996 Standard and Sport Suspensions Analyzed

Spring rate and shock dyno data comparing different 996 C2 six-speed coupe factory suspension configurations

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The Porsche 911 Carrera (Model 996) is available in Europe and the USA with an optional factory installed sport suspension listed as option code M030 that includes stiffer springs, shocks and stabilizer bars. A similar sports chassis kit is also available in Europe for aftermarket installation through Porsche Tequipment. The story behind this article began when Russ took delivery of a new C2 996 six-speed coupe in the summer of 1999 equipped with the USA M030 suspension and noticed that the ride height seemed to be too high with excess space showing between the fender arches and the tops of the tires. This aesthetic problem was compounded in the rear when the original 265/35 tires were replaced with lower profile 285/30 tires. Bob collects Porsche literature and noticed in the British Tequipment catalogue that the sports chassis kit lowers the center of gravity by approximately 10mm. He researched this further and discovered the ride height specifications shown in Table 1.

The Rest of World (RoW) cars with standard suspension are on average 10mm lower in the front than the USA cars while the RoW sport suspension cars are 20mm lower in the front and 10mm lower in the rear. The much lower GT3 ride height specs are also listed in Table 1. This situation led Russ to contact Mike at Schatz Motorsport who had the RoW sport suspension components in stock including different front and rear springs as well as shocks. The M030 stabilizer bars are the same for all markets and did not need to be replaced on the subject car. Part numbers and wall thickness dimensions of the standard and sport tubular stabilizer bars are shown in Table 2. We were curious how much stiffer the sport stabilizer bars are than the standard bars and used the spring rate equation shown at the bottom of Table 2 to make this calculation. The percentage-increased stiffness values for the sport vs. standard stabilizers are shown in the yellow shaded areas of Table 2 with the front sport stabilizer bar about 10 percent stiffer than standard while the rear is 24 percent stiffer.

Static ride height was measured before and after installation of the RoW sport suspension as shown in Table 3. Notice that the front of the subject car was lowered 12mm and the rear 8mm in addition to the 5mm resulting from the tire change. The pictured subject car with lowered RoW sport suspension installed pictured shows very little wheel well at the top of the tires resulting in considerable aesthetic improvement. Per the Porsche workshop repair manual, there are no significant differences besides ride height in the alignment specifications for the USA vs. RoW suspensions.

On the road, the RoW M030 996 suspension felt noticeably stiffer than its USA counterpart especially in the front. The handling seemed to be improved quite a bit more than would be expected from the slightly lower center of gravity with the subject car exhibiting sharper turn-in and flatter cornering. This piqued our collective interest to discover the differences between the USA and RoW M030 springs and shocks.

Spring and bumpstop research

This article is limited to 996 C2 six-speed coupes because of the springs. Spring specifications vary with weight differences depending on whether the car is a cabriolet, has a Tiptronic transmission or is equipped with four-wheel drive. For example, a C4 cabriolet with Tiptronic weighs 386 pounds more than a C2 six-speed coupe and requires stiffer springs. The model and equipment complexity of the spring specs is then layered on top of the M030 and USA vs. RoW specs so it would have been impractical to obtain all of the springs for testing.

Shown in Figure 1 are the conical front springs tested for this article and cylindrical rear springs are shown in Figure 2. Note the decreasing height from USA standard to RoW sport with the latter about one inch shorter than USA standard in the front and around 1.5 inches shorter in the rear. Although the USA sport springs are shorter than standard, the cars end up the same height because the sport springs are stiffer and don't compress as much with the weight of the car. The 0.2 to 0.35mm front and 0.57mm rear thicker gauge wire of the sport vs. standard springs is not as easy to see in the pictures but this difference was measured and is listed in Table 4. The spring color code stripes are also demonstrated in the pictures. At the top is the spring "tolerance group" color stripe that is either white or green with the green springs on average 3.5mm shorter than the white ones. White or green spring equipped cars end up the same height because of different thickness "compensator disks" incorporated into the struts during assembly and a car may have a front and rear mixture of tolerance group springs but they will be the same on each axle. The "application color stripes" at the bottom of the springs translate into part numbers as shown in Table 4. In general, a brown left bottom stripe indicates RoW or USA standard suspension, gray is USA sport and green is RoW sport so these colors are used in the charts and tables accompanying this article to designate these suspension configurations.

The front and rear bumpstops or "micro-cellular progressive jounce bumpers" pictured in Figure 3 are actually auxiliary springs that work in tandem with the steel springs to provide a very progressive spring rate at the extreme of suspension compression. The front bumpstops are the same for all markets and suspension configurations. There are standard as well as sport rear bumpstops all of which were measured as shown in Table 5 with the rear sport bumpstop found to be 13mm shorter than the standard version.

We then had load vs. height (length) data for the springs and bumpstops measured on the hydraulic testing machine pictured in Figure 4 during one of the front spring tests. Load in pounds was measured every half inch of compression for the steel springs to a minimum height of 2.5 inches for the front and 5.5 inches for the rear springs. The front spring data generated is shown in Chart 1 which demonstrates that the curves are linear (constant slope or spring rate) except for some increasing slope for the USA springs at around a height of four inches. This is better depicted in Chart 2 which plots the slope (1^{st} derivative) or spring rate in pounds per inch at each point of load vs. spring length measurement in Chart 1 with a moving average smoothing algorithm applied to the data to generate the bold curves. The linear spring rates for the front springs turn out to be approximately 170 lbs/inch for the RoW and USA sports and 146 lbs/inch for the USA standard implying that the sports are 16.6 percent stiffer than standard. We are not entirely certain that the USA springs have a progressive rate toward the end of travel in compression since there are only a few data points and the RoW sports which also have a conical configuration do not have a progressive rate in the measured range as shown in Chart 2.

The rear spring load vs. length data is shown in Chart 3 which demonstrates that the curves are linear implying a constant slope or spring rate, i.e., the springs are not progressive rate in the measured range of lengths. Notice how the slopes (spring rates) of the sport spring curves are quite a bit steeper than the standard spring curve so that they actually cross over it. The slopes or spring rates at each data point in Chart 3 are plotted in Chart 4 with a moving average smoothing algorithm applied to generate the bold curves. The spring rates are linear with the RoW and USA sport springs measuring approximately 260 lbs/inch and the USA standard springs 203 lbs/inch so that the sport springs are 28.2 percent stiffer than standard. The measured front and rear linear spring rates are summarized in the yellow shaded areas of Table 4.

The bumpstop load was measured every 0.2 inch down to one inch of height with the data plotted in Chart 5. Unlike the linear steel spring load vs. length curves, the bumpstop curves demonstrate rapidly increasing slope (progressive spring rates) with compression. This is better depicted in Chart 6 where the spring rates or slopes (1^{st} derivatives) at all data points in Chart 5 are plotted vs. bumpstop height. The exception to the progressive bumpstop spring rates are the curious initial "humps" in the rear bumpstop spring rate curves shown in Chart 6 which seem to be a designed in but unexplained feature. It is interesting that a similar "hump" is not present on the front bumpstop spring rate curve. Note that the rear sport bumpstop has a much stiffer progressive spring rate than the standard bumpstop.

Spring and bumpstop interactions

There were two missing pieces in the spring puzzle at this point. How did the steel springs and bumpstops interact i.e., when did the bumpstops come into play on the road in relation to the amount of spring compression and what was the "working range" in terms of length for the springs? With the subject car in the RoW sport suspension configuration, the static loaded and unloaded lengths of the springs were measured on the car along with the spring lengths at bumpstop contact. The measurements are shown in Table 6 with extrapolation to the USA standard and sport suspensions based on our ride height as well as spring, bumpstop and shock absorber strut measurements for all suspension configurations. These measurements enabled us to combine the spring and bumpstop spring rate data at the appropriate steel spring lengths to generate the combined spring rate curves depicted in Chart 7 and Chart 8. The vertical bars on the curves represent the spring length measurements from Table 6 converted into inches as noted in the callout boxes and are color coded according to suspension configuration. Where the USA standard and sport spring length measurements are the same, the default color of the vertical bars in Charts 7 and 8 is "brown" and the double-headed arrows indicate the directions of spring extension and compression about the static loaded positions. The steel spring and bumpstop spring rates were combined beginning at the points of bumpstop contact indicated by the red vertical bars in the charts. Notice that since the RoW M030 suspension is lower, bumpstop contact occurs with less spring compression from the static loaded position than the USA M030 suspension. Also, the rear USA standard suspension has a higher spring rate around the 6.8” spring length position than either of the sport suspensions because of the taller standard bumpstop.

We elected to display the spring rate measurements in British units since these are most familiar to U.S. readers and this facilitates comparison with several aftermarket spring sets discussed later.

Shock absorber research

Investigating the shock absorbers proved to be easier than the springs because there are no variants in the standard and sport shocks based on body style or transmission type. Only the C4 has different front shock specs with the rears the same as on the C2. The three different shock types that we needed to test were therefore the USA standard and sport as well as the RoW sport. Pictured in Figure 5 with bumpstops in place on the piston shafts are a USA sport front strut on the left and a rear shock on the right. The red arrows on the shocks demonstrate the color dots matching the left lower application stripes on the springs with “brown” designating the USA standard, “gray” the USA sport (pictured) and “green” the RoW sport specifications.

The first order of business was to carefully measure the shock body and piston shaft lengths. We also measured the relative positions of the lower spring perches to the shock bodies. The front lower spring perch is shown in the picture as the oblique rounded platform on the front shock/strut and the gold washer on the rear shock body is the lower spring perch. The only dimensional differences we found were in the shock piston shaft lengths shown in Table 7 with the front RoW sport piston shaft length 12mm shorter than on the USA shocks which interestingly is the amount the front of the subject car was lowered with the RoW sport springs. The rear RoW sport and USA sport shock piston shafts are 15mm and 5mm shorter respectively than the USA standard piston shaft. The part numbers in Table 7 refer to the engraved numbers on the shock bodies since the USA M030 shocks have paper labels demonstrated in the picture that have different part numbers. The front strut paper label says “USA SPORT COUPE” with a part number 996.343.031.36 and the label on the rear shock says “USA COUPE SCHALT SPORT” with a part number 996.333.055.20. We don’t know why the part numbers on the labels are different than the engraved numbers but the latter are used in the Porsche parts books so that is why we used them in Table 7.

Our next step was to contact Bilstein, the 996 OEM (original equipment manufacturer) shock supplier to Porsche and they generously agreed to perform dynamometer tests on the six shocks we were analyzing. A rear shock is shown on the Bilstein dyno in Figure 6 and the dyno run printout for a rear RoW sport shock is reproduced in Figure where the sharp-eyed reader will note that there is a typo in the part number which should read “996 333 051 13.” The damping force (newtons) vs. shock piston shaft velocity (mm/sec) data points generated on the dyno in rebound and compression were utilized to create the front and rear shock test curves in Chart 9 and Chart 10 with the curves furthest away from the x-axis (piston shaft velocity) exhibiting the stiffest damping characteristics. We also included data on the new Bilstein aftermarket "Heavy Duty" front (VN7-4612) and rear (BE5-2993) shocks. The front dyno runs revealed that of the three factory installed shocks, the USA standard is the stiffest in rebound and of intermediate stiffness in compression between the stiffer RoW sport and least stiff USA sport. The USA sport was also the least stiff in rebound. The front Bilstein HD shock was by far the stiffest in rebound and compression. The rear dyno runs demonstrated the USA standard shock was the least stiff in rebound and compression while the RoW sport shock was the stiffest and the USA sport was intermediate. The rear Bilstein HD shock was similar to the USA standard with a little more stiffness in rebound.

Metric shock characteristics utilized by Bilstein, Koni and others are specified in "decanewtons" at a piston shaft velocity (PSV) of 0.5 meters (500mm) per second indicated by the vertical blue dotted lines in Charts 9 and 10. Newtons are a metric unit of force and for those who prefer to think in British units, a "decanewton" or 10 newtons is about 2.2 pounds of force. The damping force vs. piston shaft velocity curves demonstrate that the shock specs at 0.5m/sec do not tell the entire story. Note for example in Chart 10 that although the rear USA standard and sport shocks have an identical spec in compression at 0.5m/sec, the curves are actually crossing over at this point with different damping force characteristics above and below this piston shaft velocity. The behavior of these shocks on the road would therefore be different despite the same compression spec at 0.5m/sec. Measured specs in decanewtons at 0.5m/sec for the shocks tested are included in the callout boxes within the test charts as well as in the yellow shaded area of Table 7.

To understand how the shock absorber data translates into the "real world," think in terms of piston shaft velocities (PSV). A "low-speed" event such as a gentle undulation in the road would have a PSV of ≤ 0.13m/sec while an example of an "intermediate-speed" (0.14-0.50m/sec PSV) event would be driving across railroad tracks, i.e., mild to moderate bumps. A "high-speed" event with PSV > 0.5 m/sec would be hitting a pothole. "Speed" as it is used here refers to PSV and not the velocity of the vehicle. Low-speed events relate to chassis (sprung weight) motion while high-speed events relate to wheel/suspension (unsprung weight) movement. Note that the PSV of 0.5 m/sec used for shock specs is at the high-speed threshold. Keep in mind that compression damping controls displacement of the car's unsprung weight on the initial contact with a bump while rebound damping controls movement of the car's sprung weight related to the elastic or restorative force in the compressed spring. Since sprung weight is much greater than unsprung weight, there is generally less compression than rebound damping.

Discussion of spring and shock absorber research data

We were disappointed that the RoW sport springs didn't lower the car more. The front was lowered 12mm and the rear 8mm vs. USA ride height. The rear had already been lowered 5mm by the lower profile 285/30 Pirelli PZero vs. 265/35 Continental Sport Contact tires so the net drop was 13mm. The 285/30 tires also provide for slightly lowered gearing of 1.5 percent and do fit under the rear fenders without any clearance problems. The reason we expected the car to be even lower is that according to the factory alignment specs, the RoW M030 cars are on average 2cm lower in the front and

1cm lower in the rear vs. USA cars. However, the specs vary by ±10mm so it is theoretically possible for a high RoW sport suspension car to be the same height as a low USA car and the subject car was well within spec. It did occur to us that one could obtain the shorter "green" tolerance group springs and assemble them with the thin "white" compensator disks to lower the car another 3mm or so but to our knowledge this issue is not addressed by the Porsche factory so we cannot recommend it.

Interestingly, Bruce Anderson discusses ride height in the June, 2001 PORSCHE PANORAMA (p. 35) noting that what most people consider "Euro Spec" is actually lower than true European specifications. He feels that 25½ inches in the front and 25 inches in the rear for ride height measured in the same way as for this article looks "right." This compares to just slightly over 26 inches all the way around for the pictured RoW M030 subject car, which still looks a little high. One other issue to consider is ground clearance since the mildly lowered subject car scrapes the undercarriage noticeably more on bumps and driveways than it did at the USA height.

The sport stabilizer bars exhibit quite a bit more stiffness vs. standard in the rear compared to the front (about 14 percent) which would bias the handling away from understeer and more toward oversteer as summarized in Table 8. The same is true for the springs since the average front linear spring rate for sport vs. standard is 170 vs. 146 lbs/in while the rear is 260 vs. 203 lbs/in implying a 16.6 percent increase in the front vs. 28.2 percent in the rear. The 12 percent relative greater stiffness in the rear for the M030 springs would also bias the handling away from understeer and more toward oversteer compared to the standard springs as shown in Table 8. While assuming linearity of the spring rates is useful for comparative purposes, all of the spring units tested in this article demonstrate progressive rates toward the lower end of their travel mainly when the bumpstops come into play as shown in the spring rate Charts 7 and 8. The conical configuration of the front spring could theoretically allow it to be compressed to about one inch with testing to 2½ inches for this article. The cylindrical configuration of the rear spring would allow theoretical compression to three inches before coil binding with testing to 5½ inches. In reality, it seems very unlikely that the bumpstops would ever compress to less than one inch because of extremely high spring rates and at this compression, the steel spring heights would be about three inches front and 5½ inches in the rear both within the tested lengths for this article.

We were very surprised how quickly the bumpstops come into play especially on the RoW sport front suspension where static loaded position to bumpstop contact is only 6mm as shown Table 6. This compares to 18mm for the USA suspensions and probably accounts for a lot of the perceived stiffer ride vs. the USA sport configuration. For perspective, spring rates for some aftermarket springs as well as the springs tested in this article are shown in Table 9. In general, the after-market springs are quite a bit stiffer than the OEM sport springs especially in the front. The aftermarket spring rates were obtained from the vendors and were not independently verified by us.

We had expected the USA and RoW sport shocks to have similar and stiffer damping characteristics compared to the USA standard shocks but we were again surprised by the data. Of the front factory shocks, the RoW sport is the stiffest in compression but the USA standard is the stiffest in rebound. Most interesting was that the front USA sport had the least damping force of all in both compression and rebound as demonstrated in Chart 9. In the rear, the results were more what we had anticipated: the RoW sport shock has the stiffest damping in both compression and rebound. While the rear USA sport shock is not as stiff as the RoW sport, it is generally stiffer than the USA standard except for the interesting initial (low to intermediate-speed PSV) higher damping force in compression of the USA standard similar to the RoW sport. This could relate to reducing front suspension harshness on the USA M030 specification. The Bilstein aftermarket HD front shock is considerably stiffer across the board than the factory shocks while the rear HD shock has similar characteristics to the USA standard shock but provides more control in rebound with a little less in compression. Per information on the Bilstein web site, using increased compression damping can mimic the effect of a stiffer spring so installing the front and rear Bilstein HD aftermarket shocks would likely bias the handling more toward understeer compared to the OEM suspensions.

How reproducible are our test results? Since all of the tests were somewhat time consuming and performed "pro bono", we could not realistically test duplicate springs and shocks but we believe the results to be valid since the RoW parts were all new and the USA parts were from cars with low mileage (around 6,000 miles) that had never been abused or in any accidents.

What about cost for the RoW sport suspension conversion? Budget about $1200 for the springs and shocks and $300 for the stabilizer bars if you are upgrading from standard suspension. The conversion takes most of a day to perform and the cost of labor at a Porsche dealer would be in the range of $600-$800.

The reader is probably wondering at this point why a lower, stiffer and better-handling RoW M030 sports suspension spec is not offered in the USA? We can only speculate on this: it is unlikely that bumper height requirements are an issue since the new 911 GT2 has "Sports suspension with ride height lowered by 20mm *for all markets* (unlike 911 Turbo)" per the product information book. A USA spec GT2 was measured (Table 10) and confirmed to be approximately 1.38 inches lower front and rear than a USA 996 Turbo. We have heard semiofficial scuttlebutt that Porsche does not believe USA drivers are as tolerant of a stiff ride and low ground clearance as European drivers, so this could be a factor. The fact that our tests demonstrate the USA sport shocks are softer than the RoW sport specification would lend some credence to this idea. Per an October/November 2001 *Christophorus* article, *"Pliant Power,"* the shock specs on the 2002 996 have been changed with stiffer rebound damping in the front and "…increased differentiation between rebound and compression stages…" in the rear but it is unclear what suspensions and markets this applies to. A preliminary check by Mike of the MY 2002 part numbers indicates that for a C2 six-speed coupe, the springs and shocks are different from MY 1999 through 2001 while the stabilizers and bumpstops are the same.

There is also the new mystery of the "Minus 30" or "Thirty Low" Porsche Exclusive suspension option MX74 per the article *"Hard-Core Suspension Tuning"* in the August/September 2001 *Christophorus*. This is listed on the British Porsche web site as a "Sports chassis (-30mm)" option on 996 coupes both C2 and C4 but not cabriolets and is very expensive at £1.727,25 vs. the regular (M030) sports chassis at £352,50! There is no listing of this option on the North American web site under "Porsche Car

Configurator." Mike has researched the MX74 suspension and found that it consists of different springs and shocks as well as front strut mounts and front bumpstops. The rear bumpstops and stabilizers are the same as the M030 spec. The parts apparently cannot be ordered without the vehicle identification number (VIN) of a car that was originally equipped with the MX74 option since there are also some chassis "reinforcement" measures involved in the installation which is performed in the Exclusive workshop and not on the assembly line. We plan to research "Thirty Low" further and possibly install the components on the subject car if it is feasible. Stay tuned for a follow-up article!

Conclusions

Table 11 is a summary of our findings in comparing the 996 C2 6-speed coupe USA standard suspension to the USA (gray shaded area) and RoW (green shaded area) sport (M030) suspensions. In the subject car, the RoW sport suspension resulted in about 1cm lower ride height compared to USA cars. The stiffer sport stabilizer bars and springs provide for greater stiffness in the rear than in the front relative to the USA standard suspension and therefore bias vehicle dynamics away from understeer and more toward oversteer. The RoW M030 suspension "feels" stiffer than the USA sport because of earlier deployment of the front and rear bumpstops related to lower ride height as well as stiffer shock absorbers. We believe that the conversion to RoW sport suspension is a worthwhile though expensive upgrade if you want sportier handling than the available USA suspensions provide, don't mind a stiffer ride and can tolerate more scraping of the undercarriage associated with the lower ride height. We also do not recommend "mixing and matching" the various springs, shocks and bumpstops evaluated for this article since all of these parts have different design characteristics that work in concert together.

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