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ENSURING THE AVAILABILITY AND RELIABILITY OF UREA DOSING FOR ON-ROAD AND NON-ROAD

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ABSTRACT

The purpose of this presentation is to address two important issues. The first issue is nationwide availability of urea. The second is assurance by the engine maker that the engine cannot operate without urea.

In regard to the first issue, North American urea production can support SCR needs for the Heavy Duty truck industry. The existing distribution methods, pathways and technology could be utilized for urea supply with no new invention required. Urea usage and storage capacity on vehicles would support long distances between tank refills, as SCR could be initially rolled out with a limited infrastructure. The price of urea should be less than diesel fuel and urea SCR should have a fuel economy advantage over competing technologies. It can be in place by 2007.

In regard to the second issue, sensor technology exists to monitor urea tank level and verify that the fluid in the tank is urea. NOx sensors are available to monitor tailpipe NOx, ensuring the entire SCR system is functioning properly, and inferring that urea is in the system. The monitoring system could be used to monitor compliance, record faults, and initiate enforcement actions as necessary. The monitoring system could initiate actions to encourage compliance.

Background

A report in August 2001 by A.D. Little entitled "Supplying Urea for the On-Road Vehicle Market" concluded that "Urea is a viable reductant for using SCR technology in diesel vehicles".[1] It further identified the establishment of a urea distribution infrastructure as a major issue with many open questions. These findings prompted additional study.

TIAX released a study analyzing possible business cases for a viable urea infrastructure in the United States. This study identified key stakeholders as engine and truck manufacturers, truck operators, urea manufacturers and distributors, and diesel fuel retailers. The study identified potential business models to support profitable distribution of urea for SCR. It further identified potential distribution pathways utilizing existing pathways and equipment. In conclusion, the study determined that the infrastructure can be in place by 2007.

European Urea Distribution Plans

In Europe, the diesel manufacturers, suppliers, refiners, and urea suppliers have formed a working group for SCR urea distribution called "AdBlue". Companies in the AdBlue working group include refiners: OMV, Shell, Aral, Esso (ExxonMobil), BP and TotalFinaElf. Diesel engine/vehicle manufacturers include: DaimlerChrysler, Ford, Opel, VW, Fiat, Volvo, MAN, Deutz, Audi, DAF, Iveco and Renault.

AdBlue's goal is to resolve potential problems with urea supply, distribution and handling. It developed a standard for SCR quality urea. The group is currently developing standards for urea nozzles and urea tank filler necks. Refiners will open SCR urea facilities this year. They are negotiating with commercial fleet operators on installation of urea resupply centers at terminals. AdBlue expects distribution to facilities to begin with private trucking company terminals, then move to commercial fleet card locks and truck stops, and then to public diesel fueling stations as demand grows.

NA SCR Urea Demand/Supply

The urea demand and supply in the US for 32.5%wt SCR quality for new Class 8 trucks has been estimated as 200-350 million gallons in 2007, and 600-1100 million gallons by 2015.[2] The NA urea production in 2007 is projected to be 13,700,000 tonnes (equivalent to 9.7 billion gallons of 32.5%wt urea).

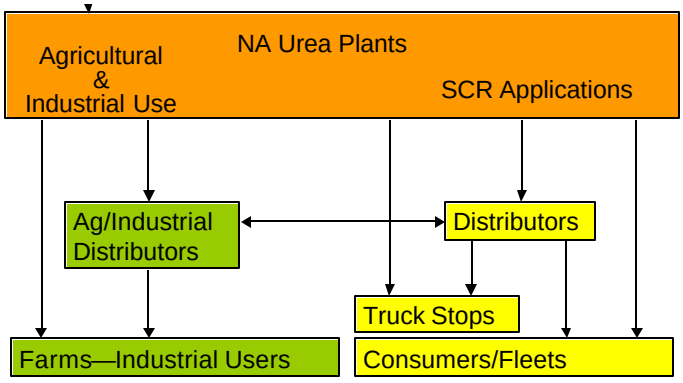
In 2007, global urea production is estimated to be greater than 124 million tones, with the NA urea SCR needs less than ½% of the supply. More than 30 million tones will be available on the global export market. The additional demand created by NA SCR would be 1.6% of current projected global urea export supplies.

Urea Distribution Pathways (Fig.1)

The distribution of urea from the plant could be in the form of solid urea or concentrated liquid urea 70%wt and diluted later in the distribution chain. These are a more efficient/cost effective way to transport. Due to purity, cleanliness and ease of dilution and handling in distribution, we recommend liquid

[1] A.D. Little, August 2001, *Supplying Urea for the On-Road Vehicle Market*

[2] TIAX LLC



urea. It is a simple process at the distribution center to dilute the liquid urea with distilled water to the desired concentration. Imported urea would best be used to supplement supplies for agricultural use and domestic supply used for SCR due to cleanliness and purity.

Distribution Phase-In

Long-term distribution would be through distribution networks similar to diesel fuel – using rail cars and tankers to deliver to distributors, truck stops, and commercial stations – or directly to fleets.

In the interim, while demand and distribution is ramping up, a variety of distribution methods could be used. For sites with large demand and throughput, concentrated urea could be delivered by rail car or tanker at low cost and diluted on site for distribution. For sites with moderate demand, 32.5%wt urea could be delivered by tanker to storage tanks for distribution. For sites with low demand, 32.5%wt urea could be delivered in 200-gallon totes or 55-gallon drums.

Urea Cost

The urea cost to the end customer would be dominated by distribution costs. The material cost for urea coming out of the NA plants would be low – approximately 41 cents per gallon (32.5%wt equivalent) with a natural gas cost of $5.40 per MMBtu. Natural gas price fluctuations would primarily affect only the material cost and even large fluctuations in natural gas prices would cause fluctuations of only a few cents in urea prices. The urea price to the customer would be highly affected by the throughput at the distribution point. Urea prices to the end user assuming reasonable demand and throughput at the distribution points should be in the range of $1.00 per gallon.

Impact on Consumer

Assuming an average fuel economy of 6.5 miles per gallon and a urea consumption ration equal to 5% of diesel fuel, to travel 1,000 miles, 7.69 gallons of urea would be needed. A 25 gallon urea tank would provide a range of 3,250 miles before refilling, which would allow a trip from coast to coast. A 50 gallon urea tank would allow a trip from coast to coast and back again, which supports a worst case fleet central filling station scenario.

Assuming a urea price of $1.00 per gallon, this would equate to an operator cost of 0.769 cents per mile. Urea cost could be offset by the fuel economy savings expected with an SCR system versus alternatives.

Non-Road Supply

Urea distribution for non-road (i.e., agricultural) diesel applications could be supported in a number of ways. The end-user could get the urea from the same source used for diesel fuel supply. In non-road agricultural applications, the agricultural urea distribution pathways may be able to support urea supplies – cleanliness and purity may be issues. For customers with small urea needs, urea could be made available from distributors or diesel filling stations in 55 gallon drums, or even using a 5 gallon "urea can" that could be refilled at a filling station or truck stop as necessary.

Ensuring Urea Use During Operation

Urea level in the tank could be monitored with sensors. The tank level sensor could light a low level warning light to alert the operator, and a second level sensor could trigger enforcement actions such as engine de-rate or shutdown. The sensor technology exists to measure urea concentration to ensure that the fluid in the tank is urea of acceptable concentration. An NH_3 sensor could alternatively be used to ensure urea is available in the system. A NOx sensor in the tailpipe can monitor full function. This would ensure that •urea is being used as needed and that the entire system is functioning properly

NOx sensors

NOx sensors are currently available with performance necessary to support SCR system operation and monitoring. They are accurate in the low range necessary to measure compliance (+/- 20ppm), have response time approximately 750ms (future target of 500ms), currently have 120,000 mile life for HD and expected to be capable of at least 150,000 miles by 2007, and NOx sensors are currently in production in Europe for passenger car applications

Monitoring and Enforcement

A monitoring system similar to On Board Diagnostics (OBD) could support actions such as warning the operator when urea tank levels are low (level sensor), triggering enforcement action if urea tank is empty or near empty (level sensor), triggering warning and enforcement action if fluid other than urea is filled into urea tank (urea concentration or ammonia sensor), warning the operator and/or trigger enforcement action if NOx level exceeds limits (NOx sensor). Enforcement actions of increasing severity could be triggered depending upon duration of high NOx level. NOx level monitoring would also accomplish monitoring of the presence of urea in system.

Enforcement actions could include:

- Light a warning light or Malfunction Indicator Light (MIL)
- De-rating engine performance to encourage corrective action if initial warnings are ignored
- Engine shutdown or blocking engine restart after shutdown if system faults exist and corrective actions are not being pursued in a timely manner
- Vehicles found to have a MIL light on and/or fault codes due to emission system faults that have not been corrected could be subject to fines

- More discussion is needed between industry and government groups to determine the best enforcement options, but the technology and processes necessary are available today

Conclusion

Solutions exist to resolve the major issues that are obstacles to the implementation of urea SCR technology for HD Trucks. But, the trucking, diesel, urea and petroleum industries must organize and begin taking action now if urea SCR is to be ready for 2007.

REFERENCES

Diesel Fuel News, 2003 Hart Publications

A.D. Little Report, August 2001

TIAX report, July 30, 2003, SCR-Urea Infrastructure Implementation Study.