Introduction

In order to comply with ARB’s retrofit regulatory requirements and in an effort to minimize field service issues Ironman has implemented a thorough engine inspection process and record keeping practice to help support and document service and engine issues. This engine inspection process is performed on each vehicle up for retrofit consideration. The PIC process assesses engine condition and determines vehicle maintenance practices by using a combination of customer and Ironman gathered data helping create a engine baseline performance for recording prior to retrofit installation.

This process has helped substantial reduce VDEC infant mortality substrate issues. Having the baseline data helps understand if an engine condition issue is present down the road, how it compares to that of the baseline data, clearly pointing out engine related issues. By obtaining this baseline data, Ironman is able to have a data driven discussion with each fleet about what maintenance practices are required and what engine details we have found that needs resolve. In almost every case we not only that they have an engine issue but exactly what that engine issue is as the recommended repairs.

The Ironman PIC has proved so helpful in identifying engine issues that Ironman started performing full engine inspections each time we visit a customer’s vehicle, regardless of the reason, in which we can compare to the baseline data retrieved prior to installation to identify any upward trends of engine condition symptoms and alert the customer. Ironman intention is to help educate customers and highlight any trends discovered in a proactive approach, rather than waiting until a filter is destroyed or the vehicle is not operating properly which causes lost revenue when the vehicle is taken out of service.

Ironman realize implementing our full Engine PIC procedure may be the ideal preventative maintenance situation – above and beyond regulations. Ironman also recognize there are non-negotiable checks that must be implemented in PIC’s across the board. Ironman will describe what we propose to be the “Recommended Minimum PIC” and what the “Ideal Situation” to look like and why each test matters.
Ironman Observations

Current Situation:
Based on 2013 calendar year data reviewed, Ironman experiences a 38% PIC failure rate today on 1661 inspections (we have several tears of data but will use this for this explanation. Ironman helps direct and support fleets through making the necessary repairs to correct the engine condition symptoms discovered to ensure a PIC pass status at install.

<table>
<thead>
<tr>
<th>Prior to Retrofit Installation</th>
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<tbody>
<tr>
<td>Determination</td>
</tr>
<tr>
<td>Maintenance</td>
</tr>
<tr>
<td>Pass</td>
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While Ironman has lots of data showing the benefits of fleets conducting routine preventative maintenance, we would need client approval to share any specific client data. Ironman recommend that CARB fund a program that shows scientifically the real savings of a truck that operates say at 40% versus one at say 20% and one at 5% - proving fuel savings always requires a controlled independent study.

Ironman current Observations:

- Customers do not understand how a DPF works or what it does and does not do. While we train and provide online training – most clients do not invest the time in training.
- Customers have issues understanding the importance of oil and coolant consumption. If the oil and coolant are making their way into the exhaust it will be cause high backpressure and deteriorate the filter.
- Customers are not responsive to the monitoring lights, and only act when notable issues are present - usually power loss.
- Customers think they can idle for hours as long as they do a long highway run, however the initial backpressure spike before the filter begins to regenerate usually does cause the DPF light to be triggered.
- While a DPF does require higher temperatures to operate, there is such a thing as temperatures too high, caused from an fuel injection of other engine upset conditions.
- Key engine components (Injectors, Turbos, EGR’s, Injector Harnesses etc.) operating just below spec can greatly contribute to soot production of an engine.
- An inactive code that occurred a few operational hours ago with a high count should be treated just as seriously as an active code.
- Opacity tests are great for determining high PM output, but they do not detect white or blue smoke very well. If opacity is in an acceptable range but visual smoke is present, an engine issue is present.
Substrate cleanings need to follow manufacture guidelines regardless of ‘how clean the engine is running.’

The Ironman experience is that it requires a certain amount of annual nagging to get the annual inspection and deash process to happen for most of our fleets.

EGR systems need service – and cleaning.

**CA Fleet Frustrations:**

The following broadly implemented practices may interfere with identifying engine issues and result in addition frustration and monetary loss to the end user:

- Fleet owners not aware of ECU software updates and service companies are in the dark.
- Emission system now installed masks high opacity and wasted fuel issues.
- Industry lack of education and training on completing and reading engine downloads.
- Industry lack of active and inactive codes. This requires much more education, standardization and less secrecy.
- Lack of engine software and training on how to use the software to deal with active and inactive codes.
- Lack of qualified industry standards for diesel mechanics and heavy duty mechanics in general is compounded by more complex diesel engine technology.

**Recommended Minimum PIC**

Ironman recommend all truck owners perform a full engine inspection every year to ensure and preserve the integrity of their emission system and to manage costs. Cost effective preventative maintenance actions to prevent or identify emission component failure can be a long list but Ironman feel the non-negotiable checks are as follows:

1. Confirm no check engine light is present on the vehicle dashboard-
2. Inspect for fuel leaks that add to the VOC load
3. Opacity Testing - Opacity done initially without the filters installed. Ironman strongly urge CARB to revise the current California trucking opacity standards. While installers and VDEC applicants treat an acceptable opacity standard for retrofit to be 15- 20% the California standard can no longer be 40%. The opacity standards need to be the same to eliminate general industry confusion. Further annual CA opacity testing must be performed pre-filter and not post-filter to get an accurate assessment of engine condition. Based on Ironman’s data, during the 2013
calendar year, Ironman found approximately 23.3% engines testing 15% and higher for opacity. CA opacity “standard” should be no more than based on engine and at the high end 15-20%.

4. Post filter Opacity – this is done to ensure the filter integrity with a max standard again could be related to the engine cert – but one would image 3-5% max opacity. Anything more indicates a compromised emission substrate.

**Ideal Pre-Assessment**

In addition to the minimum PIC items described, Ironman believe the ideal situation includes the following additional tests:

**Opacity** – All trucks should do annual opacity – pre filter and post filter. Pre filter will help gauge engine condition while post filter opacity readings help gauge filter damage. An opacity test is performed with the engine at operating temperature. VDEC manufactures require opacity to be below 15% for EGR engine and below 20% for Non-EGR engines. Common causes for high opacity are injectors, turbo chargers, and EGR systems not working to manufacture's specification.

**Fuel Inspection** - Ironman and VDEC Manufactures require fuel be free of any contaminants before and after and VDEC is installed. Common causes for contaminated fuel are failed fuel injector seals and contaminated fuel being used. Ironman have learned based on 2013 data, approximately 7% of vehicles inspected failed the fuel inspection.
Oil Inspection - Ironman and VDEC Manufactures require oil be free of any contaminants before and after and VDEC is installed. Contaminated oil can occur under many circumstances and will require a trained technician to determine the root cause. Ironman have learned based on 2013 data, approximately 3% of vehicles inspected failed the oil inspection.

Charge Air Cooler Inspection: Charge air cooler is inspected for signs of any contaminants being present and helps determine if there is a failing turbo. Charge air coolers covered in black soot tells us there is oil coming from the turbo and a strong indication the seals on the turbo are wearing out. When a CAC is covered in orange gunk, this usually is an indication coolant is present, generally when the charge air cooler itself is cracked allowing coolant to get into the cylinders and would in turn cause high EGT temperatures. Presence of dirt is usually caused by an overwhelmed air filter. Ironman have learned based on 2013 data, approximately 10% of vehicles inspected failed the charge air cooler inspection and were contaminated with either oil or coolant. If ARB does not require CAC inspections as part of the PIC, 105 of the engine condition issues would not be identified at PIC.
On-Board Diagnostics - Engine onboard diagnostics is available as a tool to help fleets identify and take corrective action on engine issues. Ironman has been surprised that a number as high as greater than 90% of fleets do not train themselves to do regular engine downloads and repair “active” codes. Ironman and VDEC Manufactures require all active emission related faults codes be diagnosed and repairs completed before installing a VDEC. Once a VDEC is installed all emission related fault codes will require prompt action. CARB should encourage engine manufacturers to share engine software – on pre 2007 – and allow Engine Control unit OBD to switch on “check engine light” for meaningful active OBD codes.

More importantly we need a centralized web site at ARB that shows the latest ECU software version available from the OE dealers. This is important for all fleets.

Based on Ironman’s data, during the 2013 calendar year, we found approximately 20% of vehicles sampled had active fault codes present. There was a 20% increase as the percentage rose to over 30% when sampling the vehicle another year later after installation, at the annual Durathon appointment.

<table>
<thead>
<tr>
<th>ECU Fault Codes</th>
<th>Prior to Retrofit Installation</th>
<th>Post Installation - Annual Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Codes Present</td>
<td>16.76%</td>
<td>36.70%</td>
</tr>
<tr>
<td>No Faults/Inactive Faults Present</td>
<td>83.2%</td>
<td>63.3%</td>
</tr>
</tbody>
</table>

History Failure & Replacement Records - Ironman do not believe reviewing historical maintenance records is an appropriate indicator of maintenance practices today. If there is a history of failures that were addressed, these are good candidates for retrofits as it shows maintenance responsibility. A fleet who has not replaced components is more leery than a fleet who has found these issues, and addressed them. Most fleets do not excel in maintenance records – most time the invoices are not crystal clear on what work was really done and it has not proved to be as useful as what one may envisage.

Annual Substrate Cleaning - DPF filter substrate must be professionally cleaned at least annually to remove the ash that builds up over time inside the filter. DPF filter captures the soot and materials coming from the engine, and can mask engine problems that were previously detectable by observing the black smoke coming out of the tailpipe. DPF systems have various annual inspection and annual maintenance requirements mandated by the original manufacturer. The process includes inspection the indicator lights and DPF components, upgrading the diagnostics program if necessary, etc. This inspection must be performed by an authorized DPF dealer.

Durathon PIC - Annual Engine PIC should be a requirement at time of annual Durathon Service. In order to protect your emission investment and to maintain reliable engine and emission performance, the
internal filter substrate of your DPF must be cleared on a regular basis, but your engine must also be properly inspected and running at optimal performance. Since Ironman have implemented the Durathon engine PIC process, we have been able to collect valuable data that helps paint a picture of a new problem; engine condition issue symptoms are not readily discovered by operators as the previous obvious visual indicators are now masked by the DPF. Prior to retrofit, an engine smoking with 20+ opacity, would have a puff of black smoke exit the tail pipe each time the driver stepped on the gas, alerting the operator and the mechanics that an engine condition issue is present. Today, the DPF takes all that black smoke and masks that engine issue is present. For this reason, Ironman recommends performing a thorough maintenance and inspection process on an annual basis and goes above and beyond your typical substrate cleaning, offering extra inspection services and preventative maintenance that helps with early detection of engine malfunction and faults.

<table>
<thead>
<tr>
<th>Determination</th>
<th>Units</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>187</td>
<td>49.7%</td>
</tr>
<tr>
<td>Pass</td>
<td>189</td>
<td>50.3%</td>
</tr>
</tbody>
</table>

**Post Installation - Annual Cleaning**

**Engine Inspection at Durathon**
Prior to Retrofit vs Post Installation PIC Comparison:

<table>
<thead>
<tr>
<th>Component</th>
<th>Prior to Retrofit</th>
<th>Post Installation - Annual Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opacity 0-15%</td>
<td>76.7%</td>
<td>81.1%</td>
</tr>
<tr>
<td>Opacity 15.1-20%</td>
<td>12.3%</td>
<td>5.32%</td>
</tr>
<tr>
<td>Opacity 20.1+%</td>
<td>11.1%</td>
<td>5.85%</td>
</tr>
<tr>
<td>ECU Fault Codes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Codes Present</td>
<td>16.76%</td>
<td>36.76%</td>
</tr>
<tr>
<td>No Faults/Inactive Faults Present</td>
<td>83.2%</td>
<td>63.3%</td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contaminated Fuel</td>
<td>6.32%</td>
<td>16.76%</td>
</tr>
<tr>
<td>Clean Fuel</td>
<td>93.2%</td>
<td>83.2%</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contaminated Oil</td>
<td>2.39%</td>
<td>29.26%</td>
</tr>
<tr>
<td>Clean Oil</td>
<td>97.6%</td>
<td>70.7%</td>
</tr>
<tr>
<td>Charge Air Cooler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contaminated</td>
<td>9.93%</td>
<td>8.24%</td>
</tr>
<tr>
<td>Pass</td>
<td>90.1%</td>
<td>91.8%</td>
</tr>
</tbody>
</table>

**Damaged Filters:** Ironman have learned engine issues are the leading cause of filter substrate damage, which include but not limited to; Catastrophic engine failure incident (turbo/cylinder), Prolonged neglect.
of engine issues, and failure to service, clean or regenerate systems (could have been avoided by proper DPF maintenance). Poor maintenance practices are extended to the emission devices – this does not stop end user frustration and the instances of substrate damage. End users must understand they need to perform regular engine assessments throughout the life of the VDEC to ensure the maintenance is managed and potential VDEC issues are minimized. Just like other industries, some fleets do preventative maintenance and some breakdown maintenance. “There are no problem retrofit devices, rather problem engine maintenance practices”.

**Benefits to Clients** - creating a full engine PIC check at time of annual cleaning will provide the following:

- Equipment will be in compliance with CARB Regulations
- Experience the least possible equipment downtime
- Manufacturer VDEC warranty will remain valid
- No wasted fuel expenses
- No engine or ARB/ CHP-related fines
- Maintain detailed engine and maintenance records
- No damaged substrates

**Record Keeping**

In addition to the engine assessment checks, Ironman find the proof and documentation critical, in how results and data are recorded and maintained. *Ticks in boxes is not record keeping* – and does not help resolve service or warranty issues down the road. Ironman have developed the Ironman IQ database. We believe this to be unique in the CA industry and not all installers have this level of detail. Ironman is able to provide CARB with more specific engine performance in detail if required.

Ironman have developed internal software so technicians can easily send data, files and photos using a variety of drop downs and one click options, ensuring the right data is received, each and every appointment. Automating the process allows Ironman to retrieve the data in the field instantaneously, automatically storing the data to the applicable truck record in our database. Smart Programming checks the fields and flags issues that need review or repair. All records are stored in one central location for reporting, storage and access purposes. If repair items are noted, once the documentation is received showing repair, the additional repairs orders are added to the record moving the vehicle from maintenance status to a pass status, ready for retrofit or the vehicle is back into the fleet for operations.
**Digital Drop Box:**
Ironman's in-house software developed to assist easy of gathering data and the transmission of data from the field into our IQ database. No more manual transferring of data. SMART functionality checks data against Ironman PIC standards, and flags when data does not meet the required standards.
Clear Pass/Fail Result Guides: Ironman have established training materials and guides for all field resources, so that Ironman’s pass and fail analysis is consistent and not easily open to interpretation. Ironman highly encourage PASS/Fail reference material established and used by all VDEC installers.

Pre-Installation Compatibility Inspection: Oil Analysis

Oil Analysis

Pass

Pass

Recommend Change

Fail

Contaminated
Conclusion

Ironman Recommendations of PIC & Annual Maintenance PIC:

In the last 2 years the introduction of the engine PIC process to determine if the engine is retrofit worthy has resolved most of the issues the California retrofit industry was experiencing. There is absolutely no question that the engine deterioration and poor engine maintenance practices were initially not well understood by most applicants. What has further been most helpful is that by failing pre-assessment and making end users repair their dirty engines prior to retrofit to be retrofit worthy – the fleets are being educated that it is really the poorly maintained engines that are the issue. Quite simply at this stage – “there are no problem retrofit devices, rather problem engine maintenance practices”. What is even more helpful is by having the engine baseline performance detail – when there is a red light or service light, Ironman continue to capture the engine downloads and VDEC download – thus enabling us to quickly determine which is at issue – this was not possible a couple of years back. Ironman is convinced that no one at CARB could possibly have expected the poor engine maintenance practices and the excessive deterioration of the engine emissions. The CARB retrofit program is actually having the additional benefit to resolving these poor engine maintenance practices and retrofits are doing the job expected on well-maintained engines and well-maintained emission devices. While the Ironman recommendations continue to focus on how applicants and installers can improve even further – eventually we are totally dependent on end user fleets support, be it in attending training and taking engine and VDEC maintenance more seriously.

ARB have to provide some teeth to the requirements of annual VDEC maintenance, as today the vast majority are not performing any maintenance at all. Currently there are at least 100,000 retrofits in CA of which, 50% are not performing as expected due to the issues highlighted. These are easy fixes to ensure engine maintenance, annual system maintenance and decent record keeping are maintained, OR prepare for the uniformed to start complaining that retrofits do not have a long enough life span, etc.

Poor engine and VDEC maintenance will eventually have a serious impact to the current California Emission Inventory assumptions. Recommended actions for ARB to take:

- Annual Opacity – both pre filter (standard 15-20% suggest a Opacity level related to engine cert levels like cargo handling) and post filter (Standard 3-5%)
- VDEC should be in ready to filter condition at least one time a year. VDEC lights should be all green during the inspection. Record of annual inspection.
- What documentation should be kept in fleet files? Fleet should be required to show annual service and opacity results. It could be added to BIT inspection or just make it available on request of CARB inspector.
- The ultimate would be an “ARB Clean Truck Sticker” system. Ports did it so the precedent has been set. Maybe CARB can offer to fleets that show excellence in meeting all opacity etc. –or even better than Max ARB opacity levels –and for fleets that show some voluntary NOx reduction etc. –
- This would lead to a great deal of improvement in the overall DPF fleet maintenance and lower failure rates. Lower overall fuel consumption etc.
- We recommend that CARB fund a study to support the conclusions and can be used by industry – to show the financial investments in preventative maintenance – are all returned in lower fleet downtime – fuel savings and parts and labor. This needs to be an independent study – which most fleets cannot challenge as not based on fact or biased.
Ultimately CARB should bring registration into the process. No Opacity pass pre and post filter = no license for the vehicle.

Future Considerations:

- Many states have gone down the “right to repair” act and California should at least make it clear what the position is.
- We need a web site where all engine ECU software can be researched to ensure the owner has the latest and best version of the ECU software – Ironman have seen updates that cured major soot emissions – no easy way for second and third truck owner to be aware of the latest ECU version. (It is fine if the OE dealer is the only authorized person to do upgrade) – but the rest of the universe should be able to determine that there is an upgrade available.