

TECHNICAL TOPICS

DIESEL POWER IN THE USA by Robert Patton

As you read in the last issue's "Tailgating" editorial, there is a new addition in my automotive family, a '98 Volkswagen Beetle with the turbo diesel engine (TDI). This 1.9 liter, four cylinder, turbocharged, intercooled engine is rated at 90 horsepower at 3750 rpm; 149 torque at 1900 rpm. Interestingly, the car's diesel engine already has exhaust gas recirculation (EGR) that is cooled with a separate circuit of the engine's coolant. The engine also has an engine blowby and breather system whereby the vented gasses are plumbed (positive crankcase ventilation, PCV) directly into the air intake system just after the air cleaner.

Just as the TDR has an active web site, there is a web site for Volkswagen TDI owners (TDIclub.com). The chat is lively and the information is insightful. It did not take me long to discover what EGR and PCV can do to an engine's intake system. The PCV's vapors are introduced just after the air cleaner. Thus, the entire pre- and post-turbocharger plumbing has an oily film that coats the entire length of the air plumbing. As the vehicle is front wheel drive, the intake and exhaust manifolds are parallel with the car's firewall. Therefore the turbocharger and its associated air system plumbing are difficult to remove. Thus, I can't share pictures of the first 7/8's of the intake plumbing.

However, the final 1/8 of intake plumbing is accessible. During this final run of plumbing (i.e., after the air has been pressurized by the turbocharger and sent through the intercooler) is where the exhaust gas recirculation is introduced. To say that the hot exhaust gas mixed with the engine blowby gasses makes for a messy, gooey intake tract is an understatement. What a mess.



Crankcase vented oil mixes with EGR. The arrow points to the EGR valve. Your 2004 Cummins engine will have EGR but will *not* have the vent oil introduced into the clean intake air.

The EGR/PCV Volkswagen engine experience set me to wondering. Wondering if EGR and PCV should be used together? Wondering about what happens if the intake tract finally clogs? Wondering about the warranty consequences for the customer and Volkswagen? Wondering about the maintenance responsibility for the owner. Wondering about the life-to-overhaul of the engine? All of the above are concerns applicable to ownership of the Volkswagen diesel.

Ah, back to the focus of this magazine – your Dodge/Cummins Turbo Diesel. For the TDR readers this learning episode brings to mind farther-reaching questions that have an impact on the Turbo Diesel audience. The first subject that comes to mind is the one of diesel exhaust emissions. The Volkswagen diesel is a '98 model year car. We are all aware of the emission standards for our trucks that went into effect 1/1/98, hence the '98.5 Cummins 24-valve engine introduction. Did the same standards hold true for this passenger car engine? Or was the engine designed to meet European standards and thus was clean enough for the US market? What are the European standards? Can we present the standards in a format that will explain the absence (save for the Volkswagen 1.9 engine and the Mercedes 3.0 engine that was previously offered in their E-class sedan) of diesel passenger cars in the US? Finally, what does the above mean to me, the current and future diesel owner?

APPLES AND ORANGES

It seems I'm not the only one bewildered by the lack of small displacement diesels in the United States. For example, take the following correspondence from Ralph Odegard, Clackamas, OR. Ralph writes, "I am forwarding an article from our local paper that discusses Europe's lead in diesel technology. Do they lead the US with stricter emissions legislation?" The following is the text of the article.

"Q: I've been to Ireland and the United Kingdom several times, and each time I note that diesel exhaust is not as stinky in those countries as it is in the United States. It seems strange, but is there a different formulation for diesel outside of the United States, so it's not as bothersome? Inquiring minds want to know."

Portland, OR ("Oregonian") staff writer Chip Keen responds: "European diesel fuel *is* different; it contains fewer sulfur compounds, but that's not why European diesel engines are less stinky. The difference lies in market economics and regulatory requirements.

"In Europe, small cars are the rule. Streets are narrower, fuel prices are higher, average trips are shorter and noise regulations

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are stricter. European diesels have evolved to address these conditions. They're quieter, more fuel-efficient, and less stinky by design.

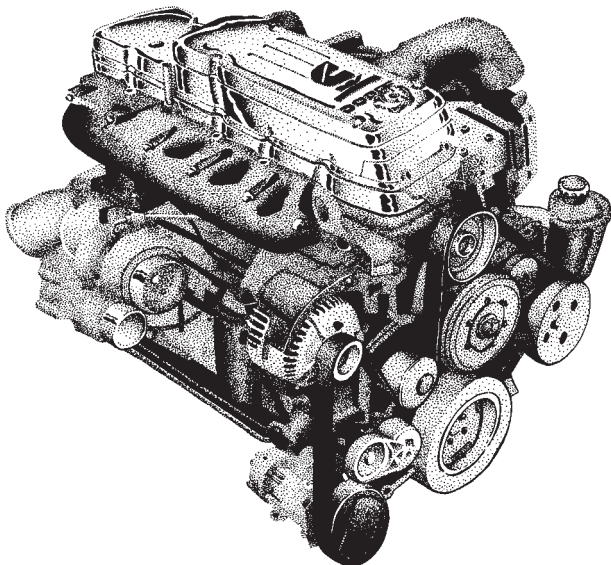
"In comparison, the fuel control systems used by most (but not all) diesel-powered vehicles sold in the United States are less sophisticated. The noise and smoke we associate with them occurs because the fuel ignites nearly spontaneously. Robert Bosch and other manufacturers have developed electronically-controlled "common rail" diesel injection systems that control the combustion process more precisely. These systems initiate combustion gradually, and vary injection timing with engine speed.

"When combined with improved combustion chamber design, this new breed of diesel engine achieves noise levels comparable to those of gasoline engines. Europeans now buy more cars powered by diesel than by gasoline.

"So why aren't more diesels on US roads? There are a number of factors:

- General Motors' ill-fated bid in the late 1970s to save us from another gas crisis by converting gasoline engine designs to diesel convinced most of us that diesels were noisy and unreliable.
- There is little economic incentive; gasoline costs about half as much here as it does in Europe.
- Demand for diesel-powered vehicles is so great in Europe that manufacturers have little reason to export them to the US market
- California and EPA emissions regulations scheduled to take effect in 2004 are so stringent that they are unable to be met by even the most sophisticated of today's diesel engines."

Writer Chip Keen presented a generalized answer. Let's take his generalization and try to be more specific.



The new Cummins HPCR engine for 2003. For the year model 2003 the engine will be without exhaust gas recirculation. The 1/1/2004 emissions regulations will dictate that EGR be added to the engine.

The Specifics

The answer lies in close examination of the emission legislation rules. What are the European guidelines? Do they, in fact, lead the US in emissions legislation? Time to drag out the old copies of "Diesel Progress" magazine to do some research to determine who has the toughest diesel emission standards and also to take a look at fuel quality.

EPA AND EUROPEAN UNION EMISSIONS NUMBERS

Doing the research for the legislation for heavy-duty trucks here in the US is easy. Here are the numbers from Issue 32.

EPA Emissions Numbers*

	CO ₂	NOx	HC	PM
1988	15.5	6.0	1.3	.60
1991	15.5	5.0	1.3	.25
1994	15.5	5.0	1.3	.10
1998	15.5	4.0	1.3	.10
		NMHC + NOx		
**2004	15.5	2.4		.10
***2007	15.5	0.2	0.14	.01

*The EPA emissions numbers are stated in grams per brake horsepower, per hour.

** October 2002 implementation date for the six consent decree manufacturers – Cummins, Caterpillar, Detroit Diesel, Navistar, Volvo, Mack.

*** The PM emission standard will take full effect in the 2007 model year. The NOx and HC standards will be phased in between 2007 and 2010.

Effective with the 2007 model year, the regulation also eliminates the earlier crankcase emission control exception for turbocharged heavy-duty diesel engines. Crankcase emissions from these engines are treated the same as (i.e., added to) other exhaust emissions. Therefore, manufacturers are expected to control crankcase emissions by routing them back to the engine intake or to the exhaust stream upstream of the exhaust emission control heavy duty devices.

The diesel fuel regulation limits the sulfur content in on-highway diesel fuel to 15 ppm, down from the previous 500 ppm. Refiners will be required to start producing the 15 ppm fuel beginning June 1, 2006. At the terminal level, highway diesel fuel sold as low sulfur fuel must meet the 15 ppm sulfur standard as of July 15, 2006. For retail stations and wholesale purchasers, highway diesel fuel sold as low sulfur fuel must meet the 15 ppm sulfur standard by September 1, 2006.

Ultra low sulfur diesel fuel has been introduced as a "technology enabler" to pave the way for advanced, sulfur-intolerant exhaust emission control technologies, such as catalytic diesel particulate filters and NOx catalysts, which will be necessary to meet the 2007 emission standards.

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The previous North American numbers are as quoted for “Heavy-duty Truck and Bus Engines.” The European Union has the same designation.

The following are the European Union numbers for their heavy-duty truck category.

European Emissions Numbers ①

		CO ₂	NOx	HC	PM
Euro I	1992	6.0	12.0	1.5	.5
Euro II	10/96	5.4	9.5	1.5	.33
Euro III	10/00	2.8	6.75	.9	.175
Euro IV	10/05	2.0	4.7	.6	–②
Euro V	10/08	2.0	2.7	.6	–

① European numbers were converted from grams per kilowatt, per hour to read as if they were grams per brake horsepower, per hour as is the measurement in the USA.

②Particulate numbers for Euro IV and V are difficult to follow as the European standards have two different driving cycles as well as a test for smoke. For purposes of our comparison these numbers are not as relevant as the CO₂ and NOx values presented in the first two columns of the two tables.

To summarize for heavy-duty trucks: US emissions specifications versus European Union emissions the numbers show that there is a discrepancy in emissions ideals. The European Union dictate lower CO₂ numbers (CO₂ is inherently lower with the diesel engine) in exchange for more forgiving and higher NOx numbers. More on this observation in a few paragraphs.

I WANT A DIESEL CAR

(or at least to understand why I can't get one)

The US has an additional category, “Cars and Light-Duty Trucks,” and, again, the European Union has the same category. To further complicate matters (or ignorance is bliss?) there are standards for Sweden, Japan, South Korea, Thailand, Singapore, Australia, Argentina and Brazil.

As I researched (www.dieselnets.com) to try and compare my Volkswagen TDI engine and other diesel passenger cars in the US to their counterparts in Europe, and then tie all these comparisons to the Turbo Diesel trucks we drive, I was overwhelmed by the complexity of the EPA's new-for-2004 (soon to be adopted) Tier 2 emissions standards for passenger cars and light-duty trucks (below 8500 GVW). The first quagmire: light-duty standards are measured differently. Note that the measurements used for the heavy-duty trucks are expressed in grams per brake horsepower per hour (not that the definition has an everyday meaning to me). However, with a standard you can compare numbers. The standards for the existing United States Tier 1 (years 1994 through 2003) and upcoming Tier 2 (2004) phase in standards for passenger cars and light-duty trucks (below 8500 GVW) are measured in units of grams per mile. European standards (Euro 3 for 2000, Euro 4 for 2005) are likewise expressed in grams per kilometer. Forget the numbers, they will make you crazy. Is there not a simple answer?

The Simple Answer

I can concur with writer Chip Keen, that current diesel fuel quality rules are more stringent in Europe. European rules dictated a minimum cetane number of 51 and a maximum sulfur content of 350 parts per million for year 2000, to be reduced to 50 ppm in 2005.

However, as you may have previously noted, the US fuel standard, effective 6/1/2006, will result in the US having the lowest specification for sulfur, as the numbers go from the current 500 ppm to 15 ppm. And we should also note that this ultra-low sulfur fuel is now available at 500 ARCO stations in the Los Angeles, CA area (BITW, page 70).

Now, for the overly simplistic answer: In my research I did note that the European Union light-duty standards are different for diesel and gasoline engines. Diesels have lower CO₂ standards (CO₂ is inherently lower with the diesel) and diesels offer better fuel economy and are thus allowed a higher output NOx.

Unlike the European Union, the US standard for diesel and gasoline engines are the same. The NOx standard is so stringent that diesel passenger car/minivan/SUV options are non-existent. It appears that the answer is simply political preference. Governments that want reductions in greenhouse gas emissions (CO₂) and value better energy efficiency (i.e. the European Union) have included diesels in their strategy by relaxing the NOx standards. A government that focuses primarily on NOx will tend to eliminate diesels from the market. If you take a glance back to the heavy-duty charts where we were able to do conversions to make apples-to-apples comparisons, this difference in thinking is easy to see by its legislative numbers. Therefore, the upcoming 2004 United States Tier 2 standards for passenger car and light-duty trucks will likely deliver the final blow to the small diesel engine.

The above conclusion is well substantiated. There is an organization, The Diesel Technology Forum, that is “dedicated to demonstrating clean diesel's critical economic importance, highlighting continuous improvements in fuel efficiency and emissions, and educating the public about the latest diesel technology. Established by vehicle and engine manufacturers, petroleum refineries, and leading makers of emissions control devices, the Forum serves as a leading voice on a host of key issues affecting the industry.” Via their website (dieselforum.org) and through a wonderful press kit that they forwarded to me, I was pleased to note their positive influence in promoting the diesel's future in the US. Via materials for Diesel Technology Forum, let's note some of the concurring magazine commentary.

From Ward's AutoWorld, September 2001: “Emissions issues are the Big Chill for diesel's US prospects.

“Because of their superior fuel economy, diesels emit less hydrocarbons (HC), carbon monoxide (CO), and, most importantly, less carbon dioxide (CO₂) than do spark-ignition (SI) gasoline engines. The output of these pollutants effectively is directly proportional to the amount of fuel used by a particular engine.

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“Europe has aligned its near-term emissions-reduction strategy along the lines of the infamous Kyoto Protocol; its initial emphasis addresses a serious reduction of CO₂. Upcoming 2005 Euro IV emissions regulations thus favor the CO₂-friendly diesel. The European Community, says the industry’s Diesel technology Forum, has targeted aggressive reduction of CO₂, while Euro IV’s PM emissions standards also are relatively assertive to reflect the fact that PM emissions-reduction technology is rapidly advancing. With regard to the tougher nut of NOx, the Forum says European emissions standards ‘have ratcheted down more slowly to reflect the technological limitations in achieving those types of reductions.’

“Upcoming US and California emissions standards, conversely, have delivered diesels a knockout punch – before the match is started. Federal environmental Protection Agency (EPA) Tier II and California’s LEV2 insist upon drastic – some say unattainable – cuts in, you guessed it, NOx and PM emissions.

“Also, when the standards are fully phased in, light-duty trucks and SUVs are required to meet the same limits as passenger cars, eliminating current loopholes that permit trucks and SUVs to emit more.

“In a 1998 interview, Bosch officials predicted that by 2004, particulate emissions will match the microscopic dust that comes off tires in the course of normal wear.

“Bottom line: Automakers want to get diesels started in the US and say the standards have to be ‘relaxed,’ at least until emissions-reduction technology and fuel-quality improvements can make possible such severe reductions.”

From The New York Times, May 27, 2001: “Diesel engines powered 32.3 percent, or nearly one-third, of all new cars sold in Europe last year, compared with 21.7 percent in 1997. Analysts predict the share will rise to at least 40 percent by 2005.

“Fewer than one percent of new American cars have diesel engines. And the gap is likely to widen, because American antipollution regulations severely restrict the sale of diesel engines, and American environmental groups are adamantly opposed to relaxing them.

“Differences in attitudes among environmentalists are reflected in the stringency of air pollution rules, with European regulators giving fairly lenient treatment to diesels (read: relaxed NOx and PM standards as a trade-off for the diesel’s inherently low CO₂ numbers) while American regulators have virtually banned them.”

From Automotive News, December 17, 2001: “But I have to tell you: Our government had better get with the program. There are rules coming in the next few years that will make it impossible to develop and market a proper diesel engine for a US passenger vehicle.

“Here’s the deal: California and Washington are creating tougher clean-air rules for 2004 to 2009. They mainly are trying to curtail smog and soot. While the California regulations effectively outlaw diesel engines, the federal version was supposed to be flexible enough to allow some diesels.

“But automakers say the limits on diesels make any efforts to develop them impractical.

“Right now, Volkswagen offers a couple of diesel-powered cars. But Mercedes doesn’t anymore.”

Final Analysis

In the final analysis, as a diesel enthusiast I am in agreement with the European way of thinking that allows the diesel more lenient NOx and PM standards as a trade-off for the diesel’s lower CO₂ emissions. Another common-sensical (is that a word?) point that was made in the articles is the fuel economy benefit of the diesel. The diesel gets 35 to 40% better fuel economy than its gasoline counterpart, thus putting even less CO₂ into the air and reducing a country’s dependency on oil. Go figure.

In the final analysis for “Joe USA Citizen,” Joe is wondering what all the fuss is about. Diesel power offers the benefit of fuel economy, but Joe is bombarded by the negatives of diesel ownership: previous poor products (GM), non-supportive environmental hoopla, and the negative smoking and loud diesels brought to you each day by the local dump truck drivers association. Did I mention that cheap gasoline prices keep Joe fat and happy? The cards are not stacked in the diesels favor.

One final consideration: put yourself in the shoes of the automakers. Is business driven by a “Field of Dreams” business model – build it and they will come? Were there a great demand for diesels would we not all be in line at the Volkswagen dealership? Food for thought.



The VW New Beetle with diesel power. Is there a line at Volkswagen dealerships to purchase these 42 mpg diesels?

From periodic updates from the “Champions of the Cause” at the Diesel Technology Forum I’ll keep the audience current on the diesel’s acceptance in the US marketplace and on happenings in the emissions legislation arena. Stay tuned.

Robert Patton
TDR Staff

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SIDE BAR ARTICLE: Worldwide Small Diesel Popularity

With a more thorough understanding of why we do not have diesel automobiles and light trucks in the US, let's take a look at what is happening in Europe.

Previously we quoted numbers from a New York Times article (Diesels in Europe: 21.7% in 1997, 32.3% in 2000, and expectations of 40% by 2005), so let's take a minute to look at some other numbers. Ward's AutoWorld, September 2001 quotes the following: "Diesel power stormed from a modest 14% of European new-car sales in 1990 to 33% last year. And they're expected to grab 50% market share by 2010. That's all thanks to fiendishly effective new-technology improvements to the diesel.

"In Europe, suppliers and OEMs can't revise their market-penetration figures fast enough. The general consensus is that Europe-wide diesel penetration for light vehicles will approach or exceed 40% of the market in just a few more years, and likely account for 50% by 2010. So it's no secret that everyone who sells in Europe is moving to make the diesel a cornerstone powertrain."

Yes, diesels are popular in Europe. However, I would be remiss if I did not discuss another part of the globe where diesels are not wanted. Back to Ward's AutoWorld for the story.

"Meanwhile, city dwellers clad in facemasks in order to breathe safely are a common sight throughout Asia. Air pollution – which the World Health Organization says accounts for 4% to 8% of deaths on the continent – has become a tremendous problem from Bangkok to Beijing, and experts say toxic vehicle emissions are the primary contributor.

"Because of the magnitude of the problem, Asia's automakers have bypassed diesel engines as an intermediary solution and instead have focused on developing fuel cells and hybrid-powered vehicles.

"Like the US, Asia largely views the diesel engine as an environmental culprit."

Robert Patton
TDR Staff

The advertisement features a red background with a repeating geometric pattern. On the left, there is a large 3D 'C' logo with 'Cummins' written on it, and a banner below it that says 'TURBO DIESEL'. In the center, the word 'MAC'S' is written in large, metallic, 3D letters. Below 'MAC'S', the text reads 'FORT WORTH, TEXAS', '800-850-3828', and 'MACSPOWER.COM'. On the right side, there are several logos: 'BD POWER!' in a yellow diamond shape, 'banks POWER' in a stylized font, 'EDGE PRODUCTS INC.' in a black and white font, 'Superchips Inc.' in a yellow and black font, 'afe' in a circular logo with 'high performance • high flow air filter system' and 'ASSISTED FLOW ENGINEERING, INC.' around it, and 'US GEAR' in a shield-shaped logo.