PROJECT LS2, PART 3

Assembly of the short block and cylinder head installation

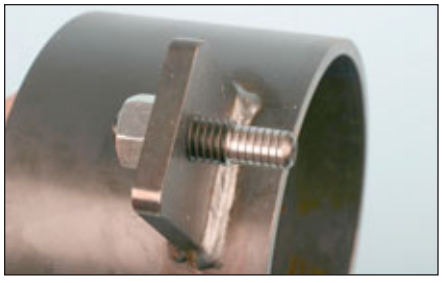
by Mike Mavrigian

Goodson reluctor ring installer jig is an absolute must for installing LS crank timing wheels.

INSTALLING THE RELUCTOR WHEEL

The reluctor wheel features a series of teeth that provide crankshaft position signals via a sensor to the ECM. The wheel press fits to the rear of the crank, immediately forward of the No. 5 main bearing. The wheel features about a 0.007" interference fit. While an OE LS crank is already fitted with this timing wheel, an aftermarket crank may or may not be provided with an installed wheel. If you need to install the wheel yourself, be advised that the clock position is critical for proper timing reference.

The Goodson tool indexes the ring via the 8mm hole in the ring face.



The 8mm dowel is pictured here. It's attached to a tang on the outside of the tool.

Since LS cranks feature no keyway or other index point (thanks a lot, GM), how do you know where to locate the wheel? As usual, Goodson rode to the rescue. The company offers a very handy (and damn-near essential) indexing and installation tool for LS reluctor wheel mounting. The RRJ-350 Reluctor Ring Jig (for Chevy 350 type applications) is a short steel tube that's equipped with two indexing pins. An external tang secures a threaded stud, with the stud tip turned down to 8mm diameter. This pin engages into the sole 8mm hole in the reluctor wheel. An internal guide pin (a threaded stud with the tip turned down to 11mm) engages into the 11mm blind dowel hole in the crank's flywheel flange. This jig orients the reluctor wheel precisely in the correct timing position. The two dowel studs feature jam nuts to allow depth adjustment (you simply want to make sure that the 8mm dowel passes through the wheel's 8mm hole and that the 11mm dowel projects out far enough to engage into the crank flange dowel hole).

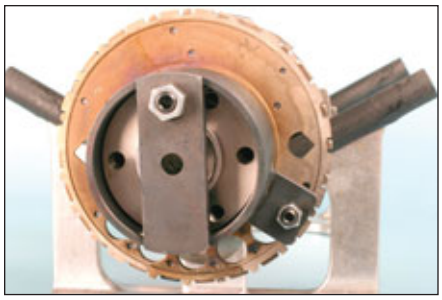
Before attempting the installation, I lightly chamfered the entry hole of the reluctor wheel and lightly chamfered the edge of the crank's reluctor wheel flange. Goodson's instructions advise this chamfering to ease installation. The instructions also state that the wheel may be pressed onto the crank or heated to 450 degrees F for a slip-on fit. I admit that I did try to cold-press the wheel onto the crank but maintaining a square alignment of the wheel to the crank was difficult (hey, I'm a klutz). Ultimately, I took the easy way out and heated the reluctor wheel's I.D. lip with a torch, slipped the wheel onto the Goodson jig and the wheel slid onto the crank as easily as a rock drops into water. My advice: install the ring by pre-heating it instead of potentially ruining the ring by cold pressing.

An internal dowel in the tool engages into the crank's rear flange dowel pin hole.

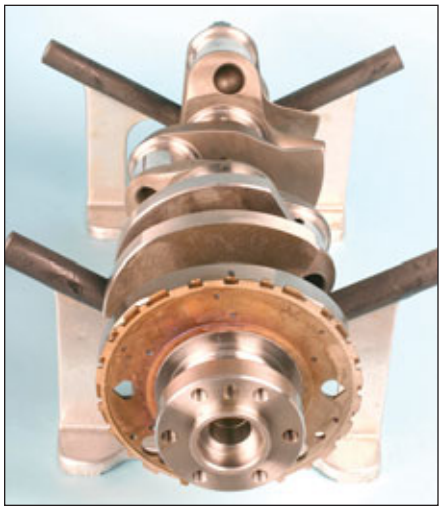
Here, the Goodson tool is shown affixed to the reluctor ring.

Caution: The ring is made of two plates riveted together. If you cock it out of alignment and continue to press, the plates can begin to separate. If this happens, you can pinch the plates together

Here's the dowel pin hole in the crank. The locating pins on the Goodson tool fit the holes in the ring and crank very precisely.



Once the ring is heated to 450 degrees F and affixed to the Goodson tool, the ring slips on easily and locates the ring exactly in the proper clock location.



The reluctor ring is shown here mounted to the crank.

with C-clamps and carefully tack-weld it back together at the rivet hole locations. Just be careful to avoid creating a warp/runout condition.

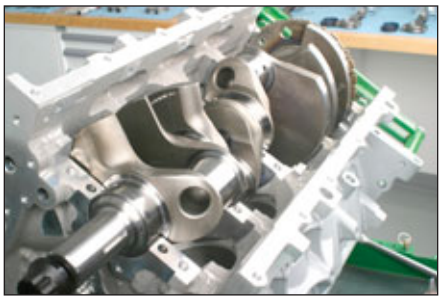
Again, because the jig indexes to both the wheel and to the crank, misalignment isn't an issue. If you expect to build LS engines, I *highly* recommend buying this jig. It takes all of the guesswork and time consuming measuring out of the equation. Don't even try to press it on cold. Simply heat the ring, seat it onto the jig and place the jig and wheel onto the crank. With heat and the right tool, it's easy.

INSTALLING THE CRANKSHAFT

After a final wash (hot tank followed by a soap/water rinse and blow-dry), the upper main bearings were installed in the block saddles. The Clevite thrust bearing (at No. 3 main cap) feature two thrust face oil grooves on one side and three grooves on the opposite side. The three-groove side must face the rear of the block. The lower bearing shells were installed to the main caps (again, with the three-groove side of the thrust bearing facing rearward) and all exposed bearing surfaces were liberally coated with Royal Purple Max Tuff assembly lube.

The caps must be installed in proper orientation.

The main thrust bearing is located at the No. 3 main saddle.



The Lunati 4.000" stroker crank fit our block beautifully with no need to perform any counterweight clearancing.

The No. 3 MAHLE Clevite thrust bearing features three grooves on one side and this three-groove must face toward the rear of the block.

Each cap is number-stamped for location, as is the adjacent pan rail surfaces of the block. The side of the cap that features the number stamp must be placed adjacent to the number stamp on the block (place cap numbers closest to block numbers). This will orient the small curved tangs on the caps facing rearward, except for No. 5 cap where the tangs face forward (the number stamps for No. 1, 2, 3 and 4 are located on the left side of the block, while No. 5 is stamped on the left side).

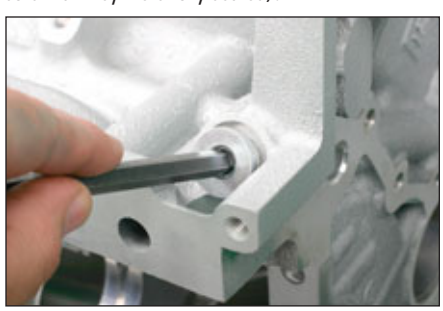
The side bolts are tightened to 20 lbs./ft.

ARP main studs were installed finger-tight. The longer studs install inboard and shorter studs outboard. Once seated, though, the installed height will result in the inboard studs lower than the outboard studs.

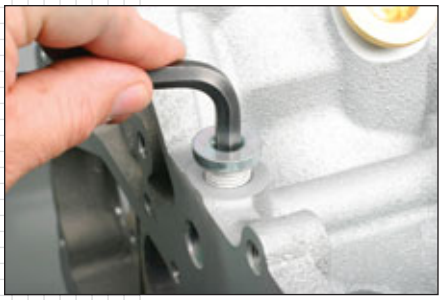
Our crank thrust measured 0.005".

Once the primary main cap nuts have been tightened, the 8mm main cap side bolts are installed.

With the crankshaft carefully laid onto the upper bearings, I then installed the ARP main studs (I applied a light coat of ARP moly on the block-side threads) finger-tight. The caps were then hand-installed, paying attention to cap angle, nestling the caps into position as evenly as possible. I then lightly snugged each stud using a hex wrench to about 3 to 5 lbs./ft. preload (basically just making sure that they were fully seated).



Three water jacket threaded (straight thread) plugs are installed. This plug is at the lower rear on the left side of the block.



A plug also threads into the lower front on the left side.

A large brass plug installs at the upper forward area of the left side. These GM plugs were pre-coated with thread sealant, so just stick 'em in and tighten.

I coated our Crane billet cam with Royal Purple's Max Tuff engine assembly lube.

The left front face of the block requires a small expansion plug.

I coated the expansion plug with Hylomar sealant before installing.

The camshaft retainer plate (front of the block) features a pre-applied sealant bead. This plate also serves as a thrust stopper.

Our timing set from Scoggin-Dickey featured a Torrington bearing. The black hardened face locates forward. The bearing actually installs onto the rear of the cam gear.

Here the spacer bearing is installed onto the rear of the cam gear. It's a reasonably snug fit and will snap into place with hand pressure.

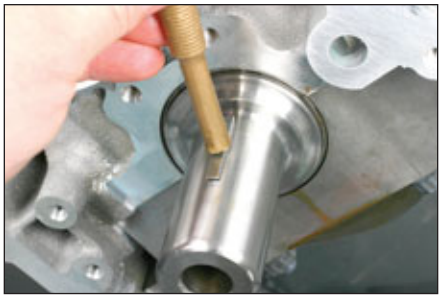
Our cam thrust checked out with 0.0035" endplay.

The aluminum block is very "alive" so any forces applied (such as main cap fastener tightening) will cause the block to move around. Keep this in mind when tightening the mains. Don't be tempted to try rolling the crank after partial tightening. The main bores won't straighten out until all primary main cap fasteners are fully torqued. Instead of following the OE torque/angle spec, our ARP main studs require a straight torque value. Following the proper sequence, I tightened the stud nuts (with ARP moly on threads and nut undersides) to 50 lbs./ft. at the inboard stud locations (closest to the crank) and 60 lbs./ft. at the outboard studs.

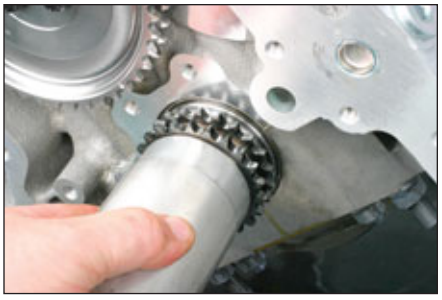
I started by carefully drawing the caps down by tightening the nuts to about 10 lbs./ft. I then continued by tightening the inboard stud nuts to 25 lbs./ft., followed by tightening the outboard stud nut to 25 lbs./ft. This allowed the caps to settle and provided an even baseline of clamping. I then tightened the inboards to their final value of 50 lbs./ft., followed by final-tightening the outboards to 60 lbs./ft. At this point, the crank rolls like butter. I checked crank thrust at 0.005".

Once the primary stud nuts were fully tightened, I then installed the 10 (five per side) 8mm side bolts (threads and head undersides coated with ARP moly), tightening to 20 lbs./ft. These are tightened

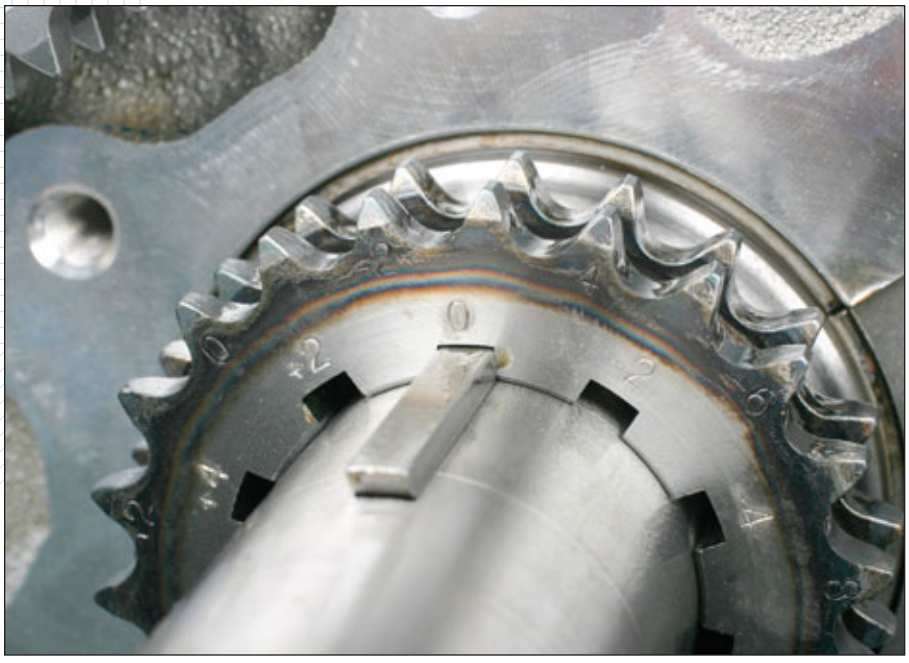
The GM crank key was way too tall for our crank, but the Lunati key was a perfect fit.



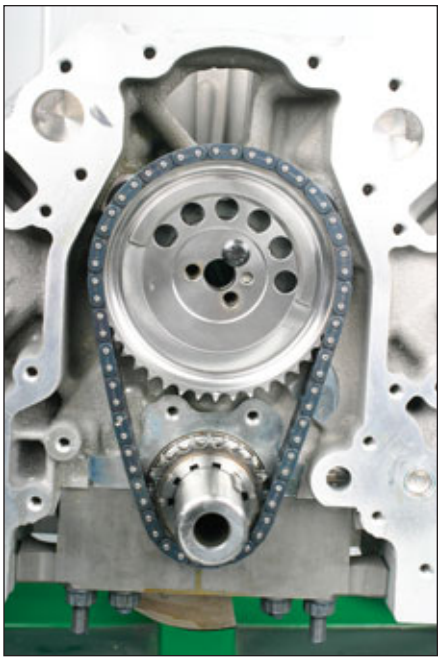
The crank key (for crank gear and oil pump drive) was tapped into position with a brass drift.



The crank gear was tapped into full-seat position using a hollow aluminum driver.



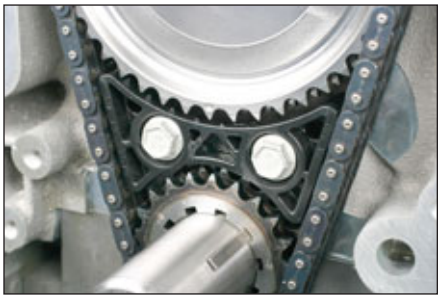
I opted to install the crank gear at the zero timing mark, but this gear allows adjustment +/- 4 degrees.



Our timing chain setup installed.

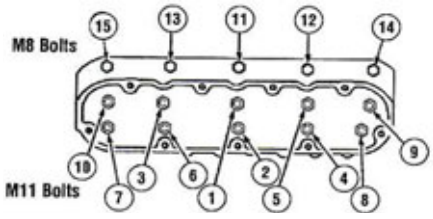
With No. 1 rod pin at TDC, the timing dot on the cam gear is at 6 o'clock, and the) mark on the crank gear is at 12 o'clock. Notice the @2 o'clock position of the crank snout key.

A GM timing chain damper installs with two 8mm bolts.



The chain damper serves as a rub-block to reduce chain harmonics.

in sequence, starting at No. 3 main cap, followed by No. 4, No. 2, No. 5 and No. 1 cap locations.



CAMSHAFT

Since our cam is a steel roller (Crane's P/N 144HR00162, grind No. HR-256/367-2S-14), I coated the journals and lobes with Royal Purple Max Tuff assembly lube and slid the stick into its bore. No surprises here.

Note: I tried to install an OE crank snout key but it was way too tall for the Lunati crank snout's key groove. The 1.5" radiused Lunati key (P/N CS001) fits perfectly, however. This is simply a tidbit I wanted to pass along. Don't assume that the OE key will fit all aftermarket cranks, so make sure that you obtain a key from the crank maker (actually, Lunati supplied a key but I have to admit that I forgot about it until I attempted to install the GM key. Hey, I never said I was smart).

We chose a Performance Billet Gear Set (P/N 5623T), sourced from GM performance distributor Scoggin Dickey. This kit includes a double roller chain, cam gear, adjustable crank gear (with timing adjustment from 0 - +/- 4 degrees), a Torrington-type bearing that is placed between the cam retainer plate and cam gear, two spacer shims to move the oil pump out for the timing system clearance, and a drive gear for the stock type oil pump. The crank gear featured about a 0.001" interference fit to the crank snout. I easily tapped it into place using a thick-wall aluminum tube to prevent marring the gear.

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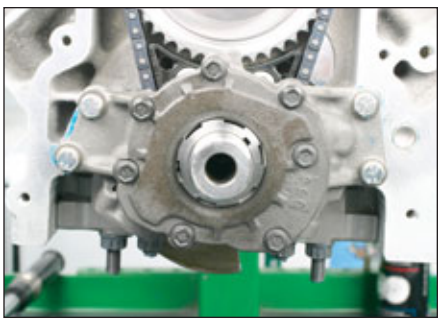
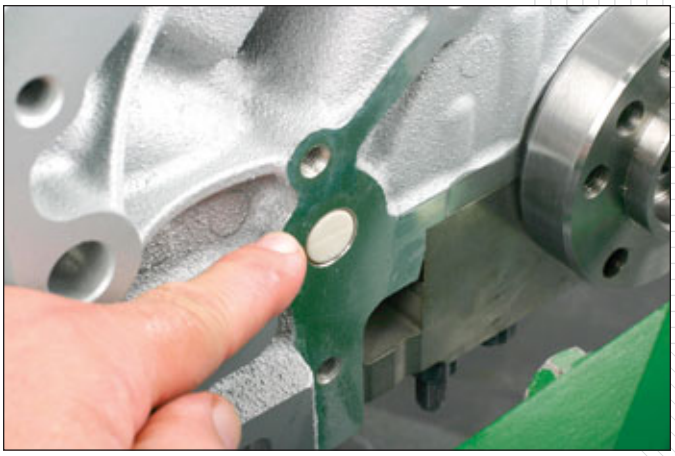
The timing chain setup included an oil pump drive adapter gear. This wide-toothed gear inserts into the oil pump's drive gear. The key slot in the adapter engages to the crank's key.

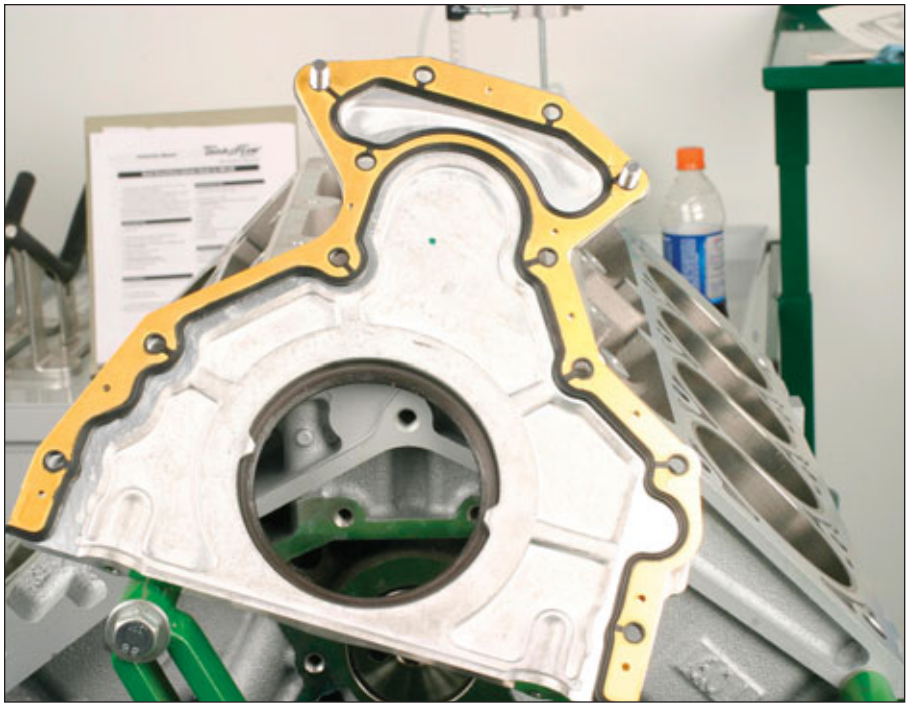


Because of the thickness of the Scoggin-Dickey timing chain setup, two spacer plates must be installed between the block and oil pump for chain clearance. Be sure to apply sealant to both sides of the block-left spacer.

The oil control plunger installs at the lower left of the block with the O-ring end facing the rear of the block.



Here the oil plunger is fully installed flush with the block.

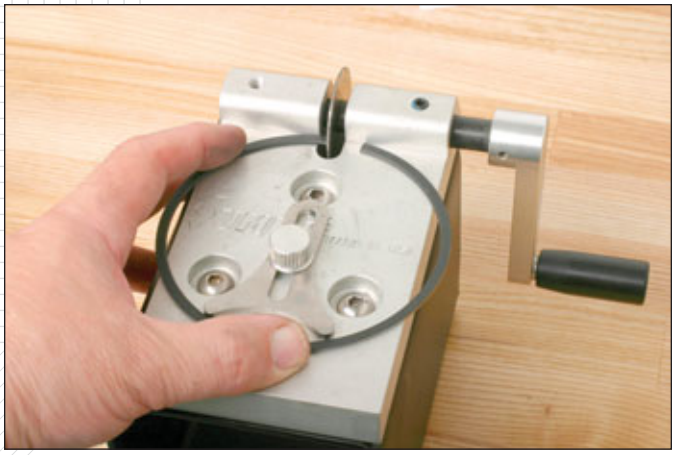


The rear engine cover requires a metal gasket with a pre-applied sealant bead. We used the gasket from the MAHLE Victor gasket set.

The rear cover is first lightly positioned with the rear seal properly seated onto the crank flange. I rotated the crank a bit to make sure that the sealing surface was concentric.

Before fully tightening the rear cover bolts, I also placed a straightedge across the bottom of the cover and the adjacent pan rails to make sure that the plate was positioned correctly. The ARP 12-point stainless bolts were then tightened to 18 lbs./ft.

During my file-fitting checks of the top and second piston rings, I used Summit Racing's ring squaring tool. This little guy is an anodized aluminum piece that's adjustable for bore diameter. A lower flange pushes the ring into the bore about a half-inch and allows you to achieve ring squareness in a heartbeat.



I file-fitted our rings using Summit Racing's diamond-wheel ring filer. This is a very fast little grinder that gets the job done quickly while achieving a square cut. After file-fitting, I simply deburred the freshly ground edges with a small file.

Here our rods, caps, bearings, pistons, pins and rings are organized on our Lista benchtop. Notice the cool towel holder? That's Goodson's 300-MPH towel holder, made using aluminum rods that were actually used in Top Fuel engines. The little race slicks even feature the Goodson name. I couldn't resist.

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In order to obtain zero timing, simply position the reference dot on the cam gear at 6 o'clock and position the small "0" mark on the outer circumference of the crank gear at 12-o'clock (the two dots should align). This places the cam's dowel pin at just after 3 o'clock, and the crank key at about 2 o'clock.

Once the ARP cam nose-to-cam sprocket bolts were treated to a small dab of thread locking compound, they were tightened to 20 lbs./ft.

Next, an OE timing chain damper was installed to the block face, between the cam gear and crank gear. These two 8mm bolts were snugged to 18 lbs./ft.

Note: The timing system must be installed before installing the oil pump.

OIL PUMP

Our pump is a high volume/high pressure crank-driven unit from Melling (P/N 10296).

Before installing the oil pump, insert the external-toothed drive gear into the oil pump's central drive gear. This external toothed gear (supplied with the timing set) serves as an adapter that is key-driven by the crankshaft snout. The external teeth on the adapter slides into the female-toothed gear in the oil pump. Apply oil to the teeth and carefully slide the adapter into the oil pump, engaging the male-to-female teeth (it's a close fit but will easily install by hand).

In order to provide clearance for the thicker-than-

CAM CARD INFO

CRANE P/N 144HR00162
Grind No. HR-256/367-2S-14

LIFT ..... INTAKE @ CAM 0.367" .....EXHAUST @ CAM 0.367"
INTAKE @ VALVE 0.624" .....EXHAUST @ VALVE 0.624"
(ROCKER ARM RATIO 1.70)

CAM TIMING
@ 0.004 TAPPET LIFT...
INTAKE OPENS 44.0 DEG BTDC; CLOSES 89.0 DEG ABDC
EXHAUST OPENS 96.0 DEG BBDC; CLOSES 45.0 DEG ATDC
ADVERTISED INTAKE DURATION .....313.0 DEG
ADVERTISED EXHAUST DURATION.....321.0 DEG

CAM TIMING
@ 0.050" TAPPET LIFT
INTAKE OPENS 17.5 DEG BTDC; CLOSES 58.5 DEG ABDC
EXHAUST OPENS 69.5 DEG BBDC; CLOSES 14.5 DEG ATDC

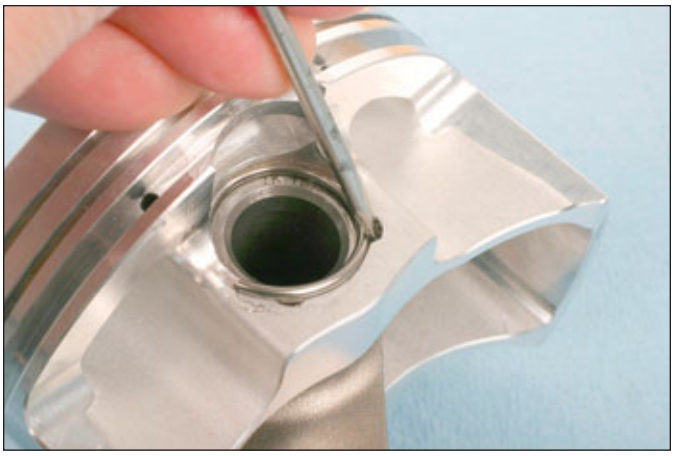
MAX INTAKE LIFT 109 DEG ATDC
MAX EXHAUST LIFT 119 DEG BTDC
INTAKE DURATION 256.0 DEG
EXHAUST DURATION 264.0 DEG

FIRING ORDER 1-8-7-2-6-5-4-3

Our rod caps were test-torqued and loosened on our GearHead Tools rod vise.

Once the rod bolts were backed off, I split the caps off using GearHead Tools' rod splitter. This beats the heck out of holding a rod upside-down and tapping the bolt heads with a mallet.

Our JE forged pistons included wire locks for floating pin securing.



The wire locks are installed by working your way around the lock with a small screwdriver.

A nice option for wire lock installation is Lockintool's W-927 installation tool. It takes some getting used to but, once you develop the knack, it's a real time saver.

Here's a closeup of an installed wire lock. JE recommends tapping the pin against the lock to ensure proper seating.

Since our pin bores intersect the oil ring groove, an oil ring support rail is required (included in the piston ring set for our slugs). The support rail is installed with its male dimple facing down, facing into the pin bore area. If the rail tries to rotate, this dimple will stop the rail at either side of the opening.

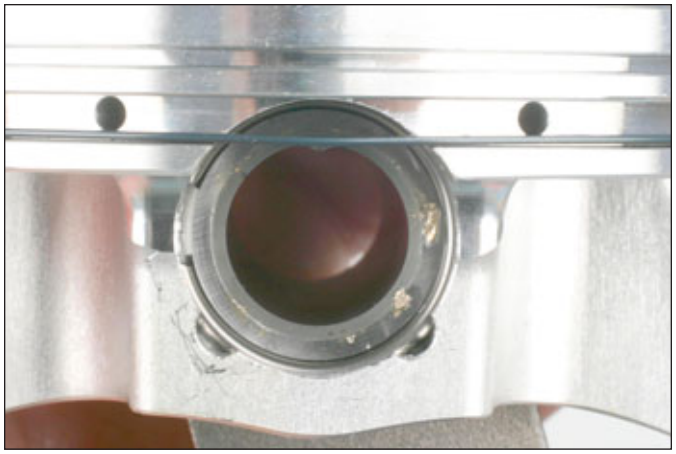
stock timing chain setup, I installed the supplied spacer plates between the oil pump and the block face. I applied a bead of RTV to each side of these plates in order to provide a seal. All four oil pump mounting bolts were tightened to 18 lbs./ft., with a drop of thread locker applied to each bolt's threads.

Note: The OE oil pump installation procedure calls for centering the pump to the crank snout. Mount the oil pump to the block, tightening the four mounting bolts to a mere 45 lbs./in. Then center the pump by nudging it around until you achieve an even 0.002" clearance around the entire drive gear (stick a 0.002" feeler gauge at one side and another 0.002" feeler gauge 180 degrees from the first gauge). Once it's centered, tighten the four mounting bolts to their final 18 lbs./ft. value.

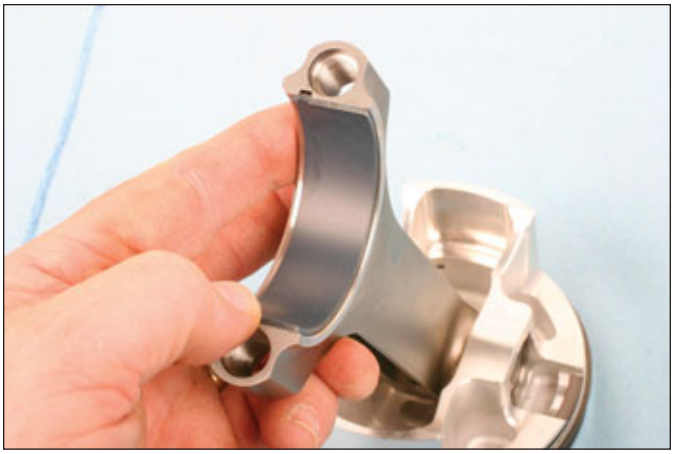
RINGS

We opted for file-fit rings for out 4.005" bores. Our rings (which were included with our JE pistons) include JE Pro Seal top rings S14000-5-1.5DMR ductile plasma moly. I filed these to achieve an end-gap of 0.018". Our second rings, JE Pro Seal J24000-3-1.5IPC iron rings were file fitted with a gap of 0.020". For a high performance street/strip application, JE recommends a top ring gap of Bore x 0.0045"; and a second ring gap of Bore x 0.0050". Minimum gap for oil rings is 0.015", which were good to go.

I file-fitted each ring to its assigned bore to

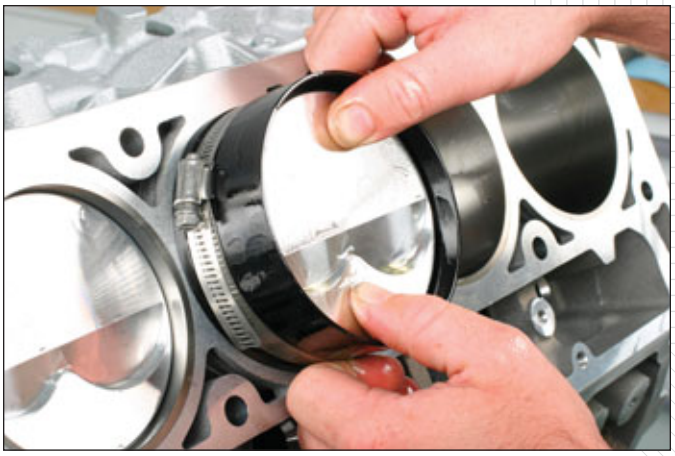


Here's a side view of a pin and support rail. Obviously, make sure that you install the pin and wire locks before installing the support rail.



Our rod bearings are MAHLE Clevite Tri Armor coated units.

Instead of using a traditional wrapped-barrel style piston ring compressor, I used Summit's adjustable billet compressor, which worked like a charm.



With the piston and ring package inserted into the compressor (and a bit of piston skirt exposed at the bottom), each piston slid into its bore with minimal effort, without a single hang-up.

I tightened our Lunati 7/16" rod bolts using the stretch method. I first indexed the Gear Head Tools stretch gauge on each bolt (zeroing the gauge at the bolt free length).

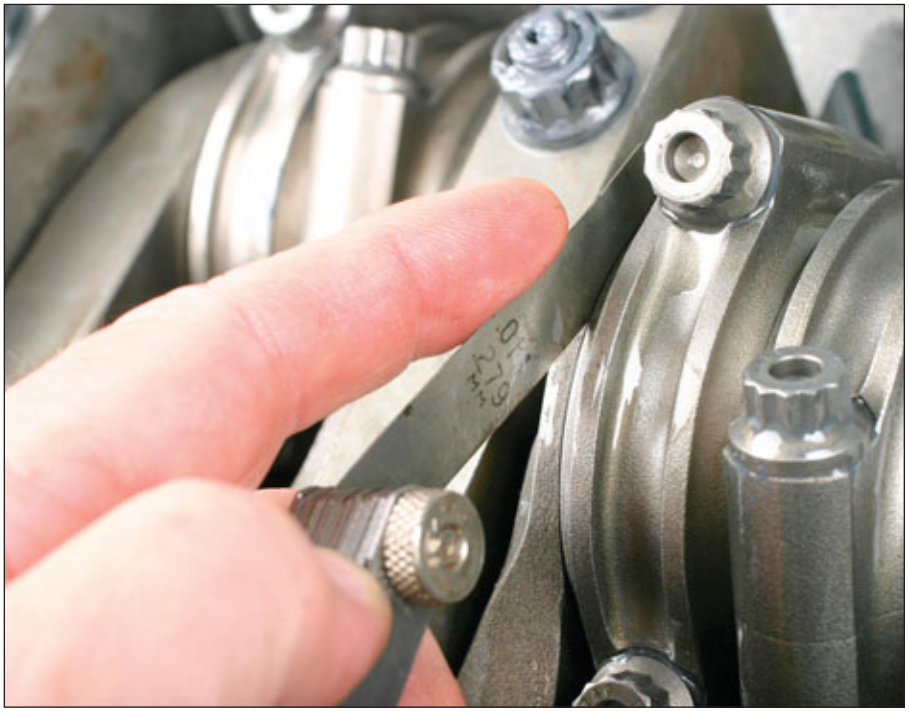
As each rod bolt was tightened, I monitored bolt stretch until I achieved the recommended 0.0050–0.0054" stretch range. If you prefer to torque instead of tighten-by-stretch, the spec for these bolts is 80–85 lbs./ft.

accommodate any variance in bore diameter. A diameter variance from one cylinder to the next changes the end gap of the rings in that cylinder by a factor of pi (3.1416). For example, a cylinder that is 0.001" larger in diameter will increase the ring end gap by 0.001 x 3.1416, or 0.003". It's critical to always fit each ring for the specific cylinder into which the ring will be installed.

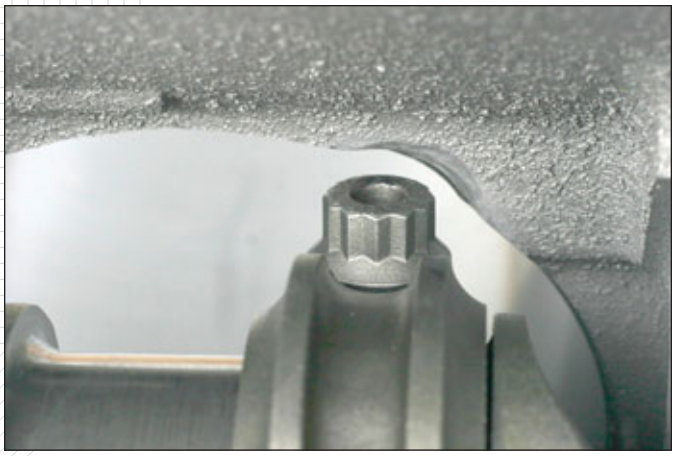
I filed all of our top and second rings using Summit Racing's rotary ring filer. It may not be as cool as an electric filer, but the diamond wheel cuts fast and clean, and it's a bunch cheaper.

When checking ring radial back clearance for top and second rings, with the ring set in its groove and side clearance (ring face radius protruding out) at 0.001–0.002", radial back clearance should be at least 0.005".

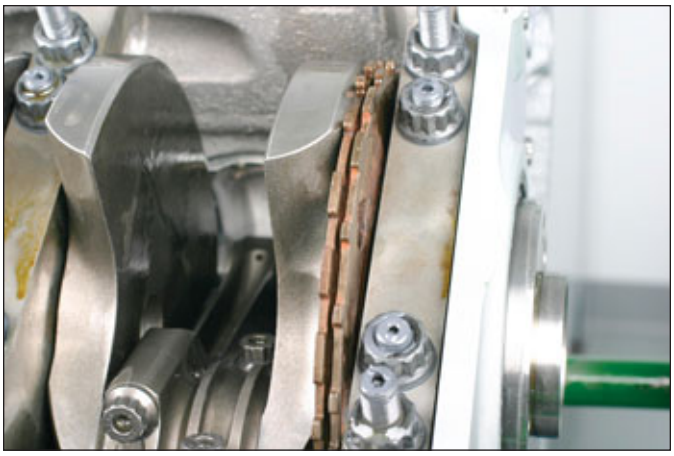
Since our JE pistons feature a pin bore that intersects the oil ring groove, an oil ring support rail is necessary to complete the floor surface area for the oil ring package. The support rail installs at the bottom of the oil ring groove with the rail's anti-



Assembled rod sideplay measured at 0.011" on each rod pin, a real testament to Lunati's precision machining of both their rods and cranks.



As mentioned in our last issue, I needed to grind a bit of clearance at the bottom of each cylinder for rod bolt clearance (due our 4.000" stroke). This took only a few minutes. Naturally, the block was properly washed before assembly began.



Notice the close fit of the crank's timing reluctor wheel. It clears but it's admittedly scaring looking at first.

rotational locking detent facing downward. When installing the support rail, rotate the rail until the detent falls into the void at the wrist pin hole.

Note: Do not install the support rail until the pistons are assembled to the rods since the rails will block the pathway for the wrist pins.

PISTON/ROD ASSEMBLY

Our full-floating wrist pins are secured with the supplied wire locks. Install the end of one lock at 90 degrees from the pin lock groove. Use a stiff small blade screwdriver, inserting the tip into the pin lock groove while you wedge the lock into the groove. As you walk the lock clockwise, you can insert a small screwdriver into the lower right access groove (two of these grooves are featured along the lower circumference of the pin bore). Using the screwdriver as a lever, pivot the screwdriver inboard to engage part of the wire lock into its groove. Then insert the screwdriver into the lower left access groove and finish levering the wire lock into place.

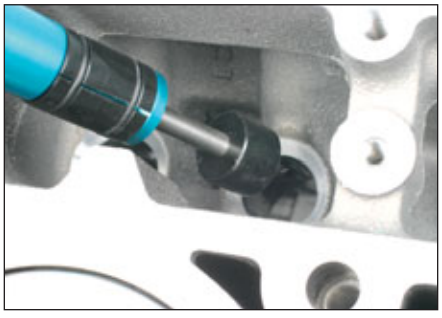
An option is to use Lockintool's W-927 wire lock installer. This tool features a step-faced head that allows you walk the wire lock into place by working the tool in an angle and "rolling" the wire in a clockwise path into its groove. I will admit that it took me a while to get the hang of the technique but it does work well with a bit of practice.

After installing one wire lock, place the wrist pin against the lock and, using a brass drift, hit the lock to ensure full seating. Lube the wrist pin and assemble the connecting rod to the piston. Install the second wrist pin wire lock. JE recommends hitting both sides of the pin with a brass drift to ensure proper wire lock seating. Perform these lock-seating steps on a soft pad to avoid piston damage.

Once the rods are assembled to the pistons, install the oil ring support rail, making sure to place the rail's small male dimple facing down and positioned over the pin bore void.

The oil ring package is then installed (expander ring, followed by the lower oil ring rail followed by the upper oil ring rail), followed by the second and top rings.

The JE second rings feature JE type laser-etched

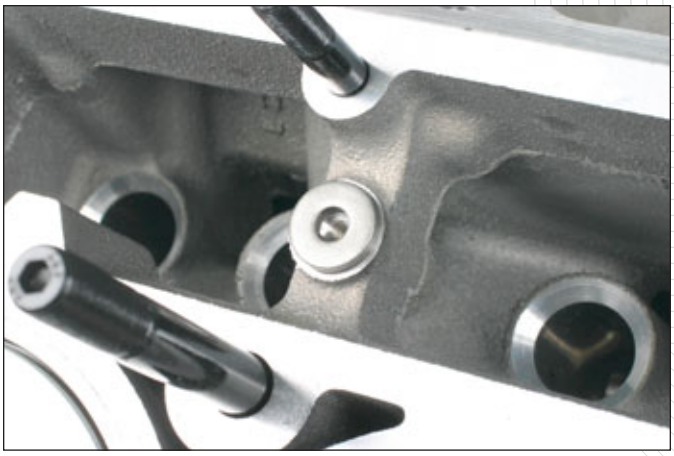


The Foster lift checker features a spring-loaded plunger that glides across the lobes.

I used our Foster Tools' cam lift checking gauge to verify our 0.367" lobe lift.

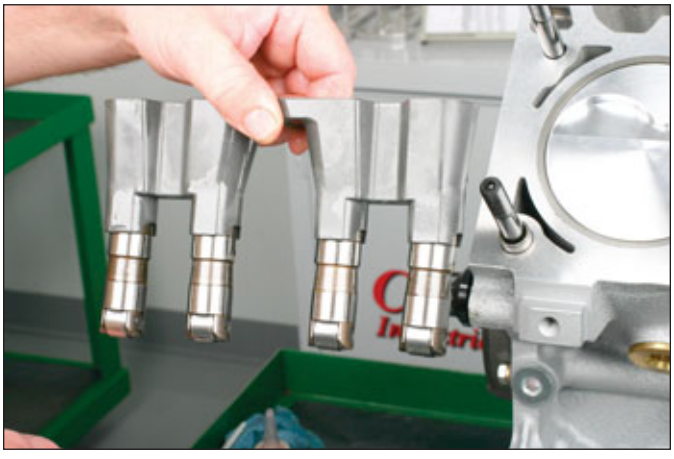
Our ARP cylinder head stud kit included primary studs (11mm bottom threads and 7/16" top threads), 8mm upper studs, and washers and nuts.

All head studs were installed finger-tight.



Our taller-than-OE Crane roller lifters required the use of spacer washers between the block and lifter buckets.

The oiled roller lifters are inserted into the OE plastic lifter buckets. These register flat-to-flat, orienting the lifters properly for roller bearing operation at the lobes.



With all four lifters snapped into the lifter bucket, the assembly is then installed.

on the top of the ring and the top rings feature a small dimple at the top. Just remember that the inside bevel on the second ring must face down and the top ring's bevel must face up.

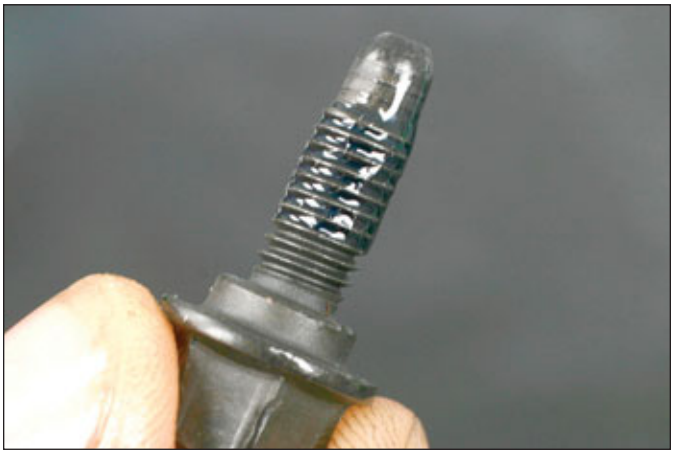
JE's recommendation for gap location is as follows: When viewing the bore from overhead, with the front of the bore at 12 o'clock, the bottom oil ring package rail gap is at 11 o'clock. The top oil ring rail gap is at 7 o'clock. The second ring gap is at 9 o'clock facing engine left and the top ring gap is at 3 o'clock facing engine right.

PISTON/ROD INSTALLATION

With the cylinder bores wiped clean with a lint-free towel, apply a light coat of engine oil to the walls. After making sure that the connecting rod and cap saddles are clean and dry, install the rod bearings to the rod and cap and coat the exposed bearing surfaces with oil (I used Royal Purple Max Tuff assembly lube on our MAHLE Clevite CB-663HNK Tri Armor rod bearings) . It's super-slippery and clings without running off, even after long periods of storage. Using a clean oil can, pump engine oil over

Guide the package of lifters into their respective bores simultaneously. This was surprisingly easy.

Push the package of lifters until the tray fully seats.



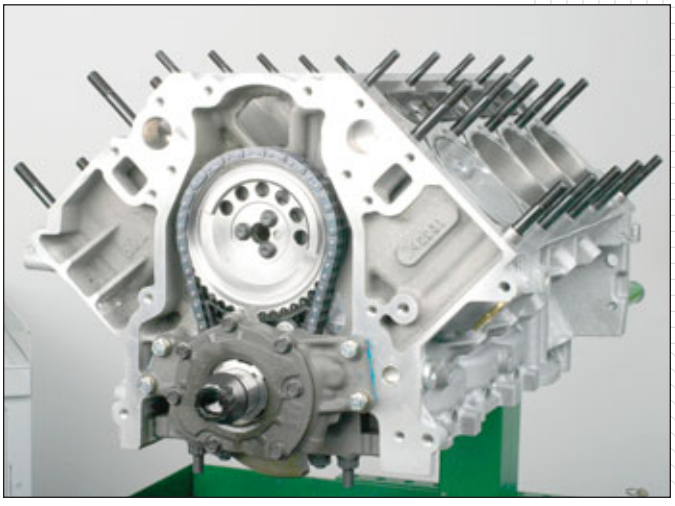
A single 6mm x 1.0 bolt secures each lifter bucket to the block. I added a dab of Valco medium thread locker to the threads. Notice the shoulder under the bolt head. This centers the lifter bucket to the block.

the ring and skirt areas of the piston. Double-check all ring end gaps to make sure that they're in the proper positions. The critical thing to remember is to avoid allowing any of the ring gaps to align with each other.

After installing the rod bearings in the rods and caps, and coating the bearings with Royal Purple Max Tuff, the ring packages and piston skirts were treated to a liberal douse of 30W oil. Instead of using a "barrel" type ring compressor, I used Summit Racing's tapered aluminum ring compressor. This one features a split in the barrel wall and a captive worm drive clamp, which makes it adjustable from 4.000" to 4.090". I adjusted it to 4.005" to match our bores. I slid the rod and piston through the compressor (inserting the piston from the bottom of the compressor). With a bit of skirt exposed below the compressor, I inserted the assembly into the bore, using the skirts to square the piston in the bore. Using a closed fist, a smooth push against the piston dome slid the assembly into the bore easily and smoothly, with no hang-up interruptions. This is a nice ring compressor and, since it's adjustable, it's more versatile than a dedicated one-size billet piece.

The Lunati 7/16" rod bolts (made by ARP for Lunati) call for a stretch of 0.0050–0.0054", or a

This photo shows the left side lifter assemblies secured in place.

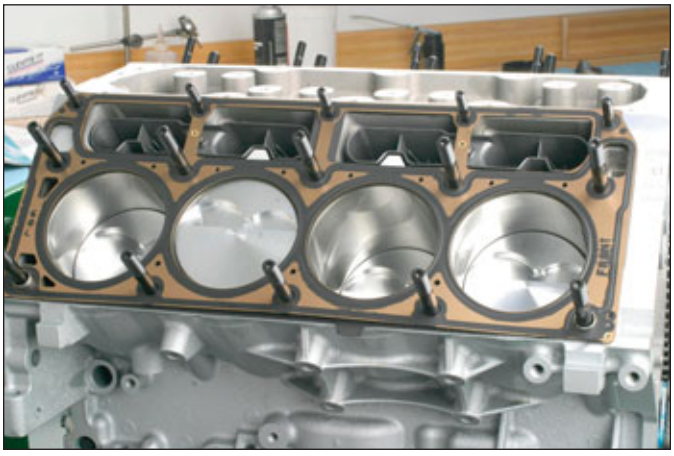


A shot of our short block, ready for heads.

torque value (with oil) at 80–85 lbs./ft. I opted for the stretch method, using the Gearhead Tools billet-bodied stretch gauge. After initially tightening the rod bolts to a mere 10 lbs./ft. (enough to locate the rod cap but not enough to begin stretching the bolts), I placed the stretch gauge onto a bolt using the gauge's pointed anvils to nestle into the dimples at each end of the bolt. I then zeroed the gauge. I next began to tighten, using a torque wrench, up to 70 lbs./ft., at which point I measured about a 0.003–0.0035" stretch (each bolt varied, but that's an average). I continued to tighten bit by bit, rechecking as I went, until I reached a bolt stretch within the 0.005–0.0054" specified stretch. It's time consuming, but what I like is the fact that you're actually measuring (and recording) exactly how far each bolt stretches, instead of only using torque (in which case some bolts might stretch by as little as 0.004" or, in an even worse case, the bolt might stretch beyond the spec). Tightening by monitoring stretch is definitely a more accurate method of both achieving proper clamping load and knowing how far the bolt has stretched, instead of guessing.

Once the rods were fully installed, I checked rod sideplay. In each rod pin location, I noted 0.011" sideplay. This consistency is yet another illustration

A pushrod was used to fully seat each lifter. Simply push down on the lifter to bring it into contact with the lobe. The lifters are still registered in the buckets for operational orientation.



Our head gaskets are MLS type from MAHLE Victor. Each gasket is marked FRONT for easy orientation. Cooling passages must be located at the rear of the deck. The right deck is seen here.

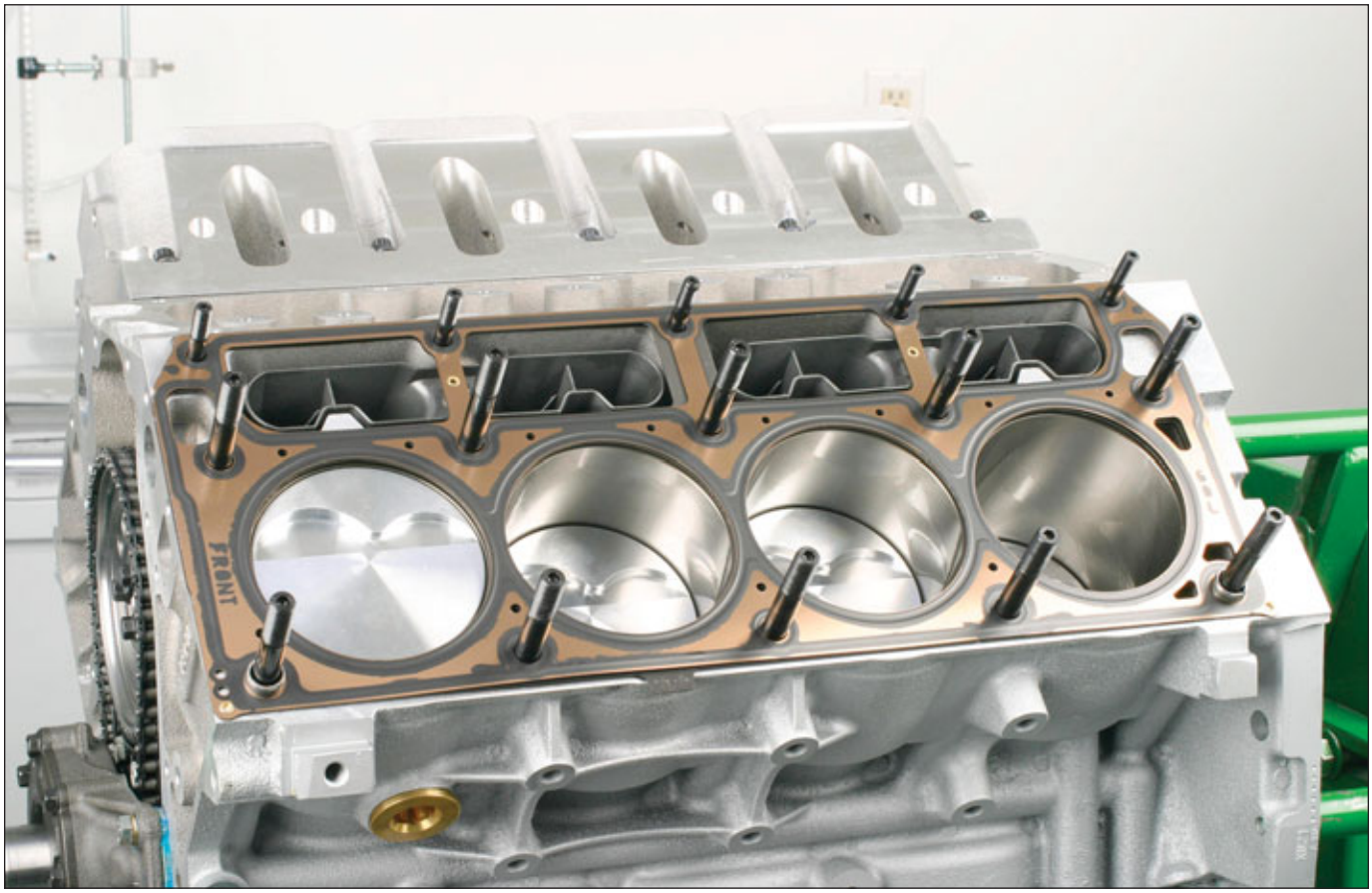
of the precision with which Lunati makes its connecting rods and cranks. I saw no deviation at all from pin to pin.

OUR CYLINDER HEADS

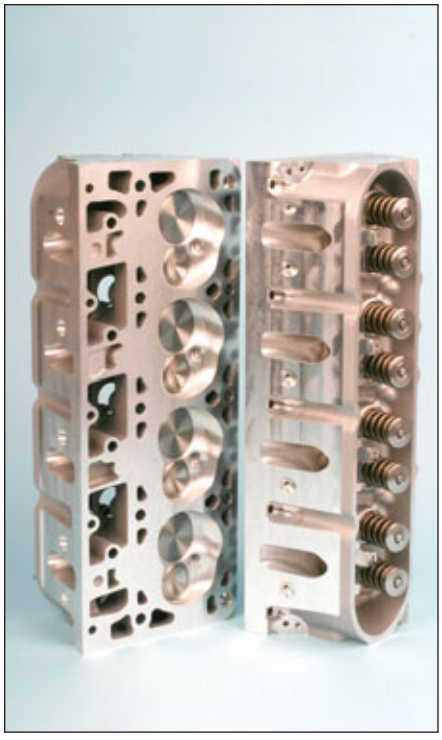
For this build, we chose a pair of fully-assembled Trick Flow aluminum *GenX* street/strip heads, which are fully CNC-ported for optimum airflow. The clever boys at Trick Flow spent quite a few hours developing these heads to maximize horsepower and torque for the LS engine, both in computer mapping and dyno cell testing.

During the development stage of the Trick Flow GenX street/strip CNC-ported cylinder heads, Trick Flow engineers determined that the valve angles needed to change from the stock 15 degrees to 13.6 degrees in order to decrease valve shrouding, increase mid-lift airflow and to improve rocker arm-to-valve-cover clearance. Testing also proved that relocating the spark plugs in the combustion chambers further enhanced mid-lift airflow and increased rigidity of the casting for extreme horsepower applications. Additional material was also added to the rocker arm mounting points for high-rpm valvetrain stability.

These fully CNC-ported performance cylinder heads feature 215cc (LS1), 225cc (LS2) or 235cc (LSX) intake runners, 80cc exhaust runners, 64cc (LS1), 65cc (LS2) or 70cc (LSX) combustion chambers, 2.040" (LS1), 2.055" (LS2) or 2.080"



The left deck is shown in this photo. Notice that sections of the gasket bridge across the lifter buckets. Makes sure to install the lifters before installing the head gaskets.



Our Trick Flow TFS-3060T001-C02 aluminum heads feature CNC-machined ports and chambers.

(LSX) intake valves, 1.575" (LS1/LS2) or 1.600" (LSX) exhaust valves, bronze valve guides and ductile iron intake and exhaust valve seat inserts. Assembled heads include 1.300" dual valve springs (for hydraulic roller camshafts up to 0.600" of valve lift), Viton fluoroelastomer canister-style valve seals, 7 degree machined steel valve locks and 7 degree titanium retainers.

Note: While the official recommended valve lift limit is listed at 0.600", Trick Flow engineers tell us that our 0.624" valve lift cam will be fine, providing that we check valve to piston clearance during our build, which we would naturally do as a matter of course. The recommended limit of 0.600" is a "safe" figure for novice engine builders who might not think to check their clearances.

INSTALL LIFTERS BEFORE THE HEAD GASKETS!

BE AWARE that the roller lifters and lifter buckets MUST be installed before installing the head gaskets, since sections of the gaskets are located above the lifter buckets.

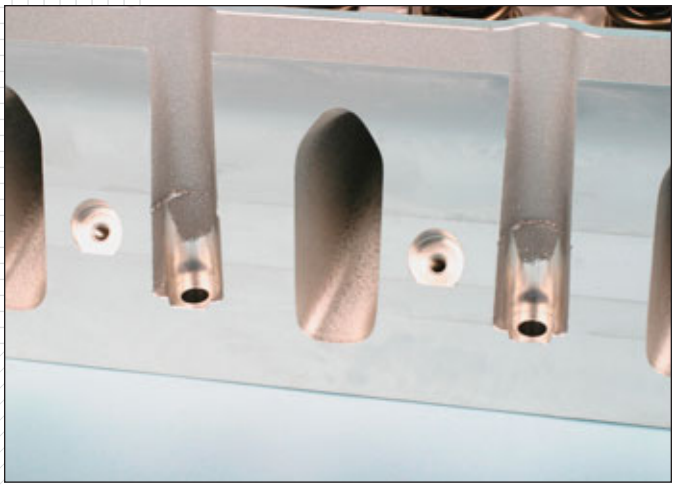
We used Crane's hydraulic roller lifters (P/N 144536-16). These roller lifters are specially designed for use in Gen III engines. They incorporate a specially designed body with relocated oil passages that allow the lifter to retain full oil delivery even with extreme lift cams. According to Crane, this model lifter will handle lobe lifts up to 0.412"

CYLINDER HEAD SPECIFICATIONS
TRICK FLOW P/N TFS-3060T001-C02

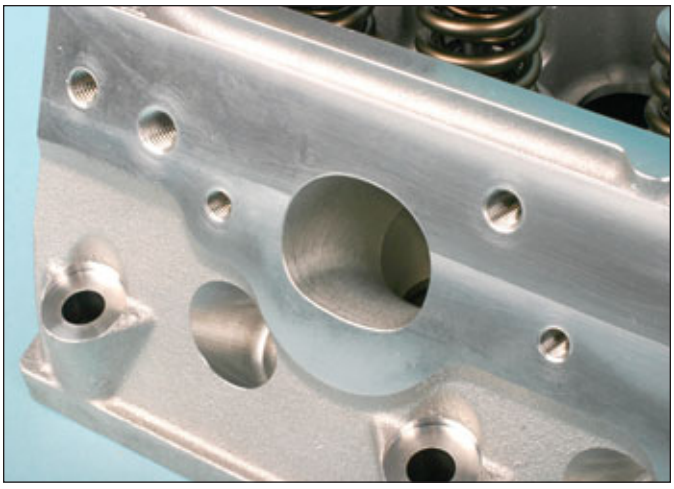
Material	A356-T61 aluminum
Combustion chamber volume	65cc
Intake port volume	225cc
Intake port dimensions	3.250" x 1.070" (cathedral port)
Intake port location	stock
Intake valve diameter	2.055"
Intake valve angle	13.5 degrees
Intake valve seat	ductile iron, 2.125" x 1.800" x 0.375"
Intake valve length	124.45mm
Intake valve stem diameter	8mm
Exhaust port volume	80cc
Exhaust port dimensions	1.460" x 1.670" oval
Exhaust port location	stock
Exhaust valve diameter	1.575"
Exhaust valve angle	13.5 degrees
Exhaust valve seat	ductile iron, 1.625" x 1.280" x 0.375"
Exhaust valve length	124.45mm
Exhaust valve stem diameter	8mm
Valve guide material	bronze alloy (intake & exhaust)
Valve guide length	2.000"
Valve guide clearance	0.0012" intake/0.0016" exhaust
Valve seals	Viton flouroelastomer canister
Valve seat angles	37 deg. x 45 deg. x 60 deg.
Valve spring pocket diameter	1.480"
Valve spring I.D. locators	1.300"
Valve spring retainers	7 degree x 1.300" O.D. titanium
Valve stem locks	7 degree machined steel
Valve springs	1.300" O.D. double spring
	150 lbs. @ 1.800" installed height
	438 lbs. @ 1.200" open
	448 lbs./in. rate
	0.600" maximum valve lift
Milling specifications	angle mill 0.008" per cc
	flat mill 0.006" per cc
Required pushrod length	longer than stock required (need to measure)
Rocker arm type	roller rocker arms only
Spark plugs	NGK 4177
Assembled head weight	24.5 lbs. ea.

CYLINDER HEAD AIRFLOW
(TRICK FLOW TFS-3060T001-C02)

LIFT VALUE	INTAKE FLOW CFM	EXHAUST FLOW CFM
0.100"	68	55
0.200"	142	115
0.300"	220	185
0.400"	279	230
0.500"	316	251
0.600"	338	259



Intake ports are the cathedral style, measuring 3.250" x 1.070" and featuring a port volume of 225cc.



Exhaust ports are 1.460" x 1.670" ovals, with a volume of 80cc.

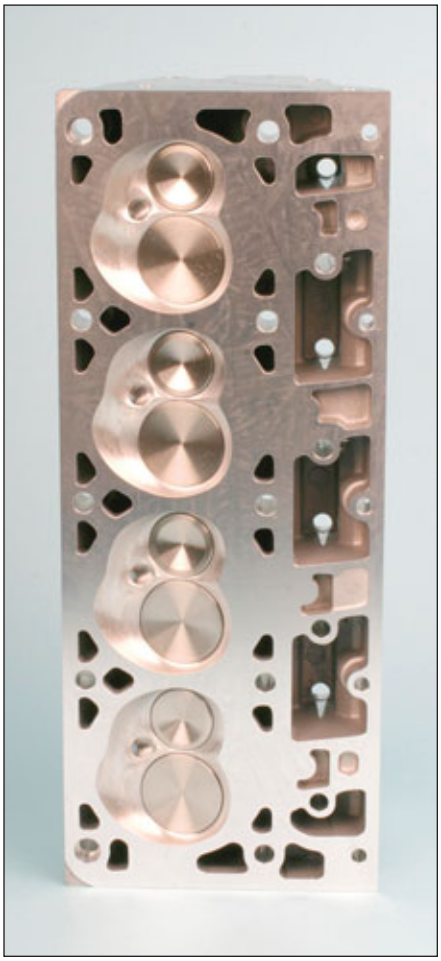
(0.700" valve lift with 1.7 ratio rockers), even on reduced base circle cams.

I first soaked the lifters in 30W engine oil for about 20 minutes. The lifters were then installed to the plastic lifter buckets. Simply orient the flats of each lifter body to the flats of the plastic bucket, and snap the lifter into the bucket. With four lifters attached to the plastic bucket, you can then ease the four-lifter bucket assembly into place, easing the lifters as a group into their respective bores. The lifter bucket is then secured to the block with a single 6mm bolt, which I tightened to 125 lbs./in. (I first placed a drop of medium-strength Valco thread locker onto the bolt threads). Once the lifter bucket is secured, you can then use a pushrod to gently push each lifter down for cam lobe contact. The lifters remain engaged in the buckets for proper lifter orientation (preventing lifter rotation).

In our particular application, Crane's roller lifters are a tad longer (to allow for higher lift cams) and require the use of a 6mm spacer washer between the bucket and the block. The spacers were provided with the lifters. To prevent the spacers from sliding down while you're trying to align the lifter bucket bolt hole, I dabbed a bit of Max Tuff lube onto the back of the washers, which prevented them from sliding out of place.

The clever aspect of the buckets is that this design allows you to perform a future cam change without the need to yank the intake manifold or the lifters. Simply loosen the rockers, remove the pushrods and turn the camshaft one full revolution. This will nudge the lifters back into the buckets to the point where they'll stay "stuck" in the bucket bores and away from the cam lobes. The cam can then be changed without the need to remove the lifters and buckets.

Chambers are 65cc in volume. Intake valves are 2.055". Exhaust valves are 1.575".

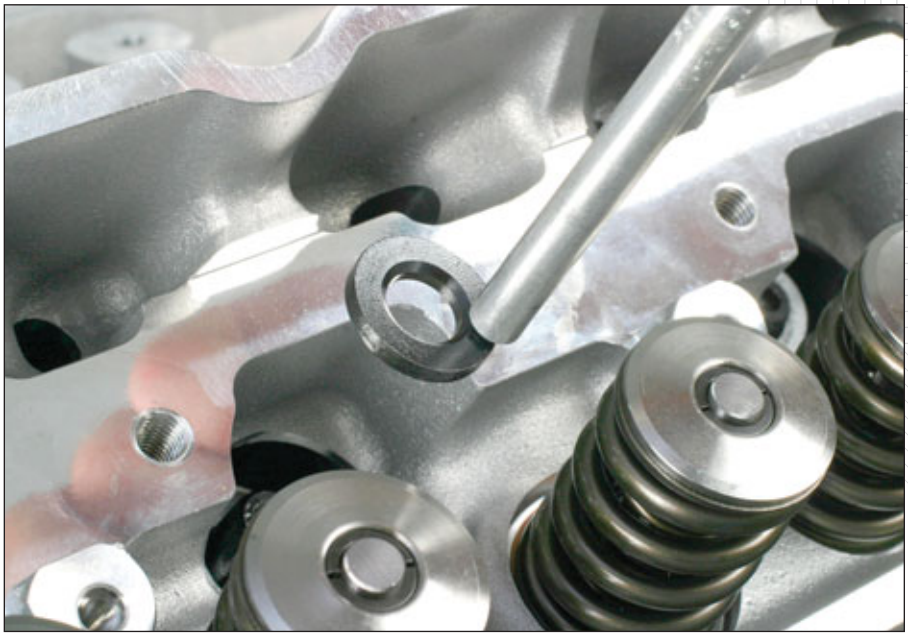


As a result of precise CNC machining, all chambers are matched at 65cc volume.

HEAD INSTALLATION

After installing the cylinder deck dowel sleeves (two per deck), I finger-installed the ARP cylinder head studs (kit P/N 234-4317). The set includes 10 primary studs and five 8mm upper studs per side. All head bolt holes are blind and not open to water, so there's no need for a thread sealant. I applied a light coat of ARP moly to the lower threads, just for the heck of it (to permit easy future servicing). **Note:** ARP designed the head studs with 7/16" upper threads. This is a nice touch—if you lose a nut, it'll be easy to locate another 7/16" nut (since this is a common size, you probably already have a few ARP 7/16" nuts lying around the shop from old jobs). This makes life easier than trying to find an 11mm nut at midnight while you're scrambling to get an engine back together.

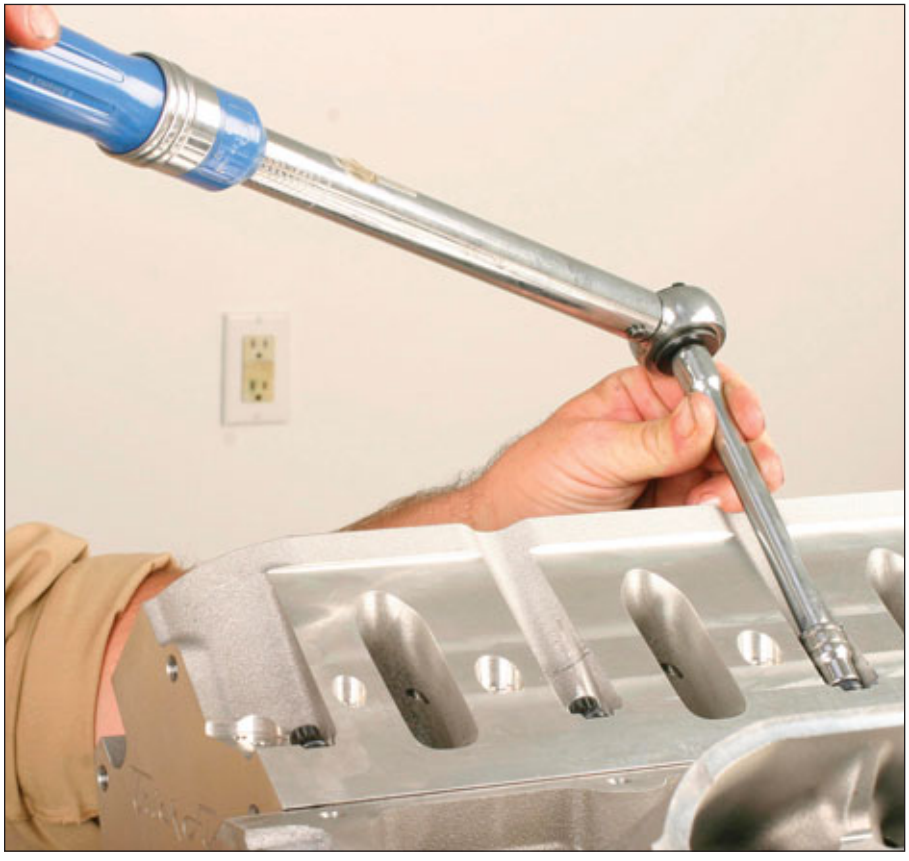
The Victor MLS cylinder head gaskets (P/N 12589227) were positioned on the decks. Both head gaskets are marked "FRONT" at one end (actually, they're marked for front orientation on both sides, which is helpful). If the gaskets you choose are not marked, it's easy to flip them end-for-end and to create a cooling system problem. If your gaskets are not marked, just remember that the cooling passages on each gasket must be placed at the rear of the decks.



Using a pencil magnet will greatly ease installation of the inboard (recessed) main stud washers.

With studs and gaskets in place the heads were lowered onto the decks. Since we're dealing with aluminum heads, hardened washers must be placed under the nuts. Installing the primary head inboard washers is made easier with the use of a pencil magnet (these locations are recessed, with no room for your fingers). I coated all nut threads and undersides with ARP moly. All 10 primary stud nuts

All head primary head stud nuts were torqued to 80 lbs./ft. with ARP moly. These were tightened in three progressive steps.



The upper 8mm head stud nuts were snugged to 22 lbs./ft. with ARP moly.

were then tightened, in sequence, in three steps to a final torque value of 80 lbs./ft. (I started at 25 lbs./ft., then stepped up to 55 lbs./ft., then to 80 lbs./ft.). Once all primary stud nuts were tightened, I then tightened the upper five 8mm stud nuts to 22 lbs./ft. These values are specified by ARP with the use of their moly lube. If using 30W oil instead of moly, values are slightly higher (85 lbs./ft. for the 7/16" nuts and 28 lbs./ft. for the 8mm nuts).

Cylinder head fastener tightening sequence of the 7/16" nuts is as follows:

1. Center upper
2. Center bottom
3. Second from front upper
4. Second from rear bottom
5. Second from rear upper
6. Second from front bottom
7. Front bottom
8. Rear bottom
9. Rear upper
10. Front upper

Once all 7/16" nuts have been fully tightened, the top row of five 8mm stud nuts are tightened as follows:

1. Center
2. Second from rear
3. Second from front
4. Rear
5. Front

FRONT COVER

The front (timing) cover is a cast aluminum piece that features a front hub seal and a cam position sensor. The gasket is a metal-reinforced unit that requires no additional sealant.

Since the front cover is viewable, and since I can't abide boring-looking stuff, I applied a thin coat of etching primer, followed by a coat of aluminum cast blast engine paint just to dress it up a bit and to prevent the bare aluminum from scuzzing-up down the road. The front cover is secured with eight 8mm x 1.25 x 30mm bolts (and two 6mm x 1.0 x 20mm bolts to secure the cam position sensor to the cover). I pitched the OE hex head bolts in favor of a set of tasty-looking ARP stainless 12-point fasteners (with stainless flat washers) (P/N 434-1502). All 8mm front cover bolts are to be snugged to 18 lbs./ft. in a criss-cross pattern.

Note: *I'll show front cover installation, along with the installation of the ATI Super Damper, in the next issue.*

REAR OF BLOCK

Before installing the rear cover (which seals the rear cam area and features a one piece rear crank seal), an oil control plunger must be installed in the lower left of the block rear face. This plunger features a white plastic "dumbbell" shape with an O-ring at one end. Lube both ends of the plunger and insert into its oil passage hole, with the O-ring end facing the rear of the block. Insert until the face of the O-ring end is flush with the block surface.

The cast aluminum rear cover features a metal-reinforced gasket. I installed a Victor rear cover gasket, included in their gasket set (P/N CS5975). The rear cover is secured with 12 8mm x 1.25 x 20mm bolts. Instead of using the OE hex-head bolts, I installed ARP's rear cover bolt set (P/N 434-1504), which includes 12-point stainless steel bolts (Hey, they're ARP, and they look cool, so why not?). With the rear main seal lip lubed, the cover is positioned and the bolts were tightened to 18 lbs./ft. in a criss-cross pattern. I slipped the rear over in place, working the rear seal lip over the crank flange. I finger-installed the bolts and made sure that the rear seal was properly centered on the crank before gradually snugging the bolts, first to 60 lbs./in., then to 10 lbs./ft., followed by final clamping at 18 lbs./ft. PE

OUR TORQUE SPECS

ARP inboard primary main cap nuts	50 lbs./ft.
ARP outboard primary main cap nuts	60 lbs./ft.
ARP 8mm main cap side bolts	20 lbs./ft.
ARP camshaft gear bolts	20 lbs./ft.
OE timing chain damper bolts	18 lbs./ft.
Oil pump mounting bolts	18 lbs./ft.
Front cover bolts	18 lbs./ft.
Rear cover bolts	18 lbs./ft.
Lunati 7/16" connecting rod bolts	0.005–0.0054" stretch (or 80–85 lbs./ft.)
ARP cylinder head stud 7/16" nuts (the 7/16" nuts are tightened in three steps)	80 lbs./ft. w/ARP moly
ARP 8mm upper studs	22 lbs./ft. w/ARP moly
Lifter bucket 6mm bolts	125 lbs./in.

OUR SHORT BLOCK CLEARANCES

Main bearing clearance	0.002"
Crank thrust	0.005"
Camshaft endplay	0.004"
Rod bearing clearance	0.0025"
Rod sideplay	0.011"