Blueprinting Basics:

Engine Block Preparation

Nitemare Performance Shares Some of its Blueprinting and Prep Processes While Building a Giveaway Engine That You Could Win!

Every rebuild starts with preparing the block. Nitemare Performance begins this process by first having a block cleaned, to allow thorough inspection, then shot-peened and magnafluxed, to check for cracks. Here, Nitemare Performance's Darrin Magro is pressure-testing the block using their proprietary deck plate, along with a typical head gasket and rubber freeze plugs. The process identifies whether there are any cracks in areas that can't be magnafluxed, specifically inside the water jackets. Cracked blocks are discarded, unless they're rare and valuable or a matching-numbers block that the customer insists be repaired.

Story and Photos by Jason Scott

Rebuilding your Pontiac's powerplant really isn't rocket science. A Ram Air IV 400 is literally nothing like NASA's Saturn V, despite the fact that they both use Roman numerals and are both from the late-1960s.

But that doesn't mean that rebuilding your Poncho's engine is child's play, either. It has a lot of individual parts, and knowing how to best prepare and assemble those parts can make the difference between having a healthy engine that's capable of propelling your Pontiac to a win ... or one that can barely get out of its own way.

Of course, having a professional build your engine is one way to improve the odds that your Pontiac will perform well and be reliable. But not everyone can afford to pay someone else to rebuild their engine. Or you may just prefer the feeling of accomplishment that

comes from rebuilding your engine yourself. Either way, though, there's no denying that we can all learn a thing or two from folks who build engines for a living.

So, when we heard that Nitemare Performance was going to be assembling a high-performance Pontiac for a charitable raffle (see the sidebar for details about how to enter to win it), we realized that their project would be a great opportunity for us to follow along and share some of their meticulous blueprinting and preparation practices with you, so that the next time you're rebuilding your Pontiac's engine, you'll be able to put it together like the pros do. Well ... almost like the pros do.

It'd be impossible for us to show you some of Nitemare Performance's closely-guarded, power-

The devil's in the details. A proper Pontiac V8 rebuild involves meticulously measuring everything and either select-fitting parts or making minute adjustments to optimize clearances, a process often referred to as "blueprinting." The reward for all the tedious labor is an engine that can produce more power and will last longer.

Speaking of matching numbers ... Pontiac blocks have lots of numbers that tell us what it is and what it originally came in. This is the casting number: 481988, which tells us that it's an early-1970s 400. The clock-like dial near the top-left of the photo indicates the hour at which the block was cast: 7 am or 7 pm, in this case. To know which, we have to look elsewhere ...

The surface adjacent to the distributor hole contains a wealth of information about a Pontiac block: "I241" is the date code: September, 24, 1971, so for a 1972 model year vehicle. The arrow pointing to "N" tells us that it was cast during the night shift ... so the clock in the previous photo indicated 7 pm. Many blocks also feature a large two-digit code cast to the left of the distributor hole, to indicate the year it was produced, but this one clearly does not.

The engine code is stamped into a machined surface on the front of the block, near the RH head surface: "YX" in this case, which – in conjunction with the date code (Sept. 24, 1971) – tells us that this was a 1972 model year 175hp L-65 400 with two-bolt main caps, a two-barrel carb, and a Turbo 400 automatic. The 7-digit number above the engine code is the engine unit number, which basically just tells us this was the Nth engine built.

This engine's displacement casting on the LH side of the block, ahead of the front freeze plug, corroborates the engine code: it's clearly a 400. Also note the five engine mount bolt holes -- four along the bottom of the block, and one up near the first and second freeze plugs; these allow the use of either the early (pre-1970), two-bolt-style motor mounts, or the later (1970-&-up) three-bolt-style mounts ... which will make it easy for whoever wins this engine to swap it for their existing one.

production secrets. Things like cylinder head machining and extensive intake preparation just can't be shown well in a magazine. And even if we could, such procedures often require prohibitively expensive machinery and years of practice to master. Most engine builders will tell you that they've ruined their share of engines (or at least individual components), too, when experimenting, looking for just a few more horsepower or foot-pounds. So, such processes are great reasons that you should still consider having a pro put together your Pontiac V-8, instead of risking making those same mistakes yourself.

But if a professional rebuild isn't in the budget or just isn't for you, you can still benefit by imitating some of Nitemare's preparation processes.

Follow along as Nitemare Performance's founder, Darrin Magro, demonstrates what goes into the proper preparation of the block of the upcoming give-away engine. In future installments, we'll cover more phases of the build-up, and do some deep-dives on specific subjects. ***PP***

Beginning in 1971, Pontiac started casting "00" onto the lifter valley boss of 400 cid engines. 428s had a "28" since 1968, while a 455 had "55" and a 350 had "50". Later, "XX" would denote a '78-'79 block. The lifter bores are measured to ensure proper clearance, and note the lack of casting flash in the lifter valley. Satisfied that the block was usable, Nitemare Performance thoroughly deburred the block to remove flash and any sharp edges that might later serve as a stress riser where a crack might develop.

In addition to chasing (cleaning) every threaded hole in the block, Nitemare taps the oil galley holes for installation of threaded plugs that can't accidentally come loose later. Note the tiny 0.050-inch hole in LH plug, which allows a tiny amount of oil to seep out, to improve lubrication of the timing set.

Before any serious machining can be performed, Nitemare addresses a shortcoming found in all Pontiac blocks: sub-standard main cap dowel pins. Factory dowel pins are too short to keep the main caps precisely located. This is a different block that Nitemare uses for mock-up purposes; note how low the factory dowel pins are in its main caps.

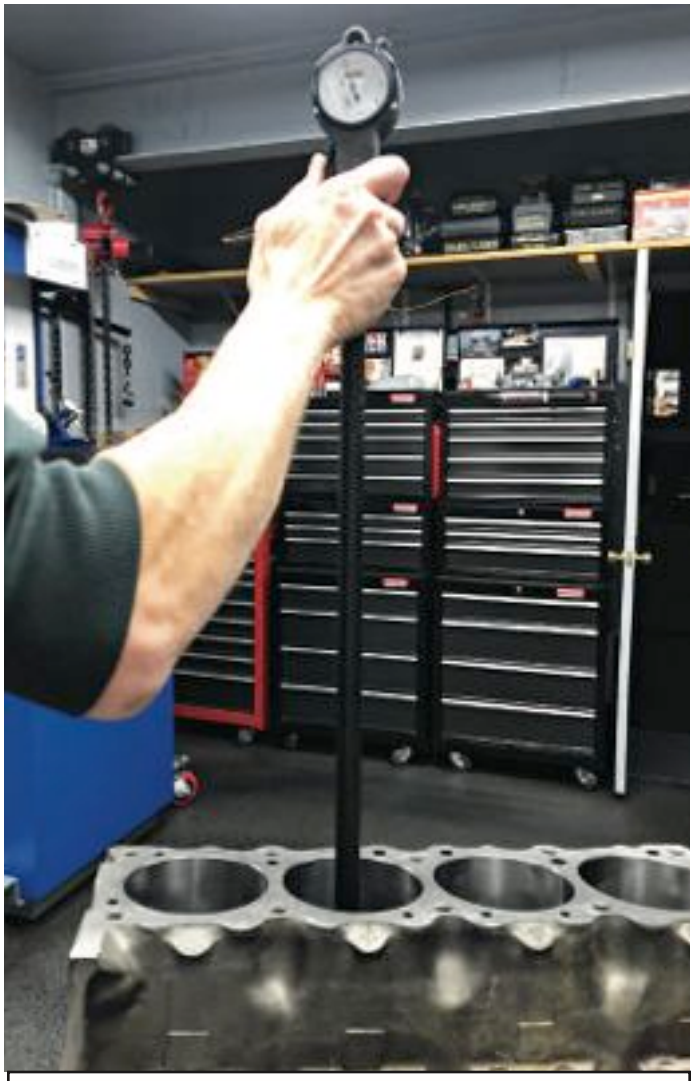
Here you can see an original, factory dowel pin to the left of the tape measure, compared to Nitemare Performance's custom-made, tall dowel pins, to the right of the tape measure. The big, red device is a dowel pin extractor tool.

Nitemare's proprietary pins are noticeably taller than factory pins, protruding significantly higher from the surface of the main web.

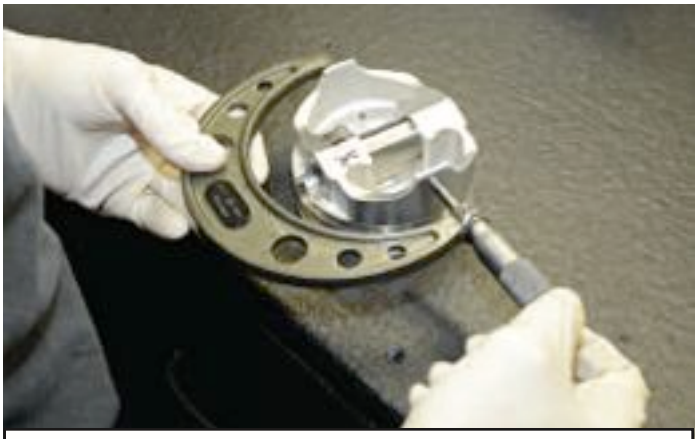
The Nitemare Performance dowel pins' extra height – nearly flush with the top of the main cap's "ear" (arrow). It prevents the cap from tipping, which keeps the cap square with the block and stabilizes bearing clearances. The taller pins do not require line-honing the mains, but Nitemare line-hones all its blocks because all subsequent machining is based off the mains, so they have to be right.

Here, Magro is checking the line-honed main journals of the Giveaway Engine's block, both for the proper diameter and also for roundness. Once the main journals are properly machined, the cam-crank centerline can be determined, then the deck surfaces can be milled and squared to that centerline to ensure they're at precisely 45-degrees.

Once the Nitemare block's deck surfaces are flat and square, the cylinders can be bored and honed (with Nitemare's proprietary torque plate) precisely square to the deck surfaces, and exactly 90-degrees apart. Nitemare also ensures that the bores are sized to deliver the optimal clearance for the engine's intended use, based on the piston diameter and material.



Of course, once the block is machined, Nitemare verifies every dimension. Here, Magro is measuring bore diameter, roundness, and taper. Every dimension is meticulously recorded. Having OCD is a good thing, at least when it comes to building high-performance Pontiac engines.



Nitemare compares the as-machined bore sizes to the as-delivered pistons, and pairs each piston with a specific bore, to ensure the optimal clearance. Machining processes today tend to result in far more consistent values than in the past, but everything still needs to be obsessively measured to verify that everything is exactly as it's supposed to be.

One of the easier processes is installing the brass freeze plugs from B&B Performance, using a light coat of Permatex sealant. Brass plugs won't rust and aren't affected by temperature as much as standard steel plugs, ensuring they'll last longer and remain leak-free.

Nitemare installs and painstakingly checks each of the B&B Performance cam bearings to ensure it's perfectly square in its journal and not damaged in any way – something that few local machine shops will take the time to ensure.

Moving on to Clevite 77 main bearings, Nitemare installs the upper bearing shells into the main bearing saddle, in order to measure them. In the process, Nitemare verifies that the bearing's oil supply hole matches the block's drilled supply hole. Magro doesn't like to take anything for granted.

And the lower half of the Clevite77 main bearings are, likewise, installed into the caps and inspected to ensure they fit flush.

The caps are then reinstalled on their respective main webs. Due to the oversized Nitemare Performance dowel pins, it often takes a little gentle persuasion from a urethane-coated dead blow hammer to fully seat the caps.

Before installing the main cap bolts, Magro applies a small amount of fresh motor oil to the surface of the cap, to ensure each bolt is accurately torqued to specifications, in three steps.

Decoding Engine Block Casting Dates

Pontiac engine blocks were cast with a 4-character date code adjacent to the distributor hole, e.g. I241

I = Month of manufacture 24 = Day of the month
1 = Year (could be 1961 or 1971)
In addition, beginning in 1969, most blocks received a two-digit year code (e.g., "71" for 1971) cast into the block near the distributor hole. The Give-Away engine, however, lacks such a cast-in code.

A: January B: February C: March D: April
E: May F: June G: July
H: August I: September (exc. 1967 MY)
J: October (exc. 1967 MY)
J: September (1967 MY) K: November
L: December (exc. 1967 MY)
M: December (1967 MY)

With all the caps properly torqued in place, Magro again measures the mains – now with the bearings installed – to verify the bearing diameter, roundness, and that each is square within its web and cap. When needed, Nitemare will swap bearing shells from one saddle or cap to another or install another shell entirely, to achieve the desired dimension for how the engine will be used.

Here's an item that many builders pay little attention to: the rear main seal. Nitemare uses BOP Engineering's one-piece Viton seal, to minimize the chance of a leak. But the seal is directional so must be installed with the helix pattern on the oil control lip facing toward the front of the engine.

Nitemare test fits the BOP one-piece rear main seal to measure it's inner diameter with a machinist's caliper.

The rear main seal's inner diameter is then compared against the diameter of the Scat forged crankshaft's rear main seal journal, to ensure the proper fit (a 0.020" interference fit, per BOP Engineering's instructions) and that the seal is perfectly round.

Factory-Specified Clearances & Specs

Piston-to-wall clearance (at skirt top):	
389 ci V-8 (1964-66)	.0005-.0021"
400 ci V-8 (1967, 1969-70)	.0025-.0031"
400 ci V-8 (1968)	.0022-.0028"
400 ci V-8 Ram Air IV (1969-70)	.0055-.0061"
400 ci V-8 (1973-74)	.0029-.0037"
421 ci V-8 (1964-66)	.0030-.0036"
428 ci V-8 (1968-69)	.0030-.0036"
455 ci V-8 (1970-74; exc. SD-455)	.0025-.0033"
SD-455 V-8 (1973-74)	.0060-.0068"
Main Bearing Oil Clearance:	
1964-65 V8	.0005-.0020"
1964-66 421 ci V-8	.0018"
1966-74 V8 (exc. 455)	.0002-.0017"
1970-74 455 (exc. SD-455)	.0005-.0021"
Crankshaft End-Play:	
1964-69 V-8	.006"
1970-74 V-8 (exc. SD-455)	.003-.009"
Connecting Rod Bearing Oil Clearance:	
1964-74 V-8	.0005-.0025"
1970 Ram Air IV 400	.0015-.0031"
Connecting Rod Side Clearance:	
1964-1969 V-8	.006-.011"
1970-1974 V-8	.012-.017"

Torque Specifications (in ft-lbs)

Fastener	'64-69 V-8	'70-74 V-8
Main bearing bolts	90-110†	90-110
Connecting rod bolts	40-46	43
Crankshaft balancer bolt	130-190	160
Flywheel-to-crank bolts	85-100	95
Cylinder head bolts	85-100	95
Intake manifold bolts	20-35	40
Exhaust manifold bolts	30-45	30

† 1964-1969 rear main: 120 ft-lbs.

Sources

Nitemare Performance
www.nitemareperformance.com
Precision-prepped Pontiac block, dowel pins, blueprinting, general assembly.

Scat
www.scatcrankshafts.com
Rotating assembly: crank, rods, pistons, rings, etc.

BOP Engineering
www.bopengineering.com/
One-piece oil pan & rear main seal gaskets.

B&B Performance
www.bbperformance.com/
Cam bearings, brass freeze plug kit

What is "Blueprinting"?

When engineers design a part – like an engine block – they specify on the blueprints the measurement for each dimension within a certain tolerance – under or over – the ideal specification. For example, GM calls for a Pontiac 455 to have main bearing clearances of 0.0005-0.0021 inches.

In the old days, the common definition of "blueprinting" an engine simply meant ensuring that the dimensions of all the parts and clearances were within the ranges specified on the blueprints. But that definition is outdated, at best, and, to be honest, it was never really accurate.

Nitemare Performance's Darrin Magro explained that a professional blueprinted engine build is really all about optimizing the dimensions and clearances for the way in which the completed engine will be operated. For example, a street engine might get tighter clearances to improve engine life; whereas a race motor might have its dimensions set up somewhat looser to reduce friction and allow for increased thermal expansion experienced during the heat of competition.

So, a professional engine builder, will not only ensure that the clearance is within the specified range, but they will also take the time to optimize the clearance for components being used and the goals of the build. According to Magro, the job has gotten somewhat easier through the years: "Provided that you use quality parts – modern cranks, steel rods, forged pistons, camshafts, etc. – the tolerances are usually very good. And, of course, great machine work is a huge factor," all of which, he points out have gotten better because of CNC equipment used in both the manufacturing of parts and during the machining process. "That being said," Magro points out, "when 'blueprinting' an engine, you still need to check every detail. We just don't need to make as many adjustments as in the old days."

Modern processes for machining and assembly have also lead to improvements. For example, it wasn't until the 1980s that folks started to understand the importance of boring and honing cylinders with a torque plate installed. And even today, the process isn't common practice, especially at most local machine shops. Magro explained that they even use a proprietary stepped torque plate that more closely simulates the torsional (bending and twisting) forces imparted by an actual cylinder head when installed on the engine. "You wouldn't believe how much the bores move when the torque plate is fastened to the deck." So, boring and honing cylinders with a torque plate in place results in cylinders that should be closer to round and more accurately perpendicular to the deck surface than they would be if machined without using a torque plate.

Ultimately, a fully blueprinted engine is an "ideal" version of that engine design, optimized for the parts with which the engine is being assembled, for how it's going to be used, and for the goal of the build: ultimate power, improved reliability, or some compromise of the two.

Nitemare Performance engineered a special "stepped" torque plate that more closely simultates the loads imparted by a cylinder head on a Pontiac block, so that the cylinders can be bored and honed and will be perfectly round and perpendicular to the block when the engine is fully assembled. The level of detail can only come from decades of experience working with one particular engine family and there is no doubt that Nitemare Performance is firmly in the traditional Pontiac V-8 camp.

Win This Engine!

One hundred tickets are being sold at $100 each, with all proceeds from the raffle going to The Tomorrow Fund and Alex's Lemonade Stand Foundation charities to benefit children afflicted with cancer. Each $100 ticket gets you a 1-in-100 chance of winning this very engine. The engine build-up will be covered here in the pages of *Poncho Perfection*, and the drawing for the raffle will take place on September 23 at the Pontiac Registry's "Pontiacs With A Purpose" event in Warwick, Rhode Island.

To purchase a ticket, make out a check or money order to Pontiac Registry Fund and send it along with a self-addressed, stamped envelope to:

Nitemare Performance
11 Belmont Rd
North Haven, CT 06473

Don't forget to include your full name, daytime phone number, and email address for notification purposes.

For more info about the raffle, visit nitemareperformance.com; event info: pontiacregistry.com.