The following is a technical article written for better understanding of the rear air-cooled VW suspension as well as our products. For the majority of people, the rear VW suspension is little understood and more often misunderstood.

**THE TRUTH ABOUT SUSPENSIONS**

If you want a smooth ride and not just looks, there is more than meets the eye at a quick glance. Anyone can lower or raise a vehicle and call it good, but just like any good engine build, if you seek performance, everything should be prepared in advance and every component’s function should be understood. It is more than just ordering the most costly parts, assembling them, and blowing away the competition. Yet suspensions are not a mystery and they certainly are not rocket science. The truth is that they are simply and easily understood if they are explained simply. Unfortunately there is a seemingly infinite amount of misinformation, which is unnecessarily complicated, leaving the reader bewildered about how to approach their own car’s suspension. This is not how we roll, so we encourage you to read on and come to your own conclusions to piece together the suspension that is just right for you.

**MYTH:** Lowering or raising my car will give it greater performance than I could expect at stock height. For example if I simply lower my car it will corner better than my friend’s car that is not lowered. Alternatively, if I raise my car it will perform better off road, absorbing bumps and jumps, than my friend’s car that is not raised.

**FACT:** Every suspension rides at its greatest potential when it is riding within the parameters that it was designed for. This means that factory suspensions perform the greatest when the ride at factory height and the geometry is not tampered with. Therefore it is of upmost importance that any part that is purchased is actually designed to operate within the altered region, rewriting the chalkboard so to speak. But doing this is like hitting the factory reset button, as the car is either lowered or raised. It also means that there is not a “one size fits all” suspension. If you seek true performance, safety, and handling then you will carefully need to select the parts that are designed to
operate at the ride height that you are most often going to drive.

**Raise Plates and Drop Plate**
Drop or raise the rear of your air-cooled VW without loosing ride quality! It seems that there are 101 different things that you can do to the front suspension, but when it comes to the rear, VW owners have been given little choice until now.

**Benefits**
It is now possible to have a full suspension performance vehicle! Our Drop Plates have been engineered to drop the rear of your VW yet allow your car to ride and feel as the factory intended. While the math and engineering may be extensive, the concept is simple: Drop Plates locate the axle up higher, but maintain factory spring plate travel in the lower region (factory articulation region) and maintain torsion in the system. This idea is similar to Drop Spindles in that sense. However with Atomwerk Drop Plates the upward range of travel is extended, which means that you will be able to roll over even taller bumps (assuming that your upper stopper has not been cut off).

**Can't I just lower or raise my VW with factory plates?**
Of course you can lower/raise your vehicle using your stock spring plates. People have been doing this for decades. Atomwerk Drop Plates were not created so that you can just lower/raise your vehicle; they were created as an alternative to a bad, clunky, and squirrelly ride that you are bound to get when you lower/raise your vehicle with stock plates.

**Why does my ride quality change when I lower or raise with factory spring plates?**
There are several reasons for this. The easiest way to think about this is that a lowered stock VW is operating outside of the factory geometry in the torsion housing. You see, the spring plate only has a limited distance that it was designed to articulate (travel) in between. This space that limits the spring plate travel is often referred to as the torsion housing. The travel is limited by a lower stopper and an upper stopper, in addition to the factory rubber bump stop. When you lower or raise your vehicle you literally force your spring plate to operate outside of its designed travel range. There are three specific factors that affect your ride quality:

1) The spring plate articulation
2) Torsion in the system
3) Toe-in on swing axles

The spring plate articulation is the factory travel range. It is the angular distance between the lower stopper and the upper stopper. Torsion is the resistance that is found in the torsion bar. The further up you push the spring plate the more torsion you are loading in the system, kind of like a heavy duty rat trap!

When you lower your VW’s rear suspension with factory plates you have made it impossible for the spring plate to articulate correctly, and that is why it will smash into the upper stopper when going over bumps. Not good! In general, the spring plate should be able to articulate downward about 25% of the total travel range and should be able to articulate about 75% upward, respectively.

Torsion in the system changes when you lower a VW and the initial torsion (pre-load) changes drastically and this significantly changes your car’s ride characteristics, as we will see later.
Mechanics of Lowered and Raised Swing Axle Suspensions

Toe-in
Toe-in is the effect of the rear wheels turning into the vehicle as a result of the rear axles being pulled forward. When using factory plates, toe-in will occur any time the spring plate is at any angle other than horizontal, as can be seen in the adjacent drawings. In a lowered or raised VW the vehicle’s toe-in on each rear tire will normally cancel out the other, assuming that the vehicle has been lowered evenly and there has been no frame damage. In the adjacent drawings it is demonstrated by the horizontal (x) distance between the center of the torsion bar and the factory axle location. It is represented by the vertical line (y). Figure 6 demonstrates the position of a stock spring plate that has been re-indexed to lower a vehicle about 2.5 inches (note that this is not the distance that an actual spring plate has been dropped, as they are separate calculations). One can see how close it rides to the upper stopper. It doesn’t take much of a bump to make the spring plate impact on the upper stopper. When the vehicle is lowered the spring plates tend to pull the axles, and thus the wheels, toward the vehicle. The dangerous thing is that bad toe-in will manifest itself when a person least expects it. This is not something that I personally like experiencing at high speeds, on slippery roads, or with my family in the car. Have you ever driven over a wet surface on one side of the road and felt the rear dart to one side? Toe-in becomes dangerous, and literally steers the rear of the vehicle when each wheel experiences a different kinetic coefficient of friction (grip to the road) in respect to each other and at the same moment in time. The tire that has the greatest grip to the road will win the grip battle and quite literally steer the rear end of the vehicle in one direction. NOT GOOD! There have been several documented cases where drivers have totaled their VWs due to bad toe-in surprising them unexpectedly. In addition, it should be noted that since the spring plates still need to travel in an arc, the toe-in can only drastically increase as the vehicle absorbs bumps in the road. It can also be seen from the adjacent figures that toe-in also happens in raised applications.

Tire Scrub
Sometimes the term “tire scrub” is used as a substitute for the term toe-in. Tire scrub is actually a description of what is happening to the tire that is experiencing toe-in, that is to say that the road is scrubbing away the tire similar to an eraser being used, although obviously not as drastic. Tire scrub is actually a greater source of wear on a tire than camber is. However camber is often blamed for all of that tire wear. Unless an additional joint is added in the axle, tire scrub can only be eliminated by elongating the spring plates so that there is zero toe-in at the new ride height deviation.

What is Bump Steer?
“Bump steer” may be defined as the toe-in effect that happens as a result of a bump. While the term “bump steer” is the common vernacular, I think that it is better described as “bump toe-in” since it is toe-in that is induced. Regardless, this is an inevitable effect of the swing axle suspension—including stock VWs. However, if it can be felt at all—it would only be while absorbing very tall bumps. Every one of us who has ever driven a swing axle VW has experienced thousands of negligible bump steering on practically every trip.

Why Shouldn’t I Notch my Plate?
Figures 4 and 6 demonstrate the position of a stock spring plate in a vehicle that has been both lowered and raised about 2.5 inches. You can see how close a factory spring plate rides to the stoppers when a vehicle’s height is changed. In extreme cases it takes “Notching” (removal of material) of a stock spring plate to fit into these positions. Atomwerk Engineering Inc. does not recommend anyone to notch a factory spring plate (either top or bottom) because this creates a stress concentration in a plate that was engineered for economy. A stress concentration should be regarded as a very bad thing because it magnifies all the forces that are found in the spring plate and concentrates it in one tiny area. Think of it like this: have you every seen someone lay on a bed of nails or tried that yourself? I have. It is easily done because your entire body weight is spread out over a large surface area (the sum of all the nails). But what would happen if all of the nails suddenly retracted except for one? You could consider this a giant stress concentration! When it comes to a spring plate, all of the forces that are distributed along
the spring plate are magnified at the notch. The more jagged the cut it follows that the stress concentration will be higher. In addition steel is notorious for fatigue under cycling loads, which means that if it takes 5000 ft lbs to fail your plate now, in two years it may only take 3000 ft lbs. Fatigue and stress concentrations together are very bad! Even techniques such as rounding it or drilling the notch do not significantly improve the week spot on the plate. Now consider that the Volkswagen spring plate was made for economy, after all it was “the people’s car.” When someone takes this economy spring plate and puts a stress concentration in it they are seeking a disaster. Nobody knows when a notched plate will fail, but when it does you will lose control of your wheel and disaster will likely strike.

What do Bushings do?
Bushings are actually an inexpensive bearing. You see spring plates were designed to pivot about a fixed point, the torsion bar, and this is why bushings are located about the spline stub and torsion bar. Ideally rolling element bearings (such as needle bearings) precisely locate the spring plate pivot point, however they prove to be the most expensive way to do this because of all the processes that they have to go through and the tolerances that they are manufactured to. They require grease and must be sealed so that they will not corrode. Yet in the end they are considered the best solution since they cannot deflect and will allow for rapid movement of the spring plate.

Secondly, sleeve bearings (bronze bushings), which are less expensive, yet still provide precise pivot point location. It is important to note that these bearings must also be properly lubricated so that excessive wear does not occur and so that corrosion does not occur.

Thirdly, and most commonly, bushings are used, in particular by Volkswagen. It can be reasoned that this was due to the economy nature of the vehicles. When it comes down to it, bushings get the job done. They are cheap and they do not need to be sealed since they can never rust. However, when considering bushings it is important to keep in mind that their purpose is to act as a bearing, that is to say they should be a pivot point that does not deflect. There are two kinds of bushings that are most commonly used: rubber and urethane.

So which kind of bushings are better? That question depends on your budget. From the discussion above it should be reasoned that harder is better. In my opinion urethane bushings give the best bang for your buck since they deflect less and are inexpensive. However, if only the best will do, then rolling element bearings are unsurpassed!

What is a Torsion Bar?
A torsion bar is a bar that delivers spring force (potential energy) in twist. That is to say that the more you twist it, the more it resists you. Volkswagen and Porsche used torsion bars very successfully for decades. Almost all of the air-cooled VW models use torsion bars, and the only difference between them are the lengths, diameters, and the stiffness. Other than that they are dimensionally equal (bus models use different torsion bars).

Every VW torsion bar (buses excluded) has 44 teeth (splines) on the outer end and 40 teeth on the inner end. Of course the stiffness of the torsion bars

Introductory Drop Plates and Raise Plate Sets
These are our introductory Drop/Raise Plates so you can start riding at any height in comfort and style immediately! These plates are sold in sets and are constructed from laser cut, factory thickness, grade 50 tool steel spring plates, and 1026 carbon steel Spline Stubs that are 1.75” in diameter. We offer these plates with instructions and all the technical support that is necessary for headache-free installation on your classic VW. These Drop/Raise Plates come standard with a powder coat finish, which is far more durable and beautiful than the industry-standard zinc coatings that you will find on most suspension components. For swing axles you can choose from 1.2” drop, 2.4” drop, 3.6” drop, or a 1.2” raise, and for IRS you have the choice of 1”, 2”, or 3” drop or raise. Keep in mind when making your selection that each spring plate has a variance of an inch in either direction. For example if you wanted to drop your VW 3.25” then you should purchase the 3.6” Drop Plates and then index them on your VW so that it sits 3.25”.
How is this possible?
Ok I know that this seems quite impossible, after all a spline precisely locates the spring plate, so it seems that you can either locate it at the given “notches” (or teeth) that are in the torsion bar and spring plate. For example you can either position the spring plate a “click” up or a click down, but there is no way to put the spring plate in the middle of the two clicks (teeth). Well the reality is even though there is a definite number of teeth on a torsion bar, there is practically an infinite number of positions that a torsion bar can fit into.

You see, a torsion bar plays on a mathematical algorithm, otherwise known as “indexing.” The inside of a torsion bar has 40 teeth, while the outside has 44 teeth. The VW engineers were no fools when they designed them that way! Since the number of teeth are different with respect to each other, this means that there is always a position for the spring plate that the torsion bar will fit into. You just have to find it.

How can you find this “Magic Position?”
As complicated as indexing may be mathematically, you don’t have to be a genius to find it. A given angle can be found by creeping up on it, so to speak. For example, say that you want to install your spring plates at exactly 20.5 degrees, but your spring plate only fits in either at 17 degrees on the one end or at 26 degrees at the other end. Choose the increment that is closest to 20.5 degrees, in this case 17 degrees, and note where the torsion bar fits with respect to the spring plate and chassis. Then, while maintaining the torsion bar to the spring plate, rotate the assembly one click in the inside splines (in the chassis of the car) with respect to the vehicle. Once you have done this, disengage the spring plate from the torsion bar and rotate it back one click. Once you put the angle finder back on, you will have noticed that the angle has been advanced to 17.8 degrees. If you keep doing this you will eventually creep up on the angle that you want.

However, those astute mathematicians may have noticed that if one were to perform the procedure that I just wrote about, that person would not be able to hit exactly 20.5 degrees. In fact one could only fall short to 20.3 degrees or overshoot to 21.1 degrees. This is nowhere near infinite, some might say. The answer – keep rotating. However since this is not practical in the real world, back off two clicks on one end of the torsion bar and advance only one click on the other end. By doing this you will now hit an angle in between the two that you were at before. And the procedure can be repeated on and on and on.

What makes this happen?
If you rotate the spring plate only one spline increment on the outside splines of the torsion bar, what you are doing is rotating that spring plate precisely 8.1818 degrees. That’s a rather large angle! That means that two clicks changes your vehicle’s height by over 4.64” or greater. Of course when you drop a factory spring plate that much, the spring plate operates much closer to the upper stopper and bump stop if your vehicle still has it – and this is also why many people start notching their spring plates, so that the spring plate will clear the stopper (NEVER A GOOD IDEA). The opposite is also true for raised applications.

If you rotate the spring plate together with the torsion bar one spline increment on the inside splines of the torsion bar, the spring plate is being rotated precisely 9 degrees. That’s an even larger angle.

However, when you combine the two above techniques you get the best of both worlds. You get fine tune height adjustment. All you have to do is rotate the torsion bar alone one spline increment on the inside splines, and rotate the spring plate in the other direction on the torsion bar. This is possible because what you are doing in fact is adding one angle and subtracting the other, or literally (9 – 8.1818 = 0.8182) degrees. It is this
small angular change that makes for this small height change.

The real magic happens when you perform this indexing procedure (forward on one end of the torsion bar and backward on the other end) so that the spring plate eventually rotates 360 degrees. This is not possible on an enclosed chassis. You see, it doesn’t return back to the same exact position that it started out as when it has been indexed exactly 360 degrees - it either falls short or passes it and enters into a new set of angulations. Keep indexing and guess what? The same phenomena will happen again, and on and on.

The bottom line (not literally) is that a torsion bar can fit any given position that you want and you are not forced to live with a choose of predetermined “clicks.” Interesting, right?!

Can I do this an easier way???

Yes you can with Atomwerk spring plates! Our spring plates are designed with an open end so that the torsion bar can slide through the front. That’s right, you do not have to put the torsion bar in first, take note of its angle, then install the spring plate over the top of it, note its angle and then repeat the procedure to find the angle that you are looking for like you have to do with other spring plates. We encourage our customers to forget about all of this indexing nonsense and just pull the torsion bars out entirely. Then install the inside bushing along with the spring plate and clamp it to the bottom stopper, noting the angle that you want (between 18 and 22 degrees usually). After this has been done, install the torsion bar through the front. It will slip in through the spline stub and engage first on the inside splines. If you are lucky it will also engage on the splines on the spring plate. However, chances are that it won’t. But if you keep rotating the torsion bar on the inside splines you will find that “magic spot” (the spot where both the inside splines and outside splines line up at a predetermined angle) without having to think too much about it.

Once you find this spot just smack the torsion bars in with a soft mallet, install the bushing housing, tighten the set screw if you have one, and load up the plate. Done!

What is Camber?

Camber may be defined as the angle of the wheel with respect to the vertical access of the vehicle, or simply put it is wheel slant. It follows then that the “cambering effect” is the constant change in camber as the vehicle drives down the road. If a vehicle has wheels that lean inward the vehicle is said to have negative camber, and if a vehicle has wheels that lean outward the vehicle is said to have positive camber. Usually on a performance street car about 2 degrees is desirable for cornering but not much more.

When it comes to a swing axle, cambering is inevitable since each side of the vehicle uses a straight axle. However, up until this point there was practically nothing that could be done to stop excessive negative camber from happening in a lowered vehicle, and transversely excessive positive camber from happening in a raised vehicle.

Will These Plates Fix my Camber?

No spring plate will fix your camber. Spring plates only supply the spring force from the torsion bar to the axles, and then, in turn, to the road. Camber is directly linked to the axle, which is straight. However we are almost ready to launch our full suspension that will include the Adjustable Camber Unit (ACU). A suspension fitted with this will inevitably raise the bar on swing axle technology and solve a problem that no company has been able to do, which is make an infinitely adjustable and highly tunable swing axle suspension. The ACU is compatible with the Adjustable Plates and definitely recommended. The hubs and Drop/Raise Plates are actually an integral
part of the system so when you purchase them you are actually purchasing a piece of the entire Atomwerk performance swing axle suspension. Our entire suspension is more adjustable suspension than the IRS and more robust, and therefore will be a competitor to the mighty IRS, but more importantly it will be an alternative to hacking and converting your swing axle to an IRS just because you want performance and you don’t want excessive camber. Ultimately an IRS conversion devalues a vehicle in the grand scheme of things.

Why Do Atomwerk Spring Plates Ride Better than Stock Spring Plates When my Car is Lowered or Raised?

Ok, so if this still seems a little bit confusing, I completely understand. There is a lot of calculation involved. However, all you have to do is see the YouTube video to observe my car easily absorbing all types of terrain. Atomwerk Drop/Raise Plates work well because torsion is retained in the system. Have you ever lowered, or seen someone lower a VW with factory spring plates? If you haven’t I encourage you to either google the procedure or look it up on YouTube. One thing that should stand out in your mind is that before the spring plate could be reindexed, it first had to be unloaded. Initial torsion is lost. Unloading a spring plate can be a dangerous process because it is under "preload" or "pretorsion." This means that stock spring plates are loaded much in the same way a rat trap is when cocked. This preload is CRITICAL for VWs to ride correctly. I want to reemphasize that preload is CRITICAL! You see Volkswagen designed the cars so that the instant they touched the ground the rear wheels already have a certain amount of force pushing away from the ground (torsion in the system). Notice figure 3 (pg.2). A car with these raise plates should ride in this position. That is to say that they should NOT look this way before the car is touching the ground, but only after. Now notice figure 1 (pg.2). Note how the distance between the bottom stopper on both drawings is the same? Thus in the same way that VW had intended, Atomwerk plates are designed to operate with the same amount of PRELOAD that the factory had intended. When properly preloaded, the only difference will be the final axle location, and therefore wheel location. Your ride quality will not lessen, but your car’s height will change.

So then do Atomwerk Drop and Raise Plates fix all of these bad issues?

Yes. When installed correctly you will have restored the factory torsion in the system, the plates will angulate correctly in the torsion housing, and toe-in will be zero. This means that your ride will feel firm, your rear suspension will have full travel to absorb tall bumps, and your ride will track straight in all weather.

The Importance of Alignment

It is important after our Drop Plates are installed that the vehicle is aligned. After aligning the car, first drive it for several miles so that the car has a chance to settle down into its natural daily driving position. Only after this can the car be regarded as safe for everyday and track usage.

Comparison

I recently had a chance to go to the Mid America Motorworks, Air-Cooled VW Funfest 2013 in Effingham, Illinois and set up an open chassis with a Drop Plate on one side and re-index the other side with the factory spring plate. The cal was sitting evenly and at first glance there was nothing unusual. Just a lowered car.

The Drop Plates fit into the torsion housing just as a factory plate would if it had not been lowered. The problem with a lowered factory plate is that there is not enough upper clearance and there is too much lower clearance. There isn’t enough clearance on the left side to stick your finger in. This causes a very harsh ride! This causes the re-indexed side to want to drop down to excessively while cornering and have rear wheel tuck (dangerous for cornering), whereas the side with the Drop Plate keeps everything in check quite nicely.

An added advantage of the Drop Plate was the extra clearance that the shock has. This is because the Drop Plate does not twist the shock underneath the axle tube like a re-indexed factory spring plate does. Factory plates were not designed to ride at any other height than stock location. This is also true for a Drop or Raise Plate. They should only ride at the height that they were designed for. What can’t be conveyed without pictures is the difference in ride quality the side with the Drop Plate had!!!

The Quality

Quality is a lot more that just nice parts for your VW. Quality is engineered in. All of our parts have been computer engineered, human engineered, tested in the lab, and then proven on the street. We do more than “seat of the pants” engineer our stuff, but actually crunch the numbers. All of our inventions have been designed on our own regardless of some similarities our parts may have to the other guys. This is why our spring plates look slightly different than anything out there, and why we have inventions that are like nothing out there! Our plates are the best quality that money can buy! This is not an exaggeration like a lot of other companies claim. Simply put, our Drop Plates are overbuilt.

Other Products

Drop Plates are only part of the complete puzzle and alone cannot give you the ride that you are after. If you have not already purchased the other parts (Urethane Bushings, Short Shocks, Spring Plate Loader Tool (323-243) & Fasteners) Mid America Motorworks can help to complete your suspension.

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