

TECH BMW PROCEDURE

Know Your Differential

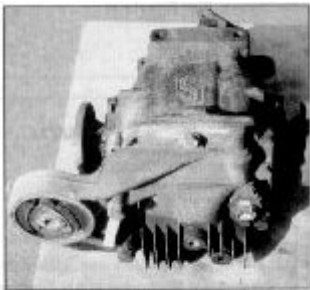
*A Review of E30 BMW
Gearing Options*

by Mike Miller

PHOTOS BY THE AUTHOR



We love differentials, especially BMW differentials with their wide variety of ratios and broad interchangeability. Why? Because while many cars live their entire lives without ever having the "pumpkin" removed, a differential gearset change or a swap to a diff with a lower (numerically higher) ring and pinion gearset remains the single most effective way to increase acceleration.



"S" marking identifies a limited slip E30 BMW differential.

This is a modification that has nothing to do with the engine, has no effect on vehicle emissions, and doesn't run afoul of any governmental regulations. Its genesis stems from the fact that many modern cars-U.S. specification BMWs in particular-are intentionally undergeared in an effort to squeeze out a few more average miles per gallon so that government corporate average fuel economy (CAFE) requirements may be appeased. The strategy works on EPA fuel economy tests, but in the real world the fuel savings is often illusory: The lack of gearing requires harder acceleration and more shifting to attain the desired level of performance. This article focuses on regearing options for E30-bodied BMWs, the second line of 3 Series cars produced in various form from 1984 to 1992.

Theoretical Top Speed Equation

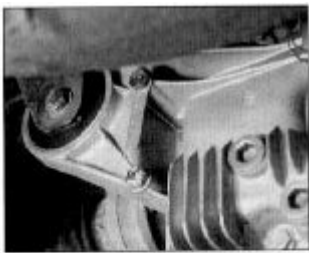
$$\text{Theoretical top speed} = \frac{\text{tire diameter} \times \text{maximum rpm in fifth gear}}{\text{Differential gear ratio} \times 336}$$

Consult tire manufacturers or The Tire Rack to find your tire diameter. And remember, your final differential gear ratio in fifth gear overdrive is the ring and pinion gearset ratio x .81. To find lower road speeds in fifth gear, substitute the desired lower rpm into the equation in place of the maximum rpm in fifth gear.

Will a lower ring and pinion gearset make your engine run faster? Absolutely. You'll be turning more engine revs at any given road speed. How much more depends upon how low you go with a gearset, but the difference may be slight and well worth the increase in acceleration. Also, an overdriven fifth gear ameliorates the higher revs inherent in the lower gearsets while traveling at cruising speeds.

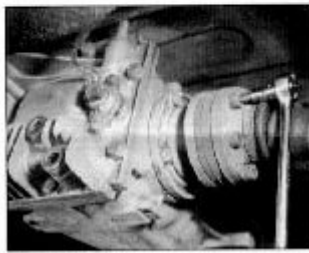
E30 Differential Ratios				
Year	Model	Type	Engine	Differential Ratio
1983-1985	318i	2/4 dr.	1.8L 4 cyl.	>11.83 3.64
				11.83 - 09.84 3.91
				09.84> 4.10 (automatic)
1984-1987	325e/es	2/4dr.	2.7L eta 6 cyl.	>09.85 2.79
				09.85> 2.93
1986-1988	325	2/4dr.	2.7L eta 6 cyl.	all 2.93
1987-1991	325i/is/iC	2/4dr.	2.5L 6 cyl.	all manual and early automatics 3.73
				09.88> 4.10 (automatic)
1988-1991	M3	2 dr.	2.3L twin cam	all 4.10
1991	318i/is/iC	2/4dr.	1.8L twin cam	4.10, cabriolet 4.27
1992	325iC	cab.	2.5L 6 cyl. 3	.73 manual/4.10 auto

For example, if your fifth gear is an overdriven 0.81:1 as in E30 BMWs, then you can go to a 4.10 gearset and still have a final ratio of only 3.32 in fifth gear ($4.10 \times .91 = 3.321$). This translates to just under 75 mph at 3500 rpm in fifth gear using 205/55-15 tires. A 4.45 gearset would raise the revs only to about 3750. So it's not like you'll be getting buzzed out of the cockpit on the highway.



The ratio tag is fitted with one of the cover bolts. This diff is identified as being equipped with a 4.27 ring and pinion gear set.

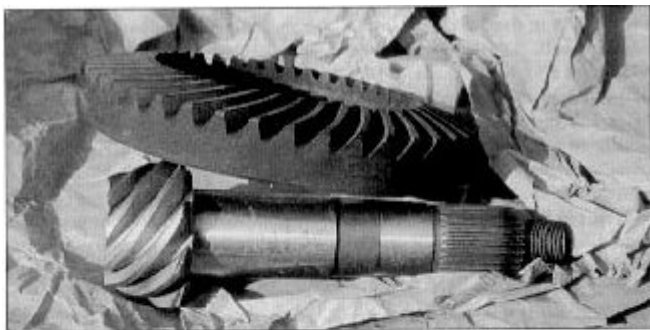
Similarly, top speed is often unaffected by a lower gearset because few cars have sufficient high-end torque to attain maximum rpm in an overdriven fifth gear anyway. You run out of pulling power against wind resistance, and wherever you are on the speedo when that happens is your actual top speed. A lower gearset will certainly reduce your theoretical top speed, but it may well increase your actual top speed capability by providing more pulling power against the wind drag.



Removing the CV joints requires a hex socket. Torque to 42 ft-lb on reassembly.

An important thing to bear in mind about swapping is that six- and four-cylinder E30 BMW differentials are different and will not interchange. The housings and rear axle carriers are totally different. Interchangeability only exists among four-cylinder cars and six-cylinder cars separately. The sole exception is the E30 M3, which uses a six-cylinder-type differential, thus providing a source of 4.10 limited slip diffs for the 325i. In addition, differentials from the E28 5 Series BMWs (1982-88) will also interchange with the E30 six-cylinder 3 Series cars, and this becomes key to modifying the early eta engine E30s.

The E28 came with one of four differentials: 2.93 in the 528e; 3.15 in the 524td (diesel); 3.25 in the 533i and 535i/is; and 3.91 in the M5. Limited slip differentials are identified by a white "S" painted on the outside of the housing, usually on top. You can also turn the input shaft and note what happens: If you're looking at an LSD, both flanges will rotate in the same direction. If it's an open diff, either only one will turn or they'll turn in opposite directions. The ring and pinion gearset ratio is identified on a small metal tag on one of the cover bolts. If the tag is gone, you'll have to remove the cover and count the teeth on the ring and pinion gears.



Each ring and pinion gear set is matched at the factory and identified by a unique numerical designation. This brand new 4.44 ring and pinion gear is stamped, "0980". The same number is electrically etched into the pinion gear, telling us we have a matched set.

The proliferation of the 533i and 535is in dismantling yards represents a veritable treasure trove for owners of E30 cars that are saddled with the lower powered "eta" engine and a 2.79 or 2.93 diff. A swap to the 3.25 is like switching on a second engine! Moreover, used differentials are normally priced quite reasonably due to the lack of demand. Used limited slip diffs generally go out the door in the \$350-500 range. M3 and M5 differentials bring more money, as do the rare 4.27 units from 1991 318i Cabriolets, which are all but impossible to find in limited slip configuration.

Ring and Pinion Gearsets			
Part Number	Ratio	Gear Teeth Price(as of 8/97)	BMW Suggested List
Ring:Pinion			
33 12 1 211 831	3.64	40:11	\$622.50
33 12 1 210 742	3.91	43:11	\$622.50
33 12 1 211 828	4.10	41:10	\$622.50
33 12 1 211 825	4.27	47:11	\$622.50
33 12 1 214 119	4.44	40:09	\$622.50
<i>For E30 M3's and six-cylinder BMW's the choices are as follows:</i>			
33 12 1 208 738	3.08	40:13	\$622.50
33 12 1 208 542	3.15	41:13	\$622.50
33 12 1 208 389	3.25	39:12	\$622.50
33 12 1 210 362	3.46	45:13	\$622.50
33 12 1 208 350	3.54	40:11	\$622.50
33 12 1 210 028	3.73	41:11	\$622.50
33 12 1 208 349	3.91	43:11	\$622.50
33 12 2 222 689*	4.00	n/a	\$1,475
33 12 1 208 348	4.10	41:10	\$622.50
33 12 2 222 692*	4.18	n/a	\$1,475
33 12 1 208 779	4.27	47:11	\$622.50
33 12 2 222 695*	4.36	n/a	\$1,475
33 12 1 211 955	4.45	49:11	\$622.50
33 12 2 221 891*	4.56	n/a	\$1,475
33 12 2 221 887*	4.67	n/a	\$1,475
33 12 2 220 910*	4.75	38:8	\$1,475
33 12 2 222 283*	4.88	n/a	\$1,475
33 12 2 220 913*	5.00	35:7	\$1,475
33 12 2 222 286*	5.13	n/a	\$1,475
33 12 2 220 916*	5.28	n/a	\$1,475
33 12 2 221 747*	5.44	n/a	\$1,475

**Part numbers marked with an asterisk are BMW Motorsport ring and pinion sets that are available in the U.S. only through importers. The prices shown were quoted by Maximillian Importing.*

If you don't mind spending more money, you can always opt to rebuild your existing differential with a new ring and pinion gerset from BMW in whatever ratio you choose. From a performance standpoint this is the only viable option of you already have a limited slip differential. Gearsets are not inexpensive, currently listing for \$622.50 from a BMW dealer and about \$450-550 from Maximillian Importing. The assorted bearings, seals and other bits will run about another \$125-150 for OEM German parts, more from the dealer. Figure on a good four to five hours' worth of labor with the diff out of the car, and another two hours for removal and installation.



Differential pinion flange to driveshaft fasteners don't readily lend themselves to a torque wrench. Make 'em real tight and see how lock nuts if yours have been off many times.

It is increasingly difficult to order any European specification Motorsport parts through BMW N.A., probably due to the paranoia of its corporate attorneys, which seems to far surpass anything exhibited by Porsche, Volkswagen or even Mercedes-Benz. Nevertheless, all BMW Motorsport parts are readily available from Maximillian Importing. The numerically higher ratios are extremely low, and their suitability for street use is equally low. They can, however, provide a great deal of flexibility for tuning a race car, particularly a hillclimber. Complete factory remanufactured differentials are also available from BMW in a wide variety of ratios.

How To Tell if Your Differential is Worn

BMW differentials rarely fail as long as the oil level is reasonably well maintained and the oil is changed at least once in a while. Failure is rare even when the oil is not changed, as long as it's in there. The limited slip differentials are fairly bulletproof, but spider gears have been known to break pretty easily on open differentials that are subject to heavy wheelspin-like those that result from autocrossing or becoming stuck in the snow. Spider gear failure will immediately become apparent as the car will not move.

The most common wear item, however, is the output bearings. Output bearing wear is characterized by a hum or whine from the back of the car that will become audible between 3000-4000 rpm, usually becoming more pronounced in fifth gear at a constant cruising speed. The noise will stop or change when you lift your foot from the accelerator pedal and may also change as the suspension rebounds from dips and valleys in the roadway. The reason is that both events alter

the nature of the load on the bearing. The noise may also stop entirely above a given rpm. It should be noted that many a differential has gone another 50,000 miles with this noise, so it's not necessarily something that needs to be addressed right away. But the longer you let it go, the more likely it is that other parts, such as the expensive ring and pinion gears, may wear out as well.

It should also be noted that bearing noises are often very difficult to trace from inside the car, as their resonance will travel throughout the structure of the vehicle and make it sound like they're coming from places they aren't. Front wheel bearings are commonly mistaken for differential whine by many enthusiasts, but there's actually a pretty easy way to tell the difference: Turn the steering wheel. Front-wheel bearing whine will change or go away as you turn the steering wheel (when the car is moving, of course) and alter the loads placed on the bearing. Further, they are far more likely to occur at low road speeds than differential bearing noises. Wheel bearing noise will also be unaffected by lifting the throttle.

Used Differentials or Quality Rebuild

Used parts are always a gamble, especially if you're buying them long distance. If you buy a used diff from a reputable dismantler and it makes noise, then they'll probably be quite willing to take it back. The problem is they might not have another one, especially if you were hunting around for something rare. Moreover, you'll be out labor, either your own or someone else's, as well as shipping charges to send back the faulty diff and get another one. But if you can check the thing out before you buy it there's one key item that will almost always ensure a good diff-cleanliness.

Take a 3/8-in. ratchet, a 17mm socket and a 10mm allen socket along with you. Drain the oil, remove the cover and have a look-see. Differential oil is supposed to be changed approximately every 30,000 miles. Is the inside of the housing clean and gray? Do the gears and internals look clean? What about the oil that you just drained out? Is it reasonably clean, or does it look like French Roast? Another clue to diff maintenance is the drain plug itself. After being removed and replaced a few times, the drain plug will bear some scars. If it looks like it's never been out, it probably hasn't. On the other hand, don't summarily reject a diff just because it's not crystal clean inside, especially if it's a limited slip unit with a rare gearset; instead, just offer a lower price. I bought an extremely rare 4.27 LSD for my '91 318is for only \$350. It was pretty black inside but works great so far.

Quality rebuilds are not as easy to spot, as the workmanship you're likely to receive depends upon the experience, equipment and work habits of the technician. A good rebuild will have certain necessary factory BMW tools, such as bearing pullers and drifts, along with a factory repair manual and torque specification book. He'll have a clean shop and an uncluttered work area to disassemble your diff. He'll use a good quality torque wrench, and recommend high-caliber synthetic lubricants such as Red Line 75W-90 gear oil. Again, one of the central issues is cleanliness.

Any differential rebuild will necessitate use of different size pinion, side gear and side flange shims. It's impossible to know which size shims are needed until the diff is being reassembled. A tech who rebuilds lots of BMW diffs will probably have a good stock of various sized shims, but Murphy's Law militates against ever having the size you need. The job will probably have to be shelved for a day or two while the needed shims are ordered from BMW.

At rebuild time, it's also wise to check the differential mount bushing. It's rare to find it worn out on an E30 unless it has unusually high mileage, but if you're going with a 4.10 or lower, it's probably a good idea to upgrade the original bushing to the solid type found on the E30 M3. The BMW N.A. parts system has superseded the standard E30 diff bushing for the M3 unit, but the later is still readily available from Europe through Maximillian. There is also a BMW Motorsport solid bushing made of extremely hard rubber. With a good set of large drifts or a large socket, any of these bushing can be pressed in on an ordinary hydraulic press or even a large vice.

Differential Mount Bushings		
Stock E30 Diff Bushing	33 17 1 135 242	\$58.15
E30 M3 Solid Diff Bushing	33 17 1 128 586	\$58.43
E30 Motorsport Solid Diff Bushing	33 17 1 417 241	\$109.00

Removing and Replacing an E30 BMW Differential

1. If there's a lot of dirt and grease under the back of your car, do yourself a favor and pressure wash under there before taking on the job. You'll cut the grief and aggravation factor by at least 75 percent.
2. Jack up the rear of the car as high as possible. Don't jack on the differential; use the rear suspension carrier. Place jack stands under the rear suspension carrier mounts.
3. Drain the differential oil. Reinstallation torque on the drain and fill plugs is 50 Nm (36 ft-lb). If you've removed the cover, reinstallation torque is 50 Nm (36 ft-lb), and you must use new wave washers.
4. Cut the safety wire with a pair of side cutters and gently remove the speed sensor cable connector.
5. Using a long-handled 3/8-in. ratchet and an 8mm allen socket (preferably a long one), remove the inner CV joint retaining bolts on both sides. You can use the parking brake to lock the drivetrain. Reinstallation torque is 58 Nm (42 ft-lb).
6. Using a 17mm short open end wrench and the park brake, remove the four driveshaft to differential flange nuts and slip out the special bolts. It's impossible to get a torque wrench on these nuts. Just make 'em real tight. They're lock nuts, so if they've been off more than once or twice buy new ones-part no. 07 12 9 964 672.
7. Using a 22mm box wrench and a 1/2-in. drive ratchet with a 22mm socket, remove the 12mm bolt that toes through the rubber differential mount. The diff will drop about 2 or 3 inches now. Reinstallation torque is 87 Nm (63 ft-lb).
8. Place a floor jack with a piece of plywood under the differential.
9. Using a 19mm short box wrench and a the 1/2-in. ratchet with a 19mm socket and a 1-in. extension, remove the differential housing to axle carrier retaining bolts. Reinstallation torque is 123 Nm (89 ft-lb), if you can get a torque wrench on the fasteners.
10. Carefully lower the floor jack and say hello to your diff. As the British say, "Assembly is the reverse; good luck!"



It helps to get the rear of the car as high off the ground as possible.



Common hand tools are all that's required to remove an E30 BMW differential!

Special thanks to Maximillian Importing and Joe Kelly from the Parts Department at Tom Hesser BMW for their assistance with parts and current pricing

Maximillian Importing
P.O. Box 749
(800) 950-2032
Fax: (410) 357-0298

Tom Hesser BMW
1001 N. Washington Ave.
Scranton, PA 18509
(717) 343-5235
Fax: (717) 342-8645