X-1R Global Ltd

To:	All X-1R distributors	**From:**	Nigel (Mac) McKenzie
Cc:		**Date**	3rd May 2021

Subject: Five in One – Detergency Technology

I have been asked a number of questions regarding the detergency capacity of our new Five in One Petrol and Diesel products, so I have taken the time to prepare a slightly more in depth explanation of the products.

For both the Diesel and Petrol products the detergency package is very similar and performs I the same way and we can make the following claims;

1. Cleans Dirty Fuel Injectors
2. Keeps injectors clean
3. Meets BMW unlimited approval requirement for IVD detergency
4. Cleans existing Intake Valve Deposits
5. Effective cleaning of dirty carburetors
6. Reduces Co and HC emissions
7. Improves fuel economy
8. Prevents fuel system corrosion
9. EPA registered and proven to be catalytic converter and oxygen sensor friendly

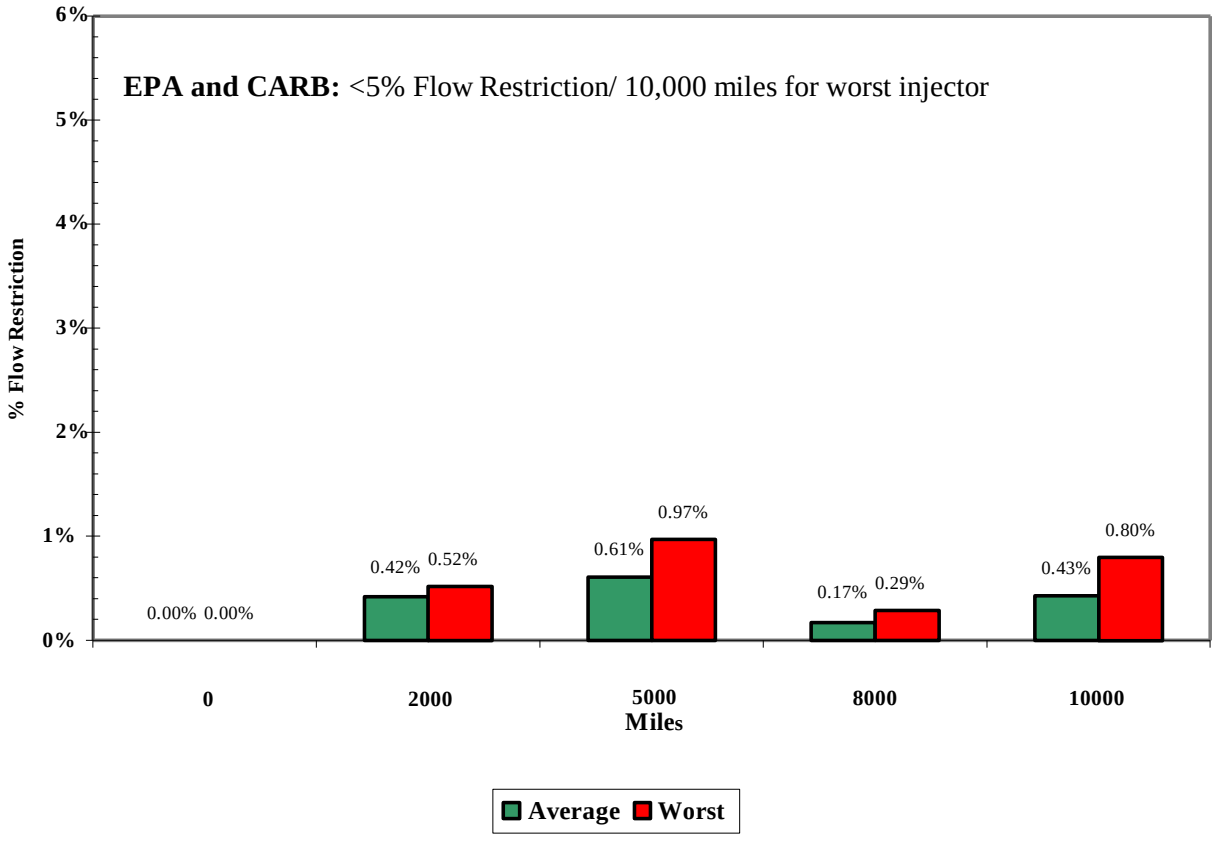
So in short the detergency package within the new formulation Petrol and Diesel Treatments is a very effective de-carbonizer and throttle body cleaner that will reduce emissions and improve fuel economy, the following details some of the proof we have for this:

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

PFI KEEP CLEAN

The fuel injectors, like the intake valves are a critical part of the fuel delivery system. Deposits can affect spray pattern and as a consequence, emissions, economics and drivability. The ASTM D5598 test procedure consists of a standard 15-minute drive cycle followed by a 45-minute hot soak. This cycle is carried out over a total distance of 10,000 miles.

EPA 65th Percentile Fuel + EtOH		
Parameter	**Actual**	**Requirements**
Olefins, % v/v	12.8	≥11.4
Aromatics, % v/v	348	≥31.1
Sulfur, ppm, w/w	431	≥340
T90, °F	348.4	≥339
Oxygenate, (EtOH), % v/v	10	≥10



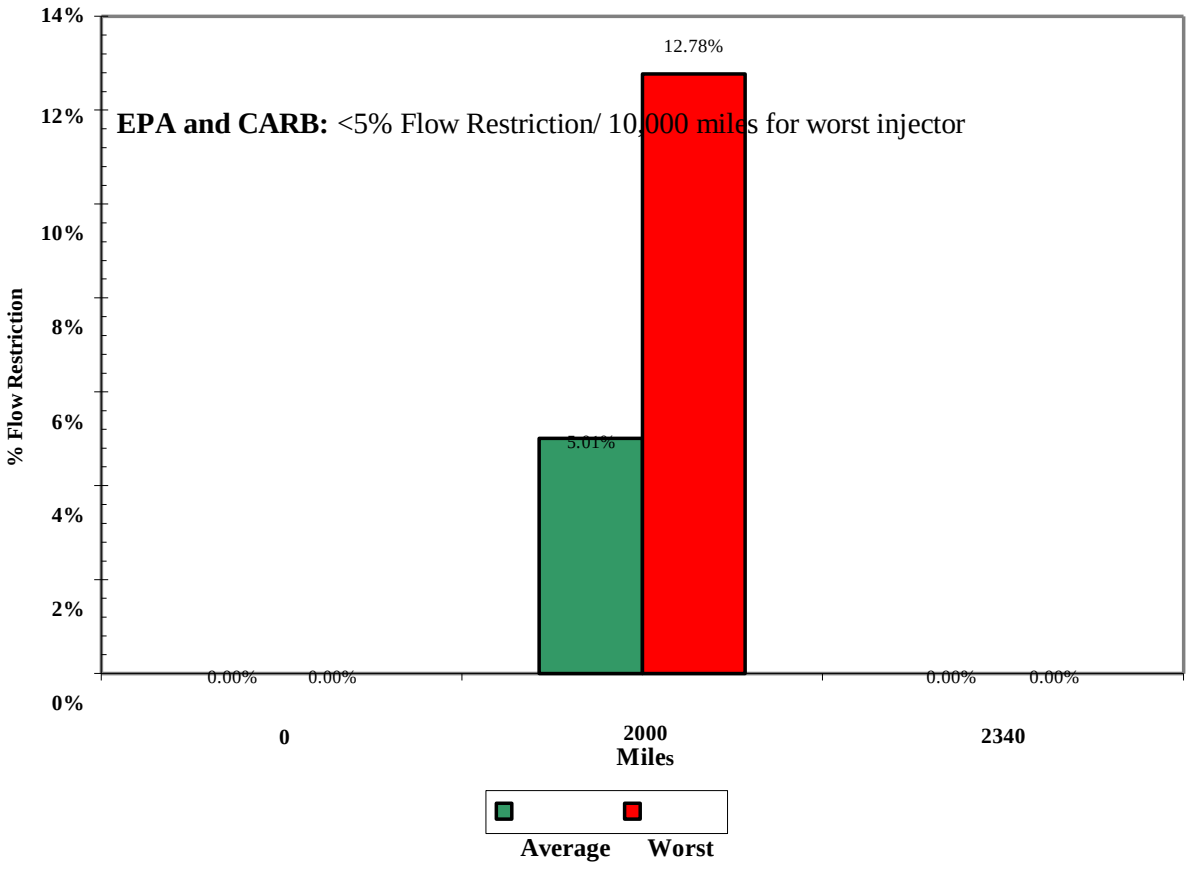
- TREAT RATE FOR X1R WAS 85 PPMV

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

PFI DETERGENCY CLEAN UP

The clean up performance of X-1R at a concentration of 85 ppmv has been evaluated using a modified CARB D5598 test method. The testing comprises a deposit build up cycle of 2,000 miles followed by a 340 mile clean up. The fuel was treated with X-1R for the second cycle.

Clean up Fuel	
Parameter	**Actual**
Olefins, % v/v	7.3
Aromatics, % v/v	33.8
Sulfur, ppm, w/w	212
T90, °F	353.5
Oxygenate, (EtOH), % v/v	10



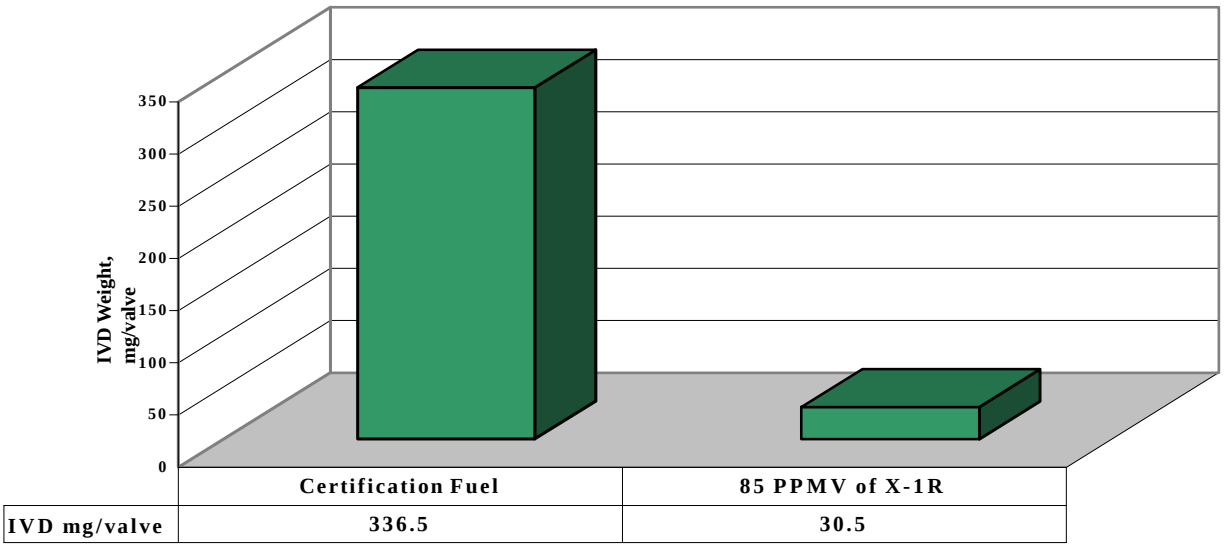
- At A TREAT RATE OF 85 PPMV X-1R EXHIBITS EXCELLENT CLEANUP PERFORMANCE WITH RESPECT TO PFI DETERGENCY

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

IVD CONTROL – BMW 318i KEEP CLEAN

Testing has been performed using the industry standard ASTM D5500 test procedure, which is commonly used for the evaluation of intake valve deposit formation. This method uses a 1985 BMW 318i, driven in a driving pattern comprising 10% city, 20% urban and 70% highway driving for 10,000 miles.

EPA 65th Percentile Fuel + EtOH		
Parameter	**Actual**	**Requirement**
Base Fuel Olefins, % v/v	18.3	≥11.4
Base Fuel Aromatics, % v/v	44.4	≥31.1
Base Fuel Sulfur, ppm, w/w	407	≥340
Base Fuel T90, °F	356.5	≥339
Base Fuel IVD, mg/valve	336.5	≥290
Oxygenate, (EtOH), % v/v	10	≥10



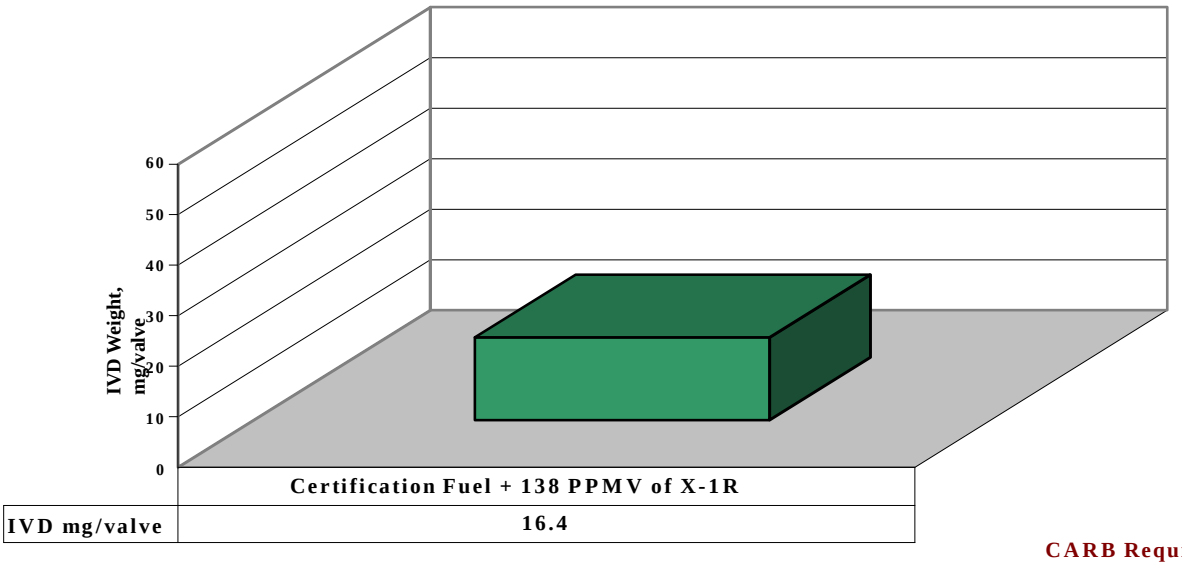
- X-1R EXHIBITS GOOD INTAKE VALVE DETERGENCY AND MEETS EPA COMPLIANCE PERFORMANCE CRITERIA.

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

IVD CONTROL – BMW 318i KEEP CLEAN: CARB DCA CERTIFICATION FUEL

Testing has been performed in the industry standard ASTM D5500 test procedure, which is commonly used for the evaluation of intake valve deposit formation. This method uses a 1985 BMW 318i, driven in a driving pattern comprising 10% city, 20% urban and 70% highway driving for 10,000 miles. Test fuel used met the CARB DCA Certification Fuel requirement and is described below.

CaRFG3 Certification Fuel		
Parameter	**Actual**	**Requirement**
Base Fuel Olefins, % v/v	9.3	≥8.0
Base Fuel Aromatics, % v/v	29.5	≥24.0
Base Fuel Sulfur, ppm, w/w	98	≥64
Base Fuel T90, °F	326.6	≥290
Oxygenate, (EtOH), % v/v	10	≥8



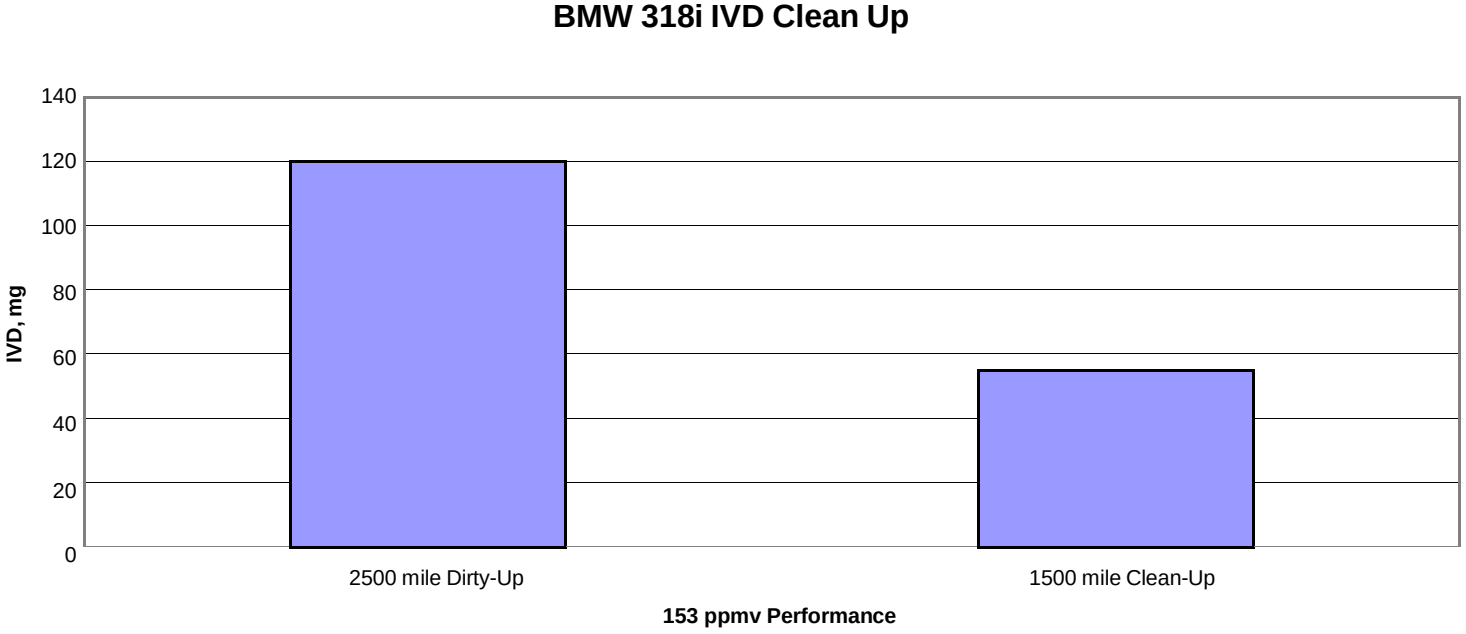
- X-1R EXHIBITS GOOD IVD DETERGENCY AND MEETS CARB PHASE 3 GASOLINE DEPOSIT CONTROL ADDITIVE IVD REGULATIONS AT 138 PPMV.

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

IVD DETERGENCY CLEAN UP

The clean up performance of X-1R at a concentration of 153 ppmv has been evaluated using a modified ASTM D5500 test method. The testing comprises a deposit build up cycle of 2,500 miles followed by a 1,500 mile clean up. The fuel was treated with X-1R for the second cycle.

Test Fuel Parameters Clean Up	
Aromatics, vol%	33.8
Olefins, vol%	7.3
Saturates, vol%	59.0
Oxygenate, wt%	0.0
Sulfur, ppm wt.	212
T90, ºF	353.5



AT 153 PPM X1R5 OFFERS THE FOLLOWING BENEFITS:

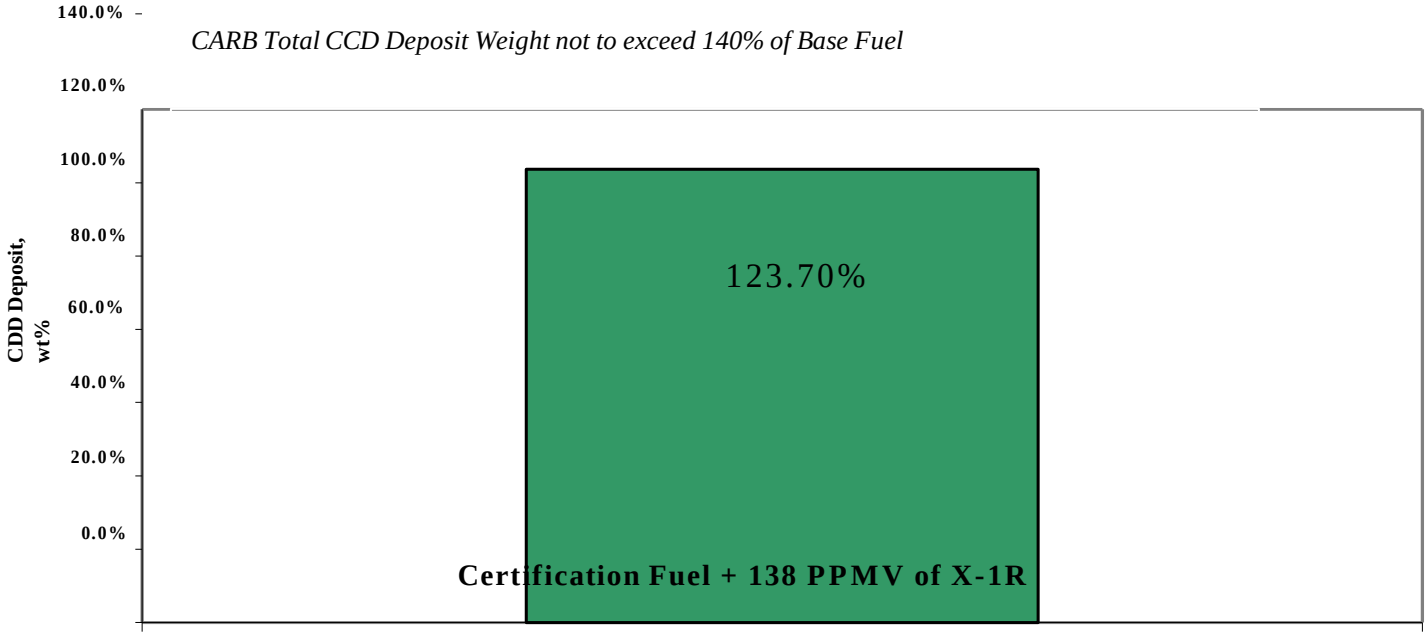
- Intake Valve Deposit clean up
- Improved fuel economy
- Reduced exhaust emissions
- Reduced fuel system maintenance and emissions control equipment
- Prevents drivability deterioration (rough idling, stalling and surging)

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

No Harm Testing – CCD Control BMW 318i

Combustion chamber deposits were measured in the BMW 318i engine dynamometer according to the CARB protocols. X-1R controls CCD levels in the BMW 318i below those proposed by the California Air Resources Board. CARB requires that the use of a gasoline additive should not result in more than an average 1300 mg total CCD deposit weight. Alternatively, the total deposit weight should not result in more than 140% of the total deposit weight of the base fuel. X-1R meets the CCD criteria.

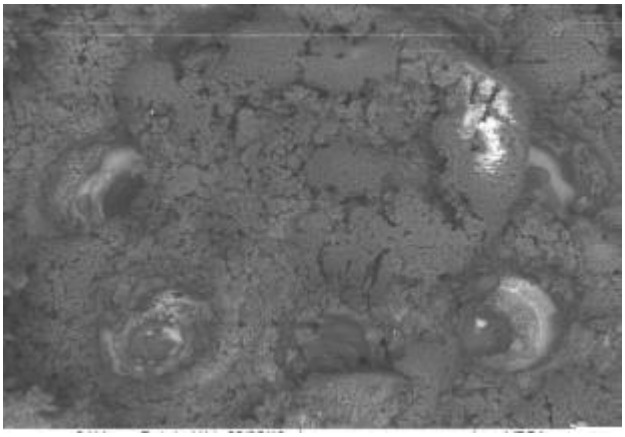
CaRFG3 Certification		
Parameter	**Actual**	**Requirement**
Olefins, % v/v	9.3	≥8.0
Aromatics, % v/v	29.5	≥24.0
Sulfur, ppm, w/w	98	≥64
T90, °F	326.6	≥290
Oxygenate, (EtOH), % v/v	10	≥8



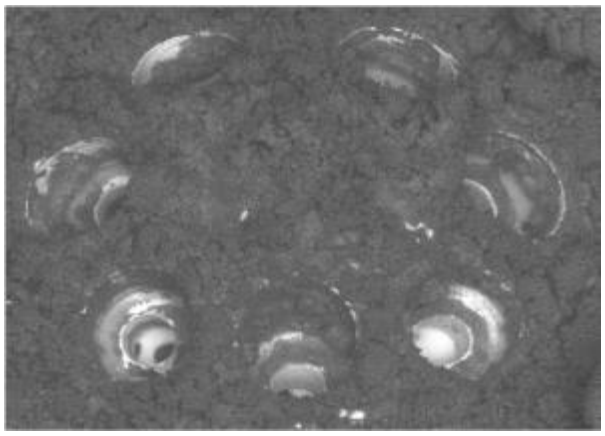
- X-1R EXHIBITS GOOD COMBUSTION CHAMBER DETERGENCY AND MEETS CARB GASOLINE DEPOSIT CONTROL ADDITIVE CCD REGULATIONS AT 138 PPMV

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

Modern GDI Injector Clean-up:



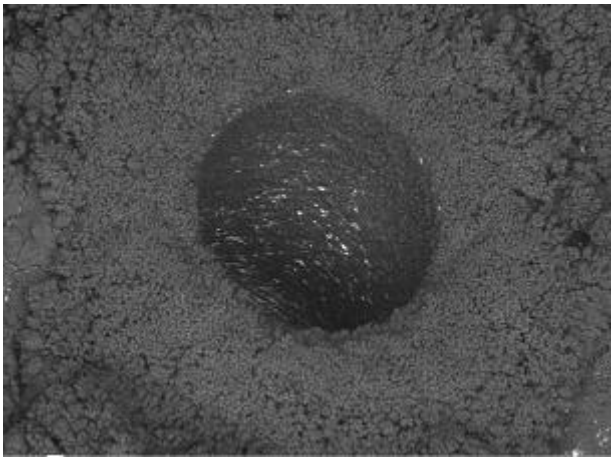
DIRTY-UP



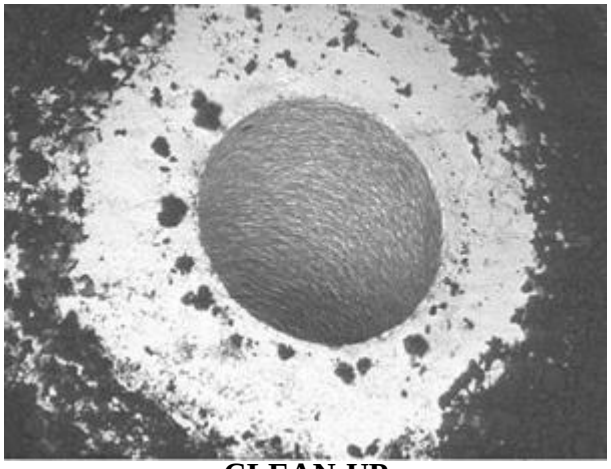
CLEAN-UP

- Dynamometer test with a modern 1.6L turbocharged GDI engine
- 60 hours dirty-up, followed by 20 hours clean-up in severe fuel,
- Treat Rate: 610 ppm detergent - Restores Injector and Engine Performance.

Early Model GDI Injector Deposit Clean Up:



DIRTY-UP

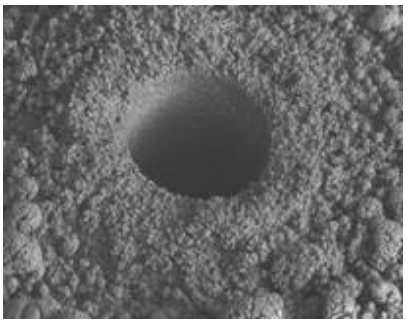


CLEAN-UP

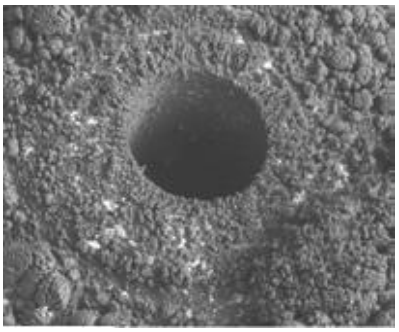
- In-house high load test cycle with Volkswagen 1.4L GDI
- Duration: Dirty-Up: 60 hours Clean-Up: 60 hours
- Treat Rate: 430 ppm detergent - Restores Injector and Engine Performance

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

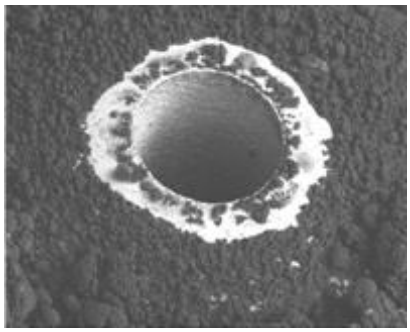
Early Model GDI Injector Deposit Control:



800 ppm Mannich PIBA



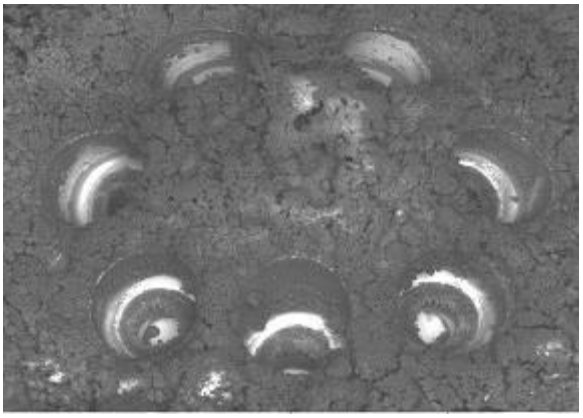
420 ppm PEA



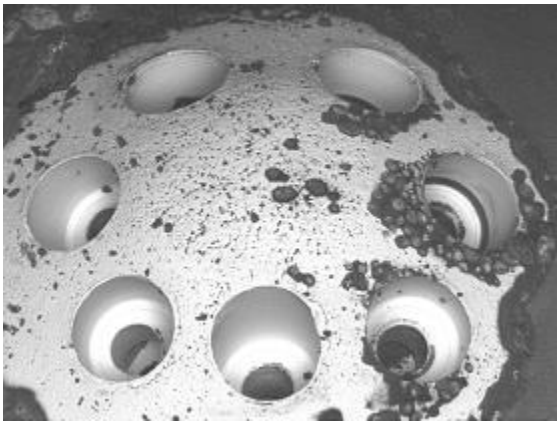
450 ppm X-1R

- Detergent present in AFD -2575 superior to common fuel detergent chemistries
- 1.4L Volkswagen, 60 hour, high load city cycle (EN228 RON98 gasoline)

Injector Deposit Keep Clean - Modern GDI:



Keep-clean with 230 ppm detergent

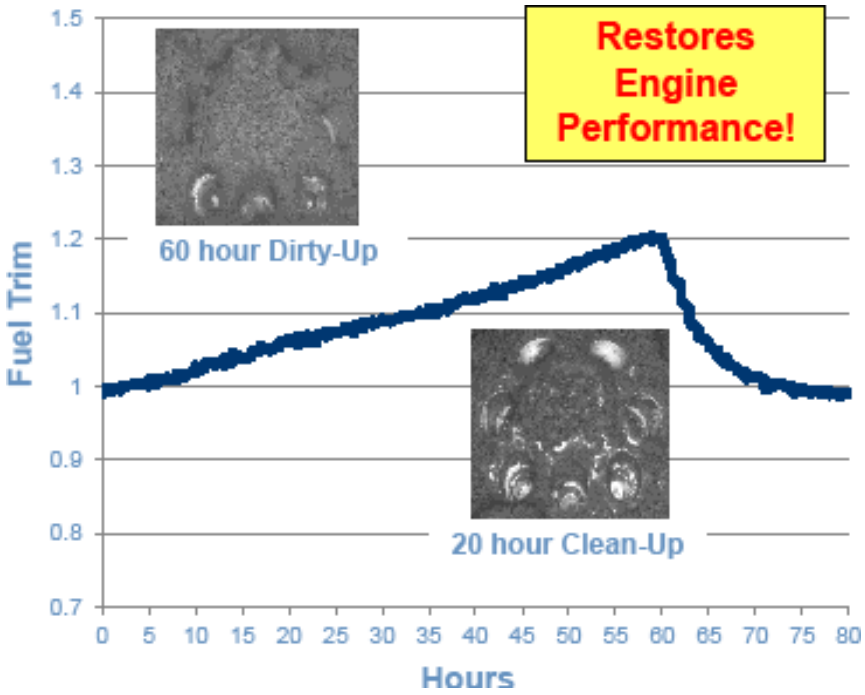


Keep clean with complete fuel system clean dosage (500 ppm detergent)

- Dynamometer test with a modern 1.6L turbocharged GDI
- 50 hours keep-clean in severe fuel

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

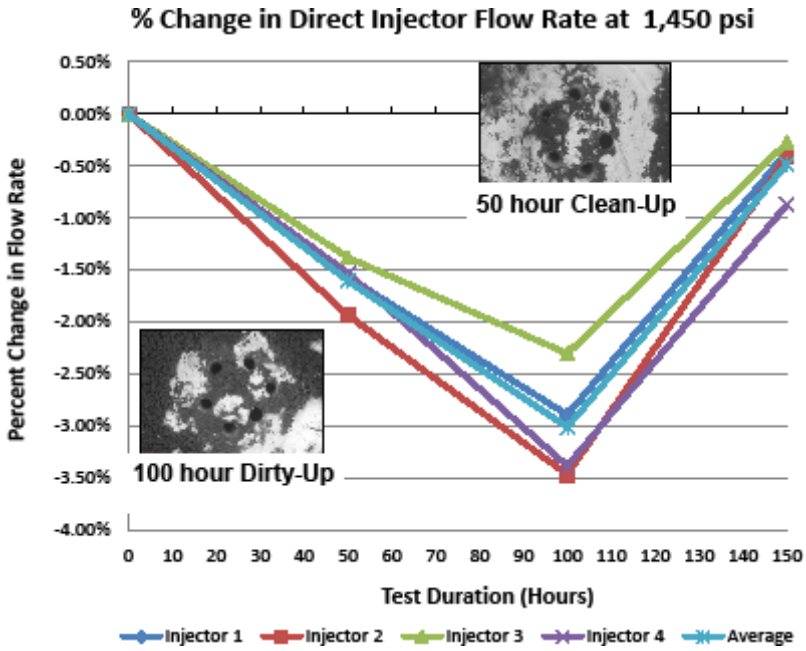
Injector Deposit Clean Up - Modern GDI:



- Dynamometer test with Modern 1.6L turbocharged GDI
- Duration: 60 hours Dirty Up; 20 hours Clean Up
- High severity fuel
- Treat Rate: 610 ppm detergent

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

Injector Deposit Clean Up - Modern GDI:



- Steady state conditions; simulated highway speed
- Ford 2.0L GDI turbocharged engine
- Duration: DU: 100 hours; CU: 50 hours
- Treat Rate: 325 ppm detergent

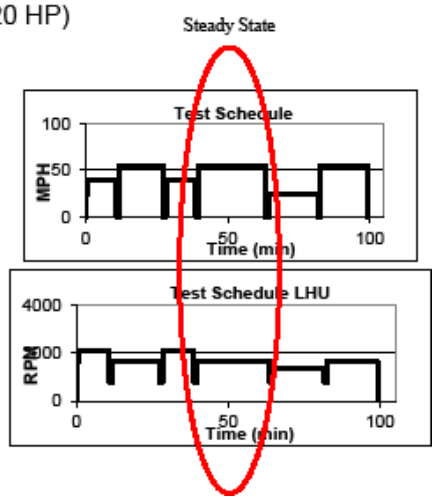
GDI - Clean-up @ 300 ppm active detergent:

LHU GDI Fouling Test

Draft Procedure provided by GM

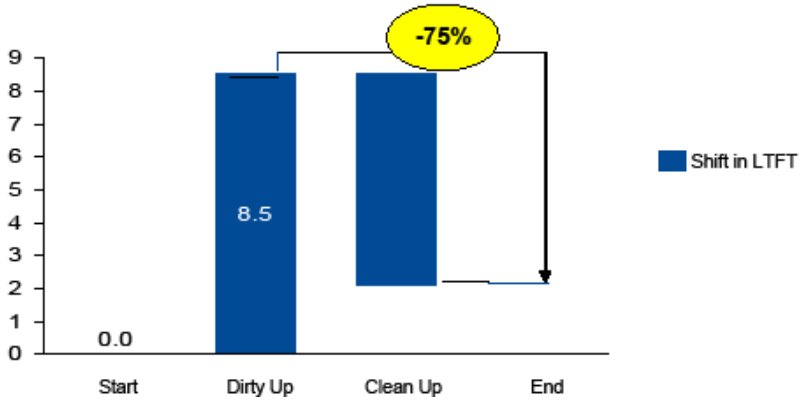
LHU engine – I4, GDI-T, 2.0L used in 2012 Buick Regal CXL (220 HP)

- Test Cycle
  - RPM and Load based
- Long Term Fuel Trim (LTFT)
  - Adjusts duration of injector spray
  - Correlates to injector fouling
  - Used by GM to evaluate fouling



2012 Buick Regal 2.0L GDI-T:

- Fouled injectors with Retail E10 (with LAC)
  - 20 Hours of Fouling (2.5 tanks)
- Cleaned up injectors with Retail E10 + 300 ppm Active Detergent
  - 24 Hours of Cleanup (3 tanks)
  - 75% Reduction in Fouling Evident



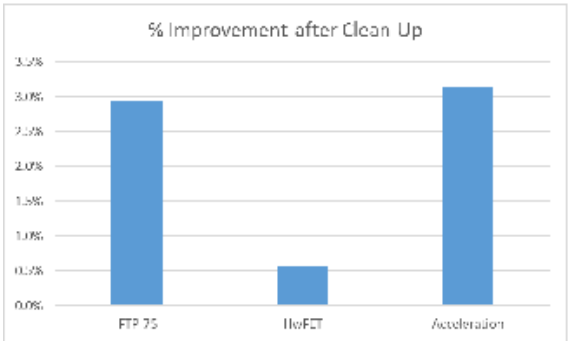
MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

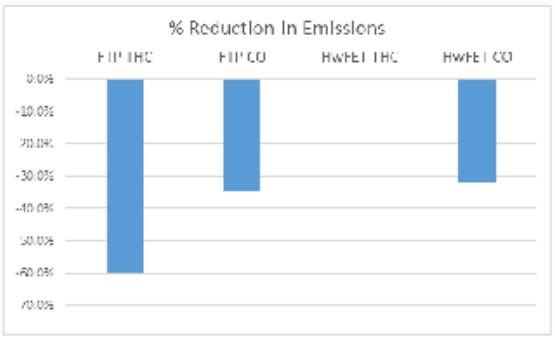
2012 Buick Regal 2.0L GDI-T: Fuel Economy and Acceleration Results

Fuel Economy and Acceleration Results

Results after clean up:

- 2.9% improvement in FTP FE (mpg)
- 0.6% improvement in HwFET FE (mpg)
- 3.1% improvement in acceleration rate (mph/s)





Emissions Results

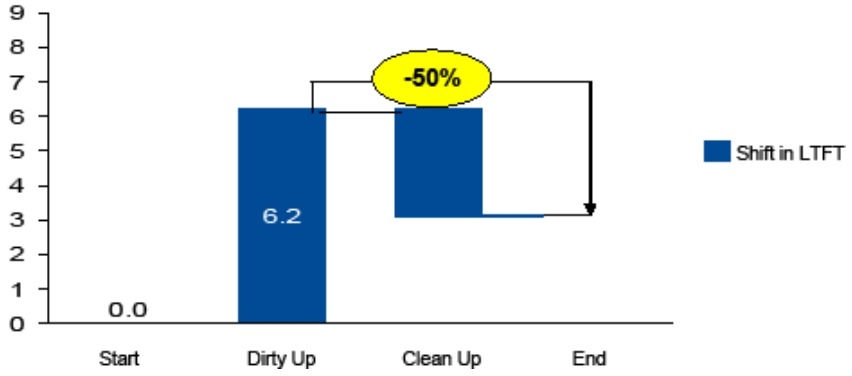
Results after clean up:

- 60.0% reduction in FTP THC (g/mile)
- 34.5% reduction in FTP CO (g/mile)
- 0.0% reduction in HwFET THC (g/mile)
- 32.0% reduction in HwFET CO (g/mile)

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

2015 Ford Escape 1.6 L GDI-T

- Fouled injectors with Retail E10 (with LAC)
  - 16 Hours of Fouling (2 tanks)
- Cleaned up injectors with Retail E10 + 300 ppm Active Detergent
  - 16 Hours of Cleanup (2 tanks)
  - 50% Reduction in Fouling Evident

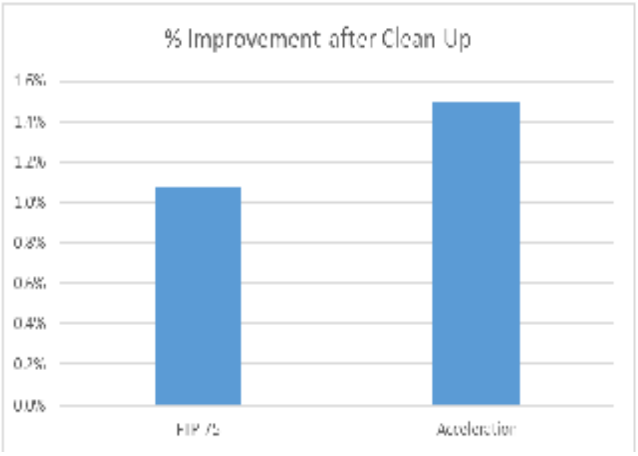


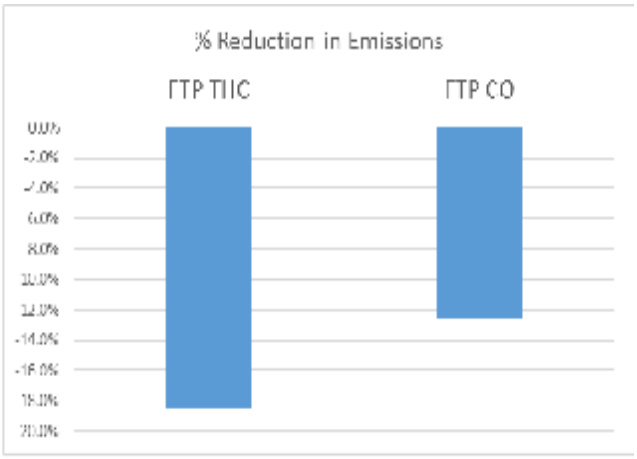
2015 Ford Escape 1.6 L GDI-T: Fuel Economy and Acceleration Results

Fuel Economy and Acceleration Results

Results after clean up:

- 1.1% improvement in FTP FE (mpg)
- 1.5% improvement in acceleration rate (mph/s)





Emissions Results

Results after clean up:

- 18.5% reduction in FTP THC (g/mile)
- 12.7% reduction in FTP CO (g/mile)

GDI - Results Summary:

Procedure	Test	Fuel	Duration	Tanks	Measurement	Result
GM 2.0L turbo GDI LHU Engine (Dyno)	Severe fuel performance	Haltemann GDI Fouling Fuel (FF) Haltemann GDI FF + 190 ppm detergent	14 cycles 14 cycles	2 Tanks 2 Tanks	Shift in LTFT	Fouling reduced from 4.81% LTFT to 3.23% shift in LTFT at Top Tier
GM 2.0L turbo GDI LHU Engine (Dyno)	Dirty Up Clean Up	Haltermann 65th E10 + 275 ppm Mannich PIBA detergent Haltermann 65th E10 + 300 ppm detergent	28 cycles 21 cycles	4 Tanks 3 Tanks	Shift in LTFT	100% clean up of GDI deposits
GM 2.0L turbo GDI LHU Engine (Dyno)	Keep Clean	Haltermann 65th E10 190 ppm detergent	14 cycles	2 Tanks	Shift in LTFT	LTFT shift -0.45% after 14 cycles, keep clean at Top Tier
2012 Buick Regal	Dirty Up Clean Up	Haltermann GDI Fouling Fuel Retail E10 treated with 360 ppm detergent	28 cycles One tank	4 Tanks 1 Tank	Drivability Acceleration Fuel Economy Emissions	100% drivability improvement Acceleration improved 6% City FE increased 8% Hwy FE increased 3%
2012 Buick Regal	Dirty Up Clean Up	Retail E10 LAC Retail E10 with 300 ppm detergent	20 hours 24 hours	2.5 Tanks 3 Tanks	Shift in LTFT Acceleration Fuel Economy Emissions	75% improvement in LTFT Acceleration improved 3% City FE increased 3% Hwy FE increased 1%
2015 Ford Escape 1.6L GDI-T	Dirty Up Clean Up	Retail E10 LAC fuel Retail E10 with 300 ppm detergent	16 hours 16 hours	2 Tanks 2 Tanks	Shift in LTFT Acceleration Fuel Economy Emissions	50% improvement in LTFT Acceleration improved 1.5% City FE increased 1.1%

MULTI-PURPOSE GASOLINE DETERGENT/INHIBITOR

NO HARM TESTING

GM 5.7L Valve Stick Engine Test

Testing performed using a GM 5.7L V8 demonstrates that X-1R, at a treat rate of 722 ppmv, will not cause intake valve sticking. The test cycle involves 3-4 days of a daily accumulation of 85 miles at 60 mph followed by a 16hr cold soak at -4°F (-20°C). The compression of each cylinder is measured daily and compared to a base fuel reading.

- X-1R causes no valve sticking at a soak temperature of -4°F (-20°C).

Corrosion Protection

X-1R will protect against corrosion at a treat rate of 85 ppmv.

FUEL	NACE TM-01-72 BILLET RATING
Base fuel	E
X-1R	C