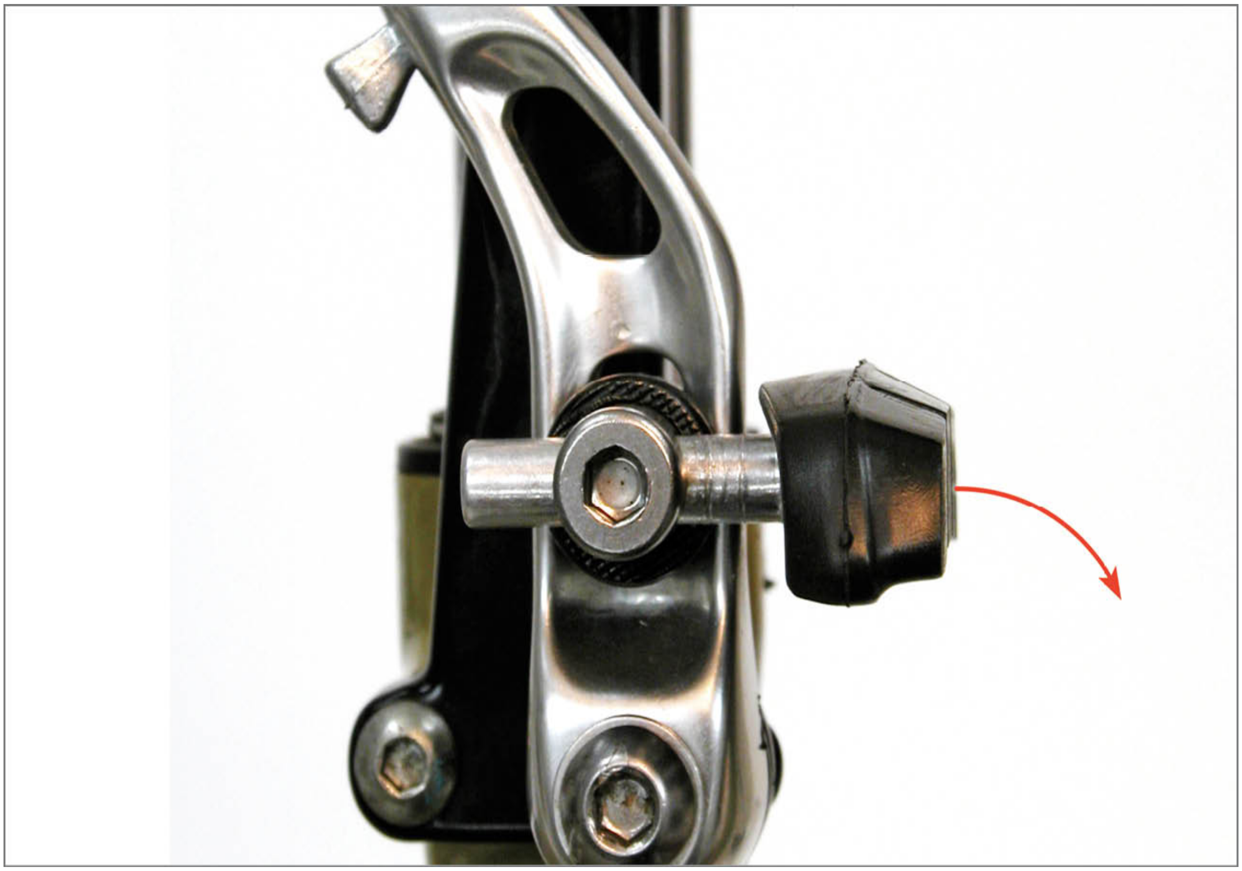


FIGURE 14.33: Cantilever pad travels downward as they move toward rim

Cantilever calipers may use either "smooth stud" or "threaded stud" brake pads. Smooth stud brake pads are secured by pressure from a "pad fixing bolt." A system of curved spacers allows the brake post to rotate for setting toe (figure 14.34). Pads can be bolted into a range of positions, closer to or further from the rim.

FIGURE 14.34: Smooth stud pad with curved washer system

There are two basic systems that attach primary brake cables from the brake lever to the cantilever caliper arms: the straddle wire carrier and the "link unit."

A straddle wire carrier is centered over the wheel and uses a pinch bolt to secure the primary brake cable (figure 14.35). The carrier pulls up on a straddle wire, a separate wire connecting the two caliper arms. Place straddle wire carriers as low as practical for best mechanical advantage at brake pads. The bottom of the carrier should be approximately even with the lowest part of the rear seat stay bridge or front fork crown, or clearing the top of a fender, if any.

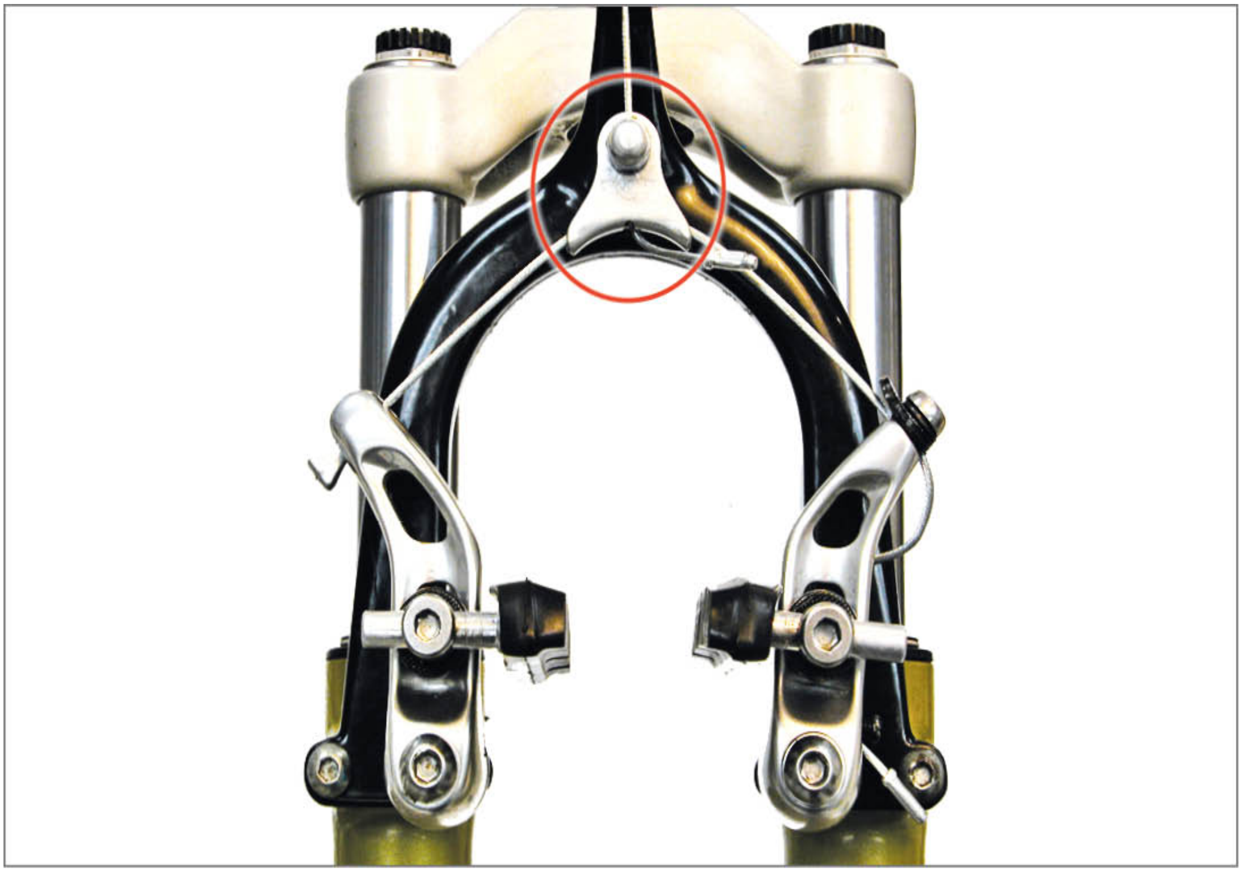


FIGURE 14.35: Straddle wire carrier for cantilever brakes

A link unit uses housing and a head that is a fixed distance above the tire (figure 14.36). The height of the link unit determines the arm position. A longer link unit will allow more clearance above the tire. The primary wire attaches to one caliper arm, and the link unit attaches to the opposite arm. The center head does not pinch the wire. The arms are drawn together when the cable is pulled and the head is lifted upward.

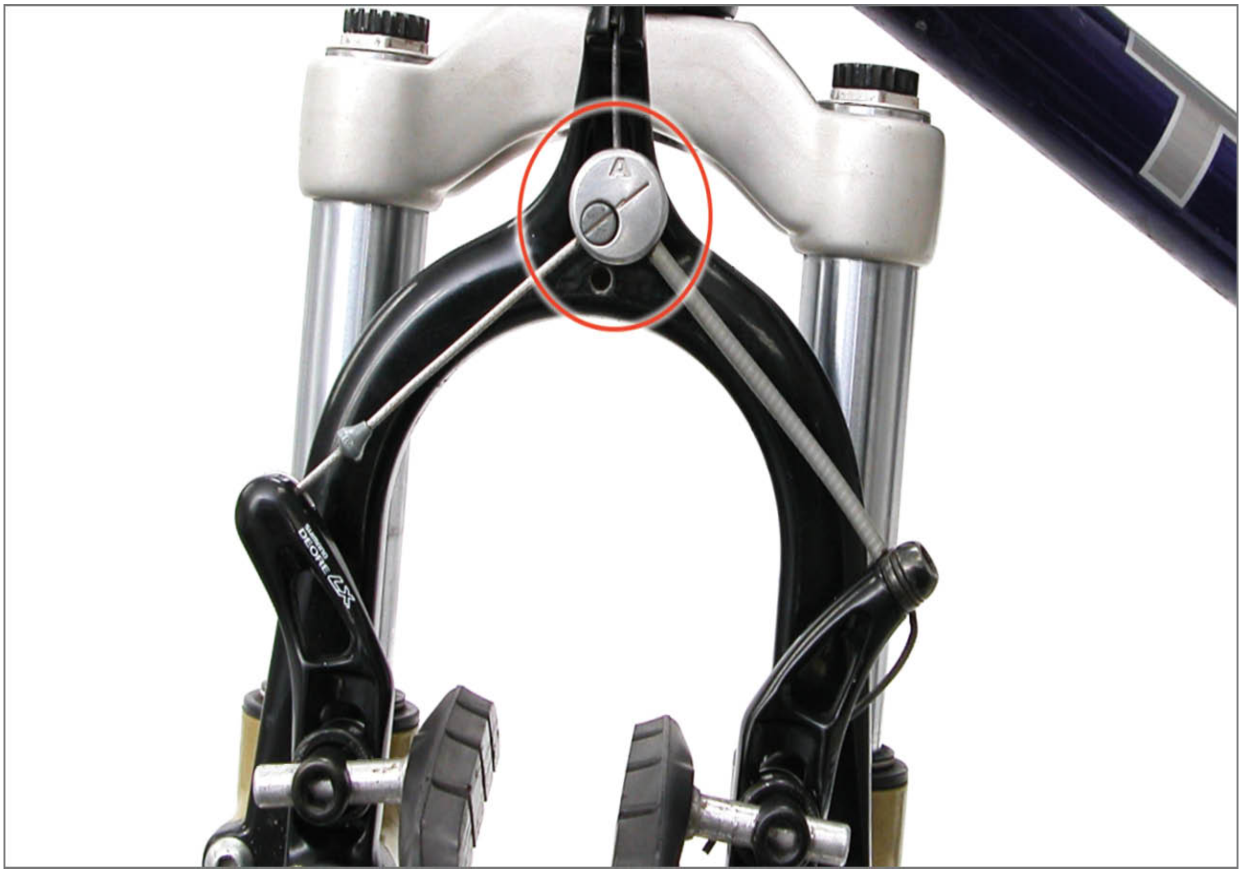


FIGURE 14.36: Straddle wire link unit

Procedure for cantilever pad and caliper adjustment:

a. For calipers using link units, attach cable to lever. Feed cable through all housing pieces and link unit to caliper arm pinch bolt. For straddle wire carriers, feed cable through housing and attach cable to straddle wire carrier. Position carrier above tire even with the lower part of frame or fork, clearing top of fender, if any. Fully secure carrier pinch bolt.

b. Turn brake lever barrel adjuster fully clockwise into lever body, then unthread approximately two complete turns. This allows adjustment after setting pad placement.

c. Loosen brake pad fixing nuts on both sides of cantilever and lubricate threads, curved spacers, and spacer-to-arm contact points.

d. Point pads down, away from rim, and gently snug nuts. This allows proper alignment of caliper arms before adjusting pads.

e. Position caliper arms parallel to one another (figure 14.37). For saddle wire carriers or link wires, adjust cable length at caliper arm pinch bolt.

Use Park Tool BT-2 Cable Stretcher to help adjust cable length. Secure pinch bolt.

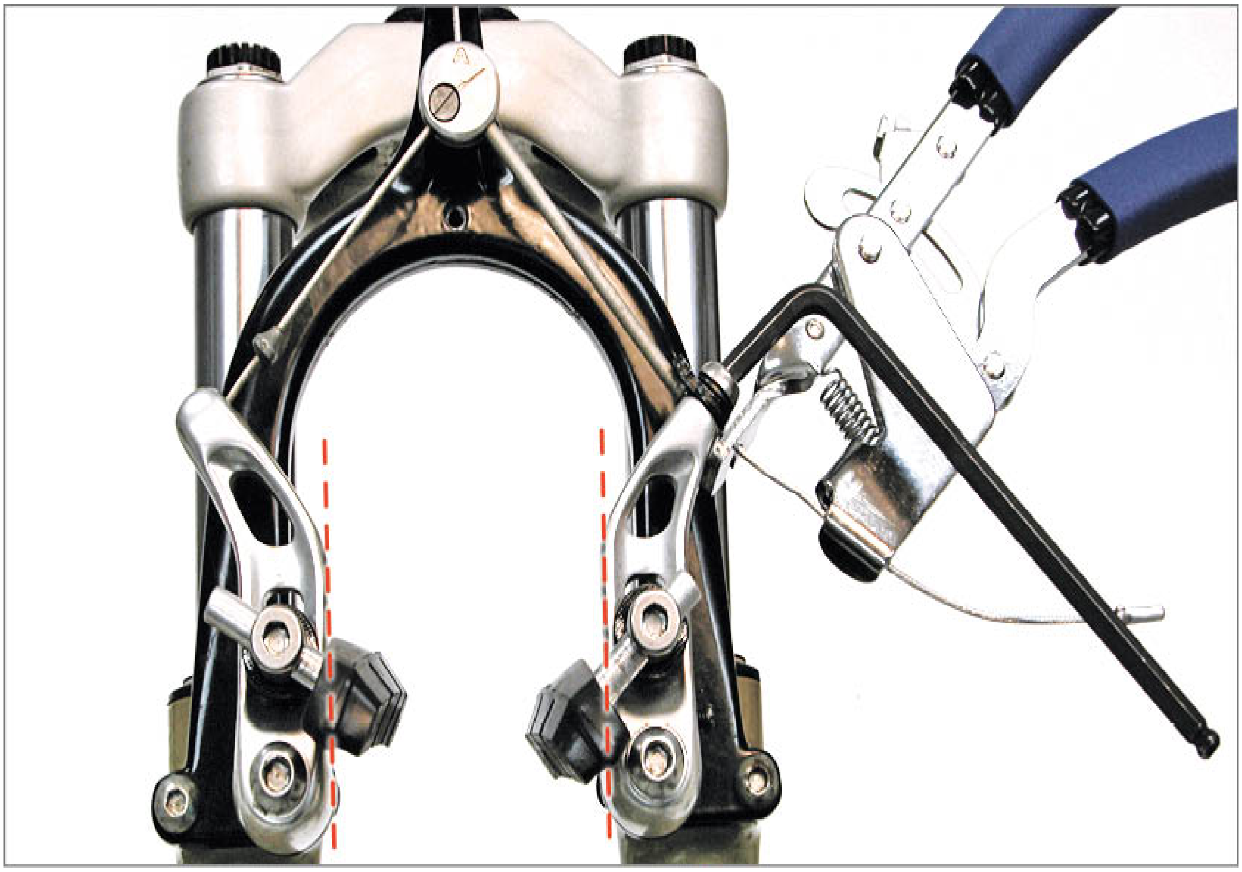


FIGURE 14.37: Adjust brake cable length at pinch bolt until arms are close to parallel

f. View centering of caliper arms to rim. Most calipers use a centering set screw on the caliper arm. Turning set screw changes spring tension. For example, to move both arms right, turn right side set screw clockwise. To move both arms left, turn right-side screw counterclockwise. Squeeze lever to work calipers and check centering again. Do not center pads to rim at this stage; consider only the position of caliper arms relative to rim.

g. Attach a rubber band around backside of pad. This is used in pad alignment only and is later removed (figure 14.38). Rubber bands act as a shim to give toe to brake pads. Some pads may have a built-in toe feature at the back end of the pad. Do not use a rubber band on these pads. Simply align the built-in toe feature flush to the rim.

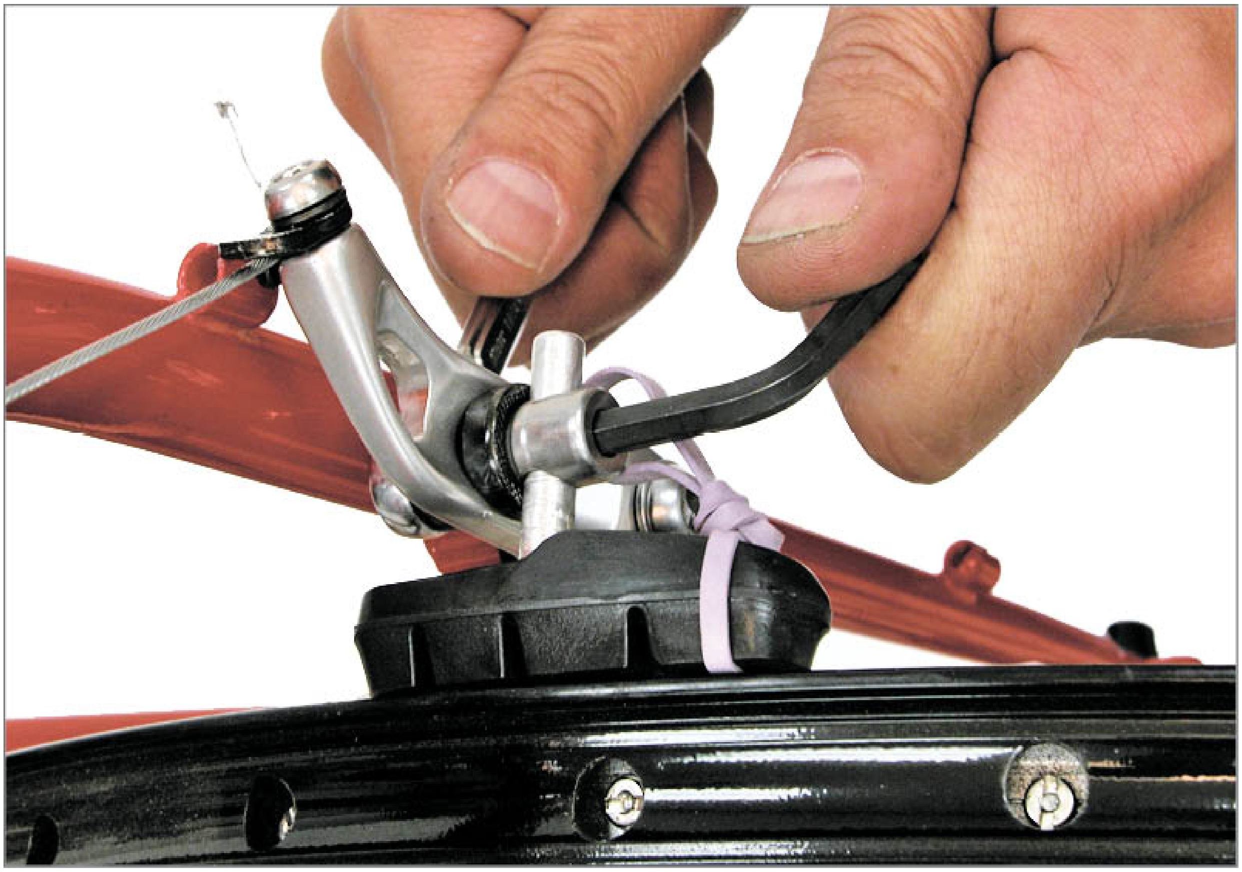


FIGURE 14.38: Adjust one pad at a time using a rubber band as a shim to create toe

h. Adjust pad alignment to rim. For smooth stud pads, push one pad through fixing bolt assembly until it is contacting rim. Use care not to move caliper arm. Set pads for correct position relative to rim in four basic alignments:

Height: with pad close to top edge of braking surface.

Tangential: with front and back edge even to rim.

Vertical face: with pad face and rim parallel.

Toe: with slight gap at trailing edge of pad. A rubber band can act as a shim to hold back of pad out slightly.

i. Hold mounting bolt with hex wrench and tighten mounting nut. Pad should contact rim after adjustment.

j. Remove rubber band from rear and view toe. There should be a slight gap at back of pad. Double-check pad alignment by viewing from top, bottom, front, and side.

k. Loosen other pad and repeat steps "h–k." Both pads should be contacting rim when pad adjustments are completed.

l. Squeeze lever multiple times to seat brake cable and test brake cable pinch bolt. Cable should not slip either at cable carrier or caliper arm.

m. Set clearance at lever for rider preference. If brake feels tight, turn barrel adjuster clockwise to shorten cable housing and loosen brake cable tension. If brake feels loose, turn barrel adjuster counterclockwise to tighten brake cable tension.

n. If barrel adjuster is all the way engaged at lever and brake lever is still too tight, loosen brake cable pinch bolt and allow slack to feed through pinch plate. Tighten pinch bolt and test again. Adjust at brake lever.

o. View pad centering to rim. If not adequately centered, use centering set screw on arm (figure 14.39).

FIGURE 14.39: Use spring tension adjusting screw to center pads to rim

p. Inspect to ensure that pads are not rubbing tire. Adjust if necessary. For smooth stud pads, use care not to move brake pad stud in or out from caliper arm as this changes centering. Move pads only up or down.

Some brands and models of cantilever calipers have no centering set screw or other system of pad-to-rim centering. In this case, move smooth stud pads laterally as necessary in pad fixing bolt. Another option on some brands utilizes an adjustable spring tension nut on each caliper at mounting bolt. Spring tension can be changed on either arm. Use wrench to hold tension nut and loosen mounting bolt. Move wrench and tension nut to improve center and retighten mounting bolt.

Cantilever calipers may also be designed for use with a threaded stud brake pad that uses a series of convex and concave spacers as a ball and socket system to allow the pad to rotate for toe and vertical face alignment.

The position of the pad to the arm can be changed laterally by moving the wider spacer to the inner or outer side of the caliper arms. Arrange spacer with convex and concave surfaces facing one another. Because there is a spacer system on either side of the caliper, the threaded stud can be secured in various positions other than square to the caliper arm.

Procedure for cantilever threaded stud pad adjustment:

a. Use straddle wire to bring pads to rim and secure pinch bolt. Pads should be just touching rim braking surface. Do not close pads to rim with force, as final pad alignment is not yet completed (figure 14.40).

FIGURE 14.40: Use primary cable carrier to bring pads to rim

b. Set pads for correct position relative to rim in four basic alignments:
  Height: with pad close to top edge of braking surface.
  Tangent: with front and back edge even to rim.
  Vertical face: with pad face and rim parallel.
  Toe: with slight gap at trailing edge of pad. A rubber band can act as a shim to hold back of pad out slightly.

c. Screw adjusting barrel into lever to clear pads from rim. Squeeze lever and set lever clearance as desired.

d. View pad centering to rim. If not adequately centered, use centering set screw on arm.

DUAL PIVOT CALIPER ADJUSTMENT

Dual pivot calipers are popular on many road bikes. They appear visually very similar to side-pull brakes (figure 14.41). However, left-side and right-side dual-pivot brake caliper arms move on separate pivots, and the two arms arc in different directions. As seen from the mechanics point of view, the left pad swings downward toward the rim while the right pad swings upward. As with other calipers, the swing of the arm determines initial pad height.

FIGURE 14.41: Dual pivot caliper brake

Dual pivot and side pull brake calipers secure in mounting holes in frame and fork. These calipers secure to the frame with a single nut centered above the wheel (figure 14.42). Front brake mounting bolts have longer threads, while the rear brake bolt has shorter threads. When mounting a dual pivot or side pull caliper, hold it centered to wheel and tighten nut.

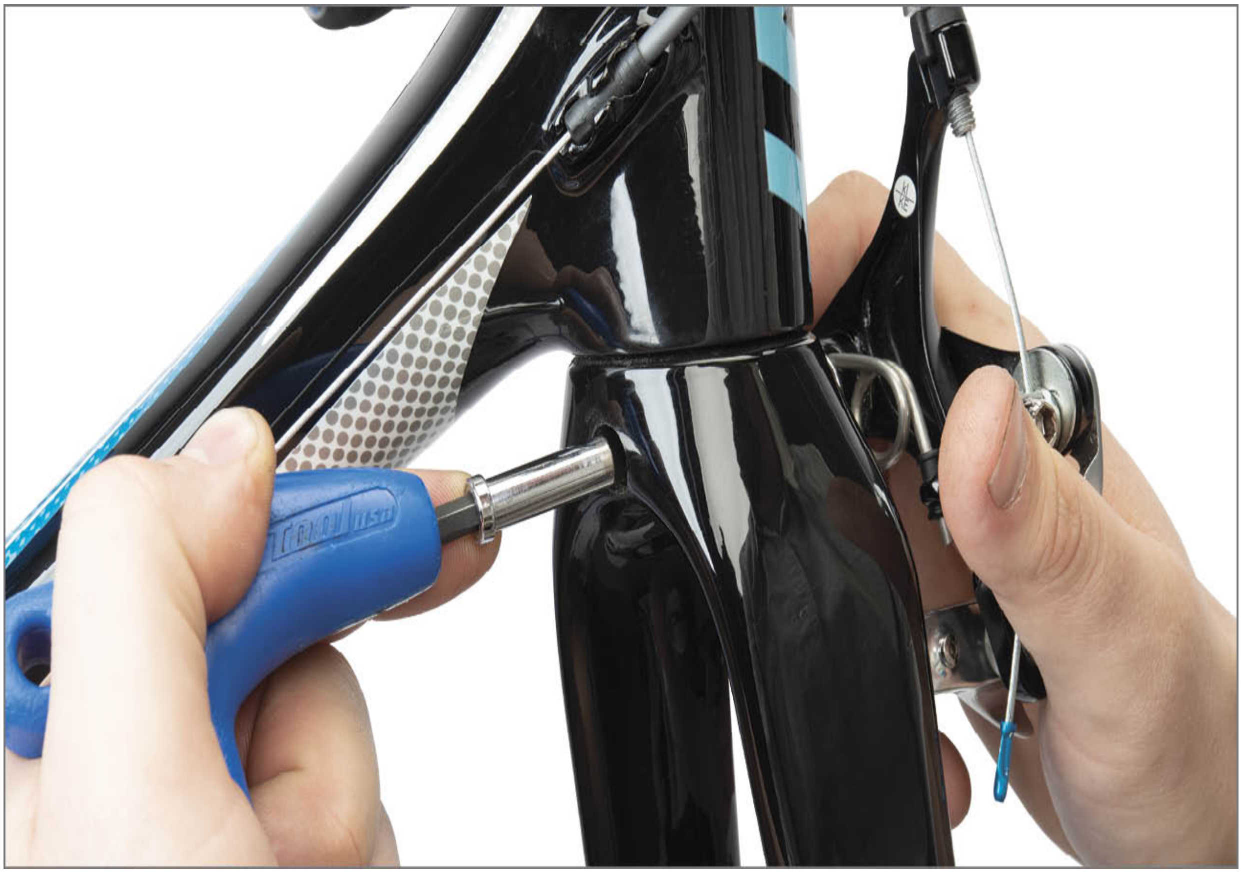


FIGURE 14.42: Hold caliper centered while securing mounting nut

Some dual pivot brakes allow for only height and tangent alignment adjustments to the rim. Toeing or vertical face alignments are possible with pads using a ball and socket system only. Dual pivot caliper arms can sometimes be bent slightly for pad toe. If caliper arms are relatively thick and difficult to bend, toe may be cut into the pad with a file. If brake does not squeal on a test ride, toeing is not required.

Procedure for dual pivot caliper and pad adjustment:

a. Feed brake cable through brake lever and through housing.

b. Attach brake cable to pinch bolt and secure.

c. Loosen threads of pad bolt/nut.

d. Squeeze both pads to rim and adjust pads for height and tangent. Right pad should be set to lower edge of braking surface. Left should be set to upper edge of braking surface. Vertical face alignment to rim and toe alignment are not typically adjustable on dual pivot calipers. If desired, toe may be set by slightly bending arm. Grasp arm with small adjustable wrench and bend arm as needed. Use rag on caliper arm to protect finish if surface scarring is a concern.

e. Fully tighten pad fixing bolts.

f. Squeeze lever to test pad clearance.

g. Use barrel adjuster to adjust pad clearance. Set clearance for approximately 3–4mm (1⁄8 inch) on each side from pad to rim or set for rider preference. Draw slack from system using brake cable pinch bolt if barrel adjuster is unscrewed to its limit.

h. View pad centering to rim. If left pad appears closer to rim, tighten set screw. If right pad appears closer, loosen set screw (figure 14.43).

FIGURE 14.43: Center pads to rim with set screw in brake bridge

There are brakes that require different methods of centering. For example, Shimano® BR-9000 uses a centering screw located in the caliper arm that holds the adjusting barrel (figure 14.44). Use this screw to move arms left to right when centering to rim.

FIGURE 14.44: Centering screw location of Shimano® PR-9000

SRAM® has wrench flats behind the caliper arms. Use a hex wrench in the mounting nut behind the brake and a brake centering wrench such as Park Tool OBW-4 at the same time, moving them in the same direction (figure 14.45).

FIGURE 14.45: Move caliper using wrench on flats of brake stud with second wrench on mounting nut

DIRECT MOUNT RIM CALIPERS

Direct mount rim calipers secure each arm directly to internal threads designed into the frame or fork. There is no brace connecting each arm as used on traditional dual pivot rim brakes. The brace is effectively the frame or fork (figure 14.46).

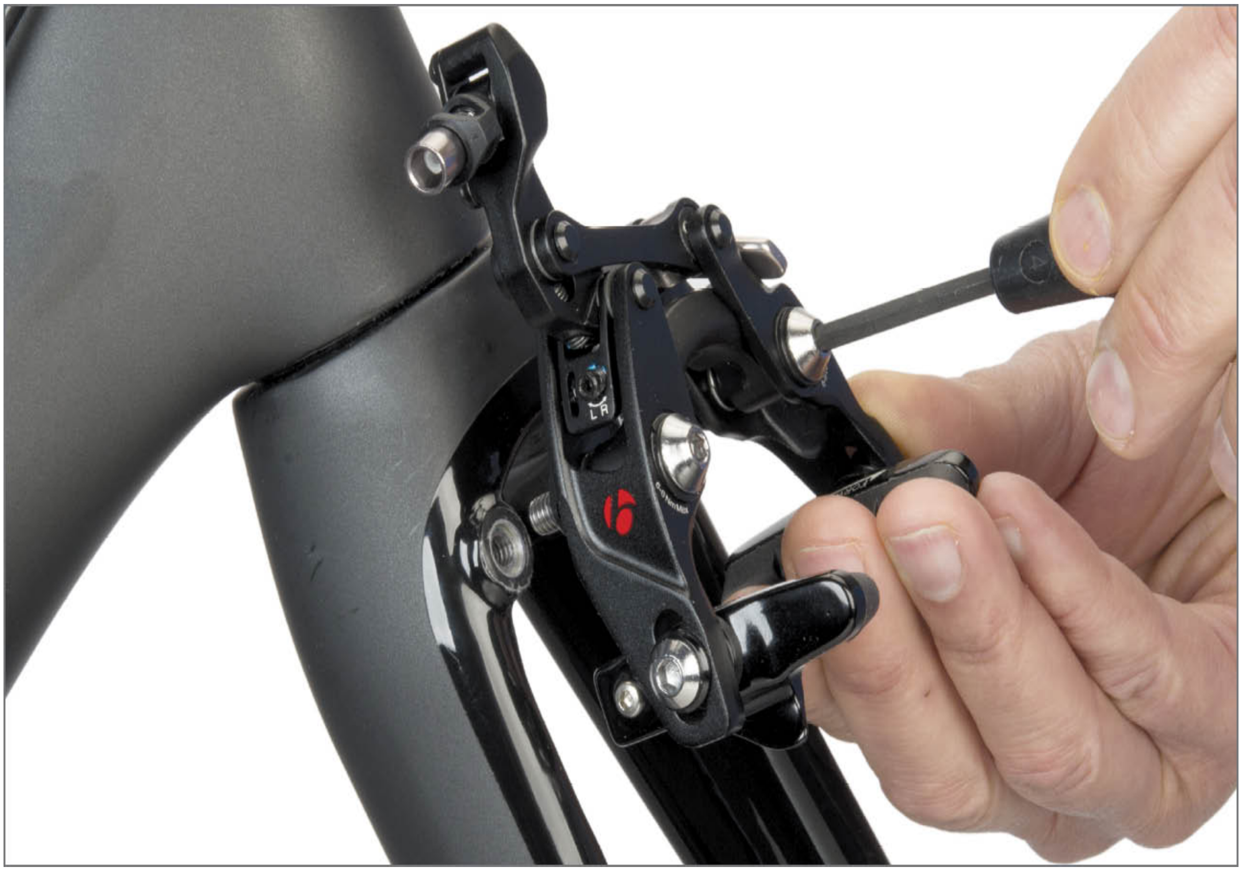


FIGURE 14.46: Direct mount fittings on fork that accept mount bolts of direct mount brake

Cable attachment and pad adjustments are similar to dual pivot brakes. Watch each arm as it swings to the rim, and set pad according. Because there is no center brace, the arms cannot be manually pulled to center the pads. Centering is done with a set screw on the side.

SIDE PULL CALIPER ADJUSTMENT

Road-type bikes can also use a side pull brake (figure 14.47). Side pull calipers at first glance look like dual pivot calipers. Each arm, however, shares a single pivot bolt in the middle of the brake. Bolts for mounting the brake and for the arm pivot are centered over the rim. Both pads swing downward on an arc toward the rim and should be set high on the braking surface.

FIGURE 14.47: Side pull caliper brake

Procedure for side pull caliper and pad adjustment:

a. Feed brake cable through lever and through housing.

b. Loosen each pad fixing nut and lubricate threads.

c. Push one arm to rim and set pad alignment. Adjust pad to strike upper edge of braking surface. Pad front and back edges should be level. Most side pull pads adjust only for height and tangent. Vertical face alignment is not typically adjustable.

d. Tighten pad fixing bolt.
e. Repeat adjustment with the other pad and tighten pad fixing bolt.
f. Insert brake cable in pinch bolt mechanism. Squeeze pads to rim and draw slack from cable. Secure brake cable pinch bolt.
g. Squeeze lever hard several times to test brake cable pinch bolt torque.
h. Check lever clearance to handlebars. Use adjusting barrel to change lever clearance to rider preference.
i. Check brake pad centering to rim. If pads are not centered to rim, hold caliper arms with one hand while loosening rear nut. Move caliper so pads are centered to rim and tighten rear nut. Some models are fitted with a wrench flat in the center bolt. Use one wrench on the stud and another wrench on the mounting nut and move wrenches the same direction and the same amount (figure 14.48). One pad may contact the rim before the other when squeezed to the rim. This is not an issue with side pull calipers. It is only important that pads are centered to the rim when they are fully open.
j. Set toe if necessary. Test ride bike and apply brakes. If brakes do not squeal, toe is not necessary. If desired, toe may be set by slightly bending arm. Grasp arm with small adjustable wrench and bend arm as needed. Use rag to protect arm if surface scarring is a concern.

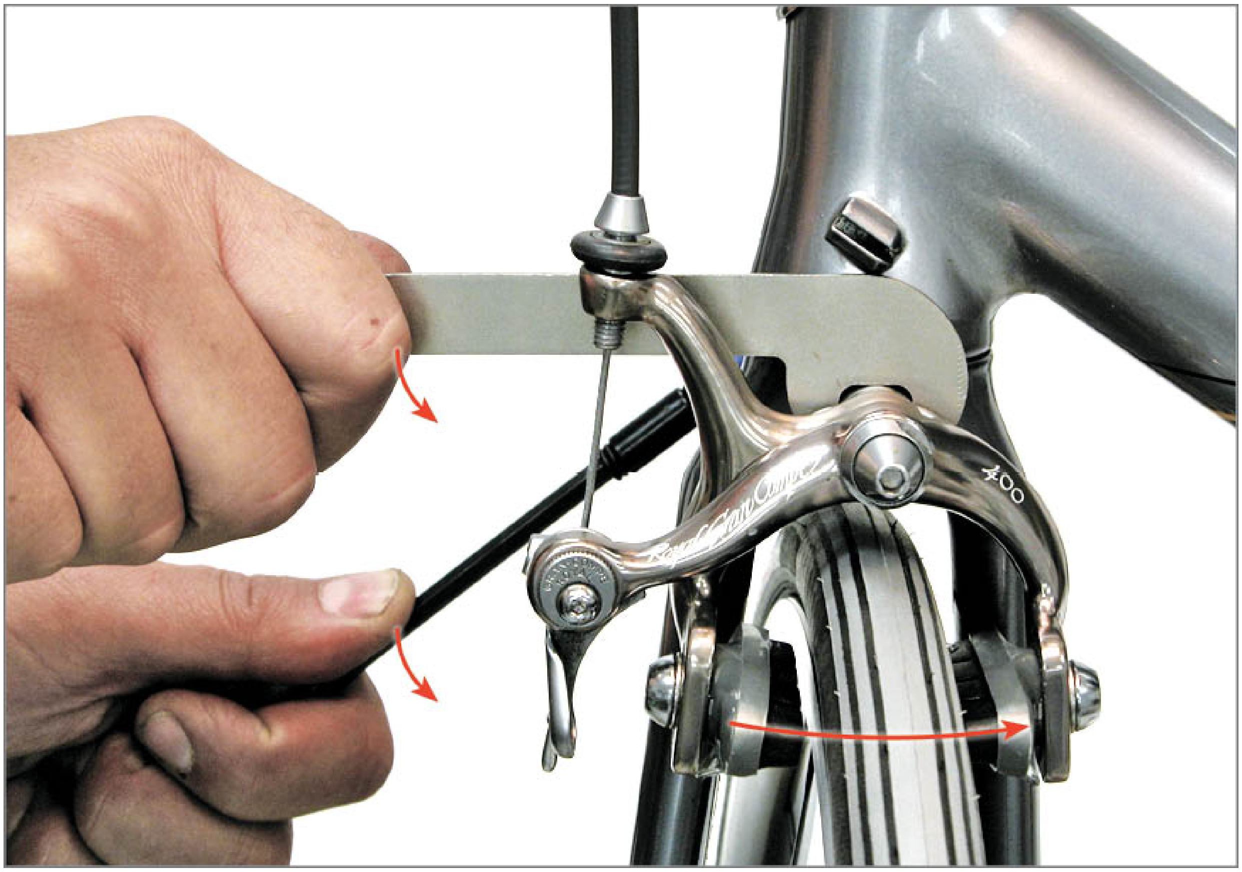


FIGURE 14.48: Centering side pull with centering flats on brake stud

TABLE 14.1: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Brakes squealing	Brake pads are hitting the rim too squarely and causing a resonance	Toe brakes in by keeping the rear section of the pad about 1mm further away from the rim in comparison to the front
One brake pad hits the rim before the other	Spring tension in brakes is not adjusted properly	Using a screwdriver or hex wrench, add tension to the side of the brake that is hitting first
Brakes are dragging on the rims and there is very little resistance at the lever for about an inch	Something is causing cables to bind	Check that housing and cables are in good working order, then replace as needed

CHAPTER 15

HANDLEBARS, STEMS, SADDLES, & SEATPOSTS

Handlebars connect the rider to the stem, which is then connected to the bicycle fork. Handlebars are one of three contact points between the cyclist and the bicycle, along with the saddle and pedals. All of these components should be selected, fitted and adjusted to the rider's body and riding style to maximize comfort and performance. Different models, sizes, and styles of handlebars and stems can be changed for individual positioning needs. There are two basic handlebar types: upright handlebars and drop (or road) handlebars.

UPRIGHT HANDLEBARS

Upright-style bars are commonly used on mountain bikes, hybrid bikes, BMX bikes, and comfort bikes. Bars can be tubular steel, aluminum, or carbon fiber, and are made with a bend or curve on each side. Generally, bars should be aligned to point straight back with the bar bend level to the ground (figure 15.1). When bars are rotated in the stem, it will affect the reach to the brake and shift levers.

FIGURE 15.1: Upright handlebar rotated to a level or flat position

Standard upright bars use a 22.2mm outside diameter at the ends for securing brake levers, shift levers, bar grips and bar end extensions. The stem tightens on the handlebar center. Upright handlebars are made with center diameters of 22.2mm, 25.4mm, 26.0mm, 26.4mm, 31.8mm or 35mm. (**Note:** 31.7mm is considered the same as 31.8mm and interchanged without issue). Shims are available for oversized stems to fit smaller bar center diameters. The stem diameter should match the bar center diameter. For example, a bar with a 25.4mm center will not secure properly in a stem designed for a 26.0mm bar center. This combination will slip and move, resulting in a very dangerous situation for the user. However, a difference of 0.1mm or less between stem and bar is considered acceptable.

Upright bars come in a variety of backsweep, width, and rise (figure 15.2). Bar width is simply measured end-to-end. The amount of bend is measured in degrees from bar center to grip. Bars can also rise up from the bar center, varying from no rise to several centimeters.

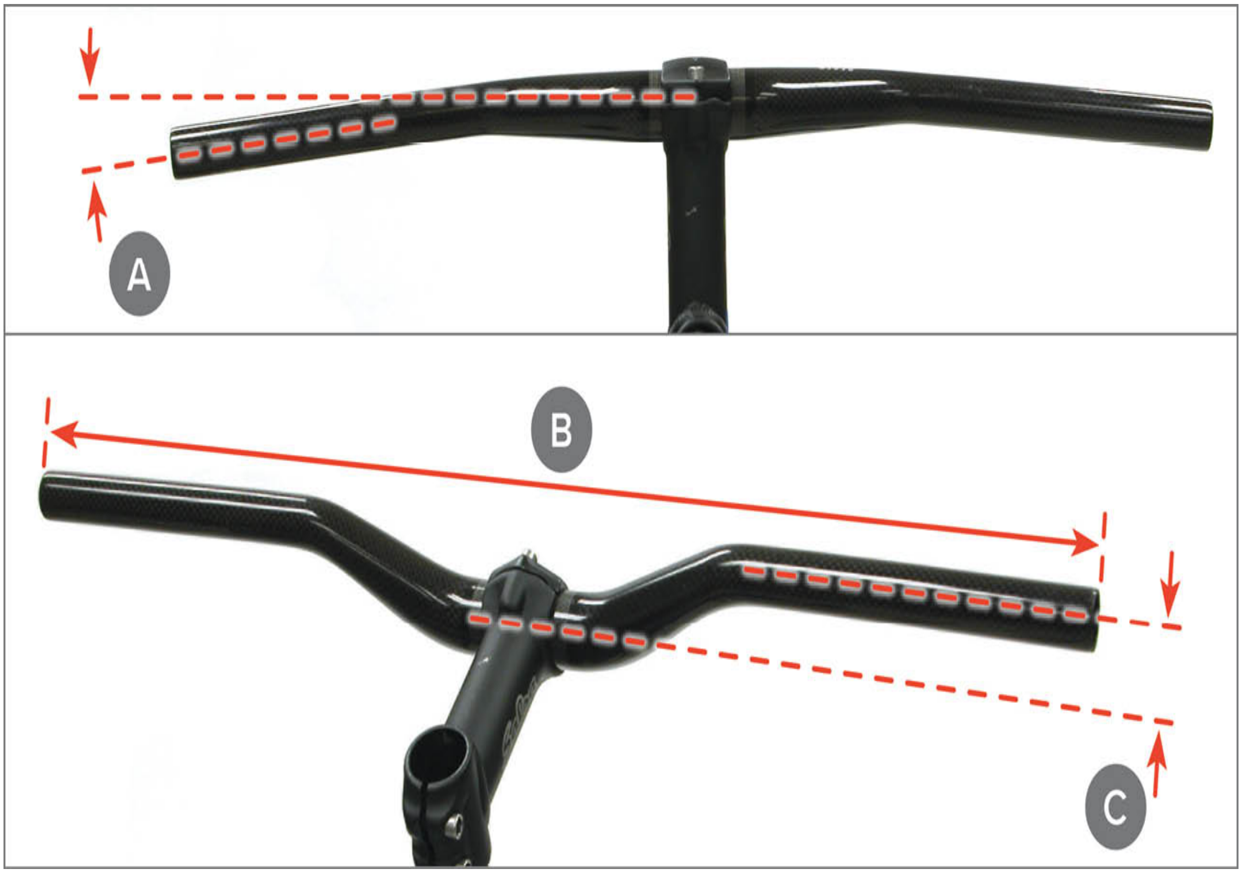


FIGURE 15.2: (A) Backsweep, (B) Width, (C) Rise

BAR ENDS

Bar ends are optional attachments to the ends of upright bars that offer more hand position options. There are both internal bar ends, securing inside the handlebars, and external bar ends that clamp onto the ends of bars (figure 15.3). Bar ends should be tight and very secure on the bar. However, external bar ends can crush the ends of very thin-walled handlebars. If the inside diameter of the bar is greater than 19mm, a plug is required to provide internal support to prevent bar damage. Consult a professional mechanic or the manufacturer if in doubt.

FIGURE 15.3: Secure bar ends so they do not move under load

BAR GRIPS

There are two types of grips: slide-on grips and lock-on grips. Slide-on grips are made to push on bars with force, and rely on tension from rubber gripping the bar. Lock-on grips use external collars fitted around the grip. Small set screws in the collars are tightened to prevent the grip from moving.

Grips vary in shape, color, compounds, size, and length, but all are designed to fit a 22.2mm bar diameter. Grips should not slip or move during the ride. With extended use, grips may loosen, and should be replaced.

When installing new grips make sure the levers are positioned to allow grips to slide fully onto the bar. For slide-on grips, it can help to lubricate the inside of the grip with a non-oily solvent, such as rubbing alcohol, hair spray, spray adhesive, window cleaner, or a fluid which will quickly evaporate. Do not use a lubricant of any type in the grip, as this will prevent the grip from holding fast.

If old slide-on grips are worn out and are being replaced, they may be cut off the bar. It is also possible to remove and reuse grips if they are in good condition. Gently work a long, flat-tipped screwdriver under the inside edge of grip. Drip or spray a non-oily solvent into the gap (figure 15.4). Work solvent around the grip to loosen the bond and slide the grip off the bar.

FIGURE 15.4: Move levers inward, then lift grip to inject liquid spray

If the grip has a sealed end, it can be removed with compressed air. Use a blow tip and place inside end of grip. Wiggle the grip while pulling as blown air loosens grip from bar. Have someone plug the exposed bar end to aid in removing the second grip.

Set screws for lock-on grips should hold the grip tightly to the bar (figure 15.5). Test grip by turning with force. The grip should not rotate.

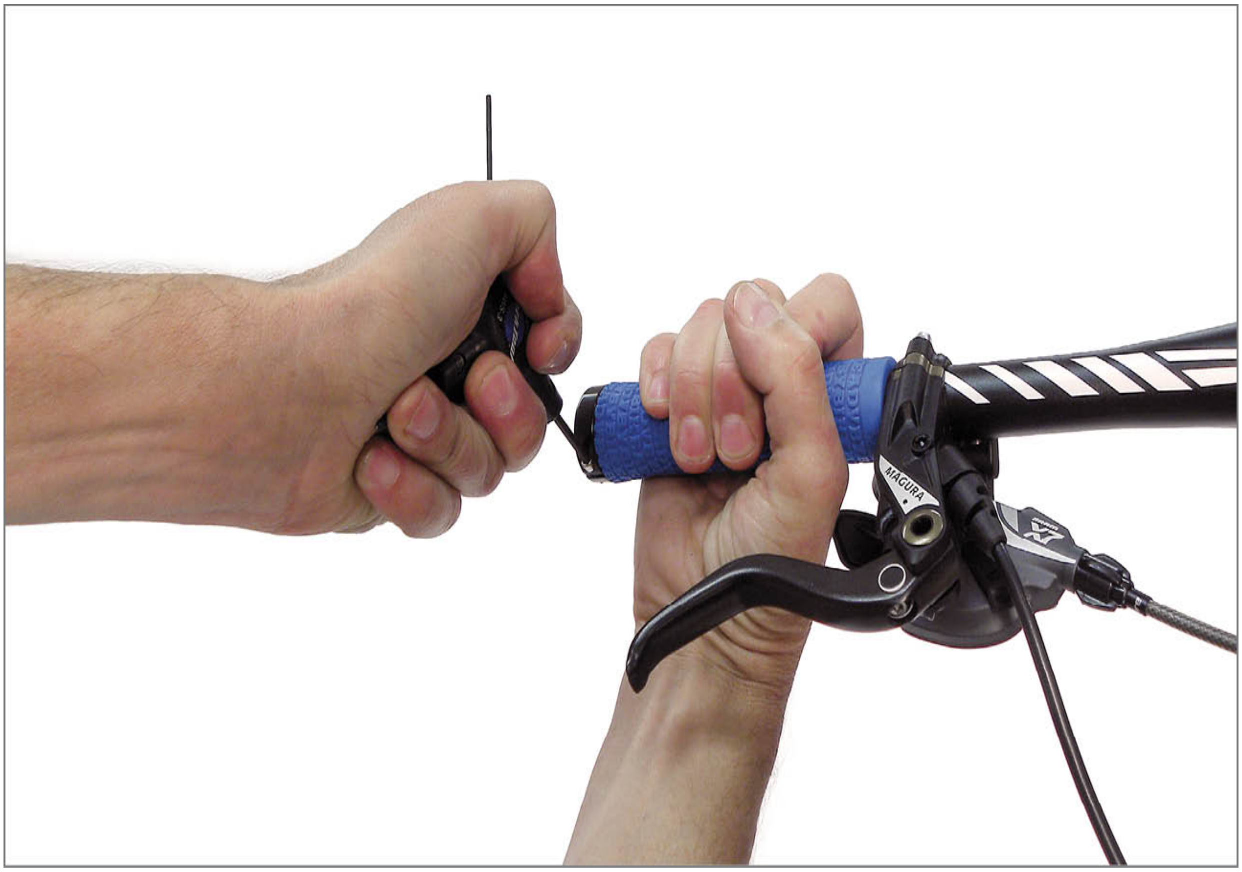


FIGURE 15.5: Secure set screws on lockring grips

DROP HANDLEBARS (ROAD BARS)

Drop bars curve forward and downward to form hooks for the hands, and may be made of steel, aluminum or carbon fiber. Typical center diameter standards for drop bars are 25.4mm, 25.8mm, 26.0mm, 26.4mm, 31.8mm (31.7mm is considered the same as 31.8mm), and 35mm. When in doubt, measure the bar center diameter with a caliper. Stems sized for larger bars can be shimmed down for use with smaller bars.

The stem diameter should match the bar center diameter. For example, a bar with a 25.4mm center will not secure properly in a stem designed for a 26.0mm bar center. This combination will slip and move, resulting in a very dangerous situation for the user. However, a difference of 0.1mm or less between stem and bar is considered acceptable.

Drop bars are made with different designs and shapes. The common method for measuring bar width is from center to center at the ends of the bars—however, check with the bar manufacturer, as some measure from outside to outside. Handlebar drop is measured from the center of the top bar down to the center of the lower bar. Bar reach is measured from bar center, where it clamps into the stem, forward to the center of the bar at the curve (figure 15.6).

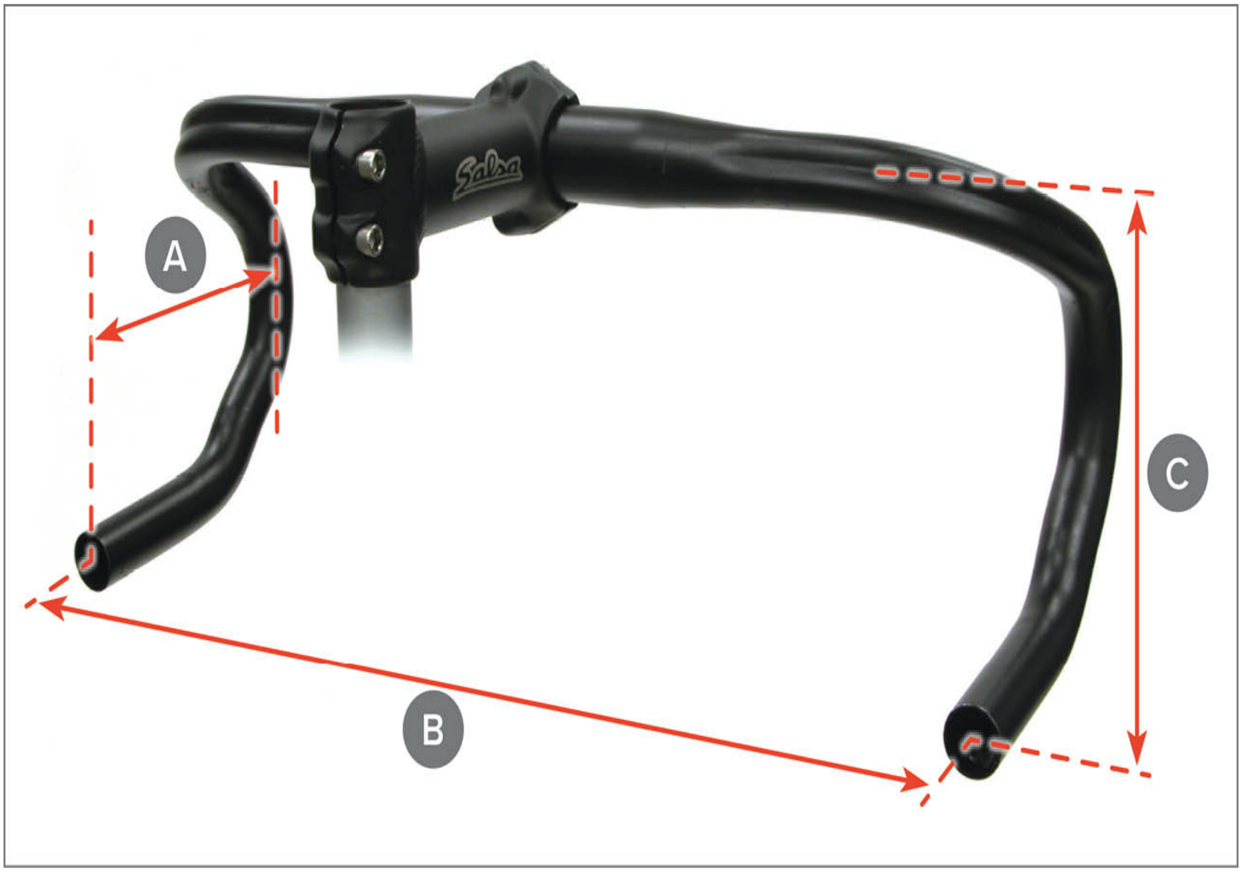


FIGURE 15.6: (A) Drop bar reach, (B) Width, (C) Drop

Drop bars can be rotated at the stem for comfort. However, there are limits to the range of rotation (figure 15.7). Too far up or down sacrifices performance and safety. Drop bars experience a significant amount of stress at the stem clamp, and it is important that drop bar be fully secure. Refer to Appendix C and/or manufacturer's specifications for torque values.

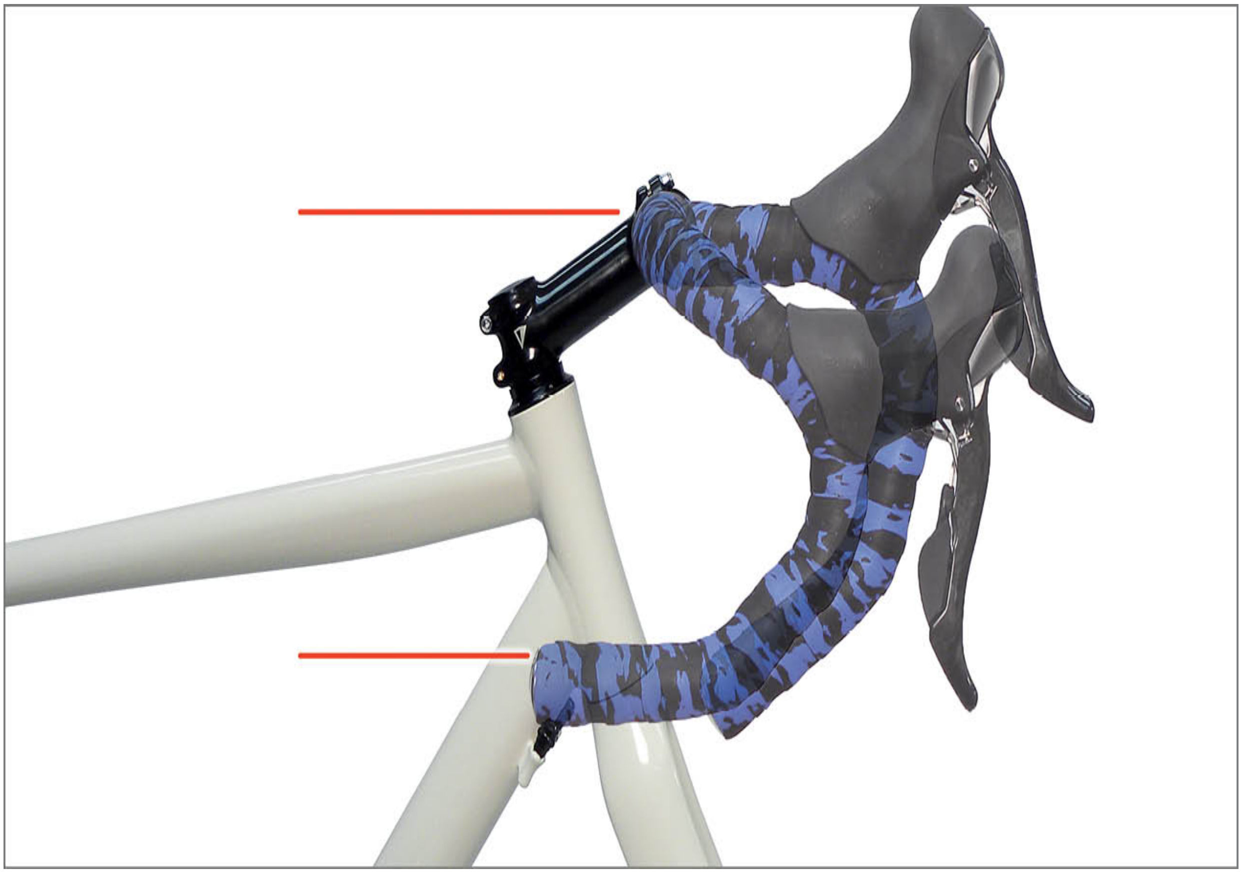


FIGURE 15.7: Upper and lower limits of drop bar rotation

Road handlebars are wrapped in a padded tape for comfort. The tape acts as a cover for the bar which prevents inspection. Especially for riders that sweat a lot and are in humid environments, occasionally check under the tape at brake levers for signs of corrosion. Wrapping bars is a skill that takes practice and patience. For the procedure to wrap handlebars see www.parktool.com/repairhelp.

CLIP-ON AND AERO HANDLEBARS

“Clip-on” aero bars are attachments intended to improve aerodynamic positioning of the cyclist and are available for both drop and upright handlebars (figure 15.8). The bars do not actually “clip” in place but are bolted to the existing bar. It is important to check that the primary bar and clip-on attachments are fully secure before riding. Loose bars will slip and cause a cyclist to lose control. Check manufacturer’s specifications for torque and compatibility.

FIGURE 15.8: “Clip-on” aero bars mounted to drop handlebars

Unlike supplemental clip-on bar attachments, integrated aero handlebars are a complete bar assembly (figure 15.9). Aero handlebars have fittings made to rest the forearms and extensions for hand controls. Extensions are usually adjustable forward and back, and forearm rests are usually adjustable side-to-side. Special purpose brake and shift levers are fitted to aero handlebars. Aero handlebars are considered primarily a racing-only handlebar system.

FIGURE 15.9: Secure all fittings on integrated aero bar systems

STEMS

The stem connects the handlebars to the fork column. Bikes with threaded steering columns and threaded headsets use quill stems. Bikes with threadless columns use threadless headsets and threadless stems.

A stem binds and holds bars using either a removable faceplate or a one-piece pinch clamp. Typically, binder bolts in the stem should be lubricated unless they have an application of threadlocker. Do not, however, allow grease or oil to get into the area where the handlebars meet the stem or column. The stem/bar interface may creak or even slip and move if not properly secured.

A removable faceplate holds the bar in the stem when the handlebar binder bolts are tightened. With the common faceplate stem, it is important that each bolt be tightened equally, and that the top and bottom gaps between faceplate and stem body are the same (figure 15.10). If the gaps are different sizes, the heads of the faceplate bolts will be stressed as they rotate during tightening. However, there are designs that use one side as a ball and socket style interface that will contact one side under normal use.

FIGURE 15.10: Gap between faceplate and stem body must be even between top and bottom plates

There are also “zero gap” stem designs that have one side of the plate contacting the stem. Tightening is done on the non-contact size (figure 15.11)

The pinch-style clamp system is typically exclusive to quill stems. Tightening the bolt secures the handlebars in the stem.

FIGURE 15.11: With “zero gap” stem design, snug top bolts before fully tightening lower bolts

Stems are designed for specific uses. If the steering column and bar diameter match the stem specifications, technically it can be used. However, riding style must dictate stem style. For example, stems designed for punishing downhill riding tend to be short, heavy, and very strong. Stems designed for road riding tend to be longer and lighter, but are not as strong. Handlebar and steering column diameters may match between two stems, but a less strong stem should never be substituted when the riding calls for a stronger stem.

Both threadless and quill stems are available in adjustable angle versions. An adjustable angle stem has a built-in pivot that allows changes to the angle relative to the steering column. These stems allow for different positions without installing a new stem. The pivot fastener must be fully secured before the stem can be safely used.

QUILL STEMS

The “quill” of quill stem refers to the vertical post that inserts inside of a threaded steering column. A bolt draws up a wedge or cone which secures the stem tightly inside the column. The stem binder bolt, bolt head, wedge, and outside of the quill should have a layer of grease or anti-seize before installing and tightening.

Quill stems are available in different stem angles and stem lengths, like threadless stems. Quill length is also specified for quill stems. The stem angle is measured from the quill to the extension (figure 15.12).

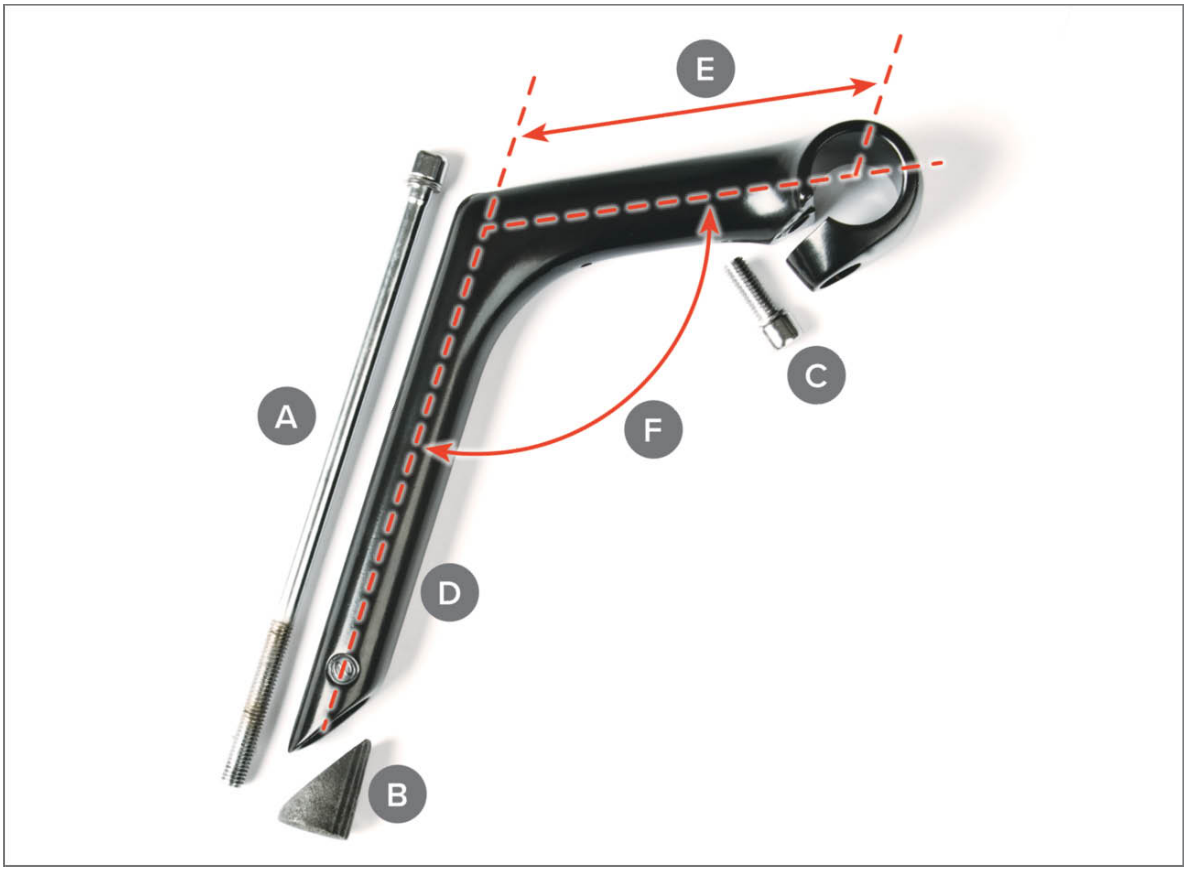


FIGURE 15.12: Quill stem: (A) stem binder bolt, (B) stem wedge, (C) handlebar binder, (D) quill section of stem, (E) stem length, (F) stem angle

It is important that the stem’s quill diameter is a correct match for the inside diameter of the steering column. The quill should be slightly smaller than the inside of the column. There are several different steering column sizes found on bikes. 22.2mm quill stems are compatible with 1" (25.4mm) steering columns. 25.4mm quill stems are compatible with 1 1⁄8" (28.6mm) columns, and 28.6mm quill stems are compatible with 1 1⁄4" (31.8mm) columns.

To change stem height on a quill stem, loosen the stem binder bolt at the top of the quill. Do not loosen the headset locknut to move the stem. Attempt to move the stem by twisting after loosening the binder bolt. If it will not move, tap top of stem binder bolt with a hammer or mallet to free wedge. The stem must not be raised too high. Inspect the stem for a “max height” line and do not raise stem past this mark (figure 15.13). As a rule, have at least 2.5 times the diameter of the quill inserted into column. For 1" diameter quill stems, leave 2.5" of quill inserted. Large changes to stem height may also require adding longer shift or brake cables and housing.

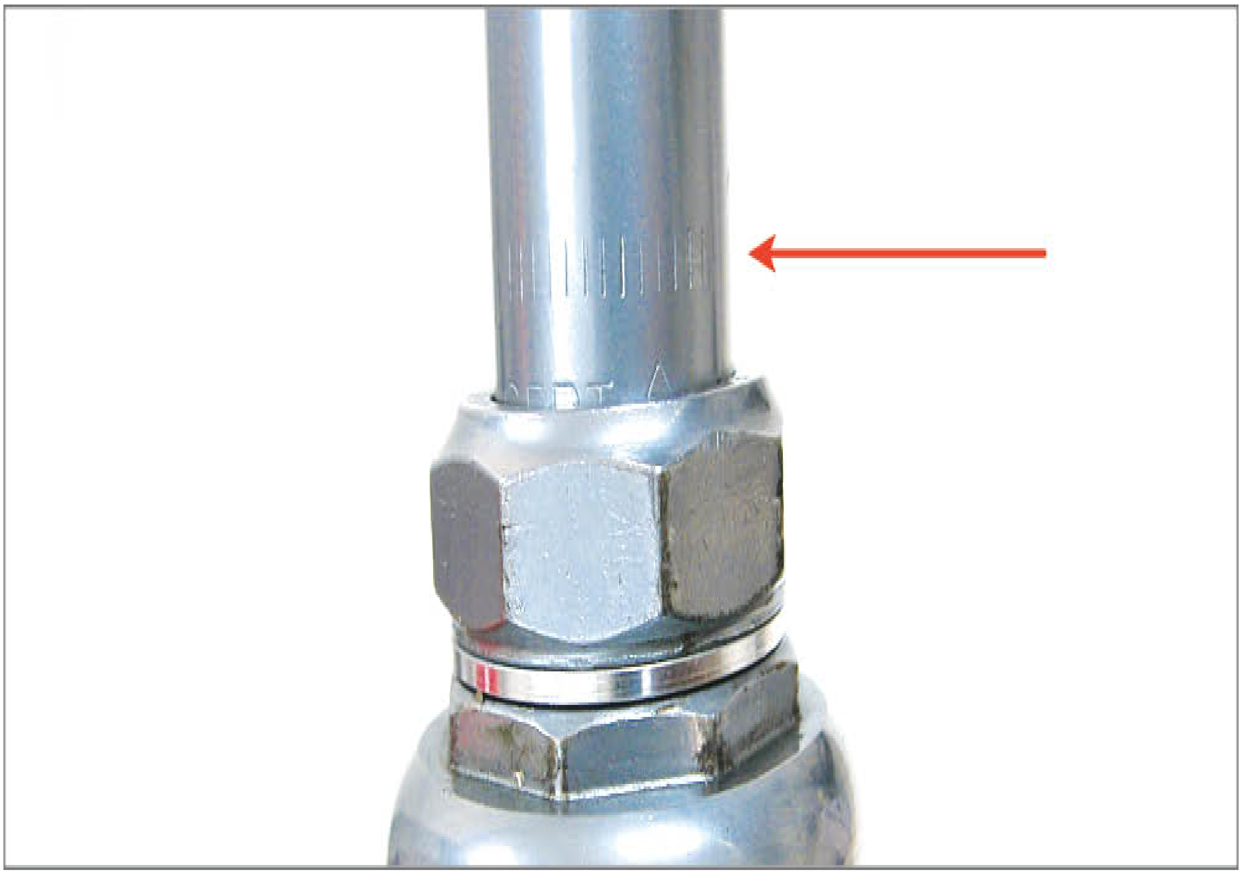


FIGURE 15.13: Example of stem set too high. “Max height” line must not be visible

The stem should be aligned with the front wheel. However, it is often easier to align the handlebars to the front axle or dropouts. Handlebars provide a visual straightedge to align bars parallel to the front hub. It is useful to place a straightedge on the fork blades and compare this line to the handlebars near the stem. If the two lines appear parallel, the stem is straight (figures 15.14 and 15.15).

FIGURE 15.14: Straightedge shows bars and stem are not aligned

FIGURE 15.15: Straightedge on fork legs is parallel to bar, which indicates aligned stem

THREADLESS STEMS

A threadless stem clamps around the outside of the steering column and also acts to lock the threadless headset's bearing adjustment. Look for the adjusting cap at the top of the steering column. Do not confuse this cap for part of the stem. A threadless stem should be mounted only to a threadless steering column; never secure a threadless stem over the threads of a threaded fork.

Threadless stem standards are determined by the outside diameter of the steering column. There are several standards in use: 1" (25.4mm),1 1⁄8" (28.6mm), 1 1⁄4" (31.8mm), and 1 1⁄2" (38.1mm). A larger stem may be shimmed down to a smaller steering column standard.

Threadless stems are available in many different angles and lengths. Stem length, or extension, is measured from center of bar clamp to center of steering column. Stem angle is the angular measurement from the steering column to the stem extension. Stem clamp stack height is measured along the steering column. The clamp stack height is a consideration when sizing and cutting the steering column to fit the bike (figure 15.16).

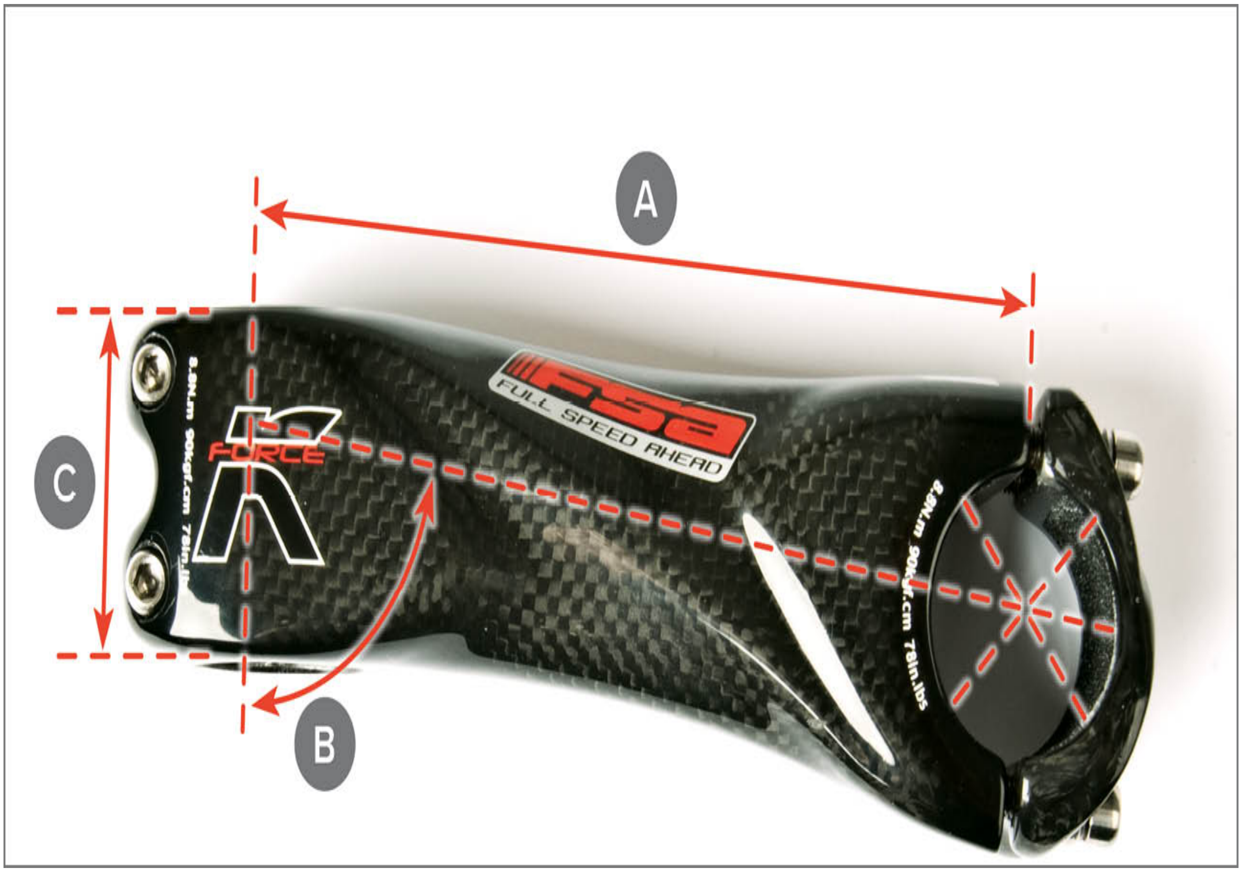


FIGURE 15.16: Threadless stem measurements: (A) stem length, (B) stem angle, (C) stem stack height

Threadless stem height adjustability is limited by the number of extra spacers used along the steering column. To lower threadless stems, remove extra spacers that are below the stem and stack them above the stem. If, after lowering the stem, there is an excessive amount of steering column extending above the stem, the column may be cut and shortened. See the section on threadless steering columns in Chapter 16—Headsets.

To raise a threadless stem, look for any spacers above the stem. Move these to below the stem, leaving enough of a gap for the top cap to allow for headset adjustment. Simply adding additional spacers below the current stem and column arrangement to raise bars may compromise stem-to-steering column engagement and make the bike unsafe. The steering column must have good contact with the inside of the threadless stem. However, the steering column should be slightly recessed below the stem top (figure 15.17).

FIGURE 15.17: Thread column recessed below stem top

Aluminum, steel and carbon fiber steering columns have limits for how many spacers can be between the lower edge of stem and headset top cap. See the section on threadless steering columns in Chapter 16—Headsets.

If there are no spacers above the stem, a different stem with a steeper upward angle can be installed. Another option for more height is to add a threadless stem extension to further raise handlebars (figure 15.18). These mount over the steering column and extend a post upward where the threadless stem clamps. It is important that the extension fully engages the steering column. Consult manufacturer for height limits.

FIGURE 15.18: Threadless steering column extender

Align stem with front wheel. If this proves difficult, use a straightedge to extend the line of the fork blades (figure 15.19). See procedure described above for quill stems. Fully secure stem binder bolts.

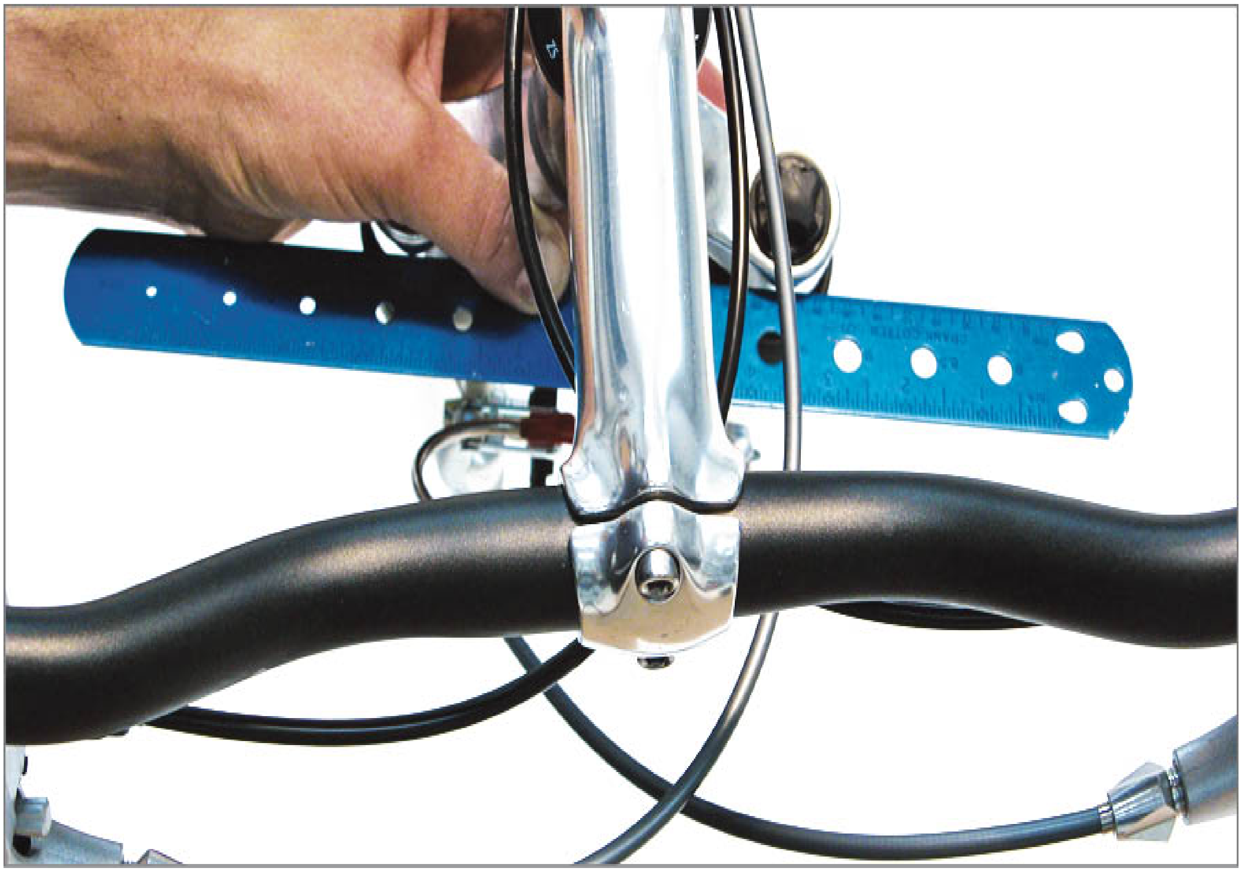


FIGURE 15.19: Stem is misaligned when bars are not parallel to fork blades

When a steering column is made of carbon fiber, it can be susceptible to damage from overtightening stem binder bolts. Excessive load here may crack the carbon fiber material (figure 15.20). Consult the manufacturer for acceptable torque limits.

FIGURE 15.20: Cracked steering column from stem binder bolt

SADDLES

The saddle is straddled by the cyclist and offers support for his/her weight. Saddles are available in many different shapes, widths and padding options. Saddles are made in both “men’s” and “women’s” specific designs. However, saddle selection is a personal choice and it is best to find a retail bike shop that will allow you to try different models. There are also designs specific to BMX, timetrial racing, cyclocross, and other types of riding.

Bicycle saddles have a rail system mounted beneath a saddle shell, which is typically a molded plastic resin. Padding and a leather or synthetic cover then covers the shell. Rails are secured to the seatpost by saddle rail binder clamps (figure 15.21).

FIGURE 15.21: Secure saddle rail binder bolts by alternating tightening when two bolts are used

Saddles commonly use two parallel 7mm round rails. Rails allow the saddle to be positioned forward or back relative to the seatpost as desired by the cyclist. Seatposts allow options in saddle tilt or angle. There are also proprietary monorail saddle designs that require a unique seat post made by the saddle manufacturer.

A common problem in this area is a creaking noise in the saddle or seatpost, which can usually be fixed by properly tightening the saddle rail binder bolt(s). However, if the saddle shell has loosened from the rail, it cannot be effectively repaired. Hard use and crashing may bend the saddle rails. Riding with a bent rail may lead to breakage of the rail. Replace saddles with cracked shells, bent rails, or rails that have separated from the shell.

To change the saddle, begin by noting the current position. Place a straightedge on top of the saddle and measure saddle tilt or angle using an angle finder (figure 15.22). Note the forward/rearward position of the saddle on the rails. Unbolt the old saddle from the seatpost cradle. Lubricate saddle rail binder bolts with a light lubricant. Install the new saddle on the post clamp and secure binder bolts. Using an angle finder, measure and adjust the saddle angle, and secure the saddle on the rails in the same position as the previous saddle. Change the position as necessary after a test ride. Generally, begin with the saddle in a level position, and then make changes in small increments upward or downward as necessary for rider comfort.

FIGURE 15.22: Use straightedge to extend saddle line when adjusting tilt

SEATPOST

The seatpost connects the saddle to the frame. Seatposts are available in different lengths, diameters, and even shapes. Better quality seatposts have a saddle rail binder clamp integrated into the top of the post.

Seatposts vary in offset, or "setback," which is the distance from center of the post to the center of the rail binder system securing the saddle. More offset allows the rider to sit further back relative to cranks and away from handlebars (figure 15.23).

FIGURE 15.23: Post on the left has no offset; post on the right has 32mm offset

Less expensive or older bikes may use a simple seatpost without built-in clamp. These are basically a simple tube swedged or tapered down to a 7⁄8" diameter top. A separate clamping bracket secures saddle rails to the top of the post.

There are many different-sized seat tubes used on bicycles, and seatpost diameters are available to match. Seatpost diameters range from 22.2mm to 32.4mm. Post diameters should be approximately 0.1mm smaller than the inside seat tube diameter. There are shims available to allow a smaller post to fit into a larger seat tube. Cutting “homemade” aluminum shims does not typically provide an adequate fit.

If the frame is steel, titanium or aluminum, use grease or anti-seize compound inside the seat tube to prevent corrosion from seizing the post. If the seatpost or frame is made of carbon fiber, use a special assembly compound, such as Park Tool SAC-2. These compounds contain both a gritty substance for more friction and a carrier that helps prevent corrosion. If you ride in an area with much rain or are often riding near salt water, remove the post every 3–4 months to clean inside the seat tube and reapply grease, anti-seize or assembly compound.

There are several mechanisms that may be used to secure a seatpost into the bicycle frame. Frames that use round seatposts typically have a compression slot cut into the top of the seat tube. A seatpost binder bolt pinches the seat tube at the top to hold the post secure in the frame. Lubricate the seatpost binder bolt before tightening. The binder bolt does not require a great deal of tension to hold the post from slipping downward. Generally, only tighten the binder until the saddle will not rotate when pressed with one hand. If it will not rotate with one hand, it is unlikely to slip downward (figure 15.24).

FIGURE 15.24: Test saddle rotation by twisting with one—not two—hands

Bike frames may use a seatpost binder mechanism with a bolt built into the frame. However, some frames use a separate collar that slides over the top of the seat tube. The collar holds the seatpost binder bolt to squeeze the collar around the seat tube and hold the post.

Another option for securing the seatpost is a quick-release cam system. This permits the post to be raised and lowered without using wrenches. The cam is similar to a wheel skewer quick-release in design. However, less tension is required for a seatpost compared to a wheel quick-release skewer. Adjust for just enough tension on the cam to prevent the saddle from easily twisting sideways.

Seatposts are usually marked with a “maximum extension” or “minimum insertion” line (figure 15.25). Do not raise the post above this line, or the post may break. Generally, keep the end of the post inserted below the frame lug or joint of seat tube and top tube. Seatposts often flex under use and can bend permanently from impact and heavy use. A bent post is not repairable and should be replaced immediately.

FIGURE 15.25: Post is too high if minimum insertion line is seen

Some bike frames are designed for flat or aero shaped seatposts. These posts cannot be rotated in the frame because of the non-round shape of both frame and post. The shapes are proprietary and are made for a close fit to particular frames. These posts are not interchangeable between frame manufacturers. Some frame designs hold the aero post using a seatpost backing plate, similar to stem faceplates. Bolts press a specially-shaped plate to the back side of the seatpost to hold it tight in the frame. Other frame designs use a compression slot and a binder bolt system. The frame is pinched tight at the compression slot to hold the aero post. When possible, secure the seatposts with a torque wrench using the manufacturers' torque recommendation.

Another frame and post design secures using a wedge system. A bolt draws together to wedge the post tight in the frame and prevent it from slipping downward (figure 15.26). Posts typically must be removed before sliding surfaces can be lubricated with grease. Reinstall and secure to manufacturers' specifications.

FIGURE 15.26: Wedge-style seat post binder

An "integrated" seatpost is a frame design using an extended seat tube built into the frame. A long seat tube extends upward past the top tube and holds a seat rail clamp mechanism. The frame acts as the seat post extension for the saddle. The seat tube is cut down to fit the rider with a saw guide such as the Park Tool SG-7.2 (figure 15.27).

FIGURE 15.27: Trim integrated seat tubes using SG-7.2 saw guide

Suspension seatposts are made to allow for rider and saddle movement up and down relative to the frame (figure 15.28). A spring system allows the bicycle to move up and down under the rider to help minimize bumps. With extensive use, the post may develop play in the bushings and linkages. Contact the manufacturer for service procedures.

FIGURE 15.28: Suspension seatpost

“Dropper” seatposts are made of telescoping tubing and can be quickly moved and then locked to different saddle height options (figure 15.29). These posts do not provide suspension for the rider, but can be useful when a lower height is desired for extreme off-road descents.

FIGURE 15.29: Range of height options for an adjustable height seat post

Dropper posts are offered with control systems operated by cable, hydraulic tubing, or by Bluetooth. Depending upon the design of the post and frame, these cables or hydraulic lines may be either externally or internally routed.

When selecting a dropper seatpost, it must correctly fit the frame. Besides the correct diameter for the seat tube, the maximum insertion should also match the length of seat tube available. Bikes of different sizes and designs will have a limited amount of straight tube to accept the dropper. Measure from top of seat tube down to the first potential impediment to the dropper post—the beginning of a bend in the tube, a linkage attachment for suspension, or water bottle mounts.

For internally routed cable systems, you need to account for removal of the post from the cable housing. Begin by mounting the dropper control lever as desired to bars. Hold housing outside the frame and roughly estimate the amount of housing necessary, then add a few inches more. This will be trimmed once installed through the frame.

Route housing through the frame as designated by frame manufacturer and out the seat tube. Position housing 2–3cm above seat tube. This will be the position used to allow removal of post from cable.

Rotate handlebars toward the exit hole on frame. For example, if the frame exit hole is on the left, rotate bars to the left (figure 15.30). Allow enough housing to comfortably reach the control lever, but nothing beyond that point. When the post is fully installed, more housing will exit the frame when bars are turned back straight.

FIGURE 15.30: Rotating bars with housing

TABLE 15.1: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Stem moves easily on steering column even when torqued properly	The inner diameter of stem contaminated with grease or oil	Remove stem and clean steering column and inside stem with alcohol, then reinstall and torque
White powder corrosion found under bar tape of drop bars	Bar material corroding from sweat through bar tape	Replace tape on regular basis and clean. Bars can break from corrosion. Replace bars if badly corroded.
Carbon handlebars slip around	Low coefficient of friction of carbon fiber can result in slipping	Supplement joint with assembly paste that contains silica
Left and right side of bars seems to be at different angles	Bent bar material, possibly from an impact	Replace bars immediately—do not use until bars replaced
Dropper post not rising back up	Seat clamp on seat tube overly tight	Loosen seat clamp bolt slightly and test

CHAPTER 16

HEADSETS

The headset is the bearing system that connects the bicycle fork to the head tube of the frame. A properly maintained and adjusted headset permits two-wheeled vehicles such as bicycles to make small self-corrections in steering. These small corrections in handling allow us to ride a relatively straight and smooth line.

The fork column is supported by bearings in the upper and lower areas of the frame head tube. If these frame support surfaces are not machined parallel to each other, the bearings will bind as the fork is rotated. This can lead to premature bearing wear and poor adjustment. Head tubes can become deformed by welding or by inadequate manufacturing techniques. If necessary, the head tube can be machined ("faced") so top and bottom surfaces are parallel by using a head tube reaming and facing tool, such as the Park Tool HTR-1 (figure 16.1). The base of the fork steering column should also be cut square to the fork. If it is not properly machined, the fork crown race will not sit square to the steering column and will add to the binding effect. The fork can be machined with a crown race cutter, such as the Park Tool CRC-1. Facing the head tube and fork crown is best left to professional mechanics. Generally, if a headset adjusts well, with no binding, the machining is considered to have been adequate and there is no problem.

FIGURE 16.1: Facing head tube surface to improve bearing adjustment

HEADSET TYPES

The two basic headset types are threaded and threadless. Threaded headsets use a threaded top bearing race that screws onto a threaded steering column. A locknut is used above the threaded race to lock and hold the bearing adjustment. A quill stem inserts down inside the steering column but is not part of the bearing system (figure 16.2).

FIGURE 16.2: External cups (EC) of a threaded headset with quill stem installed

The threadless headset is used on steering columns with no threading. Bearing adjustments are performed with a non-threaded adjusting race that slides along the steering column. This race is pushed against the bearings by pressure from an adjusting cap at the top of the threadless stem (figure 16.3). Pinch bolts on the stem secure it to the steering column and also lock the bearing adjustment.

FIGURE 16.3: Threadless headset with external pressed cups (EC) with threadless stem and top cap

There are currently many different headset standards. When replacing a headset it is important to select a compatible model. The cycling industry is making an attempt to be more consistent in describing and naming the different headset standards by implementing the “Standardized Headset Information System,” or “SHIS,” a code system that describes the headset style and sizing diameter of the bike. Appendix E is a table of SHIS terms, the common legacy names, and sizing dimensions.

The first part of the SHIS is a two letter code defining the headset fit into the frame. This may be “EC,” “ZS,” or “IS.”

“EC” is an abbreviation for “external cup.” Both threadless and threaded headsets can use this design. Bearing cups are pressed races that contain bearings that extend above and below (“externally”) of the head tube faces. This would be considered a traditional or conventional headset design (figure 16.4).

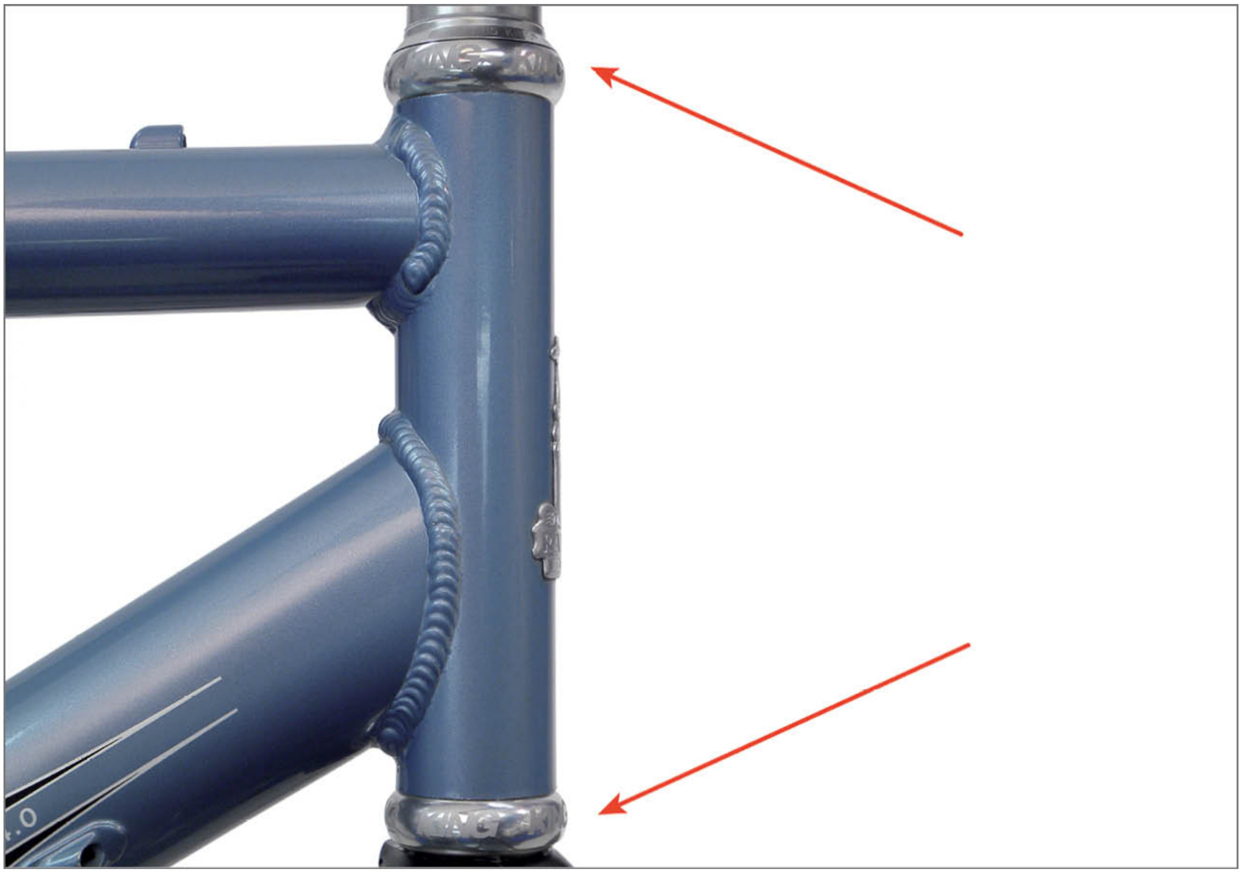


FIGURE 16.4: The “EC” or external cup style headset

“ZS” refers to the internal headset designs, also known as “zero-stack” or semi-integrated. Headset cups are pressed into a relatively large head tube. The bearings sit inside these pressed cups with the bearings nearly level with the head tube faces, rather than externally to the head tube as with the EC design. A new replacement ZS headset will include the cups that press into the frame as well as the bearings. ZS compatible bikes tend use a relatively large diameter head tube of approximately 50mm. This allows the bearings to sit hidden inside the tube (figure 16.5).

FIGURE 16.5: ZS or “zero stack” headset design

“IS” refers to an “integrated headset” design (figure 16.6). IS headsets use cartridge bearings that are a slip fit into the frame. The frame is made with a head tube profile that holds the cartridge bearings. Bearings are dropped into place without pressed-in cups. These cartridge bearings are designed with an angular contact to mate with a concave fitting in the frame. The ZS headset is not considered an integrated design because the bearings sit inside cups that are pressed into the frame. For IS headsets, the head tube of the frame acts as the cup and is effectively part of the headset system. Replacement IS headsets will include only cartridge bearings, a top adjustable crown race, and top cap.

FIGURE 16.6: Integrated or IS headset design

In the SHIS system, the letter code is followed the nominal size of the intended frame bore. For example, EC34 is the External Cup style for a nominally 34mm bore head tube. The sizing number is not intended to be the actual OD of the cup or ID of the head tube. It is an abbreviated code system to simplify the labeling of headsets. The older legacy name for this was the "1 1⁄8 inch conventional pressed headset." A ZS44 headset is a zero stack (internal) with a nominal 44mm bore diameter in the frame. IS42 headsets are an integrated headset using a 42mm bore, known previously as the "1 1⁄8 integrated Italian Standard."

The SHIS system provides for separate designations of upper and lower headset bearing configurations. This is because a bike can use different standards for the upper and lower faces of the head tube. The two letter code and bore number are followed by a backslash and numbers providing information about the steering column size. For example, one configuration could have an upper headset of EC34/28.6 and a lower headset of EC34/30. Both upper and lower are external cup (EC) headsets for a nominally 34mm frame bore. However, the upper designation indicates a steering column of 28.6mm (1 1⁄8 inch), while the lower headset designation indicates a larger diameter of 30mm (the fork crown race size). This headset would fit a 1 1⁄8 inch steering column that uses a 30mm fork crown.

Bikes may also have mixed standards with a “tapered head tube.” One such system might have a designation of ZS44/28.6 for the top bearing assembly and ZS56/40 for the lower. Forks in this example would have a tapered steering column, with a base of 40mm at the fork crown. It would then taper upwards to a size of 28.6mm, allowing for a threadless stem (figure 16.7).

FIGURE 16.7: Mixed headset standards. Lower head tube is ZS56/40, and upper headset is ZS44/28.6

There are also several proprietary designs unique to some manufacturers. It is important to know which standard the bike uses in order to find the correct replacement parts. When in doubt, consult a professional mechanic.

HEADSET SERVICE

Front wheels throw dirt and water directly up at the lower headset bearings, causing them to become contaminated with grit and dirt. Riding also stresses the bearings, especially the lower races, and bearing surfaces will become pitted and damaged. To determine if a headset needs service, pick up the front wheel and turn the bars left and right. If it feels gritty or sticky, it should be overhauled. If the headset seems to stick and stop in a pattern as it rotates, then the races are pitted. Overhauling and regreasing will not remove this pitted feeling. Replace these headsets. During any overhaul, taking notes regarding parts orientation during disassembly will help during reassembly.

Depending upon the design, headsets may use caged (retainer) ball bearings, loose ball bearings, or cartridge bearings. Cartridge bearing headsets are serviced by simply replacing the entire cartridge. Caged bearing and loose ball bearings ride on curved bearing races.

When overhauling, inspect bearing races for pitting and damage. Look for gouging and small evenly spaced pits (figure 16.8). Use a ballpoint pen to trace the bearing path. Roughness and wear will be felt as the small ball of the pen passes over bad areas. Wear in the races will not become smooth with new grease. Replace worn parts or the entire headset. Ball bearings that have been cleaned and have a shiny silver color and appear smooth may be reused. Ball bearings are generally the part of the system to wear out. Ball bearings that appear discolored or “cloudy” after cleaning should be replaced.

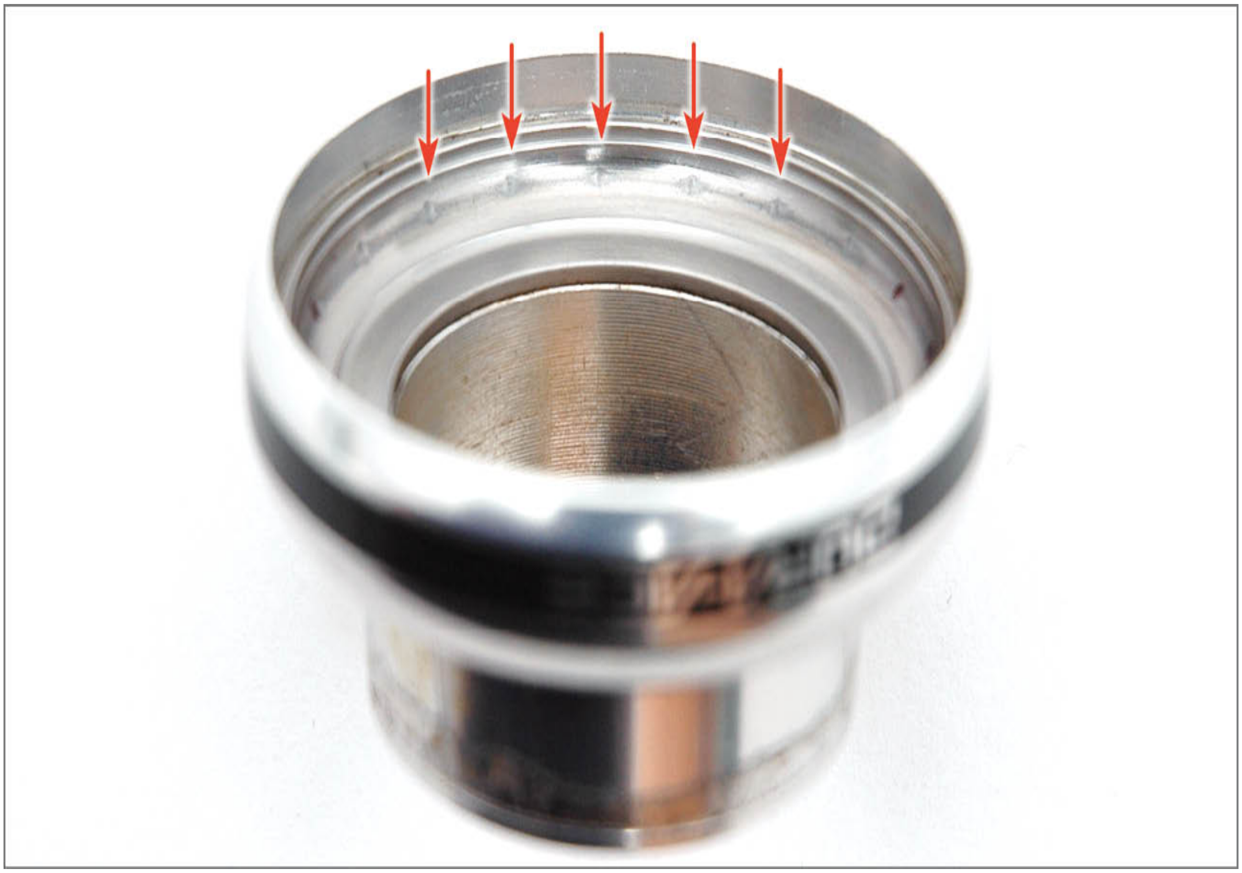


FIGURE 16.8: Pits and dents indicating a worn headset cup

Cups may be left in the head tube and on the fork unless the headset is being replaced. Clean all bearings and races with a solvent. Use care on suspension forks not to get solvent into lower sliding legs.

Remove or disconnect handlebar-mounted computer wire and/or electronic shift wires to avoid damage before removing the stem from the fork. Handlebars are often in the way when servicing the headset. It is best to disconnect the cables from the brake calipers and derailleurs and completely remove the bars. This will also help prevent damage to the cables and housing. Alternatively, use toe straps and rags to pad and bind the handlebars to the frame so they are out of the way.

THREADLESS HEADSET SERVICE

Threadless EC, ZS, and IS headset standards share the same basic service procedures. If the headset uses a cartridge bearing rather than caged ball bearings, simply replace the cartridge bearing as a unit. However, it is sometimes possible to use a seal pick and remove the seals of some cartridge bearings after removal from the bike. These can then be cleaned and regreased. However, new grease will not repair and make smooth a pitted or rough bearing surface.

The cartridge bearing is common in the ZS and IS standards. The bearings are a slip fit and will install and remove by hand. Grease the outside of the cartridge to prevent corrosion. Cartridge bearings for headsets have a concave and convex side. The concave side will face a cone shaped race on the fork crown, or it will face the adjusting race. The convex side will face toward the head tube, either top or bottom (figure 16.9).

FIGURE 16.9: Cartridge bearing orientation

Procedure for threadless headset disassembly:

a. Loosen stem binder bolts.
b. Loosen and remove top cap bolt and cap. Note location and orientation of any spacers on steering column.
c. Remove stem and all spacers from steering column.
d. Pull fork from bike. It may be necessary to use a mallet and tap top of steering column, driving fork downward (figure 16.10). Once fork is driven down a little, lift it back up and remove center cone from adjusting race.

FIGURE 16.10: If necessary drive fork column down using a mallet

e. Remove fork from frame and note orientation of caged bearing retainers, cartridge bearings, or any rubber seal as they sit in headset.
f. Unless headset is to be replaced, leave pressed parts on frame or fork.
g. For caged ball or loose ball bearing headsets, clean and inspect parts. Any worn parts should be replaced. For cartridge headset, simply replace cartridges.

If the headset uses caged bearing retainers, check retainer orientation in relation to the races before installing. Retainers have only one correct orientation. The metal wire of the retainer forms a “C” shape between the balls. The open side of this “C” should face the cone-shaped race, not the cup-shaped race (figure 16.11). If in doubt as to retainer orientation you can test it by placing the bearing between the race and cup without the fork. Press downward on the mating bearing surfaces with your hand. Rotate the race and note the feeling. If the bearing orientation is incorrect, the metal retainer will cause a rubbing feeling as it rotates and pushes against the race. If the orientation is correct, the race rotates only on the ball bearings, not the retainer cage, and the race will rotate freely.

FIGURE 16.11: Open side of cage should face cone-shape of race

Procedure for threadless headset assembly:

a. For caged bearing headsets, thoroughly pack grease into bearing retainers and cups.
b. Install bearing retainers into upper and lower cup-shaped races. For

cartridge bearing headsets, drop cartridges in place, with concave side facing to cone shape of races.

c. Install fork steering column through head tube.

d. Install top adjustable race, centering washer, and bearing cap onto column. Press centering washer and bearing cap down to contact adjusting race.

e. Install any spacers and accessories on steering column as appropriate.

f. Install stem on column. Push stem against spacers and race. Snug stem bolts to hold fork.

g. Check for acceptable clearance from top of column to top of stem and install top cap with cap bolt (figure 16.12).

FIGURE 16.12: Steel and aluminum steering columns can be recessed below top of stem

Note the height of the steering column relative to the stem. Steel and aluminum steering columns can be approximately 2–3mm (1⁄8 inch) below the level of the stem. Stems need to press down on bearings below in order to adjust the bearings. If the top cap presses on the steering column rather than the stem, there will be no load put on the adjusting race and bearings, and it will be impossible to remove bearing play. The column can be cut shorter, or alternatively, spacers can be added either above or below the stem to achieve a gap between top cap and steering column (figure 16.13).

FIGURE 16.13: Spacer added to increase clearance between top can and column top

Carbon fiber steering columns should protrude past the stem rather than be recessed. This permits the stem to secure as much column as possible and reduces the chance of cracking at the top of the column (figure 16.14). A spacer must then be used on top of stem as described above to allow top cap to perform the bearing adjustment.


FIGURE 16.14: Recessed carbon fiber columns are susceptible to cracking from stem binder bolt pressure

For headsets using caged bearings, it is possible to replace retainer ball bearings with loose ball bearings of the same diameter. Loose ball bearings, especially in the lower race, can move about in the race and this helps prevent pitting that commonly ruins headsets. Installation and assembly with loose bearings is more difficult. It is important that bearings stay aligned in the cup as the headset is assembled.

To use loose ball bearings, grease cups to hold bearings. Place ball bearings into cup-shaped races. Leave a gap equal to two to three ball bearings (figure 16.15). Do not attempt to fully fill cup with ball bearings. If possible, rotate bicycle upside down in the stand to assist assembly before installing fork. After assembly with loose ball bearings, rotate fork to check smooth rotation. Any popping or sudden change in feeling indicates a bearing out of place. Dismantle headset, reposition bearings to line up in the cup, and reassemble.

FIGURE 16.15: Loose ball bearings in the headset cup with gap so bearings can move freely

THREADLESS HEADSET ADJUSTMENT

Threadless headsets, including EC, ZS, and IS types, operate on the same principle and share adjustment procedures. Bearing races must press against the bearings to remove play. The bolt in the top cap puts pressure on the stem. The stem presses on spacers below the stem and the spacers put pressure on the bearing races and bearings (figure 16.16). Stem binder bolts then secure the stem to the steering column to maintain the bearing adjustment and keep the stem in place and aligned.

FIGURE 16.16: Threadless stem with (A) top cap, (B) adjusting bolt, (C) star nut in column

If not already inspected during assembly, remove the top cap to inspect the star nut or compression plug inside steering column. No bearing adjustment can occur if the top cap is pressing on top of the steering column. Add an additional spacer if the column is too long for the stem and spacer combination.

Procedure for threadless headset adjustment:

a. Remove top cap bolt to inspect steering column length relative to cap. Lubricate bolt and reinstall cap and bolt gently. Do not tighten cap bolt.
b. Loosen stem bolt(s) that secure stem to steering column. Lubricate these bolts if they are dry.
c. Wiggle stem side to side to ensure that it is loose. If stem is jammed, rusted, or frozen to steering column, no adjustment can be made.
d. Straighten stem to front wheel and gently secure top bolt inside top cap. Stop when resistance is felt (figure 16.17).

FIGURE 16.17: Make bearing adjustment at top cap only when stem binder are loose

e. Tighten stem bolt(s) and check for play by pulling back and forth on fork blades. Turn handlebars in different directions while checking for play. There may be play at this early setting. Grab upper portion of suspension forks, as lower legs may have play in the bushings.
f. If play is felt in headset, loosen stem bolt(s).

g. Turn adjusting bolt in center cap 1⁄8 to 1⁄4 turn clockwise only.

h. Resecure stem bolts and recheck fork for play.

i. Repeat adjustments as above until play disappears. Remember to loosen stem bolts before turning adjusting bolt in cap.

j. Check alignment of stem and tighten stem binder bolts fully.

Another test for play is to place the bike on the ground and grab the front brake tightly. Press downward on the handlebars and rock the bike forward and back. A knocking sensation may indicate a loose headset. In effect, this does the same thing as grabbing and pulling on the fork. However, play in the brake caliper arms may also cause knocking. Front suspension forks may also have play in the legs, which can also cause knocking. Place one hand at top race and feel for movement to confirm headset bearing play.

If an acceptable bearing adjustment cannot be found, there may be other problems in the headset. Bearing surfaces may be worn out, ball bearing retainers may be upside down, or a seal may be improperly aligned. If play always seems present no matter the adjustment, the steering column may be too long and may be pressing into the top cap. Another source of play can be a loose press fit in either the head tube or on the fork crown race. A loose press fit may be improved with a retaining compound, such as Park Tool RC-1. In extreme cases, the head tube can become elongated from abuse and impact. Consult a professional mechanic for options with damaged head tubes.

THREADED HEADSET SERVICE

Threaded headset bearing adjustment is held by two threaded pieces locked together. A threaded top locknut is tightened down on a threaded race. Top races often require a narrow headset wrench such as the Park Tool HCW-15. The top locknut is taller and will accept wider wrenches such as a large adjustable wrench. 30mm, 32mm, and 36mm are common headset wrench sizes for threaded headsets.

Procedure for threaded headset disassembly:

a. Leave front wheel in fork to act as a lever.

b. Loosen stem binder bolt. Attempt to move stem by twisting. If stem will not move, strike top of stem binder bolt with a hammer or mallet to free wedge (figure 16.18). Attempt to twist stem again.

FIGURE 16.18: Drive stem binder downward to free stem from column

c. Pull stem and handlebars from fork.

d. Stand in front of bike and hold wheel between your knees for leverage while working with locknut and race.

e. Hold lower threaded race with thin headset wrench. Loosen and remove top locknut with a second wrench.

f. Remove front wheel.

g. Remove any spacers or brackets that were under locknut after noting location and orientation.

h. Unthread and remove threaded race. Note orientation of top bearing retainers.

i. Pull fork from bike and note orientation of lower bearing retainer, if any. Work with care as bearings may unexpectedly fall from lower race.

j. Clean and inspect parts.

Threaded headsets commonly use a spacer with a tab or "tooth" on the inside diameter. This notch is designed to sit inside a groove running vertically in the column. However, these types of spacers will often rotate when the top locknut is tightened, resulting in thread damage as the washer tab rotates and into the threads. This is especially the case when the spacer is made of steel and is relatively thin. Inspect the threads of the fork. If any damage in the threads is present, file off spacer tab or use a new spacer without a tab.

For non-cartridge bearing headsets, it is possible to replace retainer ball bearings with loose ball bearings of the same diameter. Loose balls, especially in the lower race, can move about which helps prevent the pitting that commonly ruins headsets. Installation and assembly with loose bearings is more difficult. It is important that bearings stay aligned in the cup as the headset is assembled.

To use loose ball bearings, grease cups to hold bearings. Place balls into cup shaped races. Leave a gap equal to two to three ball bearings. Do not attempt to fully fill cup with ball bearings. If possible, rotate bicycle upside down in the stand to assist assembly before installing fork. After assembly with loose ball bearings, rotate fork to check smooth rotation. Any popping or sudden change in feeling indicates a bearing out of place. Dismantle headset, reposition bearings to line up in the cup, and reassemble.

Procedure for threaded headset assembly:

a. Grease bearing retainers (if any) and bearing race cups. Grease threads of steering column.

b. Install bearing retainers into upper and lower cup-shaped races.
c. Install fork steering column through head tube.
d. Thread on top race.
e. Install spacers and accessories as appropriate.
f. Thread on locknut. Verify that steering column is not touching inner lip of locknut. Add spacers as necessary to allow locknut to press on washers.

THREADED HEADSET ADJUSTMENT

Threaded headsets are adjusted using a top locknut and threaded race. The stem has no effect on bearing adjustment and does not need to be installed in order to adjust the bearings. Attempt to adjust bearings so they are as loose as possible but without play or knocking. To achieve this, the following procedure will first create play in the adjustment. Proceed to incrementally tighten the race until play is gone.

Procedure for threaded headset adjustment:

a. Install front wheel. Front wheel will act as a lever to hold steering column.

b. Make sure headset locknut is loose. Use a headset wrench to hold threaded race.

c. By hand, turn threaded race clockwise until it contacts ball bearings. Turn race back counterclockwise at least 1⁄4 turn from this setting. Hold threaded race with headset wrench and tighten locknut. Tighten locknut fully (figure 16.19).

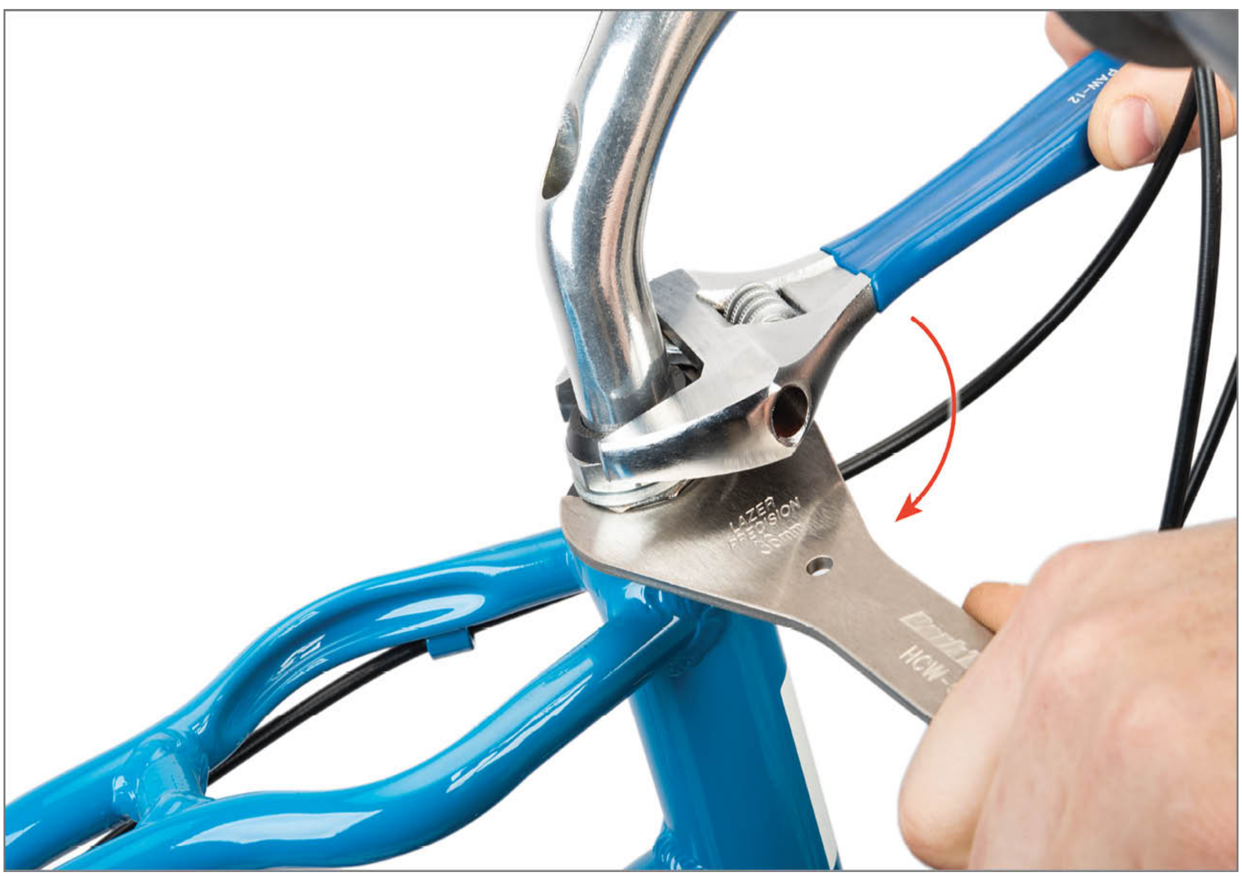


FIGURE 16.19: Holding threaded race while tightening locknut

d. Check for play by pulling back and forth on fork. A knocking sensation indicates play. Turn fork in different directions while checking for play. There should be play in this early setting. If headset feels tight, loosen adjustment further until play is found.

e. Grab front wheel between knees and hold it in line with top tube. The threaded race will need to be adjusted slightly clockwise. Use a headset wrench to hold race and note orientation of wrench relative to front wheel.

f. Loosen locknut and rotate threaded race clockwise 1⁄16 to 1⁄8 turn relative to wheel.

g. Hold threaded race securely with wrench and tighten locknut fully. Check for play by rotating fork and moving fork forward and back at different positions.

h. If play is present, repeat steps “e” and “f” above until play disappears. Adjustment is finished when there is no play in any position, the fork rotates, and locknut is fully secure.

i. Reinstall stem, align, and tighten.

Another test for play is to place the bike on the ground and grab the front brake tightly. Press downward on the handlebars and rock the bike forward and back. A knocking sensation may indicate a loose headset. In effect, this does the same thing as grabbing and pulling on the fork. However, play in the brake caliper arms may also cause knocking. Front suspension forks may also have play in the legs, which can cause knocking. Place one hand at top race and feel for movement to confirm headset bearing play.

If an acceptable bearing adjustment cannot be found, there may be other problems in the headset. Bearing surfaces may be worn out, ball bearing retainers may be upside down, or a seal may be improperly aligned. Another source of play can be a loose press fit, either in the head tube or on the fork crown race. If the headset seems well adjusted at one position but binds when rotated to another position, the head tube may require facing to improve bearing alignment. Consult a professional mechanic.

HEADSET REPLACEMENT & INSTALLATION

Headsets may be replaced when worn or when upgrading to a better model. After installing the new headset, the procedure for assembly and adjustment is the same as the procedures above.

There are several standards for headsets found on bicycles. A new headset must match the design of the bike. There are many headset standards that do not interchange. Appendix E, Headset Standards, reviews some of these standards. The table is not exhaustive, as some unusual and proprietary standards exist. It is often necessary to remove the headset to know exactly what standard is being used. If in doubt, consult a professional mechanic.

It is sometimes possible to use a smaller steering column than the head tube was designed to use. Reducing rings are available and are pressed into the head tubes of the larger standards. Reducers are available to size EC56 head tubes down to the EC34 standard or to reduce EC34 standards down to the EC30. However, it is not possible to convert a bike upward. The head tube cannot accept a steering column larger than what it was designed to accept.

HEADSET STACK HEIGHT

Stack height is the amount of steering column length the headset will occupy (figure 16.20). Headsets vary between brand and model in amount of required stack height. The steering column is always longer than the head tube length, and the stack height of the headset must be compatible with the frame head tube and steering column.

FIGURE 16.20: Stack height is composed of: (A) lower stack height, (B) upper stack height, (C) any spacers; stem height (D) not included

Replacement headsets in both threaded and threadless models will have the stack height listed on the box or instructions. The manufacturer's specifications do not include the stem of threadless headsets, nor any spacers used to give extra rise to the stem. Generally, when replacing a headset, select one of equal or smaller stack height then the original headset. Using a headset with more stack height than the original may result in the steering column being too short for the bike.

PRESSED HEADSET REMOVAL

Both EC and ZS headset designs use cups in the head tube. These are removed when headsets are replaced. IS headset designs use cartridge bearings that slip fit directly into the frame, and bearings are simply removed by hand (figure 16.21).

Begin pressed headset replacement by removing the wheel, handlebars and fork as described in Headset Service. To remove pressed races, use a race removal tool such as the Park Tool RT-1 Head Cup Remover for EC29 to EC44 and ZS41 to ZS44 standards. Use the larger RT-2 for the EC49 to EC56 and ZS44 to ZS56 headset cups. Install tool with smaller end first through the headset cup (figure 16.22). Squeeze sides of prongs and pull tool fully into head tube. Do not press prongs with hand as prongs will close and pinch flesh. A clicking sound will be heard as tool prongs engage head tube cup. Inspect that tool prongs are engaged only against headset cups.

FIGURE 16.21: Removing the slip fit integrated bearing from an IS headset

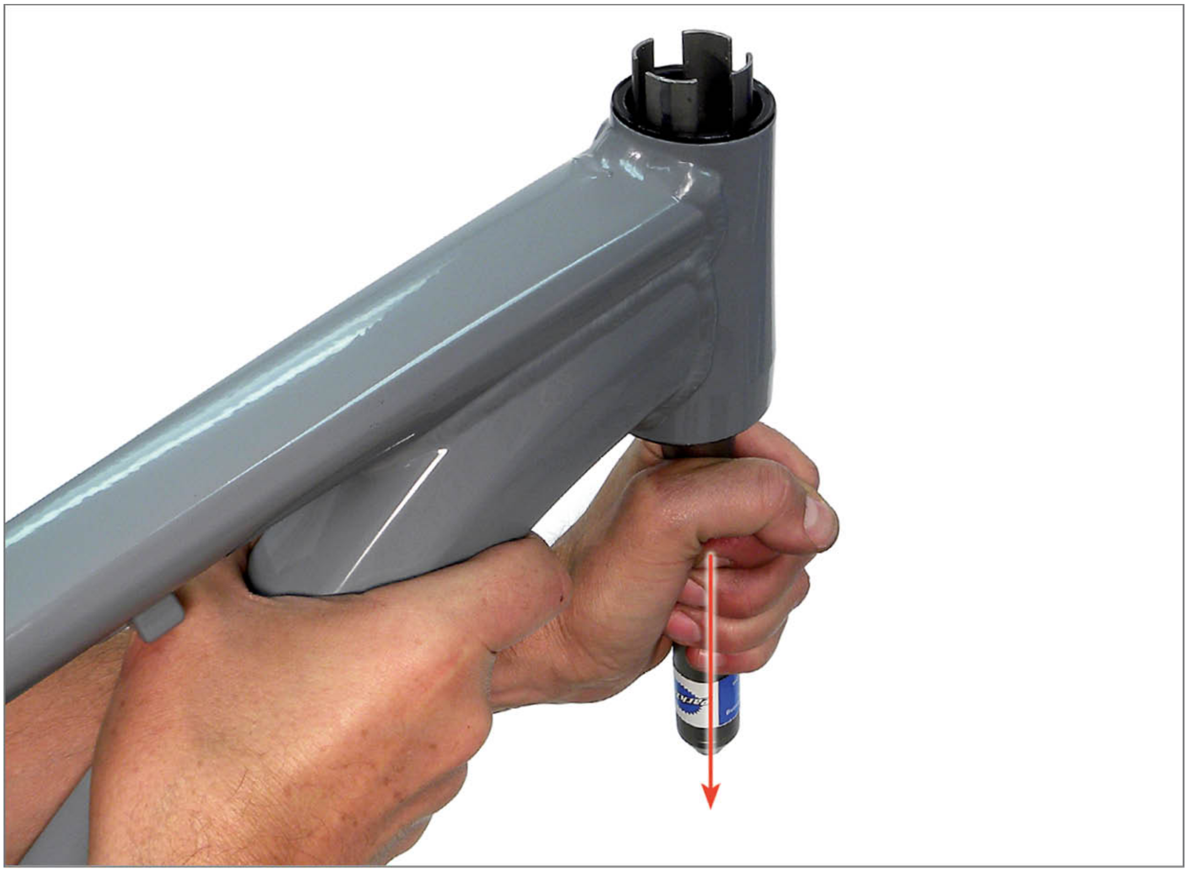


FIGURE 16.22: Draw the Race Tool RT-1 or RT-2 through head tube small end first

Use a steel hammer at the small end of the tool and drive cup from head tube (figure 16.23). Place removal tool with small end first through remaining cup and repeat process to remove second race. A long punch can also be used to remove the head tube races. Alternate tapping left to right to "walk" out the race.

FIGURE 16.23: Drive race from head tube with race tool and hammer

On bikes using a mixed SHIS standard, it is sometimes necessary to use two different tools on the same bike. For bikes using the ZS44 or EC44 on the top, and a larger ZS56 or EC56 on the lower, begin by remove the upper piece first using the RT-1. After the top is removed, install the larger RT-2 race tool to remove the lower race.

The old fork crown race must be removed from the fork. Professionals will use the Park Tool CRP-2 Crown Race Puller. An alternative is to use a punch or other tool that will engage the race. In some cases this may scar the fork and crown race. Place the fork column downward on soft material such as wood to protect top of column. Using a hammer, tap race alternately first on one side, then the other side, driving the race off the crown seat (figure 16.24).

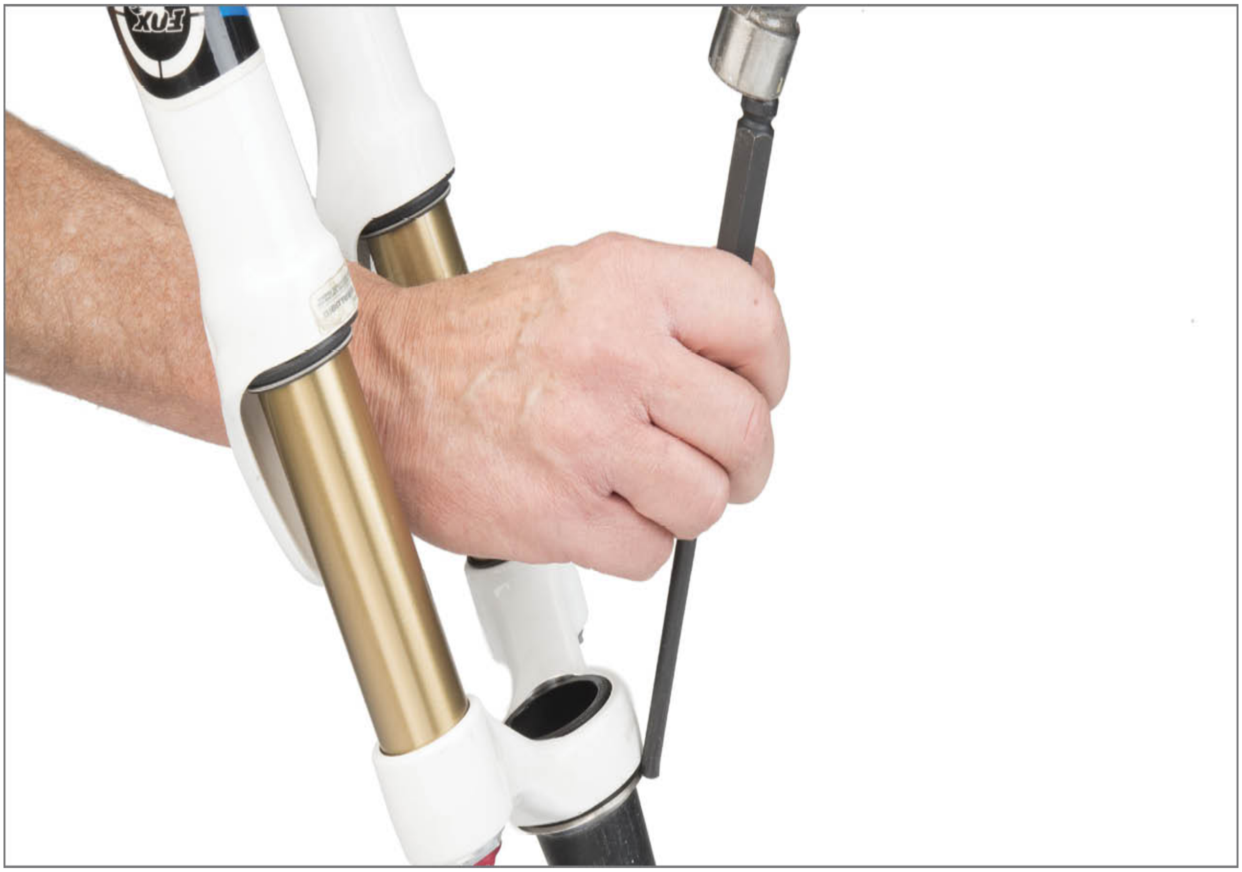


FIGURE 16.24: Carefully tap alternate side repeatedly to remove race

There are carbon fork designs that have the fork race molded directly into the fork. There is no need for removal or service of the fork crown with these designs. The fork is ready to install as is.

PRESSED HEADSET INSTALLATION

EC and ZS headset cups require a press fit into the frame. The press fit is also called an “interference fit” and occurs when a part with a slightly larger outside diameter is forced into another part with slightly smaller inside diameter. This creates tension between the parts and holds the parts tight. Generally, the difference in the headset press fit should be between 0.05mm and 0.2mm.

Use a caliper to measure and note the outside diameter of the cups. Next measure the inside diameter of the head tube in two places; each 90 degrees from the other. Average the two ID readings (figure 16.25). The difference between the outside diameter and inside diameter is the amount of interference fit. See Table 16.1 for interference fit guidelines.

TABLE 16.1: Interference Fit Guidelines

DIFFERENCE BETWEEN RACE OUTSIDE DIAMETER AND HEAD TUBE INSIDE DIAMETER	RESULT AND ACTION REQUIRED
0.26mm or greater	Too great of press fit difference. Ream head tube inside diameter to improve fit.
0.1mm to 0.25mm	Acceptable tolerances for press fit.
0.01mm to 0.09mm	Unacceptably small interference. Get a new race with larger diameter. It is also possible to use a retaining compound.
0mm or any negative number	No interference fit at all, headset is smaller than head tube. Use a different race if possible. Retaining compound may be tried if no other option is available.

FIGURE 16.25: Measure and compare inside diameter of head tube to outside diameter of pressed cup

If interference fit differences are too small, headset cups will move in the frame. The difference between the OD and ID might be zero, or even worse, the ID may be larger than the OD. One solution is to use a retaining compound such as Park Tool RC-1 in the press fit. This compound will expand and harden to increase the strength of the press fit. Retaining compounds require clean, dry surfaces. For removal, it is sometimes necessary to apply mild heat, such as from an air gun or hair dryer, to soften and weaken the compound. Significant force is normally required to press headset cups into the head tube. Additionally, races should be pressed square to one another. It is best to use a bearing press (such as the Park Tool HHP-2 or HHP-3 Bearing Press) for head tube races. The cup guides fit most 1 inch and 1 1⁄8 inch conventional headset cups. If no pressing guides are used, press one part at a time into the frame.

Procedure for pressing of head tube cups:

a. Determine acceptability of headset press fit as described above.

b. For HHP-3, remove one handle and pressing washer. For HHP-2, remove sliding press plate.
c. When available, install headset cups onto guides. Press only one cup at a time if guides are unavailable or if guides do not closely fit cups.
d. Place upper headset cup on top of head tube and insert headset press through cup and head tube. If pressing one cup at a time, install pressing washer and handle (for HHP-3), or install sliding pressing plate (for HHP-2).
e. For cups fitting headset cup guides, install lower cup and install pressing washer and handle (for HHP-3), or install sliding pressing plate (for HHP-2) (figure 16.26).

FIGURE 16.26: Arrangement of cups and pressing guides for the HHP-2 Headset Press

f. Turn handle of headset press slowly and inspect alignment of cups as they enter head tube. If cups become extremely crooked, remove cup and repress. Ensure cups are fully pressed into head tube.

g. Inspect for full seating where cups meet frame. A gap between frame and cup indicates incomplete pressing (figure 16.27).

h. Remove bearing press tool from bike. If pressing one cup at a time, repeat process for second cup.

FIGURE 16.27: This cup showing signs of not being fully seated into head tube

FORK CROWN RACE INSTALLATION

The fork crown race is pressed to a crown race seat at the base of the fork's steering column. Because bearing races are smaller than the crown race seat of the fork, bearing races expand when pressed. The crown race seat should be larger than the race by only 0.05mm to 0.15mm. If the difference between the race and seat is too large, it may crack the bearing race. When the crown race seat is too large for the fork crown race, the crown race seat may be cut smaller. A professional mechanic will use a crown race seat cutter such as the Park Tool CRC-1. If the crown race seat is nearly equal to or only slightly larger than the race (0.04 or smaller difference) use a strong retaining compound.

The fork crown race must be pressed to the fork crown. Determine acceptability of press fit as described above. The Park Tool CRS-1 Crown Race Setter will drive the race on 1 inch and 1 1⁄8 steering columns. Use the CRS-15 for 1 1⁄2 inch or 1 1⁄4 inch steering columns. Place race on fork crown and select most compatible Park Tool CRS aluminum ring. Place ring on tool and insert over fork. Use a steel hammer and strike top of tool until race fully seats (figure 16.28). The sound of the hammering will change as it seats. Inspect sides of race for full seating against fork.

FIGURE 16.28: Installing the fork crown race with a crown race setter

There are some models of headsets using cartridge bearings that use a lower race made with a split ring. The split ring races are pressed on by hand. The split race does not directly ride on the rotating bearings, it simply inserts into the cartridge-bearing race.

FORK STEERING COLUMN SIZING

Steering columns on new forks are typically longer than required, and the column is cut to fit the bike and rider. Threadless columns must be long enough to fit the stem and any required spacers. Threaded columns must be long enough to engage the threaded race, spacers, and locknut. Steering columns that are too long may be susceptible to failure.

THREADLESS STEERING COLUMNS

Threadless steering column length limits height options for stems and handlebars. When installing a new fork, consider where you would like the handlebars to be. It is possible to cut a threadless column relatively long and to use spacers under the stem to raise the bars. However, there are limits to how far the stem can safely be raised above the headset. For steel and aluminum steering columns, do not exceed 40mm between the stem and headset bearings. If more stem and/or bar height is required, purchase a new stem with more height and/or rise, or, alternatively, get a larger bike.

Carbon fiber steering columns also have limits on the height of spacers between the stem and headset. Generally, manufacturers recommend no more than 30mm additional stack height between stem and upper race. Contact the fork manufacturer for limits in regards to your fork.

The column can also be purposely cut too long so that extra spacers are stacked above the stem to allow for future changes to height. However, too much exposed column above the stem can cause safety issues, potentially striking the rider during a crash. It is not necessary to have more column height above the stem than would allow the stem to be safely raised. In general, avoid cutting the column so long that it requires more than 30mm combined in spacers above and below stem.

The safest and most practical method to determine column length is to install the fork first without cutting. Install all desired spacers and stem. Mark fork at the top for a reference point for cutting. Remove fork from the bike. Use a saw guide to produce a consistent square cut. For steel hacksaw blades use the Park Tool SG-6 or SG-7.2 Saw Guide. For the wider blades used on ceramic or carbon steering columns use the SG-7.2 or SG-8 Saw Guide.

Carbon fiber steering columns are best cut with a fine 32 TPI steel blade, or a ceramic or carbon-specific blade. Cut using moderate pressure only--do not force the blade. Carbon dust is a potential health risk due to the small size of the dust particulates. Take normal precautions of wearing a dust mask and working in a well ventilated area. Additionally, to minimize dust from the carbon, keep the cutting area wet. Use a fine emery cloth to finish the end, again wetting the paper.

Procedure for cutting of threadless steering columns:

a. Assemble steering column into head tube with bearings and parts in place. Install stem and all desired spacers, including any spacers desired above stem.
b. Press downward on stem to simulate an adjusted headset and snug stem bolts. Remove what play you can. The adjustment need not be perfect.
c. Mark steering column at top of stem or topmost spacer (figure 16.29).

FIGURE 16.29: Make a reference mark on column for cutting line

d. Remove fork from bike. For aluminum or steel columns, measure an additional 3mm from your mark toward fork crown, and remark cut line at this point. This allows top of column to sit slightly below top of stem. For carbon fiber fork columns, add at least a small amount (3mm) to this mark. Spacers will be required above the stem for carbon fiber columns.
e. Place fork inside saw guide. Loosely secure handle. Move saw guide opening over cut mark on column and fully secure handle. Place saw guide in vise. If no vise is available, hold column in repair stand jaws.

f. Cut through column using proper hacksaw techniques and a good blade (figure 16.30)

FIGURE 16.30: Cut with pressure in the forward cut and do not force blade into column

g. Loosen saw guide handle and push column further into saw guide.

h. Steel and aluminum forks: Use a flat file to finish and bevel end of column. Hold file at approximately a 45-degree angle to bevel end of column. Use a round file or deburring tool to remove sharp inside edge of column (figure 16.31). Carbon fiber forks: Column cuts can be finished with fine sandpaper or emery cloth.

FIGURE 16.31: Deburr and finish end of column before installation

i. Remove fork from saw guide, wipe clean, and install on bike.

Star Nut and Compression Plug Installation

Threadless headsets are adjusted with pressure on bearing races from the adjustment of the bolt in the top cap. The bolt is threaded into either a compression plug or a “star nut” (figure 16.32) that engages the steering column, pulling the steering column upward.

FIGURE 16.32: Compression plug on left. Star nut on right with top cap

Compression plugs are a threaded system installed into the steering column to hold the top cap bolt. A socket fitting is tightened to expand a friction plug inside the column. An internal thread inside the plug accepts a M6 bolt from the top cap. Plug diameter must be compatible with the inside diameter of the steering column. The compression plugs recommended for carbon fiber steering columns are typically removable and can be transferred to another bike.

To install a compression plug, begin by dismantling the unit and lubricating the internal threads. Note orientation of cones and wedges, and use care not to get grease or lubrication on the outside surfaces of plug. Insert plug into column and tighten fully (figure 16.33).

FIGURE 16.33: Install compression plug and secure it inside column

The star nut features a series of concave metal flanges surrounding a threaded nut. The outer diameter of the flanges are slightly larger than the inside diameter of the fork column. The star nut is forced into the column and the flanges press and bite inside the column to hold the nut tight.

The star nut system is designed to not move upward after installation and cannot effectively be removed once installed. If a new star nut is needed in the column, use a large punch and drive the first star nut down deeper into the column. This allows a new star nut to be installed on top of the old one. This system is not generally recommend for carbon fiber steering columns. Use a star nut on aluminum, steel, or titanium steering columns only.

To install a star nut, use a tool such as the Park Tool TNS-1 Threadless Nut Setter. The tool will drive the star nut about 15mm (9⁄16 inch) below the top of the steering column. This allows the adjusting bolt to thread fully into nut for bearing adjustment preload. Mount the nut with the concave side toward tool thread. Hold tool over steering column. Use care to keep TNS-1 aligned with the column. Tap squarely on top of tool with a steel hammer.

Continue until TNS-1 is fully seated (figure 16.34).

FIGURE 16.34: Using a stem to help align TNS-1 and star nut

The TNS-4 Threadless Nut Setter uses a sleeved guiding system to drive the star nut into the column. Thread star nut into tool and slide tool over the column (figure 16.35). Use a hammer to drive down the mandrel until the star nut is fully seated.

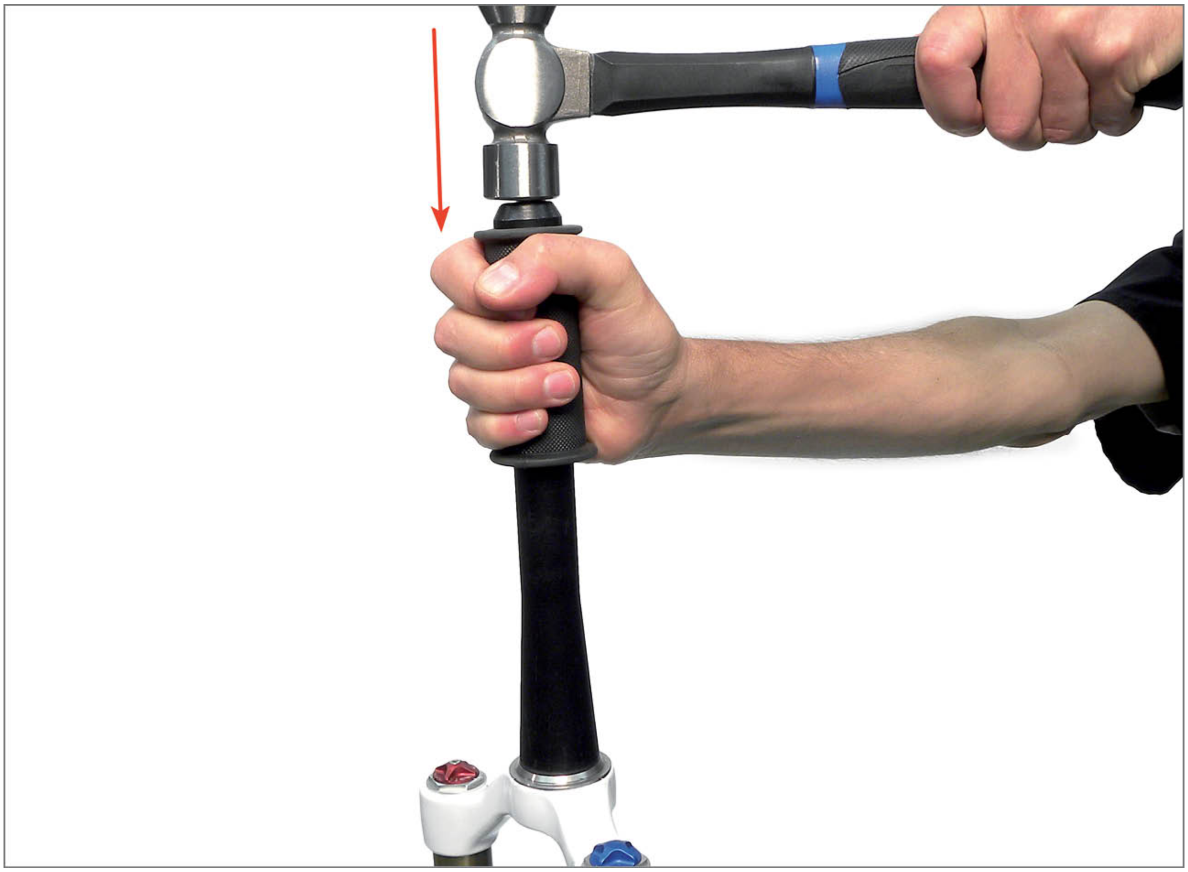


FIGURE 16.35: Using TNS-4 to drive star nut down while keeping it aligned

THREADED STEERING COLUMNS

Threaded steering columns require enough thread on the column to allow the adjusting race to reach and press on the bearings. However, threading on the steering column should never extend past the insertion depth of the quill stem. Cutting threads removes material and actually weakens the column. However, the quill of the stem supports the steering column when installed, giving it extra strength in the threaded section, especially where the column flexes when riding.

Procedure for cutting of threaded steering columns:

a. Assemble threaded fork in bike with all spacers.

b. Measure how much steering column extends past top spacer and write this number down.

c. Turn locknut upside down and measure amount of depth of locknut to "lip" at end of nut.

d. This is the amount of available threading in the nut. The steering column should not contact this inner lip when locknut is secured (figure 16.36). Deduct an additional millimeter from this number to allow a small gap between nut and column.

FIGURE 16.36: Cutaway of locknut on threaded column. Locknut lip should not contact top of column.

e. Deduct available threaded height in locknut from amount of steering column extending past spacers. For example, say a steering column extends 27mm above the spacers. The threaded locknut measures 7mm down to lip. Deduct one millimeter from nut, leaving only 6mm of threading available. Shorten column by 21mm.

f. Use a saw guide such as the Park Tool SG-1 Saw Guide (1 inch column) or SG-2 (1 1⁄8 inch column) to ensure that cut is square to fork. Thread fork into saw guide until it reaches desired cut length at gap for the blade. Clamp guide in a vise. If no vise is available, hold column in repair stand jaws. Cut fork using a hacksaw.

g. Threads at the end of the fork will require extra finishing after the cut. Thread fork further into guide to expose freshly cut threads. Hold a flat file at approximately a 45-degree angle to bevel threads at end of fork. Rotate fork into file as file is pushed forward. Use a round file to finish inside of fork, removing any sharp edges or burrs.

h. If no saw guide is available, it is possible to use a steel threaded race as a saw guide. Thread race on column and measure exposed threads. Hold column in bike repair clamp. Press race to clamp so it cannot move. Cut column using a hacksaw, holding blade against face of race. Finish the cut with a file to bevel the end of the column.

Threaded columns often are made with a machined groove running vertically along the threads. Threaded headsets may include spacers with a tab or "tooth" on the inside diameter. The groove is for this tooth. Shortening a fork may remove the groove. Do not attempt to extend or create a new groove for the toothed washer. Simply file the tooth away or get a new spacer without the tooth.

TABLE 16.2: Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Rattling sound around front end	Loose headset adjustment	Tighten headset adjustment
Creaking around front end	Dry bearing or bad press fit	Overhaul headset
Creaking after overhaul	Bad press fit to frame or fork	Repress headset using retaining compound
Tightly turning handlebars	Headset very worn or dirty	Overhaul headset replacing parts as necessary
Headset tight when turned one direction but feels fine when turned opposite direction	Misalignment of bearings	Repress bearings and inspect fork for bent column

CHAPTER 17

FRAME & FORK

The frame and front fork form the skeleton of the bike to connect the two wheels. The frame also supports the rider and the various components of the bike. Front forks allow the wheel to pivot, which permits steering. Front wheels are designed to be in line with rear wheels. As we ride, it is the rider’s balance that keeps the bike upright. Like motorcycles, bicycles have a “self-steering” feature that helps cyclists stay upright and maintain a straight line. Bicycles are steered by leaning in combination with turning the handlebars.

FRAME COMPONENTS

The frame has different parts or sections (figure 17.1). Bicycle designers manipulate the material, length and angle of each section to obtain certain ride and handling characteristics. As an example, head tube angles differing by just one degree may cause two otherwise similar bicycles to handle differently. Bicycle design is a complex topic because there are many interacting variables, including the rider's body and performance expectations. A brief description of the parts of the frame are given here.

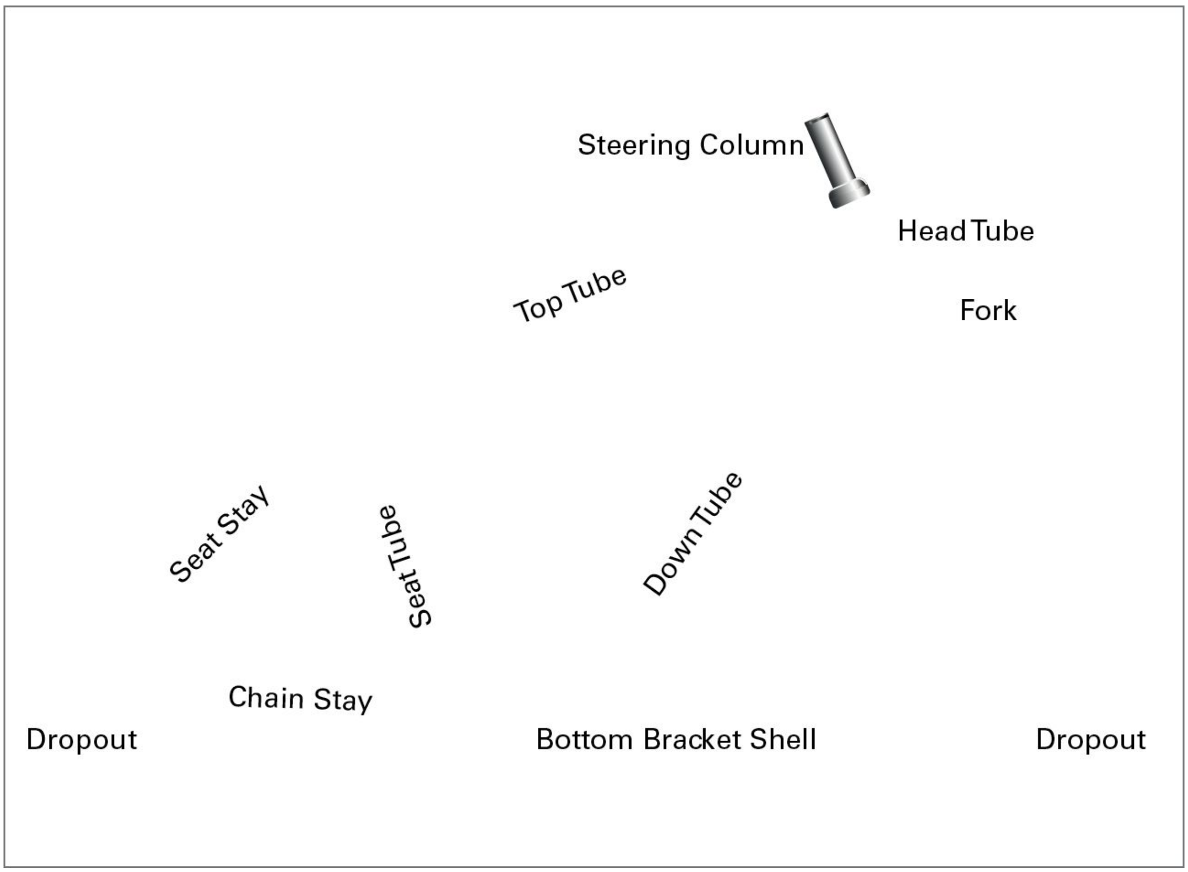


FIGURE 17.1: Part of the frame

FORK

The fork is the connection between the front wheel and main triangle of the frame. Fork dropouts hold wheels at the end of the fork blades at the lower end, while a stem and handlebars are attached to the top.

Fork blades meet at the fork crown, which attaches to the steering column. The steering column passes through the head tube and is supported by a headset bearing system. Forks vary in length to fit specific sizes of wheels. The fork will also have a "rake" or offset that gives bicycles their self-steering ability.

The stress of riding tends to flex fork legs, which transmits stress to the fork crown. This area of the bike experiences a lot of stress, even from casual riding. Fork failure is especially dangerous because the results are often a loss of control and a wheel coming off the bike (figure 17.2).

FIGURE 17.2: Bent front fork blades

A suspension fork will have moving parts that allow the wheel to move relative to the bike when riding over uneven terrain. For more discussion of suspension forks, see Chapter 18—Suspension.

HEAD TUBE

This is the frame tube that houses the fork’s steering column. Headset bearings placed at either end to allow fork rotation needed for steering. Head tube length will affect handlebar height. The inside diameter and design will determine the type of headset used.

Head tubes can become damaged in severe impacts. The fork column will push against the cups with force and the thin metal tube may permanently deform. In addition to deformity, a head tube may also crack from stress and abuse.

TOP TUBE

The top tube is the connection between the head tube and the seat tube. The top tube is vitally important to bike fit because the length will affect bar placement, handling, and rider comfort. This tube sees relatively low stress and is typically made lighter and thinner than other parts of the frame.

DOWN TUBE

This tube is the connection between the head tube and bottom bracket. It also experiences stress from pedaling and from bumps the bike experiences. It may also be fitted with water bottle cage nuts or threads. The common fitting on modern bicycles is the "rivet nut," which is fitted into the tubing and then expanded to permanently install it to the tube (figure 17.3).

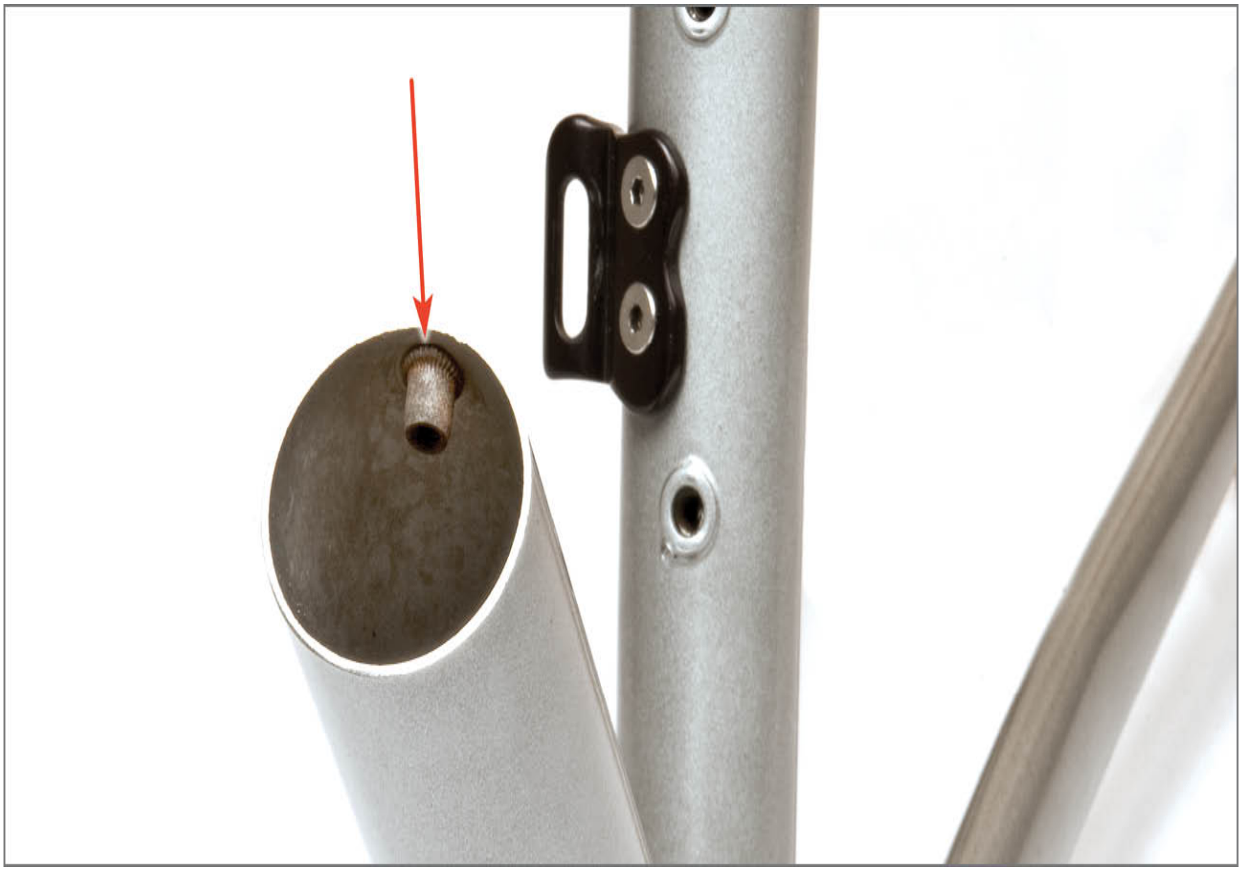


FIGURE 17.3: Cross section of down tube showing "rivet nut" in place

SEAT TUBE

The seat tube connects the bottom bracket shell to the seat post. Frames are generally sized according to the seat tube length. The seat tube may also be fitted with water bottle mounts and a fitting or brackets for the front derailleur.

CHAIN STAY

These tubes connect the rear wheel dropouts to the bottom bracket and see a relatively high amount of stress from riding. The length of the stay is designed for the type and size of wheel used, as well as for bicycle performance. For some designs, the disc brake caliper mount is on the chain stay.

SEAT STAY

This is the connection from the rear wheel dropouts to the seat tube. These tubes see less stress than the chain stays but still support the bike over the rear wheel. For some designs, the disc brake caliper mount is on the seat stay.

Rim brake calipers are commonly mounted to seat stays as well.

DROPOUTS

Dropouts are the fittings at the end of the front fork and rear stays that accept the hubs and wheels. The open dropout design accepts a 9mm axle for front forks, while open style rear dropouts accept a 10mm axle. Thru axle dropouts can be designed into most any type of bike, and completely enclose a connecting shaft. Front thru axle dropout may be 12, 15 or 20mm diameters, while the rear is a 12mm standard for all types.

The dropout of derailleur bikes is designed with a derailleur hanger, which is a bracket to accept the 10mm mounting bolt of the derailleur. The dropout may be replaceable but replacements are typically proprietary and vary between brands and even models.

BOTTOM BRACKET SHELL

This is a short tube between the cranks that holds the bottom bracket bearings and is connected to the down tube, the seat tube, and the chain stays. There may be internal threading for attaching bearing cups and adaptors (figure 17.4). There are also numerous unthreaded designs that use pressed bearing adaptors.

FIGURE 17.4: Threaded bottom bracket shell

SWING ARM

A swing arm is the rear part of the frame of full suspension bicycle designs (figure 17.5). These function as moveable stays that pivot and move when there is impact on the rear wheel from a bump. The swing arm is attached to the main frame with pivot bearings. A spring system keeps the swing arm extended and allows it to pivot. Bearing design in the swing arm is generally proprietary and bearing service varies with each model.

FIGURE 17.5: Swing arm of a full suspension bike

FRAME CONSTRUCTION & SERVICE

Frame material may be steel, aluminum, titanium, carbon fiber, magnesium, special plastics, or a combination of any of the above. Each type of material has different properties, which will affect the ride of the bike. All these materials flex to varying degrees under load or stress. Additionally, each material will require different manufacturing processes and will have limits for repairability.

Like any mechanical part subjected to stress, the frame may fail. If the frame was poorly designed, improperly constructed, or simply subjected to excessive loads and abuse, cracks and bends can occur. Generally, for steel, aluminum or titanium frames, frame failure tends to be at the tubing joint, such as the head tube and down tube connection. However, for carbon fiber frames made as a single molded piece, the tubing connections tend to be very strong. The stress of an impact or crash passes from these strong joints to the middle of the tubing where it is thinner.

Frame failure can result from many causes. A common cause is simply a crash. Tubing joints may suddenly yield, or weaken, and begin cracking or failing if metal. Carbon fiber, however, does not tend to permanently bend and stay together. A metal frame may bend and deform permanently. A stressed carbon fiber frame will flex to some degree and then break when it has reached its load limit.

Another type of failure is from a submaximal and repeated cycle of stress. Simply riding creates a stress cycle of loading and unloading of the frame and bike. This may, in time, cause cracks and eventually, failure.

A severe impact or crash may bend metal frame tubes. Repair by simply rebending the deformed tubing is typically impractical and will create a stress riser or weak spot in the area of the repair without further heat treatment.

Bicycle frames are best inspected during cleaning. Most types of paint tend to be somewhat brittle and will crack if the material has moved under it (figure 17.6). This is often a sign of failure or future failure. Cracked paint may simply be paint coming off the surface or poor paint bonding. Inspect to confirm a failure or crack and consult a professional mechanic if in doubt.

FIGURE 17.6: Bent tubing on down tube from impact

STEEL

Different types of welding typically join steel tubing. Tubes may be fitted into a lug, and then brazed or welded with alloys of silver or with brass. Tubes can also be mitered and welded by sophisticated electrical welding known as “TIG” or “MIG” welding. Steel frames are susceptible to rust or oxidation. Water inside the frame and lack of paint can worsen issues of rust, even to the point of frame failure. It is also recommended to use grease or anti-seize compound on any threaded or press fit frame fitting, such as bottom bracket threads or head tubes. A good frame builder is able to repair some failures in a steel frame by replacing lugs or the entire tube.

ALUMINUM

Aluminum is a very common material for many uses and is easily worked and welded. Aluminum frames may also be bonded together with lugs and adhesive. Aluminum is a relatively lightweight metal but can require more material to match the strength of steel. Aluminum does not rust exactly like steel but it can corrode. This results in pitting and corrosion pockets on the surfaces. The consequence is that components such as seat posts or bearing cups may seize in an aluminum frame. As with steel, it is useful to use grease or anti-seize when installing components. Local repair to aluminum frames is difficult because of the special skills needed and the need for heat treatment of the frame after welding.

TITANIUM

Titanium is a very strong material, but it can be difficult and expensive to work and shape. Titanium is commonly welded for bicycle frames. There is very little issue with corrosion, but greasing the fittings is still recommended. Local repair of titanium is difficult due to the special skills and equipment involved.

CARBON FIBER

Carbon fiber is a fabric material held in place by polymers or epoxies, called a “matrix.” The carbon cloth or fabric is laid into a mold and the matrix applied. This can create tubes to be joined, or it can create entire sections of the frame. When carbon fiber tubing is joined, it is often with a thermal-set epoxy. Often the carbon fabric will be laid up with fittings or metal tubing to add strength or to allow installation of components. For example, carbon fiber is a poor material for threading, so metal inserts are installed for threaded parts such as the bottom bracket or water bottle fittings.

Carbon fiber is susceptible to sudden failure from the stresses of riding and impacts of crashing. Because each manufacturer uses different wraps and different materials, it is difficult to draw broad guidelines as to when to replace a carbon frame. When in doubt, contact the manufacturer.

Carbon fiber bikes made by joined tubing may develop a stress crack from use, especially if the material was underdesigned. Failure in these designs are typically where tubes are joined together. Look for long cracks in the paint or in the epoxy matrix (figure 17.7).

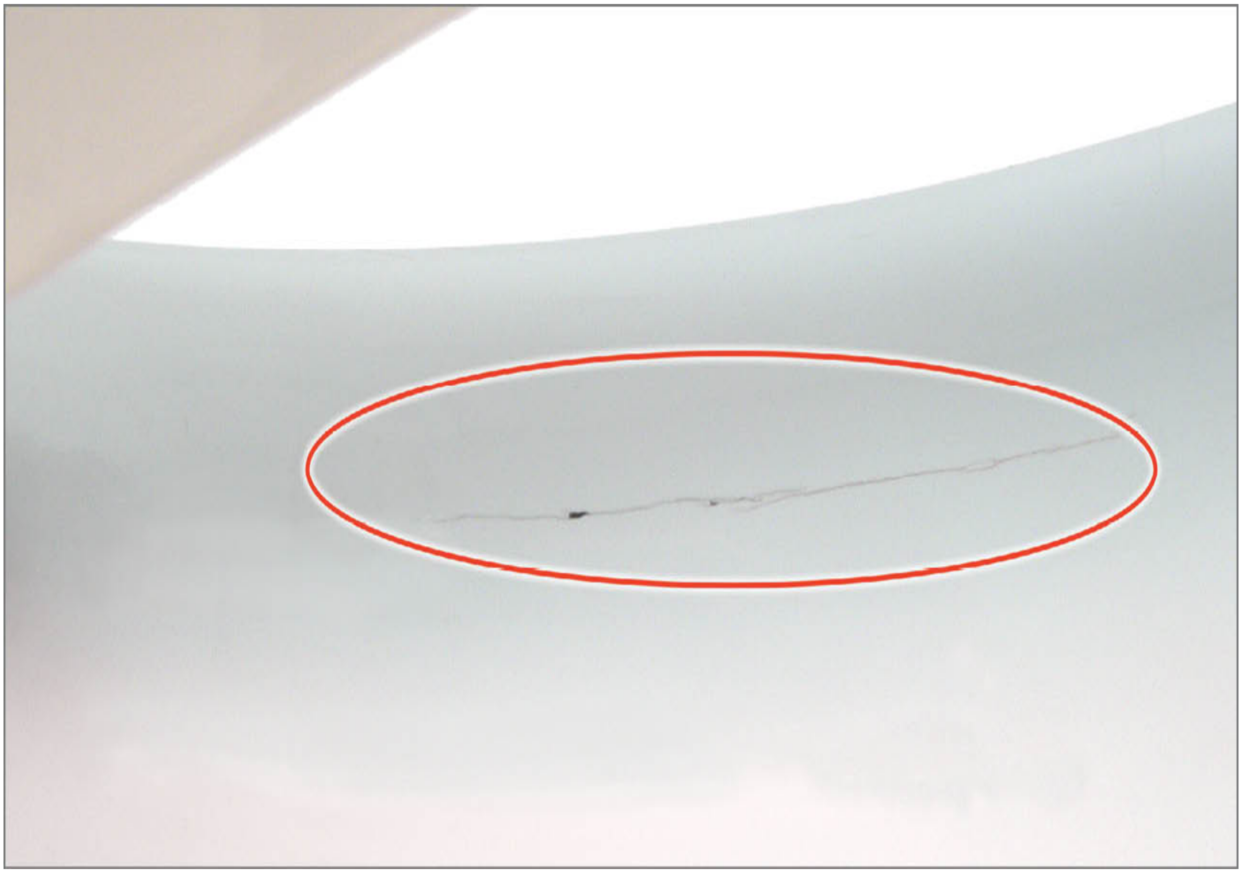


FIGURE 17.7: Suspicious paint crack in a carbon fiber frame

Another type of carbon fiber failure is from impact or from puncture. Carbon fiber material is aptly named because it is a “fiber,” and punctures and cracks cause a “tear” in the carbonized cloth. Damaged tubing will resonate differently at the failure or tear. Use a coin or spoke to tap the tubing along a section of good tubing, noticing the type of sound it makes. The pitch will rise and fall along the length of the tube depending upon the size of the tubing. By comparison, in a damaged carbon fiber frame, the sound will suddenly change and become deadened at the point of failure because the fibers are compromised at that point (figure 17.8).

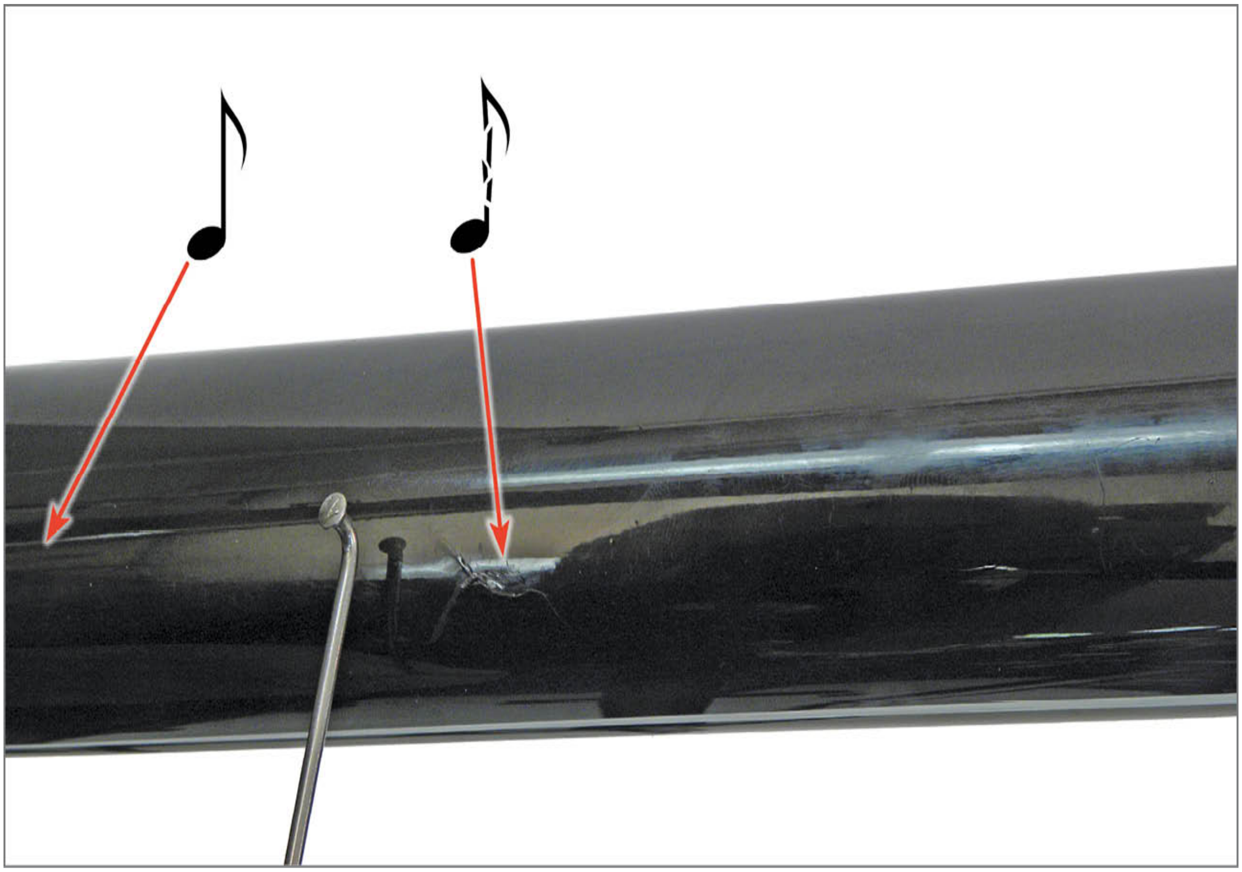


FIGURE 17.8: Tap along tubing and listen for deadened sound indicating cracks in carbon fiber matrix

Repair of damaged carbon fiber is difficult but not impossible. New carbon fiber laminate can, in some cases, be laid up over the failure with epoxy resins. Heat is applied to cure the matrix and the result is refinished for a good look. This repair should be left to professionals.

CHAPTER 18

SUSPENSION

Bicycle suspension refers to the system of pivots, levers, sliders, and parts of the bicycle that allow you to maintain a relatively steady horizontal line on unsteady terrain. “Rigid” (non-suspension) bicycles have no built-in pivots or linkage. With a suspension system, the wheels can track the terrain independently of the cyclist by allowing the wheels to move up and down to accommodate bumps and dips in the trail or road. Suspension can improve both rider comfort and performance. But as with any moving parts, there can be issues of wear. This chapter will help familiarize you with the terminology and concepts of suspension bikes. It will focus on what to look for when servicing may be required. However, many suspension service procedures require specialty and proprietary tooling and special knowledge and are best performed by a professional mechanic.

SUSPENSION FORKS

Common bicycle suspension forks use telescoping legs. The “lowers” or “lower legs” are the section that attaches to the hub and wheel. The “uppers” or “stanchions” are attached to the steering column (figure 18.1).

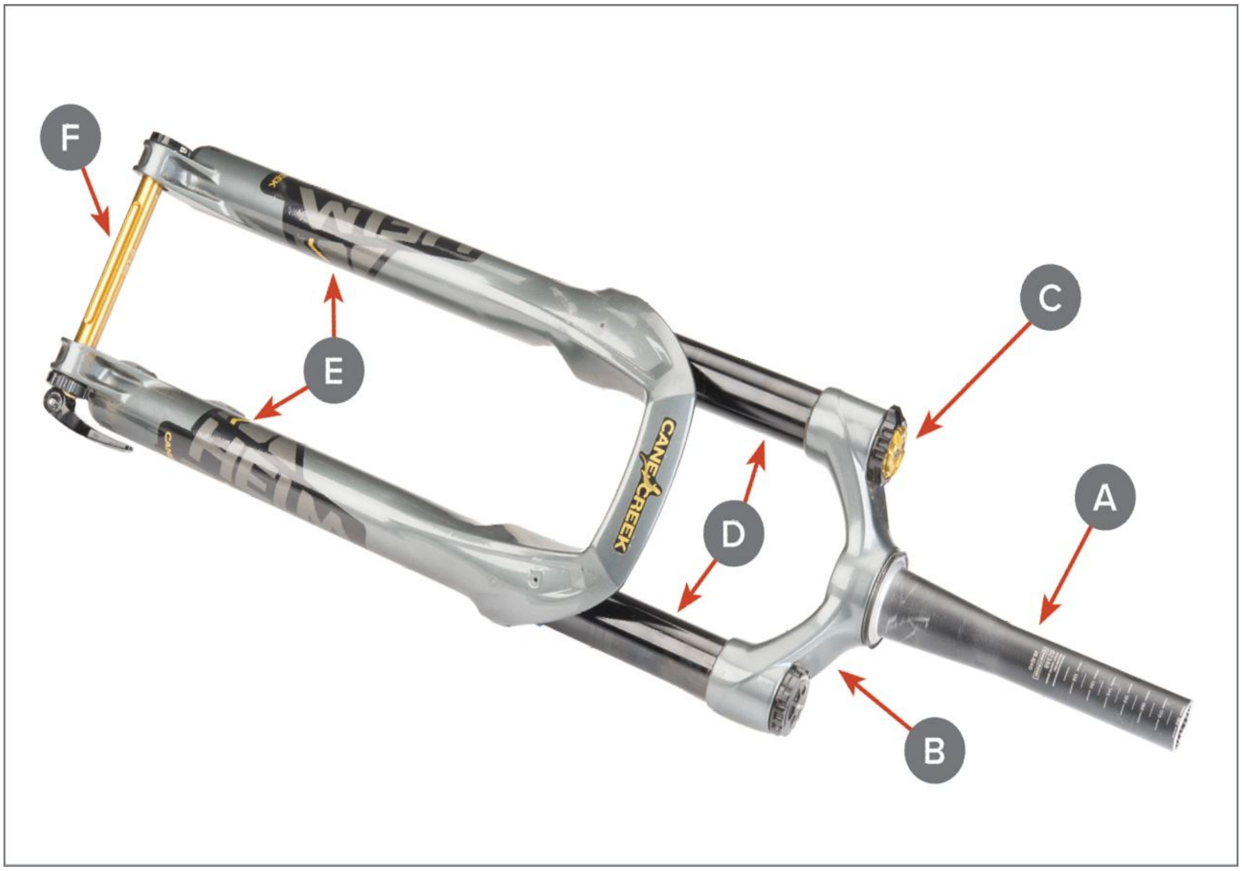


FIGURE 18.1: Parts of a suspension fork: (A) steering column, (B) fork crown, (C) tuning controls, (D) stanchions, (E) lowers, (F) thru axle

As the wheel moves over bumps, the lowers move up and down on the uppers. This movement takes place along bushings pressed into the lower legs. The telescoping action uses a spring system to keep the lowers extended. Better forks use damping systems inside the legs to reduce the speed of compression or extension by consuming energy from an impact.

Wear can develop between the uppers and the lowers as the bushings and stanchions ride against each other under load and stress. Wear will begin to show as play between the upper and lower parts. To test the wear, grab and hold the front brake tightly. Rock the bike back and forth, feeling for knocking, similar to detecting play in a headset bearing. If a knocking is felt, confirm the location by using your other hand to hold at the interface between the suspected parts. Hold where the uppers enter the lowers and note if you can sense motion or knocking (figure 18.2). Some minor movement is normal. Excessive play means the bushing should be replaced. If play is ignored and the fork continues to see hard use, the uppers may become damaged and worn. While some uppers are available as a part, it is typically best at this point to replace the fork.

FIGURE 18.2: Feel for knock or movement between stanchions and sliders while holding front brake and pushing bike fore and aft

A simple test for the compression and damping system is to push downward on the fork as a test of the compression and extension. Stand over the fork and apply nearly your entire body weight downward. The uppers should drop into the lowers, and then come back as you release pressure. If the forks feel as if they are coming up as fast as you let go, the damping system is not working well. Consult the manufacturer regarding adjustments for the rebound.

The spring system of a front fork may be simply one or two coiled springs inside the lower legs. The spring force can also be air pressure from a sealed system. For an air spring, there will be a valve to check and add air pressure for tuning purposes. If you are noting that the fork is dropping pressure over a few weeks or even months, there is likely an air leak that requires service.

The “shock” part of a suspension fork often consists of mineral oil passing through a series of valves and ports. This slows the rebound or return of the fork to full extension and consumes energy in the process. With enough use and cycles of compression and extension, the seals will become worn and no longer be able to contain the oil. Inspect the top of the fork for signs of wet fluid, which indicates a leak (figure 18.3). Internal service of the shock damper is best left to a professional mechanic.

FIGURE 18.3: Suspicious fluid weepage indicating possible seal failure

There are often several moving parts housed inside the legs of the front fork, and if these come loose, dislodge or break, they will often develop a clunking noise. Again, consult a professional mechanic.

Suspension forks often come with knobs and dials to adjust performance features. Consult the manufacturer’s owner’s manual for their use. If the knobs and dials turn with difficulty or do not stay put, consult a suspension professional.

Like any component, forks can also develop cracks, especially from crashing or abuse. Inspect the fork crown where the steering column enters, as well as where both upper legs enter. Do not use a fork with a crack.

SHOCKS (REAR SHOCKS)

The term “shock” or “rear shock” is the rear suspension linkage damping mechanism. Like the damping systems in the front fork, the rear shock is designed to help control motion. Damping in rear suspension shocks can occur both on the compression cycle and extension cycles.

Rear shocks can use one of two return spring systems. The shock may have a built-in container with pressurized air. As the bike hits a bump, the rear linkage moves upward making the shock stanchion move into the shock body. This compresses an air chamber, which provides a push to extend back the linkage after the load is passed.

The rear shock may also have a large external spring surrounding the damper. These springs are typically available in different compressive strengths. It is very unusual but these springs may fail.

The rear shock can develop wear at the bushing of the frame attachments. Play is felt when the bike is lifted up and down. Test this by placing a foot on the pedal and pulling upward at the top of the seat tube. If you feel play here, it still may only be loose linkages, not a worn bushing. Perform a double-check of linkage bolt and shock mounting bolt tightness. If play is still present, it is likely a worn bushing that requires replacement. There are often proprietary tools required and shock bushing replacement is best left to a professional mechanic.

The shock stanchion also passes through a seal or bushing which may develop leakage at the seals. Inspect around base of stanchion as it enters the main body for wet oil. For an air shock, if pressure seems to drop after a few weeks or even months, there is an air leak that requires professional service. Again, either air leaks or bushing replacements are best left to a pro.

The procedure to remove a rear shock varies somewhat between linkage and bike designs. When in doubt, take notes and pictures of the original situation. For air shocks, use a shock pump and take a measurement of the current air pressure for reference. For spring shocks, measure the amount of compression on the spring. Use a tape measure to measure spring length or count the number of turns from the compression ring, as it is unthreaded. Unthread the forward or upper pivot bolt, taking careful note of the orientation of any washers, spacers, and bushings. Unthread and remove the lower or rear pivot bolt, again noting orientation of any parts. Pull shock from the bike.

SUSPENSION LINKAGES

On rear suspension bikes, the rear wheel is connected to the rest of the bike with a series of moveable “swing arms.” There are two basic concerns in the rear suspension linkages. There should be no play in the pivot joints. Grab the top of the rear wheel and pull it side to side. If play is felt, isolate it further and eliminate the rear hub being the source. Play in the linkage can develop from simply a loose pivot bolt, so begin by checking that the bolt is secured to the manufacturer’s recommended torque.

Linkages can contain a cartridge bearing, and like any such bearing, these can develop play. Service here requires bearing replacement and again specialty tools are required.

Another aspect of linkage wear is how smoothly and evenly the linkage moves. Drop the rear wheel and remove the shock to allow the rear linkage to travel freely. From the end of the chain stay, pull the linkage up and down to get a sense of the smoothness of travel (figure 18.4). It should move up and down consistently and without any kind of force. If it moves roughly or hesitates as it travels, the linkage needs service.

FIGURE 18.4: Unbolt rear shock and feel for easy movement up and down

CHAPTER 19

ON-RIDE REPAIR

Mechanical problems can and do occur while riding on the trail or road. The best way to prevent these problems is to regularly clean, lubricate, and inspect the bike. Keeping your bike well-maintained will prevent many of the mechanical problems described below, even when riding off-road.

TOOL CHOICES

Should problems arise, be prepared by carrying a few tools. When selecting tools for the ride, consider the type of bike components being used by you and others in your group. Consider the weight of the tools and the amount of space available for carrying. Your budget and level of mechanical skill will also affect your choice of tools.

There are numerous possibilities for tool options and pre-packaged tools kits. One versatile tool choice is the “multi-tool.” These contain several tools, including hex wrenches, screwdrivers, spoke wrenches, tire levers, and others in one unit. This type of tool is compact and cost-effective. You may assemble your own take-along kit of tools. The list below outlines recommended tools for a typical off-road or road ride.

In addition to tools, having a few basic supplies can save the day. A chain quick link will get a person up and riding in a few minutes after a broken chain. Zip ties can keep many things together just to finish the day. However, no matter how clever your fix was while riding, go back after the ride and consider a long-term solution. For example, any broken chain should mean a new chain gets installed.

TABLE 19.1: Take-Along Tools

ITEM DESCRIPTION	PARK TOOL PRODUCT
Multi-tools with hex keys	Many choices including MTC-40, IB-3, IB-2, MTC-20
Chain tool	CT-5, IB-3, MTC-40
Tire levers	TL-4.2, TL-6.2
Patch kit	VP-1, GP-2
Spoke wrench	SW-0, SW-2 as needed
Screwdriver as part of multi-tool	IB-1, IB-2, MTC-20, MTC-30
Portable tire pump	PMP-3.2, PMP-4.2
Tire boot	TB-2
Non-tool Supplies and Parts:	
Spare inner tubes, purchase to fit	Even if you ride tubeless, a spare tube is a safe fall back
Chain quick links	Purchase to match width of chain
CO_2 air cartridges and head	Useful especially to reseat tubeless tires
Rag or foil cleaner wipe	To wipe your hands
Zip ties	6 of various widths, sizes
Duct Tape	A small amount

REPAIR PROCEDURES

Repairs made during the ride have some limitations. The right tools or parts are not always available. Some bikes can simply be flipped upside down to work on them, but be careful to not damage shift and brake levers or housing. Additionally, some hydraulic brake systems should not be turned upside down. If it is necessary to turn a hydraulic brake system upside down, allow it to sit upright several minutes after the repair, then test the brake to ensure no air has entered the brake lines.

The following text outlines problems that may occur on the ride and gives suggestions for addressing them. If a repair seems questionable, walk the bike home or call for a lift. Do not ride an unsafe bike.

FLAT TIRE

Always carry a spare tube. On long rides or big group rides, carry two tubes if possible. A patch kit is also essential (see Inner Tube Repair). To clean the tube before patching, carry a foil sealed alcohol wipe. These are available in drug stores.

CUT OR RIPPED TIRE

Use a tire boot such as the Park Tool TB-2 (see Temporary Tire Repair with Tire Boot). Plan ahead for this contingency. A paper dollar bill, for example, provides little holding strength for a cut tire. Always replace the tire as soon as possible.

BROKEN SPOKE

The only permanent repair for a broken spoke is to replace the spoke and re-true the wheel (see Broken & Damaged Spoke Replacement). If a single spoke is broken, the lateral true can be improved by loosening the two spokes immediately adjacent to the broken one. This will somewhat bring the wheel back into lateral true. It may be possible to continue the ride. If the wheel has 28 or fewer spokes, having one spoke missing or broken may make the wheel unsafe to use. Bent spokes, even severely bent ones, are less of a problem. If the wheel is still adequately true, continue the ride. True the wheel as necessary and then replace the spokes after the ride. See Truing Procedures.

DENTED RIM

Rims can become dented from striking objects on the ground. First determine the extent of the dent. If the braking is not badly affected, it may be best to leave it alone and finish the ride. Have the rim repaired or replaced after the ride. With rim caliper brakes, severe dents will be felt during braking and may lock up the wheel unexpectedly. A badly dented rim can also affect the seating of the tire bead. In either of these cases, it is best to not ride the bike.

BROKEN CHAINS

A broken chain can usually be shortened as an emergency repair. If you have extra links, these may be added, but the chain will be compromised and should be replaced with a new chain as soon as possible. Note that outer plates must be joined to inner plates and remove links accordingly. If the chain was shortened, use care not to shift into the largest rear sprocket and largest front chainring combination. The most common cause for a broken link is improper installation. When installing a chain, inspect all pins and links to prevent on-the-ride chain problems. Additionally, if a chain has broken on a ride, inspect all rivets and links after repairing. If there was one bad link, there are likely to be more. For chain link cutting, see Chain Removal.

CHAIN SUCK

Chain suck occurs when a chainring will not release the chain at the six o’clock position. The chain gets stuck on a tooth and continues upward with the chainring and eventually jams into the frame. If it is not too jammed, grasp the chain at the bottom, and pull down while turning the crank backwards. Scarring of the paint and frame is likely. If pulling the chain will not dislodge it, it may be possible to disconnect a link of chain, unthread the chain from the frame, and reinstall correctly. The option is to remove the right crank, which requires a crank puller. Inspect the chain after pulling it free. The chain may have become twisted or damaged. Inspect the chainring teeth as well, which may be the cause of the problem. If a tooth is bent, avoid using that chainring if possible.

TWISTED CHAIN

Chains can twist from being shifted into the spokes or from jamming against the frame during chain suck. It may be possible to twist the chain back using a pair of pliers, but it is difficult to do so by hand. Isolate the twisted section and use the rear cog to hold one end of the chain. Twist the chain back using pliers at the end of the twist. Replace the chain as soon as possible after the ride.

SQUEAKY AND NOISY CHAIN

A squeaky chain is caused by a lack of lubrication in the links. It is usually not necessary to carry chain lubricant on shorter rides if the chain has been lubricated as part of regular maintenance. If the ride is especially wet, the lubricant may wash away. In this case, almost anything that will penetrate the link will provide some temporary lubrication. Sunscreen oils or creams, bug repellent creams and cooking oils can provide some short-term relief from a noisy chain. Clean and lubricate the chain properly after the ride.

REAR DERAILLEUR SHIFTING INTO THE SPOKES OR FRAME

This problem is typically the result of improper limit screw settings. The limits of the rear derailleur act as a stop to the derailleur body. If the derailleur or derailleur hanger is bent, the previous limit screw settings will no longer be appropriate. View the derailleur from the back and sight that the pulley wheels are parallel to the cogs. If the derailleur hanger or pulley cage appears to be pushed inward toward the spokes, something has been bent. It may be possible to pull the derailleur back. Insert a hex wrench in the mounting bolt and pull upward until the derailleur appears parallel with sprockets (figure 19.1).

Check shifting and reset H-limit screw and L-limit screw as necessary (see Limit Screw Adjustment). Take the bike to a professional shop for proper hanger alignment after the ride, or see Derailleur Hanger Alignment & Repair to do it yourself.

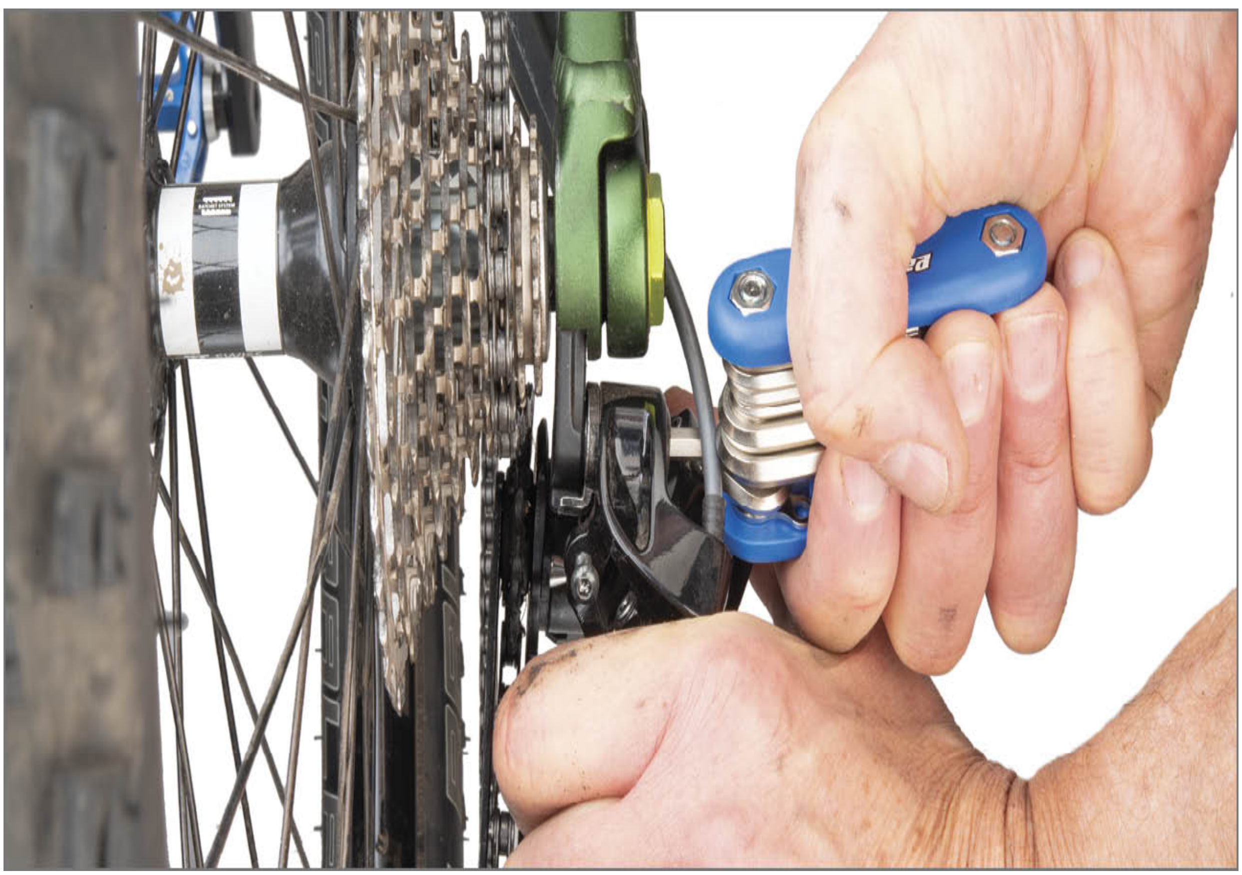


FIGURE 19.1: Bend Hanger back until visually straight

DERAILLEUR NOT INDEXING PROPERLY

The most common cause for derailleurs not indexing properly is poor derailleur cable tension adjustment. Apply the same skills and procedures as with routine derailleur adjustment (see Index Adjustment). Have someone hold the bike by the saddle while you pedal by hand, and make adjustments to the barrel adjuster.

BROKEN DERAILLEUR BODY, CAGE, OR HANGER

If the rear derailleur body, pulley wheel cage or derailleur hanger has broken, shifting is no longer possible. The bike may be converted to a single-speed to get back home (figure 19.2).

FIGURE 19.2: Bypass derailleur to create a makeshift single-speed

Procedure for single-speed conversion:

a. Remove the chain. For removal procedures see Chain Removal.
b. Remove the derailleur or other affected parts.
c. Choose a gear. For triple chainring bikes, use the middle ring and one of the middle rear sprockets. For two chainring bikes, use the smallest ring.
d. Run the chain from the chosen rear sprocket to the front chainring and determine the correct pin to remove in order to shorten the chain. It may be necessary to change rear sprocket choices to get better chain tension.

e. Cut the chain and connect the links. The chain should be tight enough so it does not come off the front sprocket.

f. Rotate the pedals backwards by hand slowly and bounce the chain up and down, keeping your fingers on the outside of the chain loop to check tension.

MISSING DERAILLEUR PULLEYS

Look for missing parts on the trail or road behind you if possible. If the parts are not available, convert to a single-speed as described above in Broken Derailleur Body, Cage, or Hanger.

FRONT DERAILLEUR CAGE BENT OR TWISTED

The front derailleur cage can get twisted if a chain jams during a shift or if it is struck. Realign the cage if it has twisted (see Front Derailleur). The outer cage should be approximately parallel with the chainrings. The derailleur may not properly shift after the realignment, so select the preferred chainring and use cable tension or limit screws to keep the derailleur on that chainring.

CRANK FALLING OFF

If the crank has completely fallen off, the fixing bolt may be missing. In this case, walk the bike back. It is dangerous to attempt riding it with the arm simply shoved back in place. If you have the bolt, reinstall the arm. If the crank was a single bolt model, the torque for crank bolts is relatively high, around 300 inch-pounds. Basically, tighten as much as you feel the tool will be able to withstand. If the arm is a two bolt compression slot style, snug each bolt until both feel tight.

PEDAL FALLING OFF

A loose pedal may be secured with a correctly fitting wrench. If there is a hex fitting behind the pedal threads, tighten it using the correct hex wrench, either a 6mm or 8mm. If no wrench is available, it is best to walk the bike. Riding with a loose pedal in the crank may cause the thread to pull out of the arm, resulting in a catastrophic crash for the rider. Some multi-tools include a small wrench for the pedals using 15mm flats. With a short wrench apply as much torque as you feel the wrench will handle.

BENT CRANK

If a bike has crashed with much force, the crank may bend. The pedal surface and your foot will then oscillate as the bike is ridden. If the crank clears the frame, it is best to finish the ride by riding lower gears and going slowly. Replace the arm. If the crank does not clear the frame, walk the bike or get a ride. Attempting to re-bend a bent arm may lead to eventual failure of the part and another crash.

BOTTOM BRACKET LOOSE OR FALLING APART

Depending on the specific bottom bracket, there may be very little repair that is possible. It is impractical to carry bottom bracket tools on the ride. If the bottom bracket is so loose that the crank strikes the frame, do not ride the bike.

BROKEN DERAILLEUR CABLE

If a derailleur cable has become frayed between the lever and cable pinch bolt, it is more likely to fail. Avoid using the derailleur if possible. Broken gear cables usually mean a non-functioning derailleur.

If a front derailleur cable has broken and a spare is not available, consider the remainder of the ride, then choose the most comfortable chainring for completing the ride. Typically, the middle chainring is best for a triple chainring bike. For a double chainring bike, select the smaller ring. Pull the cage up to the middle ring by hand and tighten the L-limit screw. For rear derailleurs, again consider the remainder of the ride. Choose one of the middle sprockets and tighten the H-limit screw to hold the derailleur in that position.

Broken cables will tend to get caught in moving parts. Remove the old cable and store until it can be disposed of properly.

BROKEN BRAKE CABLE

Do not attempt to patch together broken brake cables. If the cable were to fail again when needed, the consequences could be disastrous. Ride the remainder of the ride with caution, and replace the cable as soon as possible. Walk the bike rather than ride if in doubt as to safety. Remove and store the broken brake cable until it can be disposed of properly. For brake cable installation, see Cable System.

TWISTED OR BENT HANDLEBARS OR STEM

Handlebars may become misaligned from crashing. To realign, stand in front of the bike and grab wheel firmly between knees. Loosen stem binder bolt(s) and pull stem back into alignment until bars appear parallel with front hub and stem is aligned with wheel. Re-secure binder bolt(s). It will likely be necessary to readjust the headset if the binders of a threadless stem are loosened. For headset adjustment, see Threadless Headset Adjustment. It is possible to ride with a slight misalignment in the bars. If the crash has actually bent the bars or twisted the stem, it is best not to continue riding. A bent bar or stem may fail without warning. Replace it as soon as possible.

BENT FRAME OR FORK

Very severe crashes may bend either the frame or fork. Inspect the frame, especially behind the head tube. Look for paint cracks and wrinkles in the metal, indicating bent frame tubing (figure 19.3). If the frame is bent, it should be considered unsafe. Do not ride this bike.

Fork blades and fork crowns can also bend. View the bike from the side to see if the alignment looks odd. Again, a bent fork makes the bike unsafe to ride.

FIGURE 19.3: Bent frame at head tube

BENT SADDLE OR SEAT POST

If the saddle has come loose on the post, it may simply be realigned and tightened. For saddle security, see Saddles and Seatpost. If the clamp is broken, it will be difficult to repair away from home. In this case, remove both entire seat post and the saddle. Simply removing the seat and leaving the post installed is inviting an accident to happen.

APPENDICES

REFERENCE MATERIALS

APPENDIX A: TOOL LIST

The tool list below will stock a very complete “home mechanic shop.” The list does not duplicate a professional shop. For example, there are no bottom bracket taps, head tube reaming tools, and other tools a full service center at a retail bicycle shop would use. There are often several choices for a particular piece of equipment. It will be necessary to research these choices to make the best decision for your specific circumstances.

TABLE A.1: Tool List

✓	TOOL	PRODUCTS	INFORMATION
	General Tools		
	Bicycle Repair Stand	PCS-4, PCS-9.2, PCS-10.2, PRS-22.2, PRS-25	The stand forms the base of any good shop
	3⁄8" Ratchet Handle	SWR-8	Rachet handle in 3⁄8" drive
	Socket and Bit Set	SBS-1.2, SBS-3	3⁄8 inch drive socket bit set with metric and Torx® bits
	Torque Wrench	TW-5.2, TW-6.2	For use on small threads, use TW-5.2 For larger threads and torques, use TW-6.2
	Torque Limiter	ATD-1.2	For small threads
	Hex Wrench Set	AWS-10, HXS-1.2, PH-1.2	A variety of at least two styles of hex keys is useful
	Torx® Wrenches	PH-T1.2, TWS-1, TWS-2, TWS-3	Star-shaped wrenches for bolts using Torx® heads
	Shop Apron	SA-1, SA-3	
	Screwdriver Set	SD-SET	3⁄16 and 1⁄4 inch Straight Blade #0 and #2 Phillips
	Hammer	HMR-4, HMR-8	Double-ended, steel and plastic
	Combination Wrenches	MW-SET.2	Box end with open end on other side (6–17 mm)
	Hack Saw	SAW-1	
	Needle Nose Pliers	NP-6	
	Diagonal Side Cutting Pliers	SP-7	
	Zip Tie Cutters	ZP-5	Cuts off zip tie ends flush
	Digital Caliper	DC-1	
	Tape Measure	RR-12	Metric and inches

✓	TOOL	PRODUCTS	INFORMATION
	Air Compressor		Smaller tank, 110v is adequate
	Inflator head	INF-2	
Bottom Bracket Tools			
	Lockring Wrench	HCW-5	Fits most lockring types for adjustable square BBs
	Adjustable Cup Tool	SPA-1, SPA-6	Adjustable type bottom brackets
	Fixed Cup Tool, 36 mm	HCW-4	Adjustable type bottom brackets
	Cartridge Bottom Bracket Tool	BBT-22, BBT-32	Fits 20-tooth internal spline cups such as on Shimano® cartridge BBs, FSA®, and Race Face® ISIS Drive bottom brackets
	External Bottom Bracket Wrench	BBT-9, BBT-19.2, BBT-69.2	Fits 16-notch 44mm bottom bracket cups like some Shimano® Hollowtech®, Campagnolo®, Chris King®, FSA®, Hope®, SRAM®, Truvativ®, Race Face®, Surly®, Wheels Manufacturing®, Rotor®, Enduro®, and others.
	Hollowtech® II Crank Cap Tool	BBT-10.2	Adjusts bearing load for Shimano® Hollowtech® II cranks
	Bottom Bracket Tool	BBT-47, BBT-35	2-sided tool that fits 16-notch 39mm bottom brackets as well as 16-notch 48.5mm bottom brackets.
	Bottom Bracket Tool	BBT-18	Fits 8-notch bottom bracket cups, ISIS Drive of Truvativ®, Bontrager®, Bosch® active plus chainring and Specialized® Levo® chainrings.
	Bottom Bracket Tool	BBT-27.2	Fits 16-notch 48.5mm and 49.3mm cups like FSA® MegaEvo®, and Wheels Manufacturing® PF30 thread together.
	Bottom Bracket Tool	BBT-49.2	Fits 16-notch 39mm bottom brackets like Shimano® XTR® and Dura Ace®.
	Bottom Bracket Tool	BBT-59.2	Fits 16-notch 41mm bottom brackets like Shimano® Ultegra®
	Bottom Bracket Tool	BBT-79	Fits 12-notch 46mm bottom brackets like Race Face® BSA30, Rotor® BSA30, Zipp® Vuma®, Hawk Racing® BSA30, SRAM® DUB® and others.
	Bottom Bracket Tool	BBT-30.4	BB30 and PF30 service
	Bottom Bracket Tool	BBT-90.3	BB86 and BB90 service
	Bottom Bracket and Crankset Tool	CBP-8	Campagnolo® Ultra-Torque® and Power Torque™ service
Headset Tools			

✓	TOOL	PRODUCTS	INFORMATION
	Headset Locknut Wrench	PAW-12, HCW-6	32mm and 36mm open-end wrench in eight-point for threaded headsets; wrench wraps to fit all points
	Headset Lower Race Wrench	HCW-15	32mm and 36mm for threaded steering columns
	Headset Press	HHP-2, HHP-3	For press fit headsets and some bottom brackets
	Fork Crown Race Setter	CRS-1, CRS-15.2	
	Star Nut Setter	TNS-1, TNS-4	
	Saw Guide for Steering Columns	SG-7.2	Will work on tubing from bar to large steering column and seat tubes designed for cutting
Hub Tools			
	Axle Vise	AV-1, AV-5	Holds axles without damaging threads
	Cone Wrenches	DCW-1 through 4, SCW-SET.3	For some hub models, two wrenches of 13, 14, 15, or 16mm required
Wheel and Tire Tools			
	Truing Stand	TS-2.2, TS-2.2P, TS-4.2, TS-8	Speeds the truing of wheels
	Truing Stand with Base	TSB-2.2, TSB-4	Tilting base for truing stand TS-2.2 or TS-4.2
	Spoke Tension Meter	TM-1	Checks tension on spokes
	Wheel Centering Tool	WAG-4, WAG-5	Also see optional WAG-5
	Spoke Wrench Options	SW-0, SW-1, SW-2, SW-3, SW-5, SW-11, SW-12, SW-13, SW-14.5, SW-16, SW-16.3, SW-17, SW-18, SW-19, SW-20.2, SW-22.2, SW-40, SW-42	Many possible sizes and options; select the correct size for your wheel
	Tire Levers	TL-1.2, TL-4.2, TL-5, TL-6.2	Levers vary in design and fit
	Patch Kit	GP-2, VP-1	VP-1 has glue in tube; GP-2 has pre-glued patches
	Floor Pump	PFP-8	Pump head fits both Presta and Schrader
	Spoke Ruler	SBC-1	Measures spoke length and ball bearing sizes
Drivetrain Tools			
	Pedal Wrench	PW-3, PW-4, PW-5	PW-3 has 15mm and 9⁄16 inch; PW-4 and PW-5 have 15mm only
	Pedal Wrench	HT-6, HT-8	For pedals with 6-point socket in axle

✓	TOOL	PRODUCTS	INFORMATION
	Crank Arm Pullers	CCP-22, CCP-44, CWP-7	CCP-22 is for square type spindle only CCP-44 is for round, splined ISIS Drive or Shimano® Octalink® only CWP-7 works with either square or round spindles
	Cassette/Freewheel Removers	FR-1.3, FR-2, FR-3, FR-4, FR-5.2, FR-5.2G, FR-5.2GT, FR5.2H, FR-6, FR-7, FR-8, BBT-5/FR-11	Purchase model as needed
	Chain Whip	CP-1.2, HCW-16.2, SR-2.2, SR-12, SR-18.2	Used to hold cassette while lockring is removed Note: Older freehubs required two sprocket tools
	Chain Rivet Tool	CT-3.3, CT-4.3, CT-5	
	Master Link Pliers	MLP-1.2	
	Chain Wear Checker	CC-2, CC-3.2, CT-4	Check chain for wear
	Drivetrain Cleaning Kit	CG-2.3	Includes CM-5.2 Cyclone™ Chain Scrubber, GSC-1 GearClean™ Brush, and CB-4 Bio ChainBrite™ Fluid
	Derailleur Hanger Alignment Gauge	DAG-2.2	Aligns rear derailleur hanger
Brake Tools			
	Fourth Hand Tool	BT-2	Tightens cable slack by pulling cable
	Cable Cutters	CN-10	Cuts both cable and housing
	Hydraulic Piston Press	PP-1.2	
Miscellaneous Parts and Supplies			
	Bearing Grease	HPG-1, PPL-1	Safe for suspension elastomers, ceramic bearings, and carbon fiber
	Bicycle Cleaning Brush Kit	BCB-4.2	
	Chain Lubrication	CL-1	
	Thread and Press Fit Adhesives	AP-1, RC-1, TLR-1, TLR-2	Medium duty, service removable
	Degreaser	CB-4	For chain and parts
	Hand Cleaner		
	Isopropyl Alcohol		For cleaning brake surfaces and press fits
	Polisher	Glass cleaner, etc.	For cleaning frames
	Zip Ties	Various widths	Various sizes and colors
	Rags		Lots and lots of cotton, lint-free rags

✓	TOOL	PRODUCTS	INFORMATION
	Spare Inner Tubes		Purchase to fit
	Spare Gear and Cables		Use only high quality cables

APPENDIX B: GLOSSARY

Adjustable cup: The left-side bearing cup of an adjustable bottom bracket.

Adjusting race: A movable bearing surface typically mounted to a thread that is used to adjust bearing play and movement.

Allen® wrench: See hex wrench.

Articulated housing: Brake and derailleur index housing made of small hollow metal segments strung together over a liner.

ATB: All Terrain Bike, or mountain bike.

Axle nut: A threaded nut that secures wheel to bike. Used with solid axle hubs.

Bead seat diameter: Rim diameter measured where the tire bead is seated.

Bolt circle diameter: Diameter of a circle defined by the chainring mounting bolts.

Bottom bracket: The bearings, cups, and spindle connecting both cranks.

Bottom bracket shell: The bottom of the frame that holds the bottom bracket.

Bottom bracket spindle: The axle in the bottom bracket. It connects both cranks.

Braided housing: A cable housing made of woven wire around an inner liner.

Brake bridge: Frame tubing connection between seat stays. Located above rear tire and used for mounting side pull and dual pivot brake calipers on some bikes.

Brake cable: Wound, multiple strand wire that connects brake lever with brake caliper.

Brake cable carrier: Connection between straddle wire and main brake cable. Found on cantilever brakes, U-brakes and center pull brakes.

Brake caliper: The lever arms that move brake pads to rim or rotor to apply friction needed to slow and stop the bicycle.

Brake centering screw: The screw that changes spring tension between caliper arms, allowing pads to center over wheel rim.

Brake fluid: Either a mineral oil-based fluid or a D.O.T. brake fluid for hydraulic brake systems.

Brake lever: The mechanism pulled by hand to activate brake caliper and pads.

Brake pad: Synthetic rubber block fastened to caliper arm. Pad is forced against moving rim or disc causing friction, to slow rim rotation.

Brake pad fixing bolt/nut: Fastener system that holds brake pad to rim caliper arm.

Brake pad toe: An adjustment to the brake pad used to reduce brake squeal. Pad surface is adjusted to strike braking surface at a slight angle, usually with leading edge striking first or “toe in.”

Brake quick-release: Mechanism found on rim brake caliper to open brake arms allowing wide tires to pass brake pads. The mechanism is sometimes found on the brake lever, or at a cable housing stop.

Braking surface: Part of the rim or rotor disc that is rubbed by brake pads.

British Standard Cycle (BSC): A thread standard system used by the British and adopted by much of the world.

B-screw: Body-screw on rear derailleur that changes the distance between the derailleur body, or the upper pulley (G-pulley or guide pulley) assembly, and the rear sprockets.

Cable: Wound, multiple strand wire used for brake calipers and derailleurs.

Cable adjusting barrel: Hollow bolt that acts as housing stop. Component adjusts in or out to effectively change housing length and cable tension on brake and derailleur systems.

Cable pinch bolt: Bolt and washer system that flattens and holds secure the cut end of a cable. Found on derailleurs and brakes.

Cantilever brake: Brake system found on mountain bikes, cyclocross bikes, and touring road bikes. Consists of two separate brake arms pivoting off studs fixed to the frame or fork.

Cassette: Sprocket and spacer assembly mounted to a freehub mechanism on the rear wheel.

Centerline: Mid plane of the bike in line with wheels.

Chain: A connected series of flexible links used to transfer motion of front chainrings to rear sprockets.

Chain rivet: Small pin that connects two outer chain plates, usually considered a permanent part of chain.

Chainring: Sprocket attached to the crank.

Chainring bolt: Special bolts that secure a chainring to crank.

Chainring nut: Thin-walled nut used with a chainring bolt.

Chainring nut wrench: Special wrench with two pegs used to hold chainring nut.

Chain stay: Frame tubes connecting the rear dropouts and the bottom bracket shell.

Cleats: Fitting mounted to a cycling shoe that attaches the shoe to the pedal.

Clutch: Mechanism in the rear derailleur that improves chain retention at chainring(s) by resisting movement in adverse conditions.

Cogs: Sprockets attached to rear hub.

Compressionless housing: Plastic and metal sheath that covers derailleur inner cable, allowing it to pass around corners and between moving parts of the frame. Differs from other housing in that outer support wires run longitudinally with inner cable. Also called SIS™ housing by Shimano®.

Cone: A cone-shaped and curved bearing race that rides against ball bearings.

Cone wrench: Thin wrench made to fit the narrow wrench flats of a hub cone.

Crank (crank arm): The lever arm between the pedal and the bottom bracket.

Crank bolt: Bolt that secures crank to bottom bracket spindle.

Crank puller: Tool used to remove cranks by pulling them from bottom bracket spindle.

Crankset: Rotating mechanism, turned by feet, or in some cases by hand, which includes the chainrings, crank arms, and chainring bolts/nuts.

Crown (fork crown): Horizontal portion of fork, located at top of fork blades.

Derailleur: Mechanism used to push chain from one cog or chainring to another.

Derailleur cable: The inner cable of the derailleur cable system. Sometimes called the gear cable.

Derailleur capacity: The rated ability of a rear derailleur to take up chain slack from the gear combinations on the bike. Given as the sum of the difference between the largest and smallest number of teeth on the rear sprockets, plus the difference between the largest and smallest front chainring tooth numbers.

Derailleur hanger: The fitting on a bicycle frame that holds the rear derailleur. On some bikes this piece is replaceable.

Derailleur limit screw: Screw that stops derailleur travel when shifting to either extreme position. One screw stops inward travel, a second screw stops outward travel.

Disc brake: Caliper brake system using a disc-shaped rotor bolted to hub as the braking surface. Brake caliper attaches to either fork end or frame adjacent to hub.

Disc pads: Metal backing plates with bonded friction material that are housed in a disc brake caliper. Pads are forced against moving hub disc or rotor, causing friction to slow the bike.

Dishing tool: A gauge used to measure the centering of the wheel rim over the hub.

DOT brake fluid: Hydraulic brake fluid approved by the U.S. Department of Transportation. Does not interchange with mineral oil brake fluid.

Down tube: Frame tube connecting lower portion of the head tube to the bottom bracket shell.

Drop bars: Curved handlebars made with two bends, with the outermost section being lower than the top and offset 90 degrees. Most frequently used on road bikes.

Dropout: Part of frame and fork that accepts and hold the wheel axle.

Dropper seatpost: Telescopic seatposts that can be moved up or down and locked in place. Used to change handling of bike for descents or riding various features.

Dual pivot brake: Road type brake with two arms pivoting off separate studs mounted to a center bracket. One arm swings on an arc moving up and the other arm swings on an arc moving down.

E-plate derailleur: A front derailleur design that permanently mounts the derailleur to a plate held by the bottom bracket.

ETRTO: European Tire and Rim Technical Organization; an organization developing industry standards for tires and tubes.

Fixed cup: The right-side cup of an adjustable bottom bracket.

Flat bars: A handlebar style where the handlebars bend very slightly from the center. Also called upright bars.

Flat Mount: A low profile disc caliper brake mounting standard for frame and forks.

Foot-pound: A measurement of torque used mainly in the U.S.

Fork: Structure connecting frame to front wheel.

Fork blades: Tubes connecting fork dropouts to fork crown.

Frame: Supporting structure for the components, the wheels of a bike, the rider, and the cargo.

Frame housing stops: Fittings on the frame that hold either brake or derailleur cable housing ends.

Freehub: Ratcheting body bolted internally to hub of rear wheel. Holds cassette cogs. Mechanism does not detach when cogs are removed.

Freewheel: Ratcheting mechanism on the rear wheel fitted with one or more cogs. Cogs and ratcheting body unthread from hub as a unit. Not considered a "freehub" or "cassette."

Front derailleur: Mechanism located above front chainrings that pushes the chain from one chainring to another.

Gear cable: See derailleur cable.

Guide pulley (G-pulley): Uppermost pulley on rear derailleur. Guides chain onto rear cogs.

Gripshift®: Twist shifter manufactured by SRAM® Corporation.

Handlebars: Connector between stem and cyclist's hands.

Head tube: Tube connecting down tube and top tube; contains headset and steering column of fork.

Headset: Bearing assembly connecting the head tube and fork. Allows fork to rotate.

Hex wrench: Metal wrench made from a six-sided rod (hex-shaped) made to fit inside bolts or other mechanical fittings. Also known as Allen® Wrench.

High normal derailleur: See top normal derailleur.

Housing: The outer plastic and metal sheath that covers brake or derailleur cable, allowing cable to pass around corners and between moving parts of the frame.

Housing end cap (ferrule): Small metal or plastic cap that fits over end of housing.

Hub: The center of the wheel, contains bearings and an axle.

Hub brake: Braking system located at the center of the wheel inside the hub.

Hydraulic brake: A brake system that uses fluid to transmit force from the rider's hand to the brake caliper.

Hydraulic-mechanical brake: A brake system that combines hydraulic and mechanical systems.

Inch-pound: A measurement of torque used mostly in the United States.

Indexing: Shifting system that uses "clicks" or dwell to indicate each sprocket location.

Inner tube: Rubber bladder inside tire that holds air.

Innermost: Closest point relative to the centerline of the bike.

Interference fit: A method of assembly where one part is slightly larger than its intended fitting. Parts are held together by the force of assembly, and the elasticity of the component materials.

Internal headset: A headset type that uses a pressed head tube cup that allows bearings to sit inside head tube. Also called zero-stack or low-profile headset.

International Standards Organization: A group dedicated to setting standards for all industries involved in international trade, such as the bicycling industry.

ISIS Drive®: International Splined Interface System. A crank and bottom bracket spindle interface standard using 10 splines.

ISO: See International Standards Organization

Integrated headset: A headset design in which the frame acts as a holder for the bearings. Bearings are held inside head tube. Service or installation does not involve pressing cups, but uses a slip fit for the bearings.

Interference fit: Also known as a "press fit." Two parts held together by small differences between sizes so that when pushed together force is created holding them together.

Kilogram force: A force equal to a kilogram weight or a one-kilogram mass times the acceleration of gravity. Approximately equal to 2.2 pounds force.

Limit screws: Screws on front and rear derailleurs which stop the derailleurs from causing the chain to move too close to the bicycle center line or too far to the right of the centerline, either into the spokes, or causing the chain to fall off.

Linear pull brakes: A rim caliper brake with two long parallel arms secured to frame stays or fork legs. System uses housing stop in one arm, with no straddle wire cable connecting arms..

Locknut: Nut used to lock a cone, threaded race, or other threaded item to keep it from moving or unthreading.

Low normal derailleur: A rear derailleur design which, with no cable tension, the derailleur returns to the innermost (largest) sprocket position. Sometimes referred to as "low normal." Also called Rapid Rise®.

Low-profile headset: A headset that uses a pressed head tube cup that allows bearings to sit inside head tube. Also called zero-stack or internal headset.

Master link: Linkage system used to join the ends of a chain.

Maximum extension line: A line on a seat post or quill stem indicating the maximum amount the item should be raised above the frame or fork steering column. Also called the "minimum insertion line."

Maximum tooth size: The largest rear sprocket size a rear derailleur will be able to shift onto.

Mechanical disc brake: A disc brake that uses a cable system and has no hydraulic fittings.

Mineral fluid: A type of fluid, based on mineral oil, used in some models of hydraulic brakes. Does not interchange with DOT brake fluid.

Minimum insertion line: See maximum extension line.

Mountain bike: Bicycle design intended for rugged, off-road use. Also called "ATB," or all terrain bike.

MTB: See mountain bike.

Nipple: See spoke nipple.

Octalink®: Registered trademark of Shimano® Inc. for a crank and spindle interface standard using 8 splines. Octalink® includes the non-interchangeable V1 and V2 systems.

One-key release: Crank system that allows removal of the crank without a crank puller.

One-piece crank: Crank that uses a single piece of metal for the arms and spindle. Also called "Ashtabula" crank.

Outermost: Farthest position laterally from centerline of bike.

Pawl: Articulating tooth in a ratcheting system. Used commonly in freehubs and freewheels

PF: Abbreviation for "press fit." A bottom bracket design that uses a smooth bore shell with bearing or bearing adaptors installed with an interference fit.

Pipe Billet spindle: A splined bottom bracket spindle from Shimano® Inc. These cranks and spindles do not interchange with square spindles or square-holed cranks.

Press fit: See "interference fit."

Presta valve: Narrow valve system used for some inner tubes.

Pulley wheel: Small wheel on the rear derailleur that wraps the chain to prevent slack over a range of front and rear cog size combinations.

Quick-release skewer: Metal shaft and lever with cam, fitted into hollow axle. Allows easy and quick removal of wheel.

Quill stem: A type of stem that inserts and secures inside a threaded steering column, allowing a range of handlebar height adjustment.

Rapid Rise®: See low normal derailleur.

Rear derailleur: Shifting mechanism attached to the frame that moves chain from one rear sprocket to another.

Rear sprockets: The toothed cogs or gears on the rear wheel.

Repair stand: Fixture designed to hold bike while doing repairs.

Retaining compound: Liquid adhesive designed to expand and harden in press fit situations.

Rim: Metal or composite hoop suspended around hub by spokes.

Rim caliper brake: A brake system that applies force, producing friction, directly to the rim for slowing and stopping the bike.

Rim strip: Protective strip covering holes between rim and inner tube.

Rotor: Round disc plate mounted to hub for disc brake caliper.

Saddle: Support for posterior of bicyclist.

Schrader valve: Inner tube valve commonly seen on many bicycle and car tires.

Seat post: Connection between saddle and frame.

Seat tube: Frame tube connecting top tube and bottom bracket. Seat post inserts into top of seat tube.

Seat stay: Frame tube connecting rear dropout and upper portion of seat tube.

Setscrew: Small screw used primarily for adjustments. Found commonly on brake levers and caliper brakes.

Self-vulcanizing fluid: Special fluid used on an inner tube to adhere patch.

Shift lever: Control mechanism designed to pull cable and control derailleur.

Side pull brake: Caliper brake using one pivot for both arms and mounted to brake bridge above center of wheel.

Slip fit: Method of assembly where one part slides without force into its fitting.

Spanner: A term for a wrench.

Spindle: Axle for the bottom bracket.

Spider: Arms that hold the chainrings to the crank.

Splined spindle: A tubular-shaped bottom bracket axle with ends having machined notches and recesses. The splines mate to splines in the crank.

Spoke: Long thin bolt, connecting hub to rim. Threaded on one end with a hook or fitting on other end.

Spoke nipple: Nut located at threaded end of spoke.

Sprocket: Toothed gear or wheel used to connect with the chain.

Square spindle: A spindle design where the spindle ends are a square-shaped stud. Fits into a square hole in the crank.

Star nut (Star-fangled nut): A nut designed to press into the inside of the fork steering column. Nut provides method for headset bearing adjustment.

Steering column: Tubing that connects fork crown to stem.

Stem: Connector between fork and handlebars.

Straddle wire: Brake cable connecting two rim caliper arms. Found on cantilever, U-brakes, and center pull brakes.

Swedge: A shaping procedure that reduces the size of metal tubing.

Tensiometer: Tool used to determine the amount of tension in the wire spokes of a wheel.

Tension: Tensile force, pulling along the axis line of an object.

Tension meter: See tensiometer.

Threadlocker: A special adhesive designed to expand and harden in the threads of a fastener.

Thread pitch: Distance from one thread crest to the next thread crest.

Threadless stem: Stem that clamps to the outside of an unthreaded steering column.

Tire: Rubber and fabric casing which encloses the inner tube and contacts ground.

Tire bead: Wire or fabric cable molded into the tire edge. Holds tire on the rim when tire is under pressure.

Tire lever: Lever with smooth, rounded edge used to remove tire bead from rim.

Tire sealant: A liquid placed in the tire or inner tube. The purpose is to block minor leaks.

Top normal derailleur: A rear derailleur design where with no cable tension the derailleur returns to the outermost (smallest) sprocket position. Also called high normal.

Top tube: Frame tube connecting head tube to seat tube.

Torque: Force applied around an axis.

True: Refers to wheel rim spinning laterally straight and radially round.

Tubeless tire: Tire and rim system that maintains air pressure without an inner tube. Similar to automotive and motorcycle tubeless tire systems.

Twist grip: Shift lever fitted as part of handgrip that actuates shifting by rotation.

UST: "Universal System Tubeless." A bicycle industry tubeless tire standard for both wheel rim and tire bead fit.

Valve core: Mechanism in inner tube for inflating, maintaining inflation, and deflating tube.

V-brakes®: Registered trademark of Shimano® Inc. for a type of linear pull brake. Pads move on parallelogram attached to caliper arms.

Wheel: A composite component made of the rim, hub and spokes. May also include tire and tube.

Zero stack headset: A headset type that uses a pressed head tube cup that allows bearings to sit inside head tube. Also called low profile or internal headset.

Zip tie: Thin plastic locking straps used to secure most anything.

APPENDIX C: TORQUE RECOMMENDATIONS

Specifications in the table below are in Newton meters (Nm). Inch-pounds (in-lbs) are given in parentheses. Some component manufacturers do not specify torque for certain components or parts. Contact the manufacturer for the most up-to-date specifications.

TABLE C.1: Torque Recommendations

COMPONENT	TYPE	Nm	IN-LBS
Handlebars, Stem, Fork, and Headset Area			
Stem binder bolt: quill type	"Generic" range, using 7 to 8mm thread	16–18	144–168
	Shimano®	19.6–29.4	174–260
Threadless stem steering column binder bolts	Deda®	8	71
	FSA® carbon	8.8	78
	Syncros® cotter bolt type	10.1	90
	Thomson®	5.4	48
	Time® Monolink	5	48
	Race Face®	6.2	55
Handlebar binder: one- or two-bolt models	Shimano®	19.6–29.4	174–260
	Control Tech®	13.6–16.3	120–144
Handlebar binder: four-bolt faceplate models	Control Tech®	13.6–16.3	120–144
	Deda® magnesium	8	71
	Thomson®	5.4	48
	FSA® OS-115 carbon	8.8	78
	Time® Monolink	6	53
	Race Face®	6.2	55
MTB handlebar end extensions	Cane Creek®	7.9	70
	Control Tech®	16.3	144

COMPONENT	TYPE	Nm	IN-LBS
Threaded headset locknut	Chris King® GripNut™ type	14.6–17	130–150
	Tenge-Seiki®	24.5	217
Seat rail binder	Control Tech® two-bolt type	16.3	144
	Control Tech® one-bolt type	33.9	300
	Shimano®	20–30	174–260
	Syncros®	5 each bolt	44.2 each bolt
	Time® Monolink	5	44.2
	Truvativ®	M8 bolt: 22–24; M6 bolt: 6–7.1	M8 bolt: 195–212; M6 bolt: 53–63
	Campagnolo®	22	194
Seat post binder	Campagnolo®	4–6.8; **Note:** Seat posts require only minimal tightening to not slip downward. Avoid overtightening.	36–60; **Note:** Seat posts require only minimal tightening to not slip downward. Avoid overtightening.
Pedal, Crankset, and Bottom Bracket Area			
Pedal into crank	Campagnolo®	40	354
	Ritchey®	34.7	307
	Shimano®	35 minimum	309.7 minimum
	Truvativ®	31.2–33.9	276–300
Compression slotted crank pinch bolts	Shimano® Hollowtech® II	9.9–14.9	88–132
	FSA® MegaExo™	9.8–11.3	87–100
Crank adjusting cap	Shimano® Hollowtech® II	0.5–0.7	4–6
	FSA® MegaExo™	0.5–0.7	4–6
Crank bolt (including splined and square-spindle cranks)	Shimano®	34–44	305–391
	Shimano® Octalink® XTR® (M15 thread)	40.3–49	357–435
	Campagnolo®	32–38	282–336

COMPONENT	TYPE	Nm	IN-LBS
	Campagnolo® Ultra-Torque®	42	371
	FSA® M8 bolt	34–39	304–347
	FSA® M14 steel	49–59	434–521
	Race Face®	54	480
	Syncros®	27	240
	Truvativ ® ISIS Drive	43–47	384–420
	Truvativ® square spindle	38–42	336–372
	White Industries™	27–34	240–300
Crank bolt one-key release cap	Shimano®	5–6.8	44–60
	Truvativ®	12–14	107–124
Chainring cassette to crankarm (lockring)	Shimano®	50–70	443–620
Chainring bolt: steel	Shimano®	7.9–10.7	70–95
	Campagnolo®	8	71
	Race Face®	11.3	100
	Truvativ®	12.1–14	107–124
Chainring bolt: aluminum	Shimano®	5–10	44–88.5
	Campagnolo®	8	70.8
	Truvativ®	8–9	70.8–79.6
Bottom bracket: cartridge	Shimano®	49.1–68.7	435–608
	Campagnolo® (three-piece type)	70	612
	Campagnolo® Ultra-Torque® cups	35	310
	FSA®	39.2–49	347–434
	Race Face®	47.5	420
	Shimano® Hollowtech® II	34.5–49.1	305–435

COMPONENT	TYPE	Nm	IN-LBS
	Truvativ®	33.9–40.7	300–360
	White Industries™	27	240
Derailleur and Shift Lever Area			
Drop bar dual control brake/shift lever clamp bolt	Shimano® STI™	6–8	53–69
	Campagnolo®	10	89
	SRAM®	6–8	53–70
Shift lever: upright/flat bar type	Shimano®	5–7.4	44–69
Shift lever: twist grip	Shimano® Revoshift®	6–8	53–70
	SRAM®	17	150
Front derailleur clamp bolt	Campagnolo®	5	44
	Campagnolo®	7	62
	Shimano®	5–7	44.2–62
	SRAM®	4.5	39.8
	SRAM®	5–7	44–62
Rear derailleur mounting bolt	Campagnolo®	15	133
	Shimano®	8–10	70–86
	SRAM®	8–10	70–86
Rear derailleur cable pinch bolt	Shimano®	5–7	44–60
	Campagnolo®	6	53
	SRAM®	4–5	35.4–44.2
Rear derailleur pulley wheel (idler wheel) bolt	Shimano®	2.9–3.9	27–34
Wheel, Hub, and Rear Cog Area			
Spoke tension torque	—	Torque typically not used in wheels. Spoke tension is measured by deflection. Contact rim manufacturer for specific tension recommendations.	
Wheel quick-release	—	Measured torque not typically used. Common industry practice is resistance at lever half way through swing from open to fully closed.	
Wheel axle nuts to frame	Shimano®	29–44	260–390
	SRAM®	30–39.5	266–350
Cassette sprocket lockring	Shimano®	29.4–49	260–434

COMPONENT	TYPE	Nm	IN-LBS
	Campagnolo®	50	442
	SRAM®	40	354
Hub cone locking nut	Bontrager®	17	150
	Chris King®	12.2	100
	Shimano®	9.8–24.5	87–217
Freehub body	Bontrager®	45	400
	Shimano®	35–50	305–434
	Shimano® XTR® using 14 mm hex	45–50	392–434
Disc Brake Systems			
Disc rotor to hub: center lock type	Shimano®	40	350
	Avid®	40	350
Disc rotor to hub (M5 bolts, six per rotor)	Shimano®	2–4	18–35
	Hayes®	5.6	50
	Avid®	6.2	55
	Magura®	3.8	34
Caliper body mount	Avid®	9–10.2	80–90
	Magura®	5.7	51
	Shimano®	6–8	53–69
	Hayes®	12.4; with Manitou® forks, 9	110; with Manitou® forks, 80
	Tektro®	6–8	53–69
Caliper body mount/ Flat Mount	Shimano®	6–8	53–69
	SRAM®	5	44
Hydraulic hose fittings	SRAM®	8	71
	Shimano®	5–6	44–53
Brake Caliper and Lever Area			
Upright bar brake levers	Shimano®	6–8	53–69
	Avid®	5–7	44–62
	Campagnolo®	10	89
Brake caliper mount to frame: side-pull, dual-pivot, center-pull	Cane Creek®	7.7–8.1	68–72
	Shimano®	7.8–9.8	70–86
	Tektro®	8–10	69–89

COMPONENT	TYPE	Nm	IN-LBS
	Campagnolo®	10	89
Linear-pull or cantilever caliper mount to frame	Avid®	4.9–6.9	43–61
	Control Tech®	11.3–13.6	100–120
	Shimano®	8–10	69–89
	SRAM®	5–6.8	45–60
	Tektro®	6–8	53–69
Brake pad: threaded stud	Avid®	5.9–7.8	53–69
	Campagnolo®	8	71
	Cane Creek®	6.3–6.7	56–60
	Tektro®	5–7	43–61
	Shimano®	5–7	43–61
	SRAM®	5.7–7.9	50–70
Brake pad: smooth stud	Shimano®	7.9–8.8	70–78
Brake cable pinch bolt: linear-pull and cantilever	Control Tech®	4.5–6.8	40–60
	Shimano®	6–7.8	53–69
	SRAM®	5.6–7.9	50–70
	Tektro®	6–8	53–69
Brake cable pinch bolt: side-pull and dual-pivot	Campagnolo®	5	44
	Cane Creek®	7.7–8.1	68–72
	Mavic®	7–9	62–80
	Shimano®	6–8	53–69
	Tektro®	6–8	53–69
Side-pull and dual-pivot brake pad bolts	Cane Creek®	6.3–6.7	56–60
	Shimano®	6–8	53–69
	Campagnolo®	8	72
	Tektro®	5–7	43–61

The chart below is a quick conversion between inch-pounds, foot-pounds, and Newton-meters. For exact figures, use the formulas below.

- *in-lb = ft-lbs x 12*
- *in-lb = Nm x 8.851*

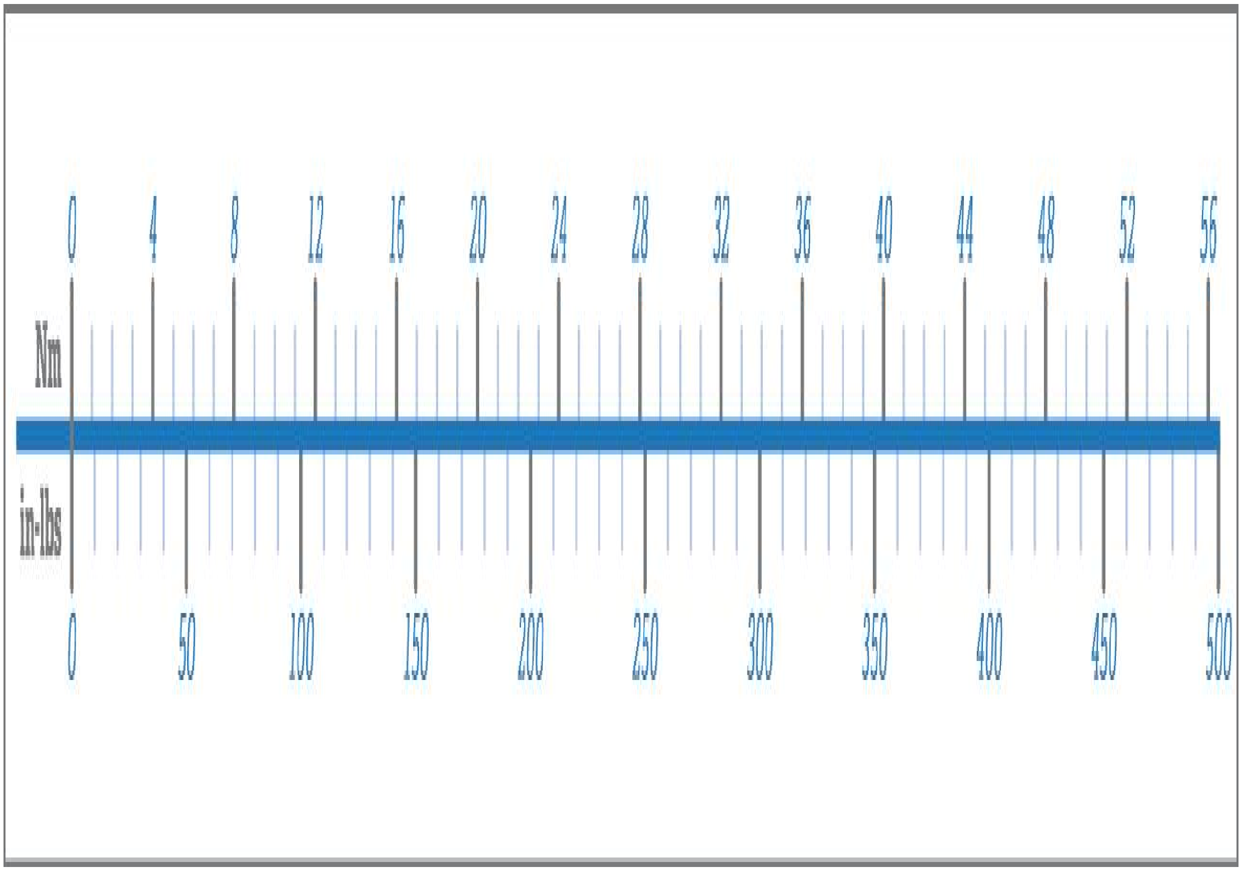
• *in-lb = kgf-cm x 0.87*

TABLE C.2: Torque Conversion
*Approximate values

IN-LBS	FT-LBS*	Nm*
10	0.8	1.1
20	1.7	2.3
30	2.5	3.4
40	3.0	4.5
50	4.2	5.6
60	5.0	6.8
70	5.8	7.9
80	6.7	9.0
90	7.5	10.2
100	8.3	11.3
110	9.2	12.4
120	10.0	13.6
130	10.8	14.7
140	11.7	15.8
12.5	12.5	16.9
13.3	13.3	18.1
170	14.2	19.2
180	15.0	20.3
190	15.8	21.5
200	16.7	22.6
210	17.5	23.7
220	18.3	24.9
230	19.2	26.0
240	20.0	27.1
250	20.8	28.2
260	21.7	29.4
270	22.5	30.5
280	23.3	31.6

IN-LBS	FT-LBS*	Nm*
290	24.2	32.8
300	25.0	33.9
310	25.8	35.0
320	26.7	36.2
330	27.2	37.3
340	28.3	38.4
350	29.2	39.5
360	30.0	40.7
370	30.8	41.8
380	31.7	42.9
390	32.5	44.0
400	33.3	45.2
410	34.2	46.3
420	35.0	47.5
430	35.8	48.6
440	36.7	49.7
450	37.5	50.8
460	38.3	52.0
470	39.2	53.1
480	40.0	54.2
490	40.8	55.4
500	41.7	56.5

TORQUE CONVERSION SCALE



APPENDIX D: BOTTOM BRACKET TOOL SELECTION

This is a table of threaded bottom brackets and thread-thru bottom bracket adaptors and the appropriate tool. The list of example brands and models is not exhaustive because new models are always being brought to market. Measure the outside diameter of the adaptor, cup, or lockring. Count the number of spline or notches and refer to the sizing and tools in the table below. Outside diameters are nominal measurements.

TABLE D.1: Threaded Bottom Bracket Tool Selection

COMPONENT INTERFACE DESC.	NOM. DIAM.	BRAND/ MODEL EXAMPLES	PART IMAGE	PARK TOOL OPTIONS	PARK TOOL MODEL NUMBER
20 internal splines	31.5mm ID	Cartridge type Shimano®, Race Face®, FSA®			Park Tool BBT-22 or BBT-32
16-notch	44mm OD	Shimano® Hollowtech® II, Campagnolo®, Race Face®, FSA®, Truvativ®			Park Tool BBT-9 or BBT-69.2
16-notch	41mm OD	Shimano® Ultegra® SM-BBR60 XT® BB-MT800			Park Tool BBT-59.2
16-notch	39mm OD	Shimano® DuraAce® BB9000 XTR® BB91			Park Tool BBT-49.2
16-notch	49mm OD	FSA® 386 MegaEvo®, Wheels Mfg™			Park Tool BBT-27.2
12-notch	46mm OD	Race Face Cinch®			Park Tool BBT-79
12-notch	48mm OD	Praxis® M30			Park Tool BBT-35
36- (or 18) notch	51.7mm OD	Praxis® M35			Park Tool BBT-35

COMPONENT INTERFACE DESC.	NOM. DIAM.	BRAND/ MODEL EXAMPLES	PART IMAGE	PARK TOOL OPTIONS	PARK TOOL MODEL NUMBER
16-notch	52.2mm OD	Enduro® TorqTite®			Park Tool BBT-47
12-notch	50.4mm OD	Chris King® T47			Park Tool BBT-47
6-notch	43mm OD	Campagnolo® Veloce®, Mirage®, Xenon®			Park Tool BBT-4
8-notch	43.4mm OD	Bontrager®, Truvativ®, Shimano®			Park Tool BBT-18
12-spline	23mm ID	Campagnolo® Record®, Chorus®, Centaur® square spindle			Park Tool BBT-5/FR-11
3- or 6-notch	44–46mm OD	Lockring of various brands of adjustable bottom brackets			Park Tool HCW-5
2 flats	36mm across flats	Adjustable BB, right-side cup			Park Tool HCW-4
2, 4, 6 or 8 hole	3mm diam.	Various adjustable bottom bracket left-side cups			Park Tool SPA-1

APPENDIX E: HEADSET STANDARDS

The three tables below refer to the different headset standards now seen on bicycles. The common legacy names are listed as well as the new SHIS system (Standard Headset Information System). Table E.1 refers to the bicycle head tube and gives the cup or bearing outside diameter (OD) as well as the frame bore or inside diameter (ID). Table E.2 gives the fork column top standards for both threaded and threadless forks. Table E.3 gives the fork race seat standards.

Use a caliper to measure the old parts and or frame when replacing the headset. Look for the SHIS listing on new replacement headsets.

TABLE E.1: Head Tube Standards

TYPE	LEGACY NAME	SHIS NAME	CUP/ BEARING OD (mm)	BORE ID (mm)
External cup: Beyond head tube	1-inch JIS pressed cup	EC29	30.0	29.80–29.90
	1-inch Pro pressed cup	EC30	30.2	30.00–30.15
	1-inch BMX standard (old)	EC33	32.8	32.60–32.70
	1 1/8-inch pressed cup	EC34	34.0	33.80–33.95
	1 1/4-inch pressed cup	EC37	37.0	36.80–36.95
	External cup (rare)	EC38	38.0	37.90–37.95
	External cup in the 44 standard	EC44	44.0	43.90–43.95
	1.5-inch pressed cup	EC49	49.7	49.55–49.60
	1.5-inch pressed cup	EC56	56.0	55.90–55.95
Semi-integrated, internal, ZS: Bearing level or below head tube	1-inch semi-integrated	ZS41	41.5	41.35–41.40
	1 1/8-inch semi-integrated	ZS44	44.0	43.90–43.95
	1 1/2-inch semi-integrated	ZS49	49.7	49.55–49.65
	1 1/2-inch semi-integrated (rare)	ZS55	55.0	54.90–54.95
	1 1/2-inch semi-integrated	ZS56	56.0	55.90–55.95
Integrated: Bearing stop built into frame	1-inch IS (Cane Creek®)	IS38	38.0	38.15–38.25
	1 1/8-inch IS (Cane Creek®)	IS41	41.0	41.10–41.20
	1 1/8-inch Italian (hiddenset)	IS42	41.8	41.95–42.05
	1 1/4-inch integrated (lower only)	IS47	47.0	47.05–47.10
	1 3/8-inch IS (lower only)	IS49	49.0	49.10–49.20
	1 1/2-inch IS (lower only)	IS52	52.0	52.10–52.15

TABLE E.2: Steering Column Top Standards

LEGACY NAME	SHIS NAME	OD (W/ TPI)
1-inch French threaded	25.0mm x 1.0	25.0mm x 1.0
1-inch threaded	25.4mm x 24 tpi	25.4mm x 24 tpi
1-inch threadless	25.4mm	25.4mm
1 1/8-inch threaded	28.6mm x 26 tpi	28.6mm x 26 tpi
1 1/8-inch threadless	28.6mm	28.6mm
1 1/4-inch threaded	31.8mm x 26 tpi	31.8mm x 26 tpi
1 1/4-inch threadless	31.8mm	31.8mm
1 1/2-inch threadless	38.1mm	38.1mm

TABLE E.3: Fork Race Standards

LEGACY NAME	SHIS NAME	FORK SEAT OD (mm)	CROWN RACE ID (mm)
1-inch JIS	27	27.1	27.0
1-inch Pro or “euro”	26	26.5	26.4
1 1/8-inch threaded/threadless	30	30.1	30.0
1 1/4-inch threaded/threadless	33	33.1	33.0
1 3/8-inch integrated race	—	—	—
1 1/2-inch with pressed races	40	40.0	39.9

APPENDIX F: BIKE MAP