The Effects of Additives on Metering in Liquid Pipelines
Class # 8160

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Overview of paper
With the release of Ultra-Low Sulfur distillates around the world several issues have come to the surface in handling the new fuels. This paper will give a brief history of the Ultra-Low sulfur fuels, the downside of Sulfur reduction, and the solutions to best handle the fuels.

History
Before 1993: All No.2 fuels were essentially the same. In 1993: USA EPA sets 500 ppm sulfur limit for highway diesel. The new fuel is called "low sulfur diesel" (LSD) to be clear. The high sulfur (> 500 ppm) is still sold for off-road fuel had to be dyed to mark the different fuels. This was at the same time but not to be confused with IRS tax plan (untaxed fuel red)!

In 2001, EPA issues final rule (on-highway) (40 CFR Parts 69, 80, 86) this rule sets PM, NOx, and NMHC limits on new engines starting in 2007. It requires refiners to start producing 15 ppm S fuel 6/1/06 (ULSD) and outlines a phase-in period. It set the rule that 80% of production must be ULSD, but 20% LSD OK until 6/1/10. It also establishes program for credits and credit banking & trading. All 2007+ model year diesel vehicles MUST be able to use this new fuel.

In 2004: EPA issues final rule (non-road) (40 CFR Parts 9, 69, etc). Various emission rules for various engine sizes/classes are set. It requires every terminal to register with the EPA by 12/31/05. The new rule sets sulfur limits

• On off-road diesel fuel 6/1/07 to 500 ppm max for non-road, locomotive, and marine
• 6/1/10: 15 ppm for non-road diesel, excluding locomotive & marine
• 6/1/12: 15 ppm for all NRLM diesel fuel

The new rule makes marker required in heating oil and regulates marker choice, point of addition, etc.

In 2004 the ASTM adds lubricity requirement to diesel spec. ASTM D975-04b sets 1/1/2005 as effective date and CARB lubricity specs match ASTM’s

USA Time line for ULSD

• 1/1/05: ASTM lubricity standards go into effect
• 12/31/05: Terminals handling diesel must register with EPA
• 6/1/06: 15 ppm limit on highway diesel (with phase-in rules)
• 6/1/07: 500 ppm limit on non-road diesel, locomotive, marine
• 6/1/10: 15 ppm limit on high-road diesel (except locomotive & marine)
• 6/1/10: 15 ppm limit on highway diesel fully implemented
• 6/1/12: 15 ppm limit on all non-road diesel, locomotive, marine
What's Been Going on Outside USA?
In Europe the use of ULSD has been going on for several years all ready. Some of the European countries are well ahead of this schedule. Note that the lubricity spec is stricter than the USA spec.
- 1996: 500 ppm sulfur limit in most countries
- 2000: 350 ppm (lubricity requirement added*)
- 2005: 50 ppm
- 2006: <10 ppm
Most other countries around the world are following suit with the producing ULSD and are requiring the fuel to meet the ASTM specs. I believe by the 2010 most all of the distillates produced world wide will be an ultra low sulfur fuel.

Downside of Reducing Sulfur in Fuel
There are many environmental advantages to lower sulfur fuels and that is the reasons for the new fuels, but there are some downsides to the new fuel. The Sulfur provides lubricity for the fuel and in turn lubricates the engines total fuel injection system including the fuel injectors and fuel pumps.

Revised ASTM Diesel Spec for Lubricity
ASTM D 975-04b sets a wear limit for diesel fuel. The HFRR (High Frequency Reciprocating Rig) Test (D6079) oscillates a steel ball against a plate immersed in test fluid. The test allows for Max wear scar diameter of 520 microns. The test predicts failure in fuel injectors, pumps, etc.
Different refineries around the world have fuels do have different lubricity but almost no ULSD (15 ppm) produced will meet the ASTM lubricity specs. The solution is to add a lubricity additive to the fuel bringing the lubricity to the ASTM required levels.

The Need for Conductivity Improver
Along with removing the lubricity the conductivity of the ULSD fuel becomes reduced. This can cause safety issues in loading tank trucks and static discharge issue handling the fuel. The distillates are typically sent up the pipeline have some conductivity from refinery. But the safety issues at the terminals require a higher conductivity reading than received on the pipelines. Conductivity is measured in units or pS/M. The typical accepted safe range for truck loading is 50 pS/M and the typical range for jet fuel is 125 – 425 pS/M. Many terminals all ready have systems in place for adding the conductivity additive to the distillates, but they need to be reviewed now with the ULSD fuels.

How Is Lubricity Improver to be Added?
The options are add it at the refinery before sending it to the terminal, adding it upon receipt of product at the terminal, adding it at the product header out of storage to the load rack or adding it at the truck loading rack

Option 1 – Addition at the Refinery
This seems the simplest and least costly solution to add the lubricity additives to the fuels. But there are several issues that make this choice very unpopular. If the additive is added at the refinery, it does its job in the pipeline and a portion of the additive gets used up before it reaches the terminal. This means either over-treatment at the refinery or re-treatment at the terminal to get the fuels lubricity back to spec. Even a bigger issue is Trail-back.

Lubricity improver Trail-back issue, contaminating jet and other products
Many of the lubricity additives are surface-active materials. They work by bonding to metal surfaces Pipelines present miles of metal surfaces. Fear is that the additive will be lost to the pipe walls Of course Loss of lubricity performance in the diesel but the big questions is where will the additive go and that it will contaminate jet. Most of the USA pipelines have set the policy not to allow lubricity improver in their pipeline.
Option 2 – Additize Going to Storage

Injecting the lubricity additives as the product goes into the storage tank eliminates trail-back issues. This method gives you a relatively low cost for equipment. You can sample tanks, analyze, take action if needed. The issue of possible additive loss in storage is still present but minimized.

Drawing Pipeline to Tankage Injection System

Option 3 – Additize Going to Rack

Injecting the lubricity additives as the product goes from the storage tank to the loading rack eliminates trail-back issues. This method gives you a relatively low cost for equipment. The drawback is all loading depends on proper injection. If the system malfunctions the load rack is shut down. Multi arms and low flow start/stops can cause a wide variations in flow rates (measurement and control turndown). This makes accurate injection ratios to be trickier to maintain.
Option 4 – Additize at the Rack

Adding the Lubricity additive at the load rack certainly eliminates the trail-back issues but requires one injector for each load arm thus resulting in adding cost for the equipment. This method is the most flexible and with a injector malfunction would only shut down one load spot. Although it would require more injectors the overall cost of the installation may be less expensive if the infrastructure for additive injectors is already at the load rack. It may be as simple as just adding injection blocks to existing injector panels.

Load Rack Injection System Drawing
Which Injection System is best for you?

There is a series of questions you must ask to determine which of the 4 system designs will work best for you.

1. The first question would be what products will share the same pipeline or delivery method to the distribution terminal. If it is just a short distance of pipeline and no jet fuel will be shipped the first option of putting it in at the refinery may work. If your answer is a long distance or yes jet fuel might follow the ULSD with lubricity additive, injecting it at the refinery is probably not a good option.

2. Will all of your ULSD require the lubricity additive in the same concentration?

3. Do you have a spot at your receiving manifold that is common to all receipt of ULSD?

4. Do you have a barrel counter or custody transfer meter on the incoming pipeline to pace the injection process? If not sometimes a insertion turbine meter or strap on ultrasonic meter is used to pace the injection.

5. Some times it is possible go without a pacing meter if the pipeline flow rates are somewhat constant. Typically a pipeline keeps a near constant flow rate. If this is the case it is possible to run the Injector in a self paced mode. In this mode the injection becomes time based and starts and stops on detection of flow via flow switch. If your product is delivered via ship or barge, typically the flow rate will change substantially and a self paced mode is not recommended

6. If you answer yes to #2 #3, #4, #5 than the option to inject as the ULSD comes off the pipeline into tankage is a good choice.

7. Do you have a single common header from tankage to the load rack for ULSD? If you have more than one product (ULSD #1, ULSD #2, fuel oil and off road diesel you would require one injection system for each line. This would probably not be a good choice. If you have only On the road USLD and less than 3 load arms delivering diesel fuel option $3 may be a good choice. You will still need to install a pacing meter in the lines to the load rack.

8. Do you all ready have an injection control system and interface at the load rack?

9. Do you have electronic presets/TAS monitoring and controlling additive injection? Using existing interface and adding just injector panels is a good choice for the addition of lubricity additives

10. Do you need to measure the concentration of additive for each truck and include it on the BOL? Do you want to stop loading if additive concentration in not correct? If you need to report additive concentration by truck load the only choice is to inject the lubricity additive at each load arm

Conductivity Injection Similarities to Lubricity Injection Systems

Both lubricity additive and conductivity additive are commonly added to the ULSD products at the terminals. Both are sometimes added by all of the 4 injection point choices. The most common point for conductivity additive injection of USLD is option #2 (as is goe into the terminal storage tanks). The Lubricity additive injection points are commonly 50/50 with Option #2 and option #4 (at each load arm). So the style of equipment and interfacing to the terminals are very close for both lubricity additive and conductivity additive.

Conductivity Injection Differences to Lubricity Injection Systems

- Lubricity additive in commonly injected at 50 – 350 ppm. Conductivity additives are commonly added to the ULSD products at 0.5 to 3 PPM. The smaller injection ratio results in smaller storage tanks, smaller pump systems and sometime dilution system to increase the accuracy of injection.
- Some of the Lubricity additives are intolerant to low ambient temperatures and may require special winter blends or heat tracing of the lines to insure proper operation of the equipment.
- There are a few inline conductivity analyzers that can provide real time conductivity information. Although they may more than $10,000 they are very accurate and dependable. On the other hand, I know of no practical way to measure the lubricity in line.
**Feedback Controlled Conductivity Injection Systems**

Many of the installed conductivity injection systems are without feedback and require manual adjustment to dosage ratios. Where it is critical to control the conductivity of the ULSD or Jet fuel to both low and high limits, a feedback control system is often provided. In the Feedback conductivity control system, an inline analyzer is required. The additive ratio is changed on the fly to bring the signal from the inline analyzer to the desired set point. This style of system is most commonly placed near a large pipeline for terminal receipts or in the header line to the load rack.

**Can you combine the Lubricity Injection system with the Conductivity Injection system?**

A common question is can I combine the lubricity additive and conductivity additive into one cocktail and inject it together. This is not uncommon if the ratios of conductivity additives do not change with the seasons. If you need more of one of the components during the cold winter time you may have to increase the dosage of the cocktail resulting in an unwarranted extra cost of the second component of the cocktail. Check with your additive supplier to see if they can give you a premix cocktail of Lubricity additive and conductivity additive.

**Equipment Selection**

There are several terminal operational issues that need to be answered before selecting the right equipment.

1. How much “backup” does your terminal require?
   a. Do you need dual pumps with hot backups?
   b. Do you need multiple injectors for system backup?
2. Do you need level monitors on the tanks to ensure you do not run out of additive?

**Chemical Storage Tank Selection**

1. The size determined by product throughput, the desired refill schedule and additive purchase volumes.
   a. First calculate the daily additive usage at the terminal
   b. Extend out the daily usage to refill schedule
   c. Make sure there is room in the tank to receive a complete load of additive. If you buy a partial load the cost per volume will be much higher.
2. Depending on the intended location of the storage tank you may need to specify a double wall or single wall tank. If you are placing the tank in an existing containment area you will probably not need a double wall tank.
3. Make sure all of the safety fitting meet the local fire codes
4. Optional Gauging and level monitoring

**Additive Pump System Selection**

To determine the best pump size I recommend calculating the maximum injector flow rate at a single time (number injectors X individual flow rate) and multiplying time 2 for the pump size. Having extra pump capacity is not a bad thing when dealing with additives. If you need a back up pump system a Dual pump skid is recommended. They often have the ability to start the second pump automatically if the first pump cannot deliver the required injection pressure. A Mag-drive pump system reduces the risk of leaking pump seals causing a spill incident.
**Additive Injector Panel Selection**
There are 3 styles of injection panels used for adding Lubricity and conductivity additive to the ULSD.

The most common is the traditional pulse injector that injects the same size injection with the frequency of injection changing product flow rates. 95% of all of the detergent additives use this style of injection panels. So selecting this style of injector keeps the spare parts to a minimum at your terminal and keeps the maintenance team from having to learn new equipment.

An injector I call the turbine driven injector is sometimes used for applications without large changes with flow rates. The TDI requires no external power, can handle multiple additives with combined ppm’s from 0.25 to 2500, and can provide good accuracy.

The third style of injector is really not an injector but a blender with continuous blending of the additives with the fuels. This is sometimes required for high flow requirements such as high ppm lubricity additive into a large pipeline. On the other end of the spectrum is the very low flow continuous blender. This technology is brand new but capable of blending conductivity additives continuously into a pipeline resulting in better feed back control.

**Summary**
ULSD is real, and so is the need for lubricity and conductivity additives. There are several choices of architecture for the both additives injection systems. Each terminal or pipeline operator, if they do not all ready have a system installed, will in the future probably need to add these systems. With the information in this paper, you should have the basic information to make the right choices.