4. Impact of the ULSD Rule on Oil Pipelines

Introduction

The petroleum products pipeline distribution system is the primary means of transporting diesel fuel and other liquid petroleum products within the United States. The Nation's refined petroleum products pipeline system is not monolithic. Pipelines are distinguished by the region they serve, the type of service they offer, their mode of operation, their size, the size of the interfaces between batches, and how they dispose of them. In preparing this report, several pipeline companies were contacted.[68] These companies represent a cross-section of size, capacity, location, markets, corporate structures, and operating modes. The assessment of the impact of the ultra-low-sulfur diesel (ULSD) Rule is complex, both because the pipeline system is complex and because there are uncertainties that cannot be resolved without operating experience with ULSD.

The first question appears to be: "Can the Nation's oil pipeline system successfully distribute ULSD without degrading its sulfur concentration?" While the answer seems to be yes, lingering uncertainties that come with the unique specifications of this new and untested product prevent a clear assertion. Among the uncertainties are the following:

- Protecting the product integrity of 15 parts per million (ppm) product will be more difficult than protecting the product integrity of the current 500 ppm highway diesel. Not only is the sulfur specification lower, with less room for error, but also the relative "potency" of the sulfur in products further upstream is higher.
- The behavior of sulfur molecules in ULSD has not been field-tested to allow conclusions about whether pipeline wall contamination is a real problem or simply a fear, and whether the migration of sulfur will require a significant increase in the volume downgraded at the interface.
- There are few pieces of the approved test equipment now in use, but its reliability and accuracy are unproven.

Although the overall costs of the program may be lower if the rule is phased in, the incremental costs associated with temporarily transporting ULSD, in addition to low-sulfur diesel and heating oil fall on pipelines and other players in downstream distribution. During the transition phase, some 20 percent of the highway diesel volume will be 500 ppm. The increased cost of tankage for handling this small volume of 500 ppm material is borne solely by the affected regions. On a cost-per-gallon basis for the small volume in the limited region, the increased cost more than doubles the current pipeline tariff for the largest carriers. Whether such an increase can be passed through in tariff rates is a matter of significant concern for pipeline operators.

Finally, there is a concern that further limitations on distribution flexibility will contribute to price spikes or spot outages. The distribution of ULSD will reduce the system's flexibility by imposing testing requirements that will increase transit times by increasing the product lost to downgrade and by "freezing" storage capacity in the event of product contamination. These adverse impacts inject new supply risks into the system, making an already burdened oil distribution system more vulnerable to product supply imbalances in local and regional markets. Supply imbalances, if they occur, could cause increased product price volatility, price spikes, and product outages. This concern is not just theoretical. During 2000, logistics problems contributed to large and sudden price spikes in the Midwest gasoline market.[69] To the extent that the system is overburdened, stresses and unforeseen circumstances will cause imbalances more often, and with greater impact.

The Role of Refined Petroleum Product Pipelines

Oil pipelines transport more crude oil and refined petroleum products in the United States than any other means of transportation.[70] Typically, as common carriers (which transport for any shipper on a nondiscriminatory basis), oil pipelines are subject to State authority if

[68] Buckeye Pipe Line Company, Colonial Pipeline, Conoco Pipe Line Company, Kaneb Pipeline Partners, L.P., Kinder Morgan Energy Partners L.P., Marathon Ashland Petroleum LLC, TE Products Pipeline Company, L.P., and Williams Energy Services.

[69] Joanne Shore, Energy Information Administration, "Supply of Chicago/Milwaukee Gasoline Spring 2000," web site www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2000/supply_of_chicago_milwaukee_gasoline_spring_2000/cmsupply2000.htm (August 9, 2000).

[70] According to the Association of Oil Pipe Lines, *Shifts in Petroleum Transportation: 1999* (2001), pipelines account for 75 percent of the ton-miles of oil transported in the United States. (One ton of oil transported one mile equals one ton-mile.)

they are in intrastate service, or to the U.S. Department of Transportation for operations and safety and to the Federal Energy Regulatory Commission for tariff rates, if they provide interstate service. Interstate pipeline carriers transport the higher volume, by far. Accordingly, the Federal Government is the major regulator of oil pipelines. Some pipelines are private, serving private (proprietary) transportation needs. These private oil pipelines are not regulated with respect to tariff rates or other economic issues. Today, transportation of refined petroleum products by pipeline is essential to move more than 19 million barrels per day of refined petroleum products to markets throughout the Nation.

The United States is divided into five Petroleum Administration for Defense Districts (PADDs), each with distinct population levels, indigenous oil production, refinery and pipeline systems, and crude oil and refined product flows. Imbalances that result from these different characteristics are brought into equilibrium by trade and hence transportation. The trade can consist of imports from abroad and shipments from other regions. Shipments from the Gulf Coast (PADD III) dominate (Figure 1), first to the East Coast (PADD I) and second to the Midwest (PADD II). Shipments from the East Coast to the Midwest are third. Thus, shipments between PADDs east of the Rockies account for almost all the interregional trade. Intraregional movements are also a core element in the market logistics, but few data are available on these movements. (See Appendix C for a more detailed discussion of the U.S. regions and their key pipelines.)

Overview of Key Pipeline Operations

Refined petroleum product pipelines in the United States fall into two service categories. Trunk lines serve high-volume, long-haul transportation requirements; delivering pipelines transport smaller volumes over shorter distances to final market areas. As the system reaches its furthest capillaries, the inflexibilities imposed by the smaller scale become more apparent. A "lockout" can occur when a terminal does not have room to accept a scheduled shipment and there are no other terminals at hand to accept the product. The pipeline is thus stalled until the product can be delivered.

Petroleum product pipelines also differ by whether they operate on a batch or fungible basis. In batch operations, a specific volume of refined petroleum products is accepted for shipment. The identity of the material shipped is maintained throughout the transportation process, and the same material that was accepted for shipment at the origin is delivered at the destination. In fungible operations, the carrier does not deliver the same batch of material that is presented at the origin location for shipment. Rather, the pipeline carrier delivers material that has the same product specifications but is not the original material.

In general, fungible product operation is more efficient; however, customer requirements for segregation limit fungible operation, and batch service is often the only feasible choice. Like the difference between trunk and delivering carriers, the difference between fungible and batch service is one of scale for many operating parameters. An oil pipeline in batch service has considerably less flexibility to offset operating "hiccups" (such as product contamination at a shipper's terminal tank) than does an oil pipeline operating in fungible service.

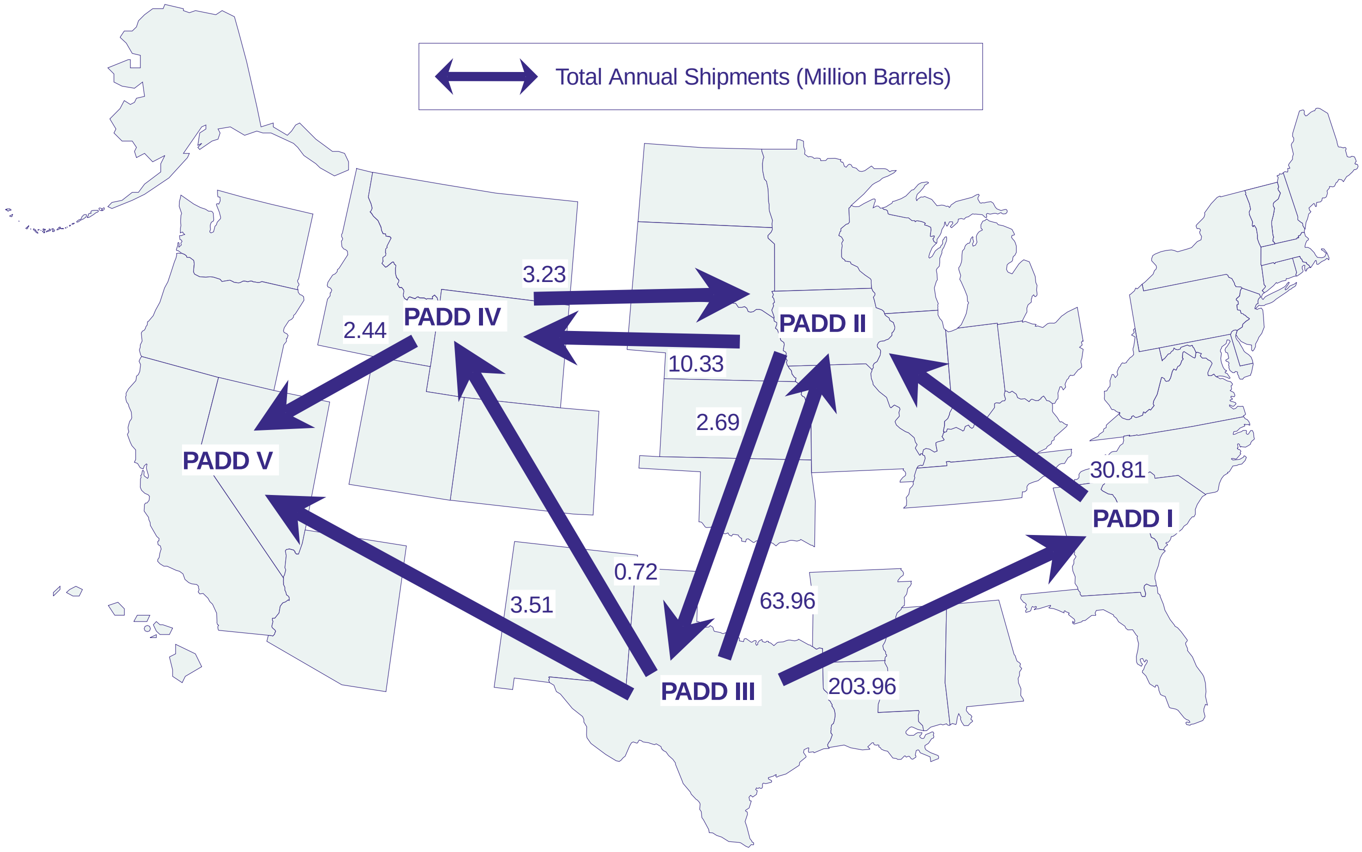
Product pipelines routinely transport various grades of motor gasoline, diesel fuel, and aircraft turbine fuel in the same physical pipeline. (For the most part, oil pipelines do not transport both crude oil and refined petroleum products in the same pipeline.) To carry multiple products or grades in the same pipeline, different petroleum products or grades are held in separate storage facilities at the origin of a pipeline and are delivered into separate storage facilities at the destination. The different types or grades of petroleum product are transported sequentially through the pipeline. While traversing the pipeline, a given refined product occupies the pipeline as a single batch of material. At the end of a given batch, another batch of material, a different petroleum product, follows. A 25,000-barrel batch of product occupies nearly 50 miles of a 10-inch diameter pipeline.

Generally, such batches are butted directly against each other, without any means or devices to separate them. At the interface of two batches in a pipeline, some (but relatively little) mixing occurs. As a guide to understanding the volume of interface generated, it would be typical for 150 barrels of mixed material ("transmix") to be generated in a 10-inch pipeline over a shipment distance of 100 miles. The hydraulic flow in a pipeline is also a crucial determinant of the amount of mixing that occurs. "Turbulent flow," as occurs in most pipelines, minimizes the generation of interface. Operations that require the flow to stop and start generate the most interface material.

The composition of the mixed (or interface) material reflects the two materials from which it is derived. While it does not conform to any standard petroleum product specification or composition, it is not lost or wasted. For interface material resulting from adjacent batches of different grades of the same product, such as mid-grade and regular gasoline, the mixture typically is blended into the lower grade. This "downgrading" reduces the volume of the higher quality product and increases the volume of the lower quality product.

Typically, refined oil products are transported from a source location, such as a refinery or bulk terminal, to a distribution terminal near a market area. Large

Figure 1. Pipeline Shipments of Distillate Fuels Between PADDs, 1999



Note: Includes low-sulfur (highway) diesel fuel and high-sulfur distillate fuel oil (non-road diesel fuel and heating oil).
Source: Energy Information Administration, *Petroleum Supply Annual 1999*, DOE/EIA-0304(99)/1 (Washington, DC, June 2000), Table 33.

aboveground storage tanks at an origin location accumulate and hold a given petroleum product pending its entry into the pipeline for transport. Petroleum products are also stored temporarily in aboveground storage tanks at destination terminals. Such tanks usually are dedicated to holding a single petroleum product or grade. Most storage tanks used in pipeline operation are filled and drained up to four or more times per month.

In addition to the minor creation of interface material that occurs in pipeline transit, creation of interface material also occurs in the local piping facilities (station piping) that direct petroleum products from and to respective origin and destination storage tanks and in the tanks themselves. Essentially, station piping represents the connection between a main pipeline segment and its requisite operating tanks. The concept is simple in theory, but in practice the configuration of station piping is not. Station piping layouts become more complex as the tanks at a pipeline terminal facility become more numerous.

The interface generation in station piping and breakout tanks may be even more important than during pipeline transit. The volume of interface material thus generated is due to the physical attributes of the system. It has fewer variables but approaches a fixed value on a barrel-per-batch, not a percentage, basis. For instance, one pipeline operator creates 25,000 barrels of high-sulfur/ low-sulfur distillate interface per batch whether the batch is 250,000 barrels or 1,000,000 barrels. In addition, a given batch of product might be transported in multiple pipelines between its origin and its final destination and even within the same system might require a stop in breakout tanks, as noted above. Each segment of the journey generates additional interface.

Challenges of the ULSD Rule

Because pipeline operators do not have experience with 15 ppm product, there are significant uncertainties related to its transport. This section discusses some of the issues:

- The volume of downgraded product likely to be produced from deep pipeline cuts necessary to preserve the integrity of ULSD
- Likely strategies for protecting the product integrity of 15 ppm diesel and their impact on the generation of interfaces and transmix
- Limitations on downgrading from 15 ppm to 500 ppm product within the diesel pool

- The sulfur content of products reprocessed from transmix
- The possibility that residual sulfur adhering to mainline pipeline walls may contaminate ULSD as it transits the pipeline
- Product testing
- The challenges and costs of the phase-in period.

Estimation of Interface Generation

The U.S. Environmental Protection Agency (EPA) estimates that the interface that will be generated under the ULSD rule will be 4.4 percent of the highway diesel fuel volume transported by pipeline. EPA arrived at this 4.4 percent figure by estimating the current level of interface as a percentage of highway diesel fuel volume and doubling the current level.[71] There are significant uncertainties in the EPA's calculation.

At the EPA's request, the Association of Oil Pipelines (AOPL) and the American Petroleum Institute's pipeline Committee surveyed their members on the impact of the ULSD rule. The survey and its cover letter are comments to the EPA's Notice of Proposed Rulemaking.[72] AOPL points out that pipeline companies do not now separately account for interface volumes and indicated that the estimates of downgraded interface from the survey should not be used for economic analysis.[73]

Six respondents provided numerical estimates of the current diesel fuel downgrade. These estimates ranged from 0.2 percent to 10.2 percent of diesel shipped by the pipeline on an annual basis. In making its calculation of the total current downgrade of highway diesel, the EPA used the range of downgrade percentages from the AOPL survey and information from a database on the pipeline distribution system published by PennWell.

The EPA assigned each pipeline diameter in the PennWell database a value between 0.2 percent and 10.2 percent (the range of response in the AOPL survey), with the smallest diameter at the low end and the largest at the high end. EPA then multiplied the assigned values by the miles of a given diameter of pipe and divided the result by the total number of pipeline miles in the database to arrive at an average downgrade of 2.5 percent.

Pipeline diameter is only one of the factors in determining the amount of interface material. The velocity of the flow and the topography of the land are also important factors. A pipeline that can run in a turbulent flow will have a lower volume of interface for a given diameter than one in which the flow slackens for any number of operating reasons. Interface generation is also affected by batch size. Moreover, station piping and breakout tanks are additional and large generators of downgrade volume. (The EPA accounted for the role of station piping and breakout tanks by assigning higher percentages to the larger diameter pipe, as a proxy for the greater complexity of the large systems.) In addition, the higher product flow in the larger lines is not taken into account. If a system like the Colonial Pipeline has a downgrade rate of 10 percent, it would result in a much higher number of downgraded barrels than an 8-inch-diameter line. In the AOPL's submission, the operator with the 10-percent downgrade accounted for 90 percent of all downgrade.

EPA then adjusted its initial estimate of downgrade volumes downward by 15 percent. EPA made this adjustment based on the following assumption:

> *Data from the Energy Information Administration (EIA) indicates that 85 percent of all highway diesel fuel supplied in the United States is sold for resale. Therefore, we believe it is reasonable to assume that only this 85 percent is shipped by pipeline, with the remaining 15 percent being sold directly from the refiner rack or through other means that does not necessitate the use of the common fuel distribution system. By multiplying 2.5 percent by 0.85 we arrived at an estimate of the current amount of highway diesel fuel that is downgraded today to a lower value product of 2.2 percent of the total volume of highway diesel fuel supplied.*[74]

This downward adjustment of downgrade volumes has some limitations. EIA's Form 782A collects data from refiners. There is no way to determine whether the volumes sold to end users transit a pipeline or not. They may have, if they were sold in a refiner's integrated system. Form EIA-782A excludes sales to other refiners, and some of the excluded volumes may also have been transported in a pipeline. Finally, the volume throughput in a pipeline system is not necessarily equal to consumption, because some volumes may travel in more than one pipeline before reaching the consumer. Thus, "sales for resale" as a share of total refiner sales is not an ideal proxy for the share of highway diesel transported by pipeline.

[71] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter IV, p. IV-93.

[72] Cited in the EPA's documents as "Comments of Association of Oil Pipelines (AOPL) on the NPRM, Docket Item IV-D325." Cited here as "AOPL Comments."

[73] AOPL Comments, p. 2.

[74] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter IV, p. IV-93.

The EPA assumed the level ULSD downgrade volumes at 4.4 percent of ULSD supplied, double their current estimate of 2.2 percent of highway diesel supplied. The EPA based this assumption in part on comments made by respondents to the AOPL survey. In its Regulatory Impact Analysis, the EPA stated a desire to ". . . yield a conservatively high estimate of our program's impact . . ." and noted ". . . an appropriate level of confidence that we are not underestimating the impact of our sulfur program . . . will help account for various unknowns that may cause downgrade volumes to increase."[75]

Pipeline operators have several concerns about the downgrade volume of ULSD. One concern is that the simple use of specific gravity—the current method—may not be a sufficiently sensitive indicator to make the interface cut. One of the AOPL / API survey respondents noted, for instance: "Our initial studies of trailback from [heating oil] to [low-sulfur diesel] indicates that trailback in interfaces to ULSD diesel may be as much as 4 times that of the gravity change between products."[76] However, the EPA viewed increased trailback from heating oil to ULSD as less of a concern.[77]

The EPA assumed that pipeline operators would not have to substantially change their current methods to detect the interface between ULSD and adjacent products in the pipeline. In the EPA's view it was highly unlikely that there would be any difference in the physical properties of ULSD versus the current 500 ppm highway diesel that would cause a substantial change in the trailback of sulfur from preceding batches into batches of ULSD.[78]

Another concern is that a protective cut, when it can be calibrated using real-world experience, may require a large volume downgrade. The conventional approach is to buffer distillate products against other distillate products to facilitate blending, as noted in the previous discussion. A batch of 500 ppm diesel might be wrapped between a batch of 2,000 ppm jet fuel and a batch of dye non-road distillate fuel oil (heating oil) at 3,000 to 5,000 ppm. Thus, the product with the sulfur restriction (500 ppm diesel) is wrapped by a product with four times the sulfur (2,000 ppm jet fuel), and by a product with six to eight times the sulfur (3,000 to 5,000 ppm heating oil). In practice, the current highway diesel is usually considerably less than the 500 ppm limitation (300 ppm would not be uncommon). Under these circumstances, it is relatively unlikely that chance contamination could move the diesel from 300 ppm to nonconforming status at more than 500 ppm.

The current situation, however, contrasts significantly to the ULSD situation. ULSD (15 ppm) may be adjacent to jet fuel at 2,000 ppm, 133 times the ULSD sulfur concentration, or to heating oil at 3,000 to 5,000 ppm, 200 to 300 times the ULSD concentration. In this case, a tiny contamination will move the ULSD batch to nonconforming status. According to one of the AOPL / API respondents, ". . . a 0.15 percent contamination (15 bbls in 10,000 bbls) of [heating oil] in ULSD will raise the sulfur level by 3 ppm . . . ." According to another, ". . . the [heating oil] at 2000 ppm can contaminate the ULSD at levels as low as 0.22 percent."[79] In combination with the concerns raised about the sulfur trailback, the issue of the volume necessary for the protective cut is another significant uncertainty in the handling of ULSD.

The assumption made about the size of the increase in interface generated after a switch from the current standard for highway diesel (500 ppm) to ULSD becomes important when calculating the cost of the regulation. EPA's estimate of additional costs of the ULSD rule that can be attributed to increased product downgrades was 0.3 cents per gallon of ULSD supplied once the ULSD rule was fully implemented and all highway diesel must meet the 15 ppm standard. This 0.3 cents per gallon cost was with the 4.4 percent downgrade assumption.[80] Turner Mason and Company conducted a study of distribution costs for the API and came up with a cost increase of 0.9 cents per gallon for product downgrade. Turner Mason assumed that 17.5 percent of ULSD shipped would be downgraded.

Strategies for Buffering ULSD in a Pipeline

Because there is no experience with distributing ULSD in a non-dedicated or common transportation system, pipeline operators are unsure how they will sequence the new product in the pipeline. Those that now ship highway diesel adjacent to jet fuel are unlikely to be able to continue the practice unless the sulfur content of the jet fuel is also lowered. At the current jet fuel sulfur content, ULSD cannot tolerate the contamination from the protective cut necessary to protect the other properties

[75] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter IV, pp. IV-93–IV-94.

[76] AOPL Comments, Attachment, p. 2

[77] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter IV, p. IV-96.

[78] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter IV, p. IV-94.

[79] AOPL Comments, Attachment, p. 2 and p. 5.

[80] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter V, p. V-124.

of the jet fuel. According to the EPA, pipelines might have to treat a mixture of jet fuel and 15 ppm diesel as transmix in separate tanks, because it will not be acceptable either as jet fuel or as 15 ppm diesel. The need for new tanks to handle this new hybrid, however, would be difficult to accommodate. In addition, it is not clear how the hybrid would be reprocessed for reentry into the petroleum products distribution system.

There is currently no regulatory requirement that the sulfur content of jet fuel be lowered to 15 ppm. Even kerosene / jet fuel used for blending into 15 ppm diesel is controlled by the specification of the finished product, not the blending component. As a practical matter, however, any kerosene / jet fuel destined for blending must have ultra-low sulfur content. Whether an ultra-low-sulfur jet fuel will present additional lubricity problems for jet engines is another unknown.

While there is a 500 ppm product in use, operators might be able to buffer 15 ppm ULSD with the 500 ppm product. Such buffering is limited by the volumes that can be downgraded within the diesel pool, however, as discussed below.

Gasoline, at an average of 30 ppm and a maximum of 80 ppm, will represent the next lower sulfur content in the overall product transportation slate. Some operators have speculated that if the trailback is significant, gasoline buffers might be the best alternative. There are considerable problems, however, with the increased generation of transmix. The availability of reprocessing facilities is the first. In addition, some transmix is now reprocessed in purpose-built facilities—a simple distillation column—on station property. Such a simple facility, or even a more complex purpose-built facility, has never needed to accommodate desulfurization. Thus, the reprocessing of transmix will be routinely more difficult under the ULSD program, and it is unclear that the facilities will exist to reprocess increased volumes of transmix.

Pipeline operators will establish interface minimization strategies on a case-by-case basis. Trunk line operators will seek to ship ULSD in as large a batch as possible. Delivery pipeline operators will do the same, but with more difficulty, because delivery pipelines ship smaller volumes and face more operating permutations related to time and location requirements. Operators of fungible pipeline systems will have an advantage in protecting the integrity of ULSD in transit and minimizing the expense of downgrading. It is worthwhile to note that the use of large batches requires more careful inventory management on the part of pipelines and shippers, to assure that requisite tanks have room for the incoming product. Given the inventory environment in oil markets, any new rigidity imposed by the logistics system can reverberate through market prices.

The result of deeper cuts will be significantly more product downgrading. The practical effect of creating a greater volume of high-sulfur distillate is difficult to estimate. Depending on market circumstances at various locations, it will range from none to significant. The worst case will be found where the creation of high-sulfur distillate affects terminals that do not have capacity to accept and store the material or in markets that do not have enough demand to absorb it.

The 20-Percent Downgrade Rule

The ULSD Rule prohibits any party downstream of the refiner or importer from downgrading more than 20 percent of its annual volume of 15 ppm highway diesel to 500 ppm highway diesel.[81] (There is no limitation on downgrading from 15 ppm diesel to the non-road pool.) This provision is designed to discourage downgrading within the diesel pool during the phase-in period.[82] The pipeline industry, however, is likely to be handling significantly increased volumes of downgraded material and to have substantial incentive to minimize the downgrade, because of the economic penalty involved. Furthermore, the downgrade limitation applies to normal interfaces.

As noted previously, the generation of some interface is irreducible, fixed by the physical attributes of the system. An operator with a high-interface system may have little room against the 20- percent limitation when all the other increases in ULSD interface are factored in. The 20-percent limitation also applies to the accidental contamination of a batch. If a batch were accidentally contaminated on a high-interface system, the operator might be required to deny that product to the diesel pool, even though it met all the specifications for 500 ppm material. Chances of localized diesel fuel supply imbalances are increased, and with them, the possibility that a system could get “frozen” by nonconforming product.

Given the uncertainties surrounding the transport of ULSD, the 20-percent downgrade rule will be particularly difficult when the first batches of ULSD are transported. There may be multiple contaminated batches before operating norms are established and equipment is calibrated.

[81]U.S. Environmental Protection Agency, “Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Final Rule,” *Federal Register*, 40 CFR Part 80.527 (January 18, 2001).

[82]U.S. Environmental Protection Agency, “Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Final Rule,” *Federal Register*, 40 CFR, Preamble (January 18, 2001), p. 281.

Residual Sulfur in a Pipeline

In comments on the proposed ULSD Rule, pipeline operators raised a concern over whether residual sulfur from high-sulfur material could contaminate subsequent pipeline material beyond the interface. The concern was based on limited experience. Recently, in light of the prospect of transporting ULSD, Buckeye Pipe Line conducted a test of possible sulfur contamination from one product batch to another. In the test on one segment of its pipeline system, Buckeye made a careful measurement of sulfur content in batches of highway diesel fuel following a batch of high-sulfur diesel fuel. Buckeye found that the sulfur content of the second batch of highway diesel fuel increased.[83] However, the EPA stated: "We believe there is no reason to surmise that contamination from surface accumulation will represent a significant concern under our sulfur program."[84] This issue cannot be resolved without further testing. Until it is, it will remain an uncertainty about the impact of the ULSD Rule.

Product Testing

Product testing is another area of considerable concern for those involved in the transport of highway diesel fuel, for two reasons: (1) The designated test method was developed for testing sulfur in aromatics and has not yet been adapted or evaluated by industry as a test for sulfur in diesel fuel. (2) There is no readily available and appropriate test for sulfur that will permit the precise interface cuts between batches that will be required in handling ULSD. The first of these issues is important for all players in ULSD markets, and the second is specific to the oil pipelines that will transport ULSD.

Currently, oil pipeline operators test the petroleum products they transport in a variety of ways, for a variety of parameters. Each product has its own relevant test parameters, and grades of a particular product are tested to confirm their defining characteristics within a product group. In many pipelines, product batches are tested four times at various stages of their entry to or transit through the pipeline:

- Rigorous testing is performed *before products enter* a pipeline to assure that relevant specifications are within the normal range.
- Many pipelines monitor materials *at strategic pipeline locations en route* for contamination.
- *At or near a product's delivery point*, pipelines perform oversight testing covering a limited number of key product parameters (but not sulfur content).
- Most pipelines test *random pipeline batches* using a full battery of tests.

All tests except in-line testing, the second testing regime outlined above, are performed on a batch basis. All but the fourth testing regime outlined above are performed on each batch of products. Pipeline operators are equipped at their own pumping and delivery stations to perform oversight testing on an expedient, on-site basis. Other batch testing is typically performed at an off-site laboratory. Some operators use test laboratories owned and operated internally and some use third-party laboratories. The large laboratories, whether operated by a pipeline operator or by a third party, will be able to meet any testing requirements. However, the designated test method presents uncertainties even to the most sophisticated laboratories, as discussed more fully below. ULSD regulations on testing apply directly only to refiners and importers, leaving additional leeway for parties downstream to choose a test method. Thus, the concerns with respect to test method apply even more strongly to refiners and importers than to pipelines and other downstream parties.

The designated testing method will be ASTM 6428-99,[85] not the widely-used ASTM 5453-99, which has been approved by the State of California and has been demonstrated to be reliable in testing very low sulfur content. The designated method, ASTM 6428-99, was developed for testing sulfur in aromatics. There is no currently available test methodology to apply the test to sulfur in diesel fuel. Because the diesel methodology has not yet been developed for the designated method, it has not yet been tested by multiple laboratories. By industry convention, new test methods are subjected to "round robin" testing under the oversight of the American Society of Testing and Materials (ASTM), in which multiple laboratories apply the test method to multiple batches to develop an objective evaluation of the method's reliability and accuracy. The correlation of the round robin's results becomes the industry standard and is used to calibrate other test methods against the designated method. The correlation is critical to the choice of test method and equipment for downstream players.

While ASTM 5453-99 has been designated as an alternative test method, its results must be correlated with the

[83]Operators at Explorer Pipeline, which formerly carried crude oil and refined products as batches in the same pipeline, also observed that refined products following high sulfur crude oil in the pipeline experienced a material increase in sulfur content. (The physical characteristics of crude oil are distinct from refined products, and its sulfur content can be considerably higher than the sulfur content of refined petroleum products shipped in a pipeline.)

[84]U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter IV, p. IV-99.

[85]U.S. Environmental Protection Agency, "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Final Rule," *Federal Register*, 40 CFR Part 80.580(a)(2) (January 18, 2001).

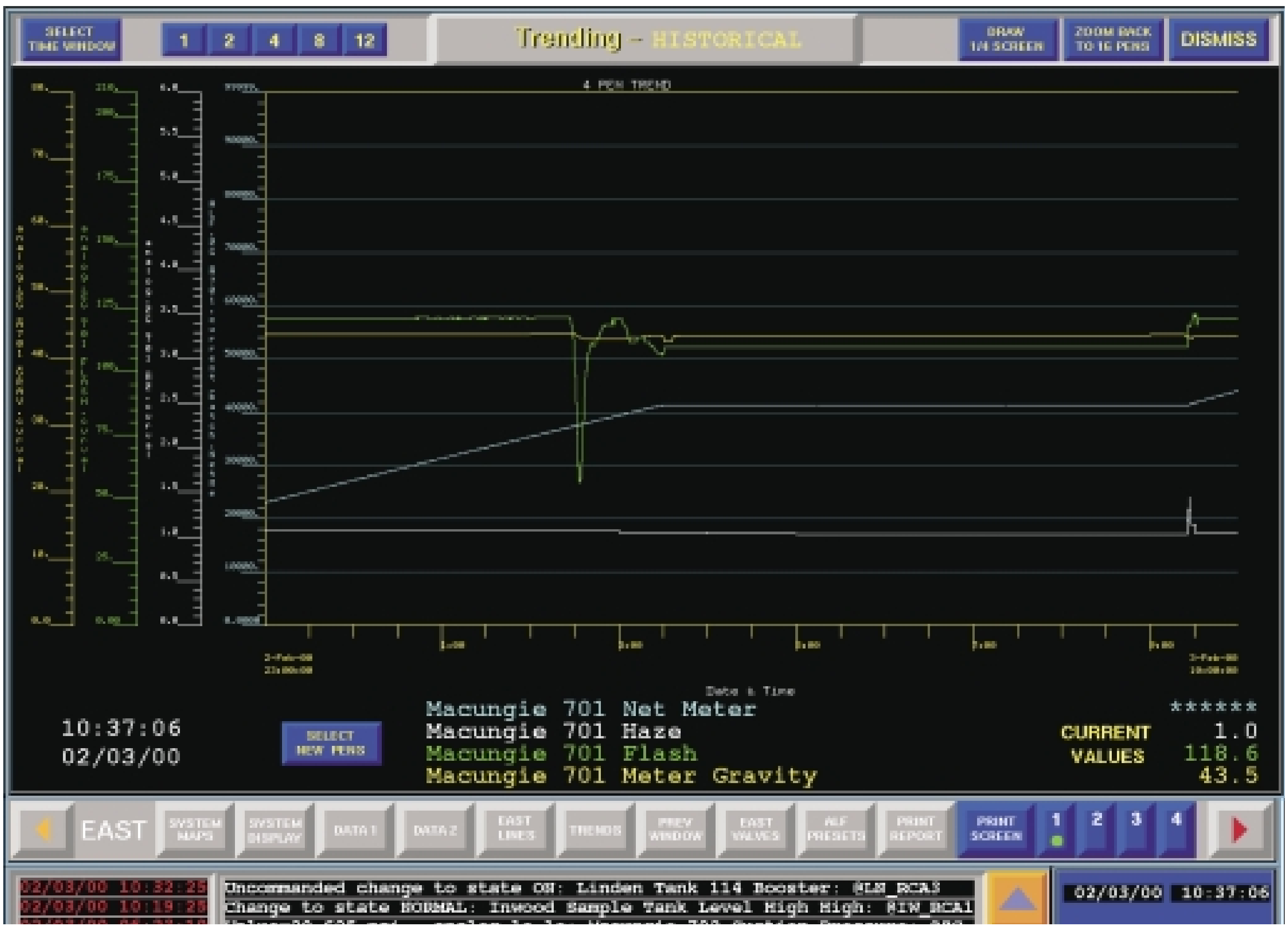
designated method. Hence, even those with experience using ASTM 5453-99 cannot be confident of the impact of the designated method on their testing practices. A downstream testing tolerance of 2 ppm will be allowed,[86] but whether this is the appropriate level, given the designated method's performance, also cannot be determined until the method is adapted for use with diesel fuel and correlated in the round robin.

Upon their entry to a pipeline, distillate fuels are given a full battery of tests, typically examining approximately 18 separate parameters. In an oversight test for distillate fuels, products are tested for flash point, specific gravity, and appearance. With respect to highway diesel fuel, sulfur content is also analyzed. Other tests relevant to distillate fuels, such as cetane, cloud point, freeze point, or corrosiveness, are performed at an off-site laboratory. The same rigorous level of testing is performed that is randomly applied to other products on a sampling basis.

The sulfur content of existing highway diesel fuel is often well under the 500 ppm specification. It is not uncommon for highway diesel to contain only 200 ppm sulfur. Thus, the statistical reproducibility of sulfur testing can comfortably be more than 20 to 50 ppm, and is. Operators anticipate that sulfur testing of ULSD will have to work within a 3 to 5 ppm reproducibility error.

With a 3 to 5 ppm reproducibility in the test, a product could be tested at 10 ppm as it enters the system and at 15 ppm as it exits. Generally, pipeline operators do not have a consensus on the sulfur content they will require as the product enters the pipeline system. Some have mentioned levels as low as 7 to 8 ppm in order to

Figure 2. Monitoring Pipeline Product for Contamination



Note: Taken from an oil pipeline control center's SCADA (Supervisory Control and Data Acquisition) system, this screen illustrates gasoline contamination (indicated by the drop in flashpoint) during a change from one kerosene batch to a second kerosene batch. The Net Meter stops climbing and shows where the pipeline was shut down to investigate the source of the problem (likely a late cut leaving gasoline/kerosene mix in the tank line that became evident when the pipeline began to draw product from the tank). The time scale across the screen is in hours. There is no similar monitoring available for ULSD.

[86] U.S. Environmental Protection Agency, "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Final Rule," *Federal Register*, 40 CFR Part 80.580(a)(4) (January 18, 2001).

leave room for test reproducibility and unavoidable contamination.

Currently, most oil pipeline operators use X-ray fluorescent sulfur analyzers such as those manufactured by Oxford Instruments, Asoma Instruments, or Horiba, Ltd., for oversight sulfur content testing of highway diesel fuel. These analyzers, however, will be unable to monitor ULSD. Some oil pipelines use Antek Instruments, administering ASTM 5453-99 in a laboratory to monitor sulfur content on a batch basis. However, this equipment and test will help with the interface cut only in some situations, because its application for in-line testing presents a number of challenges (see below).

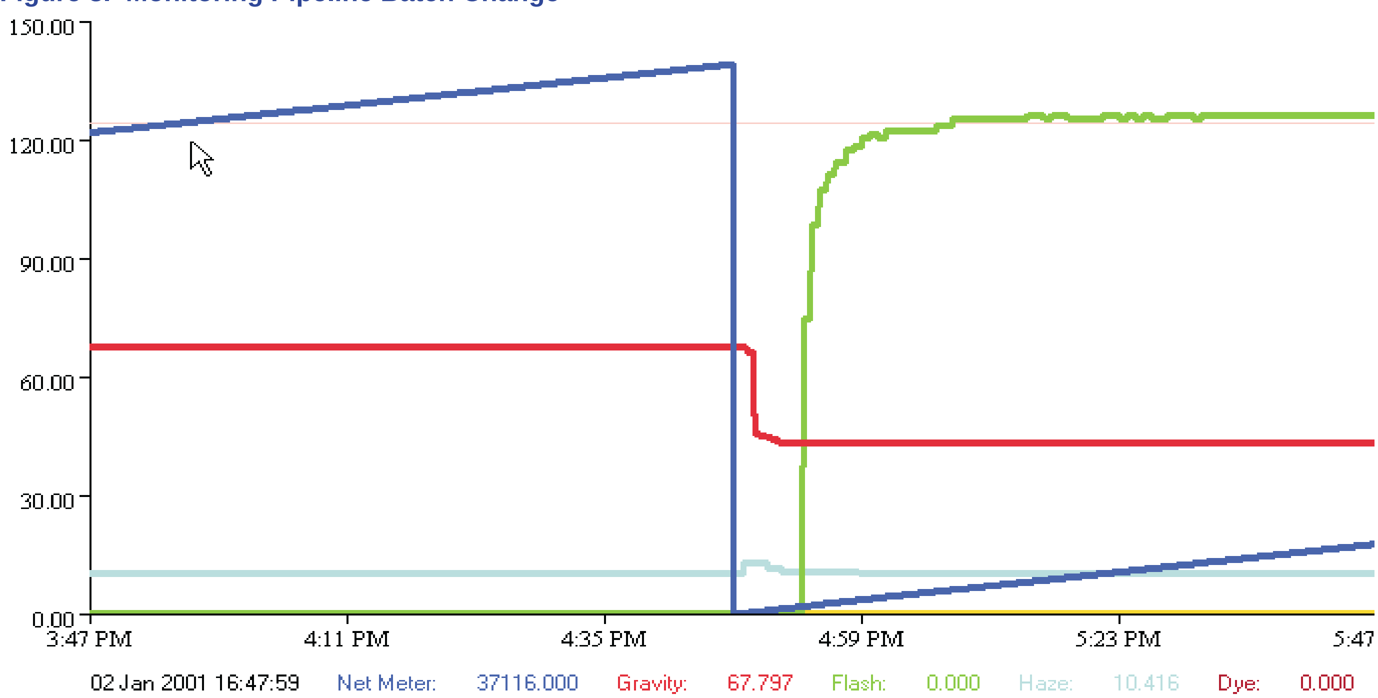
Some oil pipelines use in-line testing equipment to detect contamination close to and downstream from potential source locations where foreign or off-specification material might be inadvertently introduced into pure material (Figure 2). Early detection of contamination gives operators flexibility in correcting problems before they become intractable. However, there is no in-line test for sulfur content.

Product testing is different from instrumented detection of specific gravity, which is used to identify and track product batches in a pipeline system. Batch tracking and identification are accomplished by in-line monitoring of the pipeline stream's specific gravity at strategic pipeline locations. Such locations are typically station entry points or other locations where batches need to be "cut" and separately directed to subsequent pipeline segments in a system or to storage tanks for segregation (Figure 3). The cut, as noted previously, does not depend on sulfur content.

Most oil pipeline operators will probably want or need to perform in-line monitoring of sulfur content, because degradation of ULSD will easily and, possibly, frequently occur. The entry, for example, of only 35 barrels of heating oil (3,000 ppm) into a 10,000-barrel batch of ULSD will contaminate the batch.[87] A 10-inch diameter pipeline flowing at 4 miles per hour (a representative rate for a delivering carrier) is flowing at some 34 barrels per minute. Other carriers may be flowing faster, and on larger diameter pipelines, are moving more product. Hence, flow rates can exceed 300 barrels per minute. The 35-barrel contamination, then, is quick to occur. A normal cut, illustrated above, might take some minutes.

In-line testing for sulfur will represent a difficult challenge for the oil pipeline industry and for test instrument manufacturers. Current in-line instruments such as flash point or dye / haze analyzers cost $40,000 each to acquire, but there is no similar instrument available to meet ULSD test requirements. Current instruments for testing sulfur do not have adequate sensitivity, accuracy, or speed.

Figure 3. Monitoring Pipeline Batch Change



Note: This screen capture, originating from the pipeline's SCADA system, illustrates a normal batch change from gasoline (67 API gravity) to kerosene (47 API gravity and 123 minimum flashpoint).

[87][(9,965 x 7) + 935 x (35 x 3,000)] / 10,000 = 17.5 ppm.

With respect to speed of analysis alone there is a significant performance deficiency with current in-line analysis techniques. Current machines require 5 to 10 minutes to complete one analysis of a passing product stream. Five minutes is far too long to permit a pipeline operator to make a correctional response if off-specification material is detected in a batch of ULSD. One suggested solution would move the testing equipment to an upstream (earlier) location. The pipeline could construct a test loop, fed by samples from the main line. Samples regularly extracted from the product stream could flow through the loop to the test equipment housed in a shed, and readouts of the results could be returned to controllers to identify the interface as the product approaches.

Operators point to a number of difficulties with such an upstream testing mechanism. According to industry experts, many refiners test the sulfur content of outgoing product using ASTM 5453-99 with such a test loop, and at least one major pipeline system uses ASTM 5453-99 with an upstream test loop, so it is clearly an effective alternative for some applications. Refineries may have more success using the ASTM 5453-99 with a test loop, because product flow is slower in refinery piping than in oil pipelines, and the speed of the product flow dictates the placement of the test loop. For example, such a loop would have to be positioned far enough upstream to allow the sample flow to reach the test equipment, perform the test, and return the readout in time to make the batch cut. If the loop transit and testing took 5 minutes, for instance, and the product flowed through the pipeline at 8 miles per hour, the equipment would have to be positioned about two-thirds of a mile upstream of the valve. This distance would commonly be outside of a station property, on the right-of-way.

Although positioning certain equipment upstream is a relatively common pipeline practice, restrictions on the use of or availability of space on the right-of-way would be among the factors that could be obstacles to positioning anything as substantial as a free-standing shed on the pipeline right-of-way. Power and communications availability on the right-of-way could also be impediments. The expense of the equipment is an additional deterrent to placing equipment in an unstaffed remote location. Finally, an oil pipeline with many delivery points—a delivering carrier might have 100, for example—would find it prohibitively expensive to install such equipment at each delivery location.

Special Issues Related to the Phase-In

The temporary compliance option as well as the provisions related to small refiners provide flexibility for refiners and importers to phase in ULSD, at the expense of pipelines and other downstream distributors. The phase-in provision assumes that some operators carry an additional grade of diesel / distillate fuel oil during the transition years, providing concomitant facilities for segregating the product. As noted earlier, the East Coast is the only region where operators consistently carry both diesel, at 500 ppm, and heating oil, at 3,000 to 5,000 ppm. Many pipelines carry only 500 ppm product, serving both highway and non-road needs with the same fungible grade (dye is added at the destination terminal). Most also carry jet fuel. The ULSD phase-in will push them to carry an additional grade of distillate fuel oil—diesel at 15 ppm—in addition to diesel at 500 ppm and, for some, heating oil at 3,000 to 5,000 ppm plus jet fuel.

Tank size and utilization have been optimized at most terminals to carry the existing product slate. Pipeline executives are universal and adamant in their opinion that sufficient storage tanks and other pipeline assets are not available in most pipeline systems to segregate a third grade of distillate. Many small terminals are unable to add tanks because of space and permitting concerns, and even at larger terminals such constraints may be a factor. Permits can take years to obtain. For terminals that are able add tanks, new tanks cost $1 million or more each, an expenditure that is necessary only to carry a discrete product for a limited period of time. In addition, because of the limited volumes involved, the tanks may be used inefficiently during the ULSD transition period.

The EPA estimated that there are 853 terminals, excluding tanks at refineries, that carry highway diesel. The EPA assumed that, of these 853 terminals, 40 percent would build a new tank to distribute both 15 ppm and 500 ppm diesel fuel during the transition period. At a cost of $1 million per new tank, the additional cost of new terminal tankage was estimated to be approximately $340 million.[88]

Beyond the terminal level, the EPA estimated there are 9,200 "bulk plants" that carry highway diesel fuel, excluding tanks at refineries. Again, the EPA assumed that 40 percent of these bulk plants would build a new tank to accommodate both 500 ppm and 15 ppm diesel fuel. The EPA assumed a cost of $125,000 for each of these smaller tanks, giving a total cost of new tankage at the bulk plant level of $460 million.[89]

Finally, at the truck stop level, the EPA assumed there are 4,800 truck stops operating in the United States, of which 50 percent would sell both 500 ppm and 15 ppm

[88] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter V, p. V-134.

[89] U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter V, p. V-134.

diesel fuel. The EPA cited a survey on the expected cost of handling a second grade of diesel fuel by the National Association of Truck Stop Operators of its members. Based on this survey, the EPA estimated an average cost of $100,000 per truck stop to handle the two diesel grades, giving a total of $240 million. A Petroleum Marketers Association of America estimate gave costs of $50,000 per truck stop.[90] The total costs of new tanks and equipment to handle both 500 ppm and 15 ppm diesel fuel were estimated by the EPA at $1.05 billion.[91]

The EPA estimated the total cost per gallon of highway diesel of additional storage tanks at 0.7 cents. This 0.7 cents per gallon additional cost was for the 2006 to 2010 phase-in period. The EPA assumed that the additional storage tanks would be fully amortized during the phase-in period, and that service stations supplying light-duty vehicles with diesel fuel, centrally fueled fleet facilities, and card locks (unattended filling stations) would not install additional storage tanks to handle both 500 ppm diesel and ULSD. Therefore, no cost was estimated for additional storage tanks during the phase-in at service stations, centrally fueled fleet facilities, or card locks.[92]

Where an operator cannot add a tank, it may choose to drop a grade of product. (Such a strategy is not a clear winner, however, because a dropped grade of gasoline, for instance, requires the shipment and storage of greater volumes of another grade of gasoline to compensate.) A carrier might be able to drop a grade of distillate fuel oil, but not without requiring an additional, compensating volume of low-sulfur product or ULSD to meet the market need, exacerbating the draw on refiner capabilities.

The question of whether pipeline companies will be able to recover the increased costs associated either with moving ULSD or moving ULSD plus another temporary grade is a matter of conjecture. The only process for recovery will be tariff rates, and the path to structuring rates to allow that recovery is uncharted.

Overview of Tariff Rate Issues

The majority of transportation for refined petroleum products by volume or by barrel-miles is provided by common-carrier oil pipelines operating in interstate service, under rates regulated by the Federal Energy Regulatory Commission (FERC). Most oil pipeline carriers have approved tariff rates on file with the FERC covering the transportation of diesel fuel. If no other application or action were taken by an oil pipeline company, the existing tariff rates covering diesel fuel would apply to ULSD when that material is distributed to markets. As noted in other sections of this report, however, oil pipelines will incur large, incremental capital and operating costs in distributing the new diesel fuel.

For most regulated oil pipelines, the FERC uses an economic index as the basis for approving tariff rate increases. The index provides that tariff rates may increase without challenge by a percentage amount no more than the Producer Price Increase for Finished Goods, less 1 percent over an approved base rate. If an oil pipeline carrier is operating under the FERC's index method and applies its existing tariff rate to ULSD, there will be no basis for the carrier to recover its extraordinary incremental costs in the approved rate.

Some oil pipeline companies operate under alternative programs with the FERC. The second most prominent method is to administer some or all of a carrier's tariff rates under a market-based system.[93] Under this method, if various markets served by an oil pipeline are first found by the FERC to be workably competitive, the FERC then stipulates the basis by which the pipeline carrier may raise rates more flexibly, without application of the index. Many oil pipeline operators believe that market conditions under which they operate are far more competitive than their status as regulated utilities suggests. If they are correct (and the FERC's own findings of workable competition in many oil transportation markets suggests that they are), pipelines will be competitively constrained from simply passing through their higher ULSD costs to shippers.

A carrier might file a new tariff rate expressly covering ULSD. If that rate is greater than the previous rate (or the remaining tariff rate for other grades of diesel fuel), the FERC or a shipper might protest the new rate, a common occurrence. In such an event, it is possible that the new tariff rate would not be permitted to take effect or that it would be accepted subject to refund if it were later found to be excessive. Furthermore, such administrative proceedings to adjudicate tariff rates before the FERC are costly and time-consuming.

As an alternative to attempting to recover incremental costs through increasing an existing approved rate or filing new tariff rates, carriers could try to impose special charges to recover incremental capital or operating costs

[90]John Huber, Petroleum Marketers Association of America, "Letter to U.S. EPA, Re: AMS-FRL-6705-2." Submitted to the public docket on August 11, 2000.

[91]John Huber, Petroleum Marketers Association of America, "Letter to U.S. EPA, Re: AMS-FRL-6705-2." Submitted to the public docket on August 11, 2000.

[92]U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter V, p. V-133.

[93]Other rate administration methods are available from the Commission, but they are even less frequently used.

by filing such charges as a part of the "rates and regulations" that normally cover the qualitative aspects of a tariff rate. Under this method, tariff regulations might support cost recovery in various forms, including a mandatory provision for the shipper to provide pipeline buffer material, a volume loss allowance, facility charges, or access charges. While the imposition of such special charges outside of the transportation tariff rate is possible, it is unlikely that material charges could be imposed without eliciting a shipper or FERC challenge, making this, too, an uncertain avenue for recovery of the unique costs.

Because of the difficulties presented by fitting ULSD into tariff rates, innovative approaches may be required. For instance, a pipeline carrier or an oil pipeline industry association might file an advance request with the FERC for a declaratory order either recognizing the validity of special charges or specifying the basis under which special charges would be applied to ULSD shipments. The purpose of seeking a declaratory order would be to clear a path for cost recovery before new capital or higher operating costs were actually incurred. Such an approach, with its earlier recognition of the issue, would allow the multi-year process to proceed well in advance of the collection of the new tariff rate.

The foregoing discussion suggests that higher capital and operating costs attributable to distributing ULSD will be difficult to recover, and that carriers will need to take proactive steps with the FERC and shippers in order to do so. There is no assurance that such steps will be successful, nor is there economic assurance that any such recovery will even be possible. Therefore, resistance among pipeline operators to incurring those costs should be expected.

Distribution Costs in the EIA Model

In its Regulation case analysis, EIA closely followed the EPA's assumptions about distribution costs, with the exception that EIA calculated the downgrade revenue loss within its NEMS model, using the prices of highway and non-road diesel generated from the model. From June 2006 through June 2010, EIA assumed an increased distribution cost markup of 1.2 cents per gallon on the price of highway diesel: 0.7 cents per gallon reflected the additional capital costs associated with handling two grades of highway diesel fuel during the phase-in period, 0.3 cents per gallon was the downgrade revenue loss, and 0.2 cents per gallon reflected other distribution costs, including operating and testing costs. The 1.2 cents per gallon additional distribution cost is slightly higher than the EPA's estimate of 1.1 cents per gallon. After June 1, 2010, the additional distribution cost associated with ULSD was 0.4 cents per gallon, including 0.2 cents per gallon for the downgrade revenue loss.[94]

EIA conducted a sensitivity analysis of higher distribution costs in the 10% Downgrade case. In the Regulation case, EIA followed the EPA assumption that ULSD product downgrade would be 4.4 percent of ULSD supplied. In the 10% Downgrade case, EIA assumed that 10% of ULSD would be downgraded from the highway diesel market. From June 2006 through June 2010, EIA assumed an additional distribution costs of 1.6 cents per gallon of highway diesel supplied. Of the 1.6 cents per gallon, 0.7 cents per gallon was for additional storage tanks to handle two on-highway diesel grades during the phase-in, 0.7 cents per gallon was for the revenue loss from downgrading ULSD, and 0.2 cents per gallon was for other distribution costs. After the end of the phase-in, in June 2010, the additional distribution cost was 0.9 cents per gallon: 0.7 cents per gallon for downgrade revenue loss and 0.2 cents per gallon for other distribution costs (see Chapter 6 for more detail).[95]

Summary

The Nation's refined petroleum product pipeline system is not monolithic. Pipelines are distinguished by region, type of service, mode of operation, size, how much interface material they produce, and how they dispose of it. In preparing this report, a variety of pipeline companies were consulted, representing a cross-section of size, capacity, location, markets, corporate structures, and operating modes.

It is likely that the pipeline industry can distribute ULSD successfully, but major challenges arising from the unique specifications of a new product prevent a clear assertion that pipeline distribution of the material will be successful. In successfully distributing ULSD, oil pipelines will have to surmount numerous challenges:

- Coping with a product phase-in
- Demonstrating that untested pipeline batching techniques work
- Determining for the first time that sulfur content from other refined products does not "trailback" in pipelines and will not avoidably contaminate the new fuel

[94]U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter V, p. V-121.

[95]U.S. Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements*, EPA420-R-00-026 (Washington, DC, December 2000), Chapter V, p. V-121.

- Installing product quality testing equipment (which does not yet exist)
- Recovering operating costs that are not transparently recoverable under FERC regulations or market conditions
- Collecting, transporting, reprocessing, and selling up to twice the volume of existing pipeline transmix
- Reconfiguring an undetermined number of existing stations with new piping, tanks, manifolds, or valves
- Installing new loading facilities at distribution terminals.

Protecting the integrity of 15 ppm product will be more difficult than protecting the product integrity of the current 500 ppm product. The sulfur concentration of the neighboring product will more easily lead to contamination of the ULSD. Not only is the specification lower, with less room for error, but also the "potency" of the sulfur in the nearby product is higher.

It appears that the overall proposition of transporting ULSD is feasible. More problems can be expected to arise in handling ULSD among delivering pipeline carriers than among trunk carriers. In particular, those delivering carriers that cannot support fungible operations, are already short of working tankage, have complex routing and schedules, or have small markets at their end points will have the greatest difficulty in transporting ULSD.

The market impact of a contaminated batch will be stronger, however. With such a tight specification, there is little opportunity for blending lower sulfur material into an off-specification batch or tank. With the regulation applied as a cap with no averaging aspect, an off-specification tank in a terminal with only two tanks will quickly lead to a localized shortage of highway diesel, especially in areas where the market is thin and the infrastructure sparse.

Finally, there are uncertainties about transporting ULSD that cannot be resolved without hands-on experience with this unique product.