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BMW Engines, Heads, Differentials, Flywheels & Transmissions

M3 Engine Series

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October 2006

Metric Mechanic's M3 Engines

M3/S14 Engine Specifications

	Engines	MM 2500 HiFlo ST Sport	MM 2500 HiFlo ST Rally	MM 2500 HiFlo ST Race	BMW 2300 M3 Stock
Engines	Displacement	2465 cc	2465 cc	2465 cc	2300 cc
	Bore	95 mm	95 mm	95 mm	93.4 mm
	Stroke	87 mm	87 mm	87 mm	84 mm
	Compression Ratio (Advert)	11.5:1	12.5:1	13.5:1	10.5:1
	Compression Ratio (Real)	(10.7:1)	(11.5:1)	(12:6:1)	(9.7:1)
Cylinder Head	Intake Port Diameter	29.5 mm	30.5 mm	31.5 mm	26 mm
	Flow Increase	16 %	20 %	23 %	0
	- with Ported Manifold		22.5 %	26 %	
	Intake Valves	37 mm ST	37 mm ST	37 mm ST	37 mm
	Exhaust Valves	33 mm ST	33 mm ST	33 mm ST	33 mm
	Valve Guide	Manganese Bronze	Manganese Bronze	Manganese Bronze	Bronze
	Intake (Duration / LIft)	240° / 10 mm	260° / 11.3 mm	290° / 11.7 mm	240° / 10 mm
	Exhaust (Duration / Lift)	240° / 10 mm	240° / 10 mm	260° / 11.3 mm	240° / 10 mm
	Valve Spring Pressure	85 lbs. / 160 lbs.	85 lbs. / 166 lbs.	85 lbs. / 170 lbs.	73 lbs. / 177 lbs.
Block	Piston	Forged Alusil Vented Skirt	Forged Alusil Vented Skirt	Forged Alusil	Cast
	Piston Weight	398 grams	395 grams	354 grams	475 grams
	Wrist Pin Weight	89 grams Tappered	89 grams Tappered	71 grams Tappered	120 grams Straight
	Rod Design	"I" Beam	"H" Beam	"H" Beam	"I" Beam
	Connecting Rod	675 grams	515 grams	515 grams	675 grams
	Crankshaft Stroke	87 mm	87 mm	87 mm	84 mm
	Weight lbs. (kg)	37.5 lbs. (17 kg)	37.5 lbs. (17 kg)	37.5 lbs. (17 kg)	44 lbs. (20 kg)
	Oil Pump	Blue Printed with Bronze Sleeved Relief Valve Hole			Stock
	Oil Pan Baffle	Raised Cornering Baffle	Raised Cornering Baffle	Raised Cornering Baffle	Stock Cornering Baffle
Engine Output	Horse Power / rpm	235 HP /6750 rpm	255 HP /7250 rpm	285 HP /7750 rpm	192 HP /6750 rpm
	Torque / rpm	192 ft. lbs. /4750 rpm	195 ft. lbs. /5250 rpm	200 ft. lbs. /5750 rpm	170 ft. lbs. /4750 rpm
	60 - 80 mph	4.2 seconds	3.8 seconds	2.9 seconds	5.1 seconds

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General Engine Description

Straight from the factory, BMW M3's are great performance sedans! With their bigger brakes, better suspension and more powerful high rev engines, the M3 engine is strong, well built and reliable even though more aggressively driven. The average engine life expectancy is about 140,000 to 150,000 miles.

But some owners feel the M3 lacks low to mid-range rpm "grunt". In other words, it doesn't pull to their liking below 4,500 rpms. Metric Mechanic's "fix" is to enlarge the engine. We up the bore from 93.4 mm to 95 mm and increase the stock 84 mm stroke to 87 mm. Enlarging the intake ports from 26 mm to 29.5 mm, helps the engine breath.

The net result is a bigger engine with improved low end and mid range torque, and expanded top end breathing - in other words - a 2.5 liter M3.

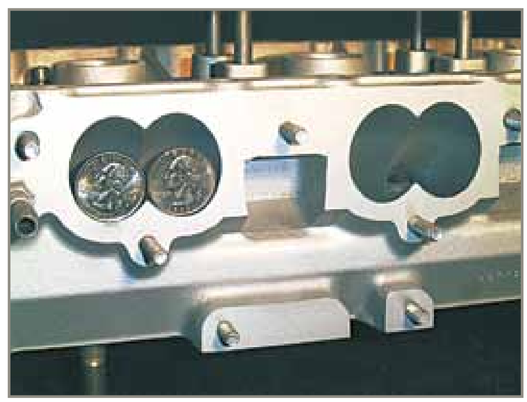
Metric Mechanic 2500 HiFlo ST M3 Engine - 235 HP

M3 Engine Anatomy

Head

Porting the 4 Valve M Head

A 16.5% flow increase is achieved by machining the intake ports to 29.5 mm (26 mm stock). See "Metric Mechanic HiFlo ST M3 Head" chart on the next page. By using stock cams and porting, the engine ends up with a very flexible power band on the street. Stock camming also helps the engine pass emissions.



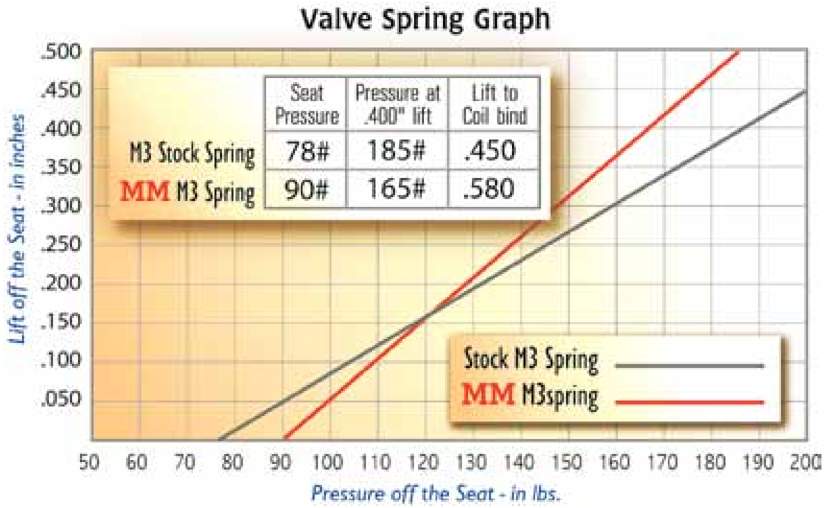
Metric Mechanic 29.5 mm M3 Intake Ports compared to stock port sizes which are about the diameter of a quarter

ST Valves & Guidelines

Our ST valves (Surface Turbulence) improve fuel economy, reduce emissions and detonation and facilitate easy tuning. Surface turbulence looks like concentric grooves machined into the head of the valves. We also replace the stock valve guides with extremely wear resistant manganese bronze guides. The valve springs we use increase the seat pressure by about 20% to reduce valve float and they decrease the nose pressure by about 15% to reduce wear on the valve train.

MM Surface Turbulence valves with Manganese Bronze valve guides

2500 Sport M3 Engine

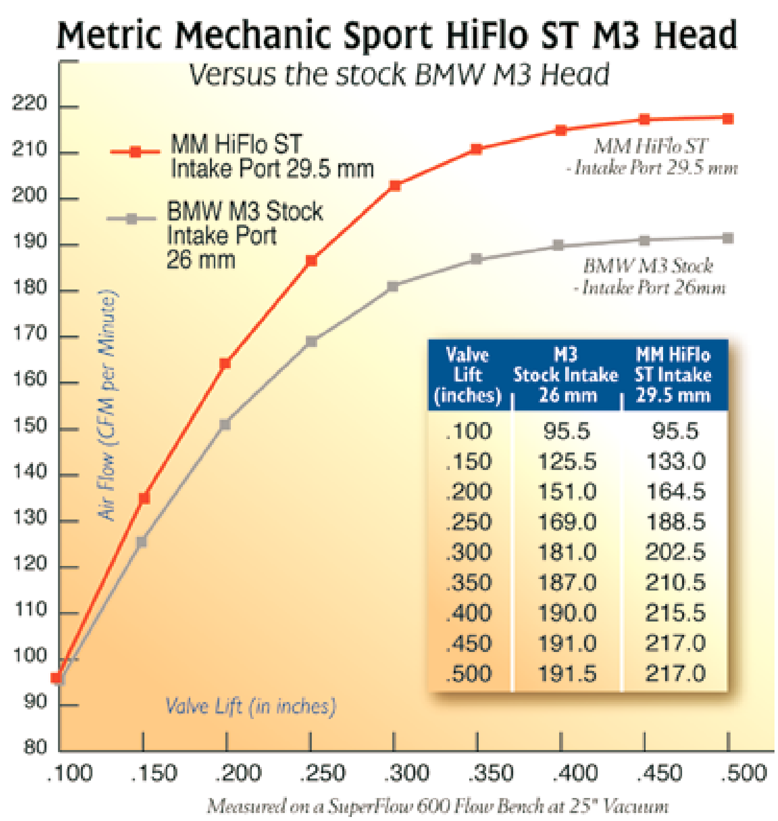


	Seat Pressure	Pressure at .400" lift	Lift to Coil bind
M3 Stock Spring	78#	185#	.450
MM M3 Spring	90#	165#	.580

Comparison of valve spring pressure between the stock and MM M3 valve springs

Port Size

We broaden the power band on our 2500 M3 HiFlo engine by using a 29.5 mm intake port. You might think that a 31.5 mm intake port (such as used in our M3 race engine) would be a hotter choice. However, these larger ports reduce flow velocity at lower engine speeds which most drivers find unacceptable for street use.

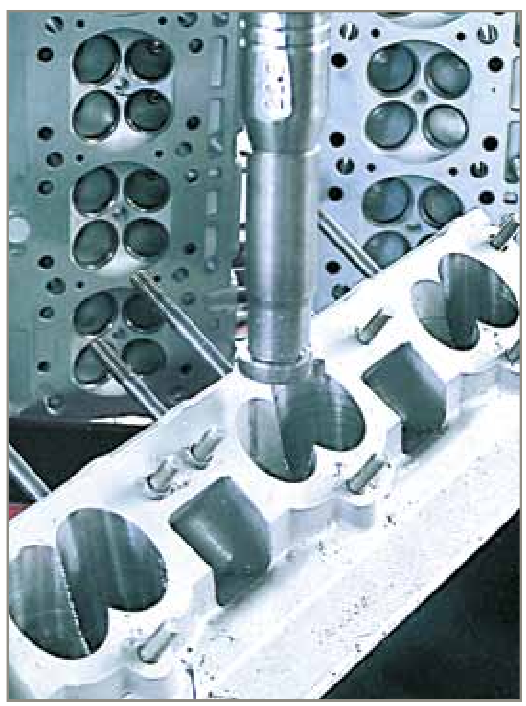


Valve Lift (inches)	M3 Stock Intake 26 mm	MM HiFlo ST Intake 29.5 mm
.100	95.5	95.5
.150	125.5	133.0
.200	151.0	164.5
.250	169.0	188.5
.300	181.0	202.5
.350	187.0	210.5
.400	190.0	215.5
.450	191.0	217.0
.500	191.5	217.0

Stock M3 double wound springs on the left and Metric Mechanic double wound springs on the right

Valve Springs

Our springs are taller with a slightly reduced wire diameter. The stock spring exerts 78 lbs. of pressure on the valve seat and 185 lbs. on the nose of the cam at full lift. Our MM valve increases the seat pressure to 90 lbs. and reduces the nose pressure to 165 lbs. Reducing the pressure differential between the seat and the nose of the cam, saves wear and tear on the cam chain and guide rails. Reducing the nose pressure adds longevity to the cam and the valve train.



M3 ports are precision machined by passing a special 29.5 mm cutter down the stock 26 mm intake ports. This method of porting offers high flowing ports that consistently flow the same

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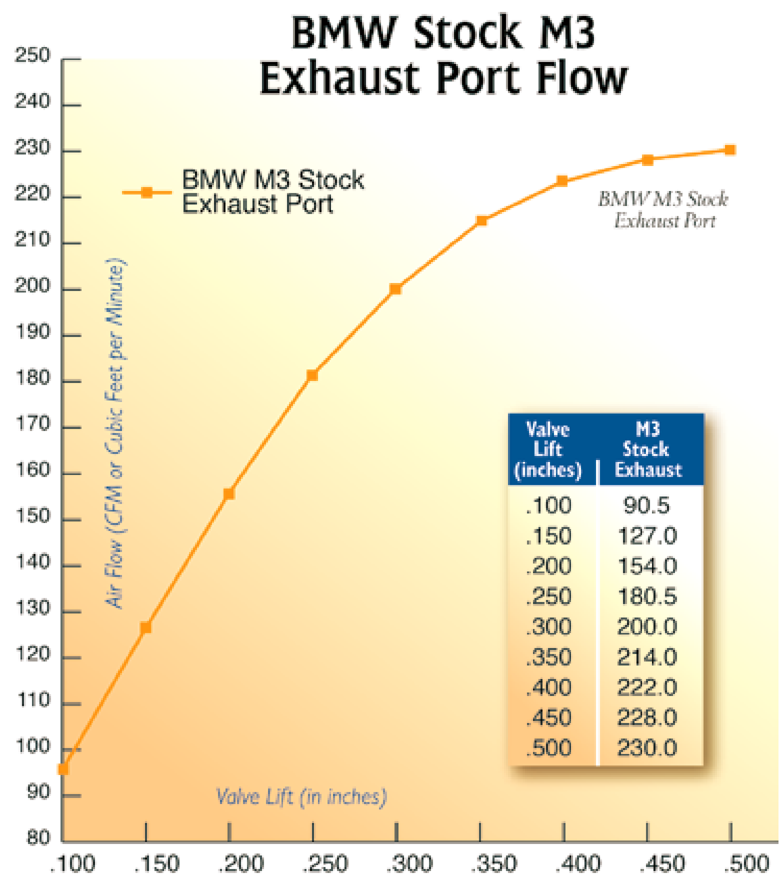
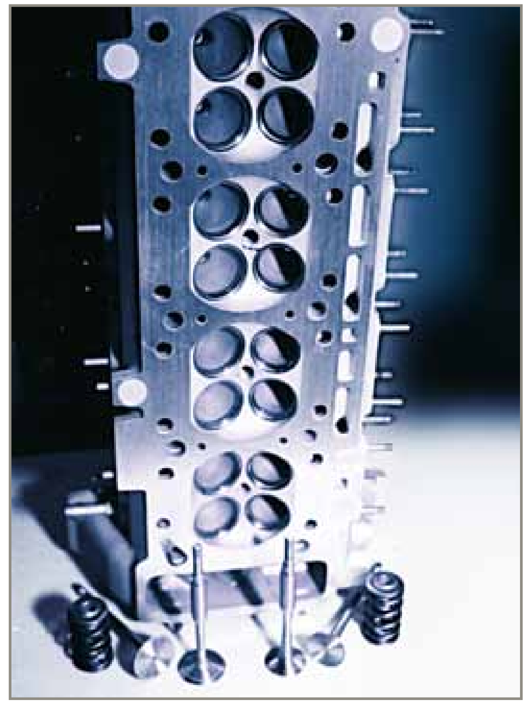


Valve Lift (inches)	M3 Stock Exhaust
.100	90.5
.150	127.0
.200	154.0
.250	180.5
.300	200.0
.350	214.0
.400	222.0
.450	228.0
.500	230.0

Measured on a SuperFlow 600 Flow Bench at 25" Vacuum

Metric Mechanic Ported M3 Head



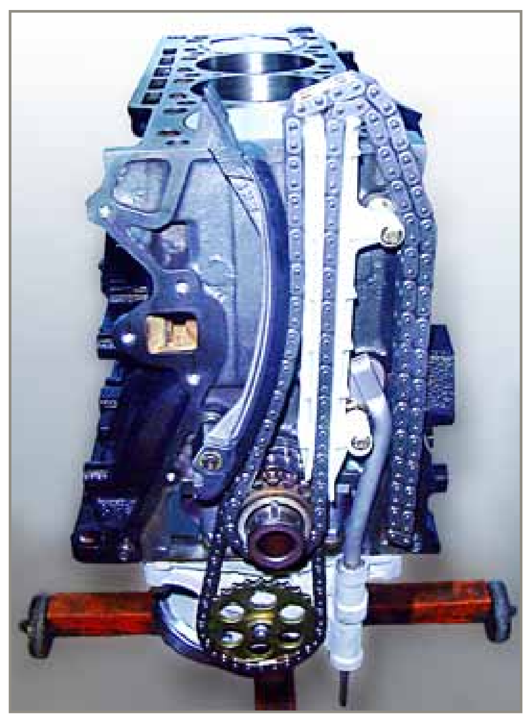
The M3 combustion chamber is 43 cc, ST intake valves are 37 mm & the ST exhaust valves are 33 mm (ST means Surface Turbulence concentric grooves & steps machined into the valves)

Exhaust Flow

On a well designed engine, exhaust flow would be 85% of the intake flow. On the stock M3, exhaust outflows the intake side by 120%!!! We do not modify the exhaust ports in an attempt to improve this already excellent flow.

Timing Chain Assembly

In the Metric Mechanic M3 engine rebuild, we replace the timing chain, guide rail, tensioner arm and tensioner piston. Unlike a single over-head cam engine in which these parts generally sell for $100, this assembly is 5 times the price at $500. To save wear and tear on this costly assembly, we use valve springs that reduce the load on the valve train. By reducing the pressure differential between the nose and the seat pressure, our valve springs reduce chain snatch or jerking. Also, by lowering the nose spring pressure, they reduce chain pull which in turn reduces chain stretch.



The M3 timing chain assembly

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Sport 2500 M3 Engine

Wrinkle painted M3 Valve Cover and Plenum Box

When popping the hood of an M3, the valve cover and plenum box stand out immediately. We restore these components purely for their cosmetic aesthetics and think they look damn good.

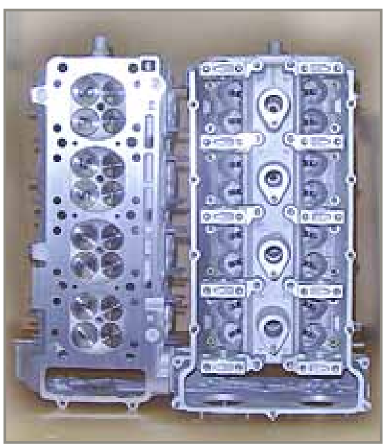
The valve cover and plenum are thoroughly cleaned, wrinkle painted and baked, letters are surfaced, and a final clear coat applied.

The M3 Valve Adjustment

The M3 valve adjustment is .013" plus or minus .001". This space is created by changing out an assortment of 33 mm diameter shim pads ranging in thickness from 3.25 mm to 4.35 mm. After performing a valve job on an M3 head, extra care must be taken to avoid going beyond the high or low side of the shim pad thickness during the valve adjustment. To avoid coming up short, we use one of two methods.

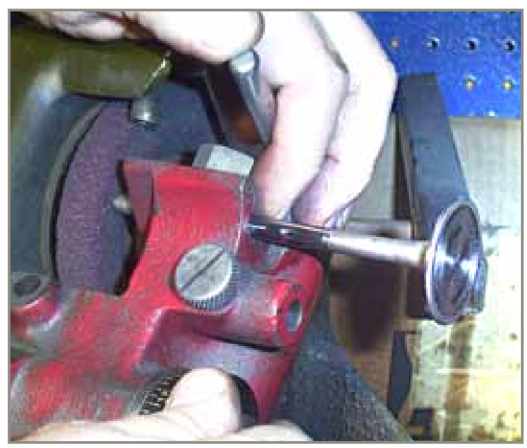
Method #1 is standard procedure used on heads sent in for porting. After the valves and seats are ground, .007"- .010" must be removed from the valve stem to position the valve approximately in the middle of the shim range. On completion, the shim pads will vary in thickness because each seat and valve is ground a little differently.

Method #2 is a more accurate and more expensive option for heads sent in for porting. However, it's standard procedure on all heads we prepare for a complete M3 engine rebuild. First, with the valve springs removed so that the valve slides in and out easily, we pre-assemble the head using 3.75 mm or 3.80 mm shim pads. Then, using a valve grinder, each valve stem is individually ground to produce .013" valve lash. On completion with this method, there is very little variation from the initial pad setting of 3.75 mm or 3.80 mm.



After grinding the seats and valves, valves are mated with their guides and numbered front to back

The shim pads, cam buckets, and cams are installed in the cam box which is then bolted to the head. Having done this, it's possible to check the valve lash. This is done by pushing the valve firmly up against the seat and using a feeler gauge to check the clearance between the back side of the cam (opposite the nose) and the shim pad.



Cutting the valve stem on a valve grinder using the micrometer knob to precisely measure material removal

After grinding the stem for the valve clearance of .013", the shim pads are numbered to correspond with the valves they're matched with

Upon final assembly, half the valves will usually be within our specifications, with the others needing only minor shim adjustment

Block

Larger Pistons

We over bore the M3 engine by 1.6 mm in order to use a larger 95 mm 11.5:1 CR high silicon content (17% silicon) forged piston that is also about 15% lighter than stock. On the picture to the right, notice our MM piston with vented skirt and the two larger half moon quench pads which are used to induce more turbulence in the combustion chamber under compression. The stock wrist pin that weighs 130 grams is replaced with a 89 gram tapered wall wrist pin.

Left: a stock M3 piston and pin
Right: MM's forged alusil piston and pin setup

Left: Metric Mechanic's tapered wall wrist pin
Right: a stock M3 wrist pin

Crankshaft

We use BMW's European Evolution M3 Crank with an 87 mm stroke. This model is 6.5 lbs. lighter than the crankshaft in the USA 2.3 liter M3 and the stem line counterweights on this 2.5 evolution crank, help reduce windage drag on the crankshaft. Also, we increase oil feeding to the rod bearings via the main bearings which have extra oil feed holes.

Foreground: the 2.5 Euro Evolution M3 crankshaft
Background: the stock USA 2.3 crankshaft

Oil Pan

Often, M3 owners have upgraded their suspension for increased handling. Understanding this, we extend the height of the corning baffle in the oil pan to prevent oil starvation to the oil pump pick-up under hard M3 cornering.

MM baffle extension bolted into the lower oil pan

Flywheel Options

For street use, we lighten the stock M3 flywheel from 17 lbs. to 12 lbs. by machining down the backside. We can take it down further to 11.5 lbs., by machining a "U" channel groove in the ring gear. This greatly improves "off the line" acceleration.

Foreground: 11 lb. lightened M3 flywheel for street use
Background: 10 lb. with "U" channel groove cut in the ring gear for street or driver's school use

MM 2500 HiFlo ST M3 Rally Engine - 255 HP

Cam and Lifter Design

The stock M3 cam is an excellent short duration design. So naturally, we based our M3 rally cam on it's unique nose action that is described below.

Metric Mechanic's M3 rally cam reaches peak HP at 7250 rpm with a mild cam duration of 260° at .020" lift. Hitting this same rpm in a single overhead cam M10 engine, requires a cam with more than 300° duration. This difference is due to the quicker rate of valve opening and closing on an M3.

Also, the space between the valve face and seat is 60% greater in the four valve M3, S14 engine versus the two valve M10 engines (2002, 320i, & 318i).

The M3 cam pushes fairly aggressively against the lifter (shim pad and bucket). Once the cam ramp becomes parallel to the shim pad, valve lash is taken up and the nose pushes the lifter down. While M3 cams work off the nose, the M10 single overhead cam works off the ramp as the rocker arm "walks up" the side of the ramp before reaching the nose. This slower motion requires more duration. Long duration cams tend to have problems with emissions, rough idle, low speed driveability, and low end torque.

Left: MM Rally Intake Cam
Right: Exhaust Cam

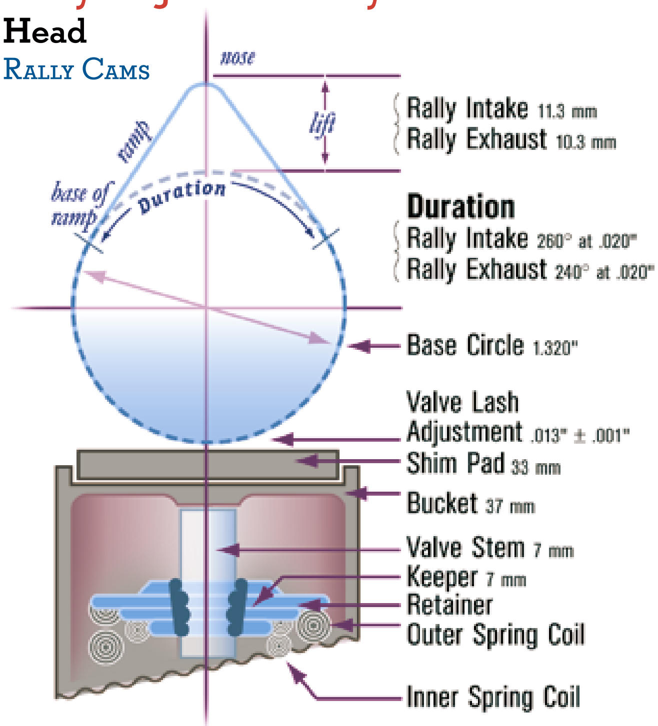
General Engine Description

Intended for a more aggressive driving style, this is our "hottest" engine for street use and driver's school events. With higher compression and a more radical intake cam, power is up 10% over the Sport 2500 HiFlo ST M3 engine. Be prepared to give up some low end torque for more exciting top end performance.

Rally Engine Anatomy

Head

Rally Cams



Intake Cam Specifications
Duration Degrees at Lift Inches

Lift Inches	Stock M3 Duration°	Evo M3 Duration°	MM Rally Duration°
.010"	282°	304°	288°
.020"	**240°**	**258°**	**260°**
.040"	226°	241°	242°
.050"	220°	235°	236°
.100"	200°	213°	214°
.150"	180°	191°	194°
.200"	160°	171°	174°
.300"	114°	126°	130°
.400"	26°	48°	70°
Crankshaft Duration at .020" Lift	240°	258°	260°
Cam Lift at the Nose	.406" or 10.3 mm	.423" or 10.7 mm	.445" or 11.3 mm

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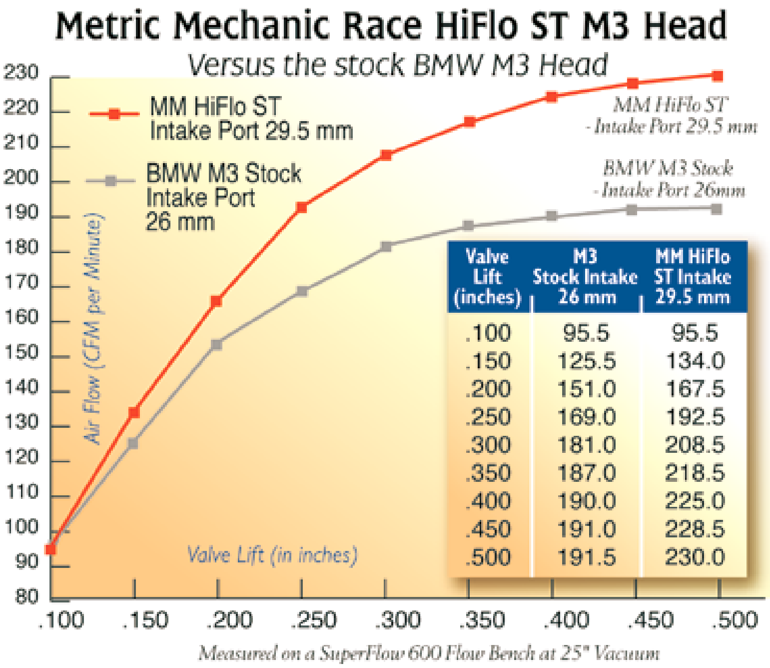


Valve Lift (inches)	M3 Stock Intake 26 mm	MM HiFlo ST Intake 29.5 mm
.100	95.5	95.5
.150	125.5	134.0
.200	151.0	167.5
.250	169.0	192.5
.300	181.0	208.5
.350	187.0	218.5
.400	190.0	225.0
.450	191.0	228.5
.500	191.5	230.0

Porting & Camming

By using larger 30.5 mm intake ports, we are able to match them with the increased intake cam. The engine's torque band is raised for more horsepower by increasing the intake camshaft duration to 260° and upping the lift to 11.3mm. To broaden the engine's power band, the stock exhaust cam, at 240° duration and 10.3 lift, is used.

High Compression Without Detonation

Detonation is greatly reduced in our motors through two routes.

First, our patented "Surface Turbulence" (concentric grooves machined into the valves) mix air and fuel particles for easier ignition.

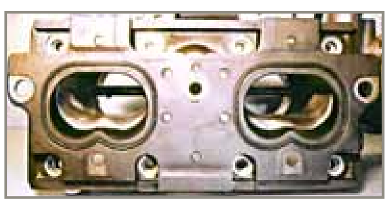
Second, our MM lightweight forged pistons run cooler in the engine, further reducing detonation. Forged aluminum pistons are more dense than the stock cast aluminum pistons and consequently they conduct heat from the skirt to the cylinder wall more quickly - hence the "cooling effect". Our Rally engine running at a 12.5:1 CR can perform well on mid to premium pump gas.

Surface Turbulence Valves

Options

Rally Ported Throttle Body

To match the 260° duration Rally Cam, we enlarged the intake ports to 30.5 mm which increases flow by 20%. When combined with ported throttle bodies, the intake track flow increases 22.5%



Ported Rally throttle body matched to the Evo M3 intake gaskets

Left: Metric Mechanic's 12.5:1, 95 mm Lightweight Forged Alusil Piston. Right: Stock 10.5:1 cast piston

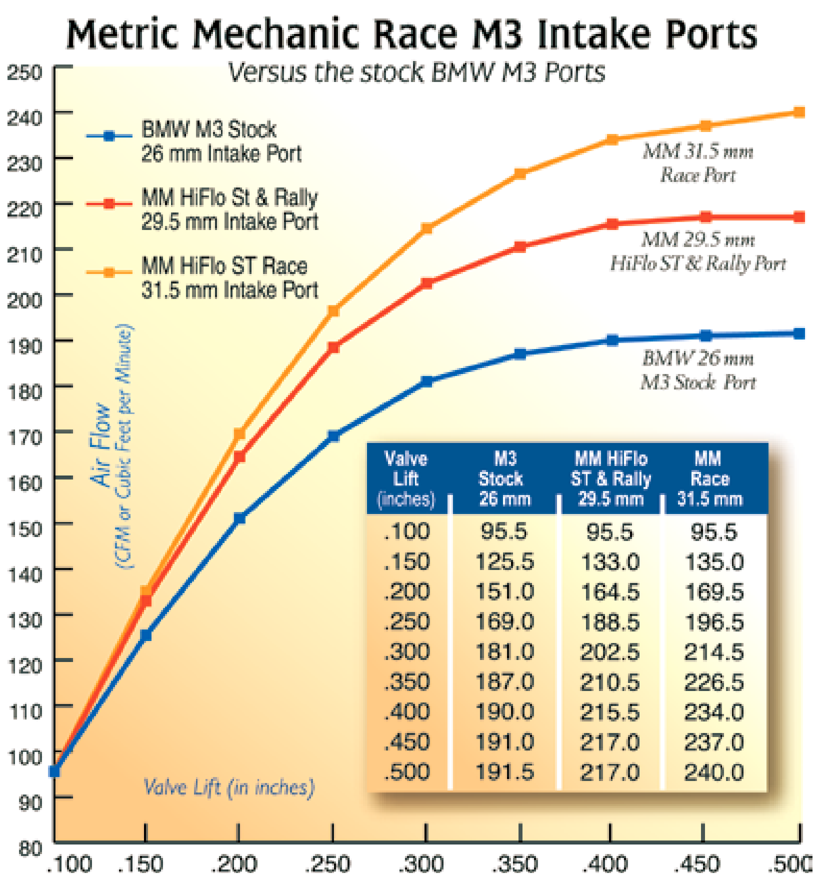
Rally Flywheel & clutch Assembly

We recommend our 11.5 lb. flywheel with a "U" channel groove machined into the ring gear. In the clutch area, we use a rigid clutch disc (822 grams) instead of the stock springer disk (1034 grams). Saving over 1 lb. in weight is significant during synchronized shifting when the gears and clutch disc must change speed. Consequently, our lighter rigid disc allows for slightly quicker shifts and extends synchronizer life.

This clutch assembly is good for 230 ft. lbs. of break-a-way torque.

Rally flywheel and clutch assembly.

Metric Mechanic M3 Race Engine - 285 HP



Valve Lift (inches)	M3 Stock 26 mm	MM HiFlo ST & Rally 29.5 mm	MM Race 31.5 mm
.100	95.5	95.5	95.5
.150	125.5	133.0	135.0
.200	151.0	164.5	169.5
.250	169.0	188.5	196.5
.300	181.0	202.5	214.5
.350	187.0	210.5	226.5
.400	190.0	215.5	234.0
.450	191.0	217.0	237.0
.500	191.5	217.0	240.0

General Engine Description

The E30 M3 is one of the most popular tracked cars at driver's schools and club racing events. They are fairly lightweight, well balanced and tossable. The high revving nature of the stock M3 engine takes well to performance modifications.

For racing, we up the compression ratio to 13.5: 1 using a 95 mm lightweight high silicon content forged piston that are coupled to lightened rods via tapered wall wrist pins. The intake ports are increased to 31.5 mm which is 2 mm larger than our performance engines and 5.5 mm larger than stock. These larger race ports have a 23% flow gain over stock. We also port the intake throttle body for an 8% flow gain and the combination of the head and manifold porting results in a 26% flow gain. The intake cam has 290° duration and 11.7 mm lift. The exhaust cam has 260° duration and 11.3 mm lift.

The following section highlights additional differences in the Metric Mechanic 2500 M3 race engine from the Metric Mechanic 2500 HiFlo ST M3 performance engine.

M3 Race Engine Anatomy

Head

Porting for M3 Racing

When porting the M3 head for racing, we look at the manifold and the head as a unit. As air starts down the air intake trumpet inside the plenum box, the first obstruction it encounters is the throttle shaft. We grind the throttle shaft width down to 4 mm between the throttle shaft screws - to improve air flow over it. Then we port the throttle body and match it to the Evolution M3 rubber base gaskets. From here the intake ports are enlarged to 31.5 mm for a 23% flow gain. In the end, the intake track and head combine to produce the 26% flow increase.

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Mathematically Calculating the Intake Track

Intake Port Sizing

At 26 mm, the stock M3 intake port is fairly restrictive when compared to the 37 mm intake valve. Usually an unrestricted intake port is close in size to the inside diameter of the valve seat (32.5 mm). Our "rule of thumb" is that a good intake port should flow about 85% of the valve head size or 31.45 mm. So, we enlarge the intake port to 31.5 mm. We do not enlarge the intake valves. Some M3 owners think that larger intake valves will increase airflow through the head, but the larger valve heads actually block air flow when delivered through the smaller stock M3 ports. We believe, for racing, the best flow occurs with the 37 mm stock intake valve and intake ports enlarged to 31.45 mm.

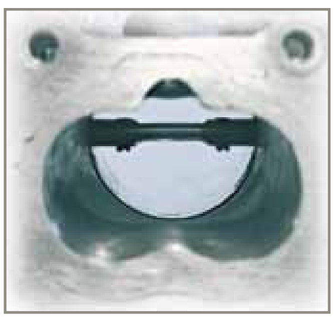
Metric Mechanic 31.5 mm race port
Note: quarters represent approximate size of a stock M3 port

Throttle Body Sizing

Throttle body area needs to equal the area of the two 31.5 mm intake ports which is 1558 sq. mm because $\pi r^2 \times 2$ = port area or $3.14 \times 15.75\ mm^2 \times 2 = 1558$ sq. mm. The area of the 46 mm throttle body is πr^2 = area of the throttle body or $3.14 \times 23\ mm^2 = 1661$ sq. mm.

The reason we port the throttle body and cut down the throttle shaft is because, when the restriction of the 8 mm throttle shaft is figured in, the throttle body comes up slightly shorter in area than the port area.

To us, the lesson here is that big bore throttle bodies and larger valves do not combine to enhance air flow. Rather, the answer is in removing air flow restriction through the stock 26 mm intake ports by enlarging them to 31.5 mm.



Close-up view of our MM ported throttlebody with cut down throttle shaft

Left: Intake Cam with 290° duration at .020" and 11.7 mm lift
Right: Exhaust cam with 260° duration at .020" and 11.3 mm lift

Metric Mechanic Race Cams

Intake and Exhaust

Metric Mechanic Race M3 Cam Specifications
Duration Degrees at Lift Inches

Lift Inches	Race Intake Duration°	Race Exhaust Duration°
.010"	310°	288°
.020"	**290°**	**260°**
.040"	270°	242°
.050"	262°	236°
.100"	240°	214°
.150"	218°	194°
.200"	195°	174°
.300"	150°	130°
.400"	91°	70°
Crankshaft Duration at .020" Lift	290°	260°
Cam Lift at the Nose	.460" or 11.7 mm	.445" or 11.3 mm

Race 2500 M3 Engine

Block

Reciprocating Mass

In a race engine, effort should be made to reduce reciprocating mass (mainly in the pistons, pins and rods), while maintaining structural integrity. This protects the engine from "beating itself apart" at the higher rpms.

Starting with the pistons, if they are designed as light as possible, then the wrist pins can be lightened, which in turns allows for lighter connecting rods which leads to increased rod bearing and crankshaft life.

2500 Race Bottom End - the main objective in lowering the reciprocating mass is to extend the life of the crankshaft

Piston & Pin

The 95 mm, 13.5:1 CR, forged alusil piston we use on race M3's features a flat top design with 4 valve reliefs and weighs 395 grams. The 75 gram tapered wall wrist pins are 20 grams lighter than those used in our 2500 HiFlo ST engines for street use. The combined piston and pin weight in our M3 race engine is 470 grams versus 590 grams for stock. This totals removing 1 lbs of piston/pin weight from the engine.

Left: Metric Mechanic piston & pin
Right: Stock piston & pin

Connecting Rods

The stock M3 rod weighs about 675 grams. For racing, we shave this to 630 grams by removing 45 grams from the small end of the rod - a significant location because at the furthest distant from the center line of the crank - it's the most detrimental weight.

Left: MM lightweight rod
Right: stock rod

Crankshaft

We use BMW's European Evolution M3 Crank with an 87 mm stroke. It's 6.5 lbs. lighter than the USA 2.3 liter M3 crank. Stem line counterweights on this 2.5 crank help reduce windage drag on the crankshaft. Also, we increase oil feeding to the rod bearings via the main bearings which have extra oil feed holes.

Left: stock 2.3 crankshaft
Right: lighter 2.5 crankshaft

Oil Pan

Often, M3 owners have upgraded their suspensions for increased handling. Understanding this, we extend the height of the corning baffle in the oil pan to prevent oil starvation to the oil pump pick up under hard M3 cornering.

Holding a baffle extension above one that has been installed

Understanding Race Engine Life

Engines that are driven on the street wear out because, over time, clearances throughout the engine become too great. But in a race engine, fatigue kills the engine, not wear. Actually, in a race engine, the clearances are similar to that of a "worn out" street engine. At high rpm's, the internal parts of an engine start to fatigue out quite quickly. This happens because reciprocating mass squares with rpm. Cruising at 4000 rpm's, the M3 rod under virtually no stress, could run for the life of the engine. Racing at 8000 rpm's, the stress on the rod is 4 times greater and breakage is likely before 40 hours.

Understanding How Lower Reciprocating Mass Extends Engine Life

"Redline" on an engine represents the upper mechanical stress point. On an M3 this is 7000 rpm's. The piston assembly has the greatest effect on reciprocating mass because it is the component furthest out from the center line of the crankshaft.

The stock M3 piston, pin and rings weigh 635 grams. Metric Mechanic's piston assembly weighs 460 grams. At 8000 rpm's, a Metric Mechanic race engine has the same reciprocating piston mass as a stock M3 engine at 7000 rpm's.

Mathematically, the calculation showing identical reciprocating mass in these two engines is as follows;

- Divide 8000 rpms by 7000 rpms for the rpm increase in the Metric Mechanic M3 race engine. The rpms are 1.14 times greater.
- Square 1.14 to get the multiplication factor for the piston mass. The factor is 1.30.
- Multiply 1.30 times Metric Mechanic's piston assembly weight of 460 grams = 598 grams which is lighter than the stock M3 piston assembly weight of 635 grams but, we're not done yet. Stroke in another factor in the reciprocating mass calculation. As the stroke increases, reciprocating mass is squared in proportion to the amount of increase. The effect of mass on stroke is calculated as follows;
- Going from the stock M3 84 mm stroke to the Euro M3 87 mm stroke is a 1.035 increase.
- Squaring 1.035 yields a multiplication factor of 1.07.
- Taking 598 grams x 1.07 = a piston weight of 640 grams.

So, even at 8000 rpms and 3 mm longer stroke, our piston exerts about the same load on the crankshaft as the stock M3 piston at 7000 rpms!

Left: Metric Mechanic forged 95 mm, 13.5:1 CR, M3 race piston weighs in at 354 grams with a 71 gram wrist pin.
Middle: Metric Mechanic's forged 95 mm, 12.5:1 CR rally piston weighs in at 398 grams with an 89 gram wrist pin
Right: Stock M3 cast 93.4 mm, 10.5:1 CR piston weighs in at 490 grams with a 120 gram wrist pin

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MM Weight Loss Program for M3 Rally and Race Engines

Years ago, while talking to a top Midget engine builder, he expressed a point of view that made a lasting impression on me. In essence, he expressed a tendency to be unimpressed by an engine's Horsepower rating - alone! If the reciprocating and rotating weight wasn't as light as possible, HP in and of itself, wasn't going to win the race.

For example, factored into racing performance, is how hard the driver can accelerate out of a corner. When rotating and reciprocating mass are not kept to a minimum, the extra weight robs power from the engine, power that should be used to increase acceleration.

In our M3 Rally Engine, we've reduced the rotating and reciprocating weight by over 15 lbs and by about 25 lbs. in our M3 Race Engine.

These reductions were accomplished by removing weight from the outer extremities of the rotating parts. Removing weight in these areas is very significant because rotating weight squares in relationship to it's distance from the center of the crankshaft. Realizing this, it's easy to see that the true weight reduction is far greater than simply the sum of removed material.

Consider the 5.5" radius M3 Flywheel. Machining off one pound of weight at 2.5" out from the flywheel's center, compared to removing the same weight at 5" out actually has the effect of a 4 lb. reduction. Distance out is "2" because it was doubled so distance squared gives 2 x 2 = 4 and 4 x 1 lb. gives 4 lbs.

M3 Race Engine Diet

	Stock	Rally	Weight Savings	Race	Weight Savings
Harmonic Balancer	2400 grams	2400 grams	0 grams	1800 grams	600 grams
Timing Chain	938 grams	938 grams	0 grams	503 grams	435 grams
Intake Sprocket	534 grams	534 grams	0 grams	429 grams	105 grams
Exhaust Sprocket	485 grams	485 grams	0 grams	381 grams	104 grams
Crankshaft	20 kilograms	17 kilograms	3000 grams	17 kilograms	3000 kilograms
Rods	675 grams	675 grams	0 grams	630 grams	180 grams (45 x 4)
Pistons	470 grams	398 grams	288 grams (72 x 4)	354 grams	464 grams (116 x 4)
Piston Pin	120 grams	89 grams	124 grams (31 x 4)	71 grams	196 grams (49 x 4)
Flywheel &				6.35 kilograms or	
Clutch Assembly	14 kilograms	10.5 kilograms	35 grams	8.00 kilograms	6000 grams
		Total Weight Savings in Grams	7 kilograms		11-12.5 kilograms
		Total Weight Savings in Pounds	15.4 pounds		24-27.5 pounds

Left: Lightened Harmonic Balancer with AC pulley groove removed Right: Stock Harmonic Balancer

Single Row Timing Chain from the early Euro M5 and Lightened Sprockets

Lightweight engine parts istalled in the Metric Mechanic M3 Race Engine

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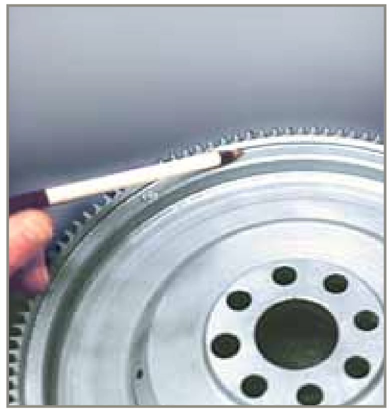
M3 Flywheel and Clutch Assembly Photos ... Photos continued on next page



Rally and Race 10.5 lb. flywheel with critical outer weight milled away and a "U" Channel groove machined into the ring gear on the back side. Using a ridged disc combined with a stock pressure plate, this assembly will weigh 23.5 lbs..
When combined with an aluminum pressure plate the weight will drop to 21 lbs.

M3 Clutch Assembly Choices

	Description	Clutch Type	Static Weight	Dynamic Weight Savings	Comments
Organic Street	Stock 228 mm with Lightened Flywheel	Stock Clutch with 12 lb. Flywheel	26#	5#	For the daily driver
Organic Street	228 mm Clutch with Ridged Disc & Ligthened Flywheel	Ridged Disc & 10.5 lb. Flywheel	23.5#	7.5#	Daily driver & occassional weekend racer
Organic Street	228 mm Aluminum Pressure Plate & Lightened Flywheel	Aluminum Pressure Plate, Ridged Disc, Lightened Flywheel	21#	10#	Lightest Flywheel & Clutch Assembly-normal clutch feel
Organic Street	185 mm (7.25") Clutch and Flywheel Assembly	2 Organic discs	19#	15#	Weekend racer & daily driver (serious autocrossing & driver's schools)
Organic Street	Stock 228 mm	Organic Springer Disc	31#	0	Daily driver
Metallic Racing	185 mm (7.25") Clutch and Flywheel Assembly	2 Metallic Discs	18#	16#	Racer only - excellent clutch life under racing
Metallic Racing	140 mm (5.5") Clutch and Flywhell Assembly	2 Metalllic Discs	14#	27.5#	Very serious racer only

M3 Clutch Assembly Notes

1. Dynamic Weight refers to the weight that the engine experiences from the flywheel as it spins as opposed to it's actual Static Weight i.e. weight as measured on a scale.
2. The lighter the Flywheel and Clutch Assembly, the greater the acceleration gains.
3. If a Flywheel and Clutch Assembly is below 21#, it will manifest driveability problems such as bucking below 2000 rpm, off-line stalling, and idle roughness up to as much as 2500 rpm.
4. The Organic clutches listed above are capable of being "slipped." Even the 185 mm, (7.25") organic disc can be slipped but it will feel rather grabby due to it's light weight and ridged disc design.
5. Metallic Clutches SHOULD NOT BE SLIPPED! They will grab and jerk when moving the car off the line. This worsens with reduced clutch size. These are "in and out" clutches which perform best when engaged and disengaged, not slipped or ridden.
6. Two disc clutches will disengage and engage rather high up and require a clutch pedal stop just below the disengagement point.
7. In summary, the lighter the Assembly, the higher the acceleration gain but with a sacrifice to driveability.

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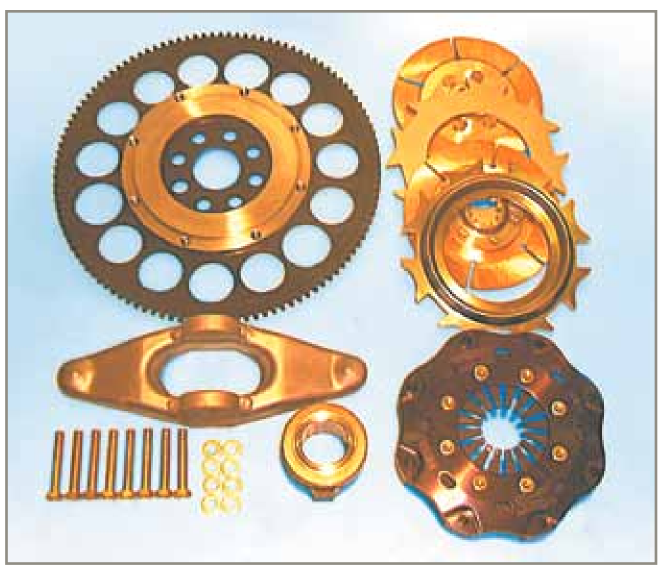
M3 Flywheel and Clutch Assembly Photos ... Continued from previous page

Assembled and exploded views of the 185 mm (7.25") M3 Clutch & Flywheel Assembly with 2 discs organic at 19 lbs. This small Clutch Assembly behaves as if it is 15 lbs. lighter than a stock flywheel and clutch assembly. Although the clutch will feel a bit "grabby", it can be slipped for street driving and used on the track by a hard core weekend racer.

The 185 mm (7.25") Clutch and Flywheel Assembly: 2 metallic discs at 18 lbs. dynamic weight reduction of 16 lbs. under stock, a lot more forgiving and long lasting than the 140 mm (5.5") Clutch Assembly.

Regarding the exploded views above and below: Shown is the breakdown of a 2 disc clutch Assembly and Flywheel. Diaphragm pressure with a raised ring, the first disc, a floater plate, the second disc, the flywheel, a curved face throw out bearing and a raised fork arm used in proper clutch assembly release.



Assembled and exploded views of the 140 mm (5.5") M3 Clutch & Flywheel Assembly with 2 metallic discs at 14 lbs and a 27.5 lb. dynamic weight reduction. We do not recommend slipping this clutch because it is small and prone to burn up when slipped. It's designed for use in the "in" or "out" - "engaged" or "disengaged" postures. When loading a race car onto it's trailer, avoid the "Big Slip". Driveability sacrifices are richly compensated for by acceleration. For the serious racer ONLY!

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