M-Register Newsletter
September 1999, pages 8 - 11

E28, E24, E34 Brake Options

Pete Read

This article can be used several ways. First it's a reference for brake parts on E28/E34 five series and E24 six series cars (front brakes only for E32 7 series and E31 8 series). I've included part numbers, rotor and caliper sizes, weights, and prices (6/99 BMW price book).

It can also be used as a general guide for parts interchangeability. With the price of E28 M5 front calipers now at $1140 *each*, owners may be interested in other options if the calipers cannot be rebuilt. All the front and rear brakes shown in the tables below will physically bolt on to any of these cars. Except for the E34 M5 and E31 840/850 fronts which require 16" wheels, all will fit inside BMW 15" wheels.

Finally I give some idea of how installing these different parts will affect brake balance and brake pedal travel.

General Brake Theory

I've read a number of books on brakes, but I still think the first one I purchased, Fred Puhn's Brake Handbook, is the most clearly written. It's available through most automotive book sources, cheap at $16, and easy to understand.

The most common brake performance problem is overheating or lack of thermal capacity. That is, the brakes either can't get rid of heat fast enough or aren't large enough to absorb the heat and keep the brakes at reasonable operating temperatures.

Typical symptoms are that the brakes work fine initially, then after some aggressive driving develop a low brake pedal (brake fluid boiling) or a normal brake pedal with a marked reduction in stopping power (brakes pads beyond their effective operating temperature). High temperature brake fluid such as ATE 200 and high performance brake pads may be all that's needed to solve the problem. If those measures don't work, the next step is increased brake cooling (brake ducts) or larger brakes. Brake ducts are effective, low cost, and lightweight. See the August '98 newsletter for installation notes.

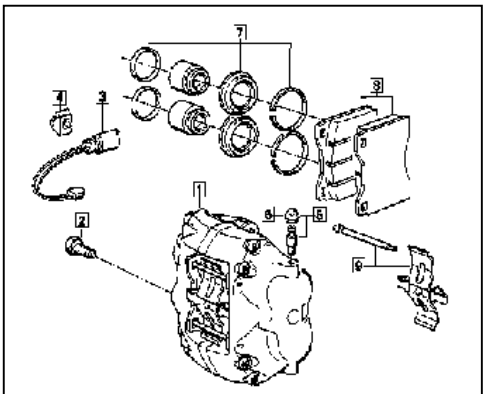
Larger Front Brakes

The most common upgrade is larger front brakes because they do most of the work, typically 70%, due to weight transfer during braking. For example, an E28 M5 will stop from 70 mph in 166 feet, which works out to 0.99 g. Stopping its 3500 pounds at 0.99 g (103.3" wheel base and estimated 18" cg) transfers over 600 lbs to the front wheels. The resulting weight transfer works out to about 70% weight on the front wheels and 30% on the rear.

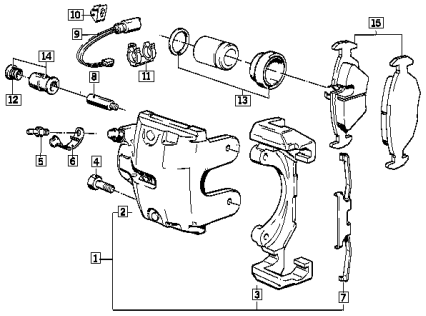
Larger front brakes many times increase the brake bias (front to rear braking) towards more than the ideal front braking force. Bias of E28/E24 brakes cannot be easily changed by installing a proportioning valve either because the master cylinder is plumbed diagonally (LF-RR, RF-LR) versus front and rear separately. If the surface area of the new brake caliper pistons is larger than the original equipment, brake pedal travel increases (see tables).

More front braking force, through larger brakes, is generally a safe modification because it insures that the front wheels will lock first during a stop, just like the original brakes. Federal automotive standards require this to prevent instability and spins from the rear wheels locking first. Of course too much front braking (front bias) prevents the rear tires from doing their share of the work.

Brake bias is much like the suspension tradeoff of understeer characteristics. All cars understeer from their designed-in suspension balance. That is, the front wheels lose lateral traction first during cornering for stability reasons. In fact, when braking and cornering at the same time (trail-braking), more front bias increases understeer because the extra braking of the front tires takes away from their cornering ability. The degree of both suspension balance understeer and front brake bias is a tradeoff of stability versus higher performance. When the rear tires handle more of the braking and cornering work, performance is increased while stability is reduced.



Fixed Caliper



Floating Caliper

Weight versus Dimensions

Increased weight allows brakes to absorb more heat, allowing more consecutive hard stops without overheating, but doesn't necessarily change brake force or bias. The stopping force is a combination of brake boost, master cylinder size, caliper piston size, rotor size and pad compound. When installing larger calipers and rotors, the brake force or bias increase is directly related to the increase of both effective caliper piston area and rotor radius (center of hub to center of pad). The piston area of floating calipers is doubled (piston and caliper move in opposite direction applying same force to both sides of rotor) while fixed caliper piston areas are simply added.

The E28 M5 and E28 535i brakes are a great illustration of weight versus dimensions. Both cars use the same brake master cylinder and essentially the same rear brakes. Even though the front brakes are different designs the combination of caliper piston size and rotor diameter gives equivalent front braking force and bias. This makes the E28 M5 and 535i brakes completely interchangeable, except for the extra weight and resultant extra heat capacity of the M5. The brake bias and pedal travel are unchanged when swapping components.

Fixed versus Floating Calipers

Notice that only the front E28 M5 and E31 840 brakes are four piston fixed calipers. Even the E34 M5 has single piston floating calipers on both ends. Racing cars generally use fixed calipers, and I don't think that will change any time soon, but after some investigation I've decided that floating designs are practical and work just fine. An indication of good brake design, floating or fixed, is even pad wear on both sides of the rotor.

Floating calipers even have a cooling advantage in that the single piston is closer to cooling air while the fixed calipers have one side located in the center of the wheel. If there's any question about brake parts in the center of the wheel being hotter, take a close look at most vented rotors. The rotor plate in the center of the wheel, closest to the hat, is usually thicker to keep the temperature down.

Single piston floating calipers don't support the brake pads as well as multiple pistons. I noticed that the newer E34 and E32 front pads have thicker backing plates than normal to prevent pad bending. The "hammer head" brake pad design (note the brake pad ears) also makes the pad more stable by putting one side in tension and the other in compression versus compression only for many pads.

Component Details

I collected much of this information by taking brakes apart and measuring components. Then I looked at the part numbers of the caliper repair kits to see which other brakes had the same piston sizes.

Later I also noticed that ATE brake dust boot part numbers indicate the caliper piston size. The boot is marked "ATE 11.8102-" and then the

Front Brakes

	Description	Quan	Part no	Price	Wt (lbs)
E28 M5, E24 M6	Total Brakes			$2541.50	63.3
	Rotor 300x30mm	2	34 11 2 225 007	$ 100.00	19.0
	Caliper(L), 40mm x4	1	34 11 2 225 002	$1140.00	11.0
	Caliper(R), 40mm x4	1	34 11 2 225 003	$1140.00	11.0
	Brake Pad Set	1	34 11 2 226 009	$ 61.60	3.3
	Caliper Repair Kit	2	34 11 1 158 692	$ 39.25	
E31 840	Total Brakes			$1608.00	61.6
and 850 8/93 on	Rotor 324x30mm	2	34 11 1 161 086	$ 150.00	21.5
	Caliper(L), 42mm x4	1	34 11 1 161 177	$ 570.00	7.2
	Caliper(R), 42mm x4	1	34 11 1 161 178	$ 570.00	7.2
	Brake Pad Set	1	34 11 1 163 923	$ 168.00	4.4
	Caliper Repair Kit	2	34 11 1 162 178	$ 26.50	
E31 850	Total Brakes			$1384.00	76.1
before 8/93	Rotor 324x30mm	2	34 11 1 159 895	$ 100.00	22.9
	Caliper(L), 60mm x1	1	34 11 1 160 325	$ 357.00	9.3
	Caliper(R), 60mm x1	1	34 11 1 160 326	$ 357.00	9.3
	Carrier for Caliper	2	34 11 1 160 327	$ 151.00	3.6
	Brake Pad Set	1	34 11 1 160 296	$ 168.00	4.5
	Caliper Repair Kit	2	34 11 1 157 037	$ 20.25	
E34 M5	Total Brakes			$1885.25	68.0
	Rotor 315x28mm	2	34 11 2 226 385	$ 184.00	20.6
	Caliper(L), 60mm x1	1	34 11 2 226 873	$ 490.00	7.9
	Caliper(R), 60mm x1	1	34 11 2 226 874	$ 490.00	7.9
	Carrier for Caliper	2	34 11 2 226 875	$ 219.00	3.4
	Brake Pad Set	1	34 11 1 159 279	$ 99.25	4.2
	Caliper Repair Kit	2	34 11 1 157 037	$ 20.25	
E32 735,740,750	Total Brakes			$1245.75	61.8
and E34 540	Rotor 302x28mm	2	34 11 1 159 896	$ 88.25	17.6
	Caliper(L), 60mm x1	1	34 11 1 160 363	$ 334.00	8.0
	Caliper(R), 60mm x1	1	34 11 1 160 364	$ 334.00	8.0
	Carrier for Caliper	2	34 11 1 160 365	$ 151.00	3.2
	Brake Pad Set	1	34 11 1 159 279	$ 99.25	4.2
	Caliper Repair Kit	2	34 11 1 157 037	$ 20.25	
E34 525,530,535	Total Brakes			$1251.50	59.2
	Rotor 302x22mm	2	34 11 1 160 936	$ 92.00	16.5
	Caliper(L), 60mm x1	1	34 11 1 160 367	$ 334.00	7.8
	Caliper(R), 60mm x1	1	34 11 1 160 368	$ 334.00	7.8
	Carrier for Caliper	2	34 11 1 160 366	$ 156.00	3.2
	Brake Pad Set	1	34 11 1 162 535	$ 87.50	4.2
	Caliper Repair Kit	2	34 11 1 157 037	$ 20.25	
E28 535	Total Brakes			$1085.50	49.9
and E24 9/82 on	Rotor 282x25mm	2	34 11 1 163 148	$ 59.00	12.8
except M6	Caliper(L), 57mm x1	1	34 11 1 160 369	$ 302.00	7.2
	Caliper(R), 57mm x1	1	34 11 1 160 370	$ 302.00	7.2
	Carrier for Caliper	2	34 11 1 160 371	$ 151.00	2.8
	Brake Pad Set	1	34 11 1 161 717	$ 61.50	4.3
	Caliper Repair Kit	2	34 11 1 153 208	$ 13.00	

next two digits are the piston diameter. For example, the E34 and E32 front calipers use 34 11 1 157 037 caliper repair kits. The rubber boot is marked "ATE 11.8102-6003.1 7399 3-4" and the piston diameter is 60mm.

The only caliper piston diameter listed that I'm not sure of is the E31 840. I estimate it at 42mm because that works out to an equivalent effective area to the single piston E31 850 caliper with the same rotor and master cylinder size.

The E28/E24 master cylinders are listed as ATE 23.81mm. The size for the E34 is not listed, but based on the increase in piston calipers, I'd estimate it at 25mm plus. Bill Shook and Carl

Rear Brakes

	Description	Quan	Part no	Price	Wt (lbs)
E28 M5, E24 M6	Total Brakes			$ 969.25	31.5
	Rotor 284x10mm	2	34 21 1 163 140	$ 39.50	10.0
	Caliper(L), 36mm x1	1	34 21 1 160 393	$ 279.00	3.4
	Caliper(R), 36mm x1	1	34 21 1 160 394	$ 279.00	3.4
	Carrier for Caliper	2	34 21 1 160 395	$ 136.00	1.6
	Brake Pad Set	1	34 21 2 226 013	$ 60.25	1.5
	Caliper Repair Kit	2	34 21 1 153 194	$ 9.30	
E28 535,533,528	Total Brakes			$ 828.00	31.4
and E24 9/82 on	Rotor 284x10mm	2	34 21 1 163 140	$ 39.50	10.0
except M6	Caliper(L), 36mm x1	1	34 21 1 160 397	$ 212.00	3.3
	Caliper(R), 36mm x1	1	34 21 1 160 398	$ 212.00	3.3
	Carrier for Caliper	2	34 21 1 160 395	$ 136.00	1.6
	Brake Pad Set	1	34 21 1 157 925	$ 53.00	1.6
	Caliper Repair Kit	2	34 21 1 153 194	$ 9.30	
E34 M5,540	Total Brakes			$1177.25	42.2
	Rotor 300x20mm	2	34 21 1 159 659	$ 79.00	13.4
	Caliper(L), 40mm x1	1	34 21 1 160 399	$ 327.00	4.7
	Caliper(R), 40mm x1	1	34 21 1 160 400	$ 327.00	4.7
	Carrier for Caliper	2	34 21 1 160 384	$ 147.00	2.0
	Brake Pad Set	1	34 21 1 158 221	$ 71.25	2.0
	Caliper Repair Kit	2	34 21 1 158 578	$ 21.75	
E34 525,530,535	Total Brakes			$1073.00	36.2
	Rotor 300x10mm	2	34 21 1 162 305	$ 59.00	10.8
	Caliper(L), 38mm x1	1	34 21 1 160 381	$ 284.00	4.4
	Caliper(R), 38mm x1	1	34 21 1 160 382	$ 284.00	4.4
	Carrier for Caliper	2	34 21 1 160 383	$ 160.00	1.9
	Brake Pad Set	1	34 21 1 162 536	$ 67.00	2.0
	Caliper Repair Kit	2	34 21 1 159 171	$ 15.70	

Brake Balance

Front Brake	Rear Brake	Front/Rear Brake % Bias	Brake Pedal Travel%increase (E28, E24)
Balanced			
E28 all, E24 all	E28 all, E24 all	70/30	0
E34 all except M5, E32	E34 all except M5	70/30	12
E34 M5, E31 all	E34 M5	69/31	14
Big Front			
E34 all except M5, E32	E28 all, E24 all	73/27	9
E31, E34 M5	E28 all, E24 all	74/26	9
Big Rear			
E28 all, E24 all	E34 all except M5	68/32	3
E28 all, E24 all	E34 M5	65/35	7
E34 all except M5, E32	E34 M5	68/32	14

Nelson both told me that there's a good chance the E34 ATE (not Girling) master cylinders will fit the earlier cars.

The weights listed are from standard BMW parts information. If you have a good relationship with your local parts department, they usually are willing to look up details like weight under "parts information" on their CD-ROM.

Options

So what's the best solution for an E28 M5 or E24 M6? The stock brakes are pretty good, especially if cooling ducts are added. If money is no object, E31 840 front and E34 M5 rear brakes, but you may want to look at a larger master cylinder. Lowest cost and easiest to locate used, are the standard E24/E28/E34 brakes. Typical used prices for each end (2 calipers and carriers) are standard E24/E28/E34 $100, E32 front $200, E28 M5, E34 M5, or E31 850 front $400, E31 840 front $500, and E34 M5 rear $300.

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	Caliper(L), 36mm x1	1	34 21 1 160 393	$ 279.00	3.4
	Caliper(R), 36mm x1	1	34 21 1 160 394	$ 279.00	3.4
	Carrier for Caliper	2	34 21 1 160 395	$ 136.00	1.6
	Brake Pad Set	1	34 21 2 226 013	$ 60.25	1.5
	Caliper Repair Kit	2	34 21 1 153 194	$ 9.30	
E28 535,533,528	Total Brakes			$ 828.00	31.4
and E24 9/82 on	Rotor 284x10mm	2	34 21 1 163 140	$ 39.50	10.0
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	Brake Pad Set	1	34 21 1 157 925	$ 53.00	1.6
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	Caliper(L), 38mm x1	1	34 21 1 160 381	$ 284.00	4.4
	Caliper(R), 38mm x1	1	34 21 1 160 382	$ 284.00	4.4
	Carrier for Caliper	2	34 21 1 160 383	$ 160.00	1.9
	Brake Pad Set	1	34 21 1 162 536	$ 67.00	2.0
	Caliper Repair Kit	2	34 21 1 159 171	$ 15.70	

Brake Balance

Front Brake	Rear Brake	Front/Rear Brake % Bias	Brake Pedal Travel %increase for E28, E24
Balanced			
E28 all, E24 all	E28 all, E24 all	70/30	0
E34 all except M5, E32	E34 all except M5	70/30	12
E34 M5, E31 all	E34 M5	69/31	14
Big Front			
E34 all except M5, E32	E28 all, E24 all	73/27	9
E31, E34 M5	E28 all, E24 all	74/26	9
Big Rear			
E28 all, E24 all	E34 all except M5	68/32	3
E28 all, E24 all	E34 M5	65/35	7
E34 all except M5, E32	E34 M5	68/32	14

My current choice is E32 fronts balanced with E34 525 rear brakes because my car sees the track on a regular basis. The calipers are inexpensive used (about $250 total – Jason Lile, Zionsville Autosport 800.246-6377), replacement rotors are relatively cheap, there's a large selection of high performance brake pads (same as E36 M3), and the single piston calipers are simple to rebuild (dust boots burn-up regularly from the heat of track driving).

I tried the E32 front brakes only first. They were fine on the street, but I felt the extra understeer when trail-braking at the track. Adding the E34 rear brakes restored the original brake balance but increased pedal travel more. Next, I'm considering adding a larger master cylinder to restore original pedal travel--which reminds me that stock is pretty good.

M-Register Newsletter
February 2000, pages 2, 3

E28, E24, E34 Brake Options Update

Pete Read

I'd like to add a couple of notes to my brake article from the September '99 Newsletter. First, thanks to Mark Amarandos, I now have a master cylinder that bolts right on and restores the original pedal travel even though I have larger than stock brake caliper pistons (E32 750 front, E34 525 rear). Second, I'll add a brake pad cross-reference table that didn't fit in the last newsletter.

750 Master Cylinder (Mark Amarandos tip)

After seeing my brake article, Mark contacted me about the p/n 34 31 1 156 643 E32 750 master cylinder he has been using for some time on his E28 M5 with E31 840 front and E34 M5 rear brakes. It sounded great, so I decided to try it.

Sure enough, the new master cylinder bolted right in without a hitch and reduces pedal travel – it feels great! The actual numbers work out pretty well. From my Brake Balance Table in the original article; notice that the brake pedal travel increased about 12% with the larger caliper pistons. The 750 master cylinder comes very close to restoring the stock travel with 10% more area that the stock part (25mm versus 23.81mm diameter piston).

If you're considering doing it yourself, it's not a difficult job, but takes some time because of the tight access. The basic steps are to first pump the brake pedal to bleed accumulator pressure, drain the plastic brake reservoir (a turkey baster works to suck out brake fluid), pull the reservoir straight up out of the rubber grommets, disconnect the brake lines, and unbolt the master cylinder. Reverse the process, fill with brake fluid, and bleed as necessary. Critical note: Don't touch the brake pedal or clutch pedal until everything is back together and filled with brake fluid.

Front Brake Pads

	FMSI #	Stock	PF Street	PF 90	Cool Carbon
E28 M5, E24 before 9/82 and M6, E12 528, E23 all	D163	$ 61.50	$ 42.50	$128.70	$ 96.95
E28 all except M5, E24 after 9/82 except M6, E30 M3	D395	$ 61.50	$117.73	$192.50	$124.95
E34 all, E32 all, E36 M3	D394	$ 99.25	$ 94.16	$170.50	$124.95
E31 840, 850 after 8/93	D639	$168.00	$168.26	$224.40	Na
E31 850 before 8/93		$168.00	Na	Na	Na

Rear Brake Pads

	FMSI #	Stock	PF Street	PF 90	Cool Carbon
E28 all, E24 all after 9/82, E23 all, E30 325	D279	$ 60.25	Na	Na	$ 96.95
E34 all, E32 all, E36 all, E30 M3	D396	$ 71.25	$ 93.87	$192.50	$ 99.95

Brake Pad Cross Reference

I thought it might be interesting to show which pads fit various cars and the price of stock, aftermarket, and track pads. Sometimes it's difficult to tell from the BMW part number which pads are similar because a pad compound change affects the part number even though it doesn't change the physical fit.

Many brake suppliers use the standard FMSI number that identifies basic pad dimensions. I've used that number below as a reference. Included for price comparison are stock pads, Performance Friction stock replacement pads, and two track pads; Performance Friction 90 and Cool Carbons (now sold by Turner Motorsport).

Notice that the front E28 M5/ E24 M6 pads are used on earlier E12 five series and E23 seven series cars. The rear pads are also used on standard E24 six series, E28 five series, and E30 three series.

E34 M5 front pads are the same size as all E34 five series, E32 seven series, and the E36 M3. The rear pads are used on all E32, E34, E36, and the E30 M3.