CHRIS KING®
PRECISION COMPONENTS

Integrated Headsets Explained

March2002

This article is an overview of the differences between "integrated" and conventional headsets. It is not intended as an engineering paper but as a plain language explanation of this often discussed but mostly misunderstood new bicycle option.

Preface

When you call King Cycle Group, you talk to a person, not a machine. Maybe that's why so many people call us with their questions and comments. Because of this we usually a have a good feel for the 'pulse' of the bike shops and riders in the US. We also have learned to identify trends in the kinds of questions people ask when they call. We are not some big company where engineering and customer service don't talk. Engineering gets to hear it all. That's why we wrote this bulletin. We have gotten an enormous number of calls about "integrated" headsets. "What is an integrated headset?", "Can I buy one from you?", "Is this a good thing for my new bike to have?" and "When are you guys going to make them?", are the most common. We also hear plenty of complaints about the "integrated" headset. Most people think that if we get enough complaints about it, King will start making "integrated" headsets. For as much confusion as there is out there, and as many frame builders using them, and as much marketing hype as is being pumped out there about this, there is no real explanation of what "integrated" is. And certainly nobody is going to tell you why this is a bad direction for the bike industry to go in, and a bad choice for your next bike. Somebody needed to say something about this. So here we are, saying something about it.

What is an "Integrated" headset?

It is a bicycle frame, fork and bearing system designed to eliminate the humble headset cup. To integrate means to combine and hopefully to simplify. What has been "integrated" by the integrated headset? The bearings now rest inside the frame instead of inside pressed-in cups. All of this trouble and confusion is to remove two 12 gram headset cups from the front of your bicycle. True, an integrated headset can give the bike a nice, smooth looking front end, but the consequences of this change to your bicycle are significant. Simply put, the performance and lifetime that you expect from your new bicycle will be reduced, most severely in aluminum mountain bikes. All bicycle frames that use integrated headsets will ultimately have substantial performance and reliability problems due to the inherent flaws in this design. The largest flaw is a bearing system that does not positively attach the bearing to the frame, leaving the bearing to "float" resulting in wear and impact damage to the frame. As an additional complication, each manufacturer seems to be doing their own thing, with no real standardization to date. As a result, there are multiple bearing types and sizes (some of which have been discontinued with no replacement options) and the frame builders and bearing makers are not all working from the same drawings. Lack of standardization is a bad thing for everyone. It means that you may not be able to get replacement headset bearings for your bike, and you ***will*** need them.

Conventional Headset Detail

Integrated Headset Detail

Internal Headset Detail

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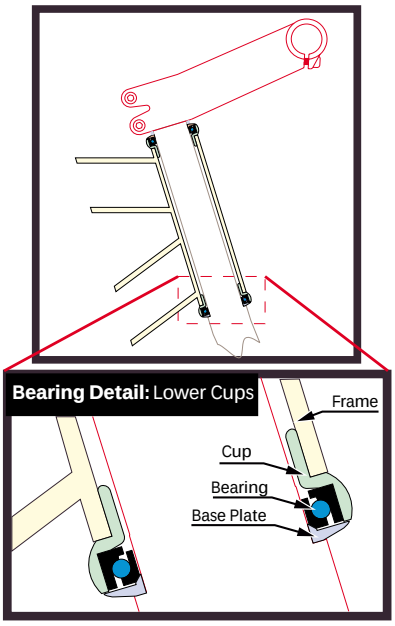
Conventional Headset Bearing Detail

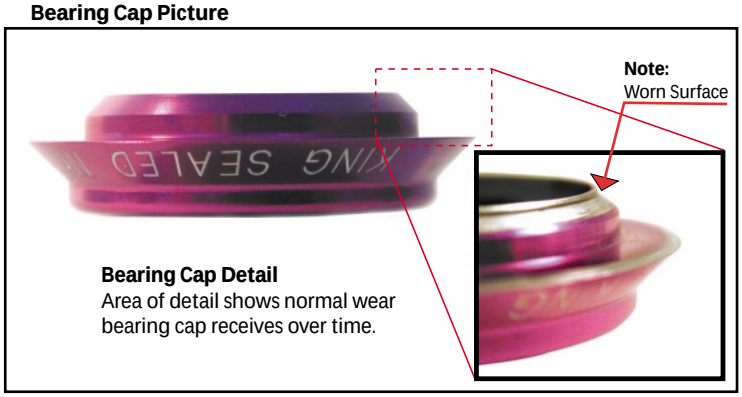


The Conventional Headset:

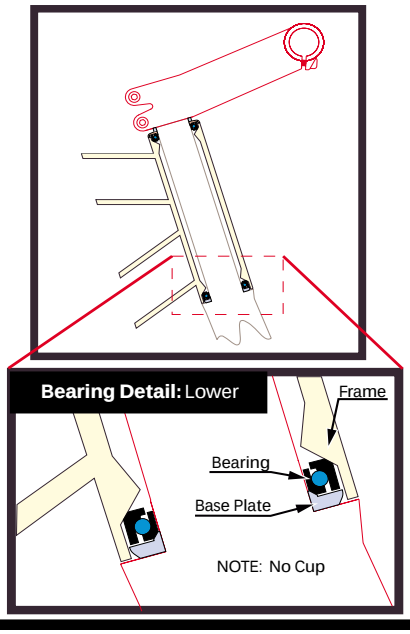
On the left you see the plain old, everyday headset. The little picture underneath is a close-up of the cup and bearing area. This is what it would look like if you split your bike right down the middle. The bearing is press fit into the cup (it won't come out and it doesn't move around in the cup), then the cup is pressed into the frame. The whole thing is trapped by the bearing cap and the crown race on the fork. Only the inner part of the bearings can move, the outer race is fixed to the frame. As you ride your bike the forces being applied (hitting rocks and bumps) are trying to shift the whole assembly around. Other than when you are turning the bars to steer, there are only 2 places where the assembly can shift (because the cups and bearings are all securely pressed together into the head tube): 1)between the lower bearing and the base plate and 2) between the upper bearing and the bearing cap. These areas are called "*dynamic surfaces*", they move all the time (see the appendix page for the details). Check out the Bearing Cap Picture below. The aluminum bearing cap on the left is a new one, the one on the right is a year old. This is perfectly normal wear and tear. This wear is right at one of the *dynamic surfaces*. Remember, we have headsets out there that are 25 years old, we have learned a lot about headset wear.

This wear is because the bearings and fork are always moving. They move even when the headset bearings are firmly attached to the head tube, like in a conventional headset. The part of the fork that goes through the frame is called the steerer tube. The steerer tube is always flexing around, whenever you brake, turn, shift your weight or hit something, the steerer tube is simply not staying straight. And the bearings themselves have some play in them that can't be adjusted out. All of these factors together explain the movement and corresponding wear on the Bearing Cap Picture. Incidentally, a new bearing cap from us will cost you a big $12 and you can replace it in 2 minutes flat using one 5mm allen key.

Bearing Cap Picture



Integrated Headset Bearing Detail



The "Integrated" Headset:

Now lets apply this knowledge to the "integrated" system (shown at left). Notice how there are no headset cups. Instead of a positive connection between the bearings and the head tube, this design allows the bearings to "float". Without any press fit, the bearings are free to move about on those ledges because, unlike a normal headset, they are not actually attached to anything.

Because the bearings are not securely pressed into anything, they will move around even if your headset is properly adjusted. The amount of movement (in an integrated system) will be much larger than a conventional headset would experience. In addition to the 2 dynamic surfaces that you have in a conventional headset, you add 2 more: the 2 interfaces between the bearings and the frame. Now the wear that you see in our Bearing Cap Picture is not only going to happen to an inexpensive part, it is also going to be your expensive frame taking the abuse. (See the Appendix for a good picture of this)

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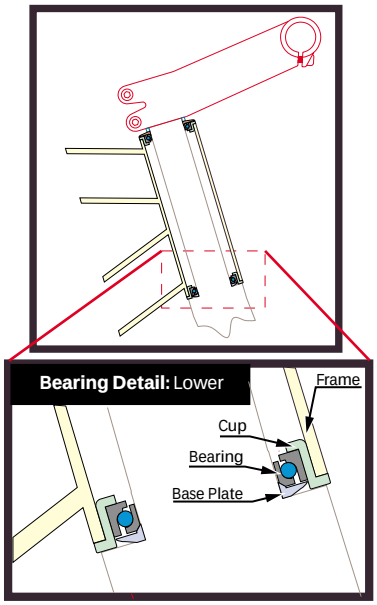
OK, enough techno-babble, what can you do to really see what is going on? Try this: You know how you can see your fork flex backward when you are braking really hard? Under this kind of braking, the front of the lower "integrated" bearing is moving down and the rear is moving up, like an airplane in a nosedive. When you let off the brake, the front comes back up and "levels off" to where it started. Enough repetitions of this and your headset will creak and click. Replacing the bearings will maybe help for a little while, but that creak will be back, louder than before.

Add a little dirt and water into the bearing area (on your first wet ride, guaranteed), and that inevitable bearing movement is going to have some abrasives to help grind away your frame. This is going to be considered "normal wear and tear" by your frame maker. When your headset starts to creak, you will need to start regularly packing your "easy to service" integrated headset area with grease just to keep it quiet. This will not be a permanent solution though. Pretty soon, no amount of grease will allow you to silence the creaking and a perfectly good frame will be ruined.

The "Internal" Headset, yet another twist:

Internal Headset Bearing Detail



An "Internal" headset (also known as "semi-integrated", for maximum confusion) is yet another headset type that places the bearings within the head tube (rather than outside the head tube, like a conventional headset does). The key difference between an integrated and internal is THE BEARINGS DO NOT TOUCH THE FRAME with an internal headset. they are contained either by a cup or an aluminum or plastic shim assembly which is pressed into the headtube.

One example is the Zero-Stack™ headset. It is an "internal" headset that uses the exact same bearings as an integrated headset. The important difference is that in a Zero-Stack™ headset, a cup is first pressed into the frame, then the bearing is placed in the cup. The bearing still floats around in the cup, and it will eventually trash the cup. This is absolutely superior to an integrated headset because you can replace the cup. The frame will never be damaged by the bearing.

Another example is the Columbus-type internal headset. It actually presses a bearing directly into the bike frame, similar to our Perdido headset. The difference is that the Columbus system utilizes a very thin sleeve to take up the gaps between the bearing and the frame. This is certainly better than a bearing rubbing around loose in the frame, but this system again relies on the frame builder to make that head tube perfectly. We manufacture our headset cups to within .0005" accuracy in order to correctly control the bearing's location and press fit. Frame builders typically hold about .005" accuracy at best. This is 10 times less accurate than a conventional headset cup and while it is perfectly fine for building a frame, it just is not close enough for holding a bearing in place properly. Result? The bearing could be held in the frame way too tightly, or much too loose. Either way, the headset will wear out faster and the frame will likely be damaged.

Important Facts to Realize:

Your frame has been designed for a specific headset type. You can't convert an integrated headset frame to use an internal headset. The frames are too different. Just like you can't convert an integrated headset frame to use a conventional headset.

Internal or "semi-integrated" headsets offer basically no structural advantage over the conventional headset. Sure they may be radially stronger, but this isn't really a weakness of the conventional design. If you think that the conventional headset is just too ugly and you can't bear to look at it, internal headsets are for you. That is the benefit. Heavier frame and fork, no real structural benefit to the assembly. Looks different though. And yes, this judgement includes our own Perdido headset.

Here at King, we have been looking into this situation for a few years now, trying to design a retrofit that would allow conversion of an integrated frame to something with fixed bearings. We have found no solution except to use a bunch of glue. Even then, most integrated headtubes simply are not strong enough to handle a pressed in bearing or cup. So we designed and released "Perdido". Our own *Internal* headset and standard.

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Frame Preparation

Conventional Headset Frame Preparation:

Proper frame preparation is critical for a good headset installation. A quality bike shop will always perform 2 steps: 1) Ream the head tube (click here to see what a reamer looks like). This makes the holes in the frame nice and round, the right size, the correct depth and in line with each other. 2) Face the head tube (click here to see what a facing tool looks like). This makes the ends of the head tube flat and parallel to each other. Frame paint can be pretty thick, especially powder coat. Many times, frame preparation just gets the frame paint out of the way so that you can get a good metal-to-metal connection. These steps insure that once the headset is installed, the bearings are nicely lined up with each other. If the bearings aren't lined up very well, all sorts of things can happen. First one is that you may not be able to get a good headset adjustment, it may come loose all the time, might have a tight spots, and it will probably creak. Secondly, you can be sure that your headset won't last as long if your frame isn't properly prepared. **BUT ONLY YOUR HEADSET WILL BE DAMAGED. AND IT IS EASILY REPLACED.**

"Integrated" Headset Frame Preparation:

Although the people that make "integrated" headsets might tell you that they have a "self-aligning feature", the fact of the matter is that frame preparation is just as critical as with a conventional headset. Since frame manufacturers have traditionally had a hard time making the conventional head tube accurately, should we believe that making the integrated head tube is going to be any easier? The roundness and alignment of those little angled ledges is very important. And your shop can't fix it. Your shop doesn't and hopefully won't ever have the ability to cut or re-cut that ledge in your head tube. Even if they could, you wouldn't want your bike shop cutting away the inside of your integrated head tube. They could easily cut too deep and pierce your head tube, or cut the ledge deep enough that the top of the fork would hit the frame. That level of damage is nearly impossible to do with a conventional headset setup. What are you going to do with this frame when you have a problem. Warranty or the trash heap. What a waste.

Marketing this Nonsense

Let's talk propaganda. Here's some of what we've seen in catalogs and magazines about "integrated" headsets:

"We chose internal bearings for the head tube, a conscious choice, because they make the bike steer more precisely"

This is simply false. A system that has the same 2 dynamic surfaces as a normal headset, plus 2 larger ones, cannot be more precise. Adding extra slop to a system doesn't make it more precise. This marketing statement is saying that 1+1 = 2, and that 2+2 = 1.5. Take a look at the appendix page for some good pictures illustrating this point.

"Simplified bearing installation and bearing replacement through the use of an integrated head tube design"

Yup, it will be easier to replace your headset bearings now. You won't need to knock the cups out of the frame. But why should you need to replace your bearings at all? A properly designed headset should last the life of the frame. Imagine a car with "integrated" style engine bearings. Sure quick change engine bearings would be easier to service, but your car's engine bearings should go hundred's of thousands of miles before replacement. Just as in the car engine example, "integrated" headsets provide a feature that is not really needed. Manufacturer's are claiming convenience and user serviceability, but the real cost of this convenience is the durability of the system and the lifetime of the frame.

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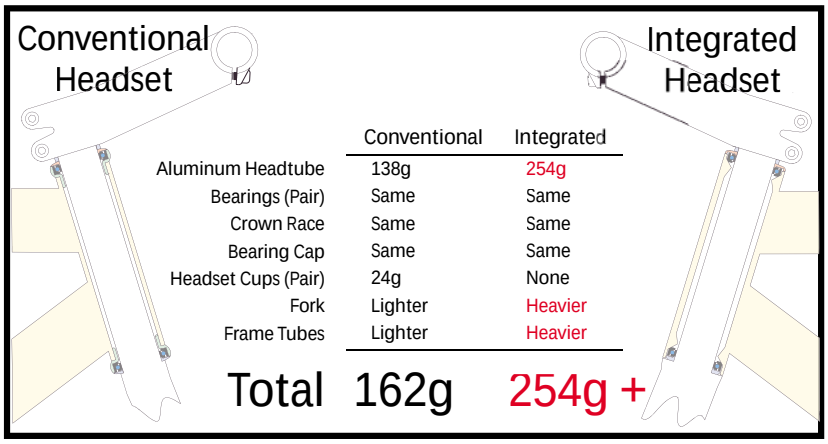
“Integrated headset build lighter, stronger bikes”

How can this be? Litespeed’s lightest frame doesn’t use an integrated headset, it is the only one in their road line without it. Why is that? Look at the Weight Comparison Table below. What is missing from this table is the fact that the top tube and down tube must increase in diameter (and weight) in order to fit properly to the larger, integrated head tube. If you increase the diameter of the head tube without increasing the diameter of the top and down tubes, the amount of weld area decreases. This makes for a weaker frame as the most common failure point is around the weld itself. Also, the crown of the fork needs to get larger so that it is flush with the bottom of the head tube. This change to the fork is nothing but window dressing, no additional strength or stiffness. Stronger? Maybe the frame is stronger. You have made it out of bigger, heavier tubing. Again, at what cost? The fork is the same strength and the headset is weaker than before. You can build your bridge out of twice as much steel, if you hold it together with crappy rivets, it isn’t going to be any stronger. The assembly can only be as strong as the weakest part.

Weight Comparison Table



	Conventional	Integrated
Aluminum Headtube	138g	254g
Bearings (Pair)	Same	Same
Crown Race	Same	Same
Bearing Cap	Same	Same
Headset Cups (Pair)	24g	None
Fork	Lighter	Heavier
Frame Tubes	Lighter	Heavier
Total	162g	254g +

Talk to your shop, email your favorite frame maker, post your opinion on a newsgroup, write a letter to a magazine. Forward this bulletin to your riding buddies. The Product Managers at your favorite frame builders need to know what you want to have on your next bike. Send them some email. Don’t let your future bike have this foolish headset. If people don’t speak up about this, we may wind up with no choice at all.

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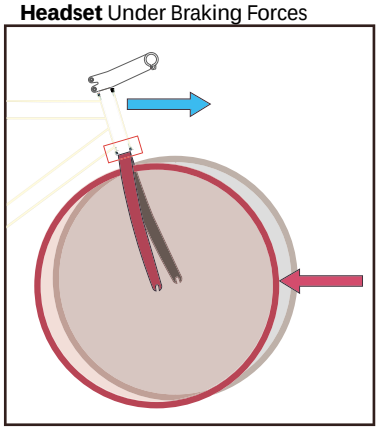
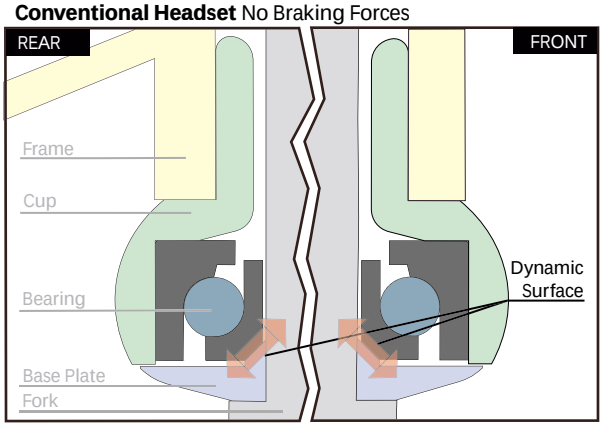
Headset Under Braking Forces



When you grab your front brake or hit a bump, the frame wants to continue moving forward (blue arrow), while the wheel wants to slow down (red arrow). As a result of this, the fork flexes backwards. Headsets can't make the flexing go away, that's in the fork design. All forks flex, you've all seen it when you hit your front brake and watch the front wheel. Most of the flexing appears to be in the fork legs, but the steerer tube (the part of your fork that is *inside* the bike frame) is also flexing. All of the forces that slow the bike down and bend the fork must act through the headset bearings. The pictures below show the position of the lower headset bearing in these 2 riding conditions.

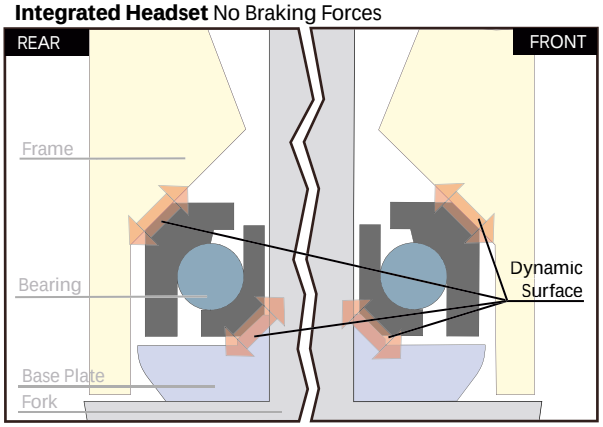
The pictures on the left are of a conventional headset. The ones on the right are of an "Integrated" headset. The upper pictures show the bearing positions when there are no forces pushing on them. The lower pictures show the bearing positions when the front brake is applied. Notice the gaps that open up as the fork and base plate move when you grab the brakes.

Conventional Headset No Braking Forces



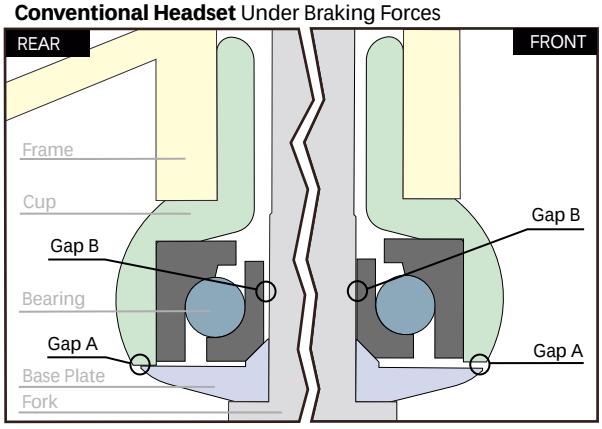
This picture shows the conventional headset at rest, no forces are acting on it. The bearing is fixed in the cup, the cup is fixed in the frame. The only place where the assembly can shift is between the base plate and the bearing. This area is called a "dynamic surface" and is indicated by the 2 red arrows. The arrows show how the base plate can scuff back and forth against the bearing. This same action happens at the other headset bearing (the one next to your stem). That's why we say that there 2 dynamic surfaces in a conventional headset system. One on the top bearing, one on the bottom (only the bottom one is shown in this image).

Integrated Headset No Braking Forces



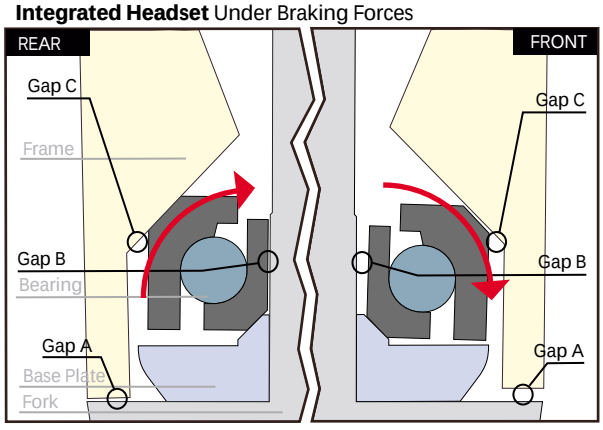
This picture shows the "Integrated" headset at rest, no forces are acting on it. The bearing is resting against the frame, held in place only by the headset adjustment. If you remove the fork, the bearing falls out. Compare this picture with the one of the conventional headset. Notice how this picture has more dynamic surfaces (the 4 red arrows). These are a extra places for the "integrated" headset assembly to shift around. These arrows show how the parts scuff back and forth against each other. That's right, the bearing scuffs against the frame. This same action happens at the other headset bearing (the one next to your stem). That's why we say that there are 4 dynamic surfaces in an integrated headset system. Two on the top, two on the bottom (only the bottom two are shown in this image).

Conventional Headset Under Braking Forces



This picture shows how the headset moves when you grab your front brake. See how Gap A is larger on the right than on the left? That's because the braking forces are pushing the fork towards the back of the bike. The bearing can't move because it's stuck in the cup. The only movement is at the dynamic surface between the base plate and the bearing. Notice how Gap A and Gap B are not the same in the left and right sides of this picture due to braking forces.

Integrated Headset Under Braking Forces



This picture shows how the "Integrated" headset moves when you grab your front brake. The big red arrows illustrate how the bearing not restricted from moving in the frame. This movement happens because the bearing is not fixed to the frame. Just like the conventional headset, Gap A is larger on one side than the other, but also notice Gap C. Gap C shows how the bearing is scuffing against the frame, causing wear and creaking noises. The bearing won't be getting worn out, bearing steel is harder than anything anyone builds bike frames out of— titanium, steel, aluminum, composites— it doesn't matter, bearing steel will wear through them all. Even faster once you get a little grit and water in there. That's grinding paste.