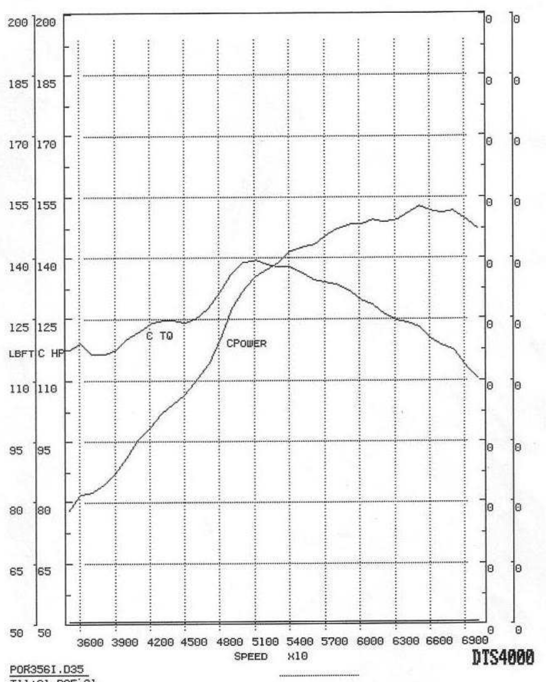
# Willhoit Auto Restoration

# DYNO TESTS(for twin plug engine development tests, please read the Engine Development Article)

The dyno tests on these pages are the result of several years of testing. Below is a sample of the original data as it is printed from the DTS dyno computer, but most of the tests are charted in a standard Excel format to make them easier to compare. Keep in mind that most tests shown are the best runs once jetting and timing was optimized unless specifically noted. All tests include the specifications of each engine and all have been run using standard Premium pump gas available in California (with our additives) unless otherwise noted. All tests are run using stock timing advance of 36 degrees unless otherwise noted. Other components are stock unless noted. Camshafts are listed as measured by us at .050”, not as advertised.

The test curves are plotted using a full throttle sweep from the beginning RPM to the max. RPM. Depending on the specific engine and the desired maximum RPM, the chart may begin sooner or later. For most lower RPM engines the sweep begins at 3000 to 3200 RPM and ends at 6000. In order for the computer to plot the test numbers it’s necessary to rev the engine approximately 300 RPM past the shown maximum. For this reason, some of the tests are limited to under 6000 RPM. Most engines won’t accept full throttle below 3000 RPM with the static dyno load, that’s why the tests begin at or above 3000.

SAMPLE DYNO SHEETS:




POR356I.D35
T11:31 D05-21
ENGINE PORSCHE 356I 1925cc
TIMING:25@PEAK TORQUE
AFTER OILCHANGE TO SYNTHETIC

C_TQ 139.29 lbft @5100
CPower 152.31 C_HP @6500
0 @0

C_TQ 0 lbft @0
CPower 0 C_HP @0
0 @0

CAROBU Engineering LLC
925 West 16th Street
Newport Beach, CA 92663
949-722-3917

Date 05-21-2004 Time 11:31:38

T11:31 D05-21 Engine PORSCHE 356I 1925cc
Timing:25@peak torque After Oilchange to Synthetic
updated with motec

FileName : POR356I.D35
Mode : A-Sweep

| Speed rpm | CPower C_HP | C_TQ lbft | Oil psi | Oil° °F | A/F Left | A/F Right | Fuel_P psi |
|---|---|---|---|---|---|---|---|
| 3500 | 78 | 117 | 47.7 | 182 | 12.93 | 13.86 | 60.3 |
| 3600 | 81.6 | 119.1 | 48.6 | 182 | 12.62 | 13.44 | 60.3 |
| 3700 | 82.1 | 116.6 | 49.2 | 182 | 12.44 | 12.99 | 60.3 |
| 3800 | 84.2 | 116.4 | 49.7 | 182 | 12.36 | 12.87 | 60.3 |
| 3900 | 87.3 | 117.5 | 50.2 | 182 | 12.35 | 13.02 | 60.3 |
| 4000 | 91.3 | 119.9 | 50.6 | 182 | 12.38 | 13.09 | 60.3 |
| 4100 | 95.3 | 122 | 50.9 | 182 | 12.41 | 12.9 | 60.2 |
| 4200 | 98.9 | 123.7 | 51.2 | 182 | 12.46 | 12.75 | 60.2 |
| 4300 | 101.8 | 124.3 | 51.5 | 182 | 12.45 | 12.66 | 60.2 |
| 4400 | 104.3 | 124.5 | 51.7 | 182 | 12.41 | 12.6 | 60.2 |
| 4500 | 106.2 | 123.9 | 52 | 182 | 12.21 | 12.41 | 60.2 |
| 4600 | 109.4 | 124.9 | 52.2 | 182 | 12.09 | 12.31 | 60.2 |
| 4700 | 114.2 | 127.6 | 52.4 | 182 | 12.02 | 12.29 | 60.1 |
| 4800 | 120.2 | 131.5 | 52.8 | 182 | 12.05 | 12.28 | 60.1 |
| 4900 | 127.1 | 136.2 | 53.1 | 182 | 12.16 | 12.37 | 60.1 |
| 5000 | 131.9 | 138.6 | 53.5 | 182 | 12.35 | 12.48 | 60.1 |
| 5100 | 135.3 | 139.3 | 53.8 | 182 | 12.5 | 12.59 | 60.1 |
| 5200 | 136.8 | 138.2 | 54.2 | 182 | 12.64 | 12.63 | 60.1 |
| 5300 | 138.7 | 137.5 | 54.5 | 182 | 12.61 | 12.67 | 60 |
| 5400 | 141.5 | 137.6 | 54.8 | 182 | 12.49 | 12.81 | 60 |
| 5500 | 142.7 | 136.3 | 55 | 182 | 12.36 | 12.87 | 60 |
| 5600 | 143 | 134.1 | 55 | 182 | 12.21 | 12.71 | 60 |
| 5700 | 145.1 | 133.7 | 55.1 | 182 | 12.18 | 12.74 | 60 |
| 5800 | 147 | 133.1 | 55.2 | 182 | 12.13 | 12.71 | 60 |
| 5900 | 148.1 | 131.8 | 55.4 | 182 | 12.1 | 12.6 | 59.9 |
| 6000 | 148.2 | 129.7 | 55.6 | 183 | 12.23 | 12.52 | 60 |
| 6100 | 149.3 | 128.6 | 55.7 | 184 | 12.3 | 12.58 | 59.9 |
| 6200 | 148.5 | 125.8 | 55.9 | 184 | 12.43 | 12.45 | 59.9 |
| 6300 | 149.3 | 124.5 | 55.5 | 184 | 12.47 | 12.67 | 59.9 |
| 6400 | 150.6 | 123.6 | 55.4 | 185 | 12.51 | 12.85 | 59.9 |
| 6500 | 152.3 | 123.1 | 55.8 | 185 | 12.6 | 13.06 | 59.9 |
| 6600 | 151.1 | 120.2 | 56.6 | 186 | 12.46 | 13.15 | 59.9 |
| 6700 | 150.9 | 118.3 | 56.2 | 187 | 12.43 | 13.3 | 59.9 |
| 6800 | 151.6 | 117.1 | 55.7 | 188 | 12.3 | 12.88 | 59.9 |
| 6900 | 148.8 | 113.3 | 55.5 | 189 | 12.18 | 12.56 | 59.9 |
| 7000 | 146.9 | 110.2 | 55.6 | 189 | 12.11 | 12.53 | 59.9 |

[ Average data ]

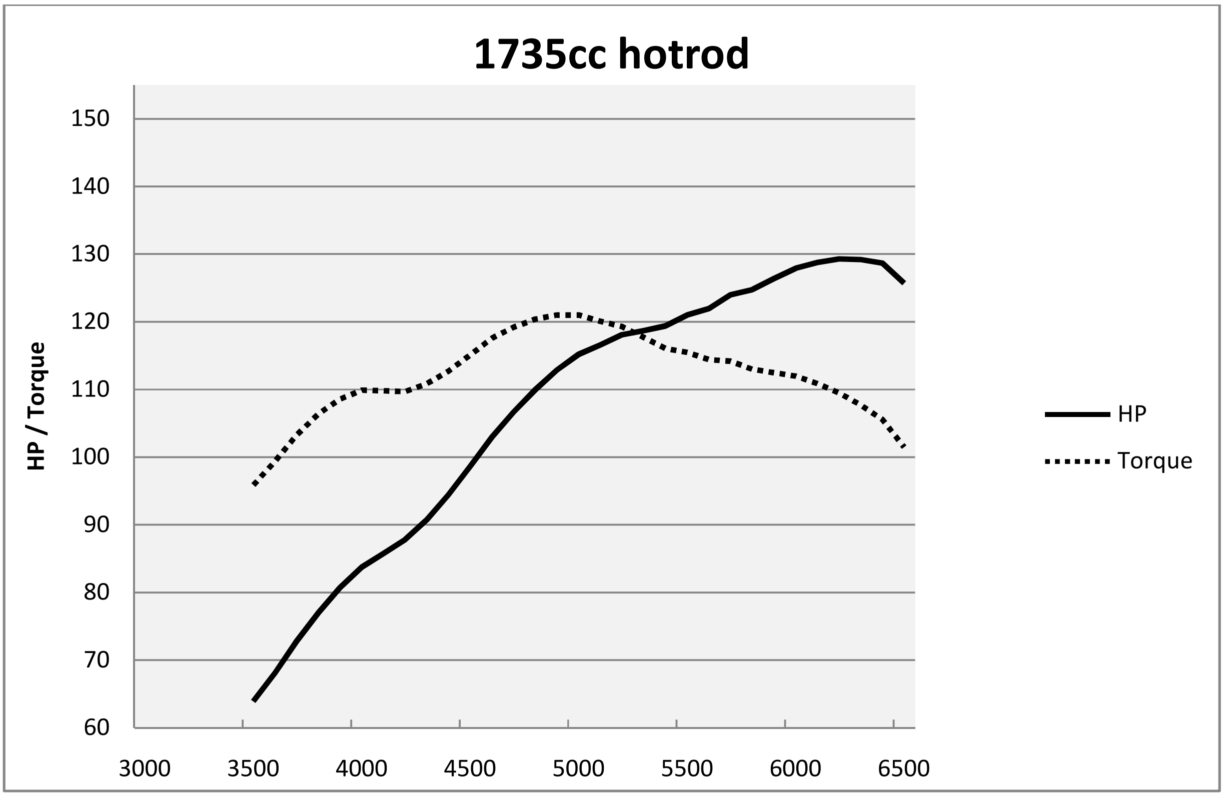
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5250 | 126.1 | 126.1 | 53.4 | 183.2 | 12.36 | 12.76 | 60.1 |

[ Inertia factor ] .81 [ Time ] 7.6 Secs

# 1735cc Hot Rod 356 SC engine

**129hp@6200 / 121ftlbs@4900**

86.5mm cast iron cylinders w/custom JE forged pistons w/ 10.2:1 CR
Scat lightweight crankshaft 74.0mm
Carrillo rods
10.5lb flywheel
911 piston squirters, full flow oiling system
5" front pulley
44IDF Webers w/36mm venturis
Custom 5" aluminum air horns (no air cleaners)
Elgin 7208 HL camshaft 248 degree, .370" lift
42mm Type-4 intake valves / stock 34mm exhaust valves, double springs, ti-retainers
Custom WR 4:1 header with 36x1.5" primaries and 10" stinger/resonater



This was the first engine we dyno tested at Carobu. The intakes were ported to flow into the valves, and the chambers were unshrouded, but the intake manifolds at the gaskets were kept stock. Peak flow at .500” was later tested at 176cfm.  The long primary pipes of the WR 4:1 header gave an excellent boost to the mid range torque, but with a VERY sporty sound.

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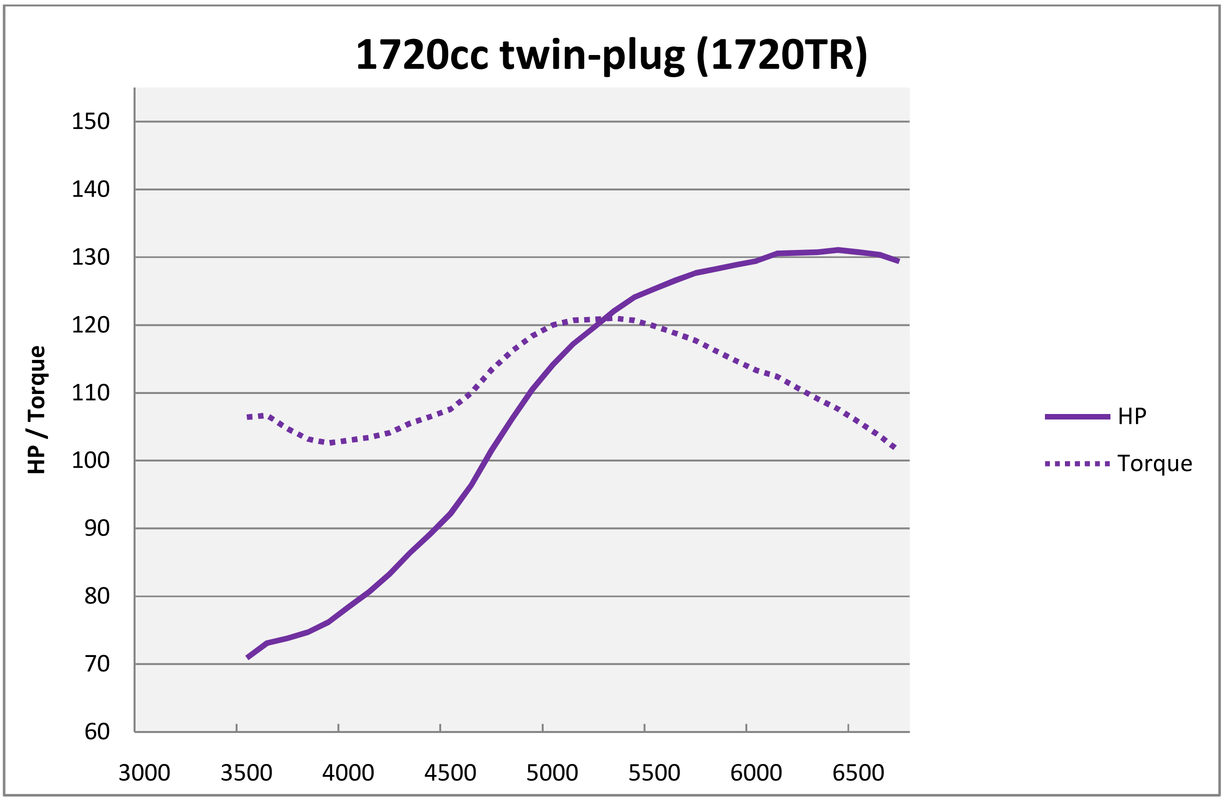
# 1720cc Twin Plug (1720TR)

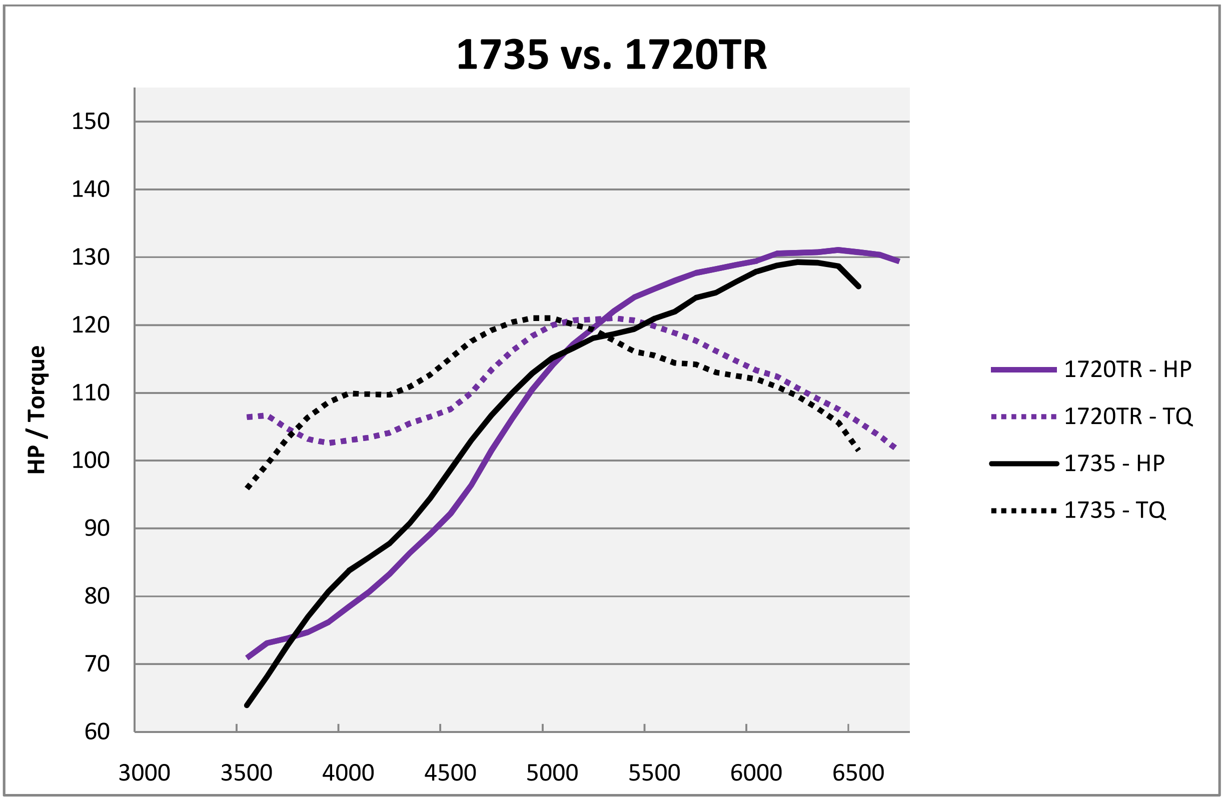
### 131hp@6400 / 121ftlbs@5300

248 degree camshaft with .370” lift (Elgin 7208 HL)
Special LN Engineering 86mm “Nickies” cylinders using custom JE forged pistons with 10.50:1 compression ratio.
Bored case with 911 piston squirters installed, full flow oiling system.
Scat lightweight crank with Carrillo rods.
WR 10.5lb Flywheel kit with aluminum 200mm pressure plate.
Aluminum 5” front pulley.
Custom twin plug distributor using a MSD CDI box firing two Bosch CDI coils. 25 degrees maximum timing advance.
42mm Type-4 intake valves / stock 34mm exhaust valves, double springs, ti retainers
Weber 44IDF carbs with 36mm venturis and 2.25” airhorns w/K&N air filters.
Crankcase ventilation in the case and heads.
Special aluminum pushrods.
Raceware cylinder head studs.
WR Sport Exhaust for twin plug.




This was basically the 1735cc engine above that we later converted to a twin plug with some of the other TR upgrades. The owner wanted to keep the engine as a 1720cc (the 86.5mm cylinder walls of the 1735cc were somewhat thin and we wanted to use the LN Eng cylinders). Also, the 4:1 exhaust was very loud, and the air horns looked cool but did nothing for filtering out dirt.  The cylinder heads were unchanged except for the addition of the 2nd plug. Even though there were some compromises made in performance, the owner was thrilled with the dyno results. Despite the smaller size the engine made (almost) the same power but was much more quiet, and the throttle response was improved by the twin plug.

A comparison of the two engines is shown below:




As you can see in the graph, the tuning affect of the long primaries and the taller air horns boosts the torque between 3500 and 5500rpm, but the TR set up with the WR Sport Exhaust and the stock Weber 2.25" air horns and air cleaners are much more reasonable for street use, and also boost power above 5000rpm. We also tried the TR engine without the K&N air cleaners and recorded no gain in power.

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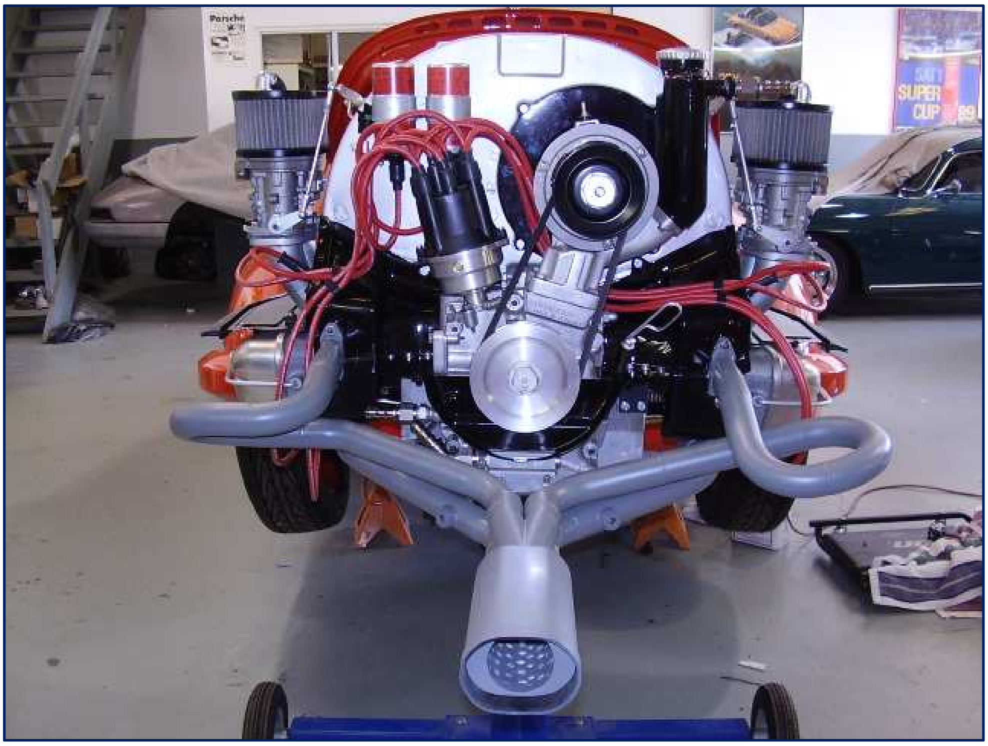
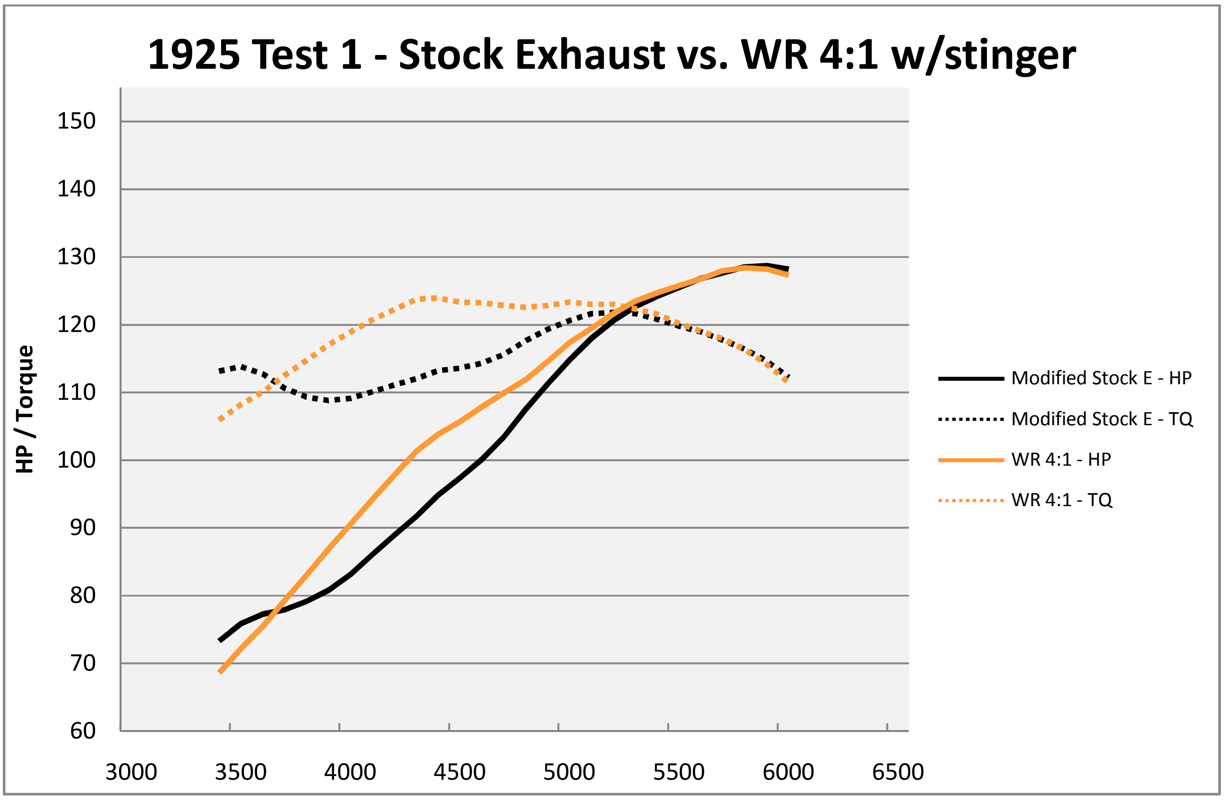
# 1925cc Test #1 – Stock vs. WR 4:1 exhaust

**129hp@5900 / 122ftlbs@5200 STOCK**

**128hp@5800 / 124ftlbs@4400 WR 4:1**

240 degree camshaft with .385” lift.
Modified VW cylinders bored to 91mm using custom JE forged pistons with 10.25:1 CR
Bored case with 911 piston squirters installed, full flow oiling system.
Lightened 912 connecting rods.
356C crankshaft.
11 lb flywheel with aluminum 200mm pressure plate.
Aluminum 5” front pulley.
Custom twin plug distributor using an M&W CDI box firing two Bosch CDI coils. 25 degrees maximum timing advance.
Stock C/SC/912 cylinder heads with 38mm intake and 34mm exhaust valves, drilled for twin plug, bored for the 91mm cylinders w/unshrouded intake valves
Weber 44IDF carbs with 34mm venturis and 2.25” airhorns w/K&N air filters.
Crankcase ventilation in the case and heads.
Chromoly pushrods.
Stock cylinder head studs.
Stock factory muffler modified for twin plug compared to WR 4:1 with same specs as above engines.






The WR 4:1 header with the 10" stinger/resonator provided an amazing boost in the mid range torque – right in the driving range. Some low end torque is sacrificed (below 3800rpm due to the lack of back pressure), and above 5800 (due to the resonating length of the primaries).

These tests were done with the first 1925cc twin plug engine and the owner has driven the car over 13M miles with the 4:1 system. The car is a lightweight C Coupe with no insulation, and the many long distance drives that have been made in the car have taken their toll on the owner's hearing and his love of the "sport" sound. Even though the tuning of the header can provide an excellent boost in power when done correctly, the look of a 4:1 on a 356 has never been popular when a "quiet" muffler is added to the system. The next step with engine #1 is to install the WR Sport Exhaust and bring the noise level down. As with any "street" performance engine, certain trade-offs have to be made.

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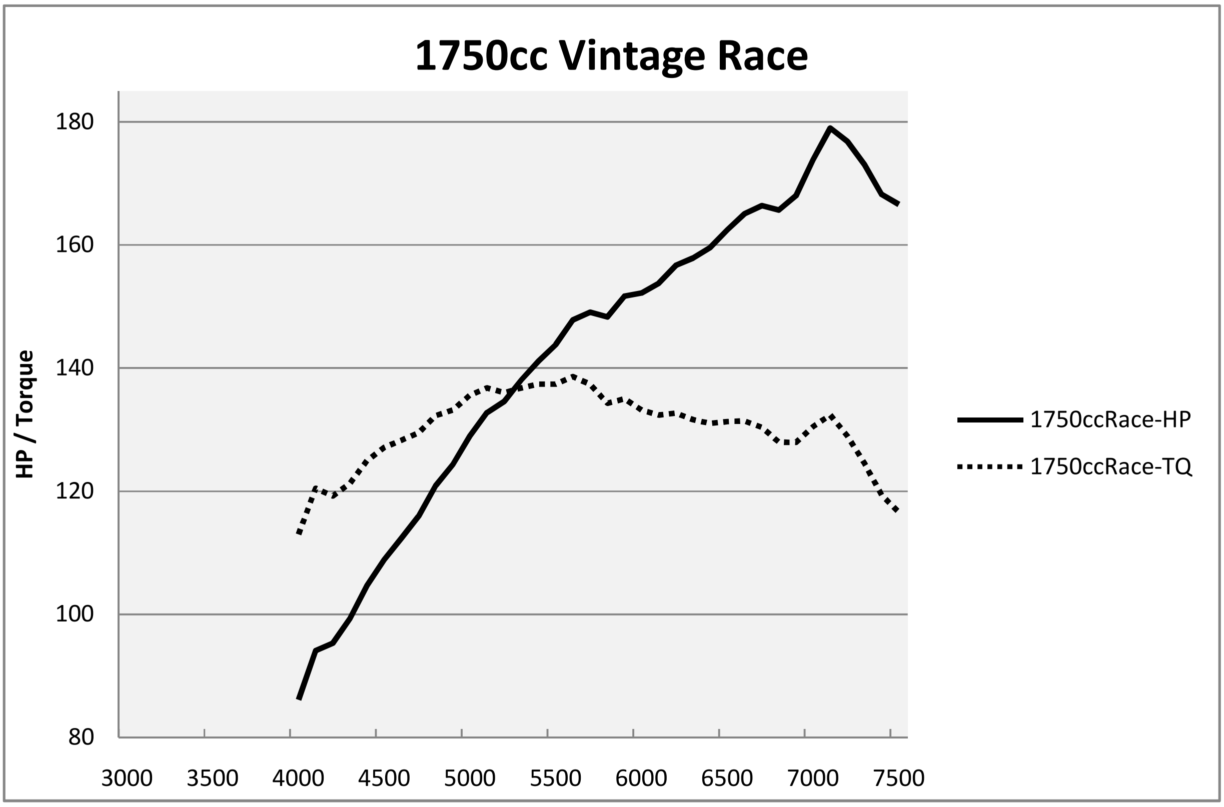
# 1750cc - FULL RACE

### 179hp@7100 / 139ftlbs@5600

279 degree Elgin race cam, .370" lift, with straight cut cam gears.
Cast iron cylinders bored to 87mm (machined for copper head sealing gaskets) with special JE pistons 11.0:1 CR.
Case modified for piston squirters, full flow oiling system, deepsump.
Scat lightweight crank, Carrillo rods.

10.5lb flywheel.
4.0” front pulley with custom vibration damper.
Race heads modified with Del West titanium 7mm stem valves w/40mm intake and 34mm exhaust, titanium retainers and double springs.
48IDF Weber carbs with 40mm venturis , 2.25” air horns, and ITG air cleaners.
WR 4:1 stainless header with 1.5” diameter primaries and 12” reverse cone megaphone.
Crankcase ventilation in the case and heads.
Chromoly pushrods.
Raceware cylinder head studs.
110 octane race fuel.




This was an incredibly strong runner. The big cam combined with the big carbs moved the torque and hp curve way up. We couldn’t load the dyno below 4000 or the engine would stall. It would be interesting to explore other possibilities with a “legal” vintage race engine. This one ended up going to a customer in the UK who was going to use it for “track days” so the 1750cc size and the 48mm carbs weren’t a problem. The bump in the curve at 6900RPM was the result of the reverse cone megaphone.

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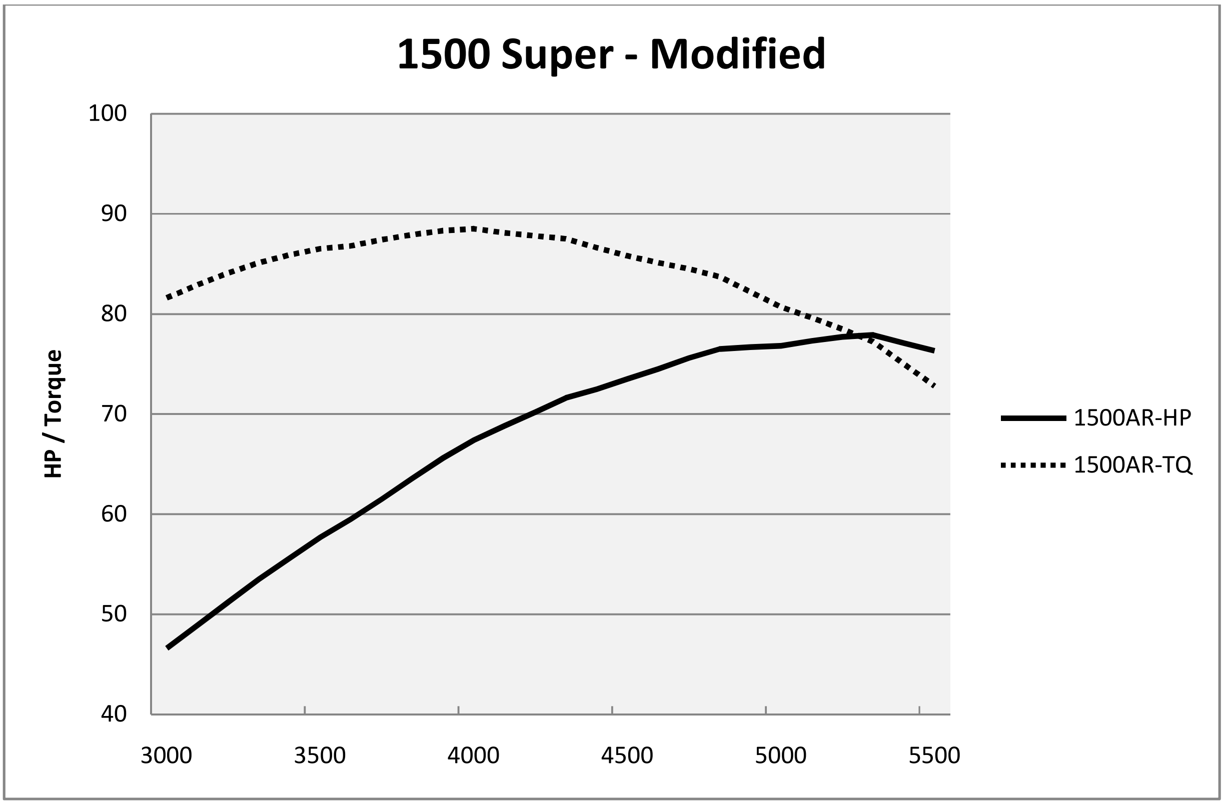
# 1500 Super – Modified

**78hp@5300 / 88.5ftlbs@4000**

This was the engine built for the Azure Blue America Roadster that is shown on the website. The purpose was to build a dependable engine that could be used for the street and occasional vintage racing. In the 1500lb Competition Roadster, with crashbox transaxle, it was a blast. Details about the build can be found in the "Articles" page of the website.




Porsche listed the power output of the stock 1500S at 70HP@5000 /80ftlbs@3600. Our torque and HP peaks definitely moved up, but not at the expense of low end performance (the 80ftlbs were already there at 3000)

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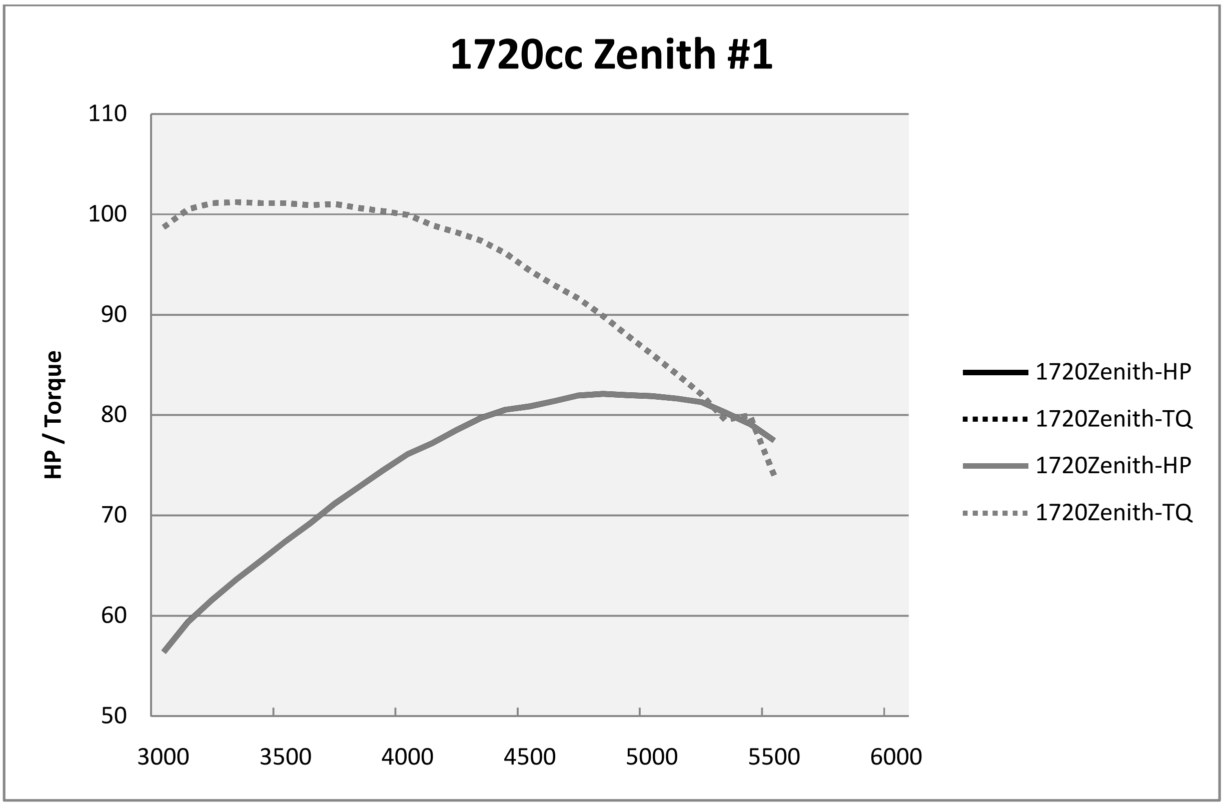
# 1720cc #1 with Zeniths

**82hp@4800 / 101ftlbs@3300**

215 degree Elgin cam (the Maestro grind) with .303” lift.
Cast iron cylinders bored to 86mm with JE forged pistons 9.5:1CR.
Stock 356B crank and 912 rods.
Stock exhaust.
Stock 356B heads (38I/31E with Super intake ports) with early rockers.
Stock Zenith 32NDIX carbs with 28mm venturis and mesh air cleaners.




This engine was an excellent runner with much improved low end torque. Since it started life as a 1600 Normal, the owner was happy with the added torque, but the power fell off very quickly due to the short duration cam, lower lift early rockers, and Zenith carbs.

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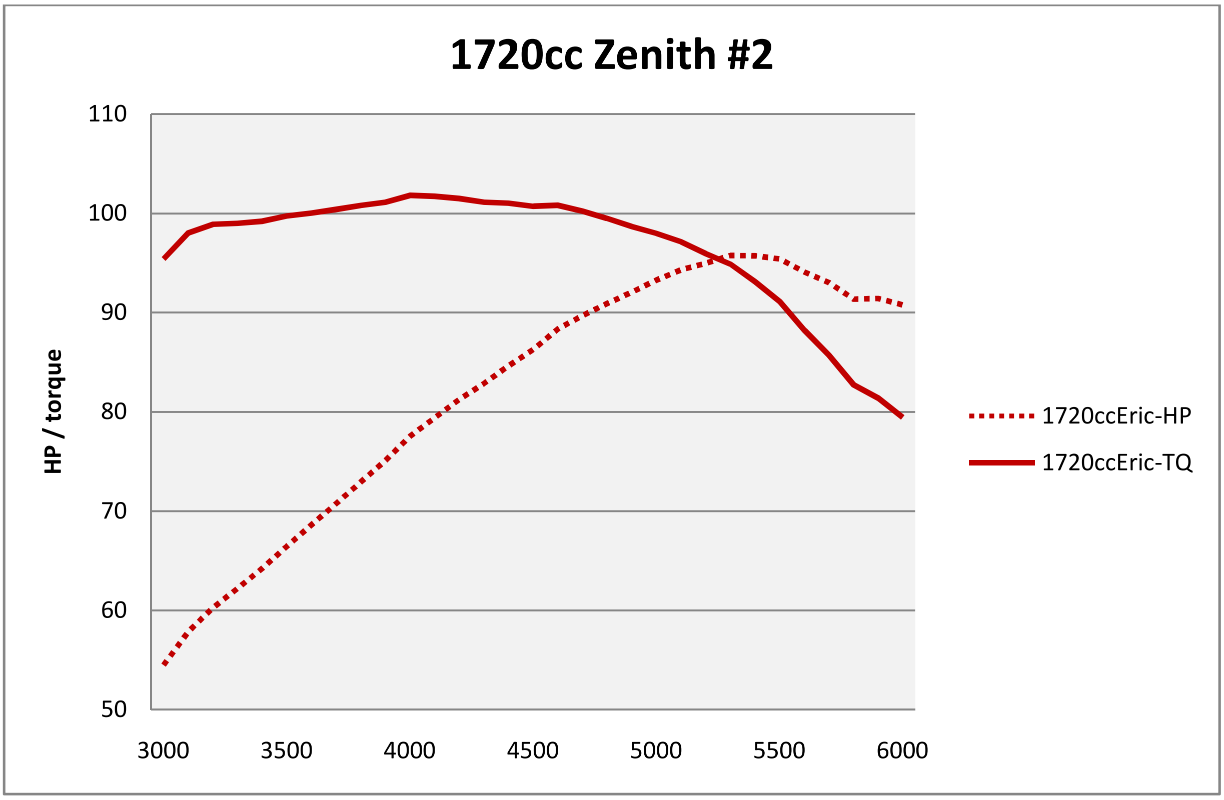
## 1720cc #2 with Zeniths

This next test shows that the Zeniths carbs were definitely not the limiting factor on the last engine. The engine started life as a 1600S but used many late model parts and a much better camshaft.

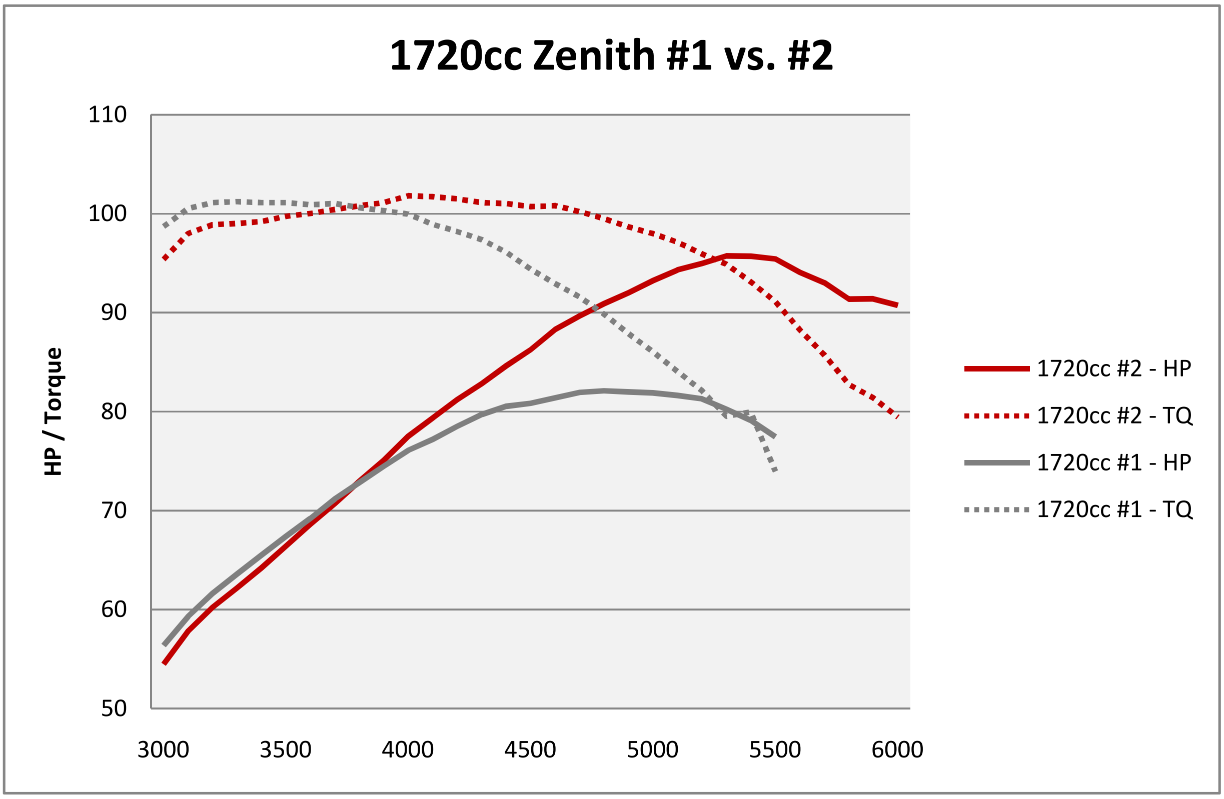
**96hp@5400 / 102ftlbs@4000**

241 degree Elgin cam 7008 with .333” lift.
Cast iron cylinders bored to 86mm with JE pistons and 9.5:1CR.
SC/912 counterweighted crankshaft with late connecting rods.
Stock exhaust.
Late C/SC heads (38I/34E) with late high-lift rockers.
Stock Zenith carbs with 28mm venturis and canister type air cleaners.




This engine was as responsive as the #1 version but pulled the power much further. The bigger cam definitely helped with the top end.  It’s obvious that more intake lift and duration is what engine #1 needed. The added lift of the late rockers helped a lot. The mild cam does help the very low end, and if around town driving and maximum fuel economy is what you’re after this might be the cam you want.

A comparison of the two tests is shown below:

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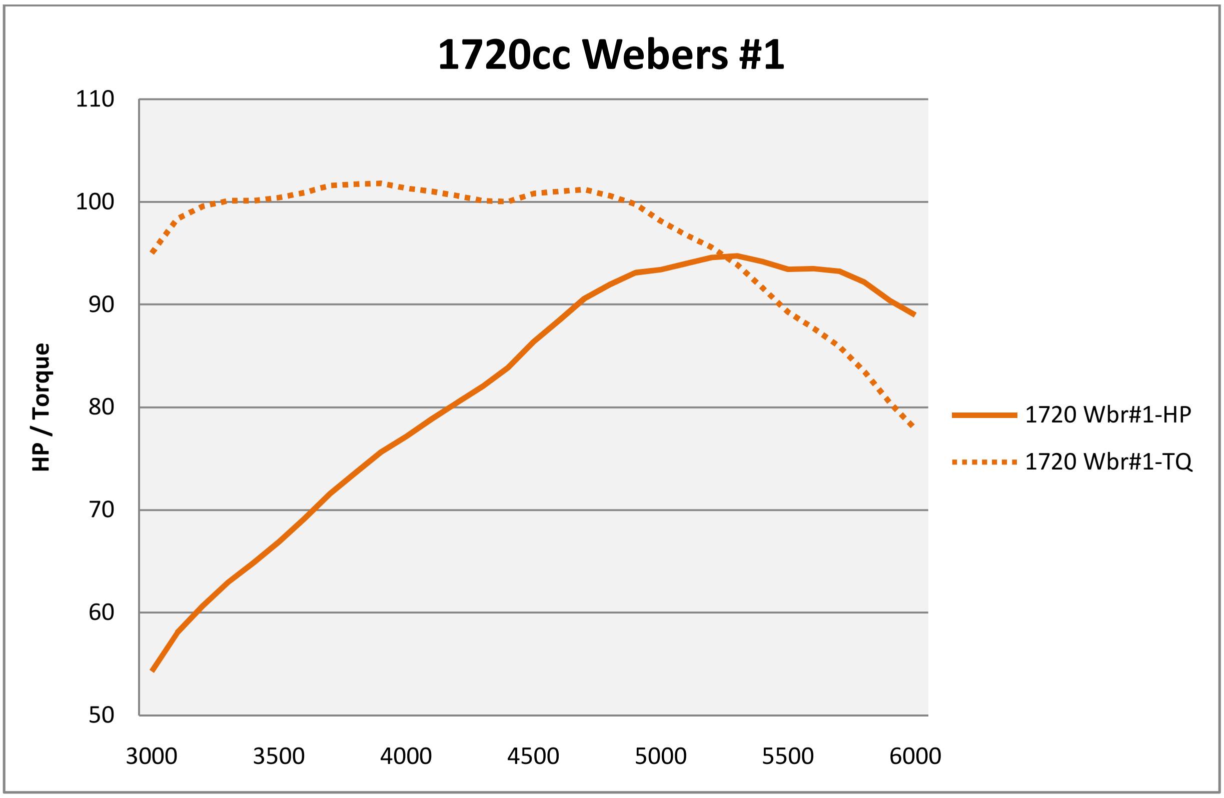
# 1720cc #1 with Webers

This was basically a stock, big bore SC engine with Weber carbs. We used 28mm venturis in the Webers which boosted the bottom and mid range torque when compared to the Solexes with 32mm venturis.

**95hp@5300 / 102ftlbs@3900**

Elgin "improved" SC #16 camshaft (see Elgin website for specs)
Cast iron cylinders bored to 86mm with JE pistons and 9.5:1CR.
Stock SC crankshaft and rods.
Stock exhaust.
Stock SC cylinder heads (38I/34E) with intake ports matched to Weber manifolds.
Weber 40IDF carbs with 28mm venturis, 2.25" air horns and K&N air cleaners.




This engine was a strong runner which provided excellent low end and midrange with a basically stock power curve. The torque curve was almost flat from 3700 to 4700.

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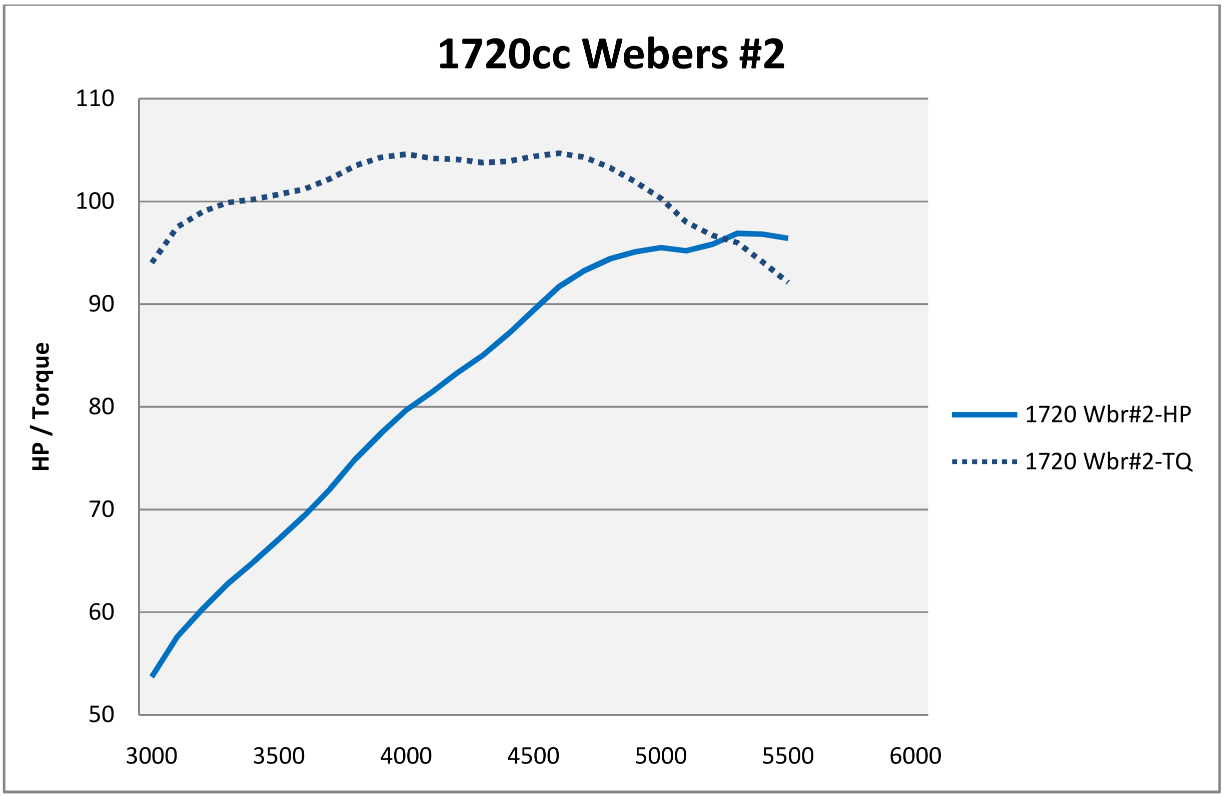
# 1720cc #2 with Webers

On this next test of a Weber carbureted SC engine, we matched the camshaft and venture size for a little more top end performance. This test was also interesting because we used modified 356B heads which retained the smaller 31mm exhaust valves.   At the owners request we limited the maximum dyno test RPM to 5500. During the test we tried 28mm venturis and lost the significant bump in power between 3800 and 4800 rpm, so the 32s obviously help with cylinder filling at lower rpm as well as above 5K.

### 97hp@5300 / 105ftlbs 4600

All specs the same as #1 except for:
241 degree Elgin 7008 camshaft with .333” lift.
32mm venturis.
86mm LN Eng. Nikasil coated aluminum cylinders.
WR aluminum pushrods.
Modified 356B heads (38I/31E) with SC intake ports matched to Weber manifolds.

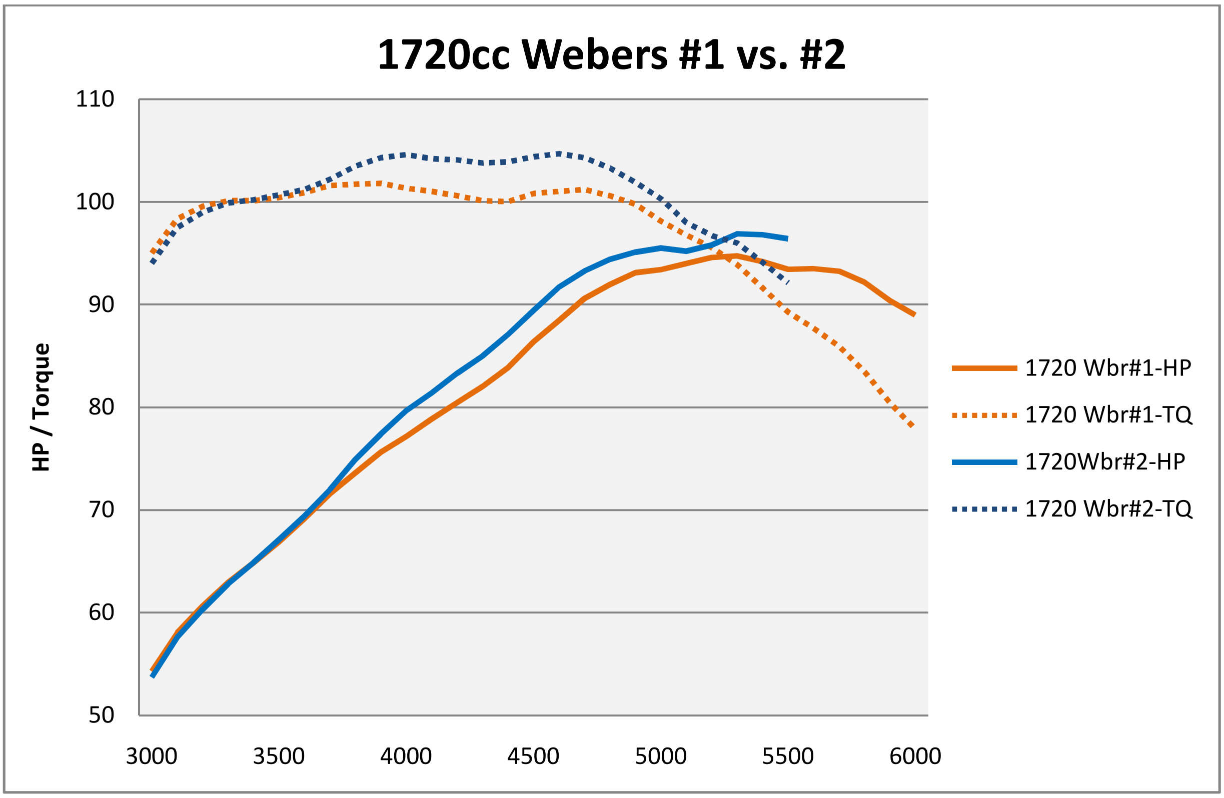



The bigger cam and venturis boosted performance everywhere except below 3300 RPM. Since these engines are so close in design a good test comparison was in order. From test driving both cars back to back (the milder engine installed in a Coupe the hotter in a Cab,) it felt like the milder engine might have somewhat better throttle response below 3000 RPM, and a slightly milder idle, but the increased torque is definitely there when needed, and the hotter engine pulls to redline faster. Both engines should be very equal after 5500 RPM. It would be up to the individual owner whether the stock cam or the sport cam was chosen.

***EXHAUST VALVES - 34mm vs. 31mm ?***

*It's obvious from the last two tests that the exhaust valves seemed to have little effect on the performance of the two engines. Typically, a larger exhaust valve will increase higher RPM performance if all other specs remain the same. It's possible that installing the larger 34mm exhaust valves in test #2 engine would have pushed the top end power up slightly. The smaller exhaust valve will also typically improve low end power and throttle response. This is exactly the result we see with the engine simulation software.*

A comparison of the two tests is shown below:

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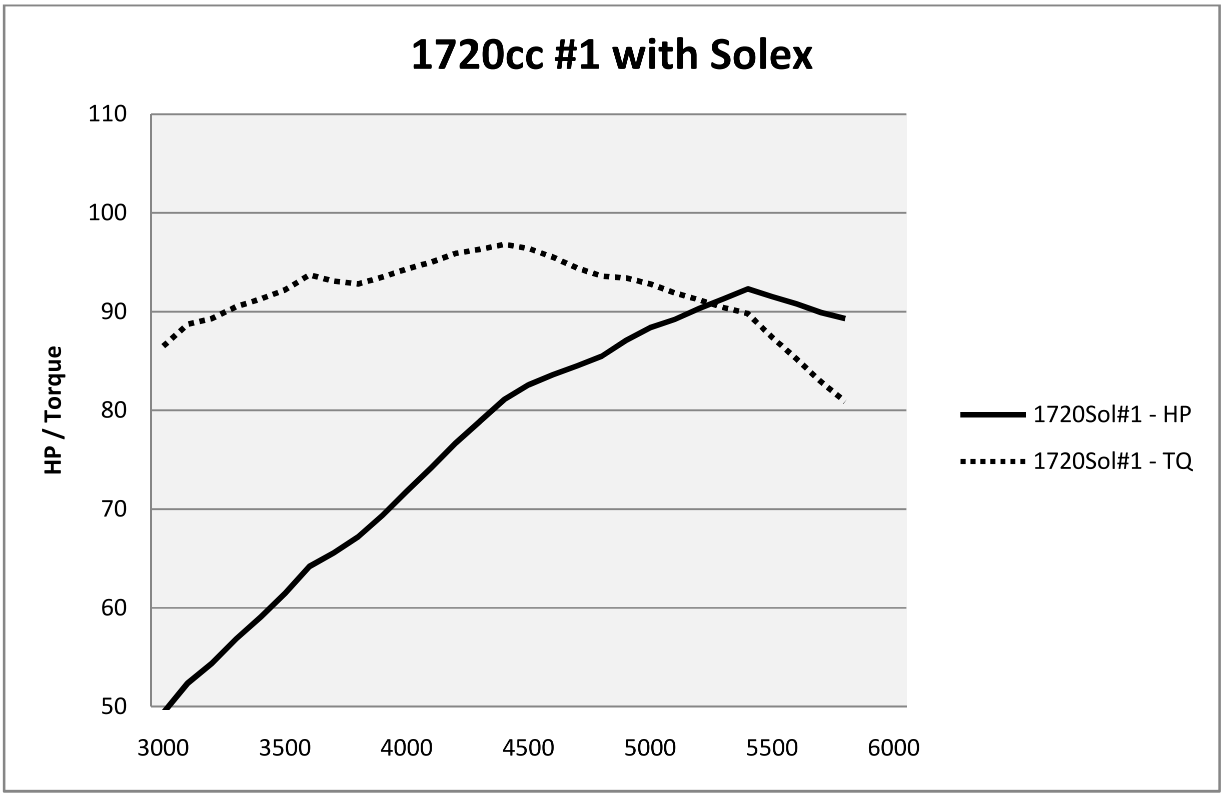
## 1720cc #1 with Solex

The next two tests are very similar engines to the Weber and Zenith tests. A close look at the specs will show the slight differences. Some interesting comparisons will be shown below.

### 97hp@5400 / 97ftlbs@4400

(this engine was not built by WR and the specs were provided by the engine builder)

215 degree Elgin cam (the Maestro grind) with .303" lift.
Cast iron cylinders with 86mm big bore pistons (unknown manuf.) 9:1CR.
Stock SC crank and rods.
Stock exhaust.
Stock SC cylinder heads with 38I/34E 8mm stemmed stainless valves with double valve springs.
Chromoly pushrods.
Stock Solex 40P11s with stock 32mm venturis and stock mesh air cleaners.




This was a good runner, with a nice flat torque curve. The performance was somewhat compromised by the very mild duration, low lift cam, and the 8mm stemmed valves with stiffer double springs and chromoly pushrods were probably wasted on this engine. The Elgin “Maestro” cam is almost identical to the 356C camshaft, and is great for an engine with small carbs and venturis, especially the early Solex 32s. This engine would have performed much better with Zenith carbs and gave away some low rpm torque because of the large Solex 40s. Even though the engine builder stated that the compression ratio was 9:1, I’m guessing that it was probably lower, especially because of the poor low rpm performance.

## 1720cc #2 with Solex

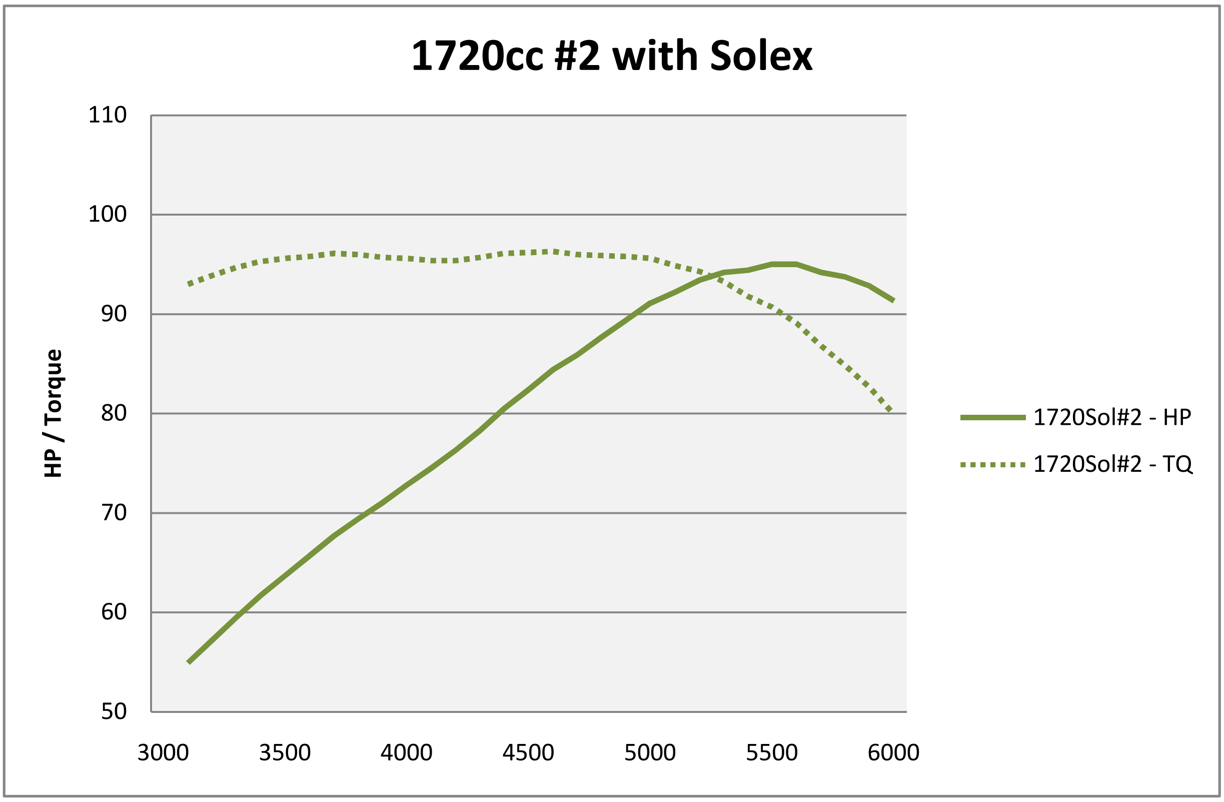
This was basically a stock, big bore SC engine with stock Solex 40P11 carbs with 32mm venturis.

**95hp@5600 / 96ftlbs@4600**

(this engine was not built by WR and the specs were provided by the engine builder)

Stock #16 SC camshaft with 234 degrees and .333” lift.
Cast iron cylinders bored to 86mm with JE pistons and 9.5:1CR.
Stock SC crankshaft and rods.

Stock exhaust.
Stock SC cylinder heads (38I/34E) with intake ports matched to Solex manifolds.
Stock Solex 40P11s with stock 32mm venturis and stock mesh air cleaners.




Comparing this test to the #1 test engine shows the advantage of the “Super/S90/SC/912” camshaft. It’s much better suited to the larger Solex carbs than the milder low lift cam.

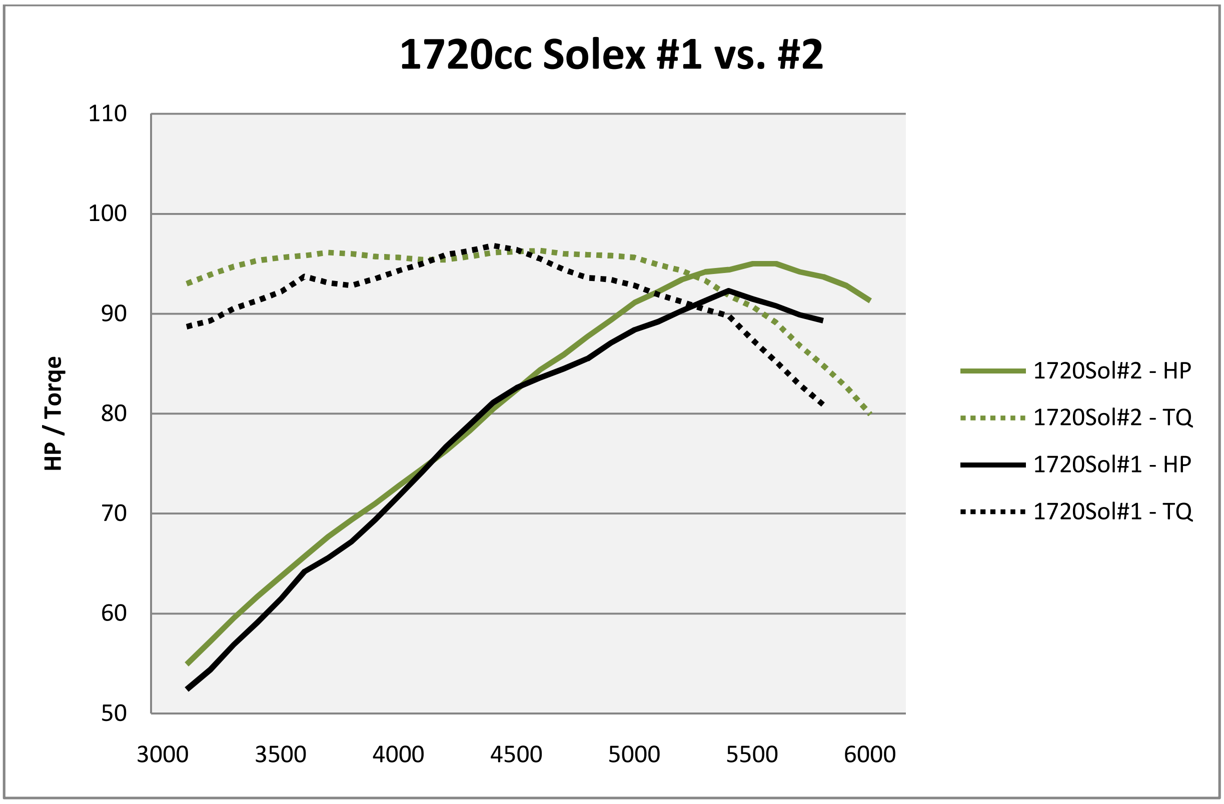
***COMPRESSION RATIO?***

*These two Solex tests show the importance of matching all engine components correctly. All cam grinders should supply recommended compression ratio and carb set ups with their camshafts. Unfortunately, most of the piston and cylinder kits available off the shelf, assume a standard combustion chamber volume for their compression ratios. Because most of our engines have had multiple valve jobs which usually change the combustion chamber volume, the off the shelf kits can vary easily by one-half compression point. The kits are usually designed for the smallest normal chamber volume, so very often your actual compression ratio will be lower than what is shown with the kit. That’s why at WR we don’t offer pre made kits. All of our pistons are custom made to the chamber volume specs so that the correct compression ratio is achieved.*

***WHAT ABOUT AIR HORNS?***

*An important option with the Weber carbs is the 2.25" air horns. They increase the resonating length of the intake channel and improve cylinder filling at low and mid range rpm. Much of the improvement when comparing Weber and Solex performance figures is due to the additional length provided by the Weber air horns.*

A comparison of Solex engine #1 and #2 are shown below:



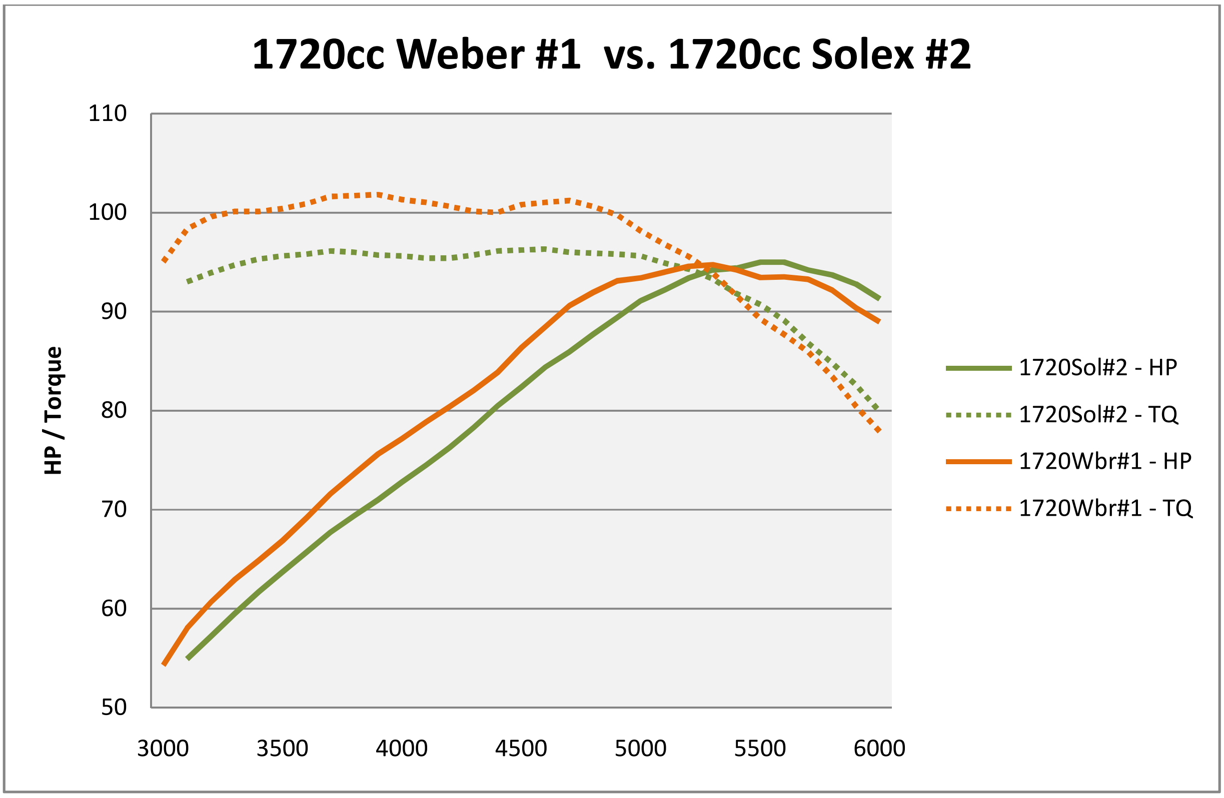

# SOME INTERESTING COMPARISONS

# 1720cc Weber #1 vs. 1720cc Solex #2

The first chart below compares two basically stock SC engines from the above tests (Weber #1 and Solex #2) built to 1720cc – one with Webers, the other with Solex. In this comparison the trade off is obvious: Much better hp and torque below 5500RPM…right in the driving range. The air horns also boost the low/mid torque.

**95hp@5300 / 102ftlbs@3900**

**95hp@5600 / 96ftlbs@4600**



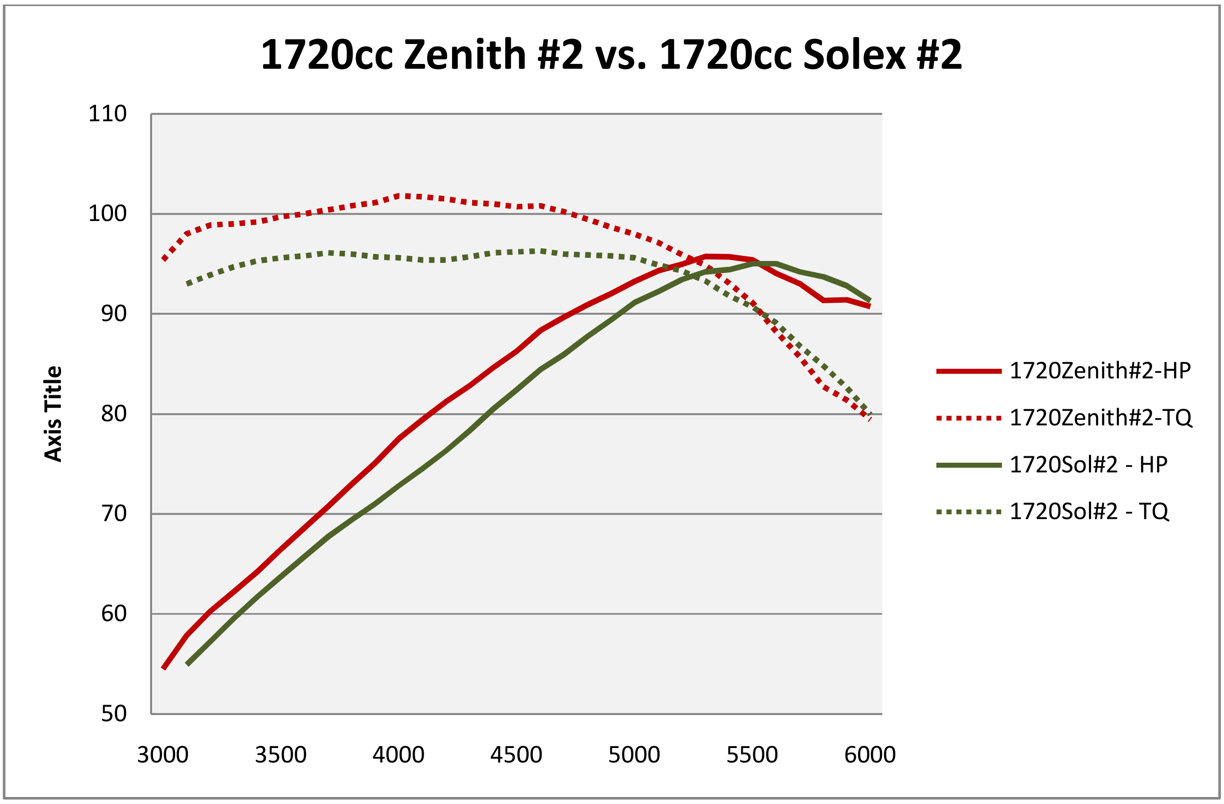
# 1720cc Zenith #2 vs. 1720cc Solex #2

This comparison shows two very similar engines but with the stock Zenith carbs vs. the stock Solex carbs. The Zenith equipped engine had the advantage of a slightly bigger cam which helped it in the upper rpm range, but because of the smaller size of the Zeniths, maintained very good low rpm numbers.

Don't swap-out those "small" Zeniths for something bigger unless you plan on increasing the engine size and camshaft.

**96hp@5400 / 102ftlbs@4000**

**95hp@5600 / 96ftlbs@4600**



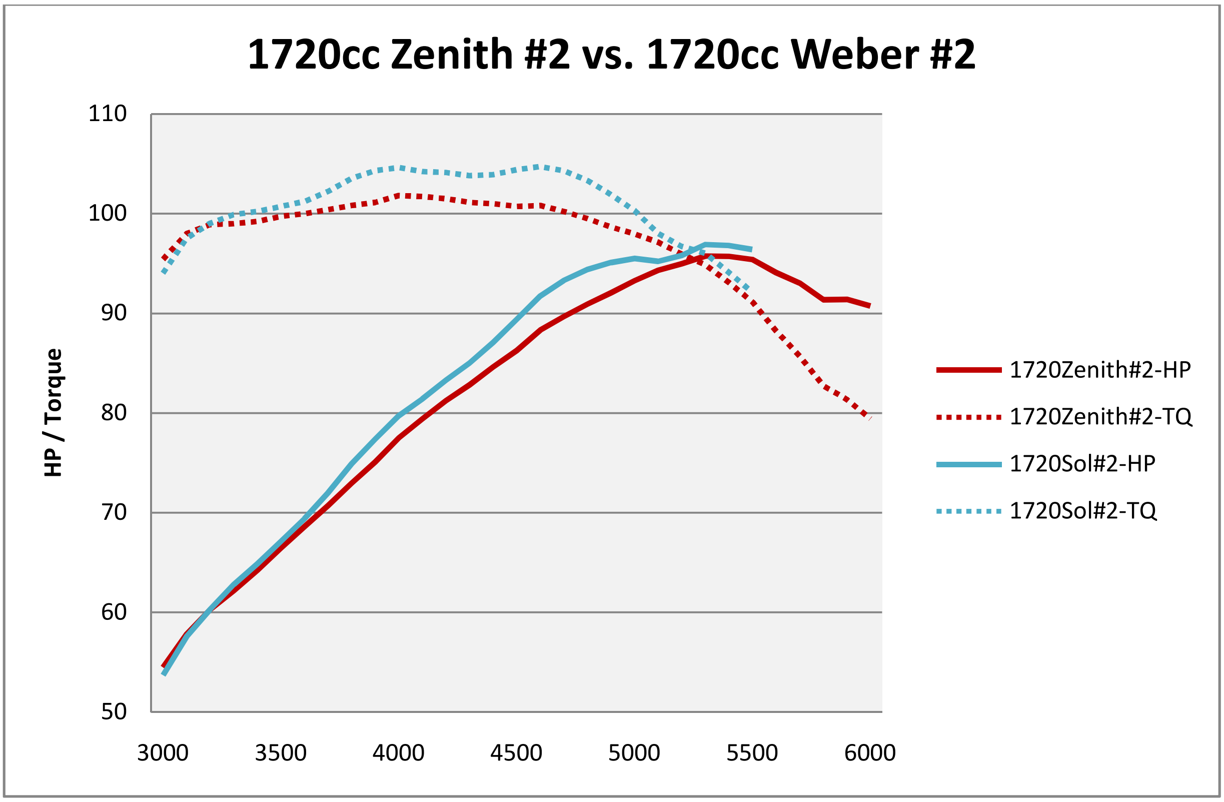
# 1720cc Zenith #2 vs. 1720cc Weber #2

This comparison shows the difference between Zenith and Weber carbureted engines with otherwise very similar specifications. The Weber engine used the LN Engineering aluminum cylinders, and also had the smaller 31mm exhaust valves. It's unclear what difference these two specs made, but it is clear that the Weber engine had more torque in the midrange.

*Testing is planned with the Zenith #2 engine (which now shows about 3500 miles) with our new 36mm modified Zeniths with 32mm venturis. The results should be interesting.*

**96hp@5400 / 102ftlbs@4000**

**97hp@5300 / 105ftlbs 4600**

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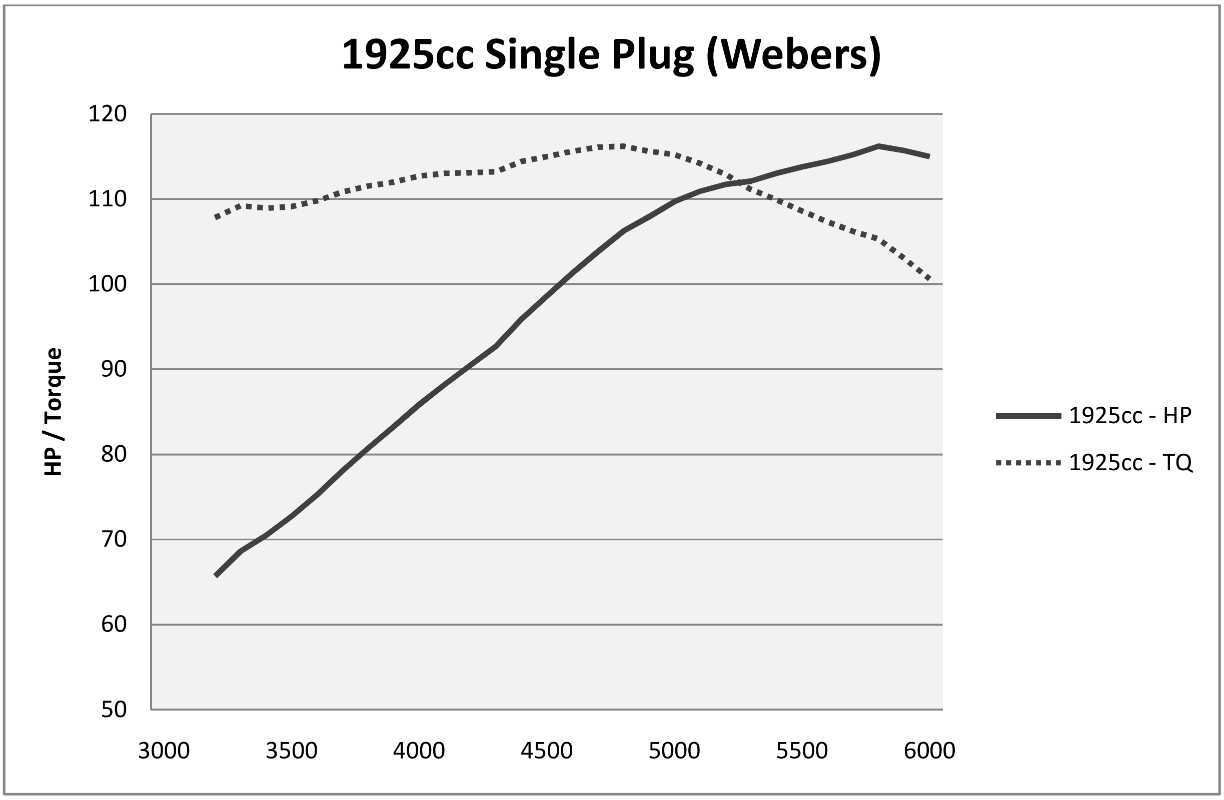
# 1925cc Single Plug (Webers)

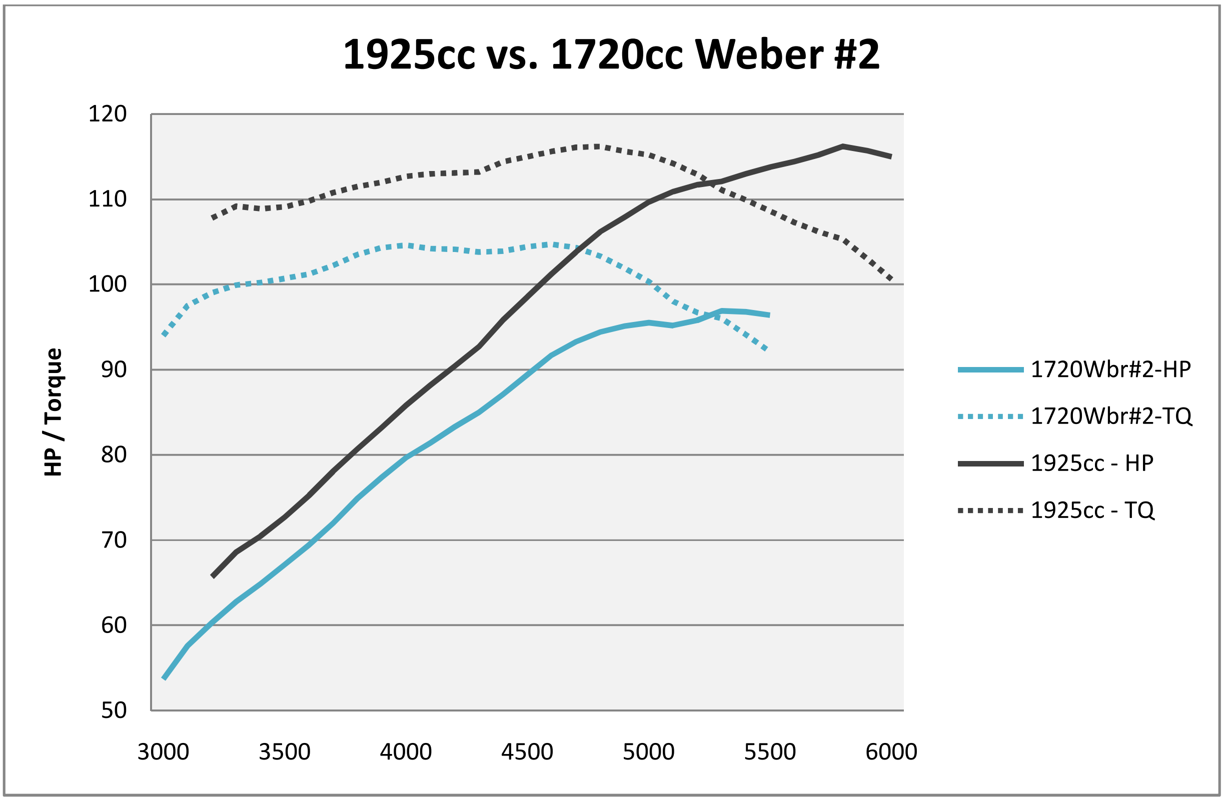
This was the first single plug 1925cc engine tested on the dyno. We used the 44IDFs because the 40s weren't available at the time. The WR60 cam was chosen since in development it showed very good results with the engine simulation. It has an intake duration of 242 degrees with .365" of lift, but uses a stock "Super" exhaust profile of 234 degrees and .333" of lift. The lobe separation is 108 degrees and it is installed straight up with no advance. At the moment we have no comparison to other single plug big bore engines, but we can certainly compare to our best 1720cc street engine. This engine is installed in a B Coupe, and the increase in power is VERY noticeable…and, it idles like a stock 1600N but pulls easily to 6K.

### 116hp@5800 / 116ftlbs@4800

WR60 camshaft 242 degree, .366"lift Intake / 234 degree, .333" lift Exhaust
91mm LN Eng, Nikasil coated aluminum cylinders and JE pistons with 9.5:1 CR.
WR aluminum pushrods.
Stock SC crank and rods.
Stock exhaust.
Modified cylinder heads with 40I/34E stainless valves, double springs on intake only.
44IDF Webers with 32mm venturis and 2.25" air horns. K&N air filters.
WR CDI ignition kit.



A comparison of the 1925cc twin plug engine and the top performing street engine in the 1720cc form is shown below:




You can see from the graph that the 1925cc engine is already beating the 1720s maximum torque at the beginning dyno test rpm of 3200. This graph shows that engine size is the best way to increase power.

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# THE NEXT STEP – 2002cc

91 millimeters is the largest reasonable piston size for the 356 engine. With the 74mm crankshaft, 1925cc is then the largest engine size possible. Stroking is a possibility but the cam to rod clearance is the issue. At 74mm the rod to cam clearance with stock rods is already dangerously close (<1mm). The only way to make the crankshaft stroke longer is to either reduce the size of the connecting rod big end or the camshaft lobe. The camshaft base-circle is already somewhat small, and must be made smaller for high lift cams. That leaves the rod bearing.

The 356 rod bearing at 53mm is relatively large by today's standards. By changing to a smaller diameter 2.0" (50mm) Clevite type bearing we are able to have special rods made that allow the extra clearance for a 77mm stroke crankshaft. In addition to being smaller in diameter, the rod bearings are now approximately 1mm wider which actually provides more oil cushion than the stock 53mm bearing. The rod length is maintained stock and the wristpin is simply pushed up in to the piston an extra 1.5mm, which is made possible by the super thin rings that we now use with the Nikasil cylinders from LN Engineering.

With a 77mm stroke the engine size has been pushed to 2002cc. A longer stroke in a street engine has the advantage of increasing the torque throughout the entire rpm range. In a race engine piston speed becomes an issue at high rpm, but since we're not looking to push the limit much above 6K, piston speed is not a real concern.

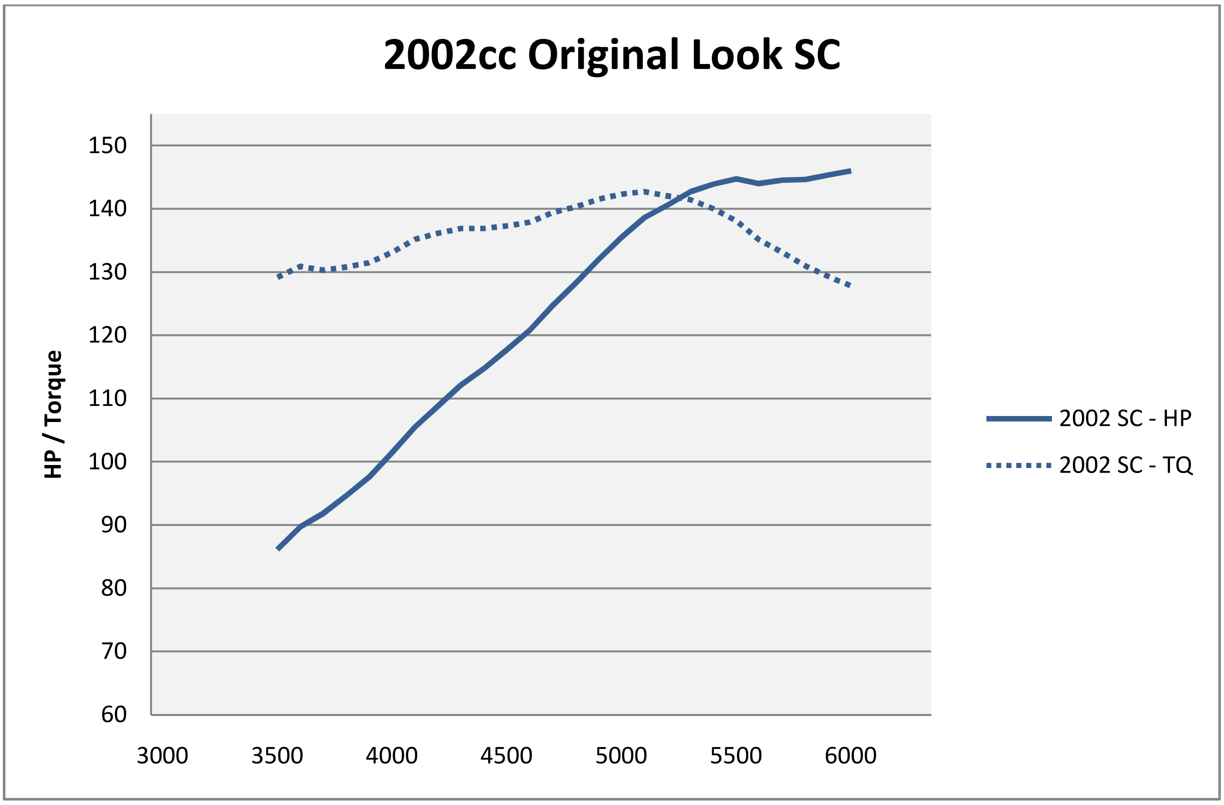
There are several 2002cc engines in the works at the moment, and we should have the test results available very soon. The first test engine is shown below. The results are impressive.

## <u>2002cc – Original Look - SC Engine</u>

The specs of this engine are listed below. Since it was being installed in a very rare Porsche race/rallye car, it needed to look completely original.

248 degree Elgin 7208 high lift camshaft with .370" lift
91mm LN Eng Nikasil cylinders and JE pistons with 10.3:1 CR.
77mm Scat lightweight crankshaft with special Carrillo rods.
WR 10.5lb flywheel kit with aluminum pressure plate.
WR aluminum pushrods.
WR High Flow cylinder heads with 44I/34E stainless valves, double springs, ti retainers.
Solex 40P11s modified to 44mm with 36mm venturis.
Stock exhaust.
WR CDI ignition kit.

## 146hp@6000 / 143ftlbs@5100




We held the test rpm limit at 6000, but the engine definitely was still pulling strong at that point. The modified 44mm Solexes performed very well and the fuel curve was excellent (this was a big question going into testing because there are no optional emulsion tubes for the 40P11 carb). Keep in mind, the goal of this engine was a completely original look, we needed to run on pump fuel, and the exhaust system had to be original. These were somewhat limiting factors, especially the stock exhaust (designed for a 1600cc engine with a 6K redline). The test shown is with factory Solex air horns installed (the way the car will be run). The stock Solex mesh air cleaners reduced the performance by about 2% overall.

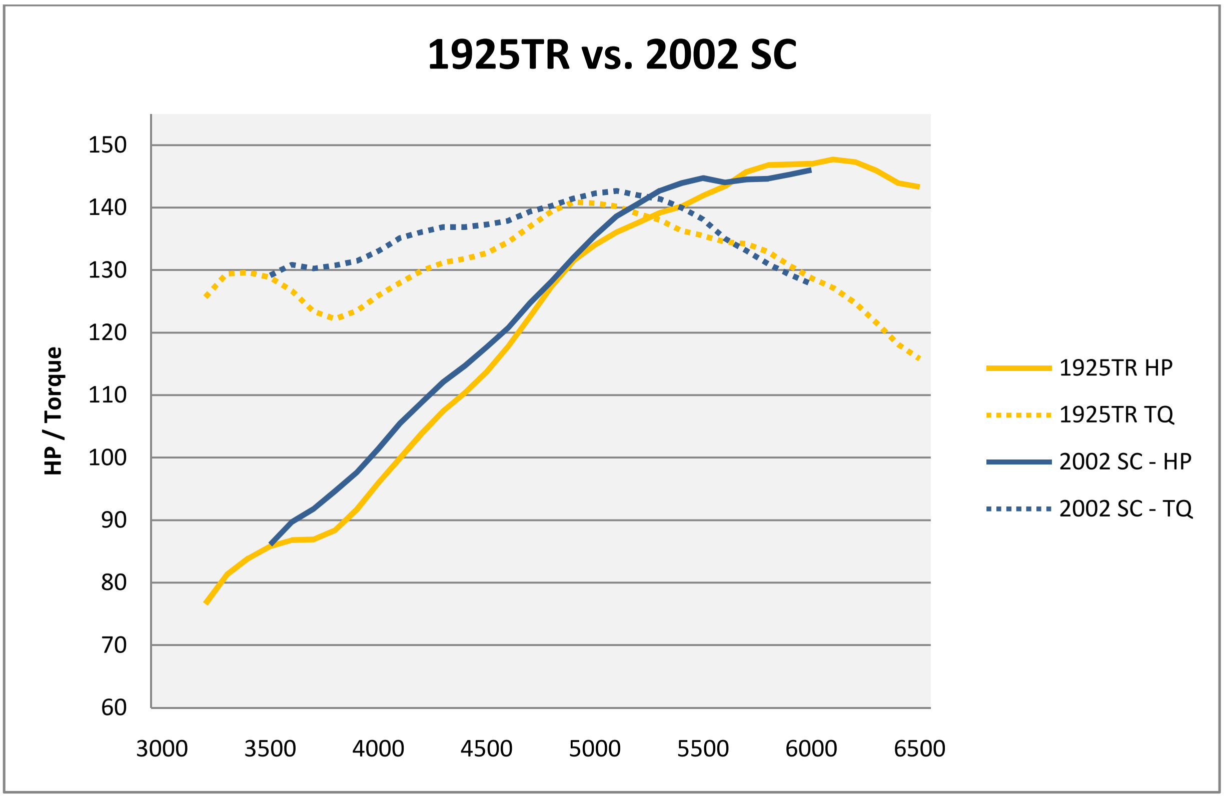
The car is one of the 5 factory delivered SCGTs, with aluminum panels, plexiglass windows, etc, and weighs in at under 1800lbs. It's equipped with its stock BBAB gearbox (probably a little short for the 2L engine). The acceleration is impressive! The car has no limited slip, and with race tires it's still possible to break the tires loose when taking off from a start. The engine idles like a stock SC and can be driven just like a normal car. There is no "loud" exhaust, and it actually feels a little too "stock" considering its potential. Amazingly it is only slightly less docile than the 1925cc Single Plug shown above.

Below is a graph comparing the 1925TR engine and the 2002-Original Look-SC. For specs of the 1925TR please look on the Engine Development PDF file.

## 1925TR vs. 2002cc SC

**148hp@6100 / 142ftlbs@4900**

**146hp@6000 / 143ftlbs@5100**

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## 1925cc - Original Look – 356B Normal

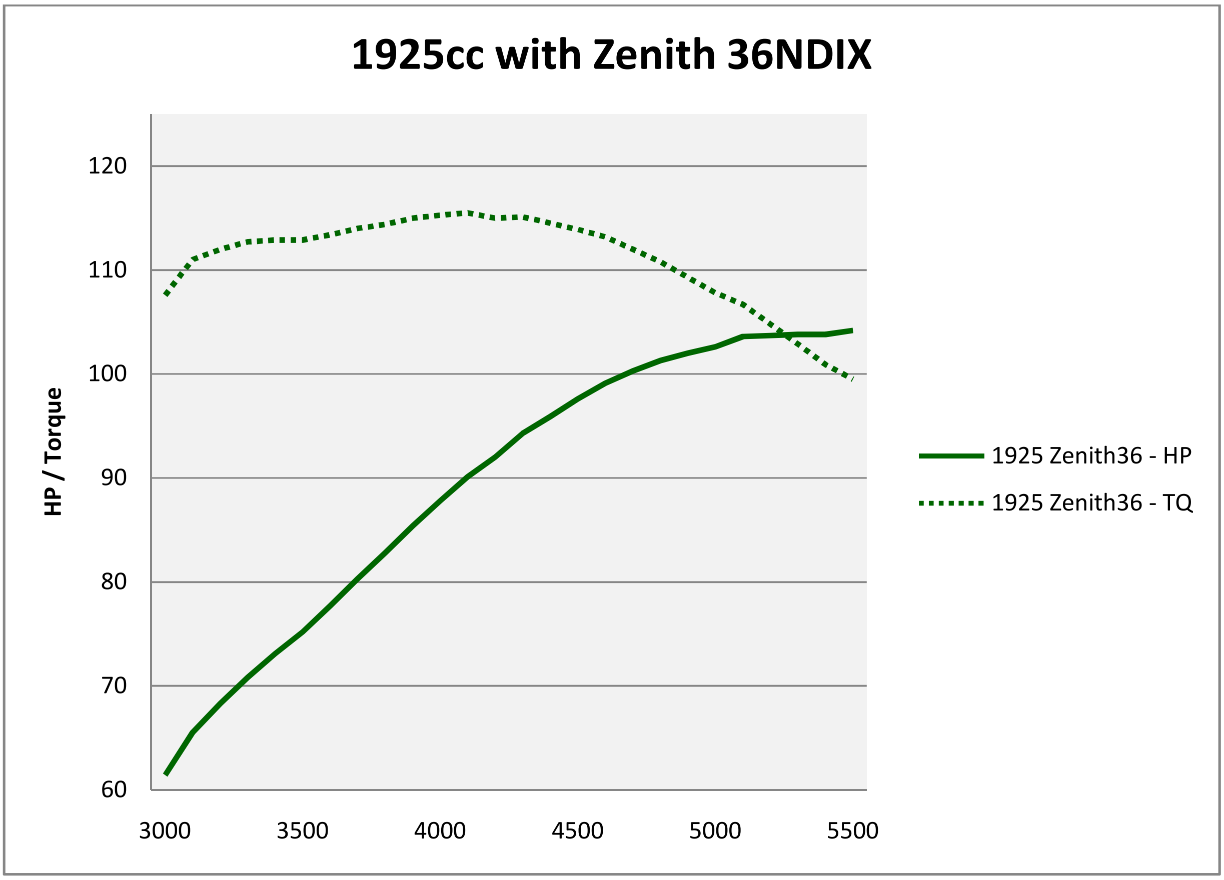
This engine was built for a 62 Roadster and also needed to have a completely original look. Since the oem engine was a Normal/60, it meant the engine would have to use the smaller Zenith carburetors. Based on tests, the stock Zenith 32 NDIX will flow about 120cfm. This works fine with the 1600cc and even the 1720cc engine, as can be seen in past tests, as long as peak power doesn't move beyond 5500RPM. We were going to keep the heads completely stock and use the new WR60 camshaft, so I wanted to at least match a carb to the stock intake valve flow at .475" of lift (the WR60's .365" x 1.3 rocker ratio). After flow testing we determined that the stock 38mm intake valve could flow just under 140cfm at .475”.   I asked Jim Kaufmann at Caburetor Rescue if he’d like to try and machine a set of 32NDIXs out to 36mm. After some experimentation by Jim we had our first set of 36NDIXs and tested them on the flow bench with the stock heads and ported Zenith manifolds. The results were exactly what I wanted! The carbs were able to flow the full 140cfm and lower lift flow numbers were also improved.  Since the small intake valves were going to be the limiting factor, I installed the WR60 camshaft with 3 degrees advance, which moved the powercurve down about 300 rpm. Since the intake valve closing point was now the same as a stock “Super” camshaft, I kept the compression ratio at 9.25:1.

The engine was assembled with the specifications as shown below. The results of the test were very close to what was expected based on the engine simulations. Some driving impressions follow the dyno graph.

# 1925cc – Original Look – 356B Normal

WR60 camshaft 242 degree, .366”lift Intake / 234 degree, .333” lift Exhaust (advanced 3 degrees).
91mm LN Eng, Nikasil coated aluminum cylinders and JE pistons with 9.25:1 CR.
WR aluminum pushrods.
Stock C crank and rods.
Stock 356C/SC heads with stock valve springs.
Zenith carbs modified to 36NDIX with ported manifolds and stock air cleaners.
Stock exhaust.
WR CDI ignition.

**104hp@5500  /  115ftlbs@3900-4300**




This was a fun car to drive with excellent power and good overall performance. I was very satisfied with the results and the owner loves the car. The engine looks completely correct and is concours acceptable.

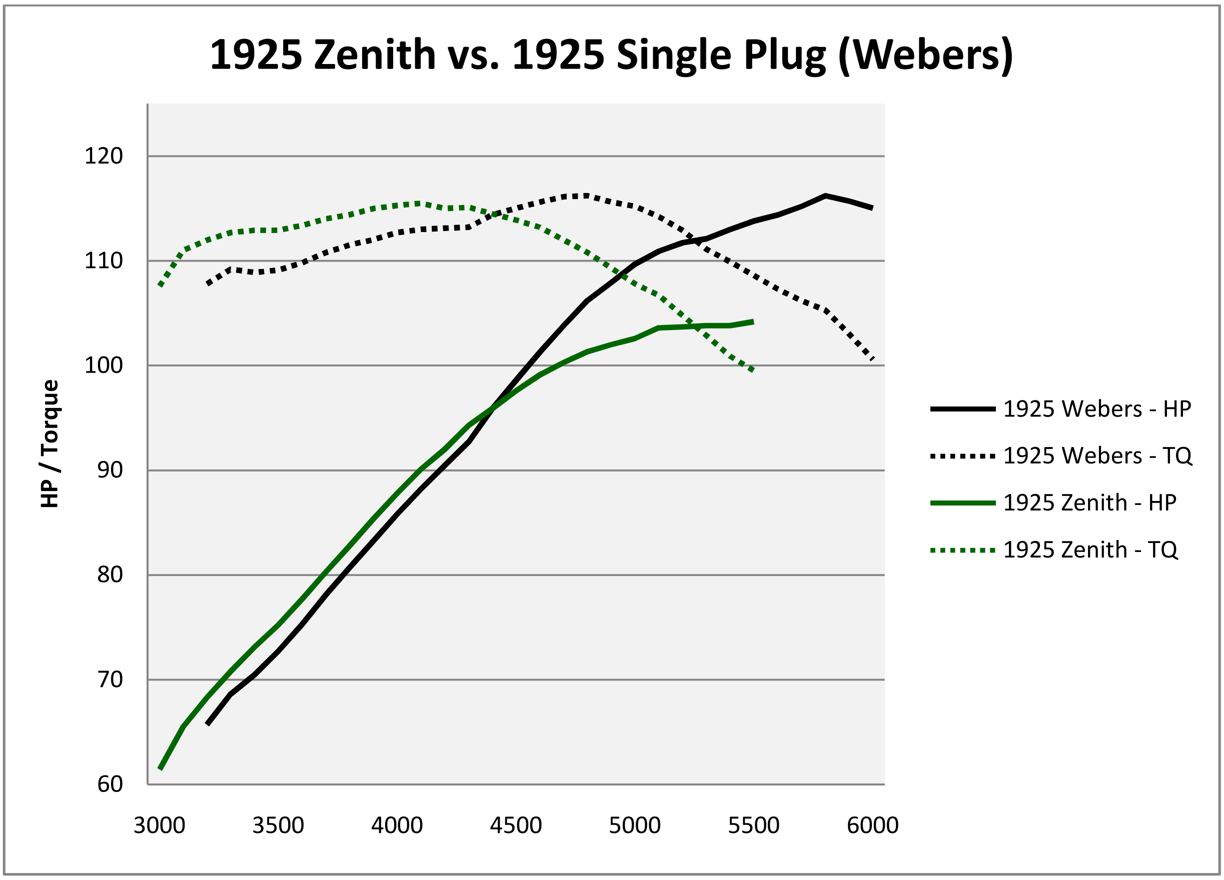
The limitations of the Zenith carbs are obvious, and the comparison chart below is a good way to see the difference that larger carburetors can make on an engine this size. If you like the sensation of a Super 90 or SC, or an engine with a sport camshaft, this engine might disappoint you. Even when modified to 36mm, the Zeniths carbs just don't flow enough air to feed an engine this size in the upper rpm ranges. The smaller carbs, and the advanced camshaft timing, do bring the power band down and do give great throttle response for around-town driving. If this is what you're after, this engine would make you happy.

## 1925 Zeniths vs. 1925cc Single Plug (Webers)

This graph shows how the 1925cc engine can benefit from improved breathing.

**116hp@5800 / 116ftlbs@4800**

**104hp@5500 / 115ftlbs@3900-4300**

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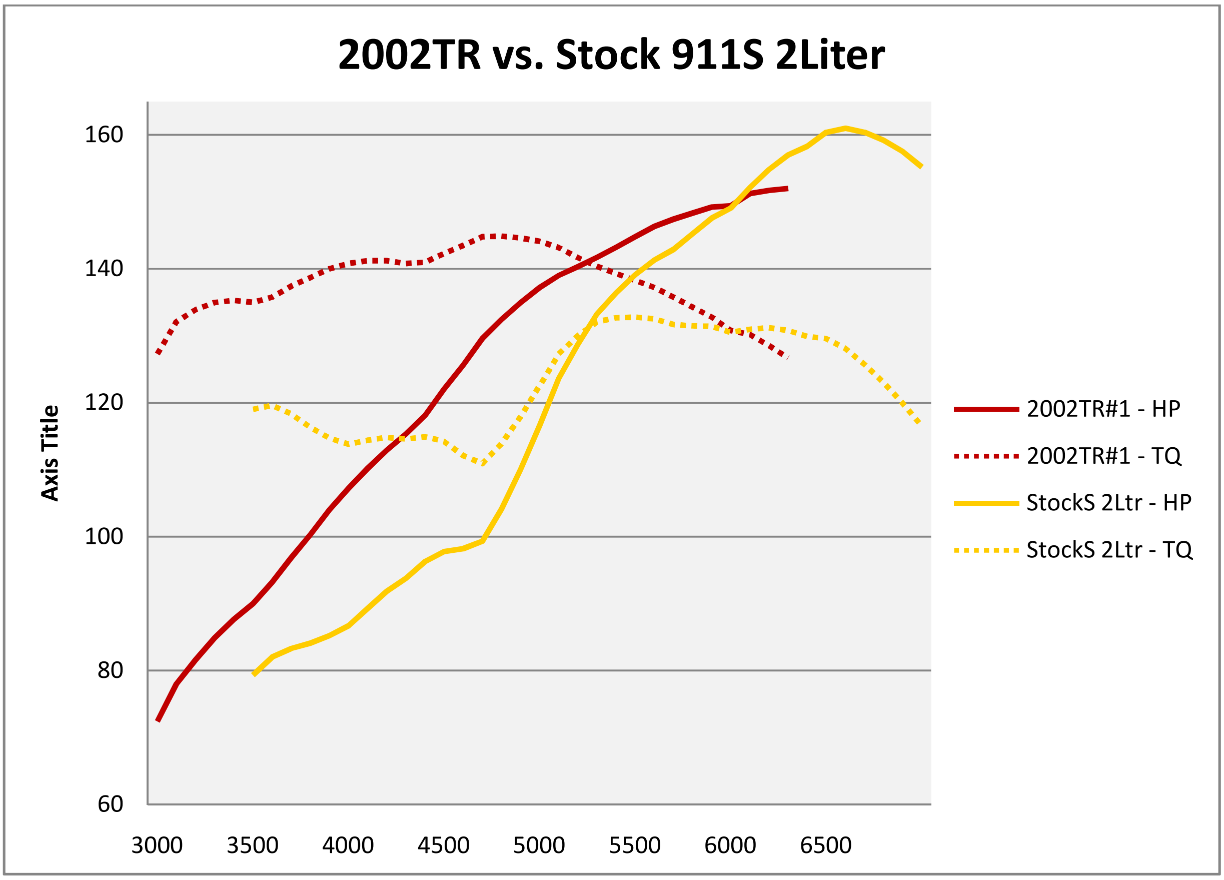
## 2002TR#1 vs. Stock 2 Liter 911S

This graph compares a completely stock 2 liter 911S engine, with stock muffler and air cleaners, to the first test of the 2002TR with stock muffler. *The first 2002TR engine test specs are shown in the Engine Development PDF file.*

**151hp@6200rpm / 146ftlbs@4900rpm**

**161hp@6600rpm / 133ftlbs@5500rpm**




The 2Ltr 911S has the advantage of a bigger cam, higher RPM, and the added cylinder filling of 6 cylinders, but can't match the power of the 4 cylinder 2002TR until 6K.   It will be interesting to compare a 2002TR with a hotter camshaft and free flow exhaust.

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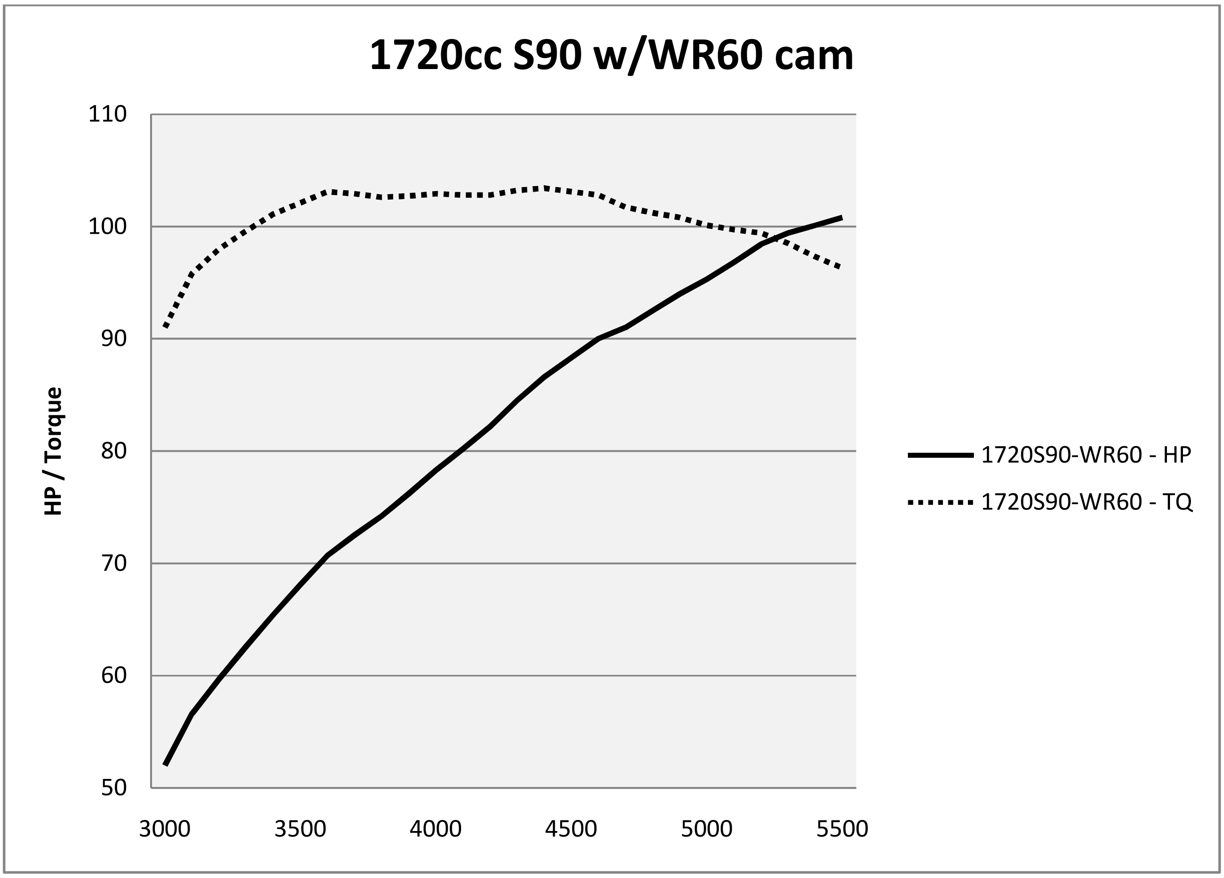
## 1720cc S90 with WR60 camshaft

This is the first test of the 1720cc engine with the WR60 camshaft. The duration of the WR60 is 242 degrees on the intake with .365" of lift. The exhaust has a stock Super profile of 234 degrees with approx .333" of lift. Lobe separation is 108 degrees. The production WR60 cam is advanced 3 degrees when ground to provide lobe centers of 105 degees on the intake and 111 degrees on the exhaust. It provides excellent low end performance and is an improvement over the stock cam and the popular Elgin 7008 as shown in the following tests. This engine was assembled completely stock with the exception of:

WR60 camshaft 242 degree, .366"lift Intake / 234 degree, .333" lift Exhaust (advanced 3 degrees). 86mm cast iron cylinders with JE forged pistons, 9:1 CR.

*Test RPM was limited to 5500.*

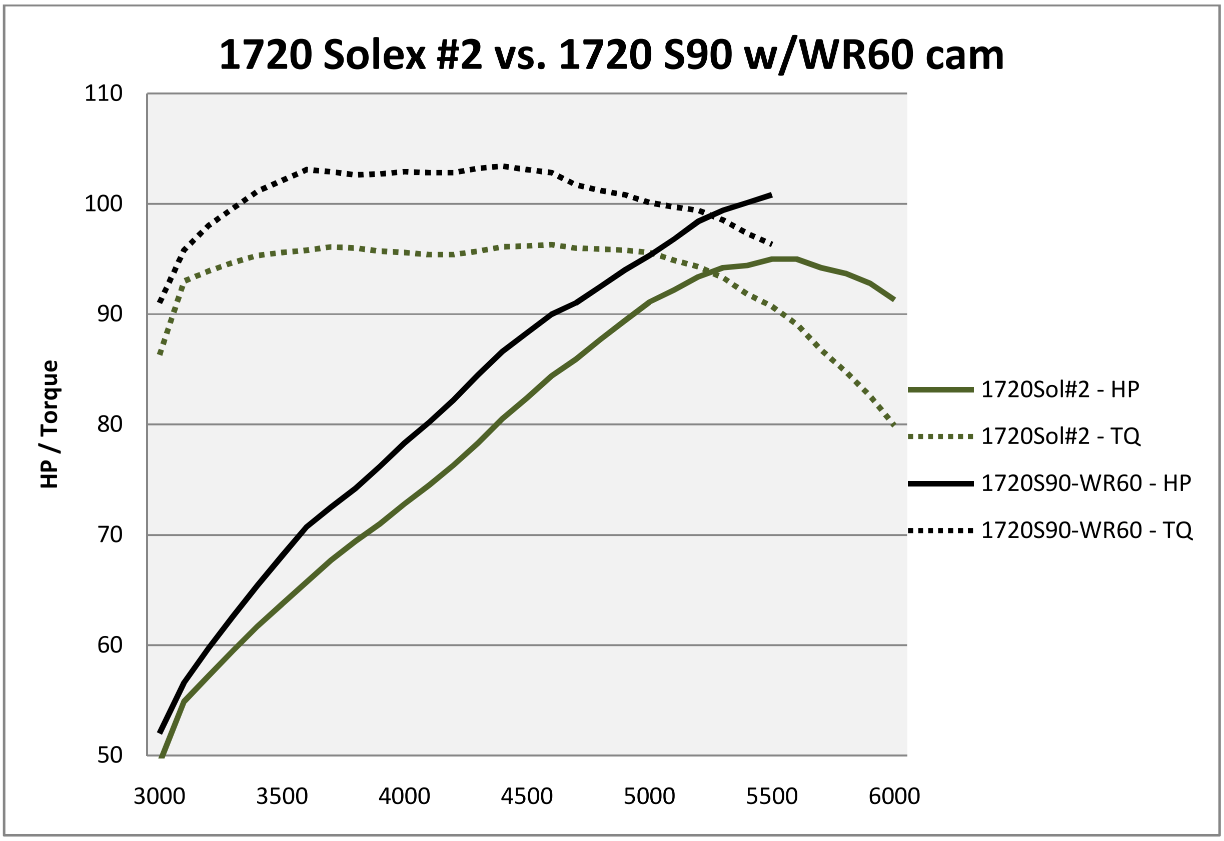
**101hp@5500rpm / 103ftlbs@3600-4400rpm**




The next graph compares a basically stock 1720cc SC Solex#2 and the 1720cc S90 with WR60 camshaft. The smaller exhaust valves don't seem to help the SC.

**101hp@5500 / 103ftlbs@3600-4400**

**95hp@5600 / 96ftlbs@4600**

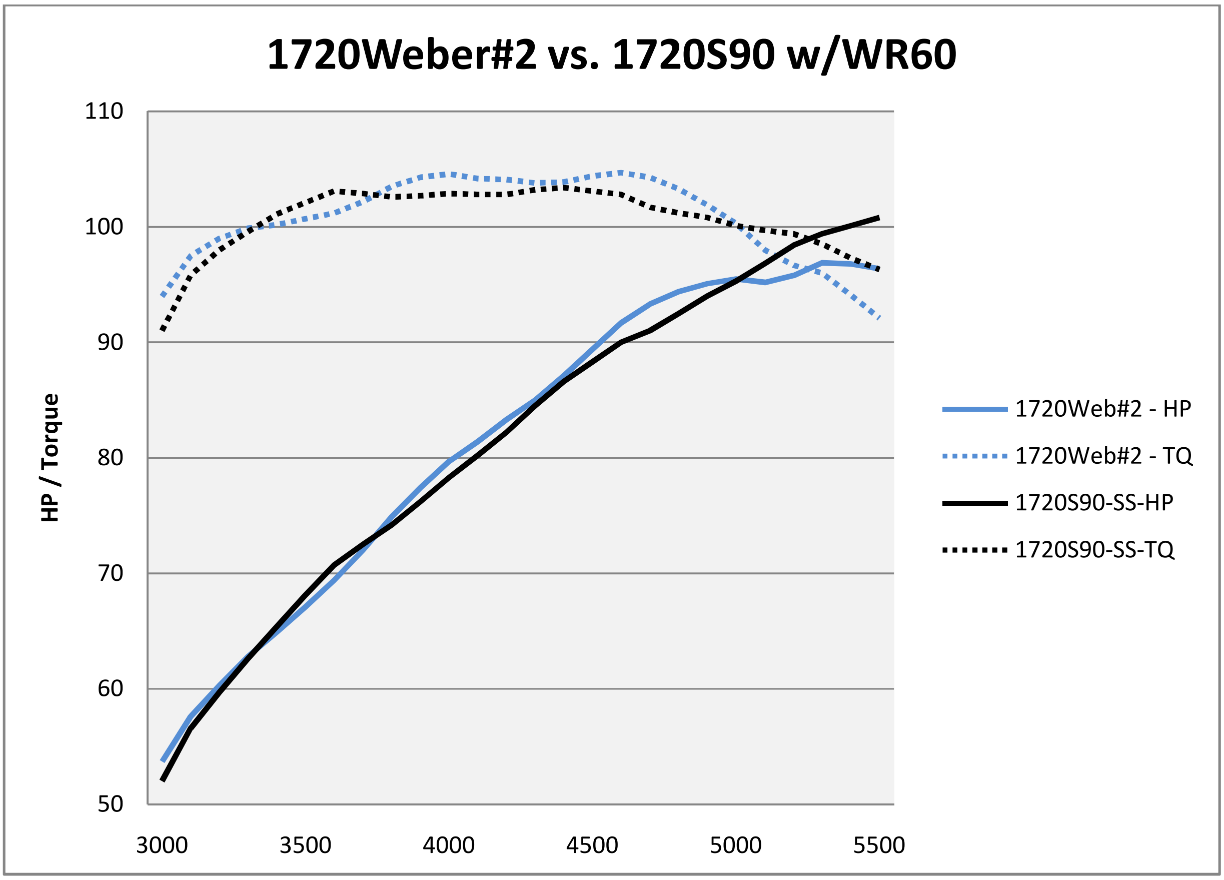



Since the Solex #2 engine wasn't assembled at WR, it's difficult to determine the exact differences in the specifications between the two engines. The WR60 S90 definitely has the edge.

The next graph compares the 1720cc Weber #2 to the 1720S90 with the WR60 camshaft. Both of these engines have 31mm exhaust valves. The S90 has the stock 40mm intakes the Weber engine has 38mm intakes.

**101hp@5500 / 103ftlbs@3600-4400**

**97hp@5300 / 105ftlbs 4600**




This comparison shows two things, the boosted mid range available with the Weber air horns, and the boosted top end performance available with the WR60 camshaft.

# In Search of Low and Mid-Range Torque

Hotrod engines for a performance minded customer, who is willing to put up with the modified look, the required shifting, and the lower rpm performance loss, can be a lot of fun. However, many 356 owners want an increase in power without modifying the power curve, or the looks of the engine (twin plug, etc). A quick check of most 356 owners driving habits will show that most shift between 3800 and 4500, and few rarely rev over 5500. After building a number of very powerful engines with extended redlines in the 7K rpm range, I decided to approach the "performance" 356 engine in a different way by designing an engine with a 6K redline and stock power curve (peak torque around 4200 and peak hp around 5500), but with an improvement in power throughout the entire rpm range. For this test engine test, I'm lowering the average horsepower/torque range from 3500-5500 to 3000-5000. I'll follow the dyno test with some comparisons of various engines.

Obviously, the larger the engine, the more power…but the engine needs to breath to make power. The WR 77mm crank and Carrillo rods are bullet proof. With the use of the LN Engineering cylinders, combined with piston squirters, and the aluminum fan shroud oil cooler, the engine temps are not difficult to control…in either the 1925cc or 2002cc form. This part of a "stock" rpm engine would be more than adequate. A stock full weight flywheel would be fine for damping the resonance of the longer 77mm crankshaft, especially when the revs were kept under 6K. The breathing was the real issue, and there are two ways to achieve this: more cylinder head flow, or more camshaft lift and duration. The problem with increasing camshaft lift and duration is that it puts more stress on the valve gear, and the increased valve overlap affects the very low rpm power and throttle response. The valve gear stress is not a major concern since the revs will be kept under 6K, but maintaining excellent low rpm power and throttle response is important.

For the next engine, I decided that a stock Super cam profile was the maximum I would use in order to keep the power curve stock. The heads were modified with 42mm intake valves (with 8mm stems) and the chambers modified to provide the best flow with the 91mm cylinders. The exhaust valves were stainless Ferrea in 34mm (also with 8mm stems). Head flow with identical intake and exhaust cam profiles was at 75%, exhaust to intake, exactly what I wanted.

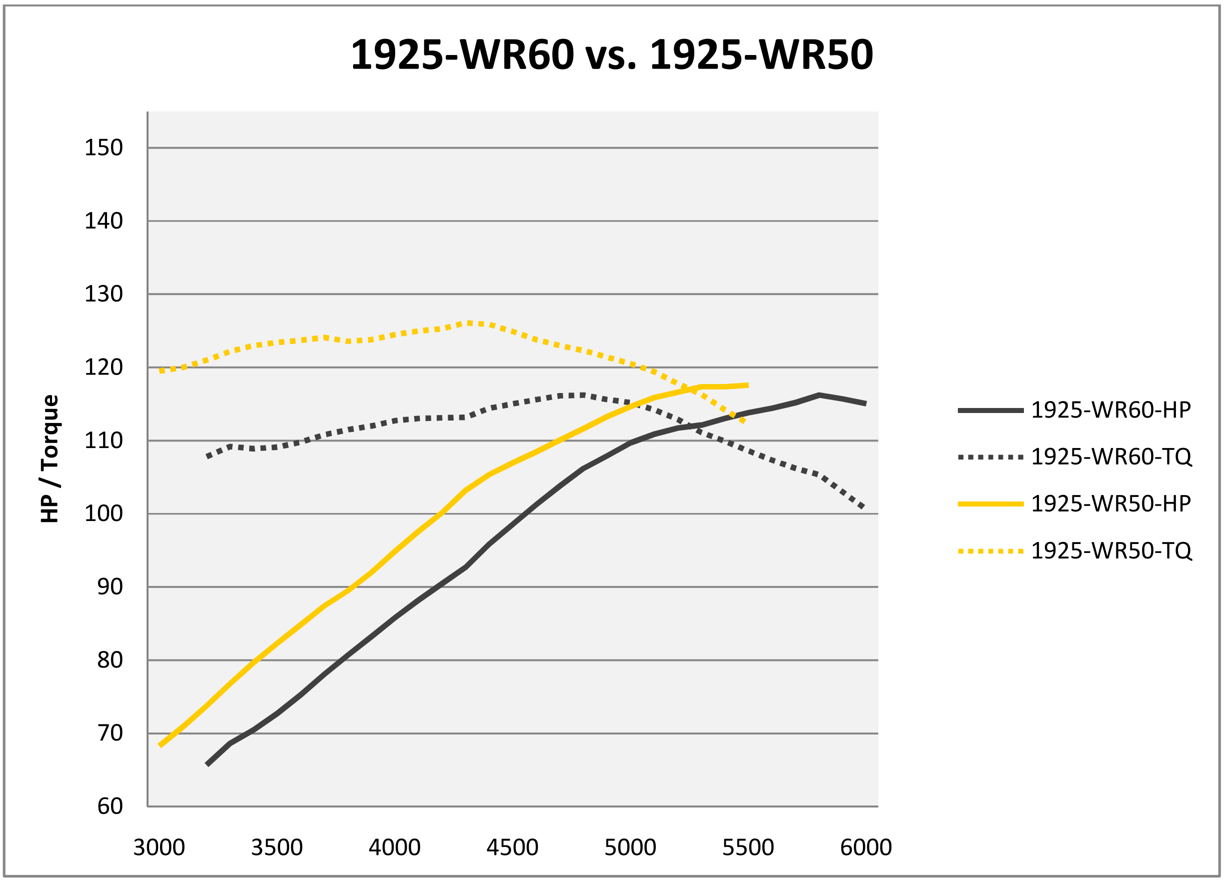
For this engine, the camshaft is a new design, the WR50, with 112 degree lobe separation. The wider lobe separation give less valve overlap and more intake vacuum. The engine specs and results of the dyno test are listed below:

# 1925cc SC w/WR50 camshaft

WR50 camshaft 234 degree, .333" lift Exhaust .
91mm LN Eng, Nikasil coated aluminum cylinders and JE pistons with 9.0:1 CR.
WR aluminum pushrods.
Stock SC crank and rods.
WR heads with 42I/34E valves.
Solex 40P11s with stock 32mm venturis. New Euro Alu. aircleaners with 2" air stacks.
Stock exhaust.
WR CDI ignition.

**117hp@5300 / 126ftlbs@4300.**

The engine is charted with the 1925 single plug with Webers and WR 60 camshaft.




You can see from the chart that the new camshaft provided a real boost to the bottom end and mid range. We limited testing rpm to 5500 but the engine would easily load with full throttle at 2500 which is usually a problem for a most 356 engines. The engine hasn't been tested in the car as of yet, so that part of the evaluation will have to wait.

The chart below compares the various average HP/Torque figures between 3000rpm and 5000rpm. The engine that were high-strung and couldn't be loaded as low as 3000 aren't included.