PISTON SELECTION GUIDELINES
Federal-Mogul Document #1104

There are several factors to consider when selecting pistons for a high performance application. Choices are made by comparing cost, design, material, and compression ratio. The relative importance of these features are dictated by the intended use of the engine. The requirements for a Saturday night boulevard cruiser are not the same as those of a dedicated race vehicle. Isolating each of these characteristics will help establish some guidelines for proper piston selection.

The single most important question an engine builder must answer is - what will this engine be used for? This is a case where the racer has an advantage, because they know the conditions that their vehicle will operate under, the fuel they will be using, and modifications are often limited by sanctioning body rules. The street oriented enthusiast must consider the quality of the fuel available, the level of performance expected of the vehicle, and the possibility of future additions such as nitrous oxide systems, turbos, or superchargers. Any modification or condition which will raise cylinder pressure and increase the possibility of detonation must be carefully considered before making a selection.

PISTON MATERIAL AND MANUFACTURING PROCESS SELECTION

Federal-Mogul utilizes two manufacturing processes for the production of high performance pistons:

SPEED-PRO Hypereutectic pistons are cast in permanent molds, while SPEED-PRO Power Forged pistons are extruded from aluminum bar stock. Each has advantages in certain applications, but there are cases where the choice is not an easy one. An honest evaluation of your needs will yield the most satisfactory results.

SPEED-PRO’S cast Hypereutectic material is a relative newcomer to the performance market, and has several attractive features. Our Hypereutectic pistons operate perfectly with standard ring end gaps, and have conventional ring land locations. When compared to traditional cast pistons, which are not designed for performance use, the Hypereutectic’s are significantly stronger, particularly in the highly loaded ring land, skirt and pin bore areas. Our FM244 Alloy contains 16.5% silicon, and has excellent tensile and fatigue strength. This material’s improved thermal characteristics, it’s greater hardness, and the increased resistance to scuffing permit tight bore clearances which help minimize noise on a cold engine start up. This quiet operation, along with a lower cost, are the primary advantages over a comparable forged piston. These pistons are an excellent choice for street performance, for “claimer” oval track engines, and for bracket racing use. They will also work well in moderate supercharged applications, and are suitable for towing and marine use.

SPEED-PRO POWERFORGED Pistons set the standard for the performance industry, with material and design superiority that has been proven in every form of racing. The forging process has inherent advantages in terms of density, ultimate strength and durability. Forging eliminates porosity in the metal, improves ductility, and will allow the piston to run cooler than a comparable cast unit. POWERFORGED Pistons start from “near net shape” forging, with a desirable horizontal grain flow and tightly controlled head thickness. This minimizes piston weight without compromising strength. These pistons are better able to withstand the high cylinder pressures and skirt loads imposed by racing use, and are more likely to survive limited detonation and valve piston contact which may occur during a race. If your vehicle is to be used for endurance racing, faster classes of drag racing, or extreme duty street performance, you should probably select a forged piston. Engines with very high compression ratios (11:1 and over), high boost superchargers, nitrous oxide, or which operate under conditions approaching detonation will benefit from the POWERFORGED piston’s characteristics.
PISTON MATERIAL SELECTION - CONT’D

Our unique VMS-75 alloy is used in our most popular POWERFORGED pistons. This alloy contains approximately 11% silicon for long life and scuff resistance - and is ideal for both street use and racing applications. Extreme performance applications will benefit from our new line of pistons manufactured with aerospace quality 2618 alloy, which has even greater high temperature strength than our traditional alloys. The 2618 does not contain any silicon though, so it is more susceptible to scuffing and wear if not run with adequate clearance. Pistons made from 2518 alloy are not recommended for street use.

While horsepower benefits are often claimed by those favoring one piston material over another. It is best to make your choice based on intended application and use, not on theoretical power improvements. Federal-Mogul make both types so that you have the option to choose the one that best meets your needs.

PISTON DESIGN CRITERIA

Both the Hypereutectic and the POWERFORGED pistons are available in a variety of configurations to meet the needs of an engine builder. The areas which get the most attention are head design, compression ration, skirt strength, weight, and pin retention method.

PISTON HEAD DESIGN

Piston head design is dictated by the desired compression ratio, the shape and volume of the cylinder head used, and by the desired number, size, and location of valve relief’s. Pistons with four equal sized valve relief’s are usually designed to work in all cylinders of an engine, while still allowing a built in pin offset. A piston which has two different sized relief’s can be used only in half the cylinders of the engine having Siamese valve arrangements, such as the small block Chevrolet. Such combinations require two piston part numbers, dedicated to specific cylinders in the engine. Engines such as the big block Chevrolet, which alternate the intake and exhaust valve across the head, can use a single two relief piston part number for the entire engine if pins are not offset.

A dome on a piston is considered detrimental to flame travel and airflow within the cylinder, but is often the only way to achieve a desired compression ratio when using large volume heads. A flat top piston with a smaller chamber head is generally more desirable. Several race engine builders have gone to a reverse dome configuration, where the piston top mirrors the combustion chamber.

Our latest line of CNC machined pistons utilize the latest in machining technology to generate dome profiles with outstanding dimensional and volume accuracy. These pistons are ideal for race applications, delivering extremely consistent compression ratios and weight, and reducing the need for extensive machine shop work.

Some domed pistons can be modified into a flat top, to lower compression ration, but this is not a job for the home engine builder. A minimum head thickness of .180” for forgings, or .220” for Hypereutectics must be maintained, with greater thickness required for endurance, nitrous, or blower use. Many pistons cannot be modified. These same cautions apply to valve relief modification.

PISTON TO VALVE AND CYLINDER HEAD CLEARANCES

Piston to valve clearance should be a minimum of .100”. This clearance will be changed if heads or block have been machined, and must be checked at assembly. While some people claim to “get away” with less clearance, there are many others that have bent valves and broken engines trying to do so. When using steel rods, the minimum clearance between the piston and the cylinder head should be .040”, aluminum rods require an additional.010 -.020” due to their tendency to stretch at higher engine speeds. Many engines use a flat “quench” area on the piston, which creates beneficial turbulence within the combustion chamber by coming into close contact with the bottom of the cylinder head. In applications having this “quench” design, the clearance between the piston and the head should not exceed .060” in this area, or destructive detonation may occur. This is the reason that stacking head gaskets to lower the compression ratio usually delivers poor results.
PISTON SKIRT DESIGN AND BORE CLEARANCES

Piston skirt strength and requires bore clearance depend on material, skirt cross section shape, oil ring groove drainback design, and where the clearance is measured on the piston. Stock replacement and moderate performance type pistons, whether forged or cast, use slots to return oil that is scraped from the cylinder walls by the oil ring. This design allows the skirt to be more flexible, and permits the tighter cold bore clearances. Forged pistons with the slot design can be set up at nearly the same clearances as cast pistons. A high performance race type piston will use “windows” or drilled holes for oil return. The drilled hole design adds significant structural strength to the skirt of the piston, but requires greater bore clearances since the skirt is less flexible and the amount of heat transferred from the piston head is increased.

Contrary to statements from other manufacturers, the greater clearances do not cause ring sealing problems as the working clearances are nearly the same once the piston reaches normal operating temperatures. These piston skirts are specially shaped to reach optimal clearances once warmed up, through careful attention to skirt cross section design and piston growth patterns. When cold, these pistons exhibit an oblong or “cam” shape around the skirt area. While a drilled hole forged piston may exhibit some noise when cold, it would be rare to hear a racer complain about it. Also important is the place where measurements are taken. Since piston diameter varies from the pin bore to the bottom of the skirt, it is possible to have two pistons with different specifications but identical operating clearances.

SKIRT COATINGS

Speed-Pro is the first supplier to the performance market to provide production pistons with a moly-graphite skirt coating. Proven in both OEM and racing applications, this unique coating delivers greater durability, reduced friction, and allows the pistons to be installed with extremely tight cylinder bore clearances. The benefits that can be realized by optimizing an engine combination around this unique feature include quieter operation, lower emissions, better fuel economy, and more power. The coating is applied in our manufacturing facility using a sophisticated process, and is then cured in place - it will not wear or flake off.

COMPRESSION RATIO DETERMINATION

Choosing the correct compression ratio for an application is key to success. Too high a ratio will cause far more problems than one that is a bit low, so be conservative in your selection. Fuel quality and intended usage are the primary limiting factors. Detonation is caused by excessively high compression, lean fuel mixtures, or overly advanced timing. Detonation will damage your engine, and must be avoided. Compression ratio calculation programs for personal computers are available from a number of sources, and are highly recommended. Don’t get hung up on getting a exact compression ratio, target a relevant range that will meets your needs. Street driven vehicles should be limited to a compression ratio between 9 and 10 to 1, which approaches the practical limit for premium fuels. Oval track applications using gasoline should normally be built with a maximum of 12.5 to 13.25, depending upon the type of car, the track size, and on the fuel used. Drag racing applications often use higher compression ratios, with fuel type as the limiting factor. The use of alcohol based fuels permits higher compression ratios than are practical with gasoline.

The compression ratios shown in our catalog are based upon a standardized block deck height and head gasket for each engine family, and can therefore be directly compared to one another. The ratios shown are for comparative reference only, as your heads and block are likely to differ from the published data. Cylinder head chamber volume and block deck clearance will have a direct effect upon actual compression ratio, and should be checked. Factory cylinder heads can vary considerably from published specifications. You cannot accurately determine your compression ration without measuring the chamber volume.

PISTON WEIGHT

SPEED-PRO has introduced a number of fully machined Competition Series pistons, with several benefits for the serious enthusiast. These pistons are forged or cast to a shape very close to the desired finished
configuration, and then all working surfaces are precision machined. This gives very tight control of head thickness, and allows light weight without sacrificing durability. A great deal of information has been circulated concerning the comparative weights of POWERFORGED pistons to those of other manufacturers, both cast and forged. The facts are, Federal-Mogul offers a far greater variety of pistons than does anyone else, and they often choose to compare our O.E. replacement forgings to their lightest race versions. An “apples to apples” comparison will show our products to be comparable to any in the market in terms of weight. The others compare their products to ours because we set the industry standards for performance, durability, and variety.

**PISTON PIN TYPE**

The choice of pin retention method is often dictated by the original engine manufacturer. Engines produce with press fit pins can be converted to the “floating” type providing that the piston has provisions for a lock ring retainer. Many POWERFORGED and Hypereutectic pistons are designed to accommodate either style pin. Floating pins are preferred by most serious engine builders, but many races have been won with press fit pins, so don’t automatically discount their potential for moderate performance use. The benefits of converting to floating pins may not justify the cost in many applications.

Our Hypereutectic pistons utilize a unique, easily installed, round wire pin retainer lock ring. Due to the unique characteristics of the Hypereutectic alloy, we have found the flat style retainers, such as spirolox, are not ideal for this purpose. Flat retainer rings tend to concentrate the piston pin’s side loads into the sharp machined corners of the piston’s pin retainer groove. The round wire retainer better distributes the load throughout the entire pin boss area, and the matching groove has no sharp corners where stresses can concentrate. Round wire retainer grooves are more difficult to machine, but the benefits are well worth the effort. Thousands of hour in dyno testing have not produced a single pin retainer failure.

**COST**

Hypereutectic cast pistons have a cost advantage over Power Forged pistons due to the manufacturing processes involved. Coupled with their quiet operation, this makes them ideal for the budget conscious enthusiast. The Power Forged parts offer greater durability in high stress applications, and are available in a greater number of specialized configurations. There are cases where the decision to use one or the other is not clear cut, and either type will do the job. If future plans call for continued modifications to your vehicle it is best to consider them when making your selection. The final decision is yours, weighing the benefits of each type against your performance needs.
# PISTON SELECTION GUIDELINES

<table>
<thead>
<tr>
<th>Piston Type</th>
<th>Application</th>
<th>Cast</th>
<th>Hypereutectic</th>
<th>Forged - with Slotted Oil Groove</th>
<th>Forged - with Drilled Oil Groove</th>
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<tbody>
<tr>
<td></td>
<td>Standard Service &amp; Towing</td>
<td>Light Truck &amp; Towing</td>
<td>Moderate Street Perf.</td>
<td>Oval Track &quot;Claimers&quot;</td>
<td>High Perf. Street/Strip</td>
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**Application Codes**

- Not normally used for this application
- May be marginal due to cost or strength
- Will work, but exercise caution with timing/mixture
- The best choice for this application

**General Guidelines**

Modifications which dramatically increase cylinder pressure, such as: very high compression, blowers or nitrous usually require drilled type forgings. Engines that see only occasional wide open throttle use, as in towing or moderate street performance, are best off with Hypereutectics. Applications which fall between these extremes can use either piston type, with the decision based on cost, desired strength and future plans for the vehicle.