Brake Upgrade Options for the AWD 3000GT/Stealth or "If it won't brake, fix it"

by Jeff Lucius

Topics

Introduction

Before you go out and spend possibly $2000 to $3000 or more for the "ultimate" stopping power for our cars, consider first that the stock brakes on all years of Mitsubishi 3000GT VR4 and Dodge Stealth R/T Twin Turbo are some of the best on production cars for the time period (1991-1999). The stock brakes are entirely adequate for street use but can benefit from better fluid, stainless-steel braid-protected brake lines, and Metal-Matrix or carbon-blend brake pads. For track or other performance use, an investment in a rotor and caliper upgrade should be seriously considered.

In the table below are some performance results for stock brakes on new production 3000GT/Stealth (3S) cars from popular car magazines. Braking distances from 60 to 0 mph approaching 110 feet are considered outstanding for street cars. For comparison, Road & Track presents these selected 60-0 mph stopping distances in their Dec 2000 and Dec 2004 issues (with 10' significant distances): Porsche 911 GT1, 98'; Lotus Elise, 105'; Mitsubishi Lancer Evolution, 108'; Ferrari Enzo, 109'; Ferrari 360 Modena, 110'; Mazda RX-8, 110'; Volvo S40 T5, 110'; Subaru Impreza WRX STi, 111'; Lexus IS 300, 113'; Mercedes-Bens SL500, 113'; Dodge Viper SRT-10, 114'; Audi TT Coupe, 116'; Chevrolet Corvette, 116'; Acura NSX, 117'; Ford GT, 117'; Volkswagon Toureg V8, 117'; Porsche 911 Turbo, 119'; Nissan Skyline GTR, 120'; BMW M Roadster, 121'; Panoz Esperante, 122'; Saleen S7, 125'; Lamborghini Diablo VT, 126'; Ameritech McLaren F1, 127'; Chevrolet Camaro SS, 129'.

3S Stock Braking Performance

Magazine	Issue	Car	60-0 mph	80-0 mph	100-0 mph
Sports Car Int'l	9/90	'91 TT	120 ft	214 ft	
Road & Track	9/90	'91 VR4	135 ft	237 ft	
Motor Trend	3/91	'91 VR4	117 ft		
Sports Car Int'l	12/93	'94 VR4	123 ft	223 ft	
Sports Car Int'l	8/95	'95 VR4	123 ft		
Road & Track	8/96	'97 VR4			347 ft in 4.5 s
Sports Car Int'l	10/96	'95 Spyder	134 ft		
Motor Trend	5/97	'97 VR4	116 ft		
Road & Track	1999 spec.	'99 VR4	122 ft	218 ft	

The Road & Track 9/90 issue also tested for brake fade on their '91 VR4. Cool brakes required 15 lb of pedal effort to execute a 0.5 g stop. After six of these 0.5 g stops in a row, pedal effort remained at 15 lb; that is pretty good for street brakes.

The Road & Track 8/96 issue published the results of their 0-100-0 mph competition. The stock '97 VR4 did not do so well overall except that it had the best 100-0 mph stopping time of 4.5 seconds (347 ft). No car in the competition decelerated faster. The four-wheel ABS system contributes to this success. Other cars did stop in a shorter distance in this competition: HKS-modified Supra in 326 ft (5.1 s), BMW M3 in 334 ft (4.5 s), and Mercedes-Benz C36 in 340 ft (4.9 s). The Porsche 911 Turbo stopped in 363 ft (4.6 s). Interesting that the Supra had to be modified to be in this competition. I wonder how well a modified VR4 would have done?

The objectives of braking system improvements are to reduce stopping distances (especially from high speeds), tune the feel of the brakes (subject to the driver's preferences), and improve thermal control (heat dissipation and temperature sensitivity). Though the tire-to-road interface always limits rapid deceleration, I don't discuss tires here. Quite often a switch to stickier tires may be the easiest way to improve your stopping distances. However, if repeated application of the brakes causes fade in the application that you are using your car, whether it is the street or the track, then thermal control must be a priority. Some of the information presented here is applicable to any automobile. However, I have concentrated on improvements for the AWD 3000GT/Stealth braking systems.

The following steps (in order) should be considered when improving your braking system.

1. Improved brake cooling.
2. High-performance brake fluid.
3. Steel braided brake lines.
4. High-performance brake pads.
5. Larger rotors and calipers.
6. Master cylinders.

There are no commercial brake-cooling kits for our cars that I know about. Improved brake cooling for 3S cars generally takes the form of homemade combinations of venting, heating, and roof-drain parts that direct cool air from the front of the car onto the rotors and calipers. Also, I am not aware of any aftermarket master cylinders that are available. The master cylinder converts the force generated by the brake pedal assembly into hydraulic fluid pressure. The stock master cylinder seems to provide a good balance between fluid capacity (sufficient for our ABS system) and hydraulic pressure (1.133 times pedal force). So I will concentrate on items 2 through 5 above. But first, I'll summarize the stock setup and present the concept of braking torque.

Stock Brakes

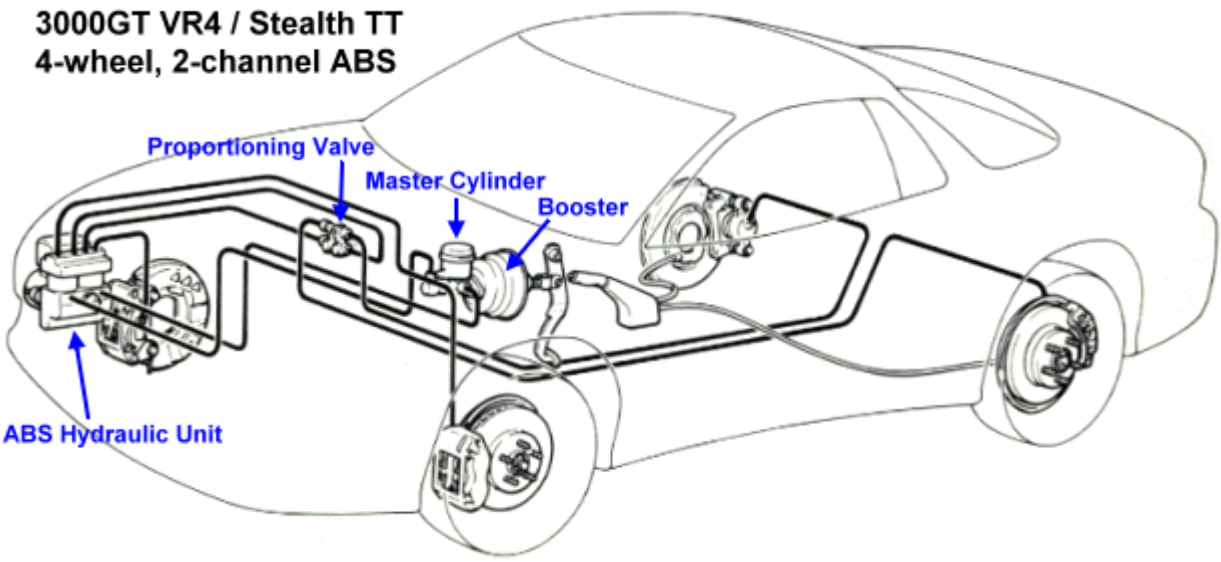
The front brakes for all years of the AWD models use ventilated, iron-disc rotors with 4-piston, rigid, iron calipers. The outside dimensions of the calipers changed in 1994 because of the larger rotors but the internal parts (such as the pistons) and the brake pads did not change. The rear brakes for AWD models up to 1993 use ventilated, iron-disc rotors with single-piston, floating, iron calipers. Starting with the 1994 model year, the AWD cars have rear brakes with twin-piston, rigid calipers. The drum-type parking/emergency brakes are incorporated into the hat of the rear rotors. The master cylinder is the

same for all model years, with a 26.9 mm (1.06") inside diameter, as is the vacuum-type brake booster, with an approximate 7:1 boosting ratio of the brake pedal force. Mitsubishi recommends DOT3 or DOT4 brake fluid for all years. Though not directly related to the brakes, the following wheel information may be relevant when upgrading. All wheels (all sizes, all years) on all models (FWD or AWD) have a 46 mm (1.81") offset with 5 lugs in a 114.3 mm (4.5") pitch circle diameter. The relevant "performance" dimensions of the stock brake systems are summarized in the table below. Note that rotor sizes are the actual outside diameters. The service manual specifications are "effective diameters", which is likely near the middle of the brake pad.

Stock Dimensions

AWD year	Front			Rear		
	Rotor O.D. mm (in)	Rotor Thickness mm (in)	Cylinder ID mm	Rotor O.D. mm (in)	Rotor Thickness mm (in)	Cylinder ID mm
1991-1993	295 (11.62)	30 (1.18)	40.4 x 2 + 42.8 x 2	284 (11.19)	20 (0.79)	38.1 x 1
1994+	314 (12.36)	30 (1.18)	40.4 x 2 + 42.8 x 2	295 (11.62)	20 (0.79)	38.1 x 2

The 3000GT VR4 and Stealth TT utilize a 4-wheel, 2-channel ABS braking system, as shown in the illustration below. The master cylinder contains two pistons which effectively divide the brake lines into two separate hydraulic systems. One system is the left-front and right-rear brakes, and the other is the right-front, left-rear brakes. This is done for safety in case a leak develops in one of these systems. These two hydraulic lines go from the master cylinder to the ABS hydraulic unit (HU). The HU controls the four output brake lines as two channels. One channel for each side of the car. However, because of the use of select-low valves between the two rear wheels and between two wheels on one channel (same side of car), a total of 3 wheels are controlled hydraulically at the same time. In order to prevent lock-up of the rear brakes during heavy braking, a proportioning valve is used on the two brake lines going from the HU to the rear brakes. For the hatchback AWD models, the output pressure will be the same as the input pressure until there is 533 to 604 psi pressure in the rear brake lines (called the split point). At pressures greater than this, the output pressure to the rear brakes will drop 34 to 42 percent. For the convertible AWD models, the split point is higher at 704 to 775 psi and the pressure drop is lower, 25 to 34 percent. The preceding is for North American and European models. The proportioning valve for vehicles bound for Australia was yet a third model. It had a split point in the range of 391 to 462 psi and a pressure drop of about 25 percent.



Braking Torque

Torque is a force acting to rotate a body about an axis. Torque can be directed to increase or decrease rotation. Torque is the magnitude of the force times the perpendicular distance between the line of action of the force and the axis. Braking torque ($\mathbf{T_B}$) then is the force applied by the caliper to the rotor ($\mathbf{F_C}$) times the effective radial distance the brake pads are from the center of the wheel ($\mathbf{R_E}$). The force applied by the caliper is determined from the pressure in the hydraulic lines ($\mathbf{P_H}$) times the total piston area in one half of the caliper ($\mathbf{A_P}$) times the brake pad coefficient of friction against the rotor ($\boldsymbol{\mu}$) times 2 (there are pads on both sides of the rotors). The complete expression is below.

$$\mathbf{T_B = F_C \times R_E = [P_H \times A_P \times \mu \times 2] \times R_E}$$

The pressure in the hydraulic lines ($\mathbf{P_H}$) is determined from the pressure exerted by the driver on the brake pedal, the length of the brake pedal "arm", the brake booster, the size of the brake master cylinder, and the condition of the brake fluid.

Please note that ultimately it is the friction of the tire acting against the road surface that actually stops the car. If there is little friction, such as "balled" tires on ice, the car will not stop well regardless of brake torque. On the other hand, if tire-road friction is good a car can come to a stop (eventually) with no application of the brakes (let's imagine the drivetrain and its "drag" have been removed, as well as aerodynamic drag).

The upgrades and maintenance discussed here are designed to optimize braking torque. Keeping the brake fluid free of water and from excessive heating maximizes transfer of pressure from the master cylinder to the calipers. Stainless-steel braid-protected brake lines reduce pressure transfer time from the hard lines through the soft lines to the calipers. Good brake pads provide the optimum friction coefficient, which is heat dependent, as well as assist in heat dissipation/absorption management. Rotors can increase brake torque if they have a larger effective diameter, and can assist in heat dissipation. Finally, better calipers provide optimal management of heat transfer to the brake fluid, and of force multiplication using piston area, reduced pad vibration, reduced mounting flex, and optimized offset loads.

Before proceeding, let's look at how the braking torque is biased in the factory system. For all AWD models, both front brakes have a total of 5441 mm^2 of piston area and both rear brakes have a total of 2280 mm^2 of piston area. When pressure is the same in all hydraulic lines, that is, when the ABS is not activated and pressures are below the split point in the proportioning valve, there is a front bias of 5441/2280 or 2.38:1, or equivalently, the rear brakes pads get about 42% less pressure than the front pads. The difference in effective diameter of the rotors further increases the front bias to an overall bias F/R of 2.5:1 for 1991-1993 AWD models and 2.58:1 for 1994 and later AWD models. When braking hard enough to exceed the split point pressure in the proportioning valve, overall front bias will increase to about 3.85:1 for hatchback models and to about 3.38:1 for convertible models. For track use, there may be some advantage in swicthing to the convertible's proportioning valve (higher split point), or if a person could find one, the proportioning valve used in vehicles exported to Australia (lower split point). For example, if the front brake bias has been increased through the use of larger rotors and same-as-stock or greater piston area, then an increase of rear bias (about 12% or so) to balance this could be achieved under hard braking by using the convertible's or Australian proportioning valve on the hatchback.

Brake Fluid

The Haynes Automotive Reference Manual defines *brake fluid* as "A compounded liquid for use in hydraulic brake systems, which must meet exacting conditions (impervious to heat, freezing, thickening, bubbling, etc.)." Well, being impervious to heat is certainly the goal! The car's brakes convert the kinetic energy of the car into thermal energy, or more simply, they heat up as they slow the car down. The heat (energy) generated by the brake pads and rotors heats up the brake fluid in the calipers. If the fluid heats up enough, it will boil creating vapor in the system. Vapor in the hydraulic system (whether it is from brake fluid, water dissolved in the fluid, or air) is *bad* because it is compressible, reducing braking efficiency, possibly to the point of loosing the brakes entirely. This is called **brake fluid fade**.

WARNING. Brake fluid is poison. Keep it away from skin and eyes. Do not allow brake fluid to contact painted surfaces.

The DOT brake fluid classifications (49CFR571.116) include a set of minimum specifications that are guidelines for manufacturers as to how impervious their fluid is to heat. The dry boiling point (when the fluid is fresh and contains no water) is the temperature at which the fluid turns to vapor. The wet boiling point (measured when the brake fluid contains 3.7% water) is related to how easily the brake fluid will absorb water (or how hydroscopic the fluid is). The lower the wet boiling point, the more water the fluid will absorb. Absorbing water is *bad*, so a higher wet boiling temperature means better brake fluid. And, of course, a higher dry boiling point is good too.

The table below summarizes the DOT guidelines plus the relative advantages and disadvantages of each fluid type. The actual performance may exceed the DOT guidelines and should be printed on the container. For example, Pyroil Premium DOT 3 Brake Fluid states a minimum wet boiling point of 291ºF. DOT 3 and DOT 4 are polyglycol-based fluids and can be mixed with each other. DOT 5.1 can also be mixed with DOT 3 and DOT 4, even though it is based on a different chemical and has about half the viscosity. If DOT 5.1 is specified for an ABS system, do not add or use any other fluid type. DOT 5 is silicone-based (not less than 70% by weight of a diorgano polysiloxane) and must not be mixed with or contaminated by DOT 3, DOT 4, or DOT5.1.

Standard Brake Fluids				
	DOT 3	**DOT 4**	**DOT 5**	**DOT 5.1**
Dry BP ºF (ºC)	401 (205)	446 (230)	500 (260)	500 (260)
Wet BP ºF (ºC)	284 (140)	311 (155)	356 (180)	356 (180)
Kin. Viscosity mm^2/second	1500 max @ -40ºF 1.5 min @ 212ºF	1800 max @ -40ºF 1.5 min @ 212ºF	900 max @ -40ºF 1.5 min @ 212ºF	900 max @ -40ºF 1.5 min @ 212ºF
Advantages	- Inexpensive - Readily available	- Available at auto parts stores - Less hydroscopic than DOT3	- Does not attack paint - Does not absorb water	- Superior performance
Disadvantages	- Attacks paint! - Most hydroscopic	- Attacks paint! - More expensive than DOT3	- DOES NOT mix with DOT3, DOT4, DOT5.1 - Water may "puddle" in the system - Careful bleeding required - Slightly compressible near its boiling pt. - Very expensive, hard to find	- Attacks paint! - Expensive, hard to find

Probably the best thing you can do to maximize the performance of your brake fluid (any type) is to change it regularly (at least once a year) to minimize the amount of water in the system. According to the Car Care Council and SAE field tests, brake fluid can become contaminated by water (2% on average) within 1 to 2 years, and in substantially less time in humid climates. Brake fluid (other than DOT 5) readily absorbs water from the air in the master cylinder. This cannot be prevented and changing (flushing) the brake fluid is the only solution. Alternating the use of different-colored fluids can aid in knowing when the flushing process is complete. The dry boiling point of DOT 4 is higher than the wet boiling point of the best brake fluid (Castrol SRF excepted). Speed Bleeder Products makes a replacement bleeder screw for the brake calipers that allows one-person bleeding. Speed Bleeders cost $7.00 each; you'll need 4 plus one for the clutch release cylinder if desired. For the Stealth and 3000GT turbo models, use Speed Bleeder model SB1010 for front calipers and rear calipers, *except* use SB7100 for rear calipers on cars with 3/92-5/93 production dates. SB1010 also works for the clutch release cylinder.

While our brake system will perform as designed using standard DOT 4, you may want to consider one of the popular high-performance brake fluids, especially for racing situations. Some of these are Ate's (Alfred Teves Engineering's) Super Blue Racing and "Super Gold" (same fluid but different color; also called Ate Typ 200), Motul's 5.1 and Racing 600, AP Racing's 550 and Ultra 5.1, and NEO's "Super DOT".

Raceshopper.com sells Ate Typ 200 (or Super Blue Racing) for $9.95/liter, and other brake fluids at some of the best prices you will find. Motul Racing 600 can be purchased at Porterfield for $18/liter. Other retailers sell AP Ultra 5.1 for about $20/liter and AP 550 for about $28/liter. Brake Man sells their racing brake fluid for about $25/liter. NEO "Super DOT" 610 sells for about $12 per 12-oz can ($34/liter) and has the highest wet and dry boiling points. Castrol SRF has very high boiling points as well, but at about $65/liter (raceshopper.com) seems to me to be a bit expensive; but not nearly as expensive as GS610 which sells for ~$84/liter! Ford Heavy Duty brake fluid is cheap ($6/liter) and has a very-high dry boiling point, making it a favorite for the weekend racer that changes brake fluid frequently. However, the DOT 3-rated wet boiling point makes Ford Heavy Duty less than desirable for street usage. Do not mix any of these fluids, some of which are DOT 4 and others are DOT 5.1, with DOT 5 silicone-based systems.

High-Performance Brake Fluids														
	Motul Ultra 5.1	AP Ultra 5.1	Ate Typ 200	Ford HD	AP 550	Brake Man	Earl's Hypertemp 421	NEO	Motul Racing 600	AP Super 600	Castrol SRF	Motul RBF 600	NEO Super DOT 610	GS610
Dry BP °F (°C)	509 (265)	518 (270)	536 (280)	550 (288)	563 (295)	577 (303)	585 (307)	585 (307)	585 (307)	590 (310)	590 (310)	593 (311)	610 (321)	610 (321)
Wet BP °F (°C)	365 (185)	375 (191)	392 (200)	290 (143)	293 (145)	300 (149)	421 (216)	421 (216)	421 (216)	410 (210)	518 (270)	420 (216)	421 (216)	421 (216)
Price per liter	$12-14	~$14-20	$10-15	~$6	~$28	$25	~$30	$34	~$18-21	~$36-40	$65-75	~$30	~$34	~84

Ate Super Blue and Type 200 - the best deal in performance brake fluid for the street at $9.95/liter.

Ate Super Blue or Typ 200	
Store	Price/liter
raceshopper.com	$9.95
Strictly German	$9.95
DaliRacing	$10.00
SP Motorsports	$10.85
Spec Miata Superstore	$10.95
Cobalt Friction Technologies	$11.99
Mach V Motorsports	$14.00

Brake Lines

The brake fluid is contained in rigid steel tubing from the master cylinder to about 1 foot from the calipers. To allow for movement in the suspension, a flexible rubber-coated nylon hose connects the steel tubing to the calipers. These eight short hoses (two per wheel for the 3000GT/Stealth) can expand a small amount as pressure increases in the system. The expansion of these hoses increases the hydraulic volume of the brake system and causes a small delay in actuating the calipers. As the hoses age, their expandability can increase. To reduce this delay and improve "pedal feel" (increased firmness and reduced pressure), the rubber hoses can be replaced with nylon hoses covered by stainless steel braiding. SMC (using lines and fittings from Goodridge) supplies a steel braided brake line kit (part number 46200-M3000) for our cars ('90-'95). The SMC kit costs from $200 to $250. MVP Motorsports has advertised this kit for as low as $188. Pictures of the SMC lines mounted on my car can be seen at 2-brakelines.htm. New stainless-steel braid-protected brake lines are supplied with many of the combination rotor and caliper upgrade kits mentioned later in the web page.

Brake Pads

As mentioned above, the brakes convert the cars kinetic energy (its forward or reverse movement) into thermal energy (heat) in order to assist in stopping the car. Notice I said assist; this is because it is the friction of the tire acting against the road surface that actually stops the car! The brake pads are pressed against the rotor by the pistons in the calipers. The amount of force actually exerted on the rotor is

determined by the force exerted on the pads by the caliper pistons multiplied by the brake pad coefficient of friction against the rotor. Typical coefficients of friction are in the range of 0.25 to 0.50 when the rotors and pads are at their working temperatures. The exact value is not that important as the driver can simply press harder on the brake pedal or use larger pistons in the caliper or larger rotors to compensate for pads with a lower-than-average coefficient of friction. What is very important, though, is how the coefficient of friction changes as the pads and rotors heat up. With hot rotors and pads the coefficient of friction can drop dramatically (even below 0.10) depending on pad composition. This condition is known as **brake fade**, which should not to be confused with "brake fluid fade" from vapor in the brake lines or "green fade" from improperly bedded pads.

There are two solutions for brake fade: thermal management (such as cool air ducts or better rotor and caliper design) or improved brake pad material. Performance brake pads maintain an acceptable and relatively stable coefficient of friction under a variety of driving conditions and temperature ranges. However, some pads designed for racing may require higher temps than are achieved on casual street driving for optimal friction. For example, according to Rennsport the Ferodo DS11 racing pad doesn't develop much friction until it is near 450ºF. Be sure to look at the manufacturer's working temperature range for their product to be sure it is suitable for your intended use.

Green fade is caused by the rapid boiling out of the resins and glues used in pad construction to form a liquid layer between rotor and pad, reducing the coefficient of friction to near zero. Green fade occurs when brake pads are overheated before the material has had a chance to "cure" on the car. "Bedding in" the brakes (see next section) causes this boiling out to occur in the first few heating cycles and so "cures" the pad.

Based on composition, there are basically four types of brake pads. ***Organic*** pads are made of cellulose bound with a phenolic resin, with less than 20% metal content. They have a good coefficient of friction at low temperatures and are very quiet, but are not suitable for high performance applications. ***Semi-metallic*** pads are similar to organic pads with some powdered metal added (typically 40% to 60% by weight), usually brass, iron, or bronze, to stabilize the coefficient of friction at higher temperatures, making them excellent for all-around use and quite common as OEM pads. ***Ceramic*** pads are similar to semi-metallic pads except that metal content is reduced to about 15% and ceramic materials are added. This can result in a pad that produces less visible dust (it's lighter color), is less noisy (vibration frequency is above human hearing), and can handle higher brake temperatures with less fade than semi-metallic pads. Bosch recommends against using ceramic pads for towing applications. ***Metallic*** pads consist of at least 60% by weight powdered metal that is pressed into a mold at high temperature with a some organic binder to form a somewhat homogeneous block (called sintered metal). Most metallic pads have excellent grip at high temperatures but are not suitable for street use because they often are noisy, grip poorly when cold, chew up rotors, and make black dust that gets deposited on the wheels. The exceptions are Axxis/Repco/PBR/Autospeciality/Stillen Metal Matrix/Master/Lux pads that are made of brass and bronze powder with a resin binder. Metal Matrix pads are excellent for street and mild track use but are not ideal for heavy-duty track use. Metal Matrix pads generate minimal dust build up, wear well, and work great with drilled rotors. ***Carbon blend*** pads are probably the ultimate pad for street and track use. Carbon is added to a metallic or Kevlar matrix to improve heat absorption (cooler running rotors) and durability (long-life yet low rotor wear) while providing excellent friction properties over a wide range of temperatures (from cool street to hot track use). Carbon carbon pads must be used with carbon rotors and are reserved for high-energy races like the Indianapolis 500.

There are several aftermarket brake pads available for stock VR4/TT calipers. The most popular are the metal matrix brands by Axxis (Autospecialty) and Stillen that cost from $45 to $60 for a front or rear set.

These are available at many stores. Brembo makes OEM replacement pads for about $75 each set (available at MVP Motorsports).

The Brake Man sells performance brake pads for our cars. They do not state pad composition. Contact them for more information. Carbotech Engineering is a relatively new source for performance pads for our cars. They offer several different pad compounds for both street and track use. Contact them for more information.

KVR carbon fiber pads for the front calipers only can be found for about $60 at Accelerated Accessories. Performance Friction makes carbon metallic pads for our cars; I am not sure where they can be purchased. Nippon Power sells Hawk Ferro-Carbon pads for the Stealth and VR4 for about $65 a set. They claim "Ferro-Carbon is a unique, high-tech friction material developed and manufactured by Hawk Brake for the racing community. All Ferro-Carbon materials exhibit non-fade performance and have been evaluated up to and beyond 1,800 degrees F. Each material offers lower wear rates and higher torque values than all other competition materials available on the market today."

AP Racing makes carbon metallic front brake pads for 1991 to 1994 models (part no. CPFC460). AP Racing also supplies paint kits, pyrometers, and temperature strips to directly check the temperature of your pads and calipers (http://www.apracing.com/car/brakepad/temperature.htm)

Many people claim Pagid makes the best pads money can buy. Almost every Formula 1 and many World Rally teams use them. Their brake pads resist fade up to 900 degrees Celsius, especially the carbon RS4-2 model. Pagid closely guards the exact compounds used in their pad. They make a wide variety of pads for both street and racing and the compound characteristics are described at http://www.pagidusa.com/characteri.html. Some Pagid pads are reported to produce a lot of dust.

EBC Brakes sells carbon Kevlar blend brake pads for the stock Stealth and 3000GT calipers in their "Greenstuff" line. They advertize a friction coefficient of 0.46 and heat fade resistance to 550 degree Celcius. EBC claims there is no carbon content in these pads so that very little dust is produced. The high level of Kevlar content also leads to very low rotor abrasion. No warm-up is needed with these pads.

Porterfield offers carbon Kevlar pads (R4 and R4S models) for both front and rear stock calipers ($89-$149 front, $69-$149 rear, depending on year). These pads also can produce a lot of dust. From Porterfield's web site: "Carbon Kevlar pads are different because they are rotor friendly, work well hot or cold, have very high friction level and exhibit no fade, and on some compounds offer little to no dust or squeal. The difference between the R-4 and R-4S pad is the R-4 has a higher friction level and will withstand higher temperatures than the R-4S. Also the R-4 was designed for racing use, if driven on the street you may experience some dust and or squeal. The R-4S is designed for street and limited track use. It is a serious high performance highway pad with high friction levels and is designed for driver's school, and light track events. R-4S was designed to produce no squeal and less dust than OE pad."

Supercar Engineering sells Axxis, Carbotech, and Porterfield brake pads for stock front and rear calipers.

Porterfield Brake Products To order contact: orders@speedtoys.com		
Product	**Part number**	**Price ($US)**
Mitsubishi 3000GT SL (all years)		
Front Rotors	JBR 583	$79.95
Rear Rotors	JBR 584	$80.00
Front Pads	R4S AP 530	$83.00
Rear Pads	R4S AP 383	$63.00
1st Gen Mitsubishi 3000GT VR4 (4/90 to 5/93 production)		
Front Rotors	JBR 582	$82.00
Rear Rotors	JBR 585	$90.00
Front Pads	R4S AP 531	$69.00
Rear Pads	R4S AP 532	$56.00
2nd Gen Mitsubishi 3000GT VR4 (6/93+ production)		
Front Rotors	JBR 785	$104.50
Rear Rotors	JBR 786	$99.00
Front Pads	R4S AP 531	$69.00
Front Pads	R4 AP 531 or R4E AP 531	$116.00
Rear Pads	R4S AP 631	$76.00
Rear Pads	R4 AP 631 or R4E AP 631	$95.00
Porsche Big Red Calipers		
Front Pads	R4S AP 594	$128.00
Front Pads	R4 AP 594 or R4E AP 594	$137.00
Rotor prices are for each rotor. Check for current prices. Rotors are made by Brembo, Bradi, ATE, or American made. Add $45 per rotor for each of these processes: slotting, drilling, cryo-treatment		
Pad prices are for both left and right wheels. Check for current prices. All pads are a Carbon Kevlar blend made by AP Racing. **R-4: Race** Versatile and a superior performer. **R-4 S: Street High-performance & Limited Competition** The high performance street pad of choice. No dust or squeal. Very high friction level even at cold temperatures. **R-4 E: Endurance Racing Pads with Longer Life** This is an endurance pad, especially formulated for long races. It runs cool and wears longer than the R-4. Great for extended time events.		

Clinton Battersby (of MMCd datalogging fame) recommends the following when replacing brake pads to prevent caliper piston corrosion. To avoid sticky caliper pistons, remove the piston boot and apply a little silicone grease to the end of the piston and boot.

Brake Bedding

New brake pads require a smooth rotor surface. If you have not replaced the rotors then have the surface

turned (milled) so that no ridges or grooves can be felt with your fingernail. Be sure the rotor thickness exceeds factory limits.

The manufacturer should supply brake bedding instructions specific for the pads you are using. Sometimes the manufacturer cures the pads before shipping and so bedding is not required. If bedding is required, the general procedure (from Rennsport) is to warm new brake pads with 25 to 30 stops, gradually increasing pressure but not letting the pads get hot. After that a safely executed "panic" stop is made from high speed (like from 100 mph at a drag strip) down to about 30 mph. The car is then parked soon after without any pressure on the brake pedal until the brakes and rotors are cool to the touch. Tom Wilson had the following to say about brake bedding for street-driven vehicles in his Technical Correspondence column in the August 2004 issue of Road & Track magazine.

" *Brake bedding provides several benefits to both brake pads and rotors. For starters, it thermally relaxes a new rotor. It wipes off any minor machining nicks or light oils that may be present on the rotor. It thermally adjusts the brake pads so the binding material in the pads does not "boil off" excessively, and most famously, it applies a layer of brake pad material on the rotor to allow the most tenacious grip possible.*

Brake-bedding procedures vary, but all involve slowly bringing the brakes to operating temprature and letting that temperature stabilize through the pads and rotors to thermally set the pads and rotors, followed by minor cooling, then hard brake applications to transfer some pad material to the rotors, then controlled cooling.

Frankly, the public isn't ready for such involved procedures. Enthusiasts may revel in the prospect of making four stops from 80 mph at near lock-up; others would simply say it's illegal or akin to bungee jumping.

By advising easy braking for a couple of hundred miles, the manufacturers achieve most of the goals of proper bedding without bothering the owner. With a new car, such easy driving promotes good engine break-in as well. The downside is a small amount of brake life or performance is not realized. For the rare panic stop, this typically won't matter as other factors make a larger difference in stopping distance, and as for wear, no one knows what they're missing and it typically takes years to realize any benefits -- too long for the average consumer's attention span.

Racers and enthusiasts want every last erg of braking performance, so they'll go to the trouble to educate themselves about brake bedding. But for general use it's not worth the trouble."

Rotors and Calipers

The stock rotors and calipers are adequate for any sane and legal street driving activity. However, if you use your car on the track or just want improved braking to match improved engine power output, then you want to consider upgrading the rotors and/or the calipers along with the other upgrades discussed above. Any performance upgrade rotor for our cars will have a vented design (like the stock rotors) with or without the addition of holes (cross drilling) or slots. Larger diameter rotors will improve both the effective swept area as well as heat dissipation (more surface area). An upgrade caliper should have a similar amount of total piston area as the stock calipers, or perhaps a little less. If going with a larger rotor and caliper you want to be sure that they will fit in the wheels you are using. I leave it to the reader to determine the merits (or lack thereof) of cross-drilled and/or slotted rotor designs over smooth-faced rotors. However, I will provide the quote below from Tom Wilson's Technical Correspondence column in the March 2003 issue of Road & Track magazine.

" *Assuming minimal attention to where the holes are drilled, there is no meaningful difference between cast-in and drilled-in holes in rotors. ... The real difference is between drilled and non-drilled rotors. All*

those holes detract from a rotor's mass, and high mass content is a main ingredient in avoiding warping. As for cracking, all rotors will crack if overheated, and there is little difference between drilled and non-drilled rotors in that regard.

Cosmetics is why most rotors are drilled nowadays -- the old gassing problem that holes are supposed to address is negligible with good pads and all but absurdly flamboyant street driving -- so, many aftermarket brake tuners offer rotors with or without drilling to suit demand."

For the normally-aspirated, FWD cars, the front brake setup is the same as the 1993 to 1999 DSM turbo cars (Eclipse and Talon); please check out Tom Stangl's web page for advice http://www.vfaq.com/mods/BigBrakesInfo.html.

There are several **stock-size rotor replacements** for the AWD 3000GT/Stealth cars that may be better than the factory rotors. The stock front rotors (1994+) are 314 mm x 30 mm and weigh about 17.2 lbs (7.8 kg). PowerSlot and PowerStop rotors, with prices ranging from $100 to $140 for each rotor, work well on the street but may not be appropriate for race track use. Porterfield rotors ($80 to $105 from orders@speedtoys.com) are made by Brembo, Bradi, ATE, or un-named American company. Porterfield offers cryogenic treatment for about $45-50 extra for each rotor. Stillen also offers OEM replacement rotors (made by Brembo I think) that are either cross-drilled or slotted for $115 to $150 each (depending on model). Brembo makes cross-drilled or slotted rotors for all 3000GTs/Stealths (both front and rear axles, and FWD or AWD). MVP Motorsports sells the Brembo rotors for $121 to $190 each, depending on model and axle. Supercar Engineering sells stock replacement front and rear rotors made by Carbotech Engineering for all models and years of 3000GT/Stealth. Slotting and cryogenic treatment are available.

For those of you with 1991 to 1993 AWD models, it is a relatively easy upgrade to switch to the 2-piston rear calipers and larger rear rotors used on 1994+ AWD 3S cars (cars produced from 6/93).

Caliper upgrade choices include StopTech 4-piston (with various combinations of 34, 36, 38, 40, 42, and 44-mm pistons), Brembo 4-piston (2x40/44 mm), Porsche 4-piston (manufactured by Brembo; 2x38/44 mm, and 2x36/44 mm), Alcon 4-piston (2x38.1/44.5 mm), AP Racing 6-piston calipers (2x27/32/38 mm), and MOV'IT 4-piston (2x36/44 mm). Trailing piston pairs are larger to compensate for mechanical end load, which maximizes friction, and to reduce tapered wear. The caliper piston area is calculated by finding the total piston area from one side of the caliper, regardless of the number of pistons (that is, 1 piston is used for single-piston or 2-piston calipers, 2 pistons are used for 4-piston calipers, and 3 pistons are used for 6-piston calipers). The stock VR4 front 4-piston calipers have approximately 4.2 sq in of piston area each. Except for the largest calipers by Brembo and StopTech, aftermarket calipers have less piston area per caliper (see the table below). Given the same pedal effort by the driver, this means that the hydraulic pressure transferred to the pads by some of these calipers is somewhat less than by the stock calipers. This can be advantageous when using larger rotors to optimize front-rear brake torque balance.

Front Caliper Information

Caliper	Piston 1 (mm)	Piston 2 (mm)	Piston 3 (mm)	Total Piston Area (mm^2)	Total Piston Area (in^2)	Difference from stock	Brake Pad Area (in^2)	Weight (lb)
Brembo F50	40.0	44.0	--	2777	4.30	2.06%	9.6	7.01
StopTech ST40 "F50"	40.0	44.0	--	2777	4.30	2.06%	9.6	7.01
Stock VR4/TT	40.4	42.8	--	2721	4.22	0%	8.0	8.0
Alcon	38.1	44.5	--	2695	4.18	-0.96%	?	?
StopTech ST40 "F40"	38.0	44.0	--	2655	4.11	-2.43%	9.6	7.01
Brembo F40	38.0	44.0	--	2655	4.11	-2.43%	9.6	7.01
Porsche Big Black	38.0	44.0	--	2655	4.11	-2.43%	9.6	?
Porsche Big Red	36.0	44.0	--	2538	3.93	-6.73%	9.6	8.1
MOV'IT	36.0	44.0	--	2538	3.93	-6.73%	??	??
StopTech ST40 (332mm rotor)	38.0	42.0	--	2520	3.91	-7.39%	9.6	7.01
AP Racing	27.0	32.0	38.0	2511	3.89	-7.72%	11.8	6.6
StopTech ST40 (355mm rotor)	36.0	40.0	--	2274	3.53	-16.43%	9.6	7.01
StopTech ST40 (380mm rotor)	34.0	40.0	--	2165	3.36	-20.43%	9.6	7.01

So why upgrade the calipers? Six reasons:

- better heat absorption and dissipation from using larger brake rotors,
- lighter weight for reduced unsprung mass,
- larger brake pads for better heat capacity and wear rate,
- improved design for better strength and better force transfer to the pads,
- improved design for better heat transfer and reduced brake fluid heating, and
- for management of the force multiplication by the piston area when using larger rotors.

The stock 3000GT/Stealth Sumitomo calipers weigh about 8 lbs (3.6 kg) each. Brembo and StopTech calipers weigh about 7 lbs (3.2 kg) each. The AP calipers weigh about 6.6 lbs (3 kg) each. I measured the stock front pads to have about 8 sq in of surface area. The Brembo, Porsche, and StopTech pad area is about 9.6 sq in, and the AP Racing pad area is about 11.8 sq in.

Please note that larger pads do not stop the car faster than smaller pads of the same compound at the

same location on the rotor. Stopping force is determined by the applied pressure, the pad coefficient of friction, and the distance the pad is from the center of the rotor (basically rotor diameter). Larger pads of the same compound as smaller pads have a longer life and absorb more initial heat (better heat capacity).

When looking for a brake upgrade for better stopping distances and reduced brake fade, generally look for larger diameter and thicker rotors, and calipers with slightly less piston area than stock. Larger rotors provide better heat dissipation because of directional cooling vanes and more mass (thicker and larger diameter). Calipers with less piston area will decrease the force transferred to the rotors in order to balance the larger rotor diameter, and slightly decrease pedal travel. For example, the AP Racing 6-pot calipers have about 7.7% less piston area, which should result in perhaps 7.7% less applied force but also perhaps as much as 0.4 to 0.5 inch less pedal travel; they would be a good match with 355-mm rotors for 1994+ 3S cars or 332-mm rotors for 1991-1993 models (assuming the factory rear brakes are retained).

Upgrade rotors are available from the same manufacturers that provide upgrade calipers, usually as part of **big brake kits**. Wheels with a diameter of 17" or 18", or possibly larger, are required for these larger rotors and calipers. Be sure to check with your vendors to be sure your wheel and selected brake kit will work together.

AP Racing and Alcon Components make some of the best rotors in the world according to Rennsport Systems, which says AP and Alcon rotors are superior to Brembo rotors in terms of wear and crack resistance. For what it's worth, Automotive Products Group Ltd. sold its subsidiary AP Racing to Brembo in July 2000.

Alcon offers custom-made high-performance rotors (332 mm) and 4-piston calipers but these have not been extensively tested on 3S cars. Bozz Performance should be able to get the custom Alcon kit for about $4300 (includes SS lines and pads, but at that price it should include installation also!).

Front Rotor Information

Rotor	Diameter mm (in)	Thickness mm (in)
1991-1993 VR4/TT 1994 - end VR4/TT	295 (11.62) 314 (12.36)	30 (1.18) 30 (1.18)
StopTech	380 (14.96) 355 (13.98) 332 (13.07)	32 (1.26) 32 (1.26) 32 (1.26)
AP Racing	362 (14.25) 355 (13.98) 343 (13.50)	36 (1.42) 35.5 (1.40) 35.5 (1.40)
Brembo	355 (13.98) 343 (13.50)	32 (1.26) 32 (1.26)
Alcon	332 (13.07)	? (?)
Porsche GT2 max w/ "Big Red" max w/ "Big Black"	322 (12.68) 332 (13.07) 322 (12.68)	32 (1.26) 32 (1.26) 32 (1.26)
MOV'IT	322 (12.68)	32 (1.26)

The AP Racing brake kit, with 6-piston calipers and either 355-mm x 35.5-mm or 343-mm x 35.5-mm rotors, is available from Stillen, KVR Performance, and HP Racing for about $3000-3400. The AP Racing kits include their larger-diameter vented discs, aluminum hats, 6-piston calipers, aluminum mounting brackets, high-performance brake pads, and anti-rattle springs and inner wipers and dust seals in the calipers. Supercar Engineering offers 343 mm (13.5") by 35.6 mm AP rotors and calipers for about $2700, and 362 mm (14.25") by 36 mm (1.42") AP rotors and calipers for about $3000.

StopTech claims their floating, two-piece, directional-vaned AeroRotors® flow more air than any rotor available for superior cooling (see Rotor Airflow Chart). These rotors are available in 380-mm (14.96"), 355-mm (13.98"), 332-mm (13.07"), and 322-mm (12.68") diameters with a 32-mm (1.26") thickness standard. However, these rotors can also be requested with 28-mm (1.1") or 35-mm (1.38") thickness. StopTech says the rotor's special iron formulation reduces cracking under severe driving conditions. AeroRotors are available in standard (smooth surface), slotted, or drilled. The 7075-T6 billet aluminum hats are also directionally veined.

StopTech developes brake upgrade systems specifically to optimize brake balance and ABS performance for the shortest stopping distances. They are available exclusively from Supercar

Engineering for all models of the Stealth and 3000GT. The StopTech aluminum ST40 4-piston caliper is a available with a choice of piston sizes. With 38-mm and 44-mm pistons the ST40 is a direct bolt-on replacement for Brembo F40 calipers; with 40-mm and 44-mm pistons it is a replacement for the Brembo F50. The StopTech ST40 uses Porsche-style brake pads, so a large variety of brake pads are available. StopTech front brake kits are available for all models and years of 3000GT and Stealth in a variety of rotor sizes and piston sizes for $1800 to $2900 from Supercar Engineering. Included in the kits are Inconel® anti-rattle spring washers that allow for rotor expansion, stainless-steel braid-protected brake lines, rubber dust boots to keep dirt and water away from pistons and piston seals, and brake pads.

StopTech and Supercar Engineering Recommendations

Rotor Diam. mm (in)	Diff. from stock 295mm	Diff. from stock 314mm	ST40 Pistons	Piston area mm	Diff. from stock
380 (14.96)	28.81%	21.02%	2x34/40mm	2165	-20.43%
355 (13.98)	20.34%	13.06%	2x36/40mm	2274	-16.43%
332 (13.07)	12.54%	5.73%	2x38/42mm	2520	-7.39%

For balanced front-rear braking bias and shortest stopping distances, Supercar Engineering and StopTech recommend the piston and rotor combinations shown in the table to the right. As discussed in the Braking Torque section above, torque applied by the calipers is directly proportional to the pad-to-axle distance, or basically, rotor diameter. Hydraulic fluid force multiplication by the caliper is directly proportional to the piston area size. Therefore, to maintain proper braking balance, as rotor diameter increases the piston area should decrease approximately the same amount percentage-wise. Less piston area than stock also decreases the pedal travel as there is less swept volume behind the pistons to fill with fluid. These combinations of rotor diameter and pistons sizes should work well for 1991-1993 models (295-mm front rotors) and slightly increase front braking torque. However, the suggested combinations will slightly decrease front braking torque for 1994+ models (314-mm front rotors). Owners may want to discuss other piston size combinations (available at no additional charge) with Supercar Engineering.

Supercar Engineering also offers a **rear brake upgrade kit** using the new StopTech ST22 2-piston calipers (2x36-mm pistons, other sizes are available) and 328x28mm rotors. The calipers are made of billet aluminum, weigh 4.4 lbs (2 kg) unloaded, use FMSI 961 brake pads, and include dust boots. This kit will be available standalone (they retain the standard drum parking brake) or as part of a 4-wheel upgrade kit.

Additional information concerning brake systems is available from StopTech at the links below.

Technical Articles
Stoppping Distance Vs. Brake Bias Chart
FAQ Index

Supercar Engineering Front StopTech Brake Upgrade for '91-'99 VR4/TT

Photo (c) Supercar-Engineering

Supercar Engineering Rear StopTech Brake Upgrade for '91-'99 VR4/TT

Photo (c) Supercar-Engineering

The Brembo Gran Tourismo Brake System ("F50") is available from some of the vendors listed above from and MVP Motorsports at similar prices ($3000 range). The Brembo big brake kit includes 355-mm x 32-mm, cross-drilled rotors with directional cooling vanes, two-piece, 4-piston (2x40/44 mm) aluminum calipers with dust seals, anti-rattle clips, and mounting brackets, Goodridge stainless steel brake lines, and high-performance street brake pads.

Porsche is widely regarded to have some of the best brakes for street cars. Porsche calipers and rotors are made by Brembo to Porsche's race-quality specifications. Porsche's "Big Red" brakes (named after the caliper color and installed on the 993) have been modified by several companies to fit on our car's front hubs. Currently, Supercar Engineering offers Porsche "Big Red" brake upgrade kits with 332x32-mm rotors.

Darren Schilberg and Steve Lasher have some instructions for installing the Big Red calipers at their web page http://www.team3s.com/~dschilberg/cars/brakes/BigReds_install.htm.

For some comments regarding the Big Red and some other big brake kits for our cars, please read the information below that Ken Middaugh posted to the Team3S email list. I have added some emphasis and performed minor editing, but the message content has not been changed. Prices are in $US. Please note this post is over 4 years old. Recently, Philip Glazatov (Supercar Engineering) told me actual maximum rotor size for "Big Red" and "Big Black" calipers is the opposite from that mentioned in the email below. The correct information is in my Front Rotor Information table above.

Update: January 25, 2003
Gary Skanes, Sales Manager at KVR Performance, notified a member of 3si.org that Porsche "Big Red" and "Big Black" kits are no longer available from KVR. KVR now exclusively uses the AP calipers in their big brake kits for the 3S cars. These kits cost $2950 and include front calipers, front rotors and hats (check with KVR for sizes), front brackets, braided lines for both front and rear calipers, performance brake fluid, and street performance pads (front). KVR, a Canadian company in Ontario, can be contacted at 800-636-0854 for more information.

Update: November 29, 2004
Brad Bedell's link is no longer active and presumably his Big Red kit is no longer available. It appears from visiting Stillen's web site that they no longer sell big brake kits for 3S cars. MOV'IT still sells front (322x32 rotor; monoblock caliper with 2x36/44-mm pistons) and rear brake (299x24 rotor; monoblock caliper with ??? pistons) upgrade kits for the Stealth and 3000GT.

---------- Original Message ----------
From: "Ken Middaugh"
To: [edited]
Cc: stealth_d@starnet.net; Team3S@stealth-3000gt.st

Sent: Thursday, October 12, 2000 12:40 PM
Subject: Team3S: Brake summary (long), was: Brake Kit Discount Available

As you may recall, some of us track and "deceleration" enthusiasts banded together in search of better, reasonably priced brakes for our cars. There are already lots of kits available for our cars, but most are expensive. We wanted something that was economical, yet was a big improvement over stock brakes. Our original goal was to fund research and development of a 2 piece rotor for Brad Bedell's Porsche "Big Red" upgrade kit. With a 2-piece rotor, Brad's kit would be very similar to Mov'it's $2800 kit but we were hoping that Brad's kit with a 2-piece rotor would be about $2100. A lot of investigation was done and here is a summary.

We ended up not spending any money on R&D since our investigation uncovered existing economical solutions. It turns out that there would be little if any cost savings if Brad were to fabricate his own hats for 2 piece rotors versus just buying them from a reputable and experienced manufacturer.

Front Kits
$1450
Brad's Big Red kit, http://home.austin.rr.com/overboost/. It currently sells without rotors but includes Porsche 993 calipers, caliper mounting brackets, Goodridge stainless steel brake lines for 4 wheels, a set of pads, and fluid. This is the entry point to serious brake upgrades and folks have reported dramatic results. With a set of $250 Porterfield rotors you can seriously upgrade stock performance for about $1700.

~$1900
KVR "Lobster" kit (his name for the Big Reds) with 2 piece Porsche rotors. Terry Gosse of KVR, http://www.kvrperformance.com, has been doing custom brake kits for many years and has a lot of knowledge and experience. Basically, he can do anything for any budget. This price was approximate, and includes Porsche 993 calipers, mounting brackets, 2 piece rotors using Porsche GT2 322x32mm disks and custom 6061 T6 aluminum hats, stainless steel lines for the front, AP racing fluid. I don't know if this price would include SS lines for the rear, or include pads. However, this is basically the same thing as the Mov'it kit for a lot less money. Porsche makes awesome disks. They are directionally veined, the holes are cast and then drilled to final diameter. If desired, he could substitute other, larger disks for about the same price. KVR also has directionally veined disks that you can get solid, cross drilled, or slotted. The Porsche and KVR disks have "reasonable" replacement costs, less than $200 each. The hats should last 5 racing seasons or a lifetime on the street.

~$2100
KVR "Big Black" kit with Porsche 928 S4 calipers with 2 piece rotors. This kit is the same as the above Lobster kit except for the calipers. Terry Gosse of KVR says these calipers will be a better match for our car since the 928 is a similar heavy weight, front engine car like ours (VR4). The Big Red calipers are for lighter, rear engine cars. The Big Black calipers have 2x38x44mm pistons while the Big Red has 2x36x44mm pistons. This extra 2mm makes a big difference over 4 total pistons. Also the Big Black calipers are bolted together more near the centerline and will deflect less than the Big Reds. The Big Blacks use shorter 50mm pads, which deflect less than the Big Reds 60mm pads. The Big Blacks can accommodate 332mm rotors while the Big Reds max size is 322mm. Finally, there are more pad choices for the Big Blacks versus the Big Reds. This is IMHO the best deal of the survey.

~$2200
Stillen Brembo kit, http://www.stillen.com/brakes/systems/systems.html. This was the price a few years

ago. Some folks have this and are very happy, but others have reported that their cross drilled disks crack and warp. The replacement disks are also costly. Supposedly, the Porsche treatment of Brembo calipers in the above kits is better than the stock Brembo caliper in this kit. The calipers do compare to the 928 though since the pistons are also 2x38x44mm.

~$2100 - $2800
Mov'it Big Red kit, http://www.ultimategarage.com. The Ultimate Garage's web site say they utilize the Porsche 996 monobloc calipers (instead of the 993) and the GT2 2 piece rotors. These 996 calipers would make it better than the above Lobster kit. Supposedly, our European friends can get these directly from Mov'it for about $2100 although Ultimate Garage's price is $2800. I think Roger Gerl was investigating becoming a Swiss distributor.

$2500 - $3000
KVR AP Racing 6 piston caliper and 2 piece rotors. Terry said he could sell this kit for $2500 for a group purchase of 5 or more. $3000 is the normal price. I'm not sure if this is the identical kit to the one on Stillens web page. This is the entry to the "very serious" upgrades and is really a step above the previous kits. It can accommodate 355x35.5mm rotors!

$3000+
There are other kits available but not investigated because of their prices. Mov'it's Terminator kits (14.9" disks!!), Baer, and Wilwood, come to mind. Probably the awesome looking NewTech fits this category too.

Rear Kits
~$1800 - $2600
Mov'it has a kit for the rear brakes too. It uses Boxter S components including a 299x24mm rotor. It should cost about $1800 in Europe but $2600 in the states.

Summary
All of these kits including the Mov'it kits should fit '91+ 3000GTs and Stealths, as long as you have the wheel clearance. To improve clearance and increase front track width (reduces under steer), you could utilize a thicker facing on the hat with longer wheel studs. Since Mov'it is now using 996 calipers, it would be worthwhile to compare them with the 928 S4 caliper. Regardless, Terry Gosse of KVR should be able to build custom front kits with any caliper and any disk and still have unbeatable prices.

Happy braking,
Ken
---------- End Original Message ----------

Synopsis

Improved braking usually means one or both of the following: (1) shorter and/or faster stops, (2) reduced or eliminated brake fade. If you are already engaging the ABS then the braking system is adequate for your needs or you need "stickier" tires or you need a better road surface. However, not all uses of the brakes require that braking be taken to the point of exceeding the available tire-road friction force (that is locking the brakes or excessively sliding the tire). These uses are encountered on the street (for example, extended downhill grades, enthusiastic driving of the twisties, towing) and on the race track. For this type of use brake fade is often a greater concern than faster stops.

When we need to stop more than once and may be using the brakes in a manner that does not come close to engaging the ABS, we need to improve braking *availability*. This means not necessarily stopping faster or shorter, but reducing or eliminating brake fade and brake fluid fade.

Brake fluid fade is reduced by:

- Regularly changing the brake fluid.
- Preventing or minimizing the amount of heat that gets to the fluid in the calipers.
- Using a brake fluid with high boiling points.

We can reduce brake fade by improving heat management to maintain the optimal temperature at the rotor-pad interface to maximize brake pad coefficient of friction. This can be accomplished by:

- Using air or water to cool the brake area.

- Using pads, calipers, and rotors that dissipate heat better.
- Switching to an entirely different rotor and pad setup, such as the carbon-ceramic brakes on the new Ferrari 360 Challenge Stradale and the Ferrari Enzo (for those that have a spare $20,000 lying around) or the Porsche GT3 (at the bargain basement price of a little over $8000).

For shorter and faster stops you must have a road surface favorable for braking, meaning the road is not excessively wet or oily or icy or covered with debris, sand, or gravel. You also need the stickiest tires available. As usual, life involves compromises. Sometimes there are economic reasons or race "rules" or strategy factors that prevent us from using the stickiest tires. Sometimes we need a certain flexibility or stiffness or longevity or water-handling ability that may compromise the "stickiness" concerns.

When shorter stops means exerting more force on the wheels/tires, this can be accomplished by:

- Better driver management of the brake pedal.
- Using SS braid-protected brake lines (reduces pressure losses or delays).
- Using different pads (with materials and a coefficient of friction optimal for the use of the pads).
- Using a caliper with a total piston area appropriate to achieve balanced brake bias with the rear brakes.
- Using a larger diameter rotor to increase the torque applied by the caliper to the wheel.
- Improving the front-rear braking distribution (could involve upgrading the rear rotors and calipers, especially for 1991-1993 models).

The main advantage of the larger-rotor, different-caliper braking kits is improved heat management, that is, reduced or eliminated brake fade. It would be interesting to see how much faster and shorter our cars stop with the big brakes, but that does not seem to be the main reason for installing them.

Available Front Big Brake Kits

Manufacturer	Rotor sizes (mm)	Caliper pistons (mm)
Alcon	332x??	2x38.1/44.5
AP Racing	343x35.5, 355x35.5, 362x36	2x27/32/38
Brembo	343x32, 355x32	2x38/44, 2x40/44
MOV'IT	322x32	2x36/44
Porsche	322x32, 332x32	2x36/44, 2x38/44
StopTech	332x32, 355x32, 380x32 (28 or 35 widths avail.)	combinations of 34, 36, 38, 40, 42, 44

Available Rear Big Brake Kits

Manufacturer	Rotor sizes (mm)	Caliper pistons (mm)
MOV'IT	299x24	2x??
StopTech	328x28	2x36 (other sizes available)

Acknowledgments

Some of the information presented here was gathered from various books, email lists, message boards, and vendor web sites. I would like to acknowledge and thank the following for their contributions (in no particular order).

- Stoptech High Performance Brake Systems (http://www.stoptech.com/)
- Avalon Ent Racing (http://www.avalonracing.net/)
- AP Racing (http://www.apracingusa.com/)
- James Walker, Jr. (http://www.teamscr.com/grmbrakes.htm)
- Ken Middaugh, Rich Merritt, and Jim Berry (with Team3S)
- Terry Saltzman (Grd4Spd Racing)
- Geoff Mohler (with Team3S and http://www.speedtoys.com/)
- Darren Schilberg (aka Flash) http://www.team3s.com/~dschilberg/)
- Philip V. Glazatov (http://supercar-engineering.com/)
- Jim Matthews (http://www.team3s.com/~matthews/brake_upgrade_considerations.html)
- Kenneth Streeter (http://www.vtr.org/maintain/brake-fluids.html)
- Mike Kojima (http://www.se-r.net/car_info/brake_performance.html)
- James Walker, Jr. (http://www.scirocco.org/faq/brakes/pulpfriction/pfpage1.html)
- Rennsport Systems (http://www.rennsportsystems.com/~porsche/2c.html)
- RPM.net (http://www.rpmnet.com/techart/fluid.shtml)
- US and Canadian Standard 116 (http://www.tc.gc.ca/actsregs/mvsa/jan98/english/mvsr116.html)
- MOV'IT (http://www.movit.de/)

Page last updated January 17, 2005.