



ULSD Operational and Quality Issues

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Opening: Good afternoon. It's a pleasure to be with you today and have an opportunity to discuss some of the issues related to the production and distribution of ULSD. Mary Welge called me a few months ago and asked that I share some thoughts on this subject at this conference based on some things we have identified in the course of our working with various clients preparing to produce and ship ULSD.

So this paper will give a sort of status report, from my perspective, on the preparations being made by the industry as we approach the June 2006 scheduled launch of this new product.



Turner, Mason & Company

- ◆ Engineering/management consultant to petroleum downstream industry for over three decades.
- ◆ Extensive work on clean fuels issues for individual companies as well as industry groups/associations.
- ◆ Studies of lead phase-out, RVP, sulfur reductions and RFG in the gasoline area.
- ◆ Several diesel studies including sulfur reductions, CARB diesel and current ULSD program.

Slide 2: But first, let me tell you a little bit about Turner, Mason & Company and the background we bring to this subject. TM&C is a professional engineering/management consulting firm specializing in the petroleum downstream industry. The firm was formed in 1971 and consults in the RMT or refining, marketing and transportation segments of the business.

Over the past three-and-a-half decades, we have done quite a bit of work in the clean fuels area. Engagements have ranged from industry and governmental agencies evaluating new policy to individual companies trying to figure out what investments will be necessary and how to comply with a steady progression of new transportation fuels specifications. We also consult with companies that have compliance issues or are looking to avoid compliance problems down the road. We also served as independent auditors for the RFG gasoline baseline program as required by EPA and, through an arrangement with a CPA firm, offer attestation services for the gasoline program.

Studies by our firm go back to lead-phase down and eventually the phase-out of lead anti-knock compounds in motor gasoline. We also worked on volatility reduction, RFG and, more recently, Tier 2 gasoline.

In the diesel area we worked on the initial sulfur reduction to 500 ppm in 1993, CARB diesel a few years later and the current ULSD program.



Recent TM&C ULSD Work

- ◆ Downstream surveys/studies since 2003 regarding issues facing refiners, shippers, terminals and others in distribution system.
- ◆ Over two-thirds of U.S. refining industry capacity participated in our studies.
- ◆ Scope of four studies included supply/demand for ULSD, production plans, capex, etc.
- ◆ Surveyed plans of refiners, shippers and terminal operators in 2003 and 2004.

Slide 3: In the ULSD area, we have conducted a number of surveys and studies in the past 2½ years covering the decisions to be made and plans of refiners, shippers, pipelines, terminal operators and others along the distribution chain.

Over two-thirds of the U.S. refining industry capacity participated in our studies of refining options and plans in 2003.

In the four studies we have completed since 2000, we have looked at the supply and demand for ULSD over the next several years, the production plans of U.S. refiners facing large capital expenditures right on the heels of similar expenditures to produce ultra-low-sulfur gasoline and an assessment of capital spending options and operating moves available to refiners seeking to minimize the cost of production.

Our latest studies, which were conducted in 2003 through early 2005, included independent studies and surveys of the plans of key players in the production and distribution network.



Current Status of ULSD Preparations

- ◆ U.S. refiners are well along with plans/implementation to produce ULSD by 2006.
- ◆ Supply capabilities will be far greater than forecast demand in 2006-2010, the Temporary Compliance Option (TCO) period.
- ◆ Major pipeline systems have been working with shippers and terminal operators to define distribution system issues for the past year or more – but are not as advanced in their preparedness as the refineries.

Slide 4: U.S. refiners are, for the most part, into the **implementation stage** of projects to produce ULSD. There are a few stragglers that have sister facilities with large enough projects that enable them to delay expenditures and a couple of smaller facilities whose disposition regarding a sale were uncertain so decisions have been delayed, but these a few and far between.

We estimate that projects already in the implementation stage at U.S. refineries will provide ULSD production capacity that far exceeds the “real demand” for this product in the first five years, the Temporary Compliance Option (TCO) period. In fact, our surveys indicate that U.S. refiners will have capacity to produce in excess of 95% of their diesel pool as ultra-low-sulfur product.

The major product pipelines have been working vigorously since the ULSD program was finalized to try to define their individual needs and sort through the myriad of issues associated with handling this unique product, but they are not generally as advanced in their preparedness as refiners.



U.S. Refining Industry Plans

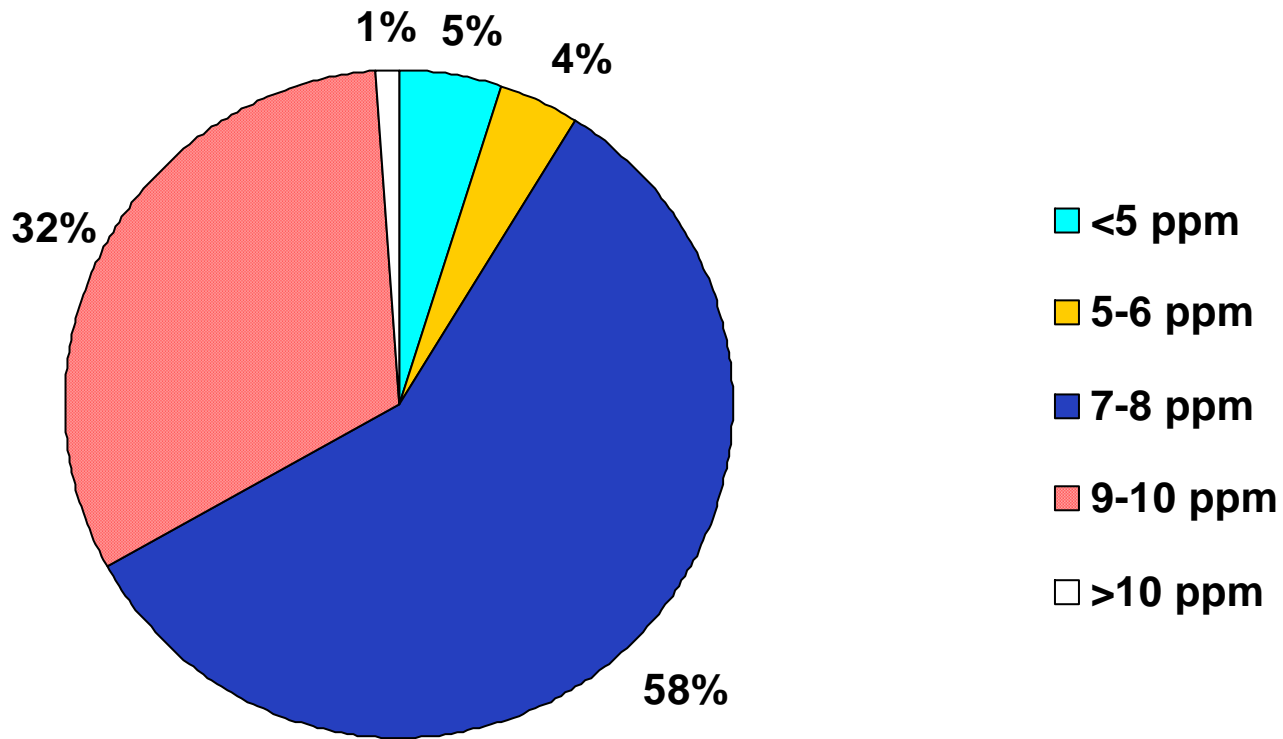
- ◆ **Planned ULSD capacity by June 2006 is >2.5 million BPD.**
- ◆ **More than one-third of refineries we surveyed who plan to produce ULSD are pre-investing in capacity for ULS off-road diesel.**
- ◆ **90% of the refineries we surveyed have designed HDS units to produce ULSD with 7-10 ppm sulfur.**

Slide 5: We estimate that the capacity to produce ULSD in the U.S. will be greater than **2.5 million BPD** in the first month of the program.

And, more than **one-third of the refineries we surveyed** that plan to produce ULSD are **preinvesting in capacity for ULS off-road diesel**. Often, this makes sense due to the lower incremental cost of additional capacity and the synergies associated with doing the projects simultaneously.

90% of the refineries that participated in our surveys have designed HDS units to produce ULSD with a sulfur content of between 7 and 10 ppm.

What Sulfur Level Will Be Produced at Refineries?*



* As measured at distillate HDS unit outlet.

Slide 6: This slide shows this graphically. Over 50% of the refineries in our surveys are constructing units to produce ULSD in the 7-8 ppm sulfur range. Almost one-third have designed projects to produce 9-10 ppm sulfur content ULSD. A very small number of plants are designing units to produce ULSD with more than 10 ppm sulfur. These plants are unique and are very close to retail sites such that contamination downstream of the refinery is not an issue.

A few plants will be capable of producing less than 7 ppm sulfur ULSD. These are refineries equipped with hydrocrackers, and many of these reside in California.

Slide 7: Let's take a look now at total U.S. highway diesel demand, how this demand breaks down regionally and where the production comes from.

Total highway diesel demand was ~2.4 million BPD in 2003.

As you can see here, most of this demand is in PADD I and II – in the Northeast and Midwest, respectively. Note that 711 MBPD of demand is in PADD I and 770 MBPD is in PADD II. Almost half of the production is in PADD III, however, which included the U.S. Gulf Coast. So very large volumes of material must be moved from PADD III refineries to make up the shortfall in production, especially in PADD I and, to a lesser extent, in PADD II.



ULSD Supply and Demand

- ◆ **“Real” demand for ULSD**
 - » **Government fleets**
 - » **Special applications**
 - » **Mandated retrofits**
 - » **New 2007+ engines**

- ◆ **Little “real” demand for ULSD in 2006**

- ◆ **EPA has mandated 80% of on-road diesel supply be ULSD by June 2006.**

- ◆ **ULSD “real” demand projected to be ~25% of all on-road diesel when the TCO period expires in 2010 and 50% by 2015.**

Slide 8: Real demand for ULSD comes from the following sources:

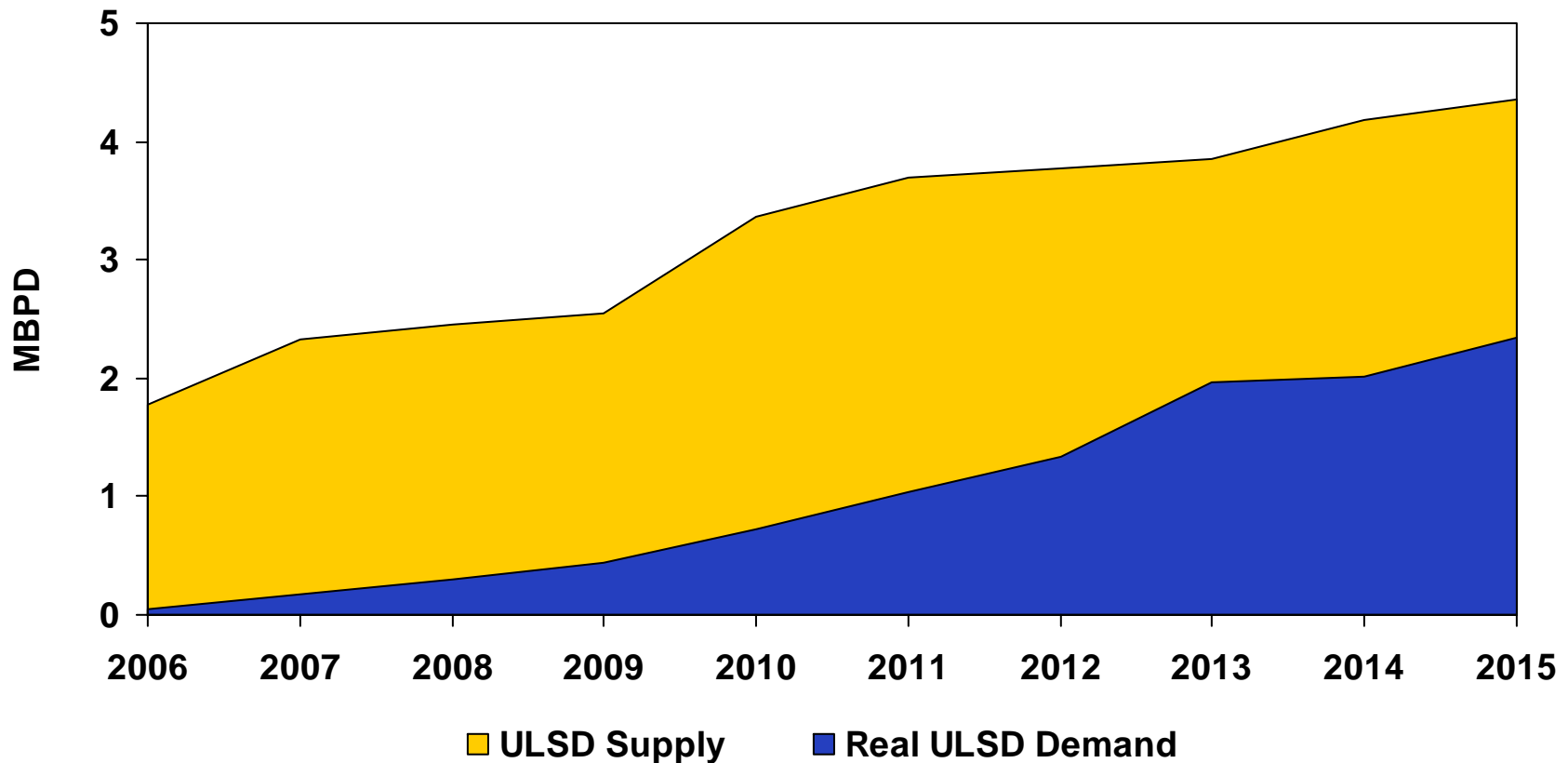
- Government fleets;
- Certain special applications that will require ULS product;
- Mandated retrofits; and
- Of course, the new engines that the program is designed around that begin coming out in 2007.

There is almost no real demand for ULSD in 2006.

EPA is requiring, however, that refiners produce 80% of highway diesel as ULSD beginning in June 2006.

As fleet turnover of the newer diesel engines advances, we estimate that the real demand for ULSD will grow to about 25% of all highway diesel consumption by the end of the TCO period in 2010. And to 50% by 2015.

Expected ULSD Demand vs. ULSD Supply



Slide 9: This slide illustrates this graphically. The gold portion denotes our estimate of ULSD supply, and the blue portion is what we call real ULSD demand. Note that in the early TCO period years we have estimated how much ULS product will be produced given the option to produce up to 20% of highway diesel as 500 ppm sulfur material.

Step changes occur in 2007 when off-road diesel must be ULSD and in 2010 after the TCO period ends.



Refiners Have Few Alternatives to ULSD

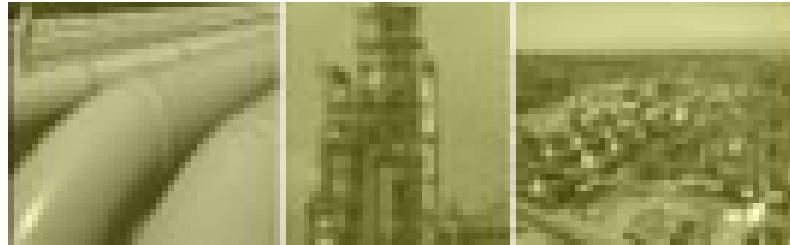
- ◆ Heating oil is a viable alternative for PADD I facilities.
- ◆ Off-road diesel, which EPA will lower to 500 ppm in 2007 and 15 ppm in 2010 and later, is the dominant HS distillate outside PADD I.
- ◆ The nature of the supply chain dictates some off-road demand will be supplied “on-road quality” product.
- ◆ Loss of fungibility between heating oil and off-road diesel will limit or eliminate HS diesel supply in certain regions.

Slide 10: Refiners really have very few options to producing ULSD. PADD I and PADD III refiners have the option to produce some heating oil. But total demand for heating oil is about 20% of the total distillate pool, and this amounts to less than 1 million BPD.

Off-road diesel demand amounts to about 400 thousand BPD in the entire U.S., and this product is scheduled to be ULS in 2010 with a transition step to 500 ppm sulfur in 2007.

Historically, refineries produced distillate products that were “fungible,” so many refiners didn’t even know the ultimate disposition of what left their facilities. Quite a bit of the product produced to highway diesel specifications was “downgraded” to off-road use. To some extent this is due to the limits of the distribution system, especially where off-road products were in small demand relative to highway diesel.

The loss of fungibility between heating oil and off-road diesel, beginning in 2007, may limit or in some cases eliminate HS diesel supply in certain geographic areas.



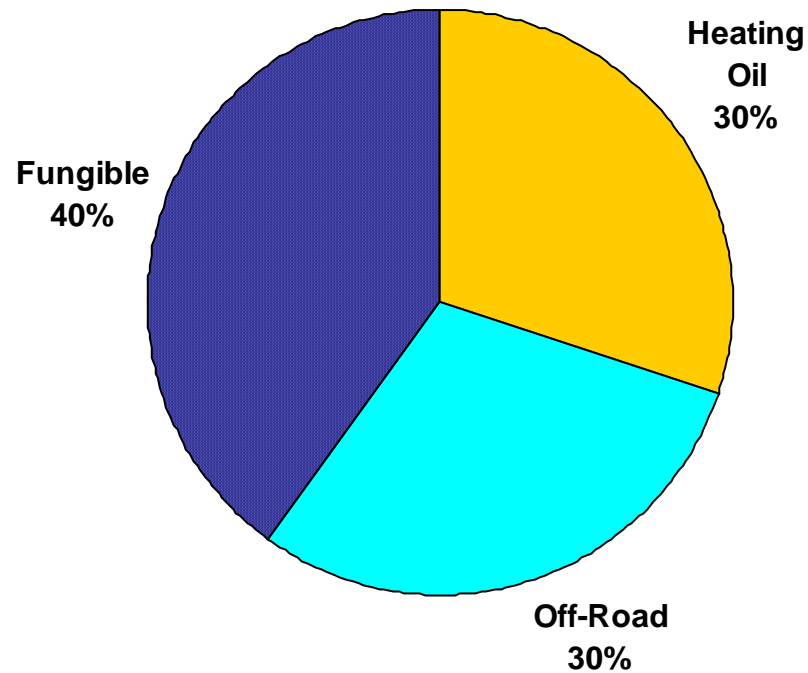
OPIS

Ultra-Low Sulfur Diesel Summit

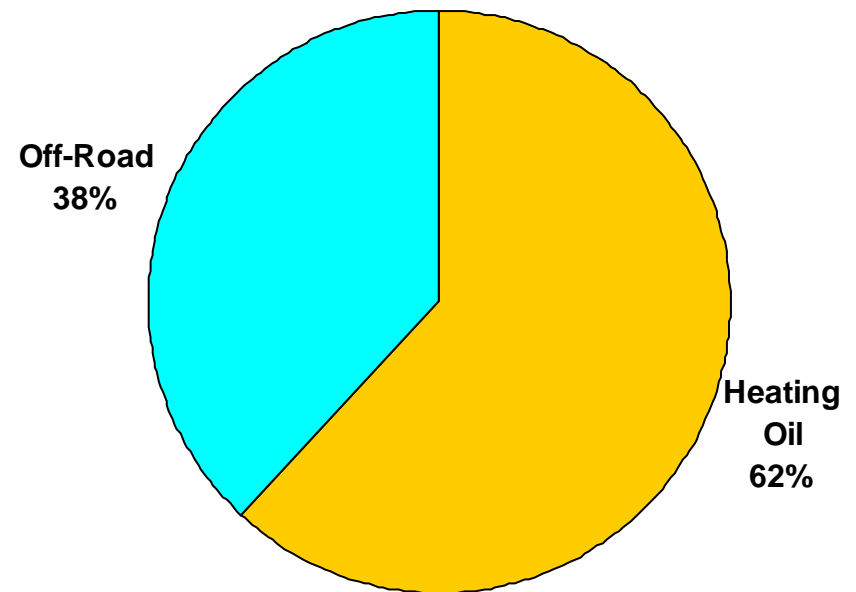
April 21-23, 2005 • The Westin Grand Hotel, Washington, DC

US Non-Highway Diesel Supply⁽¹⁾

2003



Planned for 2007



(1) Based on TM&C survey responses.

Slide 11: This pie chart shows how refiners categorized their **Non-Highway Diesel** production in 2003 compared to what they are now planning for 2007. The fungible volume provided considerable flexibility for seasonal and other variations in demand between these products. Once off-road diesel and heating oil become significantly different products, this loss of fungibility could result in tight or short supply in certain locations and at certain times of the year.



Distribution System Issues

Slide 12: Let's look now at some distribution system issues based on our current understanding of what refiners will be producing and what diesel consumers will require.



ULSD Sulfur Contamination Sources

	<u>Sulfur (ppm)</u>
Heating Oil	2,000-5,000
Jet Fuel	Up to 3,000
LSD	Up to 500
Gasoline	30-80

Slide 13: As ULSD moves from the refinery to be distributed to the ultimate customer, it typically has many opportunities to be contaminated with other products that move through these same facilities. This illustrates the sulfur specification differences between the various other products that are sources of “contamination” for ULSD.

Heating oil is the worst thing it can come into contact with since it contains between 2,000 and 5,000 ppm sulfur.

Jet fuel is also a troublemaker with its up to 3,000 ppm sulfur.

LSD is much better at 500 ppm, and by the time ULSD is required, gasoline will only contain 30-80 ppm sulfur, except where small refiners are involved.



ULSD Sulfur Contamination

100M barrels of 10 ppm sulfur ULSD contaminated with:	Gasoline 30 ppm	Diesel Fuel 500 ppm	Jet Fuel 3,000 ppm	Heating Oil 5,000 ppm
500 Barrels, or 0.5%	+0.1 ppm	+2.5 ppm	+15.0 ppm	+25.0 ppm
1,000 Barrels, or 1.0%	+0.2 ppm	+4.9 ppm	+29.9 ppm	+49.9 ppm

Slide 14: This slide illustrates how quickly we can have problems with relatively small amounts of each of these sources of contamination coming into contact with ULSD. Whether it be in a pipeline system where interface mixing or line fills of previously handled product is the source or in marine or shore tanks/tankers, we've calculated the resultant sulfur content of 100 M barrels of ULSD starting at 10 ppm and then being contaminated with 500 and 1,000 barrels of each of these products.

Note that the gasoline contamination is manageable as it only raises the sulfur content of the diesel by 0.1 and 0.2 ppm, respectively.

Diesel Fuel containing 500 ppm sulfur is more of a problem as it raises the sulfur content of our ultra-low-sulfur product 2.5 and 4.9 ppm, respectively.

But jet fuel and heating oil contamination are "game breakers". 500 barrels of jet fuel in our 100 MB batch of ULSD raises the sulfur content by 15 ppm, which is our total sulfur content specification. And 500 barrels of heating oil raises the sulfur content by 25 ppm.

This illustrates the magnitude of the problem. Systems handling ULSD will have to be segregated to preclude contamination from the other products moving through the distribution system.



Sulfur Testing at Ultra-Low Levels

- ◆ The ASTM Inter-Laboratory Crosscheck Program has tested the accuracy at 15 ppm for four different sulfur methods – D2622, D3120, D5453 and D6920.
- ◆ Reproducibilities are generally reported in the 3-5 ppm range.
- ◆ EPA's current downstream test tolerance is 2 ppm.
- ◆ EPA is undertaking an ULSD round robin sulfur testing program to qualify labs under its Performance Based Measurement System and possibly adjust the 2 ppm test tolerance.

Slide 15: Now let's talk about testing at these ultra-low sulfur levels.

The ASTM Crosscheck program is testing the accuracy at 15 ppm sulfur for the four methods that can be used. The early data resulted in reproducibilities in the 3-5 ppm range. I understand some additional data may be presented later in this meeting.

EPA's current downstream test tolerance allowance is 2 ppm.

A new round of round robin testing is being commissioned by EPA to qualify labs under its Performance Based Measurement System and possibly adjust the 2 ppm test tolerance.



Batch Testing of ULSD Movements

- ◆ Batch testing by MAP and others, and studies by the AOPL/API ULSD Fuels Team have shown that contamination through the distribution system could be very significant.

- ◆ Tests show that the potential for sulfur contamination increases with each “hand off”:
 - » Tank farms 1-5 ppm
 - » Pipeline movements <1 ppm
 - » Barge/water movements <1 ppm
 - » Transport trucks 1-2 ppm

Source: MAP and Buckeye Pipeline presentations at Hart’s World Fuels conference, March 11, 2005.

Slide 16: A limited number of batch tests have been made by MAP and others to get some data on how much contamination occurs in the pipeline distribution systems. Some of these data were shared at the recent Hart World Fuels conference in San Francisco.

The AOPL/API ULSD Fuels Team has studied several scenarios using the batch data collected to date and have shown that contamination through the distribution system could be very significant. The numbers shown here illustrate the levels of contamination that could occur with each hand-off through the system. Some have used a rule of thumb that on the order of 1 ppm of sulfur contamination can occur at each “hand off”.



Compliance Concerns

- ◆ The AOPL/API ULSD Fuels Team study raises concerns about consistently meeting the 15 ppm specification at all locations with a 2 ppm compliance margin.
- ◆ Several scenarios were examined starting with 7 ppm ULSD at the refinery gate.
- ◆ Out-of-compliance scenarios were projected for shipments between:
 - » Houston – New York state;
 - » Houston – Minneapolis; and
 - » Billings - Salt Lake City – Spokane

Slide 17: Work to date raises some concern about the ability to consistently meet the 15 ppm sulfur limit downstream at all locations with a 2 ppm compliance margin.

Several study scenarios by the Study Team resulted in product arriving off-spec at the end of pipeline shipments where numerous opportunities for contamination exist. Starting with 7 ppm sulfur containing ULSD at the refinery gate, out-of-compliance scenarios were projected for shipments originating in Houston and Salt Lake City.

In one scenario, product originating in Houston and moving through Kinder Morgan and Colonial Pipeline via breakout tankage at Greensboro and Linden then moving through the Buckeye system for delivery into New York resulted in product arriving out of compliance.

A similar scenario resulted in the same product originating in Houston but moving via Explorer through Greenville, Tulsa and Drumright transferring to Magellan and moving through El Dorado and points North and also through Des Moines on to Minneapolis.

The third scenario involved product originating in Billings, moving through Seminole Pipeline to tankage in Casper, then moving through Pioneer to Salt Lake City and transferring via the Chevron Pipeline to Spokane via Boise and Pasco arriving out of compliance.



Other Concerns

- ◆ **Minimizing downgrade/interface generation**
 - » Pipeline operating practices
 - » Terminal procedures
 - » Interface detection techniques/analyzers

- ◆ **Dealing with off-test ULSD at terminals**
 - » Regrade as much as possible to LSD
 - » Processing/treatment at terminals
 - » Reprocessing

- ◆ **Potential supply problems, especially near the end of major pipelines in the Midwest and Northeast**

Slide 18: These study scenarios carried out by the AOPL/API ULSD Fuels Team highlight the need to get additional data, make capital investments necessary to minimize contamination, especially in the major products pipeline systems, and perhaps make fairly significant changes in operating practices all along the way.

Pipelines will need to work hard at minimizing interface generation and excessive downgrade of ULSD through changes in operating practices in the pipelines and terminals. Improved interface detection devices and procedures would help mitigate the problem.

The industry will need to find ways to deal with off-test ULSD at terminals regrading as much as is allowable to LSD. Options for treating off-test ULSD at the terminal are being explored, and depending upon how much material is actually generated, regional treating facilities may need to be installed at some of the larger terminals, or in some cases, reprocessing at refineries may be necessary.

Depending upon how quickly and efficiently the major pipeline distribution systems can deal with the interface/off-test ULSD, some remote areas or areas at the end of pipeline distribution systems in the Midwest and Northeast may have supply issues in the early stages of the ULSD program.



Current Status

- ◆ Refinery plans are well underway for June 2006 compliance
- ◆ Distribution system modifications still being developed
- ◆ Initial batch test results raise some red flags, but much more work needs to be done
 - » More batch tests on pipeline systems
 - » Facility-by-facility and system-by-system reviews to minimize contamination/eliminate dead legs
 - » Further work on testing procedures

Slide 19: So let's summarize where we are today then talk about some things the various downstream players might be able to do to help with the transition to ULSD and assure reliable supply at all locations.

The plans of the nation's refineries are pretty much set. The time required to design and install facilities to produce ULSD required most refiners to finalize their decisions in early to mid-2004. Very little flexibility is left as far as refiners are concerned at this juncture.

Distribution system modifications, on the other hand, are still being implemented and in some cases still being developed.

Initial testing and studies raise some red flags, and these issues need to be dealt with promptly.

The major pipelines are scrambling to get ULSD early to facilitate more batch tests. Everyone downstream is conducting facility-by-facility audits to identify contamination sources and eliminate them.

And finally, much more work needs to be done to identify the practical limits of the existing testing procedures and improve these or develop new procedures and/or test methods which will tighten up the reproducibility and repeatability of tests at ultra low levels of sulfur.



Possible Solutions – Regulations

- ◆ **EPA increase sulfur test tolerance at least on an interim basis**
 - » Not just a test reproducibility issue
 - » Allows time for distribution systems to work out the kinks in handling ULS products; perhaps ratchet down later
- ◆ **Consider increasing ULSD downgrade volume provision to 500 ppm highway diesel above 20% during the early TCO period; ratchet down as distribution systems gain experience**
- ◆ **Consider the possibility of allowing credits generated at the refinery to be applicable downstream**
- ◆ **Institute economic incentives/penalties for different sulfur levels on highway diesel to allow movement of off-test ULSD**

Slide 20: In order to head off possible supply problems, especially in the early phases of the ULSD program, we've brain-stormed a bit to try to identify some things that might be done.

From a regulatory perspective, increasing the sulfur test tolerance during the first year of the program, for example, might help. This would allow time for each segment of the distribution system to work out their individual issues as more data and experience are gathered.

EPA might also consider increasing the downgrade volume provision, again during the early stages, to provide additional flexibility for dealing with off-test product at terminals. As experience is gained and improvements made, the number could be ratcheted back down to the 20% for the remainder of the TCO period.

Some consideration might be given to allowing refinery-generated credits to be applicable downstream, again to provide some flexibility for dealing with marginally off-test product in the distribution system.

And finally, some mechanism for allowing marginally off-test ULSD to be used by payment of a penalty depending on the sulfur level involved might be considered.



Possible Solutions – Refineries

- ◆ Undercut distillate streams to reduce the sulfur level of ULSD leaving the refinery
- ◆ Increase HDS unit operating severities to maximize desulfurization of diesel streams
- ◆ New or modified HDS projects are generally too far along to make significant changes now

Slide 21: As I mentioned earlier, refinery level investment decisions are for the most part already made. So the flexibilities at the refinery are largely operational in nature.

These include undercutting of diesel streams (at significant economic penalty) to reduce the sulfur level further and provide more of a cushion for downstream compliance.

Increasing the severities of HDS units can be done at higher operating costs and reduced run lengths.

Again, most new or modified HDS units are just too far along at this time to make significant design changes.



Possible Solutions – Distribution Systems

- ◆ Install dedicated ULSD tankage, lines, etc. throughout the distribution system and at retail locations
- ◆ Major pipelines policies
 - » Limit/exclude Heating Oil at some locations
 - » Minimum batch sizes and sequencing
 - » Consider the merits/practicality of a sulfur bank concept
- ◆ Increase marine shipments of highway diesel from PADD III
- ◆ Employ dedicated transport trucks, barges and tankers
- ◆ Utilize sulfur reduction equipment at major terminals

Slide 22: Downstream of the refineries, dedicated ULSD tankage, lines and other facilities are being installed.

Pipeline systems are reexamining policies concerning products being handled at specific location as well as minimum batch sizes and sequencing to minimize contamination. Some consideration might be given to a sulfur bank concept to give shippers some flexibility in complying with what is likely to be tight refinery gate limits on ULSD sulfur.

Due to the limitations on existing pipeline systems for dealing with another very difficult product segregation, marine shipments from the Gulf Coast to the Northeast may need to increase.

Further downstream, dedicated transport trucks, barges and tankers may need to be employed in certain instances to minimize sulfur contamination.

And finally, technology for treating off-spec ULSD at terminals may need to be further developed and employed.

This concludes my presentation. Thanks for your attention.



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