ENGINE BLOCKS

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CHOOSING DISPLACEMENT

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STREET / STRIP ENGINES

The term "There's no replacement for displacement" is very true when it comes to making power, but the budget comes into play as well. A 500+ cubic inch big block is useless if you cannot afford to complete it.

Once you select the engine that you want, you must sit down and figure out what it will cost to build it to suit your needs, and if it's in your budget. A street engine will need low-end power and enough vacuum to run power accessories, which is easier with larger cubic inch engine.

I believe in building the largest engine that is in your budget. Some people will swear by 327's, but for the same money you could have a 350 with more power.

WEIGHT PER CUBIC INCH

Some classes of racing require a certain amount of weight per cubic inch. If this is the case, big cubic inches is no longer a concern. The concern should then be power per cubic inch to maximize the power to weight ratio.

Originally the small-block Chevy was 265 cubic inches, and over the years has stretched to 400+ cubes. There is no doubt that a 400 has more power potential, but what about HP per cubic inch? The heads and block were not originally designed to handle 400 cubic inches, and there is only so much room for head modifications. A 400 cubic inch engine places a very big flow demand on the head compared to a smaller engine.

Basically, a smaller engine has less flow restriction and can breath easier. Better breathing also allows a smaller engine to rev higher, making better use of the inertia of the air to help fill the cylinders more. In weight per cubic inch classes of racing, you see many small-blocks in the 300-330 cubic inch range. Not because they make more power than 350's, but they have more HP per cubic inch potential simply because the bottom-end is not as restricted by the top-end.

BORE & STROKE

One more thing to confuse the matter is how to get a desired displacement. If the rules of a racing class call for a maximum of 350 cubic inches, is a 350 engine with the stock bore and stroke your best choice? Probably not.

If the engine does not need to have low-end power for street driving, then building high rpm horsepower and gearing it to suit will make a faster combination. In that case, a stock bore/stroke 350 Chevy may not be your best option. It is possible to build a 400 block with a 327 stroke to get 348 cubic inches.

The larger bore will reduce valve shrouding and improve airflow. The short stroke will also allow for a much better rod length to stroke ratio, which is better for high rpm racing.

Many people will say torque is the most important thing, but what they do not realize is that torque can be increased through gearing, horsepower cannot. If you move the power band up 2000 rpm in the powerband, the engine can gain horsepower while trading off low-end torque. Then the rear wheel torque can be regained with the proper gearing. This is not the best option for a street motor, but in an all out racing car, horsepower will win races. Do not get roped into any horsepower verses toque arguments, horsepower IS torque. Torque measured over a timeframe is known as horsepower. Torque only tells you how much work can be done. Horsepower tells you how much work can be done in a certain amount of time. More horsepower equals more work in the same time, which means a faster accelerating car.

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CHOOSING AN ENGINE BLOCK

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USED BLOCK

Don't think that a new block is the best choice. A used block can actually make more power. When an engine block is cast, it is left with a lot of internal stresses. As the block heats up and cools down from normal use, these internal stresses relax. As this happens, the block will distort some. The tolerances of the engine can become less than optimum as the block settles. A high mileage block, as long as it passes all the high performance checks will not distort over time as much as a new casting.

These blocks are called "seasoned" blocks. The term blueprinting (which is the most misunderstood and abused term I have ever heard) means nothing more than machining the block within factory tolerances. The "Seasoning" process distorts blocks enough to make them out of specification, not to mention many blocks were just poorly machined form the factory.

NEW BLOCKS

In the 70's auto manufactures realized that they could save money by eliminating extra cast iron in the engine. Cast iron is also heavy, with fuel mileage becoming a big concern; any weight savings was also better for mileage. These, lightweight thin walled castings are not desirable for high performance use. They flex and crack easier. It may be hard finding a good core suitable for high output.

Automakers started making high performance blocks available. These blocks have the more desirable features, like thicker cylinder walls and less core shift. If a "seasoned" block is not available, a new high performance block is a better choice than a thin walled emissions era casting.

RESEARCH

Once you know what engine you want (size, type and desired output) you can start looking for a suitable core. Do plenty of research on your block, have books to identify casting and stamped numbers. Do not trust sellers, most will tell you anything you want to hear to get a sale. Know what you're looking at. Make sure any accessory bolt holes and fittings that you'll need are there.

A tip for Chevy V-8's is numbers behind the timing chain cover. A 010/020 is a desirable block. The 010 means that the casting has 1% added tin and the 020 means 2% added nickel. The added tin makes the block less prone to crack and the nickel makes the block stronger and harder. Harder cylinder will not wear as fast or scuff as easy. A single number mean that no extra tin was added. It will be either a 10 or a 20, 1% or 2% added nickel. If there are no numbers on the block behind the timing chain cover, then no additional material was added.

CORE SHIFT

If there are obvious signs of core shift, the block should be rejected. Core shift is when the casting cores move during the casting process, leaving material thinner in some areas and thicker in others. Cylinder bores can be dangerously thin on one side and plenty thick on the other. I like to have around 0.200" thick cylinder walls for high performance use, preferably closer to 0.250" on the thrust side of the bore, but that is very rare in a factory block.

Thin walls flex and hurt ring seal and also have a large effect on the cooling system. Thicker metal will dissipate heat faster and more even.

The first place to look for core shift is the cam bores. If the cam bore is not in the center of the casting boss, it a sure sign of core shift. You can also check a few of the cylinder walls though soft plug holes and such. If wall thickness varies greatly, reject the block for any type of performance use.

OVERSIZE BORES

If the block has been bored over size, reject it for high performance use. Chances are that a used block will need a re bore and sizes over 0.030" over can compromise bore strength. The best blocks are stock bores that can clear at 0.020" - 0.030" over size.

If it's a stock rebuild, 0.040" or more may be fine, depending on the engine and application. If you want to go more than 0.030" over, it's best to sonic test to make sure the walls are thick enough for the desired output.

Some blocks are known for having thick walls and can safely be bored more than 0.030" over, this goes back to doing research on your engine. For the most part, if in doubt, don't bother with a block that has already been bored unless you know the walls are thick enough.

CRACK INSPECTION

You need to check the block for visible cracks, a more thorough inspection will come later, but there's no sense in bothering with a block that has visible cracks. The lower parts of the bores are areas that should be checked closely, it is quite common for people to hammer out the pistons and rods not paying any attention to what damage they're doing. The rods can catch on the bottom of the bore. This is not a high stress area, but it is usually on the thin side. A crack there can go into the water jacket. Cracks in those areas are usually caused by a hammer.

The areas that are subject to high stress are the main bearing saddles. Check all around the main webs for any signs of cracks or discoloration. Darker or a bluish discolor in extreme cases; can mean an overheated or spun bearing.

MAIN BEARING CAPS

Many engines were made with either 2 or 4 bolt main caps. Chances are that you'll pay more for a 4 bolt engine, but do you really need one? If your goal is 500+ hp a 4 bolt is a better choice, but some engines like the small-block Chevy, the 4 bolt blocks will have more of a tendency to crack around the main saddles. A stronger solution is to find a 2 bolt block and fit it with aftermarket 4 bolt caps. Aftermarket caps will have splayed outer bolts, so the holes will be drilled in a thicker part of the main web.

Make sure that the main bearing caps fit tightly in the block. A loose fit can mean that the cap has distorted. If you plan on installing aftermarket caps, this wont be a problem, but if the original caps are to be used, it will be best to find another core. It may be possible to peen the edges of the block to tighten this up, but if it is loose due to the cap oblonging, it's usually a short lived fix (the cap is just plain weak).

STRIPPED THREADS

Look for any stripped threads. Threads are repairable, but if it's more than a few holes, especially the main bearing cap bolts, reject the block. Heli-coils work great and make stronger threads than cast iron for head bolts and main bearing cap bolts.

The downfall is that you must drill the hole oversize, which can leave less material around the hole, and then use the threaded insert. When you see several holes with stripped threads (or repaired threads), it just shows the ignorance of a previous builder, and who knows what else he did to that engine. Just avoid any other headaches by rejecting that block.

RUST

Avoid a heavily rusted block. Rust makes pits and pits cause stress risers. Heavy rust can also hide imperfections that you are looking to avoid, like cracks. Some of the best blocks you'll find are the ones that had oil leaks and are covered with a nasty thick oily mess.

Source: www.grapeaperacing.com

CLEANING & INSPECTING ENGINE BLOCKS

Source: www.grapeaperacing.com

DISASSEMBLY

You must strip the block down for cleaning. Remove any ridge at the top of the cylinders so the pistons come out easily. Make sure you mark all the rods and main caps, so they can be installed back to there original positions. Put something over the rod bolts so they do not damage the crank journals on the way out. Be careful that the rods to not get caught on the bottoms of the cylinders, many blocks get damaged when the rod is hung up and a big hammer is used. If anything feels wrong, stop and find out why.

While you're tearing the block down, continue to check for cracks and other imperfections. Remove all soft plugs and oil galley plugs. Stubborn screw in plugs can be removed by heating the plug red hot, letting it cool, and they should then spin out easily.

If the block is going to be chemically cleaned, you need to remove the cam bearings as well, since the chemicals will ruin them anyway. I like to remove them anyway so that no deposits can get trapped behind them in the oil grooves. Cam bearings are cheap, so don't try and save a buck there. If a press in plug has a peen holding it from loosening (like many front oil galley plugs), make sure you deburr the peen before removing it.

MAIN & ROD BEARINGS

Check the condition of the bearings as you remove them. Any bearings that are worn down to the copper color babbit is a sure sign of oil starvation.

There will be an undersize number stamped on the back of undersized bearings; this will let you know if the crank has been reground. Also check the back of the bearings for any signs of movement. A bearing that shows signs of movement in the bore shows a lack of bearing crush. This could be a problem with the main or rod bore, or a poorly made bearing.

A main or rod bore that looks dark or burned around it means that a bearing was on the verge of failing. Finding problem areas will better help in block selection and limit future problems.

BORE SIZE

You should measure the bore wear at the highest point of the top rings travel. Take a few measurements on each bore to find out of round cylinders. There will usually be a ridge at this point unless the motor had low mileage on it. Determine what minimum overbore the engine will need.

Do not assume that boring it to the largest size piston available will make more power, it wont. Thinner cylinder walls are weaker and do not dissipate heat as well. You want to remove as little metal as possible to get a new surface.

CLEANING THE BLOCK

The block must be cleaned before any machining can take place. There are a few ways to clean the block. One is hot tanking, where the block is dipped in a chemical solution that brings the block to bare metal. The Chemicals are heated, which is where it got the name hot tank.

A jet cleaning tank uses the same type of chemical solution, but the block is rotated in tank and spray nozzles pressure wash it kind of like a big dishwasher. The jet spray tank is a little better at breaking loose heavy deposits, but as long as the chemicals are fresh, the hot tank does a good job.

Many shops do not like to deal with the chemicals, so baking ovens are getting popular. A baking oven will heat the block to over 500 degrees for about 25-30 minutes, drying up and burning off any deposits. This method is acceptable, but will probably require some additional cleaning. I have seen high temp. silicone gasket sealer go through this process untouched. After

the block is baked, it is put in a cabinet where it rotates while steel balls are shot at it. This is sort of like shot peening, but not as hard, the balls are not shot hard enough to dent or damage the block. They are only to break away any residual deposits.

Whichever method you used to clean the block, make sure that you give it a check over to make sure it's clean. Once all the machine work is finished, it will need another thorough cleaning before any assembly takes place.

MAGNAFLUXING

If the engine is going to be built for high performance, magnafluxing is worth the money. Magnafluxing will find any cranks that you cannot see. A powerful magnet magnetizes the block. The magnet is placed across the section of the block that you will be tested. Then a metallic powder is sprinkled around the area, any cracks are found by the metal shavings standing on end defining the crack. This method is also used to check for cracks on connecting rods, crankshafts and iron cylinder heads.

SONIC TESTING

This is expensive, but if you're after maximum power, you need to know how thick the cylinder walls are. A sonic tester can tell you exactly how thick the walls are. It is the best tool for finding core shift in areas that you cannot measure. I like to see cylinder walls at least 0.200" thick and preferably closer to 0.250" for goal in the area of 600 hp or more.

Source: www.grapeaperacing.com

PREPPING BLOCKS FOR HIGH OUTPUT

Source: www.grapeaperacing.com

OIL GALLEY MODIFICATIONS

All engine blocks have drilled oil passages that connect at various angles. There are many areas that could use some clean up to limit flow restrictions. Anywhere the oil flows through two parts that bolt together should have the oil ports matched so no sharp edges restrict flow (the rear main bearing cap on a small-block Chevy is a good example. Also give the edges of any drill oil passage a radius to avoid turbulence; the oil filter area will almost always need this. Place the bearings in place and check how the oil holes matched the ones in the block. If there is any misalignment, grind the port in the block to match the bearings.

DEFLASHING & OIL DRAIN BACK

You will want to remove any casting flash inside the block. There is usually lots of casting flash around cast in oil drain back holes. Not only will this help get out any trapped casting sand, but it will also aid in returning the oil back to the pan faster. I've seen people grind the entire lifter valley smooth, but this is a wasted effort. On most V-8 engines there are oil return ports at the ends of the heads and none in the middle, so concentrate on helping flow where the majority of the oil is.

Another downfall of a totally smooth surface is that a smooth surface has less surface area than a rough one. Oil helps cool the engine and oil splash in the lifter valley takes heat off the cylinders; more surface area will transfer more heat. The same goes for painting, I have seen no gains from painting the inside of an engine. Paint on the inside of a block also has a chance to peel and clog the oil filter. I do not recommend painting the inside of engine blocks.

THREADED BOLT HOLES

When using a tap to clean threads, it is a good idea to use a tap that was made to clean threads, not cut threads. These taps are slightly undersize and will not remove additional metal. After tapping the threads, used a chamfering tool to take off the first thread of all the holes. If the block is going to be decked, chamfer the head bolt holes afterwards. This will prevent the first thread form pulling upwards when tightening and limiting clamping force. This is especially important on head bolt holes.

If the block originally had press in plugs for oil galleys, it a good idea to replace them with screw in tapered pipe plugs, but be careful not to tap too deep. If the plug goes in too far it can block oil passages, so be sure to check. If you decide to use the press in style plugs, be sure to stake them in to prevent them from getting pushed out by oil pressure. If any threads are stripped or damaged to the point that you don't think they hold, a heli-coil insert is a perfectly acceptable repair as long as drilling the hole oversize to install the insert does not leave the material dangerously thin.

MAIN BEARING BORES

The first thing that should be done is to make sure that the crankshaft bores are straight in the block. All other measurements will be taken from the crankshaft centerline, so if it is out of alignment, all the other machining operations will be as well.

If crankshaft centerline errors cannot be fixed, scrap the block, or save it for something other than a performance engine. If you need to hone the main bores (if you're installing different caps or to fix small errors), you'll need to mill the bottoms of the main caps, then hone them to size. In many cases using main caps from another block is not as easy as it may seem. Depending on the machining errors, you may not be able to take off as much material as you need to. Milling too much from the caps will leave the caps thin when the bores are resized. A better solution would be to install aftermarket caps that have enough material to machine.

If you are installing aftermarket steel caps, there will be too much material to hone, so you'll need to line

bore the block. The trick here is to set up the boring bar to just barely touch the block and take the material off the caps. If much metal is taken off the block, a shorter timing chain will be needed, because the crank will then be closer to the camshaft.

If you must take some off the block to correct alignment errors, Cloyes does offer special timing sets for most popular engines if you give them a crankshaft centerline to camshaft centerline measurement.

When doing any boring or honing of the mains, always have the caps torqued to spec and anything else that bolts to the caps (like an oil pump) should be on and torqued to assure roundness of the bores when the engine is assembled.

CYLINDER BORING

Any machining to the bores for any high performance engine should be done with a torque plate installed and torque to specs. This will simulate any distortion of the bores from the cylinder head being torqued. A block may seem like a rigid piece, but is actually quite flexible. If the shop that is machining your block does not have torque plates, find a new shop, they are obviously not a performance-orientated shop.

When boring, you want the least amount of oversize that will get the engine to clear, do not think that boring it to the maximum size to get the most cubic inches will make more power. Thin cylinder walls flex more, loose ring seal and loose power.

Make sure that the bores are machined in relation to the crankshaft centerline; this is something that machine shops rarely do unless you specifically ask for it. What this does is make sure that all of the bores are the same in relation to the crankshaft centerline. The bore alignment has a large effect on where the piston is at certain camshaft positions. It's not good for performance if every piston reaches peak velocity at different cam lifts. You also want every cylinder to have the same valve events for a given piston position. BHJ makes a special fixture called the Bore True fixture to locate the bores correctly.

Once the boring bar is set up right, bore the engine 0.003" less than the desired bore size. The remaining metal will be removed in the honing process. Once you know for sure what the bore size will be, you can then get pistons of that size.

BORE FINISH

Once you have the pistons, you must measure them and add the recommended clearance to know what the final bore size will actually be. Most pistons will be measured on the skirts level with and 90° of the wrist pins bores, but always check the manufactures recommendations. Always use a torque plate to assure roundness of the bores when the head is torqued in place.

The final honing grit will depend on the type of rings used. A Chrome or Stainless-steel ring will require 280 grit stones and the more popular Molybdenum (moly) rings will need much finer 400 grit stones. As you near the final bore size, make sure you use plenty of honing fluid and minimum cutting pressure.

If you are having this operation done, you can check the machinist's work using a shim feeler gauge of the desired piston-to-wall clearance. The piston should slide snugly, but freely past the feeler gauge (make sure you put the feeler gauge in the same area that the piston is measured. Now used a feeler gauge 0.001" thicker, the piston should not fit through the bore with the gauge in place. Be very careful doing this check, it is very easy to damage the piston skirts.

DECKING

To resist the chances of detonation, a close piston to head clearance is desired. Most engines will have the pistons below the deck at TDC. Decking will bring the piston closer to the heads and also straighten out any machining errors. You want to make sure that the decks are parallel to the crankshaft centerline and they are at the correct angle.

A BHJ decking fixture is used to make sure the decks are in the correct position in relation to the crankshaft centerline. This is not common equipment for the average machine shop, so you must look for a performance-orientated shop.

When figuring piston to deck clearance, be sure to add the compressed thickness of the head gasket.

Measure the piston deck height over the wrist pin; otherwise piston rock will change the measurement.

Piston-to-head clearance is critical, the pistons must come as close to the heads as possible when running, but not hit them. You must take into account any piston rock, pin flexing and rod stretch. The average street motor with steel connecting rods can go as tight as 0.035" piston-to-head clearance, but 0.040" is the norm to allow a little room for error. Aluminum rod or high revving motors will need more clearance to allow room for more stretch. The idea here is to get as close to zero clearance as possible when the engine is revving at its peak rpm.

CAMSHAFT & LIFTER BORE ALIGNMENT

This is something that is almost never checked, but can be, and usually is, a big power robber. The camshaft bores are commonly out of alignment. When the cam is moved left or right in a V-8, one bank will be more advanced and the other will be retarded.

To find such errors it is always recommended to degree the cam on cylinder 1, then check it against cylinder on the opposite bank. When degreeing the cam, you can split the difference of minor errors with little effects, but large errors need attention. I have seen over size cam bearings to repair such errors between the left and right banks, but be careful, boring the cam bearing bores will reduce the size of the oil grove around them and restrict flow. So if this is done, make sure that the oil grooves are opened up a like amount to compensate.

A better solution is to relocate the lifter bores to cam bore centerline (if the errors are minor). Lifter bore errors can be as much as 0.020" and this can change the cam timing events 5-7° from cylinder to cylinder. This will compound any cam bore errors. It may be an expensive operation to straighten them out, but it is well worth the money.

The BHJ Lifter True fixture is used to bore the lifter bores accurately. When fixing lifter bore alignment, they must be bored oversized, unless rules require stock lifter diameter it is a good idea to leave them oversized, as this allows peak lifter velocity to be higher. A Chevy lifter for instance is 0.842”, which can be bored to 0.875" (a Ford size). If the rules require a stock diameter lifter, you must bush the new correctly aligned bores back down to 0.842". BHJ also makes the bushings you'll need.

There is a lot of time and effort in this process, but it gives very good returns for the time involved. Most people know about the advantages of camshaft degreeing, but few people seem to get past cylinder number 1. There's little sense in degreeing the cam to the last degree, if the all the cylinders vary as much as 5°of each other.

Source: www.grapeaperacing.com