What is Blueprinting?

By: **Mike Kojima**

This is a question that I hear time after time again. Blueprinting is not some weird magic nor is it snake oil, Blueprinting is merely shifting the manufactures tolerances for the engine to the side of the tolerance that will give you the best power. The tolerances involved are the weights of the rotating and reciprocating engine parts and the clearances of the bearings, pistons and rings.

Generally, blueprinting usually makes a huge difference powerwise in old school domestic engines, such as the venerable, favorites of the domestic fans, Chevy or Ford small blocks with their large clearance and part weight variations. The improvement is less drastic in most import engines and more recently designed domestic motors, such as the newer Chevy Vortec, and Ford 4.6 V-8's because their tolerances are controlled much more tightly from the factory.

The opinions of which side of the factory clearances works best to produce the most power varies depending on the engine builder. Many experts feel that the most important aspect of blueprinting is getting the bearing clearances to the loose side of spec to reduce friction. Most experts also feel that getting the cylinder piston to wall and ring end gap clearances to the tight end of the spec to maintain good ring seal and reduce blowby is important. Of course other experienced engine builders will have differing opinions on the correct way to set things but the important thing is to make sure that the clearances are all equal and controlled.

My personal take on this is that you always want to try to maintain close to the minimum clearances possible on the pistons and the crank and rod bearings for any engine for longer life, less windage-loss causing oil slingoff, to maintain better long term ring seal and to maintain bearing oil pressure better. On an SCCA showroom stock class motor where no mods at all are allowed, I might run bottom end bearing clearances a little looser, towards the middle or larger side of the clearance spec in the hopes of reducing viscous friction but everything else, like the pistons gets clearances towards the tighter side of the spec.

Blueprinting bearing clearances on import and modern domestic motors is easy because they feature select fit bearings. These are bearings available in several different thicknesses so the exact clearance can be maintained for each journal even if there is variation in the machining from journal to journal. The block, rods and crank are stamped with a code for what bearing size is used for each journal and you can use a chart in the factory service manual to decode the stampings. If you want to tighten or widen clearances, you can go up or down a size from the encoded bearing size.

Because most import cranks are so tough, it is rare that they have to be turned undersize, when the engine is gone through. This is a common rebuilding

practice on domestic motors. If the engine has some miles on it, it is usually enough just to lightly polish the journals and use the next tighter sized bearing on the service manual chart.

Another important aspect to blueprinting is to get the piston to wall clearances for each cylinder equal. This is done by measuring each piston and having the machine shop match each piston to its bore with the exact same piston to wall clearance. Good machine shops can do this easily by honing each bore after rough boring for a precise fit. Like the bearings, most import engines have select fit pistons with the size used stamped on the block in a code that can be decoded with the factory service manual. If you are replacing the factory pistons, you can specify a piston grade a little bigger and hone the cylinder to get the fit. This gives you the benefit of a nice fresh bore surface with tight, like-new clearances, as you never want to put new rings in a used bore, they will not break in properly and will not seal that way.

With aftermarket racing pistons, you do not have this select fit option so the machine shop must match the bores to the pistons, not a big deal for a high quality machine shop. The piston to wall clearances should all be matched to within 0.0001- 0.0002" of each other by the machine shop. This match should be confirmed when you assemble the motor as shops have been known to mess up. With aftermarket pistons you are usually going for a significant overbore any to get some more displacement. Most import engines can be bored 0.040" or one millimeter oversize with no problem. Forged aftermarket pistons run looser piston to wall clearances so you will want to use the clearances specified by the pistons maker, not the ones in the factory service manual.

With aftermarket pistons, slightly oversize rings can be bought so the end gaps can be controlled by filing the ends of the rings to so every bore will have the exactly the same ring end gap. Usually you will want to make the gap on the first compression ring slightly wider as this ring runs hotter and expands more under use. Many engine builders are running some of the newer gapless compression rings where the number-two compression ring has a staggered gap. Correct cylinder wall finish is also critical and is a point where many engine builders mess up. Modern rings found on import motors are usually low tension and chrome faced. This type of ring requires a very smooth cylinder wall finish, usually 600 grit followed by a platue hone to make the finish even smother. Many old school engine builders are not aware of this and make the cylinders finish too rough. Quick wear, poor seal and oil burning result.

Making sure that the combustion chamber volumes of every cylinder are equal is a blueprinting job given the cylinder head porter. Usually a good head person will try to get all the chamber volumes to be within 0.5cc of each other so all the cylinders will have pretty close to the same compression ratio.

Every engine should be balanced. By balancing the engines internal parts, vibratory stress on the engine is greatly reduced. An out of balance condition of a few grams can result in an unwanted load of many pounds in the wrong place. If these imbalance loads are added up, they can result in quite a bit more stress on an engines critical internal parts. Balancing means dynamically balancing the crank, equalizing the weights of the pistons and the big and small ends of the connecting rods. The weight variation between all moving parts in the motor should all be less than one gram for best results.

This is accomplished by drilling holes or grinding the counterweights of the crank, for connecting rods, sanding the balancing boss on the bottom of the rod caps and the small end wristpin boss on a belt sander works. For pistons you carefully remove metal from around the sides and upper corners of the pin boss and the underside of the dome on pistons. With pistons you have to be careful not to make the dome thinner that 0.200" or to weaken the pin boss.

One of the trends that many builders of import motors are starting to follow as a fad is excessive lightening and knife edging of the crank. I don't believe in doing this for two reasons. It is important to maintain about a 50% overbalance of the crank when the counterweights of the crank are around 50% heavier than the reciprocating mass of the motor. This helps the engine work smoother on the compression stroke. Pairing down the counterweights to almost nothing and reducing the overbalance may introduce additional stress introduced into the crankshaft. This is a definite no-no for engines that must last a while like street or road racing cars. I question it for even short duration races like drag racing.

On old school domestic engines, I have found the weight of parts to vary by several grams to some times more than 10 grams, making balancing very critical. Lots of metal had to be removed. On tight tolerance import engines the weight variation is usually less than a gram or two. Now you know yet another reason why I love these engines so much!

Hopefully this article will help you understand blueprinting and help you communicate with your engine builder or catch a bogus engine builder that is trying to BS you.

Until next time, Happy Motoring!

Mike