



# **DEF Infrastructure**

## **An Industry Progress Report**

**Fall 2010**

**WHITE PAPER**



## Sponsored by:

TerraCair  
SPATCO®DEF  
Brenntag

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## Executive Summary

Finding diesel exhaust fluid to supply fleets is becoming easier thanks to infrastructure investments that provide the market with a variety of product delivery options. The ways in which DEF is produced, stored, transported and vended are key components of ensuring product purity and stable supply.

In this paper, we outline the advancements that have been made in DEF infrastructure, urea manufacturing, distribution and proper handling procedures.

## DEF Infrastructure

By some estimates, at least half of all diesel vehicles on U.S. roads in 2014 will be equipped with Selective Catalytic Reduction (SCR) technology in order to meet the U.S. Environmental Protection Agency's (EPA) standards for reduced diesel emissions.

By injecting Diesel Exhaust Fluid (DEF), a non-toxic mixture of water and urea, into the exhaust of vehicles using SCR technology, harmful NOx emissions are reduced to almost zero. In addition to reduced emissions, extensive testing has shown that SCR systems exhibit a 4-6% fuel savings over standard diesel engines.

Finding DEF to serve SCR-equipped engines has become much easier in the past two years thanks to the investment by both DEF producers and marketers, and the widespread adoption by engine manufacturers of SCR technology. This gives the OEM's direct ownership of the technology change - which is what they've done.

Fleets and the truck stop marketers who serve them now have a wide variety of options for accessing DEF. Packaging sizes range from small plastic jugs to large bulk containers. Fleets may find the smaller sizes meet their initial DEF needs and choose the larger package sizes as the 2010 emissions-compliant SCR vehicles in their operation increases in number.

The demand for DEF is growing, but it is much less than previously projected due to the slowed economy and fleet companies pre-buying trucks with 2009 engines to avoid the substantial upcharge for the 2010 engines. Gone is the "hockey stick"-like growth projected two years ago by the Engine Manufacturers Association and other industry observers, replaced by a more moderate projection of about 20 million gallons of DEF that will be sold this year (compared to earlier estimates of 70 million gallons). Estimates of demand in the year 2014 have fallen from more than 600 million gallons to just over 300 million gallons, or about 1% of ultra-low-sulfur diesel (ULSD) demand.

Still, even with a more modest demand projection, DEF represents the largest addition to the motor vehicle liquids marketplace in decades; this represents a rare opportunity for retailers and a challenge for fleets.

### Section 1: Infrastructure Development Progress

Manufacturers of 2010 EPA emission-compliant heavy duty on-highway diesel engines say their engines have been well received in the marketplace. Reports and feedback from fleet customers, as well as from demo trucks in the field, have been positive, with the engines meeting expectations and consistently delivering fuel economy improvements over the previous generation of engine technology.

With the 2010 engines really starting to hit the road, many fleets and truck stop retailers are scrambling to purchase DEF and the equipment needed to dispense it.

Net orders for new heavy-duty Class 8 trucks averaged about 14,000 units in April and May of 2010, according to data from ACT Research Co. This was up sharply from the average of about 7,500 in the same two months in 2009. Yet, even though orders have nearly doubled, they still remain below the monthly average of the past 10 years of 18,000 units.

**Pilot's first 100 DEF  
"at the pump" locations are:**

Amarillo, Texas  
 Avondale, Arizona  
 Bordertown, New Jersey  
 Brooks, Oregon  
 Carlisle, Pennsylvania  
 Charlotte, North Carolina  
 Cheyenne, Wyoming  
 Denver, Colorado  
 Dexter, Michigan  
 Effingham, Illinois  
 Ft. Pierce, Florida  
 Gallup, New Mexico  
 Greenville, Virginia  
 Hesperia, California  
 Houston, Texas  
 Meridian, Mississippi  
 Milford, Connecticut  
 Murfreesboro, Tennessee  
 Oak Creek, Wisconsin  
 Oklahoma City, Oklahoma  
 Santa Nella, California  
 Seville, Ohio  
 St. Cloud, Minnesota  
 Stanfield, Oregon  
 West Memphis, Arkansas

DEF began showing up on product shelves in truck stops and travel centers as early as 2009 and has now become a regular catalog item for truck stop and automotive retail merchandise suppliers, joining lubricants, windshield wiper fluid and other motor vehicle Do-It-Yourself items as standard SKUs.

In addition, some larger fleets have begun installing bulk quantities of DEF to service SCR-equipped trucks at central locations, and a couple of the large truck stop chains have installed specially designed DEF dispensers on the fuel islands. Mobile bulk supply is also available through tanker-truck, and truck stop chains that offer mobile emergency service are offering DEF on their vehicles as well.

### DEF Availability at Truck Stops and Travel Centers

Retail availability of DEF in large fuel-like dispensers may be limited to the larger truck stop chains over the next couple of years, as smaller truck stop owners are reluctant to make the investment needed to add DEF in bulk quantities. A few of the top US truck stop chains have rolled out the product in advance of demand in order to establish a reputation for having DEF available.

Although retailers may not sell much DEF initially, the lost revenue resulting from a driver, or a fleet dispatcher, switching to another truck stop when theirs doesn't offer DEF could be substantial. Getting a customer to return after they've found what they are looking for elsewhere is an uphill struggle.

Currently, the inventory of DEF in the nation's delivery system is much higher than demand will cover in six months. Simple economics suggest retailers will pay lower prices for DEF until demand catches up with supply, providing them with the option of using the savings to increase margins or to compete on price with other retailers.

Pilot Travel Centers was the first to install a bulk DEF dispensing tank in a retail application. To date, it has more than 65 units installed nationwide and plans to offer DEF at the pump at 100 truck stops this year. Though all Pilot Travel Centers will sell pre-packaged containers of DEF, the focus is on the convenience of being able to pump DEF directly from the fuel island.

Truck stop merchandise distribution chains such as DAS and McLane have product available to supply case quantities to truck stops and convenience stores. DAS lists a TerraCair DEF 2.5 gallon jug for \$11.99.

### Section 2: Urea Manufacturing

Although there appears to be sufficient supply to meet current demand, don't look for sizeable increases in supply until manufacturers see the market mature further.

"There is adequate ammonia/urea productive capacity available to meet market requirements going forward," says Barry Lonsdale, president of Terra Environmental Technologies/CF Industries (TET/CF). "However, the stringent DEF product specification requires considerable plant investment to achieve. Those

DEF finder maps

Over the past several months, several web-sites have popped up offering searchable maps for finding DEF supply. Most allow the user to type in a zip code to locate retail outlets offering DEF.

Here are a few examples:

- U.S. Department of Energy  
www.afdc.energy.gov/afdc/locator/def/
- DiscoverDEF.com  
www.discoverdef.com/fleet-supply.aspx
- Cummins Filtration  
www.fleetguard.com/wrl/retaillocator.do?\_locale=en
- FindDEF.com  
www.finddef.com/def\_map.php

investments are taking place relative to the evolving market requirements, but are not near complete.”

“There are no industry numbers available to accurately reflect available capacity relative to demand since the market is in its infancy,” Lonsdale says.

Still, urea production volume is available since it is used in much greater volumes in the agricultural sector and has been for many years. According to data provided by CF Industries, worldwide urea production is about 140 million metric tons, representing growth of about 40 million metric tons in the past 10 years.

Meanwhile, worldwide consumption of urea for fertilizer production and use is about 100 million metric tons and is growing not as quickly as production. In 2000, consumption for fertilizer production was just 80 million metric tons.

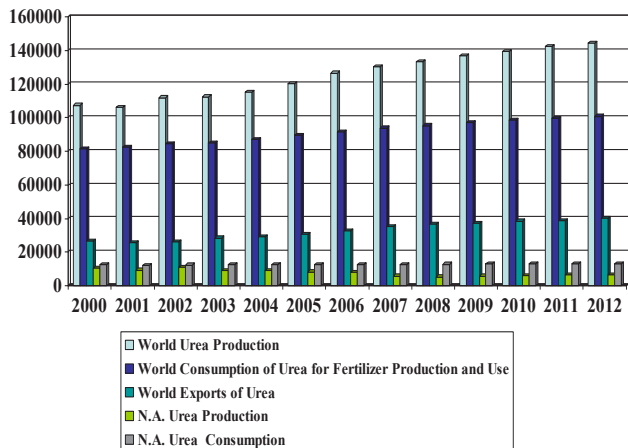
North America urea production is below 5 million metric tons and has shrunk in the last decade. Consumption for fertilizer production is roughly double at about 10 million metric tons. Imports must be brought in to meet the rest of North American demand.

It is important to note that most urea does not meet the strict ISO 22241 specifications to qualify as automotive-grade DEF, says John Lounsbury, director of marketing for TET.

Section 3: Distribution

Eventually, the DEF mixture can be transported in higher concentrations and then diluted in regions that are farther away from production facilities if quality can be maintained.

UREA GLOBAL SUPPLY/DEMAND '000 Metric Tons



7 CF-TET Nitrogen Production Plants #1 North American Producer



Urea-based reductants are already being sold and distributed across North America, for NOx reductions in stationary SCR applications such as those used by industrial power plants.

The key to successfully distributing DEF across the country will be transporting urea products to existing terminal locations in major metropolitan cities. These facilities are ISO certified, have massive liquid storage capacity, blending, rail, and their own fleet of tanker trucks. Urea products for other markets are already being distributed through these facilities.

The primary distribution point will be chemical distribution companies which will provide DEF in bulk tanker and mini-bulk quantities.

This model has been successful in Europe where chemical distributors have compatible assets such as stainless tankers. Fuel oil distributors will supplement the distribution chain in select markets and geographical areas.

Distribution of DEF, like petroleum products, is a multi-tiered system that uses a variety of modalities including rail, tanker, bobtail truck and barge. The mode of transport is chosen based on urea concentration, proximity to market and customer requirements.

### **1. Distribution – Tier 1**

The first tier of distribution is national terminal systems such as Brenntag and Airgas. These companies have assets ready to bring in DEF by rail or tanker and store and package across the U.S. and are currently moving large quantities from manufacturer to customer. DEF is produced in 32.5%, in concentrate or in granular form and shipped by rail or tanker to regional terminals and packaging centers. Some companies have as few as one terminal and ship to warehouses across the country. Brenntag occupies the other end of the spectrum, having over 100 locations to warehouse and/or process and package DEF. Brenntag today has the infrastructure in place to satisfy DEF demand across North America. Even in the early stages of DEF development, Brenntag is receiving multiple rail car loads every week at their DEF terminal locations. Brenntag currently stocks DEF at the tier 1 distribution point; Brenntag Tier 2 distribution partners pick up DEF at Brenntag Terminals or product is delivered. This is critical to the quality process and offers geographical advantages.

### **2. Distribution – Tier 2**

The second level of distribution brings product to the customer in cases or less than truck load. Oil marketers, fuel marketers, and goods distributors such as Barjans bring product to the end user with like products such as oil and fuel. In many cases the DEF volume will be high enough at the end user that the terminal locations will deliver direct.

### **3. Supply Models**

An efficient supply strategy and one that ensures the highest quality is essential. The DEF brands you seen in the marketplace were created by the manufacturer, the distributor, or the Original Equipment Manufacturer (OEM).

### Product Stability

It is generally accepted that DEF will have a 1-year shelf-life if stored between 86°F (30°C) and 12° F (-11 ° C). If it is stored at temperatures above 86°F (30°C), and the fluid temperature itself rises above 86°F (30°C) for a prolonged period, the shelf-life will be reduced.

**Manufacturer Brands** – Manufacturer brands such as TerraCair and Yara are the urea supplier’s brand and they carry the quality process to the tank. This type of channel is governed by the manufacturer. One source of DEF is used and it’s audited by the manufacturer through the process. This ensures quality and consistency to the point that it’s guaranteed to the tank. Any issues with quality can be easily traced and corrected through the system.

**Distributor Brands** – Brands such as AirX, BlueDEF, and DEFendal are created at the distributor level. The source of DEF or pure urea can be from a variety of sources. The quality responsibility is at the distributor who is sourcing raw materials and blending DEF at their facilities.

**OEM Brands** – These are branded at the end of the channel by the OEM. The DEF comes from one of several manufacturers and the quality responsibility is with the OEM.

## Section 4: Fluid Handling and Dispensing

In ideal temperature and storage conditions, the shelf-life of DEF is about one year. The long shelf-life of DEF means retailers can worry less about spoilage than they’d have to for some other automotive products.

To ensure product stability, DEF should be stored at temperatures between 12°F-86°F (10°C-30°C). DEF stored in conditions where the temperature is higher than 86°F for a prolonged period will detrimentally affect urea quality.

Stored at temperatures below 12 ° F, the product will begin to crystallize. While crystallization renders DEF difficult to dispense, the liquid will begin to thaw once the temperature is above 12 ° F and suffers no detrimental effect on the specification.

DEF pack sizes range in size from small bottles, to totes and drums to bulk dispensers. Typical configurations include 330-gallon totes, 55-gallon drums, 2.5-gallon jugs and 1-gallon bottles. DEF is also available in bulk quantities.

Jugs are more expensive and time consuming than bulk dispensing, and are not practical for multiple vehicle fleets. If fleets will be fueling multiple vehicles, typically 330-gallon IBCs/ Totes are a better option.

For smaller fleets and service bays, a light duty dispensing system may be appropriate. For retail truck stops, stand-alone units of 1,000 to 2,000 gallon capacity are available and can be tied to the POS (Point of Sale) technology, making the transaction part of the overall sales experience. Several manufacturers offer specially designed DEF dispensers that mount directly on the fuel island.

Engine makers plan to dose DEF at a rate of 2%, or 2-gallons of DEF for every 100-gallons of diesel fuel. A heavy-duty truck with an average fuel economy of six miles-per-gallon could travel 600 miles on that same 2-gallons of DEF. That

**Above Ground**

vs.

**Below Ground Storage Tanks**

While it is possible to use below ground storage for DEF, it is not an ideal option. Widespread abandonment of underground storage tanks by the chemical industry is proof of this. The DEF storage tank must be 100% stainless steel and that is expensive. Regulations also require regular visual inspections which include completely draining the tank. Also, it is cost-prohibitive to install an underground tank at an existing facility when you factor in piping, installation, etc.

same trip would therefore only take around two gallons of DEF. That would give the truck a reasonable number of miles to get to a larger DEF dispensing facility to refill.

**Proper Handling and Storage**

In accordance with ISO 22241 specifications, each component of the dispensing system, including tank, piping, pump, meter and filtration, must be used exclusively for DEF in order to prevent cross-contamination with other chemicals or products.

The following are some key considerations for those planning to own and/or dispense DEF:

a) Open System vs. Closed System: A closed/sealed drum and IBC/Tote system ensures no contamination by dirt and foreign objects. For example, a dip-tube based, quick connect closure system specifically designed for dispensing DEF from containers such as 55-gallon drums and large IBC totes. The key benefits to a closed dispensing system is that the DEF is transported and dispensed in a completely sealed manner, ensuring compliance with ISO 22241 standards.

b) To date, DEF can only be safely stored in stainless steel, or in a high density polyethylene container. High-density polyethylene can be used in bottle packages and mini-bulk quantities of up to 2,000 gallons, but larger containers should be stainless steel or other ISO 22241-approved materials in order to avoid contamination.

c) Materials not recommended include non-ferrous metals and alloys (copper, aluminum, magnesium, silver, zinc, lead), solders containing non-ferrous metals, and nickel-coated plastics and metals.

Hose Specifications: Do not use standard curb hose. Users cannot use standard rubber hoses. Hoses must be ethylene propylene diene Monomer (M-class) rubber.

Nozzles: all stainless, magnetic vs. non-magnetic.

*Nozzles have been developed to prevent the possibility of introducing DEF into the diesel tank. OPW, for example, offers a 21Gu DEF Filling system that will not work if it is placed in a diesel tank. This mis-filling prevention device eliminates the risk of accidental DEF filling or environmental contamination. A magnetic actuated interlock device is located on the spout and it is colored blue to provide an easy color cue.*

**What to Consider Before Selecting DEF Dispensing Equipment**

Evaluate your usage requirements when selecting equipment. Consider selecting equipment that matches your short-term and long-term DEF dispensing needs.

Light and medium duty equipment will work but has a limited life expectancy versus heavy duty equipment that is designed for more robust and higher volume usage over time.

a) Make sure you are comparing apples to apples when evaluating equipment manufacturers. One company's "Light or Medium" Duty equipment line may

### Standards for DEF Purity

Standards for the purity, handling and dispensing of DEF have been established by the American Petroleum Institute (API), the International Organization for Standardization (ISO) and the Petroleum Equipment Institute (PEI).

For more information on these standards, please visit...

[www.api.org](http://www.api.org)

[www.pei.org](http://www.pei.org)

[www.iso.org](http://www.iso.org)

ISO has developed a document detailing the specification, testing methodology, storage, handling, transportation requirements, and the refilling interface for DEF. That document is ISO 22241 parts 1, 2, 3 and 4. This copyrighted document is available for purchase from ISO's website at: [http://www.iso.org/iso/iso\\_catalogue/catalogue\\_tc/catalogue\\_detail.htm?csnumber=42941](http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=42941).

offer the same features as another manufacturer's high-end, or Heavy Duty line. Ask for equipment specifications (or "spec sheets") for all pieces of equipment you are considering.

b) Consider location – where you will place your storage and dispensing system equipment. DEF freezes at 12° F so the location of the equipment guides the type of equipment you require. If the DEF will be stored and dispensed inside a shop environment or service depot, the dispensing systems can be set next to or on top of drums or totes without the use of heaters. If the DEF will be stored outdoors or dispensed outdoors, enclosed systems are available. These systems include tank storage and dispensers in insulated enclosures with heaters that keep the product from freezing, as well as offering additional protection from truck traffic.

c) Consider the environment in which the DEF will be stored and dispensed, the amount of space available for the equipment, the need for multiple dispensing points if required, the amount of DEF that will be required initially and in the future. (You may need to start with drums, move to totes/bulk in the future, or you may want to invest in a bulk system initially).

d) Durability – concerns about equipment on the island, what is the building made of? What are the impact/crush rates, weight-bearing capacity? Take into account local regulations regarding snow-loads (snow and rain on a weak roof may cause it to collapse), wind and seismic ratings.

e) Does the equipment meet or exceed ISO 22241 compliance standards?

f) For retail truck stop or bus garage applications: Does the dispensing system offer the flexibility to feed multiple DEF dispensers on the island? Or, do you have to purchase a separate system for each dispenser?

g) Does the DEF need to be metered? Will standard metering work or do you need weights and measure metering?

### Conclusion

The role of DEF in the U.S. fleet business will grow as more SCR-equipped trucks make their way on to the nation's highways. With proper care and planning, problems with impure product and supply disruption can be avoided. Fleet managers and retailers will undoubtedly find that integration of DEF can be achieved smoothly with certified equipment, training and execution.

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## About the Sponsors

### About Terra Environmental Technologies (TET)

TET is a wholly owned company of CF Industries, the world's second largest nitrogen products producer and North America's largest Diesel Exhaust Fluid (DEF) manufacturer.

TerraCair® Ultrapure Diesel Exhaust Fluid is an automotive-grade, API-certified DEF. Selected by Volvo, Mack, Freightliner, Hino and others as their factory fill and dealership choice, TerraCair works with SCR-equipped diesel engines to meet the EPA's NOx emission tailpipe standard and to deliver a fuel economy benefit.

Terra Environmental Technologies

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### About SPATCO®DEF

SPATCO® has been an industry leader since 1935, providing a complete line of equipment and services for storing, pumping, mixing, and metering petroleum and industrial liquids.

Working with retail petroleum and bulk fuel distributor customers, they have been at the forefront of developing alternative fuel solutions that address the business needs of their customers, including: Customized Fuel Blending, Ethanol Dispensing and Storage, Inline Injection and Splash Blending Systems, and DEF Dispensing Systems.

The SPATCO®DEF product line provides DEF Dispensing Systems for commercial and private fleets, municipalities, school and city bus garages, trucking companies, and retail truck stops. They installed North America's first fuel island bulk DEF systems at Pilot Travel Centers and offer the industry's first secondary containment feature to their tote storage enclosure system.

SPATCO®DEF is headquartered in Charlotte, N.C. and has 34 distributors throughout North America who provide sales, service and installation for its DEF Dispensing equipment.

### SPATCO®DEF

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### About Brenntag

Brenntag is the global market leader in full-line chemical distribution. Linking chemical manufacturers and chemical users, Brenntag provides business-to-business distribution solutions for industrial and specialty chemicals globally. With over 10,000 products and a vast supplier base, Brenntag offers one-stop shop solutions to more than 150,000 customers. The value-added services include just-in-time delivery, product mixing, formulation, repackaging, inventory management, drum return handling as well as extensive technical support. Headquartered in Mülheim an der Ruhr, Germany, Brenntag operates a global network with more than 400 locations in more than 60 countries. In 2009 the company realized global sales of EUR 6.4 billion (USD 8.9 billion) with approximately 11,000 people.

Brenntag

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