Diesel Exhaust Fluid
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Colonial Chemical
Agenda

- What is the Purpose of DEF?
- How Does Diesel Exhaust Fluid (DEF) Work?
- Why DEF?
- What's In DEF?
- Customer/Technician Awareness
- Handling/Dispensing/Storing
- Vehicles That Use DEF
- Where Will Customers Purchase DEF?
- A Look Ahead
What is The Purpose of DEF?

- EPA mandated a reduction of Oxides of Nitrogen (NOx) levels
- NOx has been identified by the EPA as being harmful to air quality, which can cause negative health effects
- NOx production increases with engine efficiency
- Manufacturers needed a way to maintain efficiency while also reducing NOx levels.
How Does Diesel Exhaust Fluid (DEF) Work?

• DEF is injected into the exhaust
• The heat of the exhaust converts DEF to ammonia.
• The ammonia allows for a reaction to take place inside the SCR Catalytic Converter.
• The process results in NOx being converted to nitrogen and steam.
What’s really going on in there?

“*The more efficient an engine is, the more NOx it create*”

(IH Case Website)
Typical 2010 and Beyond SCR Configuration

- Urea Tank
- Urea Dosing Control Unit
- SCR Catalyst
- NOx Sensor
- Particulate Filter
- ECM

Some graphics included above courtesy of Cummins
How Does Diesel Exhaust Fluid (DEF) Work?

• Unfortunately, NOx is created as a result of the normal heat that is generated in the cylinders of an efficient, powerful diesel engine.

• Since consumers demand efficiency and power from their diesel engines, a conflict exists - *How do you get efficiency and power, and at the same time, reduce this harmful emission?*
How Does Diesel Exhaust Fluid (DEF) Work?

Two Different Strategies to Reduce NOx:

Inside the engine – “In Cylinder Technology”

OR

Outside the engine – “Selective Catalyst Reduction”
...one strategy:

Inside the engine - In Cylinder Technology

By reducing combustion temperatures (EGR), engine manufacturers were able to reduce NOx to meet EPA 2007 requirements – However:

• Fuel economy decreased
• Power was reduced
• More soot was created
• Frequent issues with soot build up in exhaust particulate filter resulted in excessive vehicle downtime
...a different strategy:

Inside the Exhaust (Selective Catalyst Reduction)

By adding DEF into the exhaust prior to the catalytic converter, manufacturers were able to reduce NOx to meet the new lower NOx levels mandated by the EPA (2010 and beyond) – And:

• Fuel economy increased over previous systems
• Power increased
• Less soot production
• Less vehicle downtime - Less “regenerations”
Why DEF?

- SCR systems require an on-board supply of ammonia or other nitrogen-containing chemical that decomposes into ammonia in the engine exhaust system.

- Storing ammonia on-board poses several hazards since it is corrosive and a health hazard if spilled or vented.

- DEF is a safe way to “get to the ammonia state” where and when it is needed.

- Driving forces to use urea in transportation: low health hazard, urea produced in large quantities (farming*), proven NOx abatement strategy in stationary SCR applications.

- *UREA processed for agriculture use, it CANNOT be used to make DEF
What's In DEF?

• DEF is a water based solution of a nitrogen containing chemical called UREA.
• 67.5% Di-Ionized Water & 32.5% UREA
• Water white clear, odor free, non-hazardous, non flammable, non combustible.
• Readily available – Ready to use.
Where Does Urea Come From?

Urea is a normal product of protein metabolism in the human body and is not considered to be a hazardous material (Source MSDS)
A large chemical complex produces ammonia, urea & other nitrogen containing chemicals for many markets.

The plant converts energy, natural minerals and nitrogen from the air into useful products for farmers and industrial customers.
Example of large stainless steel DEF storage tank
Uses for Urea
Customer/Technician Awareness

- Is it a fuel additive?
- Do I have to use it?
- Will the vehicles that now use DEF always use DEF?
- Can I make it myself?
- Is it corrosive?
- Can’t I just put water in instead?
- What if I run out?
Driver’s Dashboard

- **Low DEF warning light**
- **Light bar shows DEF level**

Instrument displays:
- ULTRA LOW SULFUR DIESEL FUEL ONLY
- Fuel gauge indicating fuel level
- DEF indicator

[Image of a driver's dashboard with fuel and DEF indicators]
Driver’s Dashboard

- The light bar indicates the level of fluid in the DEF tank.
- Low DEF levels will trigger a decrease in engine performance.
- The use of improper fluid will trigger a decrease in engine performance.
- In the empty and ignored state, if the diesel tank is refilled without filling the DEF tank, vehicle speed will be limited to 5 mph until DEF is detected in the tank.
Customer/Technician Awareness

- Fleet Managers?
- Folks buying diesel trucks, diesel SUV’s, etc.,
- Folks selling these vehicles?
- Drivers
- Our Employees?
- All of us?
Need to know...

• Temperature Concerns: (freezes at 12 degrees) Consider having a heated cabinet/dispenser to keep hose/nozzle from freezing if dispensing in cold climates.

• Extreme heat can effect shelf life. In hot climates, consider shade (covering) and/or a fan to circulate the air where DEF is stored.
Handing/Dispensing/Storing

DEF Shelf Life-vs-Temperature

Shelf life decreases to 1 year when stored consistently at 80 degrees. Do not store DEF in direct sunlight.
Handling/Dispensing/Storing

3 days in DEF at 105° F
Handling/Dispensing/Storing

• Purity of DEF is critical for vehicle/system performance
• The supply chain determines the purity.
• DEF requires proper storage, transporting, handling and dispensing to assure quality all the way from production, to your customer’s DEF tank.
Handling/Dispensing/Storing

- Using DEF that is not up to ISO 22241-1 and contains minerals or materials (out of spec) may result in problems with:
  - Sensors/components in the vehicle’s DEF tank
  - DEF injector
  - Surface area of the catalytic converter
  - NOx sensor
- Reduced performance of any of the above will eventually cause the vehicle’s emission control system to fail resulting in the illumination of a DEF/SCR failure light on the dash, subsequent de-rate, and/or failure of expensive emission system components.
## Handling/Dispensing/Storing

### Specification Limits

<table>
<thead>
<tr>
<th>Specification</th>
<th>Limits</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea by weight</td>
<td>31.8 - 33.2</td>
<td>% by weight</td>
</tr>
<tr>
<td>Density (at 77°F)</td>
<td>9.05 - 9.09</td>
<td>pounds / gallon</td>
</tr>
<tr>
<td>Refractive Index (at 77°F)</td>
<td>1.3814 - 1.3843</td>
<td></td>
</tr>
<tr>
<td>Alkalinity (as Ammonia)</td>
<td>max. 0.2</td>
<td>% by weight</td>
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<tr>
<td>Insolubles</td>
<td>max. 0.002</td>
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<tr>
<td>Calcium</td>
<td>max. 0.00005</td>
<td>% by weight</td>
</tr>
<tr>
<td>Magnesium</td>
<td>max. 0.00005</td>
<td>% by weight</td>
</tr>
<tr>
<td>Aldehydes</td>
<td>max. 0.0005</td>
<td>% by weight</td>
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<td>Sodium</td>
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<td>% by weight</td>
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<td>Phosphates</td>
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<td>Biuret</td>
<td>max. 0.3</td>
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<td>% by weight</td>
</tr>
<tr>
<td>Copper</td>
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<td>% by weight</td>
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<tr>
<td>Zinc</td>
<td>max. 0.00002</td>
<td>% by weight</td>
</tr>
<tr>
<td>Chromium</td>
<td>max. 0.00002</td>
<td>% by weight</td>
</tr>
<tr>
<td>Nickel</td>
<td>max. 0.00002</td>
<td>% by weight</td>
</tr>
</tbody>
</table>

### Determinations

- **Determines shelf-life**
- **Clogs spray nozzle**
- **Form gummy deposits in exhaust pipe**
- **Damages catalyst**
Handling/Dispensing/Storing
Impact of Aldehydes, Hard Water, and Insolubles
Can you test your DEF?

You can check the urea content by weight (% of urea) using a hand held meter – It’s a quick (initial) indicator as to whether the DEF is in spec (31.8% – 33.2%) or if further testing is warranted.

Visual Inspection – clear, not hazy, “water white”, no layering, no sediment. If out of spec, or doesn’t pass the visual check – CALL YOUR DEF SUPPLIER IMMEDIATELY AND GET THEM INVOLVED!

Beyond a visual inspection, only an actual lab analysis can provide quantitative information as to the purity of the product (ISO 22241-1 spec.).
DEF – Safe to Handle

• DEF: Safe to handle and use. It is not explosive, flammable toxic or subject to any hazardous product regulations.

• DEF is not corrosive to human tissue. If you get it on your skin or clothes, rinse with water.

• DEF will not burn and will not aid combustion

• Do not fill containers in a closed-in space

• MSDS: EXPOSURE CONTROLS & PERSONAL PROTECTION
  – Use in a well ventilated area.
  – Industrial setting: Wear rubber gloves and safety glasses.
  – Retail setting: No hand or eye protection required under normal use.
**Labels – Material Safety Data Sheets (MSDS)**

**Diesel Exhaust Fluid (DEF)**

**Health:** Exposure could cause irritation, but only minor residual injury even if no treatment is given.

**Fire:** Materials WILL NOT burn.

**Reactivity:** Normally stable, even under fire exposure conditions and are not reactive with water

**Specific:** **Personal protection** (Rubber gloves and eye protection recommended)
Vehicles That Use DEF

- Almost all vehicles produced for on road service in North America equipped with diesel engines use DEF.
  - Examples: Mercedes SUV’s, BMW SUV’s, Chevy Cruze, Chevy & GMC Trucks, Ford Trucks, Dodge Pick Up Trucks, Various classes of trucks…
  - Off Road Diesel (Construction Equipment, Farming Equipment, etc.,..)
  - Some Marine applications
Where Will Customers Purchase DEF?

- Truck Stop/Fuel Plazas (Over the road trucks)
- Oil/Lubricant Suppliers
- Auto/Truck Repair/Service Facilities
- Dealerships
- Auto/Truck Parts Stores
- Large Retailers
A Look Ahead

• EPA’s commitment to lower NOx has stayed in place
• DEF pump/island dispensing locations increasing
• Where/when will DEF be added?
  • Where fueled? (island dispenser/totes/drums)
  • Where serviced? (2.5 gallon bottles, drums, totes inside service facility)
A Look Ahead

• Anything on the horizon to replace it? *Answer:* “No.”
• Some light duty **pickup trucks used** a combination of heavy EGR and EPA credits to meet the EPA’s 2010 requirements. **All** now require the use of DEF.
• Some small diesel automobiles **used** “an SCR Brick” located in the exhaust that contained materials that produced a similar effect as DEF (ammonia) that would then work with the catalyst to reduce some NOx.
A Look Ahead

• New International/Navistar Trucks beginning in 2013 require the use of DEF.
• Caterpillar (CAT) now back “on road”
• As of 2014 most off road diesel
• As of 2016, many marine applications will need DEF
• Farm tractors/off road equipment (usually under 100 HP) may use an in cylinder only strategy. (SCR/DEF used on higher HP applications.)
• CNG & LNG powered vehicles do not use DEF
DEF – For the long run...

• SCR works
• The only strategy that diesel engine manufactures have found that achieves low NOx emission levels and low soot output, while supporting the goal of increased performance and fuel economy.
• SCR is, and will continue to be essential to the overall strategy manufactures use to meet Greenhouse Gas (GHG) requirements.
**API Diesel Exhaust Fluid (DEF) Certification Program Overview**

**Primary goal:** To ensure that API-certified diesel exhaust fluids meet industry-established performance requirements and are easily recognized by consumers

**Certify** brands of diesel exhaust fluid that meet the performance requirements developed by diesel engine manufacturers

**License** the use of API quality mark on diesel exhaust fluid meeting the performance requirements given in ISO 22241

**Monitor** DEF quality through Aftermarket Audit Program (AMAP) by sampling and testing certified products purchased in marketplace
Benefits of Certification

Helps ensure availability of diesel exhaust fluid meeting industry-recognized standards

Identifies for consumers which products meet diesel engine manufacturer recommendations via real-time, online Directory of Licensees at www.apidef.org

Offers consumers choice of quality products from which to choose
Benefits of Certification

Provides rigorous monitoring of API-certified products in marketplace

Offers source of third-party testing results to licensed marketers

Takes enforcement action against companies not meeting API certification requirements

Contributes to overall goal to reduce NOx emissions
DEF Performance Requirements

ISO 22241, Diesel Engines NOx Reduction Agent AUS 32

- **Part 1** – Quality Requirements
- **Part 2** – Test Methods
- **Part 3** – Handling, Transportation and Storage
- **Parts 4 & 5** – Refilling Interfaces
  - Not part of API’s program

Addresses **product quality** from manufacturer to installer
Licensing Program Website

API Diesel Exhaust Fluid Website (www.apidef.org)

- API Diesel Exhaust Fluid Certification Program Overview
- Online Application System
- Online Directory of Licensees
- Links to DEF Locator
Application Requirements

Application required for each individual brand to be licensed and must include:

All supply points where the product will be manufactured

Typical values of all required physical and chemical properties of the product

Certificate of Analysis showing that the product has been analyzed and meets spec tolerances

Traceability Code formatting for packaged products

License agreement must be accepted by applicant
API Diesel Exhaust Fluid
Certification Mark

Registered trademark issued to marketers only if diesel exhaust fluid satisfies requirements of most recent and applicable edition of ISO 22241, Part 1
Licensed Marketers (as of today)

First License issued March 2009

66 API-certified diesel exhaust fluid marketers
  • 50 in the U.S.
  • 9 in Canada
  • 4 in China
  • 1 each: Taiwan, Mexico, Chile

One each pending in US and Canada

91 individually-licensed brands
**Diesel Exhaust Fluid Audit Program**

**Primary goal:** Test as many licensed products as possible from the broadest geographic area possible

**Packaged and Bulk** samples drawn from marketplace annually (packaged and bulk)

**Samples randomly purchased** at consumer points

**Bulk shipment paperwork** may be reviewed

**Quick tests** performed by collection contractor using hand-held refractometer

**Samples blind-coded** and shipped to separate testing lab

**Chain of custody maintained** throughout process
Diesel Exhaust Fluid Audit Program

**Primary goal:** Test as many licensed products as possible from the broadest geographic area possible

**Test results evaluated** and licensees notified of results

**Enforcement action taken** as needed
- Corrective Action to API satisfaction
- Cancellation of License
- Recall of product
- Legal Action

**Emphasis placed on confidentiality of test results!**
# Scope of Audit Testing

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
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</thead>
<tbody>
<tr>
<td>Urea Content</td>
<td>ISO 22241-2 Annex B</td>
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<tr>
<td>Urea Content</td>
<td>ISO 22241-2 Annex C</td>
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<td>Potassium</td>
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<tr>
<td>Identity</td>
<td>ISO 22241-2 Annex J</td>
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</tbody>
</table>
Audit Evaluation Methods

Test Results evaluated against ISO 22241 limits, adjusted for Reproducibility, R

Retest ordered for any non-conforming property

Referee test ordered from separate laboratory to settle any disputing test/retest results

Packaging examined for conformance to trademark specifications and labeling requirements
Audit Summary- 2013

Samples collected in US and Canada

100 samples collected
• 39 bulk products
• 61 packaged products

99 conforming samples
• 88 conformed to ISO limits
• 11 accepted within expanded limits

1 non-conforming samples
• Bulk sample
• Calcium failure
• Confirmed by retest
2013 - Sampling Distribution

Bulk Samples
- Truck Stop: 87%
- Manufacturer/Distributor: 13%

Packaged Samples
- Truck Stop: 20%
- Dealership: 13%
- Service Station: 10%
- Retail Store: 15%
- Repair Shop: 3%
- Manufacturer/Distributor: 39%
AMAP 2014 and beyond

New online system for analyzing and reporting audit results is launching tomorrow

Audits underway for 2014
  • 77 samples collected

Number of samples increased to 150 and will likely increase again in 2015

Bulk sampling to be increased to match market trends

Sampling footprint will continue to expand
Important News for DEF Retailers!!!

National Conference on Weights and Measures recently voted to add DEF to Handbook 130
- Uniform Regulation for the Method of Sale
- Uniform Engine Fuels and Automotive Lubricants Regulation

Defines DEF for regulators and W&M inspectors

Requires distributors to provide their customers with information about the DEF’s origin
- Manufacturer and Brand Name
- Statement identifying DEF as conforming to latest ISO 22241 Standard
- To be reported on invoice, bill of lading, or other shipping document
- Retailer may need to be able to produce this info

Check with your state regulators or inspectors!
Industry Groups

SCR Stakeholders
Made up of DEF manufacturers, OEMs, DEF equipment suppliers, regulators, trade organizations, etc.

Objectives
- Exchange information with U.S. Government and other stakeholders on the potential market and urea availability
- Education and outreach to consumers
- Promote retail availability

Recent Activity
Providing recommendations to ISO for upcoming review of standard (Parts 1, 2 and 3)

Next Meeting: TBD
Industry Groups

ASTM Subcommittee D15.25 on Diesel Exhaust Fluids

Industry-driven open-committee with the goal of developing standards to complement existing ISO 22241 standard or to address areas not covered in ISO 22241

Recently approved Standard Test Method for Field Test Determination of Urea Concentration in Diesel Exhaust Fluid (DEF) – ASTM D7821

Next Meeting: Chicago, October 22-23, 2014
Questions?

Thank you for your attention!

Contact: Joe Macfarlan
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Any Questions?

API Diesel Exhaust Fluid Certification:
www.apidef.org

Diesel Exhaust Fluid
www.colonial-chemical.com/colonial-def

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