Ruthless Pursuit of Power

GM brings us to the next GEN III: LS6

Photo: Author
Click Image For Larger View

Drive it like ya stole it and the LS6 engine in the Z06 kicks ass, big-time.

Shift an LS6 at 6500 rpm, just 100 rpm shy of its rev limiter. While the motor peaks at six grand, it's power curve from there to its 6600 rpm fuel cut-off is nearly flat. Better yet, it out-powers the '97-'00 LS1, not just at the top end; but everywhere once you're off idle. As always, *The Idaho Corvette Page* brings you in-depth coverage of high technology in the Chevrolet Corvette. We hope you enjoy our look at the new, LS6.

This new member of the "Generation III Small-Block V8" engine family presents us with a chance to quantify the rate at which technology marches by comparing it to the LT5, introduced by GM 13 years ago.

Developed jointly by England's Lotus Engineering and GM Powertrain Division and manufactured by MerCruiser in Stillwater, Oklahoma, LT5 was the first American production V8 to pass the one, SAE net horsepower per cubic inch mark. This historic, all-aluminum, four-cam, 32-valve, 350 cubic inch V8 was in all Corvette ZR-1s and is responsible for the performance that made those cars legends.


Photo: GMPT Communications
Click Image For Larger View

With LT5, the technology advancements GM, Lotus and MerCruiser made in large-bore, high-performance, mass-production V8s stunned the automotive world more than a decade ago. Key LT5 features were incorporated in GM V8s of today, such as the "Premium V8" series ("Northstar" and "Aurora") and the Gen IIIs. For a dozen years, LT5 reigned as the most powerful production engine in any GM car since 1969. It kept the ZR1 King-of-the-Hill Corvette until the Z06 debuted in the fall of 2000. When it was introduced in the summer of 1988, the LT5 generated 375 SAE net hp at 6000 rpm and 370 lbs/ft torque at 4800 rpm. That kind of performance was cutting-edge...for its day.

LT5 was then.

LS6 is now.

Drawing: David Kimble/Chevrolet Communications
Click Image For Larger View

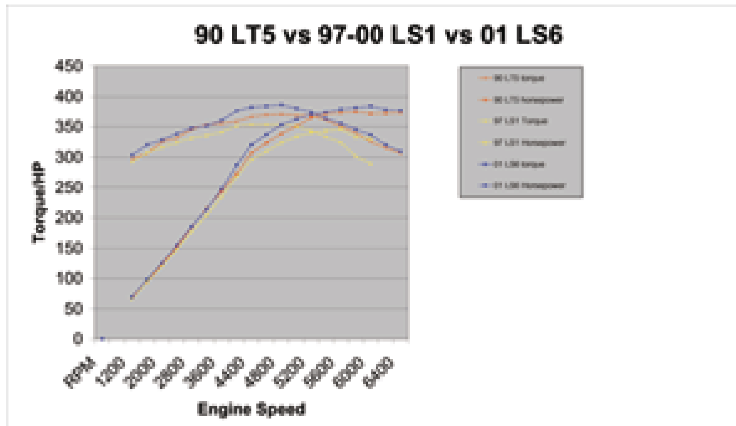
This new Gen III puts out 385hp at 6000 rpm and 385lbs/ft torque at 4800rpm. A dozen years of engine technology advancement gets us 10 horsepower and 15 pounds/feet torque with identical peaks. If that doesn't seem like much, consider that improvement comes from an engine with: slightly less displacement, smaller physical size, only one cam, only two valves-per-cylinder, pushrod valve gear, less weight and better fuel mileage.

Now that, my geargeek friends, is big news.

Development History

GM's Generation Three Small-Block engine family debuted in the 1997 Corvette as the LS1, a 346 cu. in., 345hp V8. The LS1 was a home run right out of the box. It made one SAE net-hp-per-cu.in. with a high-level of refinement and cutting-edge engine technology. For this, *Ward's Auto World* put the LS1 on its "Ten Best Engines" list in 1998 and 1999.

The LS1 is discussed in another article on this site at www.idavette.net/hib/ls1c.html . That story might be an important reference for anyone reading this article. Additional LS1 technical information is in a Society of Automotive Engineers booklet *1997 GM 5.7 Liter LS1 V8 Engine* by Richard W. Amann, Mark A. Damico, Brian Green, Charles J. Hahn, Ameer Haider, John W. Juriga and Creighton A. Mantey, SAE paper #97015, February 1997. Interesting, non-techie information about the LS1's development is available in the late Jim Schefter's outstanding book, *All Corvettes are Red* , Simon and Schuster, 1996.



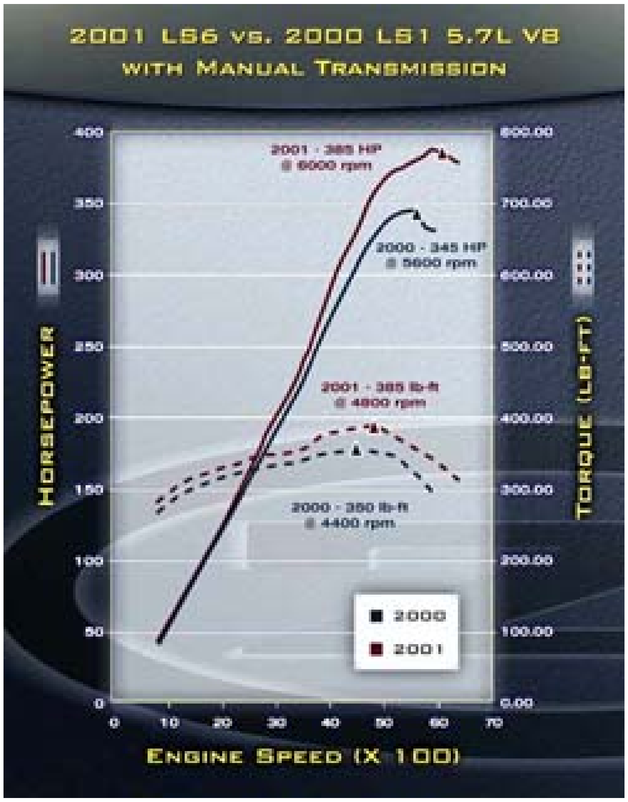
This power and torque graph of the 1990-92 LT5 vs. the 1997-00 LS1 vs. the 2001 LS6 is a revealing piece of information. There's no doubt that the LS6 either matches or exceeds the early version of the LT5 in all areas of the torque and power curves. In the mid-range the LS6 generates noticeably more torque. Also evident is that, in spite of a more aggressive camshaft, bigger intake ports and more plenum volume, the LS6 equals or exceeds the LS1 in low-end torque. Graphic: author. Click Image For Larger View & PDF Print File

"Doctor" John Juriga, Assistant Chief Engineer for Gen III Passenger Car Engines at GM's Powertrain Division has been on the Gen III program since its beginning in 1992. He describes GMPT's work on those engines as the *"ruthless pursuit of power."* Clearly, that philosophy drove Juriga and his team of engineers as they began work on the LS6.

"Even before we put the LS1 into production," Juriga told *The Idaho Corvette Page*, "*we were considering performance improvements*. *We had ideas of what we needed to do. Also the Corvette group* (the GM Car Division team which develops the vehicle) *had given us their targets for the engine's performance and we'd been looking at what other people on the outside were doing with the LS1.*

"After the LS1 was in production, in early '97 we brought the program that would result in a higher output engine up to full speed." Juriga paused while he checked his computer files, then said. "*It was June 25th, 1997 when we had our 2001 concept initiation.*

We started developing a plan based on Corvette's goal of 375 horsepower. They also wanted improvements in 0-60 and quarter-mile performance of three-tenths. We studied their targets and came back saying, 'We *think we can meet those targets, based on the development we've done to date, but we may not be able to do it if we have to meet the LEV* (Low Emission Vehicle) *emissions standard.* (required in California for 2000 and nationwide for 2001).



Graphing the '00 LS1s power and torque against the LS6 demonstrates some interesting facts. First, past its power peak the LS6 still does well, whereas the LS1 was not worth winding past 6000. Second, even though the LS6 has bigger heads and cam, it gives nothing away to the LS1, even at 1000 rpm and by 2250 rpm it's gaining. Graphic: Chevrolet Communications/Black Dog Design - Click Image For Larger View

"There was some talk of getting a deviation from LEV for the Corvette, but frankly, I wasn't crazy about it. I discussed this with the Corvette guys. Personally, I wanted this product to not have any excuses. I wanted it to have the performance and not have us say, 'Oh, but, it's a guzzler.' or 'But it doesn't meet current emissions requirements and we had to get a deviation for that.' We held the bar to ourselves. We wanted to make the power and try and meet the emissions, but we were a little unsure at first if we could do that."

As Juriga's staff of engineers began full-scale development, the first major challenge was the camshaft and cylinder head package. Both pieces were significant evolutions from the LS1 parts and the work took about a year during 1997 and 1998. The other major task was a redesign of the bare block (engineers call them "cylinder cases") to improve its "bay-to-bay" breathing and its strength. That took place in mid-to-late 1998. The final major challenge was a sort of "surprise" late in the program. Once prototype engines were available for installation in vehicles, race track testing demonstrated oil control and consumption problems in certain extreme duty situations. The problem, discovered in the fall of '98, took about nine months to solve. The LS6's final development and validation was during mid-to-late 1999. Pilot engines were built in the first quarter of 2000 and the first production units that spring.

In the end, John Juriga's reservations about power and meeting LEV were unfounded. Not only did the LS6 meet Corporate Average Fuel Economy (CAFE) requirements and LEV but it did so while exceeding the Corvette platform team's goal of 375hp.

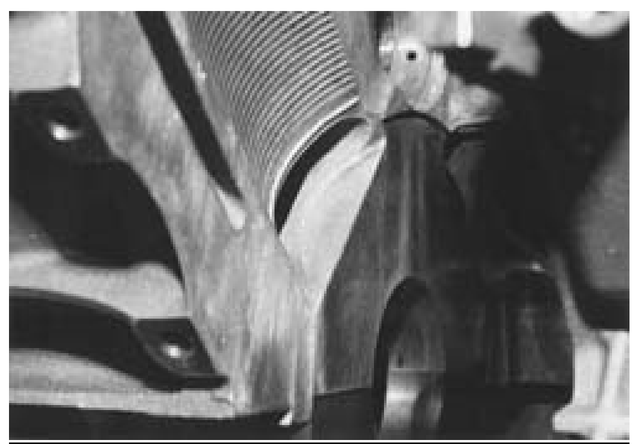
So went the ruthless pursuit of power.

The LS6 Lower End

In front of international press at the Corvette Z06 introduction on May 1, 2000, John Juriga, GM Powertrain Assistant Chief Engineer for Gen III Passenger Car Engines, debuted his team's latest and greatest, the LS6. Photo: author
Click Image For Larger View

The LS6 and the LS1 use an all-aluminum cylinder case. It's a "deep-skirted" design (block structure extends below the crankshaft centerline) with six-bolt main bearing caps (four vertical bolts and two horizontal bolts per cap) and head bolt threads deep in the main bearing bulkheads (for minimal block distortion and maximum head gasket clamping force). LS1/6 blocks are semi-permanent mold castings of 319-T5 aluminum. The LS6 case is different from LS1 blocks in the design and strength of the main bearing bulkheads.

As the pistons move up and down, they force air in and out of the spaces (or "bays") beneath them. At high rpm, this reciprocating air flow is violent and really whips up the oil. While the LS1 block has some machined openings between bays, the LS6 block, because the engine has about 500 more usable rpm, needed larger windows at the base of each cylinder to better accommodate "bay-to-bay breathing."



We got the GMPT guys to cut up a LS6 block for us. To above-left of the #2 main bearing bulkhead, at the bottom of the cylinder bore, you can easily see the rectangular bay-to-bay breathing window. Photo: author
Click Image For Larger View

Obviously, cutting windows at the bottom of each cylinder reduces the strength of the block's key structural area, the main bearing bulkheads. With 40 more horsepower, 400-500 more rpm and even more powerful derivations of this engine to come, the block needed to be even stronger than it would be without the windows. It doesn't take a rocket scientist to figure, in their ruthless pursuit of power, Dr. John and his engineers had to do more than simply reprogram their CNCs to cut those windows.

Finite element design work along with a lot of thrashing engines to death (in a few cases, literally) on the dyno eventually resulted in the special LS6 block having both the bay-to-bay breathing windows *and* more overall strength than the LS1 block.

Like the LS1, LS6 uses centrifugally-cast, gray-iron liners which are cast into it at the foundry. Their bore is 99 millimeters (3.8976-in.). ’97 and ’98 LS1s could not be overbored. For 1999, liners changed such that a service overbore of .010-in. was possible and this carries over to the LS6.

LS6’s valley mounted oil separator is similar in concept to the system used a decade before in the LT5. It uses internal baffling to force the crankcase vapors in a circuitous flow. In the process, the oil separates and drains back into the engine. Photo: GMPT Communications
Click Image For Larger View

The LS6 crankshaft is the same cast, nodular iron unit with rolled-fillet journals used by LS1s since 1997. Its stroke of 92 mm (3.6620-in), makes the LS6's displacement 5.665 liters or 345.69 cubic inches. Drilled main bearing journal centers reduce weight and assist in bay-to-bay breathing. For the 2001 model year (MY01), the reluctor wheel, pressed onto the crank to trigger the crankshaft position sensor, was redesigned to enhance sensor signal output. For MY01, all Gen IIIs use a new main bearing that has reduced diameter variation. That allowed a slight decrease in main bearing clearance which reduces the potential for bearing knocks during starts in extremely cold weather from engines having bearings on the high-side of the variation. Lastly LS6 cranks use a lightweight harmonic damper with an aluminum hub which is 2.6 pounds lighter than the LS1 damper.

The sintered, forged and shotpeened, PF1159M steel, 6.1-inch connecting rod introduced in 1997 carries over to the LS6. Beginning in MY01, all Gen III rod cap screws are stronger through a change in manufacturing process used to heat-treat and roll the screw’s threads. This particular change came as a result of the LS1’s use in the American Speed Association (ASA) race series during 1999.

LS6 puts out more power and runs faster so it has a brake-mean-effective-pressure (b.m.e.p.) that peaks about 15% higher than LS1’s. Because of this, LS6 needs a more robust piston. The new piston, as well as all other Gen III and Gen II pistons, are made by Mahle. The LS6 unit is cast of a eutectic aluminum/silicon alloy called "Mahle 142". Both M142 and the previous material, M124, also contain small amounts of copper and nickel, but M142 has slightly more of both. Mahle 142, offers increased strength and less expansion at high temperature. That offers better control of piston-to-bore clearance, both at the skirt and the ring lands. The improved dimensional stability prevents piston noise along with enhancing durability and oil control. Because the LS6 piston material has more favorable expansion characteristics, the slight barrel-shaped profile used in the machining of the piston had to be changed, too.

Camshaft and Valve Train

While the camshaft in the LS6 is more aggressive than LS1 cams, its basic construction is the same: machined from a steel billet, rifle-drilled for less mass and with a camshaft position reluctor just ahead of the rear journal.

Jim Hicks is the guy at GM Powertrain who does Gen III camshafts and we learned a lot from him in three different telephone interviews. LS6 valve lift is .525-in., intake, and .525-in., exhaust, compared to .500/.500 for the MY00, Y-car, LS1 profile. Measured at .050-in. tappet lift, LS6 intake duration is 204° and exhaust is 211°. The LS1 for MY00 was 198°/208°. The LS6 lobe centers are 116° apart where as LS1 has them at 115.5°. At .050-in. tappet lift, both cams have no overlap, but at .005 lift, LS6 overlap is 45° and LS1, 49°.

The overlap numbers make the new cam seem less aggressive but, that's clearly not the case.

"Even though the LS1 looks like it has more overlap based on degrees," Jim Hicks commented, "*the LS6 actually has more overlap based on lift area–.52 vs. .42 inch-degrees. That is why it's better to use lift area to quantify a lot of this cam data rather than just degrees."*

The only valve train item that changes from LS1 to LS6 is the valve springs. All the other pieces carry over. Photo: GMPT Communications
Click Image For Larger View

Looking at these side views of the LS6 intake port (left) and the LS1 intake port, it's very easy to see the difference in the port floors and the short-turn radii. Photo: GMPT Communications
Click Image For Larger View

We agree. With today's varying lobe configurations, comparing cams by the area under the profile is a better choice. Another issue to consider is, up to now, virtually all Gen III camshaft duration data released by GM's various communications entities has been "altered" to facilitate comparison to Gen I and Gen II Small-Block V8 profiles which, except for the LT4, used 1.5 rocker ratios. Our specifications *are not* skewed to a specific rocker ratio. Again, the duration numbers in degrees, when used for comparison purposes, can be deceiving. The lift area, in in./deg., is a more consistent method of measurement.

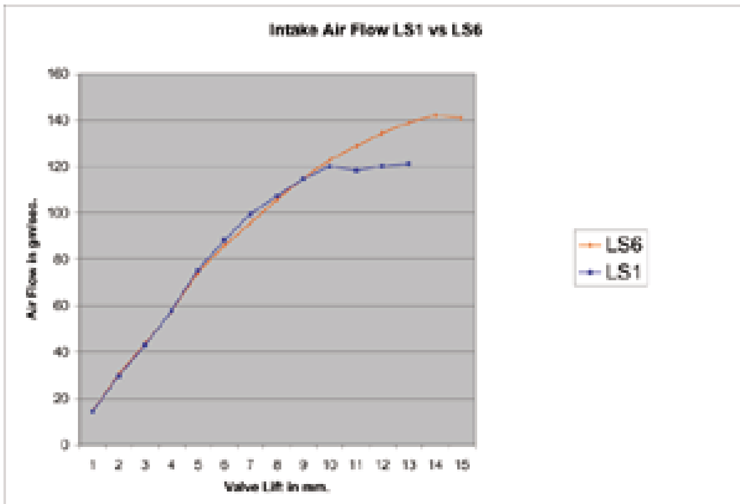
Why does the LS6 have more actual overlap when, measured by duration in degrees, it appears not to? The LS6 valve accelerations and open/close ramp configurations are dramatically different from those of the LS1. *The accelerations are higher,"* Hicks continued, *"especially the negative acceleration over the nose, which increased about 10%. That's where the increased lift and duration come from. We also changed the ramps. In the '97 model year we put constant velocity opening and closing ramps on the cam to limit valve train noise. For 2001, because* (LS6) *is a more aggressive application, we went back to a constant acceleration opening and closing which moves the valve faster. That gives us more lift area and allows us to run tighter lobe centers* (than with constant velocity ramps having the same lift). *With this profile there is a slight increase in valve train noise. but for this application,* (ie: the Z06) *it was deemed acceptable.*

"Opening and closing ramp velocity is a kind of a compromise we're always going back-and-forth on, depending on the application. If a cam is going into a Cadillac Escalade for instance (luxury SUV powered by the truck version of the Gen III), we wouldn't have aggressive valve openings and closings. We'd skew the profile's ramps towards lower noise. For this particular application–being a two-seat, light-weight, near racecar you can drive on the street–the right compromise was to take a small increase in valve train noise in exchange for more lift area, tighter lobe centers and the increased performance they bring.

Obviously, with more lift, duration, higher acceleration rates and more usable rpm, the LS6 needs a more aggressive valve spring. Erroneous information in Chevrolet's '01 Corvette Media Materials book, states the only difference between the LS6 and LS1 valves springs is tighter winding. In our interview with Jim Hicks, we learned the LS6 spring is made of different material (chrome/silicon/vanadium steel wire vs LS1's chrome/silicon steel wire) and has a different wire shape (oval vs. round), as well as, being wound more tightly. These three features make a big difference in valve spring pressure: on the seat, 90 lbs for the LS6 vs. 76lbs for the LS1, and over the nose, 260lbs for the LS6 vs 220lbs for LS1.

The rest of the LS1 valve train, including the 1.7:1, investment cast steel, roller-fulcrum rockers carry over to the LS6. Generally, the Gen III valve train is more robust and lighter than the Gen II/I pieces. It’s geometry is better and the natural frequency of the Gen III valve train is 740 Hz where as the old Small-Blocks were in the high 600s. This is why the Gen IIIs can rev higher than production Gen Is and IIs.

Cylinder Heads: The Ruthless Pursuit of Power



This graph of the intake air flow in both LS1 and LS6 intake ports clearly shows the air flow stall discussed in the text. Graphic: author. Click Image For Larger View & PDF Print File

The same basic, performance-oriented characteristics of the LS1 head are used in the LS6 unit: 356-T6 aluminum casting, replicated ports (which offer the charge air a straight shot down to the intake valve),15° valve angle, 2.00-inch intake valves and 1.55-in exhausts with three-angle faces. Additionally, the valve seats, head bolt and rocker stud bosses and oil return holes located such that they impact the intake ports as little as possible.

The major change in the LS6 intake port was alteration of its "short turn" or "short side" radius, the area of the port just upstream of the valve where the port floor curves down to the valve seat. The LS1 port suffered an air flow stall at high valve lift, induced by the short-turn radius and the goal was to eliminate that.

Ron Sperry, one of GM’s top, motorsports, cylinder head guys during the 1980s, lead the team that did the 1997 LS1 head. One of the restrictions put on Sperry was: whatever he did with the intake port, injector targeting, which affects idle quality and exhaust emissions, was to be the prime concern. Ideally, port-injected engines should have injectors squirting fuel straight down the port, directly on the back of the hot intake valve. The temperature helps vaporize the fuel and the turbulence of the charge air blowing around the valve does the rest. For least emissions we want really good vaporization.

While Sperry did a lot of cool stuff with the original LS1 intake port, a compromise he was forced into was port walls that didn’t interfere with injector targeting. The fear was: if fuel contacted walls, it would end up as droplets or pool on the port floor. Anything other than a fine spray burns poorly and causes exhaust emissions to go up. To keep injector spray off port walls; LS1’s port floor was flat, low and had a short-turn radius tighter than was ideal for optimum performance.

After the LS1 release, Ron Sperry went back to GM Motorsports and Dennis Gerdeman became the Gen III’s cylinder head ace. During the late-'90s, the ruthless pursuit of power drove continued research into effects of port dynamics and injector control software algorithms which showed injector targeting to be less important than originally believed.

A vertical view of the same two intakes shows the LS6 (left) has a port that is taller at the entrance but wider in the mid-section, thus preserving cross-sectional area. The LS1 port does not share that characteristic. Photo: GMPT Communications
Click Image For Larger View

For the LS6 intake port development, Gerdeman raised the port floor to recontour and soften the short-turn radius. That improved flow as it transitioned into the combustion chamber. When air flows though a port of varying cross-section, such as the LS1's; there are localized fluctuations in flow velocity which reduce efficiency. In the interest of better consistency in cross-sectional area, the mid-section of the LS6 port was widened and its roof was raised. Effects of these changes on injector targeting and emissions were addressed with improved fuel control software and calibration.

Side view cuts of the LS6 (left) and LS1 exhaust ports, again, show a smoother short-turn radius. On the piece at left you can also see some of the change to the combustion chamber. Note how the chamber wall in around the spark plug has been moved in, towards the valves and the roof has been lowered. Photo: GMPT Communications
Click Image For Larger View

At high valve lift, flow improved. At .550-in. lift, just slightly more than the LS6's maximum, flow jumped 10%. That GM validated the flow increase at .550 lift means the port has additional potential given more camshaft. Is this a clue to what's coming in LS6 for 2002? Probably. Is this a hint to the aftermarket camshaft industry? You bet.

The LS6 combustion chamber is quite different than that in LS1 heads. The compression ratio (CR) gains four-tenths of a point to 10.5:1, but getting there wasn't easy. A CR increase has an hydrocarbons (HC) exhaust emissions penalty, but GM wanted the payoff: more power, increased thermal efficiency and better fuel economy. The addition of the small, auxiliary catalytic converters engineers call "pup cats" required for the Corvette to meet the LEV standard also allowed the engine the small increase in HC from the higher compression.

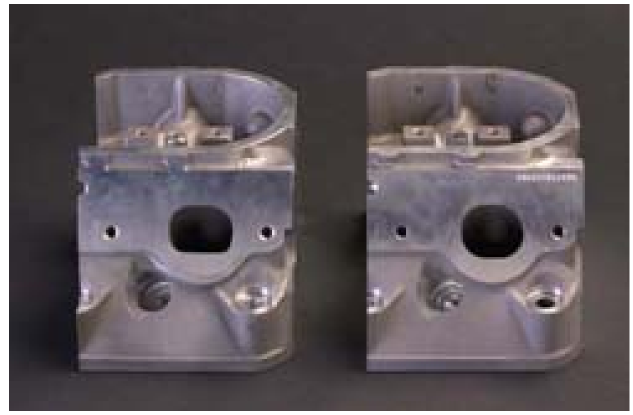
Dennis Gerdeman's challenge with the chamber was to increase compression by reducing its size but without shrouding the valves. When a valve is "shrouded," the adjacent combustion chamber wall is too close when the valve is open and the closeness of that wall presents a restriction to air flow between the wall and the valve face. Obviously, shrouded valves reduce performance.

Compared to the LS1, the roof of the chamber in the new head was lowered. This not only decreased chamber size, which increased CR, but it improved air flow over the short-turn radius. Additionally, lowering the roof slightly *unshrouded* the valves which enhanced flow into the chamber. So, he increased compression *and* unshrouded the valves. Dennis Gerdeman can do my cylinder heads any day.

The LS1 exhaust port was also revised with the same goals: improve short turn radius and make cross-sectional area more consistent. The port exits were also given the pronounced D-shape that many racing cylinder heads use. The changes to the exhaust ports also netted about a 10% improvement in high lift flow.

There were some other changes to the cylinder heads that driven by the revised ports and combustion chambers. Obviously, coolant passages had to be revised. Also, the oil drain back holes were altered to clear the different ports.

One last word on the LS6 head: right after the print version of this article went to press in *GM High-Tech Performance*, we heard rumors that Mallet Motorsports consulted with GM Powertrain on LS6 cylinder head development. When we contacted GMPT to confirm that, John Juriga surprised us by saying an aftermarket tuner did assist with the LS6 head, however, it was not Mallet, but Lingenfelter Performance Engineering.



This view of the exhaust port exits clearly shows the LS6's pronounced "D-port".
Photo: GMPT Communications
Click Image For Larger View

The basic Gen 3 head architecture is quite good so early in the development program, engines with prototype LS6 heads were well over the LS1's 345hp but not quite the 375 GM Powertrain and the people at Corvette wanted. John Juriga picks up the story, "W*e had to meet LEV emissions standard in '01, which meant adding "pup" converters* (also known at "pre-cats"). *That added back-pressure which took our numbers down to 360 or so....not good enough.*

We had friends at LPE and we knew they were porting our LS1 heads for their customers. We asked them to do some porting work for us. Our air flow guys saw this as a challenge and stepped up to the plate to work in parallel on a porting project of their own.

Some of what LPE did was not "production feasible" and we had to be content with an as-cast port vs. a CNC-machined port, but LPE had some good ideas which did much to spur our guys on and offer us some perspectives we didn't see previously. Bottom line: LPE did help us in our development and that made our production heads better."

We offered LPE's communications contact, Jason Haines, a chance to comment on this. He acknowledged LPE's role in the project but declined to be interviewed about it for this article stating LPE's agreements with its customers preclude any discussion of its work on the LS6.

Guess John L.'s folks know their Gen 3 cylinder head stuff pretty well.

Additional Changes in the Intake and Exhaust Tracts.

A unique item of Gen IIIs is the composite ("plastic") intake manifold. Plastic intakes are great for car companies because of low mass, low cost of materials and cheap manufacturing. The downside, a big difference between them and aluminum or iron manifolds, is the high cost of tooling. Car companies justify that by spreading it over a huge run of parts. As the LS1 went to production, GMPT already knew more performance would come from a revised intake manifold, however, the cost of retooling was so high, it waited for the next iteration of the complete engine to make the investment. Cost is, also, why the performance aftermarket has, to date, not offered intake manifolds for the Gen III.

The biggest change in the LS6 intake was an increase in plenum volume accomplished by dropping the plenum floor as low as allowed by the engine block valley cover. Additionally, sharp edges at the junction of the intake runners and the plenum were smoothed. Some dead air pockets (areas of no flow) were eliminated. This new manifold is worth 10 horsepower, just by itself. The new intake is so good, it’s not only on the LS6, but it replaces the ’97-’00 LS1 intake, too.

A cutaway close up of the front of the LS6 intake manifold plenum. Note that floor of the intake now is near flush with the top of the valley cover. This increase in volume, makes the new manifold 10hp to the better. Photo: GMPT Communications
Click Image For Larger View

The biggest change in the LS6 intake was an increase in plenum volume accomplished by dropping the plenum floor as low as allowed by the engine block valley cover. Additionally, sharp edges at the junction of the intake runners and the plenum were smoothed. Some dead air pockets (areas of no flow) were eliminated. This new manifold is worth 10 horsepower, just by itself. The new intake is so good, it’s not only on the LS6, but it replaces the ’97-’00 LS1 intake, too.

The other changes for the LS6 are the higher-capacity mass air flow (MAF) sensor from the 6.0-liter, Gen III truck engine. It’s worth 2-3hp and its integral intake air temperature (IAT) sensor simplifies the engine controls and reduces cost. The LS6 also uses a different air filter assembly capable of slightly better flow.

The exhaust manifolds on the LS6 and 2001 LS1s are new cast iron items. Previously, the LS1 used a double-wall, fabricated, stainless-steel manifold. Most ’97-’00 LS1s had cats downstream in the exhaust under the floor. Double-walls, available only with a fabricated manifold, were required to retain exhaust heat in the interest of quicker light-off of the catalytic converters. The addition of pup cats, immediately below the exhaust manifolds on ’00 California cars and all ’01s, eliminated the need for the stainless manifolds.

The new iron manifolds offer improved exhaust flow compared to the stainless units but, currently, the LS6 doesn’t need the improvement. There will be further performance enhancement for MY02 enough that the extra flow will be needed. The iron manifolds offer better durability, too. They don’t crack at welds as can stainless manifolds and, believe it or not, because of the type of iron used, they will tolerate a higher level of exhaust heat. There is a weight penalty of about 4.5 lbs, but that is offset by mass reduction elsewhere in the Corvette platform.

Closing out the LS6 story

The last major change made during the development was in the positive crankcase ventilation (PCV) system. In the fall of 1998, LS6 in-vehicle testing was underway at road race facilities in the north-central U. S. Once Z06 prototypes neared production intent with expected suspension and tire improvements, on tracks with long, sweeping turns, engineers noticed excessive oil consumption at high-rpm and high, lateral acceleration.

Further testing during the winter of ’98/’99 proved oil was being trapped in the valve covers then sucked into the engine through the PCV system. The solution, which took the first half of ’99 to perfect, was new PCV hardware. Taking a page out of the decade-old, LT5 book, LS6 uses a valley-mounted oil separator assembly rather than the rocker-cover units of the LS1. This significantly reduces oil aeration and oil consumption and simplifies the system.

The engine controls calibration (engineers sometimes call it "cal") for the LS6 differ mainly in larger capacity injectors and in fuel and spark schedules. The LS6 injectors flow 28.5 lbs/hr., whereas the LS1 units flowed 25 lb/hr. We asked John Juriga about the cal. "*Obviously, with higher compression ratio and higher output, the fuel curves changed as well as the spark curves–quite a bit different calibration to handle the higher air flow rates, higher fuel flow rates and higher compression. We started with the LS1 spark and fuel, then modified that until we gained the power we wanted. We also did sweeps looking at emissions–NOx, hydrocarbons and CO–at part throttle conditions making sure that is all optimized."*

Juriga also indicated that since 1997, there’s been a change in how engine controls work in the "power enrichment" mode, a staple of GM engine controls since their advent in the late 1970s, and which is enabled at high engine loads. Previously, though an engine might be operating in a manner that met the requirements for closed loop control of the fuel flow, beyond a certain throttle opening, the engine controls would ignore the oxygen sensor inputs and set fuel delivery straight from the lookup tables.

"We run closed loop even at wide-open-throttle," Juriga states,"*but what we do is we just run rich of ‘stoich’* (engineering slang for "stoichometric," a scientific term for ideal combustion) *but it’s all a closed loop system. The only open-loop portion we have is just the very, very beginning at start-up. It’s that way until our oxygen sensors ‘wake-up’–they don’t function until they reach a certain temperature. As soon as the O2 sensors start sending a signal, we stay in closed-loop all the way to wide-open-throttle.*

What will the leader of GM's ruthless pursuit of power spring on us next? Well, he's obviously not saying at this point, but we bet it's going to be 405hp in '02. Photo: author.
Click Image For Larger View

We asked Juriga if the task of calibrating such a powerful engine and still meeting LEV was a major challenge. We got the short answer, *"No. It really wasn't all that bad."*

The LS6's fuel cut-off is at 6600 rpm. Of course, the first question geargeek Corvetters are going to ask is, "What happens if I change the rev limit so I can run harder on the drag strip?" We asked Dr. John what keeps the LS6 from rev'ing to 6800 or so. *"Fuel cut-off,"* he replied laughing. On a more serious note, he added, *"With the current hardware, my recollection is the valves float about 6800-7000 rpm. The concern is all the other parts in the engine, not just the valve train. We can work on the valve train to get it to go that higher speed. Then we start being concerned about oil film-thickness in the rod bearings, rod bolt strength and piston temperatures. Even though we upgraded our piston, if we were to go with higher speed, we'd have to go with another improved piston as well as upgraded piston pins and I'm talking about forged pistons and floating pins. We'd also have to go with an improved strength rod.*

A lot of the hot rodders reading this might trivialize GM Powertrain's position and say, "Heck, what a bunch of wimps. Just put some bigger valves springs on, bigger injectors and change the rev limit. Considering that viewpoint, we asked Dr. John why the conservative approach. "*You could run an LS1 or an LS6 to seven grand,"* Juriga answered, *"and not immediately put a rod through the side of the block. What is a concern is how often and how long your run the engine like that. We have our durability goals that say we gotta be able to run these engines for 125,000 miles at a certain confidence level. If we had the engine running at those higher speeds, we'd have to validate the engine at the higher performance level for that period of time and that's something we're not ready to do right now."*

We like the tail end of that sentence: "...not ready to do--right now." Reading between the lines our guess is Dr. John and his bunch continue in the ruthless pursuit of power. No doubt, the basic Gen III architecture will support increased power output.

This writer's guess back in 1997 was the future "high-performance" iteration of the LS1 would come in a few years and be a "375hp-class" engine. I was about a year off on when, but I was close on the power. My next fearless forecast? An even more powerful Gen III is just around the corner. Think 405hp for 2002

Let's see if I'm right.

The author and *The Idaho Corvette Page* would like to thank John Juriga, Jim Hicks and Dave Roman of the GM Powertrain Division for special assistance in the preparation of this article.

The author would like to offer a special word of thanks to Tom Hoxie for his support in making this article possible. Until the end of 1998, Mr. Hoxie was Assistant Director of Chevrolet Communications. After that, he worked for Marcom, the company Chevrolet Communications retained to organize the Corvette Z06 media preview in May of 2000, the event at which much research was done for this article.

Tom Hoxie is now retired and playing golf in North Carolina, but remains a steadfast supporter of the Corvette. The author is indebted to him for special assistance at the Z06 preview and many Corvette media events in the past.