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PBS-FIAT 124/131 TWIN CAM RACING ENGINES

This brochure describes the various high performance parts which PBS manufactures for the Fiat 124/131 series twin cam engines. These engines are used in various Fiat models. Five different combinations of bore and stroke have been used to give stock displacements of 1438cc, 1592cc, 1608cc, 1756cc and 1995cc.

The 1438cc engines have the ignition distributor located in the left front corner of the engine block. Most of the larger engines have the distributor located on the exhaust cam box. By changing the appropriate parts, the distributor can be relocated from one place to the other on any of the 124/131 twin cam engines.

Two different stock bores and four different strokes are used in the five engine sizes. The 1438cc, 1592cc and 1608cc engines all have a stock bore of 80mm. The 1756cc and 1995cc engines have an 84mm bore stock. The strokes are as follows: 1438cc - 71.5mm, 1592cc - 79.2mm, 1608cc - 80mm, 1756cc - 79.2mm and 1995cc - 90mm.

The 1438cc and 1608cc have the same bore and bore spacing. The 1608cc block is taller to accomodate the longer stroke and the rod journals are larger by .107 inch. It is possible to put the 1608cc crank into the 1438cc block. This requires grinding the rod journals .107 inch smaller in diameter and cutting the counterweights smaller for clearance. The 1438cc rods and special pistons with a different pin height are required. This combination would be legal for a GT-3 engine for SCCA racing.

The 1592cc, 1756cc and 1995cc engines all have the same bore spacing, which is greater than that used on the 1438cc/1608cc engines. The 1592cc and 1756cc engines use the same crank and rods and the same block height. They, basically, differ only in bore size. However, the 1592cc cannot be bored to 1756cc as the water jacket is different. The 1995cc engine has a taller block, a larger crankcase and longer rods as well as the longer stroke.

The 1995cc crank can be fitted to the 1756cc block by cutting the counterweights, relieving the crankcase for rod clearance, and using the 1756cc rods with special pistons. This would be legal in the GT-2 class but not for E Production which requires stock length connecting rods.

The cylinder head combustion chamber spacing is the same on all of the twin cam engines. This spacing is matched to the 1438cc and 1608cc series engines. Hence the end bores are offset somewhat from the centers of the combustion chambers on the 1592cc, 1756cc and 1995cc engines. The basic cylinder heads are physically interchangeable between all the different sized engines except for the water jacket opening at the front of the head at the head-block interface. The 1438cc and 1608cc heads have a larger opening at this location which is too close to the front cylinder to be used on the 1756cc and 1995cc blocks.

The distributor on the 1438cc engine is mounted on the left front corner of the block and driven by a jackshaft. The distributor on all the other sized engines used in the U. S. version cars is mounted on the exhaust cam box and driven by a gear which is integral with the exhaust camshaft. The larger engines all have the original block mounts also and some European engines use the block mounted distributor on the larger engines. Any engine which uses multiple carburetors must have the exhaust cam driven distributor to allow room for the front carburetor.

The 1592cc, 1756cc and 1995cc engines are longer than the 1438cc/1608cc series engines and the motor mount bosses are located in a different position. However, this is compensated for in the motor mount brackets which bolt to the block. Thus the different sized engines will mount in any car by using the motor mount brackets which match the engine to be used.

The flywheel and clutch sizes vary from model to model. In general the flywheel and clutch must be compatible with the transmission bell housing. Thus, if a late engine is bolted into an early car, the early type clutch and flywheel should be used. Some 1756cc and all 1995cc engines use larger flywheel bolts than the smaller engines. In order to bolt an early flywheel on these engines, the flywheel must be drilled for the larger bolts.

Carburetion Modifications - A number of different carburetion systems are available for various high performance applications with the 124/131 twin cam engines. These include modified 34 DMSA two throat carburetors for F and G Production SCCA racing, twin 40 IDF carburetors for E Production racing, twin 48 DCOE carburetors for GT-2 racing and twin 45 DCOE carburetors for GT-3 cars. Note that the twin carburetor setups cannot be used on engines with a block mounted distributor. Also, the side draft DCOE carburetors require moving the brake master cylinder and booster for most applications.

The 34 DMSA Weber carburetor is the largest stock carburetor supplied on these engines. It has two 34mm throttle butterflies and stock venturi sizes of 25mm and 27mm on the primary and secondary sides respectively. For F and G Production racing, the venturis are bored 4mm and the jets are changed. Several different stock manifolds were used on the twin cam engines. Some of these are quite restricted. The best stock manifold for racing use is the one supplied on the 1974 1756cc engines.

Of the various twin carburetor setups available, the one which provides the best combination of engine flexibility, power and fuel economy is the twin Weber 40 IDF-13 and -15 package. These particular carburetors were offered as an original equipment, European performance option on the 1608cc Spider. They come with 32mm choke tubes which are adequate for many high performance applications. When operated at the same performance level, these carburetors typically will provide lower fuel consumption than a stock, single, two throat carburetor because of improved fuel distribution with the twin carburetors. PBS manufactures a manifold for the 40 IDF carburetors which is similar to the European Fiat manifold except that the PBS manifold does not have a water jacket. An air filter and a linkage kit suitable for cars equipped with cable throttles are also available. Early cars will require fabrication of a throttle cable installation.

Larger choke tubes can be fitted to the 40 IDF carburetors. In conjunction with relatively radical camshafts, this will increase peak power output at the expense of some low speed flexibility and fuel economy for SCCA E Production racing.

PBS can supply two different side-draft intake manifolds for the 124/131 engines. The twin 48 DCOE carburetors and manifold are recommended for GT-2 racing with the two liter engine. These carburetors are too large for the smaller engines and more power is available by using twin 45 DCOE carburetors and the matching manifold for GT-3 size engines.

Other suppliers sell different carburetor setups for the 124/131 engines. PBS doesn't offer these because our experience indicates that the performance of these systems is unsatisfactory. For example, larger single carburetors such as the 40 DFI cannot be jetted to provide a reasonable combination of power, driveability and fuel economy. Twin DCNF type carburetors are not suitable for in line mounted four cylinder engines because they will run lean when cornering in one direction and rich in the opposite direction. This results because of the offset float bowl on this type of carburetor. The DCNF carburetors will work with V-type engines or with transversely mounted engines where the float bowl can be mounted toward the front of the car.

Camshafts, Valves and Valve Springs - At PBS, we grind a number of different cam profiles to suit various applications. Table A lists data for several of these. In general, the bigger the cam, the more peak power the engine makes and the less low speed torque it has. A good compromise, for many 124/131 applications, is to use a milder cam on the exhaust side than on the intake side. This gives a wider usable power band than using the big cams on both the intake and exhaust. However, for absolute maximum peak power, a large cam is required on both sides in conjunction with improved induction and exhaust systems. It is, of course, possible to have more cam duration than the engine can tolerate and end up with a loss in power at all speeds. Typically, the longer the stroke of the engine, the more cam duration it can use. Thus, the larger cams are most suitable for the larger engines.

For maximum racing performance the valves and ports can be increased in size to aid breathing. However, this is a waste of time and money unless the rest of the induction and exhaust system is also opened up, since the stock valves and ports on the twin cam engines are adequate for moderate performance increases.

Cam timing is also important with the twin cam engines and should be carefully checked and adjusted as required for optimum performance. The best timing will depend on the application and the cam profile, etc. Generally, a good place to start is with the lobe centers at about 108° with high performance cams. Measuring this requires a degree wheel mounted on the crankshaft. A simpler way of checking the timing is to measure the valve lift at T.D.C. on overlap with a dial indicator at the valve lifter. This lift will be a function of the cam profile and the desired timing. PBS specifies the lift at T.D.C. during valve overlap for the cams which we grind. In order to adjust the timing it is necessary to either use adjustable cam sprockets or to redrill the index pin hole in the stock sprocket.

Pistons and Combustion Chamber - For racing with a naturally aspirated twin cam engine, high compression forged racing pistons are recommended. This assumes that high octane (100+) fuel is to be used. If normal pump gasoline must be used the compression ratio should not be raised significantly. Domed pistons designed to provide higher compression with the stock combustion chamber don't work well because the dome interferes with the flame travel. PBS machines pistons with a conical section dome which requires matching machine work on the cylinder head combustion chamber. The end result of this piston-chamber combination is a very tight squish area on the fore and aft areas of the combustion chamber. This promotes combustion turbulence and results in a complete and rapid burning of the air-fuel charge.

Oil System - The 124/131 engine lower ends are very durable provided they are adequately lubricated. They have gained an undeserved reputation for being fragile because of problems with the oil system encountered during racing conditions. The stock oil pumps have more than sufficient flow capacity. The oil pressure is easily adjusted upward by installing a stiffer by-pass relief spring. Generally, a pressure of about 85 psi is adequate for racing applications with these engines. However, just boosting the pressure is not enough to ensure reliable lubrication. In fact, it is likely to cause more problems than it helps.

It is essential to maintain oil around the pump pickup under all racing conditions since the bearings will not tolerate air in the oil. Raising the oil pressure alone actually decreases the oil level in the pan at high rpm because the increased pressure feeds oil up to the cam boxes at a higher rate. The cam boxes will fill with oil and can store a substantial fraction of the oil supply. This problem coupled with high speed cornering, etc., invariably results in bearing oil starvation unless the oil system has been extensively modified for racing.

Whenever the oil pressure is raised, the flow to the cylinder head must be restricted and the drain backs enlarged and lowered to minimize storage of oil in the head. The oil is fed to the head through six holes. These should be plugged in the head and redrilled to 1/16" diameter. The drain back passages in the cam boxes can be opened up by drilling 1/2" holes into them from inside the cam boxes below the level where the oil normally drains.

For racing, it is also necessary to either use a dry sump oil system or to have a very well baffled wet sump system and run the oil level about one quart high to maintain a sufficient head of oil above the pressure pump pickup at all times. The baffle for either the wet or dry sump system should effectively cover the entire area between the pan and the block except for a narrow, longitudinal slot and scraper running down the center of the baffle. This will prevent oil from climbing the walls and getting back into the crank area at speed. We have observed power losses of as much as 40 BHP due to oil being churned around by the crank in an inadequately baffled engine.

For sustained high rpm, high load running, these engines must be fitted with good oil coolers as the oil normally heats up faster and hotter than the water does.

Turbocharging - The Fiat twin cam engines respond extremely well to turbocharging. The cross flow head has ample cooling around the exhaust ports and combustion chamber to handle the increased thermal loads. The relatively low stock compression on the later engines and the mild stock cam profiles work well for moderate boost (7-9 psi). As with any other performance modification, turbocharging involves a compromise between factors such as low speed torque, peak horsepower, throttle lag, system cost and complexity and reliability. The installation must be carefully engineered as a system to ensure good results for the intended application. For example, the compressor must be sized to be operating in a high efficiency region of its performance map. The turbine and its housing must be sized to provide the desired compromise between the throttle lag and low speed boost on one hand versus minimum back pressure for peak power on the other.

Carbureted systems can be made either to blow through the carburetor or to draw through the carburetor. Blow through systems have advantages of slightly improved throttle response, particularly during warmup, and a little lower cost. However, the pressurized carburetor frequently has reliability problems as does the regulated high pressure fuel pump required. If metal floats are used in the carburetor, they may collapse or crack and leak. Also, the blow through carburetor has a problem of boiling the fuel when used for mountain driving where it is alternately subjected to heated, compressed air and then to rarified air when the throttle is lifted. The heated fuel in the float bowl will boil when the air pressure drops to atmospheric at high altitude and will probable drown the engine with excess fuel.

We prefer the draw through type system when using a carburetor because of better reliability. In any case, the carburetor must be modified to incrase fuel delivery at the high air flow rates achieved with the turbocharger. Obviously the increased fuel flow is not required at part throttle with no boost, so just increasing jet sizes throughout the carburetor would be undesirable. For this reason, a two throat, progressive linkage carburetor works better for turbocharging than one without progressive throttle linkage. Under light load conditions operation is normally confined to the primary throat. When maximum performance and boost is required, both throats will be open. Thus the secondary throat can provide the necessary fuel enrichment for boost conditions while the primary throat provides the proper mixture for part throttle operation. In addition, it is necessary to use a needle and seat which is large enough to supply the maximum required fuel flow rate at sustained power levels.

Given the right conditions, any engine can easily be destroyed in seconds by a turbocharger. The primary cause of such failures is detonation. Thus to achieve the desired combination of high performance and reliability it is essential to engineer the system to prevent destructive detonation while still maintaining a useful gain in performance and efficiency. To accomplish this the boost must be limited to a value compatible with basic parameters such as compression ratio, combustion chamber design, ignition timing, fuel type and quality, charge temperature, etc. Boost can be limited by a combination of turbo sizing coupled with exhaust and/or intake restrictions. Better performance, efficiency and tuning flexibility can be obtained by using either an exhaust waste gate or an intake pressure relief valve, however. These types of controls allow turbo sizing for good response and optimum efficiency at peak power. Exhaust waste gates, if used, must be high quality devices to ensure reliability since sticking of the waste gate will quickly lead to an overboost condition.

In addition to boost control it is necessary to employ one or more other detonation control schemes. These include reduction of compression ratio, ignition timing retard, water or water/alcohol injection, charge intercooling, etc. Of these, PBS has chosen ingition retard as the primary detonation control in addition to boost control. The ignition timing is only retarded during boost and, in fact, we use more advance than stock at low engine speeds without boost. This provides good low speed response and safe operation under boost. Dyno testing indicates that the retard, under boost, doesn't hurt power output since the extra tubulence and pressure promotes faster combustion and therefore requires less advance. Also, extra heating of the exhaust gases, caused by later than optimum timing, adds energy to the exhaust turbine and improves its performance. This effect cannot be taken to extremes, however, or the turbine will be damaged from excessive temperature.

Our experience with the 1800cc and two liter twin cam engines indicate that if boost is limited to the 7-9 psi range, depending on fuel octane, detonation control can be achieved with ignition retard under boost only. Additional boost pressure (up to 12 psi) can be tolerated with the addition of a good proportional water injection system. Boost pressures as high as 20 psi can be used in these engines with a combination of ignition retard, water/alcohol injection, compression reduction (6 to 1) and charge intercooling. The engine will live under these boost levels, but the Fiat driveline will be stressed beyond its capability.

The Bosch fuel injected two liter twin cam engines can be turbocharged quite readily by inserting the compressor between the mass-air-flow sensor and the induction manifold. Boost control can be handled with either an exhaust waste gate or an induction mounted, air, pop-off valve. In order to make additional horespower, however, the electronics must be tricked into delivering additional fuel to match the higher air flow rate achieved with the turbo. The maximum power increase is limited by the fuel supply capability of the electronic fuel injection system.

1800cc Stroker/Big Bore Kits - The 1800cc 124/131 twin cam engines can be enlarged to about 2100cc by using the two liter crank and 2mm larger diameter pistons. This requires minor machine work inside the 1800cc block for connecting rod clearance. PBS can supply the required parts for this conversion.

Ignition Systems - The 124/131 series engines have been fitted with several different distributors in the various models. The 1438cc block mounted distributors, the 1608cc exhaust cam driven distributors and the 1995cc electronic distributors all have a centrifugal advance of 14 degrees at the distributor. The dual point distributors fitted to the other engines have 19 degrees centrifugal advance at the distributor. For racing, the 14 degree distributors are best. If a point type distributor is desired, the best exhaust cam driven unit is Fiat P/N 4272975. This is fitted with a light weight, balanced nylon rotor which works well at high rpm. Alternatively, one of the dual point distributors can be modified by replacing the inboard, advance-weight stop with one of larger diameter to restrict the total distributor, centrifugal advance to 14 degrees (28 degrees at the crankshaft.)

Exhaust System - For competition use on the naturally aspirated twin cam engines we use custom built headers having 1 3/4" O.D. primary pipes. These are 26 inches long and feed into a collector followed by a 2 1/2" O.D. tailpipe. PBS doesn't supply these headers.

Flywheel and Clutch Assemblies - For competition use, the flywheel and the clutch must be modified so that downshifting at high speed will not damage the clutch pressure plate. If this is not done, the reversed loads when the engine is used for braking (either intentionally or inadvertently) will buckle the drive straps on the pressure plate and cause a severe unbalance. This is immediately followed by the flywheel shearing off the flywheel attaching bolts.

The flywheel is modified by installing three large dowel pins. The pressure plate has three bosses which are drilled and reamed to fit over the three dowel pins. These pins provide drive torque in both directions and prevent the clutch drive straps from buckling under reverse loads.

The flywheel can be lightened by machining material away on the back side. Sufficient material must be left to provide adequate support for the large dowel pins.

The flywheel and pressure plate must be balanced after modifications are complete.

A sintered metallic clutch disc is recommended for racing. This and the modified flywheel and pressure plate are all available as an assembly from PBS.

The sintered metallic clutch disc is not recommended for street use because it must be broken in properly to give satisfactory results. Break-in procedure involves slipping the clutch until it heats the flywheel and pressure plate surfaces enough to glaze them. This results in a hard, wear resistant surface on the cast iron parts. If a material other than cast iron is used for the flywheel, it must have a hardened clutch surface to be compatible with the metallic disc.

PBS can supply complete racing engines as well as the full range of competition parts for the 124/131 series engines. Refer to the price list for current availability and pricing on engines and parts.

referenced
on P. 4

TABLE A

CAMSHAFT DATA

CAM	SEAT-TO-SEAT TIMING USING 110° LOBE CENTERS AND SPLIT OVERLAP (ref. only)	SEAT-TO-SEAT DURATION CRANK DEGREES (ref. only)	DURATION @.050" GROSS LIFT CRANK DEGREE	GROSS PEAK LIFT inches	GROSS PEAK LIFT mm
124/131 STOCK	20-60, 60-20	260	224	.372	9.45
S-2	30-70, 70-30	280	238	.380	9.65
L-1	40-80, 80-40	300	252	.407	10.34
B-3	40-80, 80-40	300	256	.415	10.54
F-1	47-87, 87-47	314	270	.407	10.34
F-2	45-85, 85-45	310	262	.462	11.73
Z-1	50-90, 90-50	320	278	.428	10.87