



Technical Bulletin

Refractometers for Field Testing Urea-Based Diesel Exhaust Fluid (DEF / AdBlue) in Selective Catalytic Reduction (SCR) Equipped Diesel Engines.

Introduction

Manufacturers of diesel-powered on and off-road vehicles are required to meet strict new EPA emissions regulations and are therefore employing a number of technologies in order to comply with these regulations. One of these new technologies is known as Selective Catalytic Reduction (SCR).

Selective Catalytic Reduction (SCR) is an advanced emissions-control technology that uses urea, a liquid reducing agent, to treat diesel exhaust gases prior to them entering a special catalytic converter. The fluid, known as Diesel Exhaust Fluid (DEF) in the US and AdBlue® in Europe, consists of a very specific concentration of aqueous Urea in demineralized water. It is injected into the hot exhaust gases as a fine mist prior to it passing through a catalyst. The catalyst, in the presence of urea, converts harmful NOx into harmless nitrogen and water vapor.

Nearly all vehicle manufacturers plan to utilize Selective Catalytic Reduction (SCR) with Diesel Exhaust Fluid (DEF) to help their engines pass EPA guidelines.

Diesel Exhaust Fluid

The key element in the SCR system is Diesel Exhaust Fluid (DEF). Diesel Exhaust Fluid (DEF) is simply urea, a nitrogen-based compound that turns to ammonia when heated. SCR equipped diesel trucks will be manufactured with Diesel Exhaust Fluid (DEF) holding tanks which will hold several gallons of urea and should provide several thousands of miles of treatment.

Significant investment is being made across the country to create an entire infrastructure to sell urea-based Diesel Exhaust Fluid (DEF). Diesel Exhaust Fluid (DEF) pumps can now be seen alongside diesel fuel pumps at gas stations, truck stops and diesel service facilities across North America. Diesel Exhaust Fluid (DEF) is also available from car and truck dealers and at many retail locations as well.

Diesel Exhaust Fluid (DEF) is distributed at the pump, in 275 gallon intermediate bulk containers, in 55 gallon drums, and in 2.5 gallon retail-sized containers. It usually costs the least at the pump, slightly more in bulk, and still more in retail quantities. DEF is sold in North America as DEF, C-Blue (Colonial Chemical Co.), TerraCair (Terra Environmental), and Air1 (Yara). Outside North America, DEF is sold under the trademark AdBlue®, a registered trademark of Verband der Automobilindustrie e.V., the German automotive association.

Quality & Testing

The proper concentration of Diesel Exhaust Fluid (DEF) is essential for mitigating NOx emissions and prolonging the life of the SCR components. DEF degrades over time depending on exposure to sunlight and moderately high temperatures. Even small changes in concentration or the addition of chemical impurities can have an impact on DEF quality and performance.



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One of the biggest concerns is water dilution, but without the proper tools it is nearly impossible to know if a DEF supply has been diluted. The International Standards Organization (ISO) standard ISO 22241-1, the international standard for DEF, calls for a concentration of 32.5% (+/-0.7%), and requires DEF quality testing at each stage of the distribution process.

In the US, DEF quality is monitored and certified by the American Petroleum Institute (API). API is a non-profit trade association and advocacy group for the North American petroleum and natural gas industry. They are probably best known for developing, promoting, and maintaining standards and recommended practices for petroleum products and equipment. However, they also conduct research, publish trade statistics, provide education and training, and among other things, provide the certification and licensing for engine oil. All this uniquely prepares them for their new role in certifying producers of Diesel Exhaust Fluid (DEF) for Selective Catalytic Reduction (SCR) equipped diesel engines.

Consumers should be aware that all API certified DEF fluids will be marked with the API symbol to indicate certification of the fluid's producer. Failure to use API certified DEF fluids may also void vehicle manufacturers' warranties.

Dilution Dilemmas

Water is devious and manages to find its way into the most unlikely places. Even with all the water controls in place, water often finds its way into both in-ground and above-ground fuel storage tanks. Water infiltration happens with automotive gasoline, diesel fuel, and even aviation fuels. How then, if people can't keep water out of fuel tanks, will they be able to keep it out of the DEF tanks at each stage of the distribution process?

Even more devious are the profiteers or unscrupulous DEF distributors who try to make a few extra bucks by watering down the DEF supply. This has already happened in Europe. They don't care that they are not only diluting the DEF fluid, but may be adding harmful minerals and salts which can damage the SCR system (ultra-pure demineralized water is one of the key components used to ensure DEF quality).



New Urea Refractometer Can Detect Tampering of Urea-Based Diesel Exhaust Fluids.

The MISCO Palm Abbe [DEF-201](#) & [DEF-202](#) are handheld digital refractometers designed specifically for testing the concentration of urea-based Diesel Exhaust Fluid (DEF). Diesel Exhaust Fluid, which is required for diesel-powered vehicles employing Selective Catalytic Reduction (SCR) technology, must be maintained within a very narrow 1.5% concentration range for API Certification and in order to meet international standards.

The simple refractometer test requires only a few drops of urea-based Diesel Exhaust Fluid, and a couple of seconds, to obtain a digital reading of urea concentration with a precision of +/-0.1%. Proper urea concentration is critical for sustaining reduced diesel emissions which, besides being good for the environment, can save the Diesel Exhaust Fluid user money, prevent damage to expensive SCR components, and help identify tampering.

Simply place a few drops of DEF in the refractometer's stainless-steel well, close the evaporation cover, and press a single button to obtain a near instantaneous reading on the large 24-character backlit display. The refractometer can be quickly calibrated to water, with the touch of a button.

Key to the refractometer's precision is MISCO's proprietary OPTICAL-ENGINE®, which combines high-index sapphire optics (next hardest substance to diamond) with a detector array containing more than a 1,000 detector elements, more than seven times that of competing instruments. The instrument also boasts an optimized combination of hardware and software which automatically temperature compensates the reading specifically for aqueous urea solutions.

In addition to reading DEF concentration, the [DEF-202](#) refractometer also reads refractive index. In addition to urea, the [PA203](#) can be programmed to read up to five critical automotive parameters such as engine coolant freezing-point, engine coolant concentration, brake fluid water content, and windshield washer fluid. Each refractometer bears a laser-etched serial number for traceability. Options for the instrument include a rubber-armor jacket (in one of three colors), a virtually indestructible storage case, and NIST traceable certified calibrations.

[DEF202](#) (P/N PA202X-185-629) Shown with optional Rubber Armor Jacket.

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One indication that a DEF supply has been diluted is when a vehicle exceeds the DEF consumption specifications published by the vehicle manufacturer. Some trucks will have on-board sensors and diagnostics that will be able to immediately spot adulterated DEF, but most will not. Luckily, to help consumers combat the possibility of contaminated supply, API plans to have inspectors periodically check the DEF supply at different dispensing locations to make sure the DEF fluid meets API and ISO requirements. But, unlike human greed, the inspectors can't be everywhere all the time.

Whether caused by leaks, human-error, or human-greed, the only sure method to make sure that your DEF meets ISO and API standards is to test it yourself. Although it should be tested at each stage in the supply chain, ultimately it will fall on the end users to make sure that it is not diluted.

A refractometer is the only practical field-test method available for determining the concentration of urea in the DEF solution. It only takes a couple of drops of DEF and a few seconds to get an instant and accurate reading on a MISCO DEF Refractometer. The reading can be read precisely to +/- 0.1% concentration (see sidebar).

Tips on Getting the Most Accurate Possible Refractometer Readings for Urea-Based Diesel Exhaust Fluid:

1. Make sure to allow time for the instrument, the fluid, and the ambient temperature to equalize, within the range of the instrument's temperature compensation (10 to 50 °C). A good rule-of-thumb is to wait 10 seconds for every 10 °F the temperature differs from 68 °F. (20 seconds for every 10 °C difference from 20 °C).
2. Clean the measuring surface before storing the instrument so that it is clean and ready-to-use when needed. Likewise, make sure that the DEF extraction device is also cleaned and dried before storing it away.
3. Although the instrument is water-resistant, it will certainly last longer if not subjected to being held under a stream of urea or water.

A world leader in the refractometer field, MISCO is headquartered in Cleveland, OH, home to the company for 60-years. MISCO designs, manufactures and sells a variety of refractometers, including: digital bench-top laboratory refractometers, inline process control refractometers, digital handheld refractometers, and traditional handheld instruments. For more information, please call (440) 349-1500, or access MISCO's web site at www.misco.com.