

TOP TIER™ Program



40th API Automotive/Petroleum Industry Forum

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General Motors

TOP TIER™ Detergency Gasoline Program



OEMs, working with Fuel Marketers,
create a **voluntary** program to
address global fuel detergency
needs without mandatory
regulation changes-



Program Start: April 2004

United States and Canada

Nine auto company sponsors:



**US Required
Treat Rate
100 hrs.
ASTM D6201**



**TOP TIER gasoline
Treat Rate
100 hrs.
ASTM D6201**



TOYOTA

HONDA



Mercedes-Benz



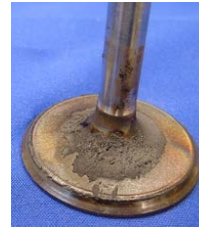
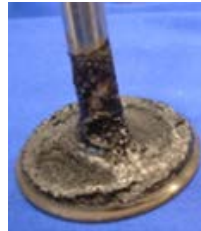
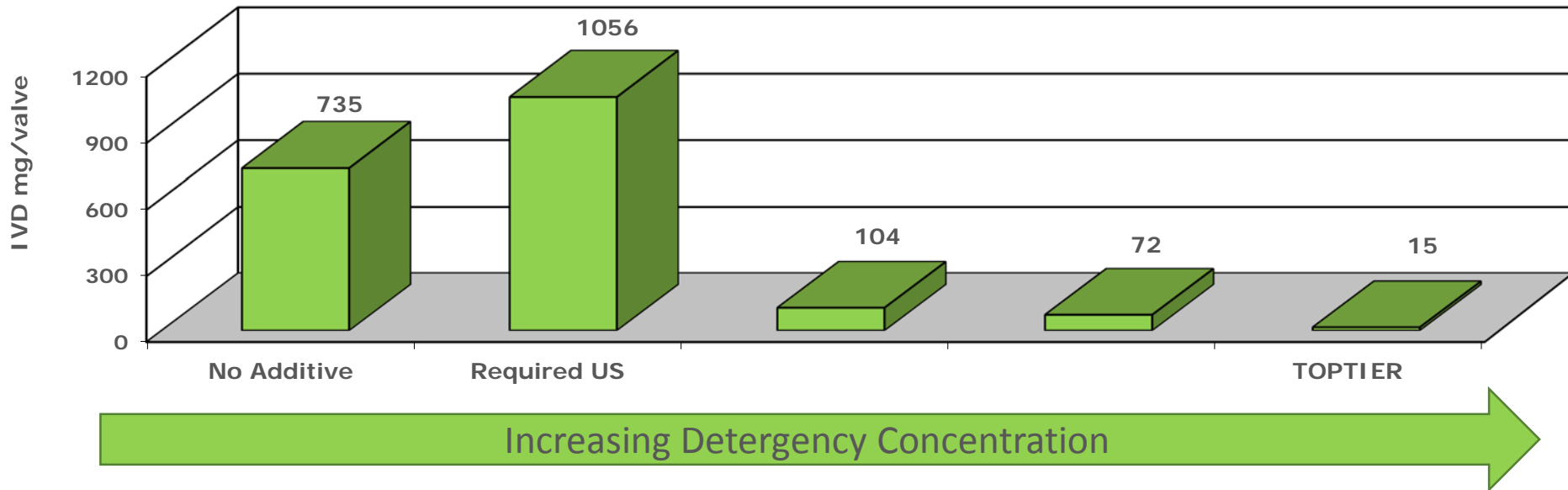
Volkswagen



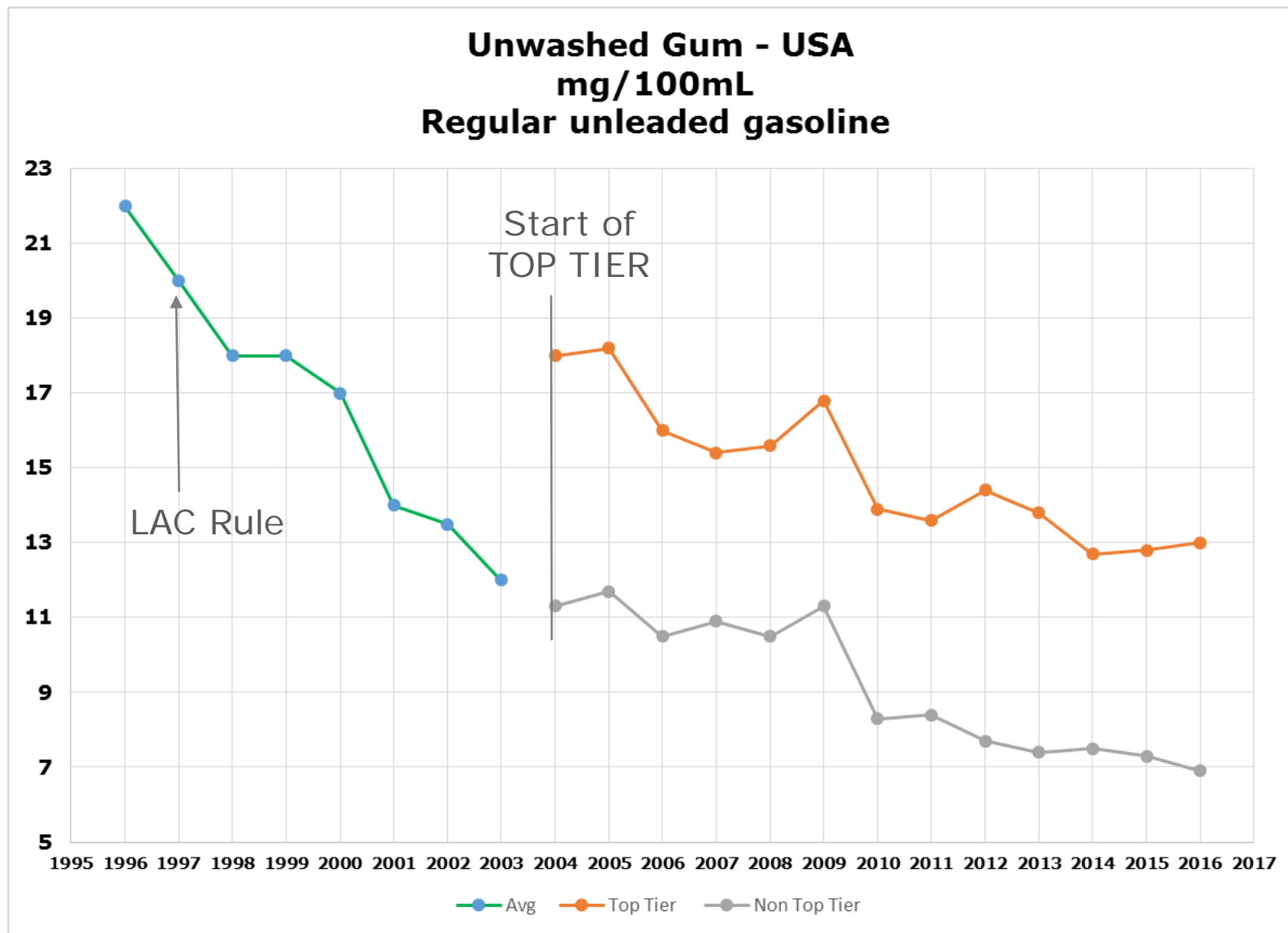
The Need for a Detergent Gasoline Program

Gasoline with the U.S. mandated minimum deposit control additive produced higher valve deposits than the same fuel containing no additive in ASTM D6201 Valve Deposit Tests.

100 hr. Keep Clean Cycle in ASTM D6201 (Ford 2.3L Dyno Engine Test)



Decline in U.S. Detergency Treat Rates



What are Engine Deposits?

Carbon build-up is a generic term used to describe the dark sticky or hard deposits that form on internal engine components. They are byproducts of combustion and will accumulate at different rates based on factors such as fuel quality and detergency.



Symptoms of Engine Deposits

Science driven decision making

Drivability Concerns

- Rough Idle
- Long crank or No Start
- Engine Misfire
- Engine hesitation/less power
- MIL Light

Looking in engine at valves



Engine Damage

- Sticking intake/exhaust valves
- Fouled spark plugs
- Valve damage
- Compression loss

Causes

- Fuel injector spray clogging
- Unburned/unvaporized fuel
- Loss of sealing
- Increased effective compression ratio (material build up)



TOP TIER™ Detergent Gasoline Performance Standard

-requirements to finished fuel (post pipeline)

TOP TIER™ Performance Standard

- Intake Valve Cleanliness –modified ASTM D6201 engine dyno test
 - 500 mg/valve dirty up on base fuel no additive
 - 50 mg/valve avg. keep clean with base fuel + additive
- Additional No Harm Tests
 - Combustion chamber build up limit
 - Valve sticking test
- Independent ISO-17025 lab verification of test results

Prohibits “MMT” (Manganese organo-metallic fuel additive)

- Plugs catalysts
- Fouls spark plugs
- Damages oxygen sensors

Developing a DI Engine Performance Requirement

**EPA allows TOP TIER test results in
Tier 3 in place of LAC testing**



TOP TIER™ Program Objectives



Customer is focus of the program

A fuel quality initiative to enable optimal vehicle performance

Motivation for Fuel Marketers

- Help in product differentiation, sales promotion, advertising and better brand recognition
- Higher customer satisfaction, prevent vehicle claims
- OEM recommends fuel – brings vehicle owners to station

Motivation for Automakers

- Restores vehicle performance from low quality gasoline
- Ensures long term vehicle performance for owners 1,2,3...
- Update program with evolving engine needs

OEMs partnering with fuel marketers to direct customers to a higher standard of fuel to enable optimal vehicle satisfaction.



Automakers recognize and recommend TOP TIER fuel to customers

TOP TIER recommended in 13 Million new US vehicle owner's manuals in 2017



STARTING AND OPERATING 589



Designated TOP TIER Detergent Gasoline contains a higher level of detergents to further aide in minimizing engine and fuel system deposits. When available, the usage of Top Tier Detergent gasoline is recommended.

Visit www.toptiergas.com for a list of TOP TIER Detergent Gasoline Retailers.

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DRIVING

Refueling

Use the proper fuel and refueling procedure to ensure the best performance and safety of your vehicle.

Fuel Information

- Use of unleaded gasoline of 87 octane or higher is recommended.
- Honda recommends TOP TIER Detergent Gasoline where available.
- Do NOT use gasoline containing more than 15% ethanol.
- Do NOT use gasoline containing methanol.
- Do NOT use gasoline containing MMT.

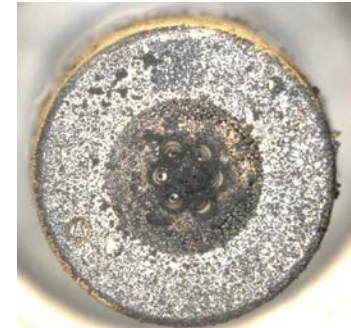
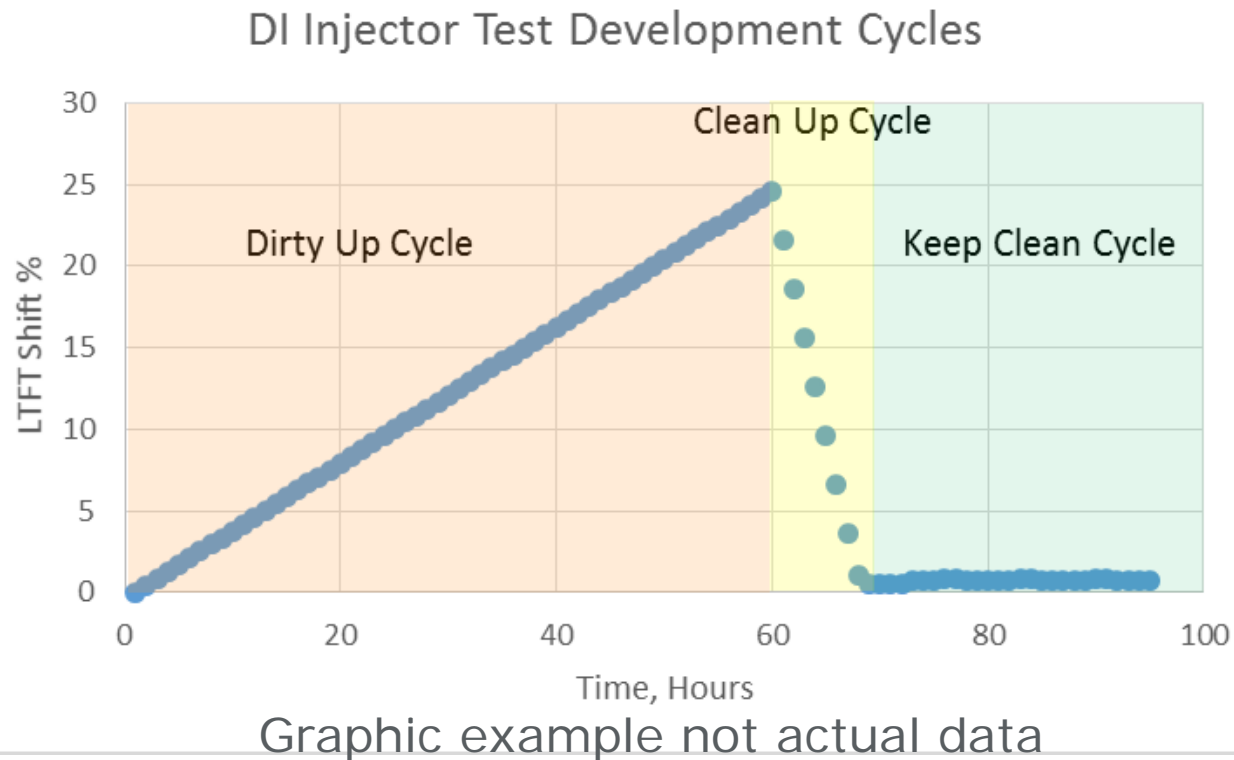
NOTICE

We recommend quality gasoline containing detergent additives that help prevent fuel system and engine deposits. In addition, in order to maintain good performance, fuel economy, and emissions control, we strongly recommend the use of gasoline that does NOT contain harmful manganese-based fuel additives such as MMT, if such gasoline is available.

- Recommendation of the use of gasoline containing detergent additives**
 - Toyota recommends the use of gasoline that contains detergent additives to avoid the build-up of engine deposits.
 - All gasoline sold in the U.S.A. contains minimum detergent additives to clean and/or keep clean intake systems, per EPA's lowest additives concentration program.
 - Toyota strongly recommends the use of Top Tier Detergent Gasoline. For more information on Top Tier Detergent Gasoline and a list of marketers, please go to the official website www.toptiergas.com.

DI Engine Test for TOP TIER Program

- Assurance that current additive packages protect DI engines
- Additional to ASTM D6201 PFI Injector Valve test
- Evaluating most reliable metrics which correlate to injector build up, keep clean and clean up



Global Evolving Engine Cleanliness Needs

Future emissions requirements

- SIDI injector deposit effects on emissions
- Vehicle emissions in-use is becoming a greater focus
- Deposits behave like sponges to trap fuel and release later

Vehicle Drivability with evolving requirements

- Issues anticipated from deposits as emissions and fuel economy regulations demand lean operation

Low Speed Pre Ignition (LSPI) research

- Research underway on Poor Fuel, Lubricants and Additives

TOP TIER Global Expansion

Central America: May 2017

- Panama, El Salvador, Guatemala, Honduras



Mexico

- First Mexico TOP TIER location opened August 2017

China Clean Fuel – NOT TOP TIER

Efforts by division of China gov't in a detergency program in China.

- Some TOP TIER OEMs participation in region as sponsors
- TOP TIER team enthusiastic about CCF program – proper solution for China

Diesel quality has not kept up with diesel engine technology

- Modern engines requires fuel to be extremely clean with acceptable properties for trouble free operation

Sponsorship to include Heavy Duty Equipment Manufacturers

Launched October 2017 and expansion outside US/Canada *TBD*

Performance Specification

- Oxidation Stability for Biodiesel
- Lubricity
- Detergency Requirement
- Water control
- Particulate filtration
- No Harms



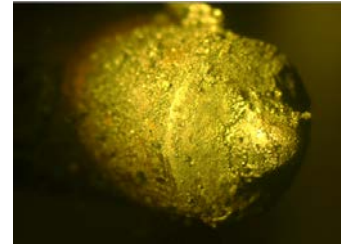
Clogged Station Dispenser Filter

TOP TIER™ Diesel Fuel Standard



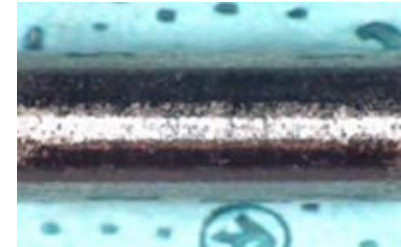
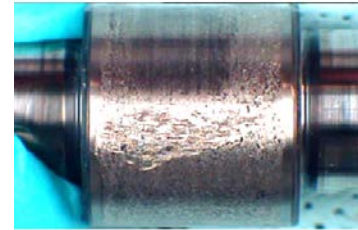
#1. Injector Deposits

Deposit control additive
DW10B and DW10C



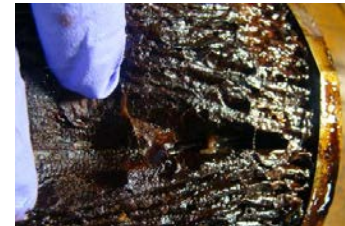
#2. Lubricity

460 micron max.



#3. Fuel stability

Biodiesel Rancimat: 8 hr. B100 or 24 hr. > B5
Base Fuel PetroOxy > 60 min. B0



#4. Water and particulate

10 micron H₂O absorbing filter at dispenser



Detailed standard can be found at toptiergas.com

Need for Higher Standard in Diesel Fuel

Customer satisfaction is key for all OEMs and include:

- Power
- Maximum fuel efficiency
- Minimum downtime and maintenance cost

Emissions standards are driving major changes to the vehicle

- Requires very precise control of the fuel combustion process

Fuel Quality is key to meeting customer and regulatory requirements

- Proper fuel chemistry can prevent corrosive acids, peroxides, gums or deposits
- Fuel must be extremely clean to avoid damage to the fuel system components
- Current ASTM standards do not address all fuel quality problems
- Fuel related customer concerns are near top of warranty claims

Global detergency

- Customers responding to fuel quality recognition
- OEMs interest in higher standards for fuel quality regionally

Evolving engines and additives role in solutions

- SIDI engines – need for updated detergency spec.
- Additives role in PM, SPI, RDE

Diesel TOP TIER™ program:

- Housekeeping practices – inconsistent and not standard
- Minimum standards approach is not adequate
 - Fuel issues prevalent in field and out of spec fuel found
- Monitoring and enforcement to ensure quality
- Need distinction of brands to stand up for diesel fuel quality

Thank you!

www.TopTierGas.com



TOP TIER™ Diesel Performance Standard



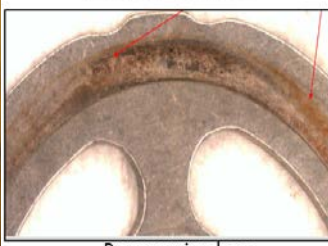
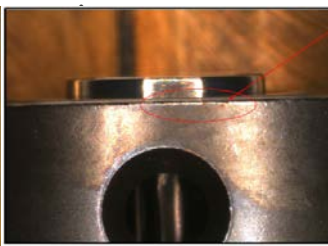
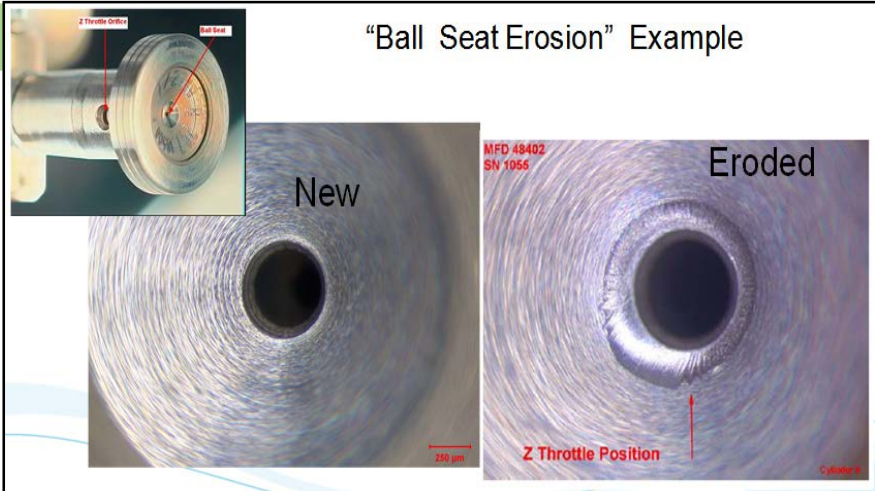
Fuel must meet relevant country/regional standards

(e.g., ASTM D975 or ASTM D7467) and these additional requirements:

Property	Test Method	Limit
Oxidation Stability (Rancimat IP method)	EN15751 (Rancimat IP method)	>8 hours for B100 as blend component OR
		>24 hours for up to B5 Biodiesel blend at retail OR
		>20 hours on > B5 the biodiesel blends at retail
	ASTM D7545 (PetroOxy Test)	> 60 minutes for B0 fuel
Lubricity	ASTM D6079	460 micron max
Detergency -Injector Cleanliness	DW-10B (CEC F-98-08)	< 2% power loss
	DW-10C (CEC F-110-16) –Place holder until approved by CEC	Rating of > 9 on Demerits Scale
	Qualified engine/vehicle test from fuel marketer or additive company to demonstrate performance for clean up of IDID deposits	Results on the qualified test as approved by OEM sponsors
Water	Refueling Station Housekeeping	Water detection media filter or approved water detection process
	ASTM D6304	To be monitored during audits
Particulate Contamination, Size Distribution	<i>Retailer dispenser filter</i>	< 10 microns absolute for low speed pumps (30 micron accepted for high flow)
	ISO 4406	To be monitored during audits

NOTE: Additive package will also have to pass 'no-harms' testing.

Examples of Fuel Quality Concerns on Vehicle



Biodiesel related
Deposits

Clogged fuel filter due to
biodiesel deposits

Water related corrosion

Bulk Tank Issues Experienced in the Field

Vent Line Contamination



Contamination from Vendor



2%
Bio

H₂O + Ethylene Glycol

Plugged Dispenser Filter



Water + Sediment



Corroded Tanks



Bugs + 10k ppm Sulfur



Failed Veeder Root



H₂O in Bulk Tank

**Rusted Pump Head
(in-vapor space)**

