

# Diesel Fuel, Air Vapors And Your Engine

## Part 1 of 4

By Steve Pollock

MARTHASVILLE, MO....Today's diesel fuel presents many challenges to a truck owner besides the "High Price." While cetane levels, lubricity, water, dirt particles and waxing have all been discussed in detail, entrained air/vapors in the fuel have not. Although comprehensive data is available through such companies as Cummins, Detroit, Caterpillar, Racor, MSOE (Milwaukee School of Engineering the foremost school of hydraulic engineering) and other fortune 500 companies, this data is hard to discover in public articles. Brad Ekstam, President of Fass Fuel Systems and an expert about diesel fuel and entrained air/vapors, has volunteered to enlighten us in a series of interviews. In our first interview with Brad we will find out how the entrained air/vapors get in the fuel. Other interviews will discuss how they affect the fuel injection components, how the entrained air/vapors are removed and the benefits associated with doing so.



*Movin' Out:* How do entrained air/vapors become mixed with diesel fuel?

*Brad:* There are a couple of sources that entrained air/vapor is introduced into diesel fuel. The first is agitation: As you travel

down the road the fuel is agitated, the longer you travel the more air. This in most cases is where the majority of air is developed. Also, the return fuel pouring in the top of the fuel tank is introducing more agitation, simply, agitation occurs as you are driving. In a little over an hour, the amount of entrained air present in the fuel is equal to the amount of vapor being produced when fuel is subjected to 11 1/2" of vacuum. In turn, creating even more of an air issue, this brings us to the 2nd source of entrained air/vapor – "VAPOR." With some exception most brand new filters "Clean," are rated at about 5" of restriction. As a fuel filter restricts, the amount of vacuum increases causing what we know as fuel starvation. Fuel starvation is "VAPOR" being produced from the fuel equating to less fuel and more air replacing where fuel should have been. Food for thought – remove the dirtying fuel from your truck and replace it with a new fuel filter, engine performs much better. Yes, this is due to less restriction; now imagine even cleaning the new filter to where there is "NO" restriction, i.e. like in the manufactures test cell!! Research from both Cat and Cummins both confirm that diesel fuel itself contain as much as 3-10% air.

One easy place to identify that air/vapor is in the fuel, and many truck owners ask themselves this, why is my suction side fuel filter almost never full of fuel when it is removed? This tells you that you always have entrained air/vapor entering your engine. We'll be covering this later in this series of articles.

Physics are also at work. Diesel fuel loses viscosity and lubricity as it heats up causing the fuel to expand and become "thinner." The thinner a liquid, the more air/vapor is created but the less air it entrains. With thicker or cooler liquids, less air vapor is created but more is entrained. Vacuum and pressure also affect this equation, pressure to fuel raises the boiling point and vacuum lowers it. Boiling Point - You may be asking yourself?? Restriction on fuel lowers the boiling point,

i.e. more vapors. Pressure/less restriction on fuel increases the boiling point, i.e. less vapors. A plugging fuel filter will create more air/vapor, as the vacuum increases to the fuel pump. The fuel pump is not working as efficiently.

*Movin' Out:* Why are air vapors a problem?

*Brad:* Air vapors entrained in the fuel can create a degree of fuel starvation for your engine. Have you ever heard your engine "miss or idle rough" while idling? This is air entering your injector and throwing the timing off of when the fuel actually enters the combustion chamber, causing an inefficient burn or "miss." The symptoms you may experience traveling down the road maybe more cab noise, less power, laboring to pull hills as well as it did earlier in your travels. The truck is experiencing a loss of performance, which equates to lost horsepower and a loss of fuel mileage. Another by-product is increased emissions – i.e. smoking. There are mechanical ramifications as well. Research by Caterpillar has shown that air can cause up to 50% greater force of the plunger on the injector tip, occasionally causing the injector tip to blow off.

The air/vapor in the fuel will also cause excess cavitation to the injector nozzle that can lead to premature injector failure. A degree of "implosion" is also created within the injector housing, adding to wear. The additional loss of lubricity caused by the air/vapor will also create gaulding and scoring of the injectors.

The air/vapor problem in diesel fuel is for the most part off the OEM radar screen. A controlled environment during the testing process is the culprit. Most OEM test facilities test the engine itself in a lab. Ambient temperatures are stable, and the fuel is gravity fed from a tank mounted on the roof or well above ground that contains thousands of gallons of fuel. Since the engine is

stationary, agitation in the fuel tanks is a non-issue. Variations in fuel pressure and vacuum are also eliminated.

Here are a couple of things to try with your own truck:

- Pay attention the next time you fill your fuel tank. You may be able to notice increased performance with a full tank of cooler fuel. As the fuel level in the tank depletes and the fuel entrains more air, you will experience a reduction in performance.

- While filling up fill up your primary fuel filter with fuel (section side). Pay attention to the engine's performance and experience how it will perform better for about the next hour. After about 1 – 2 hours after that you'll notice the performance falling off. If possible, stop and pull the filter off and see how much "empty" headspace is in it. Refill with fuel and see your performance improve. This is a small taste of what the FASS does.

Entrained air/vapors are an inherent problem for all diesel engines, including Class 8 trucks, pick-up trucks, marine engines & etc. In next month's article we will summary this issue and the variables & discuss how entrained air is removed from diesel fuel using the FASS System. The FASS System is endorsed by Kevin Rutherford of ATBS, Bruce Mallinson of Pittsburgh Power, as well as thousands of Class 8 truck and diesel pick-up truck owners.

The folks at FASS Fuel Systems welcome your questions and comments. You can call their technical department at 636-433-5410 or email them at [techsupport@fassride.com](mailto:techsupport@fassride.com). They would also like to invite you to attend the FASS Diesel Nationals, which will be held on June 5th at The O'Reilly Raceway Park in Indianapolis, Indiana. Log onto [www.nhrda.com](http://www.nhrda.com) for more information.

# Diesel Fuel, Air Vapors And Your Engine

Part 2 of 4

By Steve Pollock

MARTHASVILLE, MO....Today's diesel fuel presents many challenges to a truck owner besides the "High Price." While cetane levels, lubricity, water, dirt particles and waxing have all been discussed in detail, entrained air/vapors in the fuel have not. Although comprehensive data is available through such companies as Cummins, Detroit, Caterpillar, Racor, MSOE (Milwaukee School of Engineering the foremost school of hydraulic engineering) and other fortune 500 companies, this data is hard to discover in public articles. Brad Ekstam, President of Fass Fuel Systems and an expert about diesel fuel and entrained air/vapors, has volunteered to enlighten us in a series of interviews. In our first interview with Brad we found out how the entrained air/vapors get in the fuel and how they affect performance and injector wear.

In our second interview we will learn how what effect entrained air/vapors have on a diesel engine, mechanically and performance wise.

**Q. Movin' Out:** Brad, how does entrained air/vapor affect a diesel engine mechanically?

**A. Brad:** Probably the most damaging area affected by entrained air/vapors is the engine's fuel injectors. One of the functions of diesel fuel is to lubricate the injectors as they are working. As the entrained air/vapor passes through the

injector it is not providing complete lubricity.

This lack of lubrication for the injector's barrel and plunger becomes even more critical with the tight tolerances and high fuel pressures used in today's injectors. The entrained air/vapor creates a metal on metal situation. Over time the plunger can start to stick and as it wears, factory tolerances are lost. This causes fuel blow-by in the injector. According to Caterpillar's handbook, entrained air/vapor can create up to 50% greater forces by the plunger on the injector tip. As the fuel comes out the injector tip under high pressure the entrained air/vapor can also act much like an acetylene torch, eroding the injector tip. These two things in combination can lead to the injector tip breaking off.

Entrained air/vapor also causes a degree of implosion in the injector tip, loosening microscopic metal particles from the tip's interior. The gear pump will also experience a degree of gaulding and scoring due to entrained air/vapors. The engine will have a gradual loss of fuel pressure and eventual gear pump failure.

**Q. Movin' Out:** What are some performance issues caused by entrained air/vapors?

**A. Brad:** Fuel injection is the process of injecting a predetermined amount of fuel at a predetermined time for a controlled combustion event. Since solid fuel is not compressible but air/vapor is, any air in the fuel is throwing off and retarding the engine timing.

The majority of technical manuals for diesel engines point out that the following problems can be caused by fuel and air

restrictions: low horsepower, low fuel mileage, inconsistent performance, hard starts, rough idle, excessive smoking and etc. Simply put, entrained air/vapors do not allow the engine to perform in the working environment as well as they do in the factory. The truck may seem "sluggish" while pulling hills, especially after the fuel in partially filled tanks has time to slosh around and heat up thus entraining air/vapors. You may experience more engine and cab noise than normal and the engine may be a little rough when idling.

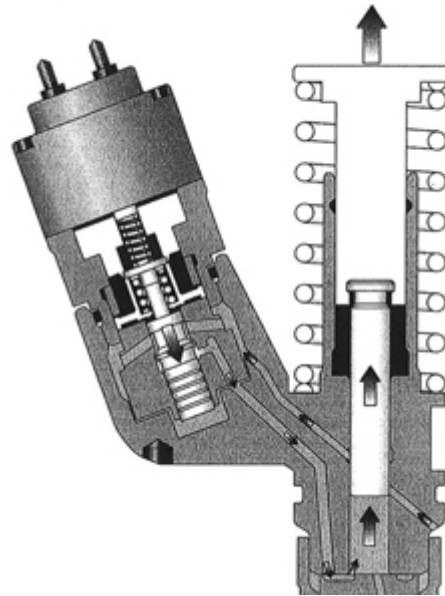
The entrained air/vapor problem is one that OEMs are not prepared to deal with. Since the amount of air and vapor that is entrained is changing constantly, there is no way to adjust ECMs to compensate for it nor does the problem show up in the R&D lab. Fuel sources at test facilities are usually above ground-mounted tanks that gravity feed fuel to the pump and eventually to the engine. In a truck's real world working environment, every fuel system's challenge is working against gravity to draw the fuel uphill and forward nearly 8-12 feet to the injectors.

Entrained air/vapors are an inherent problem for all diesel engines, including Class 8 trucks, pick-up trucks, marine engines & etc. In next month's article we will learn how entrained air/vapor is removed from diesel fuel using the FASS Fuel Air Separator System.

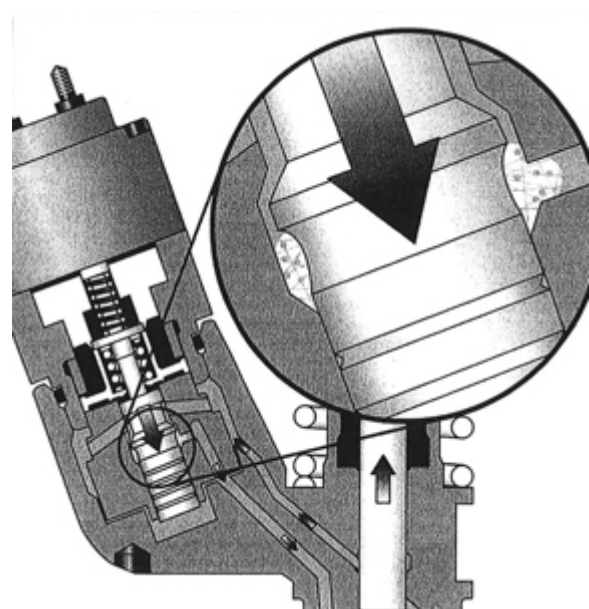
Kevin Rutherford of ATBS, Bruce Mallinson of Pittsburgh Power, as well as thousands of Class 8 truck and diesel pick-up truck owners endorse the FASS System.

The folks at FASS Fuel Systems welcome your questions and comments. You can

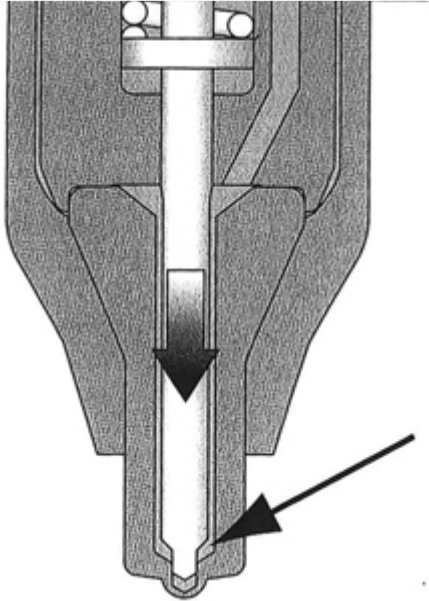
call their technical department at 636-433-5410 or email them at [techsupport@fassride.com](mailto:techsupport@fassride.com). They would also like to invite you to attend the FASS Diesel Nationals, which will be held on June 5th at The O'Reilly Raceway Park in Indianapolis, Indiana. Log onto [www.nhrda.com](http://www.nhrda.com) for more information.



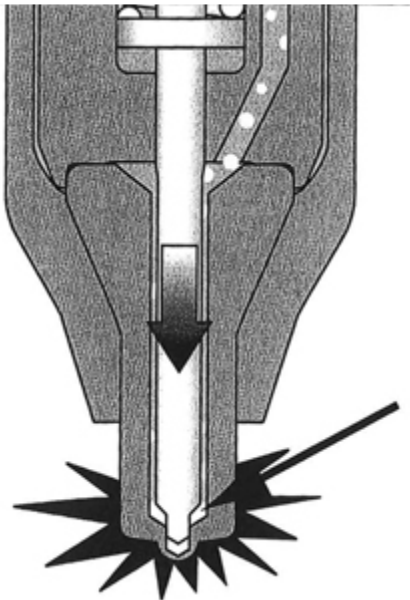
On most EUI injectors, the tappet and tappet spring lift the plunger and pull supply back into the plunger cavity.



**Low fuel supply pressure from plugged fuel filters can cause cavitation damage to injector poppet valve during injector fill.**



**Fluid trapped between the tip and check at the end of injection acts as a shock absorber, minimizing check impact.**



**An air bubble in the tip provides no fluid damping, allowing the check to impact the tip with up to 50% greater force.**

# Diesel Fuel, Air Vapors And Your Engine

Part 3 of 4

By Steve Pollock

MARTHASVILLE, MO....Today's diesel fuel presents many challenges to a truck owner besides the "High Price." While cetane levels, lubricity, water, dirt particles and waxing have all been discussed in detail, entrained air/vapors in the fuel have not. Although comprehensive data is available through such companies as Cummins, Detroit, Caterpillar, Racor, MSOE (Milwaukee School of Engineering, the foremost school of hydraulic engineering) and other Fortune 500 companies, this data is hard to discover in public articles. Brad Ekstam, President of FASS Fuel Systems and an expert about diesel fuel and entrained air/vapors, has volunteered to enlighten us in a series of interviews. In previous interviews with Brad we found out how the entrained air/vapors get in the fuel and how they affect performance and injector wear.

In our third interview we will learn how the entrained air vapors are removed and the benefits associated with doing so.

**Q. Movin' Out:** Brad, how did you discover that air vapors were an issue in diesel fuel in the first place?

**A. Brad:** Having trucks of our own, we noticed that one of our new trucks would run great at first and would then suddenly perform inconsistent. After many trips to the dealership while under warranty, it was determined that air in the fuel was causing the engine to run rough and perform inconsistent. We

were referred to a Cummins service bulletin from 1965, explaining how air & vapor separate and become evident in the fuel filter, causing the engine to perform poorly as it passes through the fuel system. As the fuel filter does its job, tiny bubbles collect on the outside of the element. These air bubbles rise to the top of the filter. As the air collects at the top of the filter, it replaces fuel until the equilibrium reached on the dirty side of the filter element. At this point the entrained air is pushed through the fuel filter into the injectors, causing a slight retarding of the engine's timing or a "miss." At this point if you would stop and refill your fuel filter you could eliminate most of the "miss," at least temporarily.

**Q. Movin' Out:** The FASS (Fuel Air Separator System) was developed specifically to remove air/vapor from diesel fuel, how does this work?

**A. Brad:** We designed the FASS Fuel System to pressurize the fuel after it leaves the water separator. As the fuel enters the fuel filter, the remaining air is trapped by the filter's element (along with dirt) and the air then rises to the filter's top as described in the Cummins Service topic. The FASS System then pumps clean, air-free fuel from the bottom of the filter to the fuel rail. The air passes through the extreme top of the fuel filter, as it does on a conventional filter and described in the Cummins Service Topic. But instead of passing to the engine the FASS is ported at the top to route the air/vapor back to the fuel tank with the return fuel being supplied with the FASS's fuel pump. Pure fuel is supplied to the engine from the bottom of the fuel filter to where the air will not reach under normal operating conditions. This is due

to the fact that air rises to the top; this is where FASS separates it. The end result is that the FASS Fuel System recreates ideal factory test cell conditions for real time working diesel engines.

**Q. Movin' Out:** What are the performance benefits of removing air/vapors from diesel fuel? And what are the mechanical benefits?

**A. Brad:** The performance benefits that the FASS Fuel System provides to diesel engines are increased horsepower/torque and consistent optimum engine performance all day long. RPMs will be more consistent at an idle and the engine will be more responsive during acceleration. Many older engines will even shift smoother. The engine will seem quieter and truck will vibrate less, also making it easier to bump a dock due to the fact that the mirrors are vibrating less. Removing the entrained air/vapor will also eliminate the "miss/roughness" when idling. Mechanically, the FASS System will solve a lot of injector issues in a diesel engine. The result is not only having the injector perform properly, but it will also extend injector life as well with increased lubrication. The FASS System will also help extend fuel pump life as well.

Since the FASS fuel pump is circulating 150-260 gallons of fuel per hour, it is continually "polishing" all the fuel in your tank. This Mass Volume Return of fuel will even polish the varnish build-up inside the fuel tank and help with algae problems. Using an algae conditioner is still recommended however. The FASS System delivers impressive cold starts. The FASS's fuel pump is very strong allowing the truck to start in extremely cold temperatures even without a winter

diesel additive, unless of course the filter is completely gelled. The system will also prime itself in the event you run out of fuel.

**Q. Movin' Out:** Are the results the same for pick-ups and Class 8 diesels?

**A. Brad:** While many of the benefits of the FASS System are similar for diesel pick-up trucks and Class 8 tractors, the results are a little different. Conservative driving pick-up truck owners typically see a mileage increase of 2-3 mpg and a gain of about 15 horsepower. Class 8 truck owners see improved performance that is consistent. Most conservative drivers are gaining a solid .4-mpg in fuel economy with some Mercedes and Volvo owners gaining up to .7 mpg. Most Class 8 trucks gain about 30 horsepower and lower their pyrometer temperature on stock engines by about 50-75° and modified engines by up to 150°. Most drivers are gaining 5-7 mph on uphill grades, typically gaining a solid gear on hills.

**Q. Movin' Out:** Are there other benefits associated with using the FASS System?

**A. Brad:** Some other benefits from installing a FASS System include extended life for fuel filters and water separators. FASS fuel filters are typically good for 30,000-50,000 miles. The FASS water separator uses a stainless steel wire mesh lining and many drivers are seeing 2-3-4 years of service before replacement. The FASS System was designed so that replacement fuel filters can be obtained from FASS, Fleetguard, Baldwin and other popular brands. The FASS pump motor has a life of around 17,000 hours or around 700,000+ miles. FASS uses a time proven, high quality pump that has a less than 2% failure rate. If the FASS pump

should fail, it has a bypass mode that allows the truck to keep running. The FASS System comes with an available 4-year warranty and will not void engine manufacture (OEM) warranties.

**Q. Movin' Out:** Is it difficult to install the FASS System? And what kind of maintenance is involved?

**A. Brad:** Installation of a FASS System usually takes about 4 hours and can be done by anyone with a little mechanical inclination. A full set of step by step instructions, complete with photos, are included in each kit. Installations can also be done at any of nearly 700 FASS distributors nationwide. With pick-up trucks, the FASS unit is installed under the bed in front of the rear wheel on the fuel tank side of the vehicle. On semis the FASS unit replaces the primary fuel filter. Maintenance consists of emptying the water separator and occasionally changing the fuel filter and separator as needed.

Entrained air/vapors are an inherent problem for all diesel engines, including Class 8 trucks, pick-up trucks, marine engines & etc. In next month's article we will review some actual customer testimonials from FASS Fuel System owners. Real results from real people.

Kevin Rutherford of ATBS, Bruce Mallinson of Pittsburgh Power, as well as thousands of Class 8 truck and diesel pick-up truck owners endorse the FASS System.

The folks at FASS Fuel Systems welcome your questions and comments. You can call their technical department at 636-433-5410 or email them at [techsupport@fassride.com](mailto:techsupport@fassride.com).



The FASS Heavy Duty Series was designed for Class 8 Trucks.



The FASS Platinum Series is used by diesel pick-up owners.



**The FASS Titanium Series can be used on a Class 8 diesel or pick-up truck.**

# Diesel Fuel, Air Vapors And Your Engine

Part 4 of 4

By Steve Pollock

MARTHASVILLE, MO....Today's diesel fuel presents many challenges to a truck owner besides the "High Price." While cetane levels, lubricity, water, dirt particles and waxing have all been discussed in detail, entrained air/vapors in the fuel have not. Although comprehensive data is available through such companies as Cummins, Detroit, Caterpillar, Racor, MSOE (Milwaukee School of Engineering, the foremost school of hydraulic engineering) and other Fortune 500 companies, this data is hard to discover in public articles. Brad Ekstam, President of FASS Fuel Systems and an expert about diesel fuel and entrained air/vapors, has volunteered to enlighten us in a series of interviews.

In previous interviews with Brad we found out how the entrained air/vapors get in the fuel and how they affect performance and injector wear. We also learned how the entrained air vapors are removed and the benefits associated with doing so.



In this month's article we would like to share some comments from FASS Fuel System owners and their personal results using the FASS Fuel System.

Lynn Chapman of Edmonton, Kentucky is the owner of a 1994 Dodge Ram 3500 2-wheel drive pulling truck, "Smoke Showin." The engine is a 5.9 Cummins. Lynn had this to say about the FASS Fuel System: "There was a noticeable difference in performance and increased horsepower in my truck after installing the FASS System."

Another satisfied customer is Keith Summers of Stanek Farms. Keith has a 2006 Dodge Ram 3500 with a W/5.9 twin turbo Cummins. Keith commented: "While a factory fuel pump is adequate, the FASS System delivers volume and pressure while removing the air. This allows a better fuel to air mixture and fuel flow from the injectors. The unit is well built and it's been out in the weather under the fender well for 3 years now without a corrosion problem."



Owner-operator Arlindo "AJ" Jardin has the FASS Fuel System installed on his 2000 Freightliner FLD 120. His engine is a 3506E 600 hp CAT. AJ said "I had already made several fuel saving modifications to my truck before installing the FASS System. I still had a

mileage improvement of .297 mpg. Pretty impressive for a big 16L engine!"

Jerry Kissinger, an owner-operator and veteran truck show participant also uses the FASS Fuel System on his trophy winning 1991 Mack Superliner. Jerry raves: "Believe it not, it makes my 800 horse V-8 run stronger and smoother. Fuel mileage went from 5.4 to 5.8 mpg!"

Steve Snyder of Wichita, KS writes: "I have a 1982 Peterbilt with a 3506A CAT. I used to struggle to get. 4.3 mpg. The engine was hard to start and ran rough and missed for a few minutes after. It always had air in the fuel return line. The engine surged during idling and smoked bad under a pull. I installed a FASS system and things really changed. The first thing I noticed was how much faster the engine started and ran smooth. The air was gone from my fuel return. After about 50 miles I noticed that the engine pulled better than it ever had. It had 3 lbs. more intake manifold pressure. The exhaust gas temp was 50 degrees less than before. And the biggest thing was it was getting about 4.75 mpg. After about two weeks I settled down and drove a little easier, the mileage came on up to 5.0"

John Marple of Georgetown, TX had this to say about the FASS System: "I am writing in regards to your FASS System I bought for my 2000 Western Star with a 500 CAT. Since installing it in late May I am getting anywhere from 1/2 to 3/4 mile better fuel mileage. I run regional in TX, LA, AR & OK. My longest haul is 350 miles and a lot of local work. I have also noticed an increase in my pulling power."

Paul Hayden writes: "Thought I would send you some information since

installing my FASS System. I am thrilled with it. It does everything you said it would. The truck idles smoother and it pulls better, too. I only have a 2002 International 9200i with a C-12 CAT that has 430 hp with max 1650 lb. torque. Before installing the FASS System my 3 previous tanks of fuel were 5.15 mpg, 5.35 mg and 5.5 mpg. After installing the system my first 3 fill ups were 5.75 mpg, 5.85 mpg and 5.95 mg. Even in the coldest temperatures 5.75 mpg has been the lowest. But as of lately it has stayed pretty consistent at 6.0 mpg."

The accolades continue with Mike Burkhart writing: "Hey Brad, you LIED to me. You said this thing wasn't going to make "Edge EZ" difference in the performance of my 24 valve. My pump must have been very weak. Your FASS woke that thing up. It runs like a raped ape."

Dan McDonald of Gainesville, TX had this to say about the FASS System: "Both Darrell and I have FASS on every thing that we drive. Me on my 2001 Dodge CTD and him on his 2002 Dodge CTD and 2000 Ford Power Stroke. We ordered our first FASS System and were immediately impressed with the quality! 3/8" line, big fuel filter, HUGE lift pump! Seemed over built... the way we like it! We installed the new injection pump and the FASS. We immediately noticed the truck ran smoother and was quieter at idle. (Don't worry! It still rattles like a Cummins! Just more refined!) I got one for my truck and now my wife asked, 'What did you do to the truck that made it quieter?' My truck also has more pep from 30-70 mph. We have since installed several for other people's trucks and have similar results with all. I think this is one of the best diesel performance products

out on the market today... BAR NONE!  
Thanks brad for a great product. You have our support!"

From Chris Behrens: "The recent installation of your FASS System has performed as well as you said it would. I installed the unit on a Cummins BC III 400 hp with 550,000 miles on the last rebuild. The improved fuel mileage was enough satisfaction but the increased power was better than I expected. My fuel mileage went from 5.1 mpg to 5.6 mpg and that is a combination of highway and rural driving. With that kind of increase the system should pay for itself before the end of the year. The increase in horsepower allows me to pull hills a full gear higher than before. Shifting is smoother since the engine is so much more responsive. The engine idles like a kitten and I noticed that the back of my stacks don't black as quickly."

"I love the product!" writes Eugene Svistun of Centennial, CO. "Technical assistance was very helpful over the phone! Would strongly recommend to other people!"

Rick Grambo of Pylesville, MD raves: "Wow! Great product! Works as advertised. Thanks!"

David Latoria of Medina, OH had this to say: "I have a CAT engine that could not find its way out of a wet paper bag with both ends open. This FASS System has made such an unbelievable difference in every aspect. Fuel mileage did not go up much – but power and performance did. Thank you!"

Rounding out the praise is Pete Rushbrook of Prescott, AZ: "I love it. I gained ½ gear on hills, lower pyro,

smoother starting and running. Wish I did this a year ago!"

The folks at FASS Fuel Systems welcome your questions and comments. You can call their technical department at 636-433-5410 or email them at [techsupport@fassride.com](mailto:techsupport@fassride.com).

