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Filtration Fixation
Fuel filters keep new diesels working for oil and gas industry; M&D sees the damage caused by dirty fuel.

Managing Risk in the Family Enterprise: It’s More than Financial
All businesses face risk - family businesses are no exception. Generally thought to adopt a more conservative approach toward managing their business operations, family businesses are often considered more risk averse than their nonfamily counterparts.

Balancing CHRA’s Plays a Critical Part in Turbocharger Repair
Since the explosion of common rail turbo diesels for passenger cars and the more recent trend of downsizing gasoline/petrol engines through turbocharging, the repair industry has also significantly increased to deal with the large percentage of much smaller turbos. This in turn has significantly increased the demand for high speed balancing.

2015 ADS International Convention & Tradeshow Wrap Up
This year’s ADS International Convention & Tradeshow combined some of the best from the past and changes you had been asking for. From additional networking opportunities and specialized business management seminars to redesigned tradeshow floor and targeted manufacturer seminars there was a lot to get excited about in San Antonio.
The ADS Online Forum: Log On and Get Connected

The ADS Online Forum community continues to grow. Every day, members log on to the Forum to interact with others for diagnostic advice, training tips and to discuss the latest news and trends within the industry. Here is a real discussion directly from the ADS Online Forum:

**Case: 03 6.0 start then die**

**July 17**

Got a truck here that will start and die 2-3 times in the morning. Rest of the day its perfect, starts great hot, just over night. My data shows that I’m running out of ICP it seems to be. IPR will cycle anywhere from 51%-85%, ICP will quickly rise to over 2200 engine will run for 2-3 seconds then ICP will almost cut in half and engine will die, but IPR spikes % in hopes to keep it alive but it still falls on its face. It isn’t a chugging and dying, it’s a simple key off dying.

I had first suspected ICP sensor so I changed that due to oil being present and a beyond FUBAR pigtail. My voltage now reads good. I had also swapped in a known good IPR for S&Gs. still same issue. I do have the correct oil filter and cap and yes the anti-drain back is working in the filter housing. To me it seems like a supply oil issue, but with an oil filter housing full of oil, I have my doubts. I am also suspecting maybe the check ball has removed itself from the pump, but it does not have the other symptoms I have come across with that issue. It’s certainly not a fueling issue since there is no chugging or sputtering.

There are also other times where right at cranking the IPR goes from 14% all the way to maximum, 84%. I am also confused on why it is doing so.

**July 17**

We have seen this a few times, it’s the HPOP. I’m sure what exactly is failing inside the pump, but replacing it will solve the issue.

**July 17**

Man, I have never ever experienced this before with an early gen HPOP, for me they either start but run so low on ICP it sounds like a Duramax or they just can’t keep up with desired ICP.

Thank you for the quick response and thank you Matt for the follow up phone call to further explain what Michael suggested, it makes perfect sense!

As always, will keep this issue updated.

Thanks again
Case: 03 6.0 start then die (continued)

July 21
I have had this issue with one truck that was 2003. After replacing everything including HPOP it turned out to be the HPOP cover. Apparently after time the sealing surface inside the cover will wear out causing this same issue. Tony Salas gets credit for that one!

July 21
Now this I have heard of but have never come across either. I just got the ok to move forward with pump replacement. Will the damage to the cover be plain as day or will I have to make measurements? I will definitely inspect it and replace if need be.

July 21
Got the pump out, cover looks good where the D-ring seals from outlet of pump, pump was definitely getting supplied low end oil. When I lifted the HPOP I had a fountain of oil draining from the reservoir. I inspected the branch tube adapter, it looks good. We usually replace the entire tube, but due to costs I may have to just reseal the adapter. Does anyone have the O-ring part number that’s inside the STC part of the adapter?

July 22
It may not be at first noticeable. If in doubt replace the cover. We had the darn thing off twice and didn’t see much wear in it but it was enough to cause the issue after a cold soak. Replace the tube while you are at it.

July 23
Replaced the pump, reused but inspected the cover and tube adapter. Started great this morning guys, thanks!

You can get quick and helpful diagnostic suggestions just like these ADS members did! Post your question on the ADS Online Forum now. It is free for members to post and view the archives; all you have to do is make sure you’ve requested to be a part of the Forum. Not an ADS member? Try the ADS Online Forum free for 30 days! Sign up on the ADS website today.
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The first of August is behind us and so is another successful ADS Convention. It was wonderful seeing you all there. It’s always terrific catching up with friends and making new ones. That goes for the great networking events as well.

The seminars were very timely and informative. Topping the list was Mike Rayne our Keynote speaker. The Friday afternoon lineup, was exceptional. I hope you didn’t miss it. I think the convention committee saved the best for last!

The convention center was huge, however the layout and the closeness of the exhibit hall to all the meeting rooms and other venues saved a lot of walking and time when moving from one event to the other. Even the hotel was just a short walk to our rooms.

The exhibit hall was filled with companies displaying the products we use every day in our business. The excitement of those who attended the convention could be felt throughout the event, even the exhibitors I spoke with said the quality of their contacts was better than in the past.

Everyone I talked to said they enjoyed this convention and the city of San Antonio. I’d like to thank my wife Rosemarie for her efforts in making the companion program a great success, and I would be remiss if I didn’t also thank Andy Girres, our convention chair and our ADS staff for all their hard work in making this convention run so effortlessly.

Plans are already in the works for our next convention in Las Vegas. The Las Vegas venue is always well attended, so be sure and mark your calendar for August 2-5 2016. Be sure to also watch your email for the ADS convention feedback survey. Please respond, so we can use your thoughts and ideas to make next year’s convention even better.

Chuck Oliveros
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If you missed attending the ADS Convention & Tradeshow in San Antonio, Texas this year, you certainly missed one of the most enthusiastic conventions in recent years and having the ability of staying on the Riverwalk in San Antonio was even more of a benefit.

For those of you who did participate, I trust you got as much as I did from this annual event. The theme for this year’s convention was “Your Voice Your Future”. As I mentioned during my opening remarks, “In this world we all have challenges – and they are always with us in one way or another. I encouraged everyone to: Embrace Challenge and Experience Success.” This year has been no exception, most of us have experienced challenges, however, we have embraced these challenges and have also experienced the successes.

The Tradeshow, although not sold out as it was last year, had nine new companies exhibiting. There were several introductions of new products and equipment, all of which were on the show floor for the delegates to try out. As for the seminars, for those who were counting we had even more than in previous years, with an exceptional lineup of industry, business management, training, etc. too many to mention here. These valuable informative and education sessions help your business and demonstrate how you can take advantage of new opportunities coming your way.

Every year our aim is to grow the ADS show, this year was somewhat of an exception, attendance was down to some degree over last year. We also made several changes to the convention this year, some major others were more subtle. The program this year gave many hours of networking time in different ways than in previous years, time to talk one-on-one and swap experiences with peers from all over the world.

The ADS show is designed specifically for you, the diesel fuel injection expert. For those who attended, we really appreciate your support, if you missed the show this year, start planning now for 2016 and join us in celebrating our 60th year. Mark your calendars for next year’s International Convention & Tradeshow – August 2 - 5, 2016 at the Wynn Hotel in Las Vegas. The Convention planning committee makes it a challenge every year to surpass the previous year’s convention; plans are already under way for 2016. You will not want to miss this one.

“Nozzle Chatter is the official publication of the Association of Diesel Specialists.

The ADS show is one of the many benefits of being an ADS member, we have many other benefits for you, if I may assist you in selecting some of the other new benefits you can participate in, or if you have any questions, as always, feel free to contact me @ 913.345.0288 or via e-mail at david@diesel.org.
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here is one thing for certain...our industry is changing.

The diesel vehicle/equipment is becoming more complex. New diesel engines are more powerful, fuel efficient and cleaner than ever before. Fuel system tolerances are tighter than ever, electronics now monitor and control all aspects of the powertrain, and exhaust systems have become more comparable to mini factories rather than mufflers. Manufacturers are releasing new diesel vehicle offerings every day. These new advanced and clean diesels will require a specialist technician, armed with not only wrenches, but a full gambit of electronic wizardry and know how.

Yet, all of these changes are not in our favor. The higher purchase and repair costs associated with the advancements of the diesel vehicle/equipment are turning away potential buyers. Fuel system manufacturers are releasing less repair options to the aftermarket or in some cases keeping replacement product distribution exclusively through the vehicle/equipment manufacturer. For as long as we can remember, diesel fuel system components and repair were only available through specialty shops. Now these items can be easily found at your local parts store and in endless supply on the internet.

So what does all of this mean for us and our future in this ever changing industry? In his opening remarks at the 2015 ADS international convention, my father stated “With change comes opportunity”. If that is the case, how does one respond to opportunity? Winston Churchill once said, “A pessimist sees difficulty in every opportunity, an optimist sees opportunity in every difficulty”. This is a fascinating statement on the different viewpoints of an individual. How do you view our changing industry? Perhaps these changes will give you the opportunity to diversify your business and focus on other aspects of the diesel industry besides “just” focusing on the fuel system. Furthermore, it may give you the opportunity to focus more on your existing practices, streamlining current processes, reinvesting in equipment or employees.

Just as is change in life, changes in our industry are inevitable. Though many times we resist change, it is how you respond to the change and the opportunity that comes with it.
This year’s ADS International Convention & Tradeshow combined some of the best from the past and changes you had been asking for. From additional networking opportunities and specialized business management seminars to redesigned tradeshow floor and targeted manufacturer seminars there was a lot to get excited about in San Antonio. This year the event was also held inside the Henry B. Gonzalez Convention Center which was a change from previous years.
The week started off with the association’s committees and Board of Directors meeting for business on Tuesday. The committees were busy working on projects for the association over the past year and the Board of Directors continue to evaluate the association and the direction it is headed. Nikki Tucker from Diesel Forward in Windsor, WI sat at her last board meeting of her term. Ted Hess of H.G. Makelim in South San Fransicio, CA will fill this seat. Ron Roach from Redat North America in Orlando, FL stepped down as chair of the Replacement Parts Committee and welcomed George Watson of DSS ProDiesel in Nashville, TN.

This year’s keynote was presented by Mike Rayne. Mike has been in the diesel industry for more than 40 years. He discussed the emerging technologies and their effects on the industry. Wednesday also saw Alliant Power and Racor Division/Parker Hannifin Corporation give updates on their companies and the new products they are offering. Jason Long with BizUnite let those in attendance know how to save money with offerings from his company which is a benefit of being a member of ADS. Tom Fulks wrapped up the presentations on Wednesday with a discussion on the ups and downs of the world diesel market.

Following the presentations was the ADS Annual business meeting and presentation of awards. This year awards were presented for Milestone Exhibitors in the Tradeshow to:

- Exhibitor Milestone Award - 5 years: Melett Ltd & Bostech
- Exhibitor Milestone Award - 20 years: DNR Industries Inc. & BorgWarner Turbo Systems
- Exhibitor Milestone Award - 35 years: Honeywell Turbo Technologies

John Walker from DIPACO, Inc. accepted the first Joe Callahan Memorial Achievement Award on behalf of his father Wayne Walker. This year’s Turbocharger of the Year award was presented to Vern Beecher of Turbo & Diesel Injection Company in Indianapolis, IN.

One big change for this year were the addition of distributor meetings for the three turbocharger manufacturers. BorgWarner Turbo Systems, Garrett, and Cummins Turbo Technologies all held invitation only meetings for their distributor network. This allowed for
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more in depth presentations for these manufacturers as well as time for more discussion.

Thursday morning represented another change for 2015 as all manufacturer seminars were presented on the same day. Six manufacturers and three turbocharger manufacturers presented information on new products, industry changes and technical information.

On Thursday evening there was an additional networking opportunity with the addition of the ADS Wild West Saloon Night. This event was held in the LDR room of the convention center and was right on the river giving attendees a great evening of networking and socializing.

Friday morning was the final hours of the tradeshow and after lunch the Business Seminars got underway. This year attendees were treated to a wide variety of presentations including, “Understanding your WIN number” by Jim Silverman of Automotive Training Institute, “Master Your Future, Master the Internet!” by Danny Sanchez from Autoshop Solutions, “Family Business: A Winning Strategy for Your Business” by Dr. Otis Baskin with the Family Business Consulting Group. Mike Cleary presented the last seminar of the week talking about “Ford Powerstroke Diesel – Fact or Fiction?”

With the week coming to a close, attendees donned their western and Mexican wear and enjoyed the ¡Fiesta de Diesel! closing event. There was a strolling mariachi band, wonderful Mexican and western cuisine, plenty of margaritas, a country/western band and line dancing lessons.

Thanks to all of the attendees and exhibitors for making this year such a great week of learning and networking in your industry. Don’t forget that ADS is your association so get involved and get your voice heard! If you would like to join a committee please e-mail lea.ann.reed@diesel.org for more information.

See you next year in Las Vegas!
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Filtration Fixation

Fuel filters keep new diesels working for oil and gas industry; M&D sees the damage caused by dirty fuel

By Chad Elmore

Adapted from an article that originally ran in the September 2014 issue of Diesel Progress

It takes fuel to get fuel, and diesel dominates where hundreds of oil and natural gas drill rigs are positioned over shale plays across North America, as it has for decades. Diesel engines have evolved and the new emissions-compliant high-pressure common rail (HPCR) powerplants have made spec’ing and maintaining proper fuel filtration more important than ever. Now microscopic debris and water levels that are measured on a molecular level can cause significant engine damage. As new engines join fleets with older units, engine specialists and component suppliers are working to get that message out before machine availability averages are significantly impacted.

“We have seen some catastrophic failures,” said Suken Patel, fuel injection production manager for Humble, Texas-based M&D Distributors. “A common rail system is very different from earlier diesels because the velocity of the fuel is a lot higher. Even a 2 micron particle, when accelerated, creates a deep scar on anything it hits. It erodes metal, digging deep gullies that destroy injectors and can cause fuel to flood the cylinder. In other cases injector nozzles freeze up because of contaminants. Older systems pumped diesel fuel as it was needed, but now there is fuel already in the rail. When the injector sticks open, fuel flows straight into the cylinder, and when the piston comes back for the compression stroke it will have nowhere to go. Liquids can’t be compressed. So they’ll get a bent rod or a whole lot of other damage.”

Founded in 1943 as Magneto and Diesel Injector Service, M&D Distributors’ main focus was and continues to be diesel fuel injection. Over the years it added original equipment turbochargers such as Honeywell Turbo Technologies (Garrett) and Cummins Turbo Technologies (Holset) and engine parts from Federal Mogul and Mahle Clevite. It has also become a filtration solution provider.

Two of the four Caterpillar 3516 diesel engines required to provide the power for a drill rig destined for central Asia. New high pressure common rail engines have made installing proper fuel filtration systems more important than ever.
Holset Turbochargers have set the standard for turbocharger technology for over 60 years. Engineered and manufactured by Cummins Turbo Technologies, Holset Turbochargers are developed as a critical component for each application to ensure the highest standard of product quality, safety and superior performance. And now with the option of genuine exchange on selected Holset Turbochargers, you can choose a high quality, more environmentally sustainable, original equipment product.

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working with companies such as the Racor Div. of Parker Hannifin as well as Cummins Filtration.

While the sizes of the particulates that can damage an engine are tiny, other numbers from the oil and gas industry are anything but small. At each well, three or four 69 L diesel engines generate the electricity and hydraulic pressure required to drill more than 10,000 ft. down and then out more than over 5000 ft. horizontally. Additionally, out on the oil patch hundreds of diesel-engined machines – from skid-steer loaders to one-ton pickups to Class 8 semis – are used to prepare the site or as personnel carriers, welders, generators, pumps, mobile offices and other applications.

One particular oilfield service company has three Caterpillar 3512 or 3516 diesel engines and a Caterpillar C18 diesel engine for cold starts at each derrick. Out on the oilfield, drill rigs use every bit of power the big engines can generate.

The engines are pulling off a 55,000 gal. tank of diesel sitting next to each derrick. Dirt and other contamination can be as issue, as the big tanks sit out in a dusty field with condensation and heat working on them. In addition to the engine-mounted fuel filters, the service company will install two large fuel filters at the storage tank through which around 3200 gal. a day will flow.

Refinery-fresh fuel may already contain some water. ASTM International considers diesel fuel to be dry if it contains 500 ppm of water or less. In 1000 gal. of diesel fuel the allowable amount of water is a half-gallon. Over time it will accumulate at the bottom of the fuel tank and create an environment for hydrocarbon utilizing microorganisms, or HUM bugs. The algae and bacteria produce acids that are not good for injection systems.

Complicating the contamination prevention challenge is that Tier 3 and 4 engines look a lot like previous models, especially in a fleet with hundreds of diesel engines. “The new engines are beginning to show up in the oilfield,” said Robert Ginsbach, central territory manager for the Racor Div. of Parker Hannifin’s Filtration Group, “and they treat them the same way they did their older electronic and mechanical engines and then all of a sudden the engines won’t run. Most fleets would like to standardize on a certain type of engine but that is very hard to do. They have equipment scattered all over Texas. So filtration is a huge part of what the oil and gas industry lives on, at least on the exploration and production side of it.”

M&D’s original location is near the Houston Ship Channel in the heart of the city’s industrial area, and during its early years the company provided injector and magneto repair service to the ship and rail industries. A couple of years ago the company moved its headquarters from the original location to a new 68,000 sq.ft. corporate office and

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“We have a good relationship with local engine distributors and everyone is able to get together and talk about issues our customers are having,” said Jim Garner, vice president, Sales and Marketing, M&D Distributors. “We don’t sell engines and so we are not a competitor to them. We are an asset. That comes into play when we can call them in or they call us in for what we do well: stock, spec, repair and troubleshoot fuel systems and turbos.

“We partner with Racor, too. They visit customers regularly and we are available when we’re needed. We have a technical background on the fuel injection side, and have an awareness of what happens downstream from the filter if users are not taking care of fuel cleanliness. We’ve seen what can happen to the injectors with dirty fuel.”

In addition to the oilfield customers, M&D supplies Racor filter products and support to major engine distributors and packagers, marine fleets and service facilities, boat builders, industrial applications, over-the-road truck fleets, diesel repair shops, fleets and aviation fueling facilities.

“M&D truly has the voice of customer,” said Dan Walters, global marketing and sales manager for Racor in Modesto, Calif. “That is critical, and they are able to get action from the suppliers and OEMs. In mining and agriculture, uptime is a request — even a demand. But in oil and gas uptime is going to happen with or without you. Uptime is not debatable if you want to be part of this industry. And these guys are part of it, and they have a legacy in Houston. If we don’t listen to them our customers may not get the uptime they need.”

M&D performs fuel injection service, including factory-authorized repair, remanufacturing and testing of Bosch high-pressure common rail injector production at its location on Houston’s northwest side.

At its injectors are disassembled, cleaned and tolerances are checked. It’s at this stage that any damage to the components is found, said Patel. After replacing critical wear items, it’s reassembled in a clean room and tested. Each injector is given a unique serial number that links the part to each measurement.

“Most of the sealing surfaces in injectors are metal to metal,” said Patel, “because system pressures are now up to 30,000 psi and you’re not going to be able to seal that with a gasket. With sealing that’s metal to metal the clearances for moving parts are very tight. A four micron ‘rock’ will mess it up.”

Today, some end-users and manufacturers install fuel filters that are good for 10 microns and a few use 2 micron filters. A decade or so ago the best available was a 30 micron fuel filter and that was all that was required to protect diesel engines.

“Now we think of that as a prefilter,” said Garner. “The fuel systems back then could digest 30 micron contaminants with no problem. Fuel injection has always been sensitive to contamination, from the abrasives, asphaltenes and other stuff that is naturally found in diesel fuel. But the newer
the engine the more sensitive it is. I think operators and manufacturers are finally realizing that the filtration that is standard on a typical diesel engine package may not be adequate for a lot of requirements, either from a capacity or filtration quality side.”

Rebuilt or even brand-new injectors may be reinstalled in a system with dirty fuel and will again fail: “Fuel injectors are very, very expensive filters,” said Garner.

Others simply don’t know why they have to change the way they’ve always done it. “They will tell us, ‘Man, I have been doing this for 30 years. Who are you to tell me it can’t be done this way?’ Sometimes it is hard to explain to certain customers that things have changed, and they need to change to keep their equipment running,” said Patel.

http://www.mddistributors.com/
www.parker.com/racor

PHOTO F & G: Inside M&D’s fuel injection repair shop today and…during in the 1950s...

PHOTO H: MCurrent M&D owner Bruce Ingram is shown with his mother outside of the company’s original location on Navigation Ave. in Houston, Texas.
Technical News

Balancing CHRA’s Plays a Critical Part in Turbocharger Repair

By Ian Warhurst

The turbo repair industry is a well-established global market, which goes back to the 1960’s. Up until the late 1990’s, the turbo repair market was predominantly involved in the repair of larger commercial vehicle turbos. Since the explosion of common rail turbo diesels for passenger cars and the more recent trend of downsizing gasoline/petrol engines through turbocharging, the repair industry has also significantly increased to deal with the large percentage of much smaller turbos. This in turn has significantly increased the demand for high speed balancing.

What is a CHRA?
A complete turbocharger is essentially a Centre Housing Rotating Assembly (CHRA or core assembly) with housings fitted to each side. The turbine housing directs exhaust gas to power the turbine wheel, the compressor housing directs air into the engine. The turbine housing will have a wastegate to control the turbine speed, or as is more common on diesel engines, there is a variable vane mechanism giving much better control of the turbo, reducing lag and improving performance. The wastegate or vane mechanism is controlled by an actuator – which could be controlled either electronically or by a vacuum system.

The CHRA is a rotor (turbine wheel one side, compressor wheel on the other) which is held in a bearing system allowing it to rotate at high speed on a pressurised oil film similar to the engine. Turbo remanufacturer’s traditionally strip the complete turbocharger and CHRA, examine all the individual components, replacing these where necessary, and install brand new bearings and seals.

Why do you need to balance a CHRA?
In exactly the same way in which a wheel needs balancing after changing the tyre, the CHRA also needs balancing after it has been dismantled and rebuilt.

It is important to understand, all objects which rotate around a centre axis have a certain amount of unbalance and this unbalance will create a resonant frequency – or vibration - at specific rpm. The speed and strength of the vibration is directly related to the amount of unbalance within the CHRA. To compare this to the car wheel, the vibration would be felt in the steering wheel. However, if the wheel is balanced more accurately, the resonant frequency is both reduced and moves to a higher rpm - which is above the fastest speed of the vehicle therefore solving the problem.

The turbo CHRA is a complex piece of machinery which has been designed to operate at temperatures up to 800°C whilst reaching rotational speeds in excess of 230,000rpm (that’s over 3,800 revolutions per second!).

To operate under such extreme conditions each component in the turbocharger, which make up the main rotor in the CHRA, is manufactured to some of the tightest tolerances in the automotive industry (as low as 0.002mm). The turbine and compressor wheels are also precision engineered and balanced on specialist equipment as part of the manufacturing process. However,
BorgWarner Buying Remy

BorgWarner Inc. announced it has signed a definitive agreement to acquire Remy International, Inc., a global manufacturer, remanufacturer, and distributor of alternators, starter motors, and electric traction motors for the automotive and commercial vehicle industry, marketed under the Remy and Delco Remy brands.

Under the terms of the agreement, BorgWarner will acquire all of the outstanding shares of Remy for $29.50/share, in cash, which implies an enterprise value of Remy of about $1.2B. The completion of the transaction is subject to the approval of Remy’s stockholders as well as certain terms and conditions, including antitrust and other regulatory clearances in the U.S. and abroad. The transaction is expected to close in the fourth quarter of 2015.

Donaldson Acquires Engineered Products Co., Maker of Filter Minder Indicators and Sensors

Donaldson Co. Inc., a global leader in engine filtration, has announced it has acquired 100 percent of the shares of Engineered Products Co., a leading designer and manufacturer of indicators, gauges, switches and sensors for engine air filtration and liquid filtration systems.

Founded in 1977 and based in Waterloo, Iowa, Engineered Products generates annual sales of approximately $9 million through its well-known Filter Minder brand. Filter Minder products connect to air and fuel filtration systems to measure, indicate and predict remaining filter life.

“The acquisition of Engineered Products supports our strategy of technical leadership in filtration products for both our OEM Customers and their end users of our filters,” said Tom Scalf, Donaldson’s senior vice president for Engine Products. “We see an increasing need for measuring and monitoring filter life in diesel powered equipment, and communicating filter status information visually, electronically and remotely as vehicles become increasingly connected with fleet management systems. The information from Filter Minder products helps equipment operators maximize the performance and uptime of their equipment, and plan their filter changes.”
when the rotor is assembled, the accumulation of the remaining tiny imbalance in all the parts can create a rotor, which is out of balance, and will vibrate at critical speeds within the CHRA operating range.

In the same way a car wheel is balanced at low speeds, traditionally, the larger commercial turbo rotors were balanced at lower speeds. By achieving a certain level of balance precision at low speed, the resonant frequency of the rotor would be well above the operating speed of the turbo. However, as turbos became smaller, the rotational speed increased significantly so that the small turbo CHRA now passes through resonant frequencies within its operating range. To ensure these smaller CHRA do not vibrate excessively during operation, they must be balanced on a high speed balancing machine which is capable of accelerating the CHRA through its full operating speed and measuring the vibration as the rotor passes through resonant frequencies. In over 99% of tests, the unbalanced CHRA has vibrations outside acceptable limits and must be further balanced to ensure the turbo will operate correctly.

What are the effects of not balancing a CHRA and the damages caused by this?

Failure to balance the CHRA on specialist equipment can cause excessive vibrations as the turbo speeds up, resulting in noise (whistling) and a breakdown of the oil film in the bearings. This in turn will cause premature failure of the bearing system, often with no obvious signs of lack of lubrication or oil contamination.

Importantly, the life of the turbo will be significantly reduced if the CHRA is not properly balanced – in worst cases the turbo will make unacceptable noise during operation and fail within days.

What are the effects of using lower quality components on balancing?

As a result of the high rotational speeds, the level of precision in the manufacturing of replacement turbo parts is extremely high. Quite simply, using lower quality repair parts makes the CHRA harder to balance. This in turn means that low quality CHRA are often not balanced to the correct level and will fail much earlier than expected.

Using parts which are not precision manufactured to the specified flatness, tolerances or dimensions, can lead to an accumulation of component imbalance issues, again causing premature failure of the turbo.
Does every CHRA need to be balanced?

CHRA, which have a turbine wheel diameter less than around 50mm, will pass through a resonant frequency during normal operation. As a guide, this will cover all turbos fitted to diesel engines up to about a 4L capacity.

All CHRA must be balanced – even if all the same components are used – the act of loosening and retightening the shaft nut will change the precise balance of the rotor – so it is not possible to carefully dismantle a turbo, fit a new seal and rebuild. All CHRA must be high speed balanced.

To conclude, the key to maximising the lifespan of a repaired turbocharger is to use quality, precision manufactured and balanced components, use the appropriate CHRA high speed balancing equipment and ensure the careful assembly and calibration of the turbo.

Ian Warhurst is the owner of Melett Ltd.

ABOUT MELETT

Melett, a British company built on strong engineering principles, supplies replacement turbocharger repair kits, complete VSR balanced CHRA/ Core Assemblies and individual turbo components to the professional turbo repair industry.

With an in-house team of highly qualified technical Engineers and an in-house Core production facility, Melett is recognized as the quality, reliable supply partner by turbo repairers ranging from small turbo workshops through to volume turbo remanufacturing facilities. Three times winners of the prestigious UK Queen’s Award for Enterprise 2006, 2009 and 2014, Melett currently supplies CHRA and turbocharger repair parts to turbo reconditioners in over 100 countries Worldwide.

The comprehensive range allows turbo reconditioning, remanufacturing and repair of turbo models originally manufactured by Garrett, Holset (Cummins Turbo Technologies), Borg Warner (Schwitzer & 3K), MHI (Mitsubishi), Komatsu, Toyota, IHI & Hitachi.
Managing Risk in the Family Enterprise: It’s More than Financial

By Michael Fassler and Wendy Sage-Hayward

All businesses face risk - family businesses are no exception. Generally thought to adopt a more conservative approach toward managing their business operations, family businesses are often considered more risk averse than their nonfamily counterparts. According to the Harvard Business Review’s article “What You Can Learn from Family Business” they “forgo the excess returns available during good times in order to increase their odds of survival during bad times.”

When it comes to managing risk, it is important to ask: How does your family dimension impact your appetite for risk? How do you manage risk tolerance differences among family members? What process do you have in place to communicate decisions that may involve greater risk in order to build alignment and understanding within key stakeholders?

To help answer these questions, we will define the types of risk family enterprises face and explore how they can take an intentional approach to identify and manage risks to their businesses. We will then examine how to measure and monitor risks as they arise. Lastly, we will share how to strengthen the communication of this process within the family enterprise so that decisions around risk are better understood and rationalized or explained.

Types of Risk in Family Enterprise

Too often, the word “risk” evokes the feeling of danger, uncertainty and the probability of loss without recognizing the potential upside that is inherently present with good business decisions. For our discussions, we will adopt the Chinese symbol for risk that combines two components: danger and opportunity. This definition perfectly captures both the essence of risk and the problems with focusing purely on the reduction of risk.

There are many domains in which a loss or gain (opportunity) can arise within a family business context:

- **Financial risk**: The potential for gain or loss on a financial level measured in terms of revenue, return on investment, return on equity, shareholder value, profitability, debt level, capital expenditures and free cash flow. Financial risk is the most commonly understood meaning of the term within a business context.
- **Performance risk**: The potential for increased or decreased performance of the business. Decisions include operations, production, materials and human resources. An example of performance risk is purchasing a new machine to potentially reduce production time.
- **Reputational risk**: The potential for gain or loss to the standing or status of the family and business including its name, brand and products or services. Decisions include ethics, safety, security, quality, innovation and sustainability.
- **Relationship risk**:
  - Nonfamily: The potential for solidifying or weakening the rapport and trust with customers, employees, suppliers and other stakeholders. Decisions include contractual, financial, procedural, communication and safety. Reputational and relationship risk are closely associated with one another. There is greater relationship risk for family businesses, for example, when making decisions about layoffs due to the loyalty and closely held relationships many family businesses establish with their nonfamily employees.
  - Family: The potential for strengthening or abating trust and cohesion within the family. Family relationship risk is similar to relationship risk except it focuses on family relationships and the family legacy. These decisions are not merely financially oriented because they can affect the livelihoods and quality of life for parents, uncles, siblings, cousins and other family members.
- **Safety risk**: The potential for creating harm or increasing the protection of people as well as material goods or properties. Decisions include compliance, regulatory, training, operational and procedural.

Family Enterprise Decisions and Risk Appetite

A framework for having dialogue about risk is foundational to aligning stakeholders on risk and incorporating risk management into your family enterprise.

CONTINUED ON PAGE 30
Ford Brings 2016 F-650/F-750 In-House

With the introduction of the MY-2016 F-650/F-750, Ford is giving fleets a menu of options. But, more importantly, the MY 2016 F-650/F-750 will now be a 100% Ford truck, said Mark Lowrey, marketing manager for F-Series fleet trucks for Ford Motor Co. The new vehicle will be designed and manufactured completely by Ford, and all the components are 100% Ford. In the past, the vehicles were assembled in a joint venture with Navistar, using a Cummins engine and an Allison transmission. The new truck will be assembled at the Ohio Assembly Plant, which has been producing the E-Series vans, cutaways, and stripped chassis there for a number of years.

The F-650/F-750 has found a home in vocational fleets, such as construction and landscape industries, where it has a dominant presence, according to Mike Levine, truck communications manager for Ford. The truck models are also used for tree service, towing and recovery, and beverage fleets.

The F-650/F-750 are offered in Regular Cab, SuperCab, and Crew Cab styles, and in straight-frame, dock-height, and an all-new dedicated tractor model for heavy towing applications. The area behind the cab was redesigned to more easily accommodate custom work bodies, such as tow trucks, dump trucks, and ambulance bodies.

The new F-650/F-750 will be available with either a diesel or gasoline engine. The available 6.7L Power Stroke V-8 turbo diesel engine is paired with a commercial-grade 6-speed Ford TorqShift HD automatic transmission optimized for medium-duty vocations.

Three diesel power levels are available for the F-650/F-750: 270 hp/675 lb.-ft. of torque, 300 hp/700 lb.-ft. of torque, and 330 hp/725 lb.-ft. of torque. The diesel engine comes with a five-year/250,000-mile warranty.

The available 6.8L V-10 gasoline engine was introduced for the MY-2014 F-650, but it proved so successful that Ford has added it to its range of options for the MY-2016 F-750.

Ford will continue offering the F-650/F-750 with a gaseous prep package. Fleets that want to convert their F-650/F-750 models to operate on either propane autogas or CNG can do so through one of the automaker’s qualified vehicle modifiers (QVMs). A QVM will change the fuel tanks, lines, and injectors so the fleet can use an alt fuel. The MY-2016 F-650/F-750 will be available during the summer of 2015.
decisions. The framework starts with uncovering and articulating your family business’s “risk appetite.” Most likely, the risk appetite has evolved over the life of your family enterprise and always been a part of making decisions. Identifying your family enterprise’s risk appetite helps formally align stakeholders around risk and more deeply imbeds risk management in the company’s decision-making process. The risk appetite can be defined as the amount and type of family risk and business risk the family enterprise is willing to assume in order to achieve its strategic financial and nonfinancial objectives. What makes risk appetite statements unique for family enterprises is the influence of the family’s values and vision on how risk is viewed and managed. After considering family input, the management team and board can develop a risk appetite statement that outlines the boundaries.

As an example, one of our client families values close geographic proximity of family members and views growth outside of their geographic core as a risk to family cohesion. They also value individual freedom of choice and support individual growth. In their risk management framework, they established that business growth beyond their core geography is an option for consideration if a family member chooses to live in the more distant geographic area. In order to mitigate the risk to family cohesion, the business provides an annual travel budget for that family branch’s trips back home.

**Measuring Risk with Quantitative and Qualitative Criteria**

To make the risk appetite statement come alive and robustly incorporate it into strategic decision-making, quantitative and qualitative criteria are needed to measure risk. This information guides the board and management on resource allocation decisions on where to deploy talent and capital. It also enables both teams to make speedier decisions and to focus on managing risk within the established boundaries.

Quantitative criteria are measurements represented by numerical indicators that are objective and verifiable such as financial ratios or a customer satisfaction survey scores. As you think about developing quantitative criteria, consider using a threshold-target approach to their measurement. This provides a range for the criteria, with the target or better being the preferred achievement and the threshold being the minimum achievement. Once the threshold and target relationships are set, the strategic decision can be modeled.

Examples of quantitative criteria include:

- Percentage of total equity or dollar amount of equity capital committed to the decision
- Liquidity to maintain in the business
- Reinvestment rate into the business
- Reserve capital and talent remaining for other opportunities in the next 3 years? In the next 5 years?
- Solvency ratio
- Impact to earnings volatility
- Impact to credit rating

In contrast, qualitative criteria are subjective and difficult to verify. But what they lack in terms of certainty, they make up for in terms of context for the stakeholders’ perceptions of risk. They play a significant role in identifying constraints as to the viability of a particular strategic decision that may not be readily apparent from only quantitative measures. Examples of qualitative criteria include:

- How does engaging in this activity support achievement of our family vision?
- What will be the impact to the family’s reputation?
- What will be the impact to the company’s brand?
- How does it leverage our core competencies?
- Do we have leadership and management capacity available?

In order to manage risk, it has to be measured. This is where both qualitative and quantitative criteria come into play. The risk appetite statement sets the boundary and when combined with qualitative and quantitative criteria, the board and management team have the guidance to make decisions which align with the family enterprise’s risk preferences.

**Risk Management and Ongoing Communication within the Broader Family**

Managing risks in the family enterprise can be a tricky affair given the different personalities and many other nuances that may exist within this unique environment. Ongoing communication with all of the key stakeholders is critical to the success of the management’s ability to effectively manage risks. Some important tips for fostering alignment amongst family members around risk include:

- Develop a common base level of knowledge in all key stakeholders. Invest in training and development of family, owners and management. A strong foundational knowledge about the business and its industry will provide an educated basis for decision making.
- Ensure good data and information is available to all key stakeholders. Be transparent and open about information relating to the decision and its potential risks and opportunities. Provide timely management information
to help all involved paint a clearer picture of the potential upside and downside of the decision.

• Establish useful decision-making criteria. Understand the most important criteria upon which the decision will be based. In addition, perform an assessment using each of the types of risks defined in this article, as well as others you may face. This process will help highlight what is important to those who will be affected by the decision.

• Identify exceptions to nonalignment. Often there is consensus on many aspects of a decision or event and only a few areas of misalignment. Therefore, it is helpful to identify those areas where alignment exists and focus attention on those areas where greater agreement is required.

• Reframe nonalignment. Sometimes misalignment can become a source of tension and conflict from the feeling of “you don’t agree with me.” Name calling and other

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**Risk Management Conversation Starter**

By Michael Fassler and Wendy Sage-Hayward

This tool is a guide to start the risk management conversations with your family ownership group and executive team. In either a group planning session or through a survey, gather responses to these questions. Analyze the answers looking for the areas of alignment on responses and the areas where there are divergent viewpoints. Use the results to prompt further discussion to move toward a consensus viewpoint on your family enterprise risk appetite and to begin the development of your risk management framework. Not all questions will be relevant to your family enterprise. You may also need to develop additional questions for the risk management circumstances unique to your family and business.

These conversations around risk are further examined in The Family Business Advisor article: “Managing Risk in the Family Enterprise: It’s More than Financial” by Michael Fassler and Wendy Sage-Hayward.

<table>
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<tr>
<th>RISK DOMAIN</th>
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| Financial   | • What is the maximum amount of leverage we will employ as a family enterprise?  
• What percentage of our total equity are we willing to commit to any one investment or enterprise?  
• What is happening in our marketplace which will impact our reinvestment rate in order to remain competitive?  
• How does a continued investment in our legacy business represent our best investment alternative?  
• Under what scenarios would our dividend rate need to be reduced?  
| Performance | • What type of leadership and management capability do we need to manage the risk associated with our planned growth? What is our current capacity in this regard?  
• To what extent is our next generation leadership development program producing leaders that will assure our continuity as a family enterprise?  
• Are we willing to commit the capital and talent to manage the risk associated with this new investment?  
• If we accept this risk, what opportunities are we foregoing in the next 3 years? 5 years?  
• What checkpoints do we need to ensure we have sufficient family commitment in the long term, and to manage through a significant economic downturn?  
• What external market factors may impact our ability to generate return on equity consistent with the past?  
• How might our performance be affected if we make this strategic decision/investment?  
| Reputational | • Is this business venture consistent with our family enterprise values?  
• What stakeholders are we dependent on in this venture? How could they impact our reputation?  
• What cyber security risks do we face? What do we need to do to mitigate these risks?  
• Does our reputation exceed our capabilities to meet the expectations of the marketplace?  
• How are changes in cultural norms affecting our reputation in the marketplace?  
• Under what conditions would we exit from our legacy business? How would this impact our family’s reputation?  
| Relationship | NONFAMILY  
• To what extent is our business dependent on external stakeholder(s) in order to be able to create value and compete in the marketplace?  
• To what extent does our customer concentration expose our company to risk of a sudden downturn in revenue?  
• To what extent does our supplier concentration expose our company to risk of interruption of our ability to meet our commitments to customers?  
• Do we have sufficient outside influence within our governance system to ensure accountability for expected behaviors and results?  
• How are we building relationships and emotional ownership in our family to ensure continuity?  
• What family participation policies and protocols do we need to effectively manage the family’s interaction with the business vice versa?  
• How are we investing in development of the next generation ownership group?  
• How do we strengthen our capacity as a family to effectively communicate, resolve conflicts and make decisions together?  
| Safety      | • What safety risks do we have in our workplace?  
• How are we addressing these risks?  
• What safety training do we need in our workplace?  
• What resources do we require to monitor our safety program and improve it over time?  
• What recovery measures do we need to adequately handle a major disaster? (i.e., to sustain safe operations, meet customer commitments and recover operating costs)  

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CONTINUED ON PAGE 34
To find out how Melett precision engineered turbo parts can benefit you and your customers, visit the ReMaTec Theatre on Sunday 1st November at 2.30PM where Kenny Taylor, General Manager - Melett North America, will present ‘Trends in the Turbocharger Aftermarket’, or alternatively visit our team at Stand 334.

Melett is the market leader in quality replacement turbocharger parts and will be showcasing an extensive range of turbo components, repair kits and VSR balanced CHRA.

Melett - Quality Matters
negative behavior can arise at these times. Instead, try to frame the misalignment as an opportunity to better understand priorities and interests, as well as to build cohesion between those involved.

- Help the family pull back to macro-level thinking. Sometimes risk-related decisions and conversations can take families, management and owners into the weeds where they lose sight of their vision, goals and the bigger picture. Refocus the discussion by reviewing the higher level strategic direction and priorities.

Fostering alignment around risk starts with having an agreed upon process for making decisions on strategic matters in advance of a decision at hand. It continues with a good set of discussion questions and dialogue related to the family enterprise’s future in order to develop consensus on how to integrate decisions related to what the business needs, the overall family objectives, individual family branch needs and wants, and individual needs and wants. Some of these questions include:

- At what rate does the business need to reinvest profits to remain competitive in our markets?
- What is the risk to our family enterprise and our family if we don’t reinvest adequately?
- What is the risk to family cohesion if we don’t grow the business further to create additional leadership and employment opportunities for family members?
- What constraints do we have that impact our commitment of capital to the family enterprise?
- To what extent do we want our investment in our family enterprise to generate personal liquidity as compared to reinvesting in the business?
- Do we prefer one focused business or more of a diversified business?
- To what extent do individual family members identify themselves with the business?

When Sufficient Alignment Cannot Be Achieved

Sometimes a family cannot achieve sufficient alignment on strategic choices and their accompanying risk. In these cases you might:

- Reduce your family enterprise’s share of the risk by aligning with another group through a joint venture.
- Bring another family enterprise or other equity partner into the mix on the opportunity.
- Segment the opportunity and fund it with capital from those family members that do want to participate.
- Establish a class of capital with a more predictable and less risky return for those owners whose personal risk appetite has deviated from the group.
- At the extreme, consolidate the ownership group.

Insufficient alignment on strategic matters and related risk to capital can be managed structurally. Family relationships can be protected in the face of insufficient alignment by having structural choices which enables the business to execute its strategy. It is having choices itself which often causes family members to be more patient with their capital.

Where to Begin?

Starting the discussion in the board room or at an owners’ meeting helps ground the family and board in the business’ realities and garners the family’s input and commitment. Involving your management team in these discussions at the appropriate time is critical to effective decision-making execution within your risk management framework. The guidance provided will deepen their engagement and be appreciated.

These initial discussions will likely feel very intangible so it will be important to develop a level of comfort with the ambiguity. The family will need to push through this phase and work towards creating version 1.0 of its risk management framework and plan. They can then apply version 1.0 of its plan when making strategic decisions as they move forward-updating and evolving the framework to match upcoming and new realities as a key part of stewarding the family enterprise.

Michael L. Fassler

Mike Fassler has been serving family businesses since 1984. Mike provides family business planning services with a focus on helping his clients grow their relationships, capabilities and businesses.

Mike helps families develop and implement plans to transfer leadership, management, and ownership of their businesses to both family and non-family successors. Most of Mike’s work is focused on family businesses owned by sibling teams and cousin teams. A significant component of Mike’s work with clients includes strategic planning with an emphasis on helping clients balance the tension of family and business as their families and businesses grow. Mike works across industries and internationally.

Wendy Sage-Hayward

Wendy is a consultant at the Family Business Consulting Group. She has 25 years of experience working with business leaders, family firms, and boards. She serves a global and diverse set of clients across industry facilitating meaningful conversations with multi-generational families on matters relating to firm continuity, next generation preparation, governance and, when needed, conflict resolution.
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<table>
<thead>
<tr>
<th>Company</th>
<th>Page</th>
<th>URL</th>
<th>City</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alliant Power</td>
<td>8</td>
<td><a href="http://www.alliantpower.com">www.alliantpower.com</a></td>
<td>Windsor, Wis. US</td>
<td></td>
</tr>
<tr>
<td>CDTI / DuraFit</td>
<td>39</td>
<td><a href="http://www.durafit-exhaust.com">www.durafit-exhaust.com</a></td>
<td>Oxnard, CA. US</td>
<td></td>
</tr>
<tr>
<td>Cummins Turbo Technologies Aftermarket Division</td>
<td>19</td>
<td><a href="http://www.cummins.com">www.cummins.com</a></td>
<td>Memphis, Tenn. US</td>
<td></td>
</tr>
<tr>
<td>Dorman Products</td>
<td>2</td>
<td><a href="http://www.dormanproducts.com">www.dormanproducts.com</a></td>
<td>Colmar, Penn. US</td>
<td></td>
</tr>
<tr>
<td>E-ZOIL Products Inc.</td>
<td>21</td>
<td><a href="http://www.ezoil.com">www.ezoil.com</a></td>
<td>Tonawanda, N.Y. US</td>
<td></td>
</tr>
<tr>
<td>Flight Diesel</td>
<td>29</td>
<td><a href="http://www.fseg.net">www.fseg.net</a></td>
<td>Lewisberry, Pa. US</td>
<td></td>
</tr>
<tr>
<td>FPPF Chemical Company</td>
<td>6</td>
<td><a href="http://www.fppf.com">www.fppf.com</a></td>
<td>Buffalo, NY. US</td>
<td></td>
</tr>
<tr>
<td>Goldfarb &amp; Associates Inc.</td>
<td>27</td>
<td><a href="http://www.goldfarbinc.com">www.goldfarbinc.com</a></td>
<td>Rockville, Md. US</td>
<td></td>
</tr>
<tr>
<td>Kendiesel Inc.</td>
<td>17</td>
<td><a href="http://www.kendiesel.com">www.kendiesel.com</a></td>
<td>Edison, N.J. US</td>
<td></td>
</tr>
<tr>
<td>KTS TurboBillet X</td>
<td>31</td>
<td><a href="http://www.ktsturbobilletx.com">www.ktsturbobilletx.com</a></td>
<td>Batu Caves, Selangor Malaysia</td>
<td></td>
</tr>
<tr>
<td>Melett Ltd.</td>
<td>33</td>
<td><a href="http://www.melett.com">www.melett.com</a></td>
<td>Barnsley, South Yorkshire, UK</td>
<td></td>
</tr>
<tr>
<td>Midwest Fuel Injection Service Corporation</td>
<td>33</td>
<td><a href="http://www.midwestfuelinjection.com">www.midwestfuelinjection.com</a></td>
<td>Bolingbrook, Ill. US</td>
<td></td>
</tr>
<tr>
<td>Modal Software – Actionrev</td>
<td>35</td>
<td><a href="http://www.modalsoftware.com">www.modalsoftware.com</a></td>
<td>Visalia, Calif. US</td>
<td></td>
</tr>
<tr>
<td>R.A.S.E.D.</td>
<td>10</td>
<td><a href="http://www.spacodiesel.com">www.spacodiesel.com</a></td>
<td>Milano, Italy</td>
<td></td>
</tr>
<tr>
<td>Robert Bosch LLC</td>
<td>Back Cover</td>
<td><a href="http://www.boscheservice.com">www.boscheservice.com</a></td>
<td>Broadview, Ill. US</td>
<td></td>
</tr>
<tr>
<td>U.S. Diesel Inc.</td>
<td>31</td>
<td><a href="http://www.usdiesel.com">www.usdiesel.com</a></td>
<td>Fort Worth, Texas US</td>
<td></td>
</tr>
<tr>
<td>Zeki Turbo</td>
<td>37</td>
<td><a href="http://www.zekiturbo.com">www.zekiturbo.com</a></td>
<td>Miami, Fla. US</td>
<td></td>
</tr>
</tbody>
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### Vision
We, the membership of The Association of Diesel Specialists, see ourselves as the leading international organization of professionals that provides sales and expert service for yesterday’s, today’s and tomorrow’s diesel systems.

Our goal is to be the complete resource for training, technical service information, member promotion and networking opportunities. Our Association encourages participation at all levels of membership and is operated with the highest level of fiscal integrity. We embrace the economical, durable and clean diesel engine as one of the key elements for addressing global pollution and fossil fuel depletion.

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### Mission
The Association of Diesel Specialists’s mission is to provide programs and services to its members that will assist them in achieving success in the operation of their businesses in the diesel industry throughout the world.

### Green Statement
The Association of Diesel Specialists (ADS) believes in the future of clean diesel as part of an environmental solution to global greenhouse gas issues. ADS believes in the future of the inherently more efficient clean diesel power plant as a method of reducing our dependence on fossil fuels. ADS applauds the work of engine manufacturers in their efforts to continuously reduce emissions in diesel engines to near infinitesimal levels. ADS believes that the use of clean diesel will improve the sustainability of consumers, businesses and communities by reducing the environmental and societal cost of their activities.

ADS does not condone the use of devices made to intentionally contravene emission controls for use in equipment or vehicles used on a regular basis. ADS believes that intentionally bypassing or altering emission controls in the name of performance enhancement undermines individual and group efforts to promote the use of clean diesel as a viable alternative power plant for the future.
For product line, application and more, please contact us at sales@zekiturbo.com
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Swap & Shop is available to assist members seeking to buy, sell or trade equipment. Swap & Shop ads run in Nozzle Chatter and on the ADS website under the PARTS section.

TO LIST
Complete the ad listing form, located online under the PARTS section of the ADS website or by contacting ADS Headquarters at nozzlechatter@diesel.org. “Help wanted” or “situation wanted” ads will not be accepted. ADS Swap & Shop ads do not constitute an endorsement by the Association. Ads must be sent electronically to nozzlechatter@diesel.org.

FEES
Contact ADS Headquarters for listing fees and details. “Subject to specific terms listed online.

SILENT AUCTION: We are offering a Corona Diesel brand, Common Rail pump tester to the highest bidder. It includes meter regulator, LCD version model 555-41-2 and the necessary harnesses. For more information and pictures contact ara@dpausa.com.

FOR SALE: Hartridge IFT 70 injector test bench with extras. Purchased new 1/2/2011 and in perfect condition. Contact will@blueridgediesel.com or call 540-389-7296 for best price.

FOR SALE: Small fuel injection & electrical shop in growing area upper midwest. Established mid 70’s. Needs expansion to drive-in service. Owner: Retirement ready. E-mail for details: fuelshop4sale@yahoo.com

FOR SALE: 815 Bosch testing bench with VP44 kit, very low usage. Power 220V, 60Hz, 3Ph. Price: referential: $135,000.00 USD. email: info@lacasadelatobera.com. Phone: xx 5934 2410561. We speak Spanish.

Hartridge IFT-70 Common Rail Injector Test Stand. Test stand includes capability to test dual spring injectors and has an ultrasonic tank for cleaning. The adapters for Duramax, Cummins, Denso and Ford common rail injectors are also included. Price is $9,500. Contact is JT Pitcher j.pitcher@dwdiesel.com

FOR SALE: HI 2000 7.3 Injector Test Bench E-mail Tom Hoeber at Thoeber@dieselinjection.com Telephone: 361-289-6666 $10,995.00

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FOR SALE: HEVI test bench H12000 in perfect condition - $32,000 USD. Contact Harold Vejarano at info@puntodieselltda.com or (057) 315 391 3954.

FOR SALE: Complete Diesel fuel shop, test stands (Hartridge AVM 20-8, 1100MK2, & HA2500), hardware, tools, bench’s, modular office, inventory, cores, great start up business. Call for details. Price: $69,000. Contact: Steve McGovern 908 964 0700 x 206, smcgovern@mackboring.com


FOR SALE: Good running condition Hartridge test bench 2500, 10 Hp is available for sale. Contact RAJ at 800-320-8166 or raj@hfhuel.com

FOR SALE: Rabotti Tec200 Evolution HD Test Bench for common rail. Used very little. Complete set of tools to work on common rail injectors, tools never used. Call 308-520-0620 to discuss pricing.

FOR SALE: Used Mustang MD 250 Chassis dynamometer Peak Power measurement 900hp at maximum speed. Peak Speed 150 mph. Complete listing of features available. Call 308.520.0620 to discuss pricing.

FOR SALE: Hartridge AVM2PC with transformer 7 years old. $80,000.00 Hartridge AVM 1 20HP new in 1996 $20,000.00 Hartridge 123 Cummins pump stand $85000.00 Hartridge HA2500 10HP pump stand $13,000.00 All in working condition, reasonable offers will be considered. Please call Jim Smith 813-623-1551 ext109.

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FOR SALE: Bosch 707 Test Bench excellent transmission maintenance records universal bracket $7995.00 Contact Ty phone number (210) 648-4500

FOR SALE: Maxwell Chassis Dyno for HP testing, Water Brake at 650HP, Accelerometer 1250HP. Good condition. Contact Rick Corder Diesel Controls Inc Massillon OH, RickC50@Gmail.com for details.

FOR SALE: USDiesel offers the following NEW & USED equipment for SALE. Also available used Hartridge HA2500/15, HA400, HA285 comparator, HA123 PT pump Tester. Bacharach A2000 20hp, Bacharach SpecialAir 10, Bacharach Test oil chiller & Heins turbo balancer TC2 & many more machines for sale. New Makttest TK1026 common rail injector tester, TK1025 common rail pump tester, TK1024 HEUI Injector tester, TK1020 EUI cam box & UTS1004 EUI tester stand-a-long, KO4000 computer aided CR injector rebuild center, & PT2012CRE Makttest common rail pump test stand. We also stock most common tools and adapters new & used. Please go to www.usdiesel.com to view our complete list of test equipment. Contact us at 800-328-0037; 817-485-6424, Fax 817-485-6404 or Mark Hagood: markh@usdiesel.com / Brad Glenn: bradg@usdiesel.com Please note our (new address) 4554 CENTER POINT DRIVE FORT WORTH TEXAS 76180.
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