Operating Fluids

February 2007

Group 13 Fuel System

Technical Service

1.0 Fuels for Gasoline Engines

Use only unleaded gasoline in vehicles equipped with a catalytic converter.

Fuels containing **up to and including 10%** of ethanol or other oxygenates with up to 2.8% oxygen by weight, that is, 15% MTBE (methyl tertiary butyl ether) or 3% methanol plus an equivalent amount of co-solvent, **will not void** the applicable warranties with respect to defects in materials or workmanship.

Although, usage of such alcohol fuel blends may result in drivability, starting, and stalling problems due to reduced volatility and lower energy content of the fuel. Those drivability problems may be especially evident under certain environmental conditions, such as: high or low ambient temperatures and high altitude.

Only specially adapted vehicles (FFV - Flexible Fuel Vehicles) can run on high alcohol fuel blends. BMW, for the various technical and environmental reasons explained below, does not offer FFV models.

Usage of E85, or any other high alcohol content blend (e.g. E30) in BMW vehicles, will cause various drivability complaints (cold start problems, stalling, reduced performance, poor fuel economy, etc.), may cause excessive emissions, and may cause irreversible damage to engine, emission control and fuel delivery systems due to incompatibility of materials with alcohols.

General Notes Regarding E85 Fuel.

E85 fuel contains 85% (by volume) of ethanol and 15% of gasoline. Ethanol can be produced chemically from ethylene or biologically from grains, agricultural wastes, or any organic material containing starch or sugar. In the US, ethanol is mainly produced from corn and is classified as a renewable fuel.

Similar to gasoline, ethanol contains hydrogen and carbon; with additional oxygen molecules build into its chemical chain. This chemical structure makes ethanol's burning process slightly cleaner compared to the gasoline (lower tailpipe emissions).

On the other hand, due to lower carbon content, ethanol provides 27% less energy (for identical volume) then gasoline, resulting in the reduced fuel economy of E85 vehicles (approximately 22% higher consumption). Increased fuel consumption requires the appropriately enlarged fuel tank capacities (usually 30% increase), and the specific DME calibrations for the E85 lower Stoichiometric air/fuel ratio (10 compared to 14.7 for gasoline engines).

E85 fuel volatility is typically lower then gasoline (RVP 6-10 psi, compared to 8-15 psi for gasoline). Lower fuel volatility will reduce vehicle evaporative emissions, but it may cause cold starting problems especially with lower ambient temperatures.

Under certain environmental conditions, mainly lower ambient temperatures, ethanol separates from gasoline/alcohol mixture and absorbs water. The ethanol absorbed water molecules are heavier then gasoline or ethanol, they remain at the bottom of fuel tank and when introduced into combustion process they tend to form an extremely lean mixture resulting in misfire, rough idle and cold starting problems.

Certain materials, commonly used with gasoline are totally incompatible with alcohols. When these materials come in contact with ethanol, they may dissolve in the fuel, which may damage engine components and may result in poor vehicle drivability.

Some metals (e.g. zinc, brass, lead, aluminum) become degraded by long exposure to ethanol fuel blends. Also, some nonmetallic materials used in automotive industry such as: natural rubber, polyurethane, cork gasket material, leather, polyvinyl chloride (PVC), polyamides, methyl-methacrylate plastics, and certain thermo & thermoset plastics degrade when in contact with fuel ethanol.

In order to safely and effectively operate a motor vehicle running on E85, the vehicle must be compatible with alcohol use. Some manufacturers have developed vehicles called FFV (Flexible Fuel Vehicle) that can operate on any blend of ethanol and gasoline (from 0% ethanol and 100% gasoline, up to 85% ethanol and 15% gasoline). Ethanol FFVs are similar to gasoline vehicles, with main differences in materials used in fuel management and delivery systems, and DME control module calibrations. In some cases, also E85 vehicles require special lubricating oils.

Aftermarket conversions of gasoline-powered vehicles to ethanol-fueled vehicles, although possible, are not recommended due to internal materials and DME software incompatibility, as well, as the high costs of conversion.

TOP TIER Detergent Gasoline

Deposit-control additives have been required by the EPA in all gasoline from 1995, however, since the introduction of the lowest additive concentration (LAC) most gasoline manufacturers have actually reduced the concentration level of detergent additives by up to 50%.

Low content of cleaning additives results in an excessive accumulation of deposits on fuel injectors, the intake valves, the exhaust manifold or inside the combustion chamber. Due to deposits build-up, customers may experience various drivability problems (e.g. cold start problems, rough idle), increased emissions with Service Engine Soon light illumination, reduced engine performance and poor fuel economy.

In order to increase the level of detergent additives in gasoline, the TOP TIER Detergent Gasoline requirements were approved by four automotive companies (BMW, GM, Honda and Toyota).
Usage of the TOP TIER Gasoline will help keep engines cleaner, and will reduce deposits-related concerns.

A number of gasoline retailers have already met the TOP TIER Detergent Gasoline requirements and are offering this product in all octane grades in all of their respective marketing areas. The current TOP TIER Gasoline retailers are: QuickTrip®, ChevronTexaco®; ConocoPhillips®; 76®; Shell®; Entec Stations®; MFA Oil Company®; Kwik Trip®/Kwik Star®; The Somerset Refinery, Inc.®; Aloha Petroleum®; Jiffy Mart®; Mahalo®; Trip-Par Oil Company®. All gasoline outlets carrying the brand of the approved retailer must conform to TOP TIER requirements on products advertised as such.

BMW recommends using TOP TIER Detergent Gasoline of minimum octane rating of AKI 91 and with alcohol content of less then 10% by volume (or any other oxygenates with up to 2.8% of oxygen by weight). Only the exclusive usage of TOP TIER Gasoline provides the full benefit of reducing deposits build-up. BMW customers may find more information related to TOP TIER Gasoline on the official website http://www.toptiergas.com.

Alcohol Detection Procedure

Fuel Blends containing a high percentage (10%and above) of alcohol, mainly ethanol, are becoming more commercially available. Usage of E85, or any other high alcohol content blend (e.g. E30) in BMW vehicles, will cause various drivability complaints (cold start problems, stalling, reduced performance, poor fuel economy, etc.), may cause excessive emissions, and may cause irreversible damage to engine, emission control and fuel delivery systems due to incompatibility of materials with alcohols. Refer to SI B13 01 06 Alcohol Fuel Blends in BMW Vehicles for complete details.
In order to correctly diagnose various drivability complaints caused by fuel blends with a high level of ethanol content, BMW is providing you with an alcohol detection test tool.
Distribution of the following tool will be through the Automatic Tool Shipment Program. Additional tools may be purchased through your PDC. All prices on this bulletin are introductory prices and are only valid during the Automatic Tool Shipment.

Procedure
Safety Precautions:
Gasoline is highly flammable; observe normal precautions for working with flammable liquids. Perform all tests away from any source of ignition. A class B fire extinguisher must be available. Wear protective eye protection with side shields and

Nitrile rubber gloves for handling syringe. Please adhere to any applicable OSHA regulations when handling Gasoline. Dispose of the mixture according to local, state and federal regulations.

Fill a clean container with gasoline drawn from the fuel system of the affected vehicle then fill another container with water. Only a small amount of fuel is needed to perform the test (5 ounces of each fluid).
Slowly draw 3cc of water into the syringe. Note: To remove air, draw at least 5cc to 6cc of water, invert the syringe and squirt the water out until the top rim of the rubber plunger is at the 3cc mark.
Slowly draw gasoline into the syringe until the fluid reaches the 12cc mark.
Place your finger over the tip of the syringe, vigorously shake the syringe for one minute. Relieve built-up pressure by occasionally removing your finger.
Place the syringe on a flat surface with the nozzle pointing up, allow the syringe to stand for one minute.
If alcohol is present in the fuel, it will separate from the gasoline and dissolve in the water. This water/alcohol mixture will be in the lower part of the syringe. Record the reading at the boundary of the two liquids, refer to the table below to determine the percentage of alcohol in the fuel.

Empty the syringe and rinse thoroughly with water, allow drying and apply a silicone lubricant to the rubber plunger before storing.

Boundary Line	% Alcohol	Boundary Line	% Alcohol
9.0cc	0%	5.0cc	45%
8.6cc	5%	4.5cc	55%
8.1cc	10%	4.1cc	60%
7.7cc	15%	3.6cc	65%
7.2cc	20%	3.2cc	70%
6.8cc	25%	2.7cc	75%
6.3cc	30%	2.3cc	80%
5.9cc	35%	1.8cc	85%
5.4cc	40%	1.4cc	90%

Warranty Information

Components damage/malfunctions, or any drivability problems caused by use of fuels containing more then 10% ethanol (or other oxygenates with more then 2.8% oxygen by weight) will not be covered under BMW warranties with respect to defects in materials or workmanship. Please document the results found on the vehicle repair order whenever performing this test

	Alcohol Detection Test Tool Order PN 83 30 0 420 667

Anti-knock Properties

The anti-knock value is the quality rating for gasoline and is a requirement for controlled combustion. Anti-knock value is expressed with an octane number. A higher number indicates better anti-knock properties of a gasoline. Internationally approved methods are used to determine the Research Octane Number (RON) and the Motor Octane Number (MON). In the United States the Anti-Knock Index (AKI) is displayed at the gas pumps.

$$AKI = \frac{RON + MON}{2}$$

Boiling Range and Vapor Pressure

Gasolines must be highly volatile. The boiling range and vapor pressure values are used for evaluation. Gasolines do not have a boiling “point”, but rather a boiling “line”, since they are produced from a mixture of various hydrocarbon components.
The boiling line (boiling range) and therefore vapor pressure have influence on, for example,

- vapor lock
- starting behavior
- evaporation loss
- transition and driving behavior
- engine oil dilution
- perfect combustion

The boiling range is different for summer and winter gasolines. The vapor pressure test is another means of determining the behavior of a gasoline.

Specific Gravity

The specific gravity is determined by gasoline components. The volume changes with the temperature. Due to the different compositions there are different values for premium grade and regular grade gasolines.

Calorific Value

The calorific value expresses the power content of a gasoline. The calorific value of a combustible fuel/air mixture is of prime importance for the power output of engines.

Purity, Combustion Deposits

Gasolines must be free of contamination. Pumps, jets, injectors, valves and lines must not be clogged or plugged up. Residue and deposits in the intake system and combustion chamber will impair engine operation. The solid residue from evaporation of gasoline provides information on the degree of contamination.

Sulfur Content

The sulfur content of all gasolines should be as low as possible. In this manner there will be less sulfuric acids or sulfur acids in the combustion residue, which would lead to corrosion and sulfuric emissions on an engine running without reaching operating temperature.

1.1 Minimum Octane and AKI Ratings for Gasoline Engines

Up to 2005 model year

	Leaded Gasoline	
	Premium Grade	**Regular Grade**
RON (Research Octane No.)		at least 91.0
MON (Motor Octane No.)		at least 82.7
AKI*	at least 93.0	at least 87.0

	Unleaded Gasoline		
	Premium Grade	**Mid-Range**	**Grade Regular Grade**
RON	at least 98.0	at least 95.0	at least 91.0
MON	at least 88.0	at least 85.0	at least 82.5
AKI*	at least 93.0	at least 90.0	at least 87.0

*Anti-Knock Index $AKI = \frac{RON + MON}{2}$

1.2 Summary of Fuel Grade Requirements

Engine	Vehicle	Model	Model Year	Unleaded Gasoline Regular (AKI at least 87.0)	Unleaded Gasoline Premium (AKI at least 93.0)
M10	E30	318i	'84-'85	X	
M20	E30	325e/es	'85-'88	X	
	E30	325i/iX	thru '91	X	
	E30	325iC	thru '93	X	
	E28	528e	thru '88	X	
	E34	525i	'89-'90	X	
M30	E28	535i	'85-'88	X	
	E34	535i	thru '93	X	
	E24	635CSi, L6	thru '89	X	
	E23	735i/iL, L7	thru '87	X	
	E32	735i/iL	thru '92	X	
M42	E30	318i/is/iC	'91-'92		X
	E36	318i/is/iC/ti	thru '95		X
M44	E36	318i, Z3	'96-'98		X
	E36	318is/iC	'96-'97		X
	E36	318ti	'96-'99		X
M50	E36	325i/is	'92		X
	E34	525i/iT	'91-'92		X
M50TU	E36	325i/is	'93-'95		X
	E36	325iC	'94-'95		X
	E34	525i/iT	'93-'95		X

Engine	Vehicle	Model	Model Year	Unleaded Gasoline Regular (AKI at least 87.0)	Unleaded Gasoline Premium (AKI at least 93.0)
M52	E36	323is/iC	'98-'99		X
	E36	328i	'96-'98		X
	E36	328is/iC	'96-'99		X
	E36	Z3	'97-'98		X
	E39	528i	'97-'98		X
M52TU	E46	323i, 328i	'99-'00		X
	E46	323Ci, 328Ci	'00		X
	E36	Z3 2.3/2.8	'99-'00		X
	E39	528i/iT	'99-'00		X
N52	E60	525i, 530i	'05- present		X
	E61	525xiT, 530xiT	'05- present		X
	E90	325i, 330i	'05-present		X
M54	E36	Z3	'01-'03		X
	E46	325i/Ci/CiCiT	'01- present		X
	E46	325xi/xiT	'01- present		X
	E46	330i/Ci/CiC	'01- present		X
	E46	330xi	'01- present		X
	E39	525i/iT	'01- present		X

	E39	530i	’01- present		X
	E53	X5 3.0i	‘01- present		X
	E60	525i, 530i	’03- present		X
	E83	X3	’04- present		X
	E85	Z4	’03- present		X
M60	E34	530i/iT, 540i	‘94-’95		X
	E32	740i/iL	‘93-’94		X
	E38	740i/iL	‘95		X
	E31	840Ci	‘94-’95		X
M62	E39	540i	‘97-’03		X
	E39	540iT	‘99-’03		X
	E38	740i/iL	‘96-’01		X
	E31	840Ci	‘96-’97		X
	E53	X5	’00-‘03		X
N62	E53	X5	’04-‘05		X
	E60	545i	’03-‘05		X
	E63	645Ci	‘04-‘05		X
	E64	645CiC	’04-‘05		X
	E65	745i	’02-‘05		X
	E66	745Li	’02-‘05		X
N62TU	E53	X5	’05- present		X
	E60	550i	’03- present		X
	E63	650Ci	‘04- present		X
	E65	750i	’05- present		X
	E66	750Li	’05- present		X
M70	E32	750iL	‘88-’94	X	
	E31	850i/Ci	‘91-’94	X	
M73	E38	750iL	‘95-’01		X
	E31	850Ci	‘95-’97		X
N73	E66	760Li	’04- present		X
S14	E30	M3	‘88-’91		X
S38	E24	M6	‘87-’88		X
	E28	M5	‘88		X
	E34	M5	‘91-’93		X
S50	E36	M3	‘95		X
S52	E36	M3	‘96-’99		X
	E36	MZ3	‘98-’00		X
S54	E36	MZ3	’01-’02		X
	E46	M3	’01-’02		X
S62	E39	M5	’00-‘03		X
	E52	Z8	’00- present		X
S70	E31	850CSi	‘94-’95		X

2.0 Fuel System Cleaner Plus

Recent field experiences have shown a significant increase in various drivability complaints due to excessive carbon deposits in engine’s combustion chambers, on the intake valves and fuel injectors.

The overall rise in carbon deposits accumulation is generally attributed to poor gasoline quality, namely, low level of cleaning additives and fuel contamination.

TECHNICAL BACKGROUND

Combustion chamber deposit formation is a by-product of the gasoline burning process. Fuel injector and intake valve deposits may become less troublesome with the recently introduced Top Tier Detergent Gasoline deposit control standards, which are exceeding the detergent requirements imposed by the EPA since 1995.

However, vehicles that do not exclusively use a Top Tier Detergent Gasoline, or are regularly driven in severe service conditions, such as stop-and-go traffic, high ambient temperatures, and high altitude can experience performance problems caused by intake system and combustion chamber deposits.

The most common customer complaints may include:

FUEL INJECTORS
Deposits at the injector's tip can impact fuel flow, upsetting the air/fuel mixture ratio.

Symptoms: Hesitation or stumble during acceleration, even loss of power. Poor fuel efficiency. Increased emissions of HC and CO. "Service Engine Soon" light illumination due to intermittent misfire faults, or lean mixture adaptation values

INTAKE VALVES:
Deposits at the valves and on the intake manifold ports can absorb fuel during the warm-up phase, leaning out the air/fuel mixture ratio. Carbon build-up may disturb mixture flow at low throttle conditions/idle speeds.

Symptoms: Poor drivability, loss of power, unstable/rough idle, increased emissions of HC, CO and NOx. "Service Engine Soon" light illumination due to intermittent misfire faults.

COMBUSTION CHAMBER:
Combustion Chamber Deposit Interference, or CCDI, occurs when there is a contact between carbon deposits on the piston crown and cylinder head. The noise can be confused or misdiagnosed as ping, knock or other noises that could indicate a mechanical failure. CCDI occurs first as a cold start noise that can fade as the engine warms to operating temperature. The noise will reoccur at the next cold start. As deposits build, there is an increase in compression temperature that may cause pre-ignition detonations.

Symptoms: Knocking, pinging, run-on, poor acceleration, octane requirement increase, increased emissions of NOx, engine idle speed surges.

Depending on the manufacturer, fuels may contain various additives such as: oxidation and corrosion inhibitors, metal deactivators, emulsifiers, anti-icing agents & dyes, plus they are required to include some form of an intake system deposit control package. Unfortunately, not all fuels are created equal, and some additive packages are not effective enough to maintain integrity of the intake systems in high performance engines, or engines operating in severe environmental conditions. Even worse, the intake system deposit control additives in some fuels may actually contribute to the combustion chamber deposits accumulation, and to the problems associated with those deposits: knock, run-on and increased emissions of oxides of nitrogen.

RECOMMENDATION

BMW recommends using TOP TIER Detergent Gasoline of minimum octane rating of AKI 91 and with alcohol content of less then 10% by volume (or any other oxygenates with up to 2.8% of oxygen by weight). Only the exclusive usage of TOP TIER Detergent Gasoline provides the full benefit of reducing deposits formation. For more information related to TOP TIER Gasoline refer to SI B13 02 06.

If the TOP TIER Detergent Gasoline is unavailable, we recommend BMW Group Fuel System Cleaner Plus (PN 82 14 0 413 341) be added to the gas tank. For optimum cleaning and deposits control, add a 20 fl. oz. bottle every 3,000 miles when refueling.

Regular use of BMW Group Fuel System Cleaner Plus can help address carbon deposits related symptoms listed above. By removing these deposits, an engine may experience restored power, performance and fuel efficiency, a smoother idle running, lower emissions, and reduced octane requirement.

BMW Group Fuel System Cleaner Plus uses polyether amine TECHRON® based technology developed and patented by Chevron. BMW Group Fuel System Cleaner Plus has proven to clean up deposits in fuel injectors, ports & intake valves and reduces the harmful effects of combustion chamber deposits. It helps restore performance lost due to deposit build-up.

Chevron and BMW have run an extensive “no harm” tests with polyether amine technology. When used as directed, it will not harm catalytic converters, oxygen sensors, or any other mechanical components of the engine, or fuel delivery system.

The effectiveness of the additive depends on its presence in the gasoline in large concentrations for short periods of time. One treatment is usually sufficient, but a second treatment (one 20 oz bottle per each, consecutive full tank of gas) may give additional benefits. To keep your fuel intake system clean, we recommend usage at every 3000 miles.

Additionally, vehicle’s fuel sending units equipped with silver plated resistor card/contacts are especially vulnerable to attacks by elemental sulfur and/or hydrogen sulfide found in fuels. Adding BMW Group Fuel System Cleaner Plus immediately upon noticing erratic fuel gauge behavior may, in many cases, restore proper performance due to the additive’s ability to remove the harmful sulfur compounds from the sending unit’s contact surface. Additionally, BMW Group Fuel System Cleaner Plus can help protect the fuel gauge from future malfunctioning by coating all metal surfaces of the fuel system.

BMW Group Fuel System Cleaner Plus.
PN 82 14 0 413 341,
1 bottle, 20 fl. oz.
Ordering in multiples of 6 bottles per case.

WARRANTY INFORMATION

Because carbon deposit build-up is related to fuel quality, it cannot be considered as a defect in vehicle’s materials or workmanship. Consequently, usage of BMW Group Fuel System Cleaner Plus is not covered under the terms of the BMW New Vehicle Limited Warranty or maintenance plan.

3.0 Fuels for Diesel Engines

Diesel fuel is obtained from distilled crude oil. The distilling process is highly complicated, involving precise control of temperatures and pressures. The diesel fuel quality will vary depending on the refining process and the crude oil source.

BMW of North America recommends using automotive diesel Fuel No. 2 with a minimum cetane rating of 45 for use in the BMW 524td. Never use other fuels such as marine fuel or heating oil, since these fuels do not have the appropriate additives or cetane values.

The cetane number is a measure of the fuel’s ignition quality, which influences both the ease of starting and combustion stability.

A high cetane number diesel fuel promotes spontaneous burning of the fuel, which is beneficial in a diesel.

Factors which are important qualities of diesel fuel are the Cloud Point (the temperature at which wax forms in diesel fuel) and the Pour Point (the temperature at which fuel stops flowing). These qualities become very important during low temperature operation. As the temperature drops, wax can sometimes form in the fuel tank, fuel lines and/or fuel filter. If this occurs, the fuel supply lines will become clogged and resulting hard starting and rough running problems.

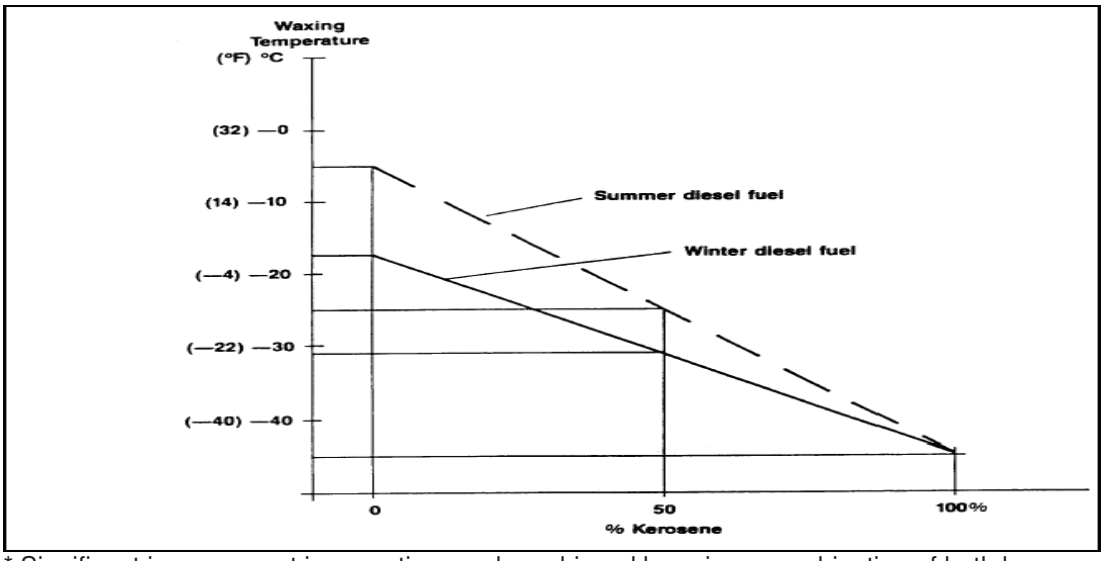
Temperatures below 20°F (-7°C) are critical to the formation of wax crystals. The following guidelines should solve any cold weather problems which may arise:

Note: BMW 524td's are equipped with an integral fuel heater, pre-delivery fuel pump, large capacity fuel filter/water separator, and block heater for cold weather operation which should be sufficient for all but the most extreme cold weather.

If outside temperature is above 20°F (-7°C):
*Use Diesel Fuel No. 2

If outside temperature is below 20°F (-7°C):

- Diesel Fuel No. 1, if available, should be used.
- Customers should ask if diesel fuel is winterized.
- Diesel Fuel Flow Improver can be added to diesel fuel No. 2 to lower the Cloud Point of the fuel.
  Note: (1) 100 ml can of additive will treat 1 tank full of diesel fuel; additional quantities will not lower the Cloud Point any further.
  Diesel Fuel Flow Improver - Würth Part No. 893532 (former BMW Part No. 81 22 9 407 289)
- Diesel Fuel No. 2 can be mixed with kerosene in the proportions shown on the graph. Engine performance will be reduced with more than a 50% mixture of kerosene.



* Significant improvement in operation can be achieved by using a combination of both kerosene and the diesel fuel flow improver since the kerosene lowers the point at which the wax formation occurs and the additive modifies the structure of the wax crystals for better flow.

4.0 Other Fluids

The throttle housing studs are to be coated with Loctite 290 on 1991-92 E30 with M42 engine.
See S.I. Bulletin B 13 06 91 (3440).

The throttle body assembly of M42 engines in E36 vehicles produced from 1/94-6/94 are to be lubricated with Optimoly Paste TA Spray, BMW Part No. 83 23 1 468 932.
See S.I. Bulletin B 13 03 94 (4042).