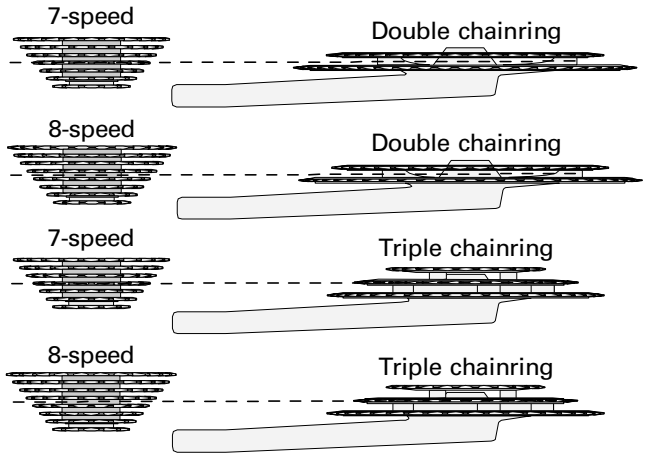
27 – CHAINLINE

ABOUT THIS CHAPTER

This chapter is about chainline. Chainline is the alignment between the chainrings and the rear cogs. By centering the rear cogs to the center of the chainring set, the chain will experience the minimum lateral deflection as it is used in all the possible gear combinations. The benefits of minimizing chain deflection are less drive-train noise, less drive-train wear, and better shifting.



27.1 *Examples of perfect chainline.*

Chainline is different from other aspects of bicycle mechanics. If two out of five indications point to a bottom bracket needing an overhaul, it would be prudent to overhaul the bottom bracket. The same applies to adjusting a derailleur, truing a wheel, or just about any other procedure; however, it is not prudent to adjust chainline if it is uncertain that there is a problem. The difference is that chainline error is difficult to measure accurately and extremely complicated to correct. Most bikes are quite tolerant of some chainline error, so it is a big mistake to measure for chainline error and then correct it only because a quantifiable error exists. Unlike other procedures in this book, the procedure in this chapter starts with an inspection to determine whether any significant symptoms exist, and only goes further if symptoms are detected. Arbitrary correction of any detectable chainline error is usually a mistake!

GENERAL INFORMATION

TERMINOLOGY

Chainline: The alignment between the rear cogset and the front chainring set (see figure 27.1).

Rear-cogset center: The point halfway between the innermost and outermost cogs. If the cogset has five cogs, the center is the third cog from either end. If the cogset has six cogs, the center is the third space between cogs, counting from either end. If the cogset has seven cogs, the center is the fourth cog, counting from either end. If the cogset has eight cogs, the center is the fourth space between cogs, counting from either end. (See figure 27.1)

Chainring-set center: The center of the chainring set is the point halfway between the innermost and outermost chainrings. If there are two chainrings, the center is the center of the space between the two chainrings. If there are three chainrings, the center is the center of the middle chainring. (See figure 27.1)

***Chainrings-out* error:** When there is an error in chainline, it could be because the chainrings are too far out from the center of the bike compared to the freewheel. This could be called either *chainrings-out* error or *rear-cogs-in* error. Although they are the same thing, *chainrings-out* error is used because chainline adjustments are easier to make by moving the chainrings than by moving the rear cogs.

***Chainrings-in* error:** When there is an error in chainline, it could be because the chainrings are too far in toward the center of the bike compared to the freewheel. This could be called either *chainrings-in* error or *rear-cogs-out* error. Although they are the same thing, *chainrings-in* error is used because chainline adjustments are easier to make by moving the chainrings than by moving the rear cogs.

Lateral deflection (of chain): The twist of the chain (in or out) that occurs when the chain goes from a chainring to a rear cog that is not directly in line with the chainring. Lateral deflection increases chain friction, wear, and noise.

PREREQUISITES

There are no prerequisites to determine whether there is a chainline error, what direction it is, and what size the error is. Correcting chainline can include moving the chainrings, moving the freewheel, and aligning the rear triangle of the frame. Each of these general procedures can require several more specific procedures, which are outlined below.

Crank-arm removal

In order to correct a chainline error, it may be necessary to replace a bottom bracket or bottom-bracket spindle. Crank-arm removal is necessary to perform these procedures.

Bottom-bracket overhaul

In order to correct a chainline error, it may be necessary to replace a bottom bracket or bottom-bracket spindle.

Front-derailleur adjustment

If the chainrings are moved in or out to correct a chainline error, the front derailleur will need to be re-adjusted.

Freewheel removal

In order to correct a chainline error, it may be necessary to move the freewheel in or out. This is done by changing the spacers on the hub axle. To overhaul the hub and change the spacers, it will be necessary to remove the freewheel. If the hub is a freehub, then go directly to hub overhaul without removing anything in regard to the rear cogs.

Hub overhaul

In order to move the freewheel in or out, it may be necessary to re-space the hub axle, requiring a hub overhaul.

Rear-derailleur adjustment

If the freewheel is moved in or out to correct a chainline error, it will be necessary to re-adjust the rear derailleur.

Wheel truing

If re-spacing the hub, then the wheel may require re-dishing.

Rear-triangle alignment

A chainline error is often caused by a misalignment of the rear triangle. Although an alignment problem can be compensated for by moving the chainrings or rear cogs, the ideal place to start is by correcting any rear-triangle-alignment error. If this is not done and the chainline error is corrected by other means, then when the rear triangle gets aligned later for other reasons, the chainline could be lost. Frame alignment can only be done with steel frames. With titanium, aluminum, and carbon-fiber frames, the first choice of chainline-error correction should be moving the chainrings. If repositioning the chainrings does not solve the problem, then change the chainline by moving the freewheel.

If re-spacing a hub to move the freewheel to fix a chainline error, it is possible that the overall hub width will change, and it will no longer fit the frame. In this case, frame alignment would also be needed.

INDICATIONS

Chainline does not have to be perfect, so measuring chainline just for the sake of preventative maintenance is not recommended. Think about chainline only when there are symptoms that indicate chainline error, or when making a change to a bike that can introduce chainline error.

There are a great number of changes that can be made to a bicycle that can introduce symptoms of chainline error. Each time a change is made in one of the following areas, operate the bike and observe whether any symptoms of chainline error have developed.

Change: New crankset

Whether the crankset is going on an existing bottom bracket or comes with a new bottom bracket, there is no way to know whether the chainring position will be the same until after installation. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New right crank arm

If replacing the right crank arm with one that is not identical, it may move the position of the chainrings. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New bottom bracket

If replacing the bottom bracket with one that is not identical, it may move the position of the chainrings. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New or reversed bottom-bracket spindle

If replacing the bottom-bracket spindle with one that is not identical, or just reversing an old one to improve the chainring or crank-arm clearance, it may change the position of the chainrings. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New rear wheel

If replacing the rear wheel with one that is not identical, then the wheel may move the rear cogs further out or in. If the position of the rear cogs from the frame is different, check whether chainline-error symptoms have developed.

Change: New freewheel or freehub body with different number of cogs

Anytime the number of rear cogs is changed, there is a new center to the cogset. Check whether chainline-error symptoms have developed.

Change: New spacing on rear hub

If changing the spacing on the rear axle to change the fit of the wheel to the frame, or to accommodate a different freewheel or freehub body, or to correct a clearance problem between the outermost rear cog and the frame, the position of the rear-cogset center will change. Check whether chainline-error symptoms have developed.

Change: New chain

As chains wear, they develop greater lateral flexibility. The degree of lateral flexibility differs from one model of chain to another. A chain's lateral flexibility determines to what degree certain amounts of chainline error will be tolerated. Check whether chainline-error symptoms have developed after installing a new chain.

Change: New rear-derailleur pulley wheels or new rear derailleur.

One of the symptoms of chainline error is that the chain derails from the lower derailleur pulley wheel. Different pulley wheels engage the chain in varying degrees of effectiveness. Anytime pulley wheels are changed, on an old derailleur or by installing a new derailleur, check whether chainline-error symptoms have developed.

Change: Newly aligned frame rear triangle

If changing the rear-triangle alignment to fix a tracking error, or to have it fit the rear wheel differently, it will move the center of the rear cogset. Check whether chainline-error symptoms have developed.

Symptom: Chain derails to outside of lower rear-derailleur pulley wheel only in certain gear combinations.

This symptom, which is one of the most likely symptoms resulting from the chainrings being too far out relative to the rear cogs, is most likely to occur when the chain is on an outer chainring in front and one of the inner rear cogs. If it only happens when back pedaling and self-corrects when pedaling forward, ignore it. If significant chainline error cannot be found after experiencing this symptom, it could be caused by an incompatibility between the chain and pulley wheel, an alignment error to the rear-derailleur hanger, or damage to the rear derailleur that affects the alignment of the rear-derailleur cage.

Symptom: Chain makes popping or snapping sound as it feeds onto a chainring only in certain gear combinations.

This *chainrings-out* symptom is most likely to occur when the chain is on an outer chainring in front and one of the inner rear cogs. If it goes away when shifting the chain further out on the rear cogs and there is an identifiable chainline error, then it is fair to assume the problem is chainline. If significant chainline error cannot be found after experiencing this symptom, it could be caused by a low-quality chain or chainring.

Symptom: While shifting, chain derails to inside of chainrings, and front derailleur cannot be adjusted to eliminate problem.

This *chainrings-out* symptom requires a very severe chainline error on the average bike, but road-racing bikes with eight-speed cogsets can be very sensitive to this error and may exhibit this symptom even when the error is not large. The symptom generally occurs when the chain is on the innermost rear cog and shifting the front derailleur to put the chain on the innermost chainring. Because this symptom can be caused by poor derailleur alignment and limit-screw settings, first check the derailleur adjustment. If the derailleur cannot be adjusted to eliminate the symptom without introducing the symptom where the chain is hesitant to shift to the innermost chainring (or rubs the chain after the shift), then chainline is likely to be the cause. With some of the eight-speed road-racing bikes, the symptom will not go away until the front-derailleur cage is modified to make it wider at the tail.

Symptom: While pedaling, chain derails to inside of chainrings.

The symptom generally occurs when the chain is on the innermost rear cog and the middle or innermost chainring. It is most likely to occur when the chain is under high load, or when pedaling very fast (low load) and the chain is bouncing (due to rough

terrain or choppy pedaling style). It is less likely to occur with the bike in the stand, but will happen particularly at high pedaling speeds.

Symptom: Chain derails to inside of lower rear-derailleur pulley wheel only in certain gear combinations.

This symptom, which is one of the most likely symptoms resulting from the chainrings being too far in, relative to the rear cogs, is most likely to occur when the chain is on an inner chainring in front and one of the outer rear cogs. If it only happens when back pedaling and self-corrects when pedaling forward, ignore it. If significant chainline error cannot be found after experiencing this symptom, it may be caused by an incompatibility between the chain and pulley wheel, an alignment error to the rear-derailleur hanger, or damage to the rear derailleur that affects the alignment of the rear-derailleur cage.

Symptom: Chain rubs against adjacent rear cog only in certain gear combinations.

This *chainrings-in* symptom is most likely to occur when the chain is on an inner chainring and one of the outer rear cogs. If this symptom is caused by incorrect spacing between rear cogs or use of a wide chain with narrow-spaced cogs, it will not go away when the chain is shifted to an outer chainring.

Symptom: Chain rubs against adjacent chainring only in certain gear combinations.

This *chainrings-in* symptom is most likely to occur when the chain is on an inner chainring in front and one of the outer rear cogs. If the chainrings have been recently installed on the crank arm, then spacers may be out of place. If the chainrings and crank arm did not come together as a set, they may be incompatible.

TOOL CHOICES

There is one tool, the Park CLG-2, that is not recommended due to limitations of its accuracy and limited conditions in which it fits well.

There are two alternate procedures for measuring chainline in this chapter. The first (pages 27-6 through 27-7) requires the following tools. None of them are bicycle-specialty tools.

- Caliper
- Quick Grip clamp (hardware stores or United Bicycle Tool)
- 2' long 3/8" square bar stock (hardware store)

The square bar stock is used as a straight edge. A conventional straight edge made from flat stock (like a ruler) will not work. Instead of a solid bar stock, square tubing may be used. The stock or tubing may be 1/2" instead of the preferred 3/8" size.

The alternate procedure (page 27-13) uses a new tool, the Stein CLC-1. The procedure utilizing this tool is both easier and more accurate than the first procedure.

Another tool used in the procedure is the Park FAG-2. This tools is used to measure the rear-triangle alignment of the frame. It is a recommended tool in the chapter **FRAME AND FORK ALIGNMENT AND DAMAGE**.

TIME AND DIFFICULTY

Chainline-error inspection

It only takes a couple of minutes to put the bike in a stand and run it through all the gear combinations to see if there are any symptoms. There is no difficulty.

Chainline-error identification

Measuring chainline error takes only 3–5 minutes. The job has moderate difficulty.

Chainline-error correction

All the difficulty with chainline comes with correction. At the minimum, chainline correction is a matter of overhauling a bottom bracket to reverse the spindle or put in a different one. With crank-arm removal and installation and re-adjustment of the front derailleur, this could easily be a 45–60 minute job of moderate to high difficulty. It may be necessary to overhaul the rear hub to re-space the rear axle, and that will also require rear-derailleur adjustment and re-dishing the rear wheel. This could be 75–100 minute and the difficulty would be high. Neither of these options includes alignment of the rear triangle, which could add an additional 15–30 minutes.

COMPLICATIONS

Chainrings will not move far enough

In some cases, there may not be a long enough bottom-bracket spindle available to move the chainrings out far enough to correct the chainline error. In other cases, in order to move the chainrings in far enough to correct the chainline error, the chainrings or crank arm might end up rubbing against the frame. In all these cases, after correcting chainline at the chainrings as far as is possible, the chainline correction needs to be continued by changing the rear-cogset position (which could include hub re-spacing, wheel dishing, and frame alignment).

Poor frame alignment is causing the problem, but frame cannot be aligned

Non-steel frames and many full-suspension frames cannot be aligned. This limits correction to moving the chainrings and shifting spacers from one side of the hub to the other in order to move the cogset.

Moving chainrings solves chainline symptom, but front derailleur will not adjust to new position

If the chainrings end up too far out or too close in, the front derailleur may have difficulty shifting to the innermost or outermost chainring. In this case, the derailleur may need to be changed, or the chainrings moved less and additional chainline correction done at the rear cogs.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into five parts. The first three parts are procedures that are combined together. In order, the procedures are inspecting for chainline-error symptoms, measuring chainline error, and determining a course of action for chainline-error correction. After determining the course of action to be taken, refer to the appropriate chapters for crank-arm removal, bottom-bracket service, and front-derailleur adjustment; or hub overhaul, wheel dish, and rear-derailleur adjustment. The fourth part of this chapter is a troubleshooting chart. The fifth part is an alternate procedure for measuring chainline.

CHAINLINE-ERROR INSPECTION, MEASUREMENT, AND CORRECTION

INSPECTING FOR CHAINLINE-ERROR SYMPTOMS

It is unnecessary and not recommended to correct chainline error unless there is a symptom indicating one exists. Do not skip the steps to determine if symptoms exist unless already experiencing one of the symptoms, or troubleshooting in another chapter has led you to this chapter to correct a chainline error.

Any of these symptoms can be caused by something other than a chainline error. After determining the symptom exists, identify if a significant error exists in a direction that is consistent with the symptom. If this cannot be done before correcting any chainline error, check and correct any other possible causes of the symptom(s).

NOTE: If symptom indicating chainrings-out or chainrings-in error is already known, skip to step 7.

1. **[ ] Shift chain onto outermost chainring and innermost rear cog and pedal fast, then slow, and observe whether chain rides off of lower pulley wheel of rear derailleur. If yes, go to MEASURING CHAINLINE ERROR and check for *chainrings-out* error.**
2. **[ ] Shift chain onto outermost chainring and innermost rear cog and pedal slow, and observe whether chain side-plates catch on top of chainring teeth before chain rollers settle between teeth. If yes, go to MEASURING CHAINLINE ERROR and check for *chainrings-out* error.**

If a chain refuses to shift down to the innermost chainring without jumping off all the way to the bottom-bracket shell, chainline error can be the culprit. This is tested for in step #3. It can also be caused by poor front-derailleur adjustment, including inner-limit screw too loose (allowing to much inward travel of the front derailleur) and poor rotational alignment of the front derailleur. This symptom has been experienced on road-racing bikes with eight-speed rear cogsets where the derailleur adjustments and chainline were good. In this case, the only solution is to deform the front-derailleur cage so that its tail end is 2–3mm wider, and then re-adjust the rotation and limit screws of the front derailleur.

Because this next symptom can't even be considered as a chainline-error symptom unless all these front-derailleur considerations are eliminated, attempt everything possible with the front derailleur before performing the test in step #3.

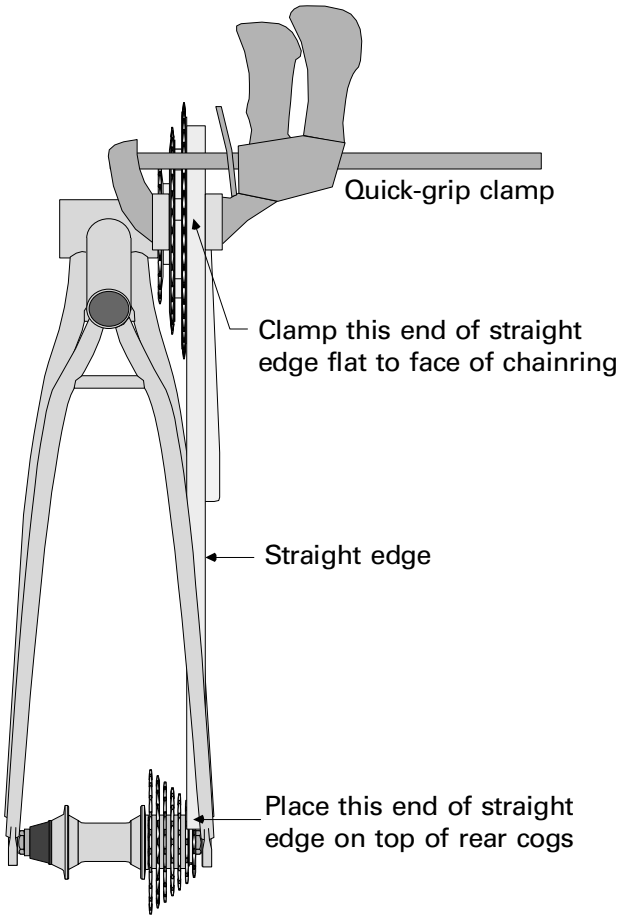
3. **For this next test, it is important that front derailleur be in known good adjustment.**
   [ ] Shift chain onto innermost rear cog and innermost chainring and check that inner plate of front-derailleur cage clears inner face of chain by ≤1mm.
   [ ] Shift chain onto next chainring outward.
   [ ] Shift chain back to inner chainring and observe whether chain drops past chainring and onto bottom-bracket shell. If yes, go to MEASURING CHAINLINE ERROR and check for *chainrings-out* error.

4. [ ] **Shift chain onto outermost rear cog and innermost chainring and pedal fast, then slow, and observe whether chain rides off of lower pulley wheel of rear derailleur. If yes, go to MEASURING CHAINLINE ERROR and check for *chainrings-in* error.**
5. [ ] **Shift chain onto outermost rear cog and innermost chainring and pedal slow, and observe whether chain rubs against the next rear cog. If yes, go to MEASURING CHAINLINE ERROR and check for *chainrings-in* error.**
6. [ ] **Shift chain onto outermost rear cog and innermost chainring and pedal slow, and observe whether chain rubs against the next front chainring. If yes, go to MEASURING CHAINLINE ERROR and check for *chainrings-in* error.**

MEASURING CHAINLINE ERROR

7. [ ] **Shift chain to any middle cog in rear, and drop chain off inside of innermost chainring.**

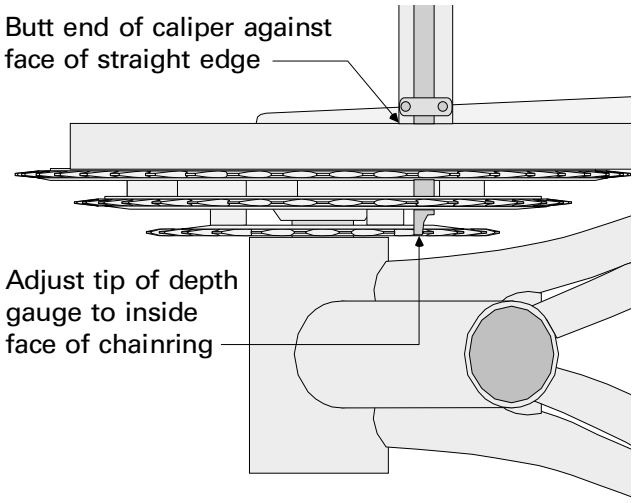
Attaching the straight edge



27.2 Attaching the straight edge to the outer chainring with a Quick Grip clamp.

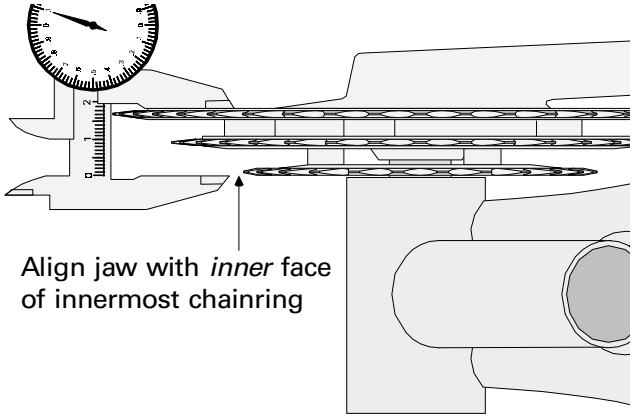
The following procedure is only as accurate as the outer chainring is straight. Every effort should be made to align the outer chainring as straight as possible before measuring the chainline error (chainring alignment is described in the **TAPER-FIT CRANK ARMS** chapter [page 20-10] and the **CHAINRINGS** chapter [page 23-12]). Most chainrings have a reasonably flat outer face; chainrings that have bumps and protrusions on their face will make this procedure less accurate. The straight edge needs to be clamped against the face of the outer chainring near the top, and the left end of the straight edge should extend back as far as possible without encountering resistance from the seat stay or dropout (see figure 27.2).

8. [ ] **Attach straight edge against outer face of outermost chainring so that end of straight edge stops just short of rear dropout, and straight edge goes across face of chainring at whatever point enables straight edge to sit flat.**
9. [ ] **Use caliper to measure from outside face of straight edge to inside face of innermost chainring and record here: _____mm**



27.3 Measure from outer face of straight edge to inner face of innermost chainring.

In the next step, use the long jaws of the caliper to measure from the outside face of the outermost chainring to the inside face of the innermost chainring. Take care to hold the calipers perpendicular to the plane of the chainrings.

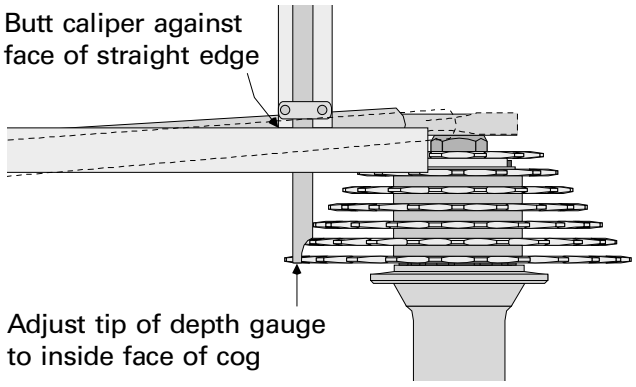


27.4 *Measure from the outside face of the outermost chainring to the inside face of the innermost chainring with calipers.*

10. [ ] Measure width of chainring set with caliper from outer face of outer chainring to inner face of inner chainring, then record here and divide by 2: width: _____ ÷ 2 = _____mm

11. [ ] Subtract result at end of step 10 from step 9 and record sum here:
FRONT CENTER FACTOR = _____mm

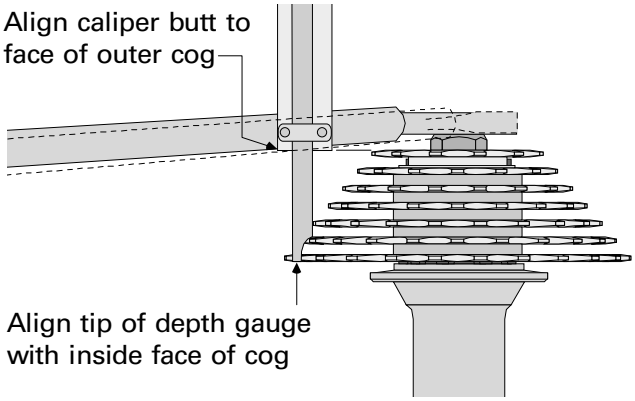
In the next step, use the depth gauge of the caliper to measure from the outside face of the straight edge to the inside face of the innermost rear cog. Take care to hold the calipers perpendicular to the plane of the cogs.



27.5 *Measure from the face of the straight edge to the inside face of the innermost rear cog with calipers.*

12. [ ] Use caliper to measure from outside face of straight edge to inside face of innermost rear cog and record here: _____mm

In the next step, use the depth gauge of the caliper to measure from the outside face of the outermost rear cog to the inside face of the innermost rear cog. Take care to hold the calipers perpendicular to the plane of the cogs.



27.6 *Measure from the face of the outermost rear cog to the inside face of the innermost rear cog with calipers.*

13. [ ] Measure width of rear cogset with caliper from outer face of outer cog to inner face of inner cog, then record here and divide by 2: width: _____ ÷ 2 = _____mm

14. [ ] Subtract result at end of step 13 from step 12 and record sum here:
REAR CENTER FACTOR = _____mm

15. [ ] Repeat FRONT CENTER FACTOR from step 11 here: – _____mm

The sum in step #16 may end up as a positive or negative number. If the number is positive, then the chainrings are further out from the bike center than the rear cogset. Chainline-error symptoms consistent with a *chainrings-out* condition might be fixed by correcting the problem, unless the error is insignificant (less than 1mm). If the number is negative, then the chainrings are closer in to the bike center than the rear cogset. Chainline-error symptoms consistent with a *chainrings-in* condition might be fixed by correcting the problem, unless the error is insignificant (less than 1mm).

16. [ ] Subtract step 15 from step 14:
CHAINLINE ERROR = _____mm

DETERMINING COURSE OF ACTION FOR ERROR CORRECTION

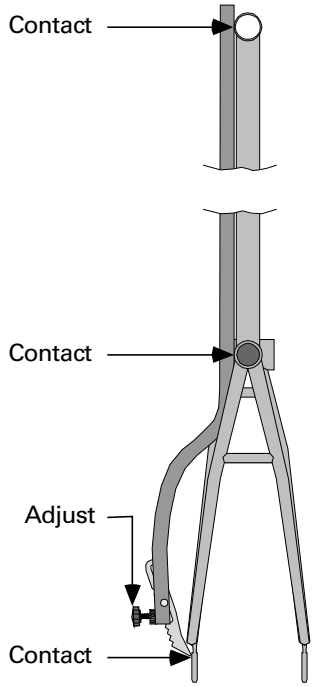
If frame will not be aligned

If not intending to align the frame, even if there is an error, then skip to step #23. This may be because the frame is not steel or because the shop does not align frames.

Measuring rear-triangle-alignment error

The procedure in steps #17–#22 is an abbreviated procedure for checking rear-triangle alignment. In the **FRAME AND FORK ALIGNMENT AND DAMAGE** chapter there is a detailed procedure and diagrams of this process (page 8-5). It is strongly recommended that you be familiar with rear-triangle alignment before performing steps #17–#22. These steps are also mentioned in the **PREREQUISITES** section of this chapter (page 27-2).

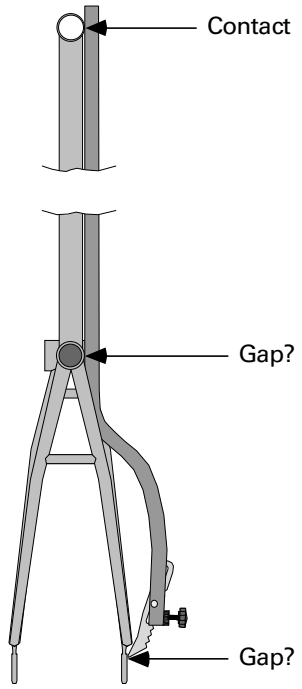
When measuring the rear-triangle-centering error, there will be a measurement that tells the difference in one dropout position relative to the central plane of the bike compared to the other dropout's position relative to the central plane of the bike. This measurement will be arrived at by measuring the gap between the adjustable tip of the tool and the face of a dropout. Whatever the gap is, the cogs will move by one half the amount of the gap when the rear triangle is aligned perfectly. If the gap is found at the right dropout, the rear cogs will move to the right. If the gap is at the left dropout, the rear cogs will move to the left.



27.7 This drawing shows the initial set up of the FAG-2 on the left side of the bike.

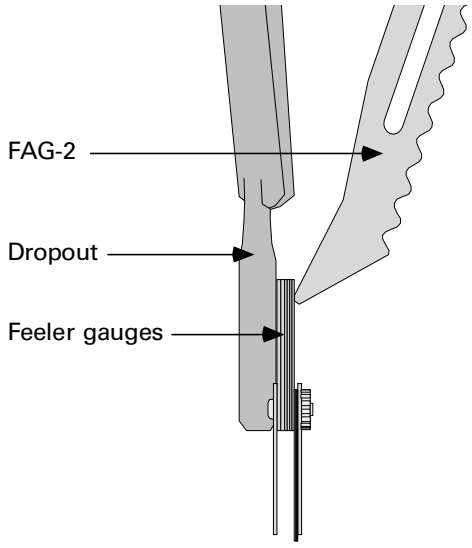
17. [ ] Place long flat section of Park FAG-2 against left side of head tube and seat tube so that adjustable tip is overlapping face of rear dropout, and adjust tool tip so that it gently contacts dropout face.

It is arbitrary which side to start on when using the FAG-2 tool, but the procedure starts on the left. If the rear triangle is off-center to the left, then it will show up as a gap at the right dropout. If the rear triangle happens to be off to the right, then a gap will show up at the seat tube on the right side. In this case, since the error cannot be quantified at this point, it will be necessary to reset the tool on the right so that the gap will show up at the left dropout.



27.8 Transfer the tool to the right side of the frame, check whether there is a gap, and check whether it is at the seat tube or dropout.

18. Transfer FAG-2 to right side of bike and observe whether:
[ ] Tool contacts simultaneously at head tube, seat tube, and right rear dropout face. There is no rear-triangle-centering error.
[ ] Tool contacts at head tube and right rear dropout and has gap at seat tube. There is some rear-triangle-centering error and adjusting tip must be set so that tool contacts at three points on right side, then transferred to left so error can be measured at left rear dropout. Check third part of this step also.
[ ] Adjustable tip shows gap at rear dropout face (either). With stack of feeler gauges or caliper, measure gap between tip of FAG-2 and dropout face and record here: _____mm *left side?* or *right side?* (circle one).



27.9 When a gap at the dropout is found, measure the gap with feeler gauges.

19. [ ] If measurement in step 18 is ≤2mm, the effect of rear-triangle alignment on chainline error would be negligible. Leave rear triangle as is and skip to step 24.

20. [ ] If gap is between FAG-2 adjustable tip and *right* dropout face, correcting rear triangle will move rear cogset *out* by half amount of gap recorded in step 18. This would have same effect as moving chainrings *in* by same amount.

21. [ ] If gap is between FAG-2 adjustable tip and *left* dropout face, correcting rear triangle will move rear cogset *in* by half amount of gap recorded in step 18. This would have same effect as moving chainrings *out* by same amount.

22. [ ] If rear-triangle-alignment error is significant and frame is steel, consider aligning rear triangle before doing any other chainline-error corrections.

23. [ ] If rear triangle has been aligned after discovering chainline error, repeat steps 1–16 to determine if symptoms remain and amount and direction of remaining chainline error.

Calculate maximum correction possible for moving chainrings in

If performing a frame alignment has not solved the chainline error, then the best place to continue to solve the chainline error is at the chainrings. If there is no frame-alignment error, then the best place to start making chainline-error corrections is still at the chainrings. If you are not aligning the frame because the frame is not suitable (or it is not shop policy to align frames), the best place to start making chainline-error corrections is at the chainrings. Chainrings may be moved in or out by changing the bottom-bracket spindle. The only practical limit to how far the chainrings can be moved *out* is the sizes of the available spindles. The limit to how far crank-arm/chainrings can be moved *in* is the potential of the crank arm or chainrings to rub the frame. The clearance between the frame and the crank-arm/chainrings must be 2mm or more to account for the amount that the chainrings, crank arm, and frame flex under load. The next steps measure the existing clearance and determine the maximum amount the chainrings can move in.

If the maximum amount the chainrings can move is not enough to eliminate the symptom, then resort to the more difficult solution of moving the rear cogs. Keep in mind that the chainrings do not necessarily have to be moved enough to make the chainline perfect, only enough to eliminate the symptom. For this reason, always move the chainrings as much as possible to achieve perfect chainline, and then test for symptoms before deciding to make any additional correction at the rear cogs.

24. [ ] Use stack of feeler gauges to measure gap between chain stay and closest part of right crank-arm/chainring assembly and record here: _____mm.

25. [ ] Subtract 2mm from number in step 24 and record answer here: _____mm.

26. [ ] Number in step 25 is maximum chainring correction. If this number is more than 1mm less than the number in step 16, moving chainrings in to limit will not complete chainline-error correction (continue at cogset).

27. [ ] If number in step 25 is <.5mm, chainline correction by moving chainrings is not possible. Skip to step 35.

Determine best replacement bottom-bracket spindle to correct chainline error

Bottom-bracket-spindle interchangeability is complex. The next steps simply accumulate the necessary information to calculate what bottom-bracket spindle would be better, but do not do actual calculations. To calculate the appropriate replacement spindle, use the spindle-interchangeability procedure in the **ADJUSTABLE-CUP BOTTOM BRACKETS** chapter (page 9-13).

28. [ ] If *chainrings-in* error exists, number in step 14 is amount new bottom-bracket spindle should move chainrings out. Record again here: _____mm.

29. [ ] If *chainrings-out* error exists, smaller of two numbers in steps 12 & 24 is amount new bottom-bracket spindle should move chainrings in. Record again here: _____mm.

30. [ ] **Remove bottom-bracket spindle and record all markings that might identify existing bottom-bracket spindle. Record brand and markings here: _____**
31. [ ] **Go to SPINDLE INTERCHANGEABILITY in ADJUSTABLE-CUP BOTTOM BRACKETS chapter (page 9-13) to determine acceptable replacement spindles.**

Determine if symptoms remain after correcting chainline error by moving chainrings

Once the chainrings are moved, it is necessary to see if symptoms persist. If the error was fully corrected but the symptoms persist, look for other causes. If the error was not fully corrected but the symptoms are gone, chainline correction is done. If the error was not fully corrected and the symptoms remain, go ahead to moving the rear cogs to further correct chainline.

32. [ ] **Repeat steps 1–6 to determine if chainline-error symptoms remain after making full or partial correction of error by moving chainrings.**
33. [ ] **If error symptoms remain, repeat steps 8–16 to determine direction and amount of remaining error. If error is ≤1mm or is in wrong direction to create symptom, see INDICATIONS (page 27-2) or *CHAINLINE TROUBLESHOOTING* (page 27-11) to determine other possible causes of symptom.**

Error and symptoms remain after moving chainrings as much as possible and significant error remains

34. ***If rear cogs need to move in*** **(chainrings could not be moved out enough) to correct remaining chainline error:**
    [ ] Amount of error recorded in *repeated* step 16 is amount of spacer thickness that needs to be transferred from left side of axle to right side of axle. Wheel needs to be re-dished and rear derailleur needs adjustment after transferring spacers.
    [ ] If spacers are unavailable to transfer from left side of axle to right side of axle, the amount of error in *repeated* step 16 is half of amount of spacer thickness that needs to be *added* to right side of axle set. Wheel needs to be re-dished, rear triangle *must* be realigned (not an option unless frame is steel), and rear derailleur needs adjustment after adding spacers.
35. ***If rear cogs need to move out*** **(chainrings could not be moved in enough) to correct remaining chainline error:**
    [ ] Amount of error recorded in *repeated* step 16 is amount of spacer thickness that needs to be transferred from right side of axle set to left side of axle set. Clearance of chain to frame when chain is on outermost rear cog or shifting from outermost rear cog to the next cog should be checked. Wheel needs to be re-dished and rear derailleur needs adjustment after transferring spacers.
    [ ] If spacers unavailable to transfer from right side of axle to left side of axle, amount of error in *repeated* step 16 is half of amount of spacer thickness that needs to be *added* to left side of axle set. Wheel needs to be re-dished, rear triangle *must* be realigned (not an option unless frame is steel), and rear derailleur needs adjustment after adding spacers.

Determine if symptoms remain after correcting chainline error by moving rear cogs

Symptoms indicating chainline error may be caused by a variety of problems other than chainline error. After checking that chainline error has been eliminated, check if any symptoms remain (step #36). If symptoms remain, it is time to look toward other things as the source of the symptoms. The other things that cause symptoms similar to chainline error are covered in the **INDICATIONS** section (page 27-2) and the ***CHAINLINE TROUBLESHOOTING*** section (page 27-11).

36. [ ] **Repeat steps 1–6 to determine if chainline-error symptoms remain after making complete correction of error. If they do, see INDICATIONS (page 27-2) or *CHAINLINE TROUBLESHOOTING* (page 27-11) to determine other possible causes of symptom.**

CHAINLINE TROUBLESHOOTING

Cause	Solution
SYMPTOM: *When pedaling in a gear combination that has the chain on one of the outer rear cogs and the innermost chainring, the chain comes off the lower rear-derailleur pulley wheel and rides against the rear-derailleur-cage plate.*	
Chainrings are too far in relative to rear cogs and lateral force on chain is forcing it to derail from lower rear-derailleur pulley wheel.	Check for *chainrings-in* error and correct if significant and in the correct direction.
If lower derailleur pulley wheel or chain was changed just before symptom developed, they are incompatible, particularly if both are a low profile configuration.	Replace lower pulley wheel with brand or model that has tall teeth, or replace chain with model that has side plates protruding above rollers.
If chainline is good or error is in the opposite direction to what would normally cause this symptom, the derailleur hanger is mis-aligned.	Check and correct rear-derailleur-hanger alignment.
If chainline is not the cause, pulley-wheel/chain compatibility is not an issue, and the rear-derailleur-hanger alignment is good, then the rear-derailleur cage is bent.	Align rear-derailleur cage or replace rear derailleur.
SYMPTOM: *When pedaling in a gear combination that has the chain on one of the outer rear cogs and the innermost front chainring, the chain seems to rub on the next inboard rear cog*.	
The chainrings are too far in, relative to the rear cogs, and the angle of the chain to the innermost chainrings is more than the space between the rear cogs will allow without interference between the chain and an adjacent cog.	Check for *chainrings-in* error and correct if significant and in the correct direction.
If chainline is good or error is in wrong direction, spacers could be wrong between cogs, particularly if cogs have recently been installed.	Check and correct spacers between cogs.
If chainline is good or error is in the wrong direction, wide chain could be in use with narrow-spaced cogset, particularly if either chain or cogset has been replaced.	All seven- and eight-cog sets are narrow. A few six-cog sets are narrow. If cog set is narrow use chain that has rivet length of 7.4mm or less.
SYMPTOM: *When pedaling in a gear combination that has the chain on one of the outer rear cogs and the innermost front chainring, the chain seems to rub on the next chainring out*.	
The chainrings are too far in, relative to the rear cogs, and the angle of the chain to the outer rear cog is more than the space between the chainrings will allow without interference between the chain and the adjacent chainring.	Check for *chainrings-in* error and correct if significant and in the correct direction.
If chainline is good or error is in the wrong direction, spacers could be wrong between chainrings, particularly if chainrings have recently been installed. A most likely case causing this would be if Shimano SG/SGX/HyperDrive chainrings have been installed on a non-compatible crank arm.	Check and correct spacers between chainrings.
If chainline is good or error is in the wrong direction, wide chain could be in use with narrow-spaced chainring set, particularly if either chain or chainring set has just been replaced. A most likely case would be if Shimano SG/SGX/HyperDrive chainrings are being used with a chain that has rivets more than 7.4mm long.	Replace chain with one that has a rivet length of 7.4mm or less.

(Continued next page)

CHAINLINE TROUBLESHOOTING (Continued)

Cause	Solution
SYMPTOM: *When pedaling in a gear combination that has the chain on one of the inner-rear cogs and the outermost chainring, the chain comes off the lower rear-derailleur pulley wheel and rides against the rear-derailleur-cage plate.*	
Chainrings are too far out relative to rear cogs, and lateral force on chain is forcing it to derail from lower rear-derailleur pulley wheel.	Check for *chainrings-out* error and correct if significant and in the correct direction.
If lower rear-derailleur pulley wheel or chain was changed just before symptom developed, they are incompatible, particularly if both are a low profile configuration.	Replace lower pulley wheel with brand or model that has tall teeth, or replace chain with model that has side plates protruding above rollers.
If chainline is good or error is in opposite direction to what would normally cause this symptom, derailleur hanger is mis-aligned.	Check and correct rear-derailleur-hanger alignment.
If chainline is not the cause, pulley-wheel/chain compatibility is not an issue, and rear-derailleur-hanger alignment is good, rear-derailleur cage is bent.	Align rear-derailleur cage or replace rear derailleur.
SYMPTOM: *The chain seems to snap or pop onto the chainring teeth when pedaling in a gear combination that has the chain on one of the inner rear cogs and on the outermost chainring*.	
Chainrings are too far out relative to rear cogs, and chain side plates are hanging up on top of chainring teeth before chain drops into place.	Check for *chainrings-out* error and correct if significant and in the correct direction.
Chain is wiggly or bent.	Sight down length of chain to inspect for wiggles.
New cheap steel chainrings have sharp edges to teeth that are catching on chain side plates.	Should go away with break-in.
SYMPTOM: *The front derailleur cannot be adjusted to eliminate the tendency of the chain to drop past the innermost chainring when shifting to it and the chain is on one of the inner rear cogs*.	
The chainrings are too far out relative to the rear cogs, and the lateral force on the chain is causing it to whip past the inner chainring once it is free of the next chainring out.	Check for *chainrings-out* error and correct if significant and in the correct direction.
If chainline is good, front derailleur is out of adjustment.	Check front-derailleur height, front-derailleur rotational alignment, and inner-limit screw setting of front derailleur.
If chainline and front-derailleur adjustment are good, and bike is a road-racing model with 8 rear cogs, front-derailleur performance is *too good*.	Modify width of tail of front-derailleur cage (widen) to retard front-derailleur performance.

MEASURING CHAINLINE ERROR WITH STEIN CLC-1

The Stein CLC-1, in conjunction with a caliper, is a relatively accurate and easy-to-use tool for measuring chainline error. The tool consists of two parts: a main bar that attaches to the chainrings and extends back to the rear cogs, and a second calibrated bar that is butted against the rear cogs in order to take an error reading.

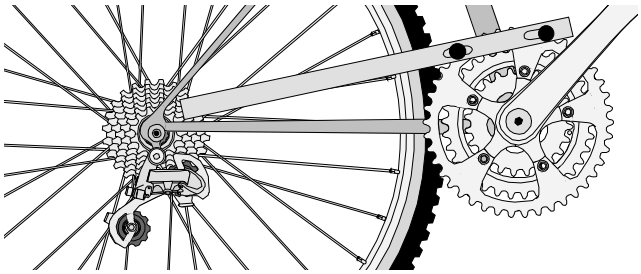
The calibrated bar over-simplifies the process. It is good for indicating whether the chainline is "good" or "not good," but it is not very effective at indicating the amount of error. The following procedure substitutes a table of dimensions and a caliper for the calibrated bar, which makes it possible to accurately determine the amount of error.

The procedure is designed with the assumption that a digital caliper is being used, but there are extra steps at the end that make the procedure work with a non-digital caliper, as well.

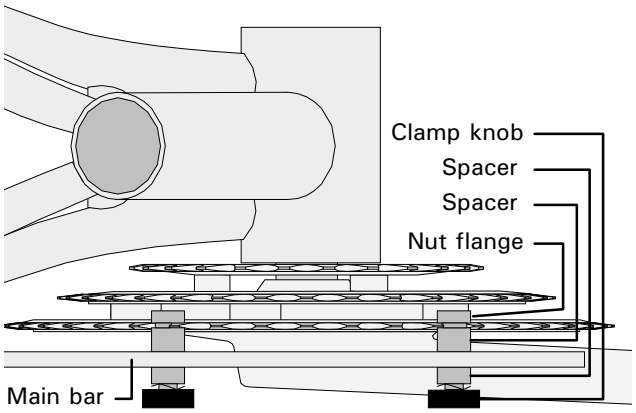
For optimal accuracy, the tool should be put in four different locations on the chainrings, and the results averaged. This neutralizes error created by out-of-true chainrings. If the chainrings have excellent true, then one reading should be sufficient. If four readings will be taken, be sure to start with one end of the tool immediately adjacent to the crank arm so that the additional readings can be taken at 90° intervals around the chainrings.

When attaching the main bar to the chainrings, note that the chainring teeth are to be sandwiched between the flange on the inner end of each clamp mechanism and the large spacer that is adjacent to the inner face of the main bar.

1. **[ ] Place tool on outer chainring so that it is on outer face of chainring and adjacent to crank arm. Left end of tool should be at rear cogs, and not interfering with frame.**



27.10 Attach the Stein CLC-1 to the outer chainring so the tool is outside the chainring and the left end of the tool is in front of the freewheel and not interfering with the frame. For the first measurement, start with the right end of the tool close to the crank arm.



27.11 Position the tool so the main bar and spacers are on the outer side of the outer chainring, and the flanges of the sleeve nuts are against the inner face of the outer chainring teeth.

NOTE: Skip step 2 if using non-digital caliper!

To use the table in step #2, simply look up the intersection of the row for the number of chainrings on the bike with the column for the number of rear cogs on the bike.

2. **[ ] Set digital caliper to appropriate value from table below (in millimeters), then zero caliper.**

Stein CLC-1 Chainline Values

Rear cogs:	5	6	7	8	9
Chainrings: 2	27.5	28.5	29.5	31.5	33.0
3	31.5	32.5	33.5	35.5	37.0

3. **[ ] Set depth gauge against outer face of innermost rear cog, and adjust butt of caliper until it is just against face of CLC-1, then record 1st reading in step 4.**
   [ ] Move tool to a position 8–10 teeth away from its current position, repeat measurement, then record 2nd reading in step 4.
   [ ] Move tool to a position 8–10 teeth away from its current position, repeat measurement, then record 3rd reading in step 4.
   [ ] Move tool to a position 8–10 teeth away from its current position, repeat measurement, then record 4th reading in step 4.

Step #4 calculates the actual chainline error if a digital caliper has been used. If not using a digital caliper, then use the result in step #4 as part of the calculation in steps #5–7. Regardless of whether the actual error is determined in step #4 or step #7, *note that a positive error means the chainrings are positioned too far out relative to the rear cogs, and that a negative error means the chainrings are positioned too far in relative to the rear cogs.*

4. [ ] **Add readings recorded below, then divide by 4 to find chainline error.**

1st reading: _____mm

2nd reading: _____mm

3rd reading: _____mm

4th reading: _____mm

TOTAL _____mm

divide by 4 ÷4

Chainline error: _____mm (result)

NOTE: Steps 5-7 are only needed if a non-digital caliper was used.

5. [ ] **Look up appropriate value in table in step 2,**

and record here: _____mm

6. [ ] **Subtract step 4 result: –_____mm**

7. [ ] **Chainline error is: _____mm**