

Storage Tank Maintenance for Today's New Fuels



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NISTM – Harrisburg, PA
April 3, 2014

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Executive V-P

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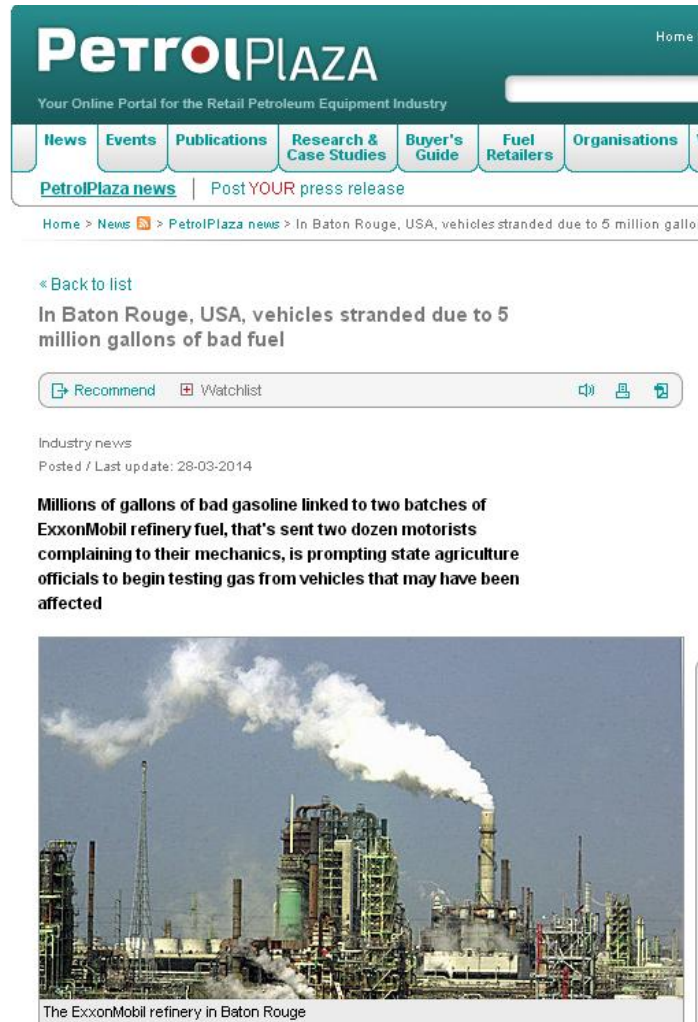
- 28 Years Experience with Storage of Petroleum Fuels
- Professional Engineer
- Executive Vice-President of Steel Tank Institute
- Member of NFPA 30 Flammable & Combustible Liquids Storage Tank Committee since 1986
- Steel Tank Institute publishes Shop-Fabricated Tank Maintenance, Inspection & Repair Standards
- Over 450,000 Tanks constructed to STI specifications

Who and What is STI/SPFA?

- Association of 186 fabricating and affiliate companies of steel construction products – shop-fab tanks, field erect tanks, pipe, pressure vessels and other special fabricated products
- STI members build a significant majority of shop-fabricated underground and aboveground fuel storage tanks



This Week's Headline News



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In Baton Rouge, USA, vehicles stranded due to 5 million gallons of bad fuel

Recommend Watchlist

Industry news
Posted / Last update: 28-03-2014

Millions of gallons of bad gasoline linked to two batches of ExxonMobil refinery fuel, that's sent two dozen motorists complaining to their mechanics, is prompting state agriculture officials to begin testing gas from vehicles that may have been affected



The ExxonMobil refinery in Baton Rouge

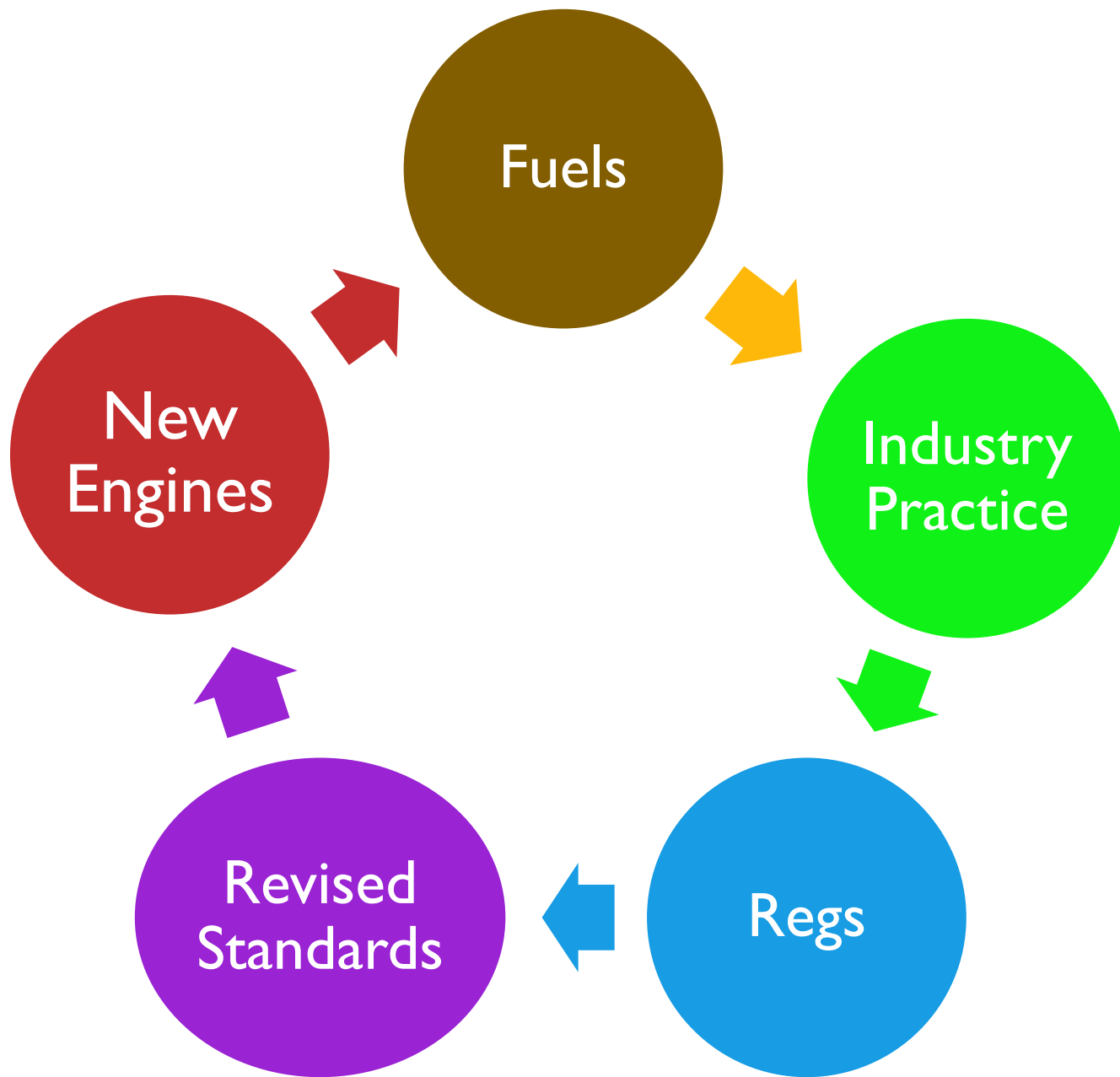
- 24 vehicle complaints
- Gunking up of engine leaving deposits in engine valves & injector system
- Officials trying to find out what chemical compound is causing the reaction



Fuel Cleanliness Important

- Newer Engines
- Gov't Regulations
- Changing Fuels
- Industry Practices



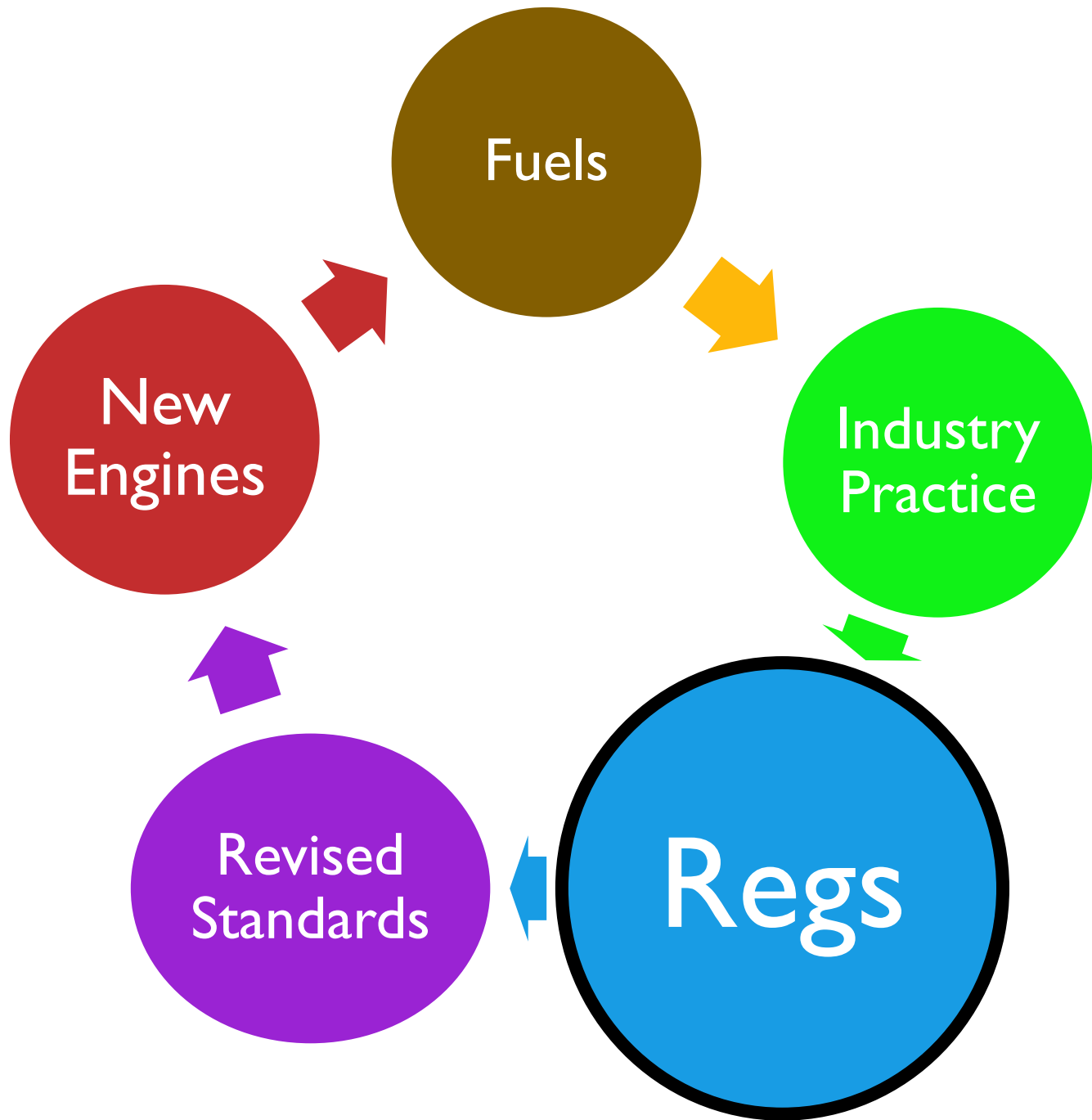


Result



**Increased
Need for
Storage Tank
Maintenance**





Air Quality Concerns

- To produce cleaner burning fuel oxygenates were added to gasoline
- To produce cleaner burning fuel, sulfur was removed from diesel
- Note changes are for Air Quality, not fuel quality

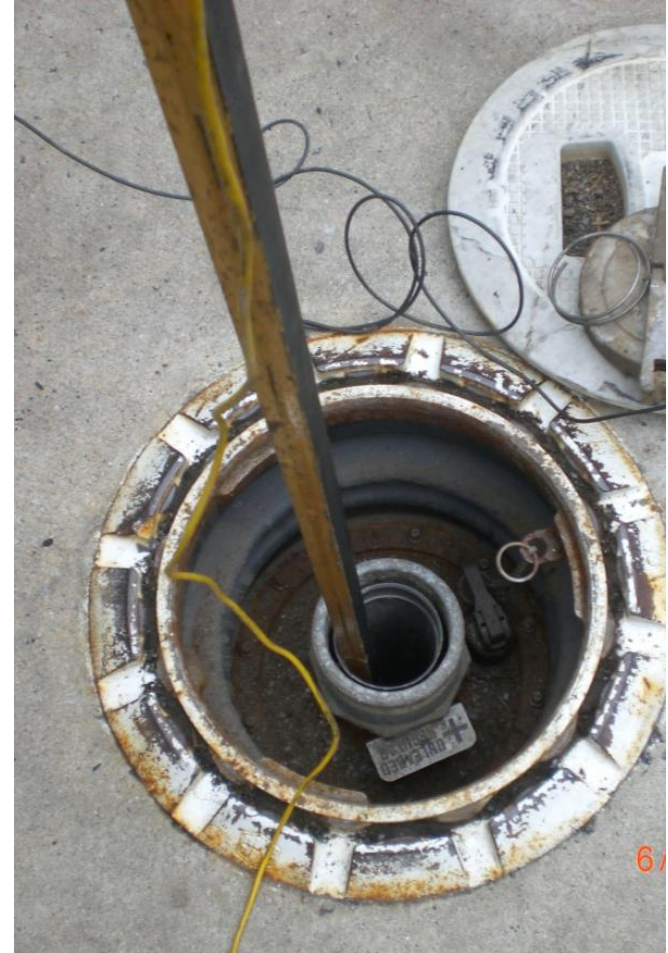
Gas Mileage Concerns

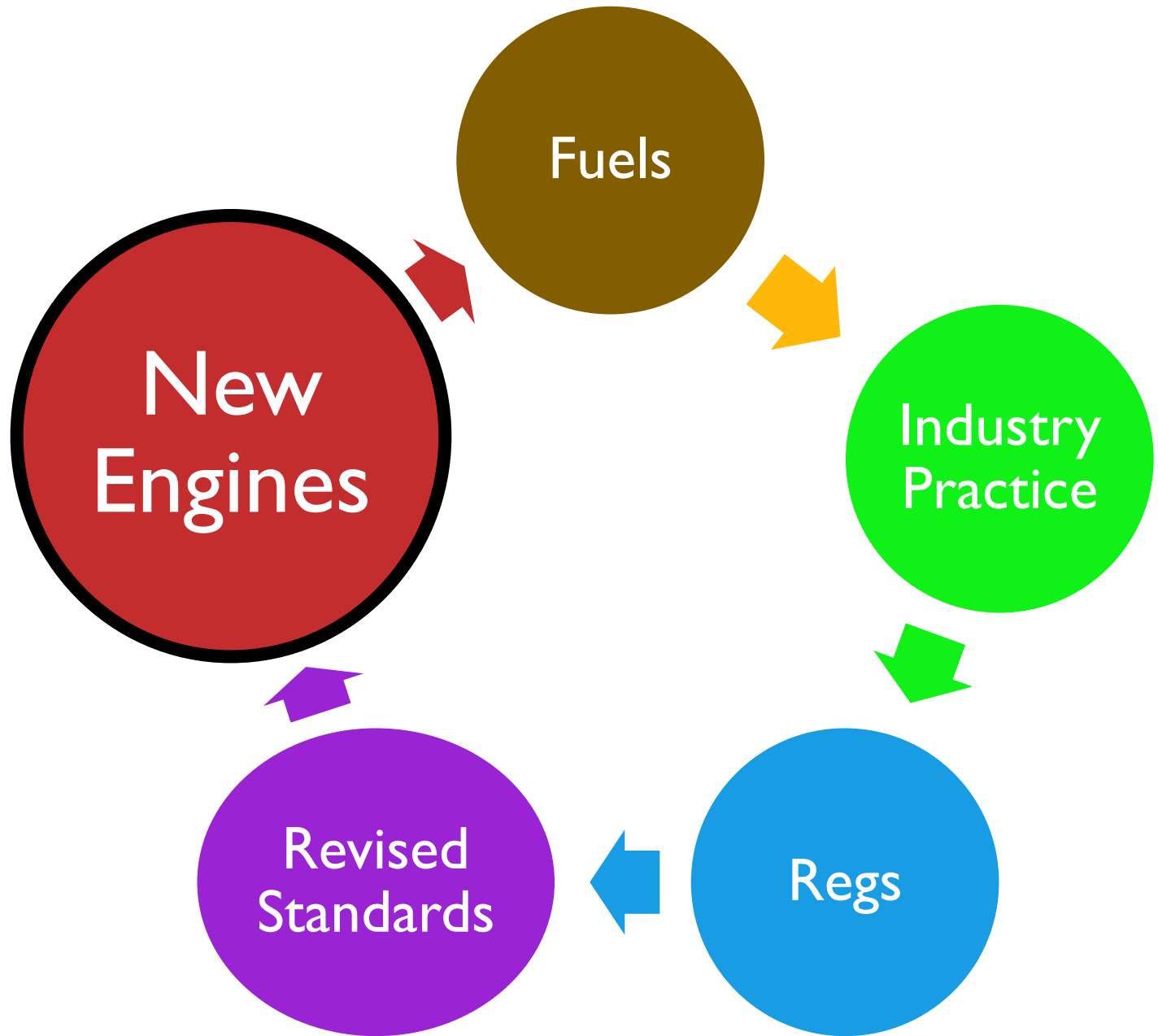
- Automobile manufacturers required to increase overall mileage
- Regulation resulted in engine changes



State Regulation Concerns

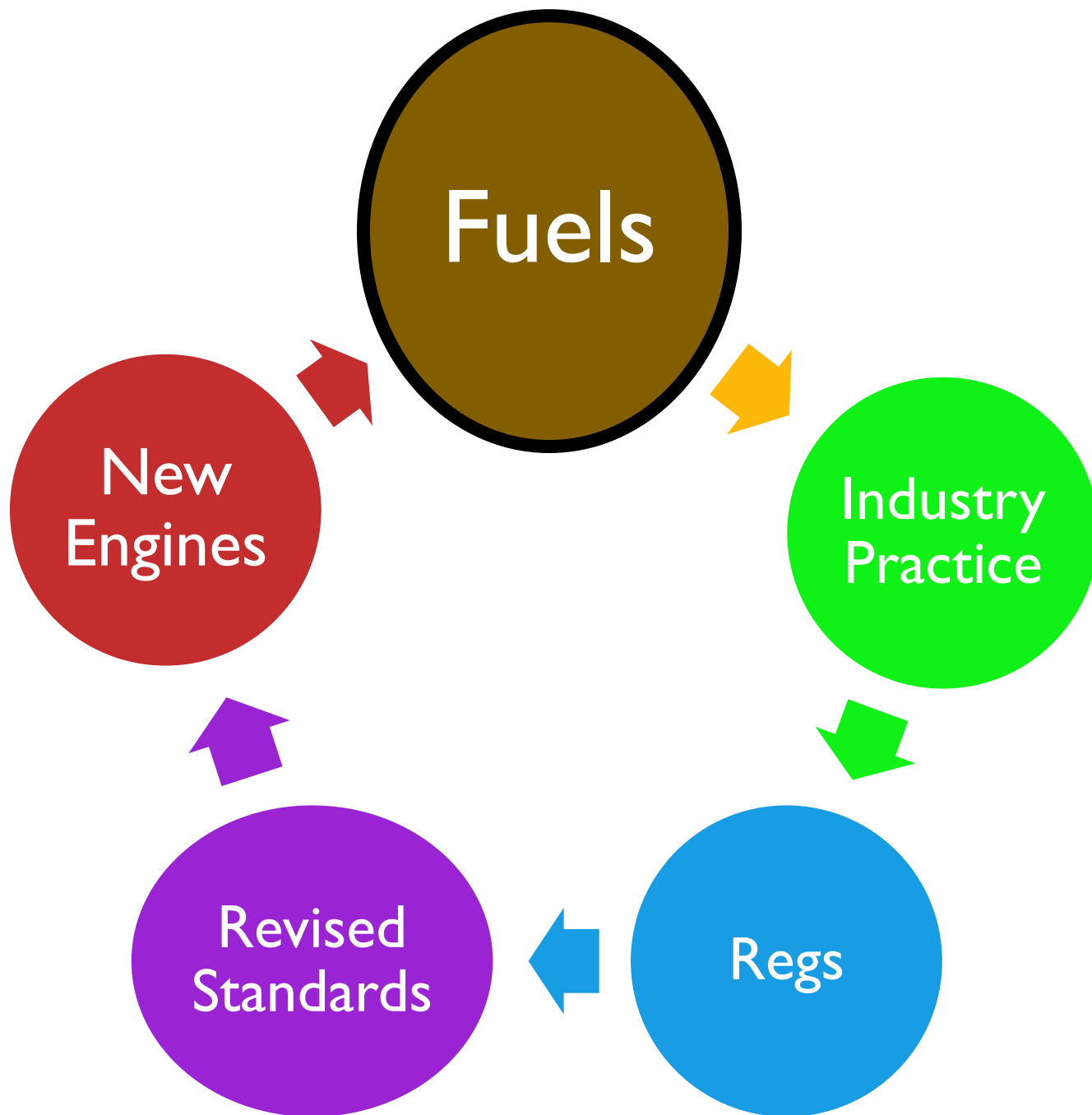
- Some states, like MO, regulate water bottoms in tanks
- 1 inch maximum water allowed





Clean Air & Newer Engines

- Engine exhaust must be cleaner to meet EPA Clean Air regulations
- Fuel injection systems instead of carburetors
- Particulates can clog injectors
- Reduced clearances in engines requires cleaner fuels



Fuel Production & Distribution

- US terminal capacity reduced, while fuel consumption increased.
- Therefore, more fuel moves distributed at faster rate = less time to settle out before final delivery.
- Industry moving to shared delivery infrastructure, so individual companies have less control over product.

New Fuels of the 21st Century

- Biodiesel
- Ethanol
- ULSD
- Additives
- Future Fuels

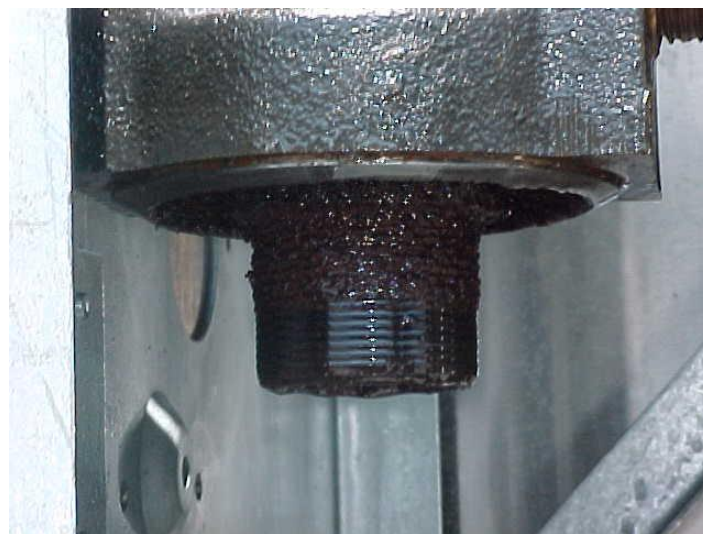


Changing Fuel Formulations

- Changing to ULSD (Ultra Low Sulfur Diesel) significantly changed fuel:
 - Had a significant impact on solids formation
 - Peroxide formation is more of a problem
 - Wax precursors and solids propagators more pronounced
- What does all this mean? Generally, there may be more particulate and sediment in ULSD compared to LSD

What is Going On with ULSD?

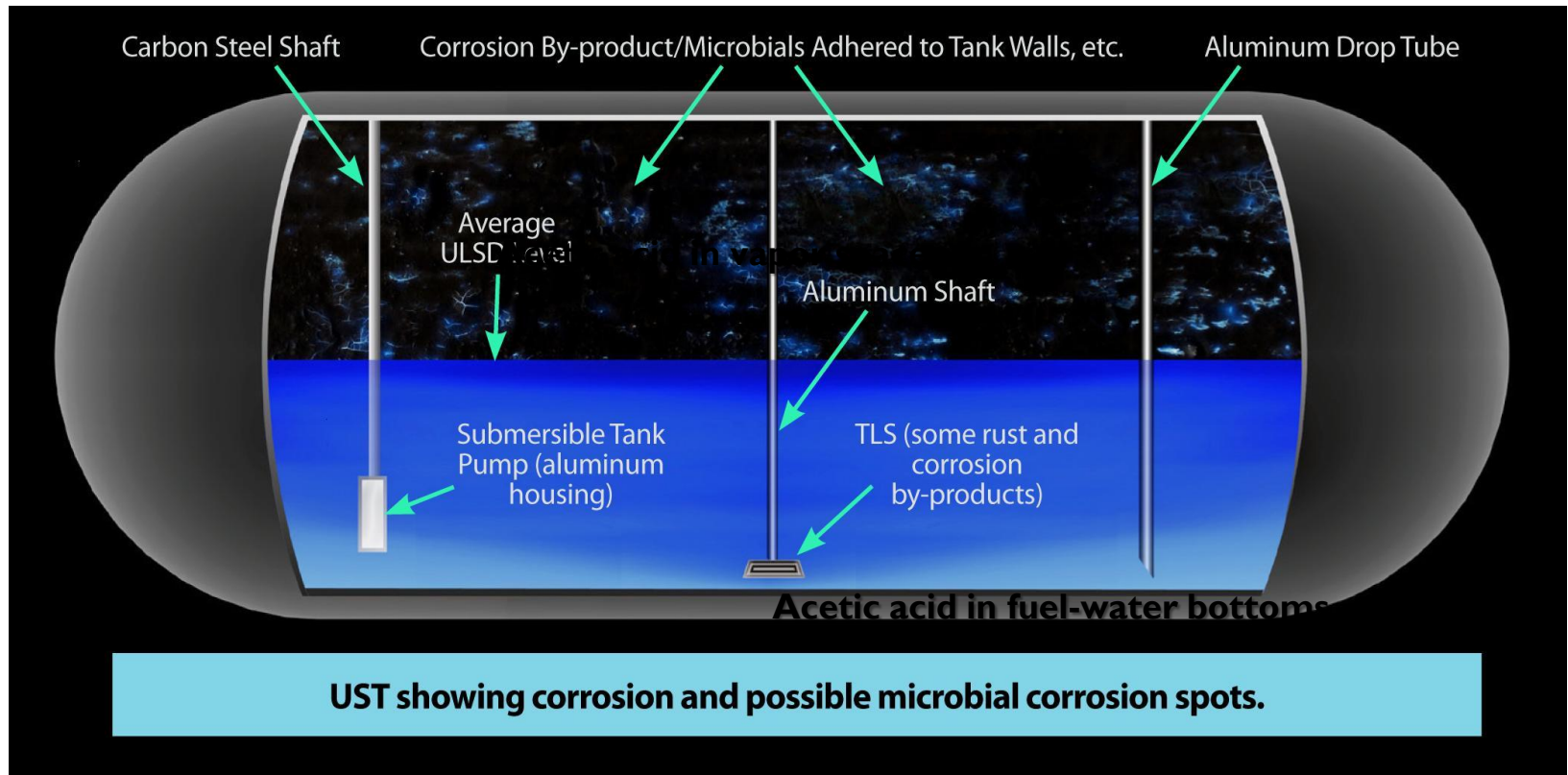
- **Corrosion of metal components within underground storage tanks storing ULSD**
- **Strainer and filter photos on right**
- **Particulates often described as being similar to coffee grounds**



ULSD Corrosion – UST Detail

(Diagram: Courtesy of Rick Chapman, Innospec)

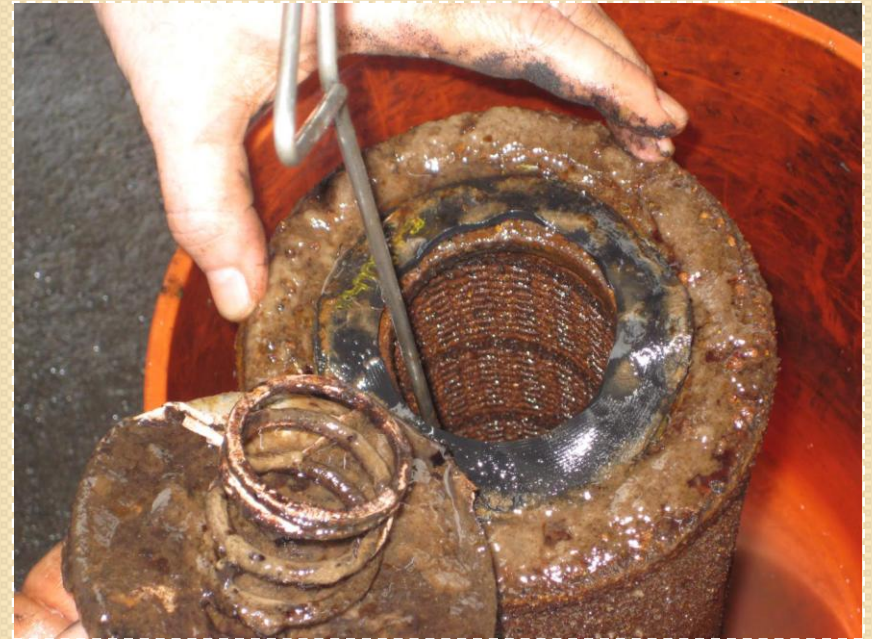
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Common Observations of Filters Used in Ultra Low Sulfur Diesel Systems



Trash Inside Strainer



Filter Canister at FRP Tank Site

**Corrosion of Submersible Turbine Pump – Jan. 2013
(One UST service provider estimates that he replaced
40 pumps in past 6 months alone, many 2-3 years old.)**



Clean Diesel Fuel Alliance

Contract No. CON00008697
Study No 10001550
Final Report

Corrosion in Systems Storing and Dispensing Ultra Low Sulfur Diesel (ULSD), Hypotheses Investigation

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

To
Clean Diesel Fuel Alliance
C/O Mr. Prentiss Searles
American Petroleum Institute
1220 L Street, NW
Washington, DC 20005-4070

September 5, 2012



- Report of first year study was published Sept 2012
- CDFA interested parties met in Chicago Oct 3, 2013
- Agreed to several goals and projects
- Presented to CRC to assume further research

Conclusions are in Hypothesis Status

- Among other contaminants, acetic acid was found in all samples taken (fuel, water bottoms, vapor and corrosion scrapings).
- Acetobacter microorganisms and traces of ethanol were found in the majority of water bottom samples.
- Combined, the two are known to create acetic acid.
- Battelle has identified this as the most likely mechanism for the cause of the corrosion.
- Conclusions are still in hypothesis stage

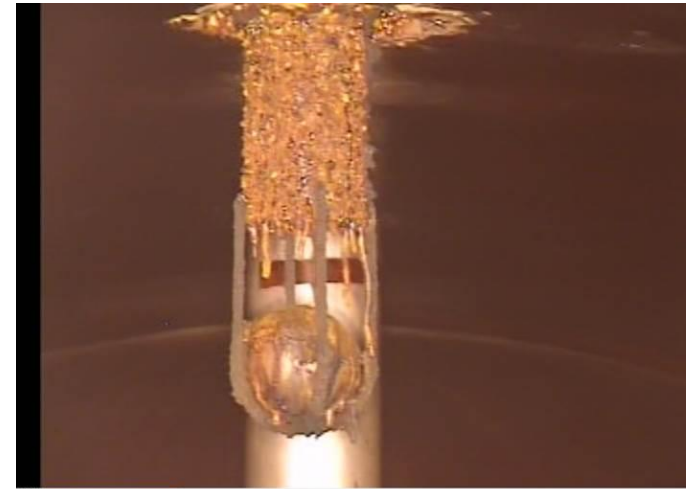
ULSD Research Ongoing

- **Coordinating Research Council**

- Diesel Performance Group
- Oil & Vehicle Industries
- Developing an RFP for further research to achieve better understanding of this issue

- **Example: STI Research**

- Tanknology hired to visually examine the insides of underground steel and FRP ULSD tanks at service stations
- Fuel samples extracted and tested
- Las Vegas service station tanks under same owner
 - FRP tank vapor control fitting – top right photo
 - Steel tank vapor control fitting – bottom right photo



About Changing Fuels: Ethanol Blended Gasoline

- 96% of all gas today is blended with 10% ethanol
- EPA has approved E15 in cars 2007 and newer
- Per US DOE EERE, 2399 ethanol stations dispense E85
- Plants can produce over 14 billion gallons/year



Ethanol Blended Fuels

- **Sumps Used Atop UST's**
 - EPA ORD Research
 - NIST Research
- **ASTSWMO Publications**
 - “Compatibility of UST Systems with Biofuels,”
 - Case Studies
- **Research and Work Groups**
 - Underground tanks storing E85



UST Sumps (slide courtesy of NIST)



E10 STP, unknown grade (Florida) – Feb. 2011



91 octane STP (California) – August 2010



Premium/E10 STP (Tennessee) – March 2010



Premium/E10 STP (Tennessee) – August 2010

Same sump!

ASTSWMO Guidance Document

http://www.astswmo.org/Files/Policies_and_Publications/Tanks/2013.06-Biofuels_Compatibility-Alt_Fuels.pdf

PURPOSE

- Resource for compatibility evaluation
- Compatibility evaluation checklist
- Links to informational resources
- Case summaries highlighting consequences of incompatible equipment on UST systems

RECOMMENDATIONS

- Require periodic monitoring for presence of water & its removal
- Incorporate equipment compatibility evaluation
- Ensure UST's are cleaned before switching to new alternative fuels
- Notifications & permitting

26 Year Old FRP Tank- ASTSWMO Study (Screen Shot from Publication)

www.astswmo.org/Files/Policies_and_Publications/Tanks/2013.06-Biofuels_Compatibility-Alt_Fuels.pdf


Tank Issues:

Tank Construction: Single Walled Tank Material: FRP

Tank Capacity: 10,000 gallons Installation Date: 1986 Current Tank Age: 26 years

Description of Issue:
Prior to the storing of blended fuels, the USTs stored unleaded 87 and 92 octane as well as diesel. It was believed that the tanks had had been properly cleaned prior to the switching of products. The premium UST was placed in temporarily out of use (TOU) status on 12/18/2008 and was put back in service on 2/5/2009. The ATG detected the presence of water in the tank and as a result, the tank was placed back into TOU status on 2/10/2009. In 9/2009, an internal inspection of the tank was conducted. The results indicated a crack in the bottom of the tank.

Supporting Pictures:
92 Octane UST – breakdown observed during pre-blast inspection



C-22

www.astswmo.org/Files/Policies_and_Publications/Tanks/2013.06-Biofuels_Compatibility-Alt_Fuels.pdf

92 Octane UST – deep crazing/crack observed during pre-blast inspection



92 Octane UST interior – water entering tank through crack



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<http://s...

Tank Lining Company Newsletter (Screen Shot from E-Mail)

News from NW Tank Lining & Inspection - Message (HTML)

Message Add-Ins

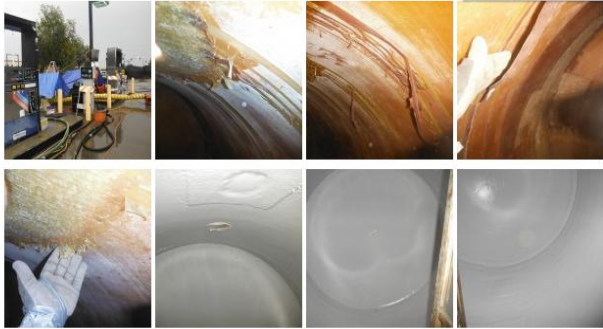
Reply Reply Forward Delete Move to Create Other Block Safe Lists Categorize Follow Find
Respond to All Folder Rule Actions Sender Junk E-mail Options Up Unread Related Select

You forwarded this message on 11/4/2013 7:27 PM.

From: NW Tank Lining & Inspection [info@nwtli.com@mail77.at51.rsgsv.net] on behalf of NW Tank Lining & Inspection [info@nwtli.com] Sent: Tue 10/29/2013 1:02 PM
To: Wayne Geyer
Cc:
Subject: News from NW Tank Lining & Inspection

Fiberglass (FRP) UST Lining System Installation
Oct 28, 2013 02:49 pm | admin

NW Tank Lining & Inspections



<http://nwtli.us5.list-manage2.com/track/click?u=493baf0aaa7924275a17ad2e&id=0491704dba&e=d55aa2ca87>
Click to follow link

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Advanced Inspection Services & Industrial Coatings, Linings & Repair

NWTLI's service crews are positioned and ready to respond to your inspection, lining, and emergency service needs. Each project is supervised by a Foreman with years of experience, ensuring a conscientious and safety minded crew to complete your project on time and on budget. We work around a client's schedule, shut downs, nights and weekends. Night or day we adapt to your needs.

In September 2013, a large California based petroleum distributor and convenience store chain contracted NW Tank Lining & Inspection, Inc. to install an interior lining system in its fiberglass (FRP) USTs at its site in Redwood City, CA.

The resin and the gelcoat were peeling away from the interior surface of the FRP USTs, leaving the UST shells completely exposed leading to probable deterioration.

The NWTLI crew sandblasted away the flaking resin and gelcoat and proceeded to sandblast the entire interior of the shell to properly prepare the UST for the installation of the lining system.

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Service Provider Observations of an Older FRP Tank (Screen Shot from Presentation)

24th National Tanks Confere x www.neiwpc.org/tankconf x

www.neiwpc.org/tankconference/presentations/wednesday/Out%20of%20Sight/Out%20of%20Sight_Hoffman_2013_Wednesday.pdf

Florida Tank Upgrade Program

- Observations during upgrading of older tanks



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Fuel Additives – Are They Necessary?

Gasoline and diesel fuel contain many additives essential for good fuel quality and necessary for good fuel stability and performance:

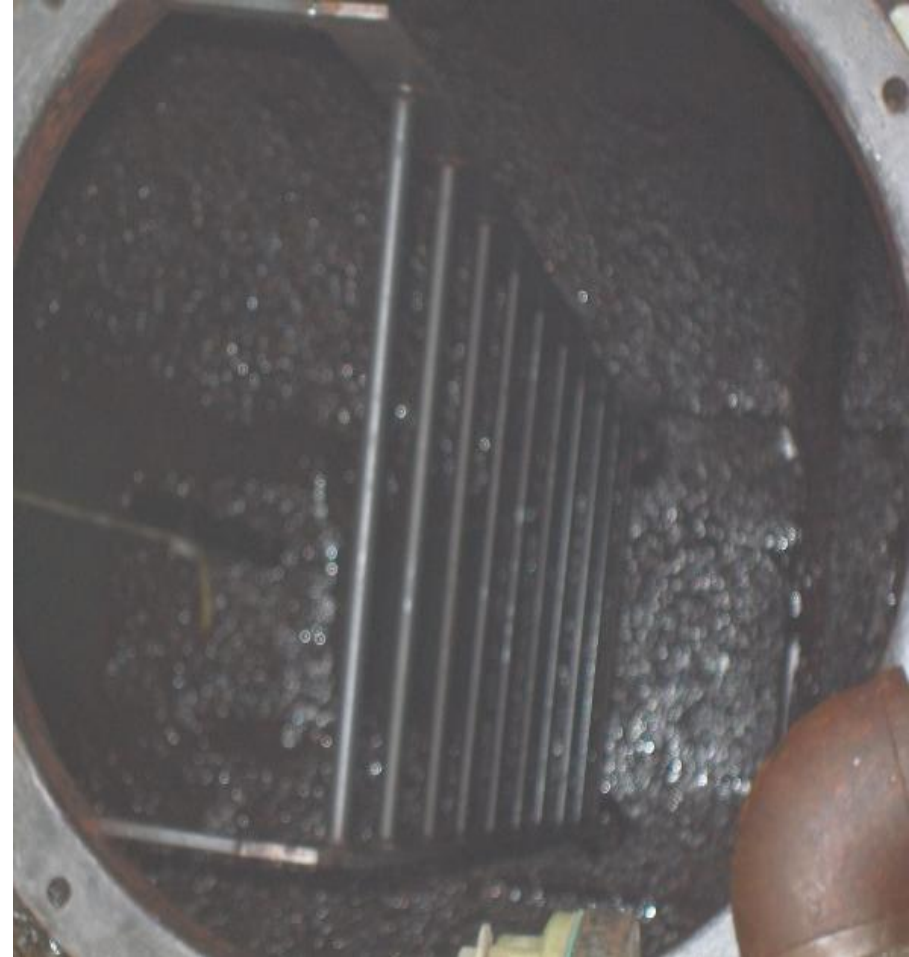
- Stability additives -- prolongs fuel life, limits oxidation/degradation and metal interaction reactions;
- Corrosion inhibitors -- protects metal in fuel systems;
- Conductivity improvers – lessens static electricity, prevents fires/explosions;

Fuel Additives – Are They Necessary?

- Lubricity improvers – provides needed lubrication in diesel injection systems;
- Biocides – preventive use minimizes bugs which may lead to corrosion;
- Anti-foulant additives – counteract fuel degradation & contaminant inter-actions that lead to filter/injector plugging
- Additives generally added at terminals
- May get “used up” along the way

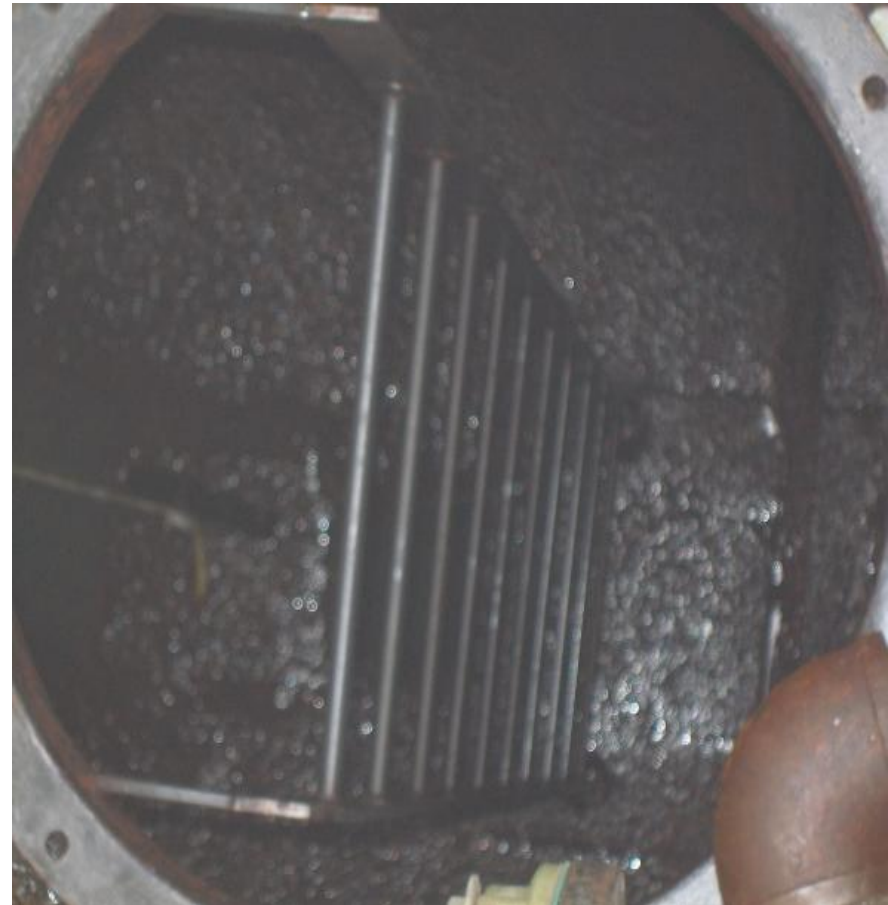
Fuel Degradation

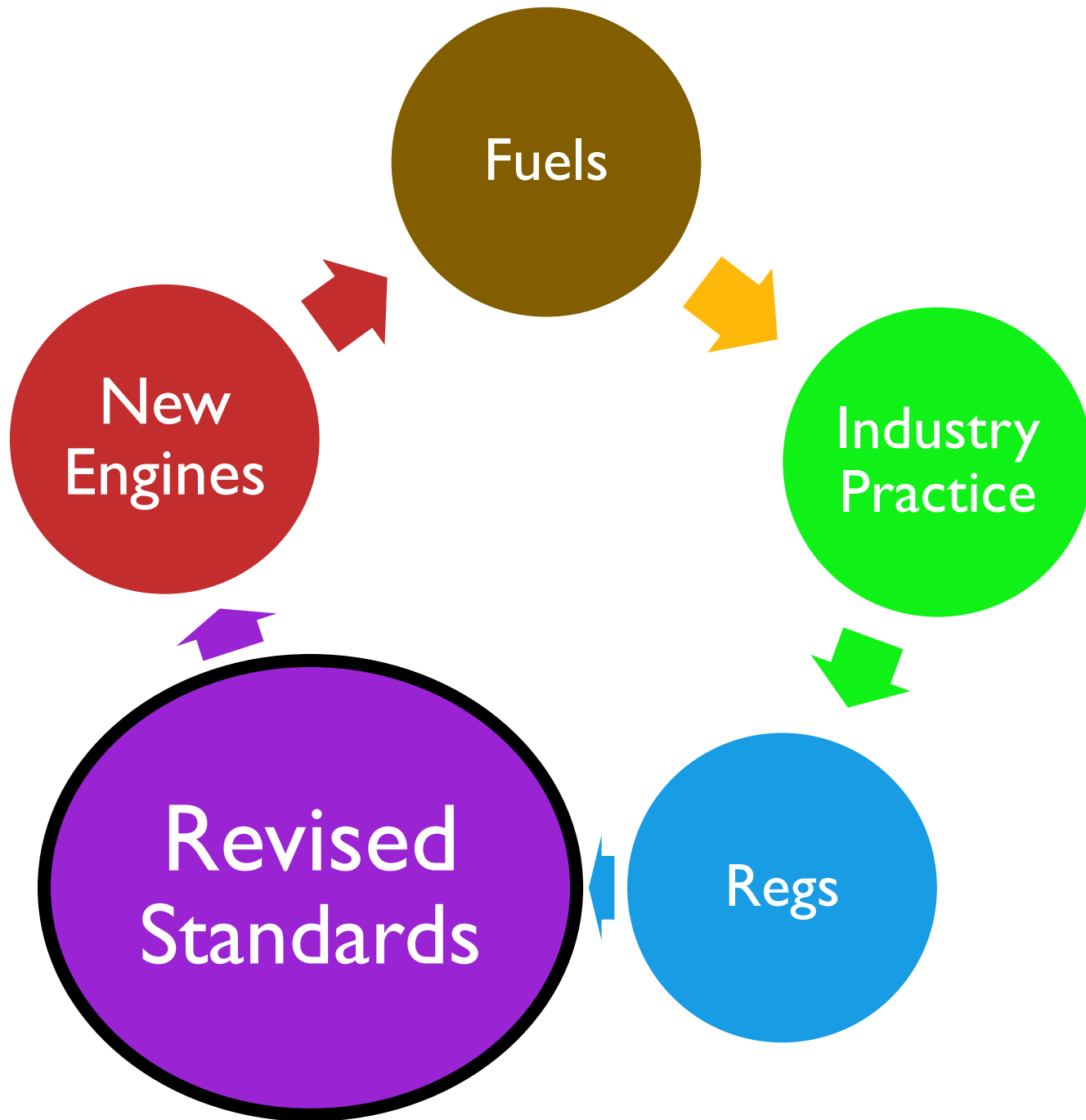
- All fuel tends to degrade in storage (this is normal) – degradation causes some fuel contaminants. Use of stability additive slows the degradation process;



Fuel Degradation

- Water is fuel's enemy and must be managed – it carries contaminants that can lead to bug problems and corrosion; fuel filter and injector deposit issues.





ASTM International - American Society for Testing and Materials

- ASTM is the primary organization in the US for developing fuel standards
- Other international organizations exist in Canada, Europe (ISO, BSI, etc.)



Designation: D 4625 – 92 (Reapproved 1998)

An American National Standard



Designation: 378/87

Standard Test Method for Distillate Fuel Storage Stability at 43°C (110°F)¹

This standard is issued under the fixed designation D 4625; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or approval.

This test method was adopted as a joint ASTM/IP standard in 1986.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers a method for evaluating the inherent storage stability of distillate fuels having flash points above 38°C (100°F) and 90 % distilled points below 340°C (644°F).

Note 1—ASTM specification fuels falling within the scope of this test method are Specification D 396 grade Nos. 1 and 2, Specification D 975 grades 1-D and 2-D, and Specification D 2880 grades 1-GT and 2-GT.

1.2 This test method is not suitable for quality control testing but, rather it is intended for research use to shorten storage time relative to that required at ambient storage temperatures.

1.3 Appendix XI presents additional information about storage stability and the correlation of Test Method D 4625 results with sediment formation in actual field storage.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard information, see Notes 2-6.

2. Referenced Documents

2.1 *ASTM Standards:*

D 381 Test Method for Existent Gum in Fuels by Jet Evaporation²

D 396 Specification for Fuel Oils²

D 975 Specification for Diesel Fuel Oils²

D 2880 Specification for Gas Turbine Fuel Oils²

D 4057 Practice for Manual Sampling of Petroleum and

Petroleum Products³

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *adherent insolubles, n*—gums formed during storage which remain tightly attached to the walls of the vessel.

3.1.2 *filterable insolubles, n*—solids formed during storage which can be removed from the fuel by filtration.

3.1.3 *inherent storage stability, n*—of mid-distillate fuel—the resistance to change in storage in contact with air, but in the absence of other environmental factors such as water, or reactive metallic surfaces and dirt.

3.1.4 *total insolubles, n*—sum of the filterable insolubles plus the adherent insolubles.

4. Summary of Test Method

4.1 Four-hundred millilitre volumes of filtered fuel are aged by storage in borosilicate glass containers at 43°C (110°F) for periods of 0, 4, 8, 12, 16, and 24 weeks. After aging for a selected time period, a sample is removed from storage, cooled to room temperature, and analyzed for filterable insolubles and for adherent insolubles.

5. Significance and Use

5.1 Fuel oxidation and other degradative reactions leading to formation of sediment (and color) are mildly accelerated by the test conditions, compared to typical storage conditions. Test results have been shown to predict storage stability more reliably than other more accelerated tests. See Appendix XI for information on the correlation of test results with actual field storage.

5.2 Because the storage periods are long (4 to 24 weeks), the test method is not suitable for quality control testing, but does provide a tool for research on storage properties of fuels.

5.3 Because environmental effects and the materials and nature of tank construction affect storage stability, the results obtained by this test are not necessarily the same as those

¹This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.14 on Stability and Cleanliness of Liquid Fuels.

Current edition approved Aug. 15, 1992. Published October 1992. Originally published as D 4625 – 86. Last previous edition D 4625 – 86.

²Annual Book of ASTM Standards, Vol 05.01.

³Annual Book of ASTM Standards, Vol 05.02.

Consensus Organizations

- Members work together to produce Fuel Specifications such as ASTM D975 for diesel fuel and ASTM D4814 for gasoline.
- Standard Test Methods (STM's) are needed so testing for properties is done consistently
 - D7548 STM for Determination of Accelerated Iron Corrosion in Petroleum Product
- Majority vote required, and all concerns and negative votes are thoroughly discussed.
Consensus process can be lengthy!

ASTM Ethanol Standards

- Fuel grade ethanol must meet ASTM standard D4806
- Mid-level ethanol, 51% - 83% D5798



ASTM Requirements

- ASTM requirements intended to be met at terminals
- A few have discussed developing standards for fuel as it is to be used
- New proposals emphasize industry practice:
 - A good industry practice is to drain any free water from a storage tank before the fuel is transferred further

Water and Sediment Limits

- D975
 - Diesel fuel shall be visually free of undissolved water, sediment, and suspended matter.
 - Max 0.05% dissolved water & sediment
- 4806 Ethanol
 - Visibly free of suspended or precipitated contaminants (clear & bright)

Cleanliness Emphasized

- **One proposal to update informational language on water and sediment states,**
 - **“Water is virtually everywhere and exists in multiple forms from solid, to liquid, to vapor”**
 - **“it is critically important that fuel be as free from water (and particulates) as possible prior to its introduction into the engine’s fuel system.”**

ASTM D975 Appendix

- Available fuel additives can improve the suitability of marginal fuels for long-term storage and thermal stability, ...
- Most additives should be added at the refinery or during the early weeks of storage to obtain maximum benefits.

ASTM D975 Appendix

- Biocides or biostats destroy or inhibit the growth of fungi and bacteria, which can grow at fuel-water interfaces to give high particulate concentrations in the fuel. Available biocides are soluble in both the fuel and water or in the water phase only.
- Contamination levels in fuel can be reduced by storage in tanks kept free of water,

Factors Affecting Water & Sediment

- **Temperature**
 - Water drops out at higher temperatures
 - Sediment can also form at different temps
- **Humidity**
 - Biofuels absorb water from air

Factors Affecting Water & Sediment

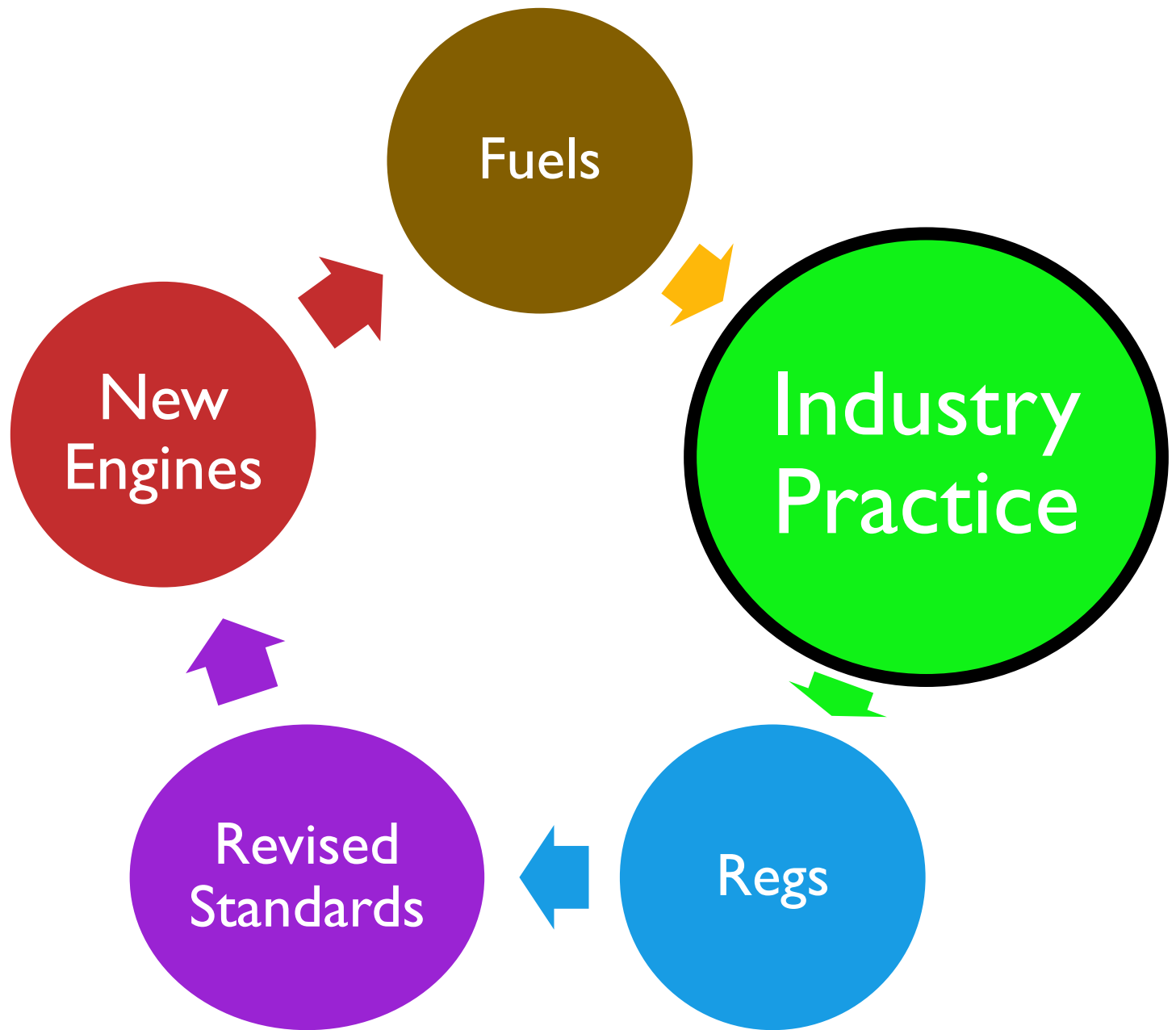
- As fuels age, degradation occurs and sediment forms



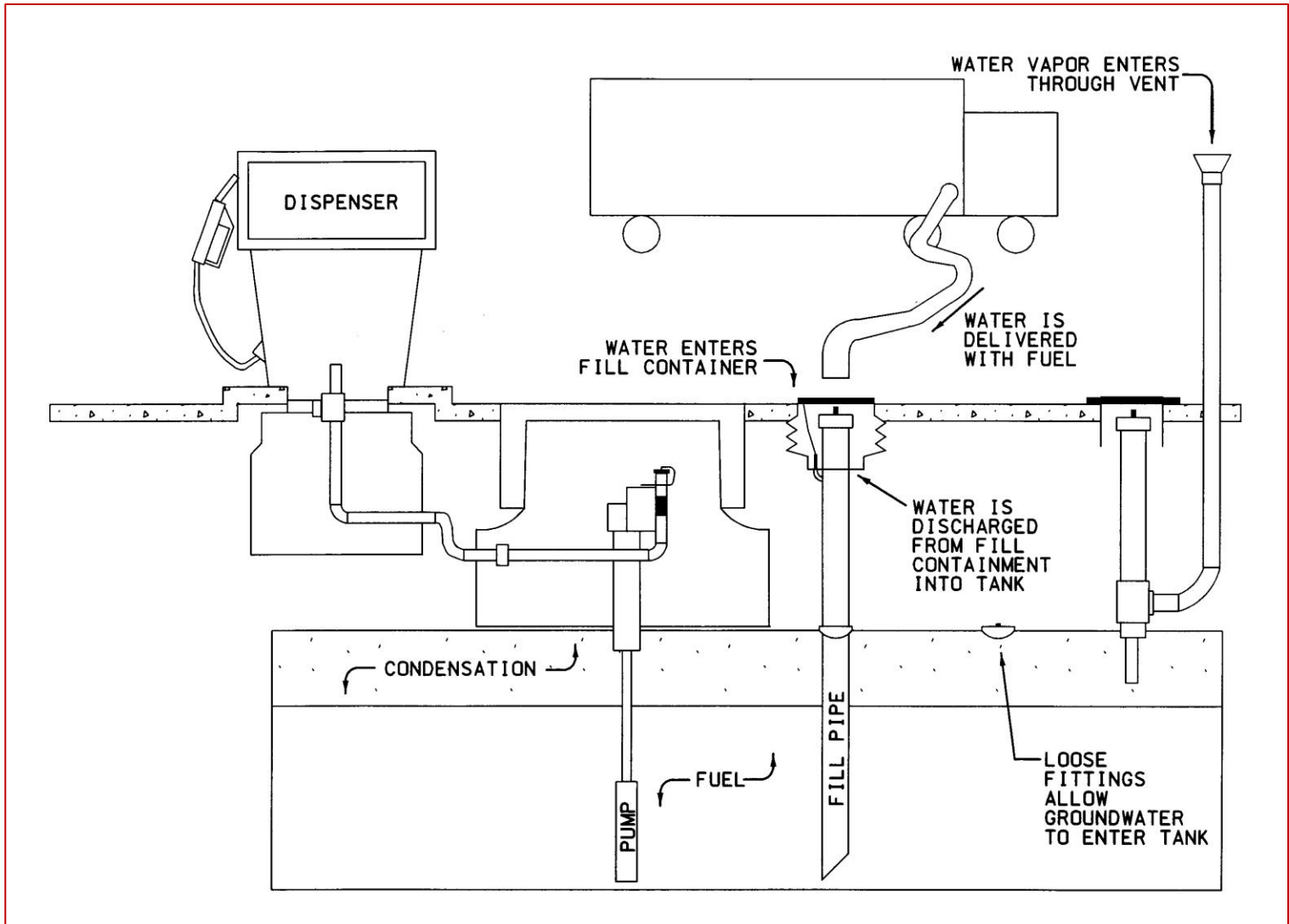
Monitoring Water in Fuel Tanks

- Operations and maintenance procedures for water monitoring and removal have been a recommended practice for over thirty years.





STI's Recommended Practice R I I I



STI R I I I , Storage Tank Maintenance

- Recordkeeping
- Changing Fuels
- How to Monitor Tanks
- How to Remove Water and Contaminants
- Change of Service
- Checklist

Today's Factors Affecting Tank Maintenance

- Common installation and maintenance procedures contribute to water accumulation:
 - Open vents
 - Low fill areas
 - Sloped tank installations



Today's Factors Affecting Tank Maintenance

- Water enters tanks through spill buckets



Microbial Contamination

- Reddish, scaly, gritty deposits: corrosion and/or silt in tank
- Black or brown deposits: water contamination has degraded the fuel
- Sludge build-up in tank bottom can be caused by the breakdown of the fuel itself.



Microbial Contamination

- As microorganisms grow and thrive, they form a slime
- Over time, sludge is formed from the slime
- Clogs may not be visible, unlike mold growth
- Sludge breaks off and clogs fuel filters and small openings throughout entire system

Microbial Activity Warning Signs

- Short filter life or flow slowed to 3-5 gpm
- Erratic tank gauge readings
- Frequent replacement of valves, hoses, etc.
- Rotten-egg odor from digestion of fuel by microorganisms
- Chemically-altered fuel components attack:
 - Rubber
 - Fiberglass reinforced plastic
 - Tank linings & coatings
 - Metal



Contamination

- Contaminants like salts in water may:
 - Degrade fuel chemical structure, yielding substances detrimental to system components
 - Cause fuel additives to leave fuel and enter water



Monitoring Tanks: All Fuels

- Inspect tanks at least monthly
- Check for water as often as possible
- If 1 inch+ water is present, must be removed within 30 days
- Best monitoring: automatic tank gauging (ATG) system
 - Some floats may not work with alcohol fuels
- Simpler, less expensive: appropriate water paste on gauge stick
- Water-sensitive filters and watch for slow fueling

Monitoring Tanks: Ethanol

- When ethanol's water absorption capacity is reached, excess water separates, causing two distinct layers of product:
 - Top layer: lower octane gasoline, possibly out of spec
 - Bottom layer: ethanol/water mix, dispose of
- Resulting water bottom:
 - Allows microbes to proliferate
 - Storage system exposed to ethanol concentrations greater than 10%

Monitoring Tanks: Ethanol

- The bottom line for storage systems and ethanol:
 - Clean the tank system before introducing ethanol blended fuels
 - Monitor frequently for water and contaminants
 - Promptly remove water and contaminants from tank when identified

Monitoring Tanks: Biodiesel

- Material incompatibility with both diesel & biodiesel fuels:
 - Brass, bronze, copper, lead, tin or zinc oxidize and create sediments, leading to clogged fuel filters
 - Pure biodiesel (B100) or blends higher than B20 cause problems with rubber seals, gaskets and hoses—use biodiesel resistant materials



Monitoring Tanks: Biodiesel

- Higher concentrations = reduced stability
- Use biodiesel within lifetime
- The bottom line for storage tanks and biodiesel:
 - Check for compatibility (steel is compatible)
 - Clean tanks before introducing biodiesel fuels
 - Monitor frequently for water and contaminants
 - Promptly remove water and contaminants from tank when identified

Monitoring & Detection Methods

- Tank bottom sampling
 - “Bacon bombs” collect samples from tank bottom
- Fuel filters
 - Use water absorbing filters to detect slowed fuel dispensing; filters expand when absorbing water

Monitoring & Detection Methods

- Fuel samples from nozzle
 - Visual evaluation by examining fuel caught in clear glass container



Monitoring & Detection Methods

- Use recommended inspection and maintenance schedules
- Daily monitoring of tanks with ATGs and water level sensors
 - If gauge shows water one day but not the next, may indicate water has been absorbed into ethanol-blend or biodiesel fuel
 - If ATG records are inconsistent, test with water paste or bottom sample
- If one inch or more of water is found, it must be removed within 30 days.

How to Remove Water and Contaminants from Storage Tanks

- Multipoint water pumping
- Fuel filtration/polishing
- Non-entry tank cleaning
- Physical entry tank cleaning
- Dispose of tank bottom water properly

Preparing Tanks for Changes in Fuel Storage

- Changing between gasoline and diesel fuels
 - Tank and related dispensing equipment must be thoroughly cleaned
 - Tank must be inspected and verified compatible with new fuel to be stored
 - Ensure gasoline is not commingled with any diesel product

Change in Service to Ethanol

- Ethanol acts as a cleaning agent: loosens any sludge, slime and scale already present in tank
- Therefore, tank must be cleaned before ethanol blended fuel is introduced



Change in Service to Ethanol

- Cleaning prevents excessive filter clogging and potential engine damage from contaminants



Change in Service to Biodiesel

- Problems with tanks that formerly held Number 2 diesel
 - Existing tank likely to have sludge & sediments
 - Biodiesel dissolves these sediments and carries them into vehicle fuel systems
 - Can rupture filters and clog fuel injectors
 - Tanks should be cleaned before switching to any biodiesel blend



RIII's monthly inspection checklist

- Inspect tanks monthly
- Checklist on pages 12-13 of RIII document
 - Covers all inspection recommendations
 - Your record of tank inspection and maintenance



Tank Number: _____
 Facility Name: _____
 Date/Time: _____

**Storage Tank System
Monthly Inspection Checklist**

	Yes	No	N/A
Tank visually inspected			
Piping visually inspected			
Monthly monitoring method for tank is performed			
Monthly monitoring method for piping is performed			
Operations and Maintenance Plan in place and is being followed			
Spill containment free of fuel, water and debris*			
Overfill alarm is operational			
Overfill prevention equipment is operational			
Normal vent(s) operational			
Emergency vent(s) lift freely			
Tank coating in serviceable condition			
Secondary containment is free of cracks, holes, tears, or other damage			
Secondary containment free of fuel, water, and debris*			
Concrete secondary containment coating is free of cracks, flaking, or other damage			
Secondary containment drain valve is closed			
Tank checked for water. Height in inches, if found:			
Interstice of double-walled tank checked for liquid. Height in inches, if found:			
If greater than 1" water found, water removed within 30 days.			
Regulated substance found in interstice of tank. Height in inches, if found: If measurable amount of liquid found, contact your service provider.			
Transition sump free of fuel, water and debris*			
Transition sump liner in serviceable condition. Transition sump sensor at proper height & orientation.			
Dispenser sump free of fuel, water, and debris*			

Storage Tank Maintenance R-111 12 July 2011

Inspection and Maintenance of Tank Systems – Need to Inform Others???

**STI Webinar of
December 18, 2013
Posted on line at
www.steeltank.com**



OTHER INDUSTRY RPS

- Clean Diesel Fuel Alliance
 - [Guidance for Underground Storage Tank Management at ULSD Dispensing Facilities](#)
www.clean-diesel.org
- Petroleum Equipment Institute
 - [RP900: UST Inspection and Maintenance](#)
 - www.pei.org
- US EPA
 - <http://www.epa.gov/oust/pubs/ommanual.htm>

STI On-Line *Tank Integrity Management*

- Establishes a basic knowledge of shop-fabricated steel storage tanks
- Review topical sessions
 - Tank Fabrication, AST Standards, Codes & Regulations, SP001 Inspection, Tank Integrity Management, Tank Maintenance
- Take a 10 question test on each unit
- Earn additional PDH's from home or office at your convenience
- Obtain *T I M* Certificate





Thank you!

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