Diesel Exhaust Fluid (DEF) for SCR equipped Heavy Duty Vehicles (BS IV & BS VI)

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Outline of the Presentation

- Quick Facts on DEF
- Emission norms
- NOx emission – Formation and control
- SCR Technology
- AUS-32 / DEF - Quality Requirements
- Production of DEF – Raw materials
- Quality Control – test methods
- Storage of DEF
- IOC ClearBlue
DEF – Quick Facts

One Product – Three Names – DEF; AdBlue; AUS32

- Helps in Reducing NOx emissions by >90% in SCR catalytic converter
- Required in vehicles (trucks & buses) having SCR
- DEF is safe to handle, Not toxic, Not flammable, Not hazardous.

- It is not a fuel additive, so Not to be added with diesel
- Urea used for DEF is not a fertilizer urea, it is made of special grade Urea
- DEF is not supplied to engine, it is sprayed in to the exhaust pipe prior to SCR
Heavy Duty Emission Norms

(WHTC – World Hormonized Transient Cycle)
(ETC – Engine Transient Cycle)

<table>
<thead>
<tr>
<th>Emission level</th>
<th>Test procedure</th>
<th>CO (g/kWh)</th>
<th>CH4 (g/kWh)</th>
<th>NMHC (g/kWh)</th>
<th>NOx (g/kWh)</th>
<th>PM (g/kWh)</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS IV</td>
<td>ETC</td>
<td>4</td>
<td>1.1</td>
<td>0.55</td>
<td>3.5</td>
<td>0.03</td>
<td>0</td>
<td>55</td>
<td>87</td>
<td>67</td>
</tr>
<tr>
<td>BS VI</td>
<td>WHTC</td>
<td>4</td>
<td>0.5</td>
<td>0.16</td>
<td>0.46</td>
<td>0.01</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

% Emission Reduction

Other Limits introduced in BS VI: PN - $6.0 \times 10^{11}$ #/kWh; $NH_3$ – 10 ppm

- Both BS IV and BS VI Heavy duty emission norms are fuel neutral
- Moving to BS VI, NOx emission to be reduced by 87%
- HC and PM emissions are also to be reduced simultaneously
NOx Emission Formation

Composition of Air: 
- Nitrogen ($N_2$) – 79% and Oxygen ($O_2$) – 21% by volume

- Nitrogen
- Oxygen
- High in-cylinder temperature during combustion (>1500 °C)
How to reduce NOx Emissions

Exhaust Gas Recirculation (EGR)

Issues with EGR alone NOx control technology in BS VI regime

- High level of reduction in NOx emissions is not feasible
- Increase in PM emissions and Engine oil contamination
- Reduced life of the engine
What is SCR?

Scr equipped vehicle offer typically 5% improved fuel economy since it allows engine to operate at high engine-NOx conditions where thermal efficiency is much high.
What is SCR?

Selective Catalytic Reduction - (Exhaust Gas After-treatment)

1. **Hydrolysis Catalyst** (Urea to Ammonia)
   
   \[(NH_2)CO + H_2O \rightarrow 2 \text{NH}_3 + \text{CO}_2\]

2. **SCR Catalyst** (NOx to N2)
   
   \[\text{NO} + \text{NO}_2 + 2\text{NH}_3 \rightarrow 2\text{N}_2 + 3\text{H}_2O\]

3. **Ammonia Slip Catalyst**
   (To convert Ammonia to N2)
What is SCR?

Main components of Bosch Denoxtronic urea injection system
A: Supply module; B: Dosing module; C: Injection nozzle

DEF Tank adj. to Fuel Tank

Consumption of AUS32 in vehicle → ~ 5% of diesel consumption

Source: DieselNet
What is DEF?

• **AUS-32** → Technical name

  *Aqueous Urea Solution* containing urea of **32.5%** by weight

• **Other names**

  ➢ *AdBlue* – Trademark of VDA (German Automobile Manufacturers Association)

  ➢ **DEF** – Commonly called as *Diesel Exhaust Fluid* (DEF) in countries like USA and others

• **Quality standards**

  ➢ *DIN 70070 : 2005*

  ➢ *ISO 22241 : 2019*

  ➢ *IS 17042 : 2018*
## AUS 32

### Quality Requirements as per ISO 22241-1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urea content</strong></td>
<td>31.8 – 33.2%</td>
<td>% by weight</td>
</tr>
<tr>
<td>Alkalinity as NH3</td>
<td>max. 0.2%</td>
<td>% by weight</td>
</tr>
<tr>
<td>Biuret</td>
<td>max. 0.3%</td>
<td>% by weight</td>
</tr>
<tr>
<td>Insolubles</td>
<td>max. 20 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Aldehyde</td>
<td>max. 5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Phosphate (PO₄)</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>max. 0.2 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>max. 0.2 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>max. 0.2 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>max. 0.2 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>max. 0.5 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Density at 20°C</td>
<td>1087.0 - 1093.0 kg/m³</td>
<td></td>
</tr>
<tr>
<td>Refractive index at 20°C</td>
<td>1.3814 - 1.3843 (-)</td>
<td></td>
</tr>
<tr>
<td>Identity</td>
<td>identical to reference (-)</td>
<td></td>
</tr>
</tbody>
</table>
Use of Contaminated / Off-spec DEF will lead to following issues

- Deposit formation in urea supply and dosing system
- Blockage of Injector nozzles
- Catalyst poisoning leading to permanent damage or reduction in efficiency
- Loss of warranty for SCR system
- Fitness approval issue
- Polluting the environment heavily
What is DEF?

**Raw Materials**

- **Technically pure urea** –
  - Industrially produced grade of urea with
  - Traces of biuret, ammonia and water only,
  - Free of aldehydes or other substances such as anticaking agent, and
  - Free of contaminants such as sulphur and its compounds, chloride, nitrate or other compounds

- **Pure water** –
  - Water very low in inorganic, organic or colloidal contaminants, produced, for example, by single distillation, by deionization, by ultra-filtration or by reverse osmosis
Production of DEF

Technically Pure Urea

Water-Treatment cum Blending Unit

Storage & Dispenser
## DEF Test Methods and Test Equipment

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Test Method</th>
<th>Measurement Method</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>ISO 22241-2 Annex B</td>
<td>Total nitrogen Method</td>
<td>Automatic nitrogen analyser</td>
</tr>
<tr>
<td>Density at 20°C</td>
<td>ISO 3675 or ISO 12185</td>
<td>Specific gravity method or Oscillation frequency method</td>
<td>Glass hydrometer or U-tube density meter</td>
</tr>
<tr>
<td>Refractive index at 20°C</td>
<td>ISO 22241-2 Annex C</td>
<td>Refractive index **</td>
<td>Refractometer</td>
</tr>
<tr>
<td>Alkalinity as NH₃</td>
<td>ISO 22241-2 Annex D</td>
<td>Potentiometric titration of free ammonia</td>
<td>Potentiometer</td>
</tr>
<tr>
<td>Insolubles</td>
<td>ISO 22241-2 Annex G</td>
<td>Gravimetric method</td>
<td>Analytical balance</td>
</tr>
<tr>
<td>Biuret</td>
<td>ISO 22241-2 Annex E</td>
<td>Photometric method</td>
<td>Spectrophotometer</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>ISO 22241-2 Annex F</td>
<td>Photometric method for Formaldehyde</td>
<td>Spectrophotometer</td>
</tr>
<tr>
<td>Phosphate (PO₄)</td>
<td>ISO 22241-2 Annex H</td>
<td>Photometric method or Spectrometry Method</td>
<td>Spectrophotometer / ICP</td>
</tr>
<tr>
<td>Iron</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Potassium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identity</td>
<td>ISO 22241-2 Annex J</td>
<td>IR spectrometry</td>
<td>IR spectrometer or FTIR</td>
</tr>
</tbody>
</table>

**Refractive index method can also be used for urea content**
Handheld Digital Refractometers for on-site quality check
## Storage of DEF

**ISO 22241-3**

<table>
<thead>
<tr>
<th>Constant ambient storage temperature, °C</th>
<th>Minimum Shelf Life Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10</td>
<td>36 (3 years)</td>
</tr>
<tr>
<td>≤ 25</td>
<td>18 (1 ½ years)</td>
</tr>
<tr>
<td>≤ 30</td>
<td>12 (1 year)</td>
</tr>
<tr>
<td>≤ 35</td>
<td>6</td>
</tr>
<tr>
<td>&gt; 35</td>
<td>Significant loss of shelf. Check every batch before use</td>
</tr>
</tbody>
</table>
Material for DEF containers: Stainless Steel / HDPE

• **Metals**
  - Stainless Steel, eg. UNS S30400, S30403, S31600, S31603, S31625 and S32100.
  - Titanium
  - Hastelloy C-276

• **Polymers** (free of additives that affect SCR system)
  - Polyethylene (PE)
  - Poly propylene (PP)
  - Polyisobutylene (PIB)
  - Perfluoroalkoxy alkane (PFA)
  - Polyfluoroethylene (PFE)
  - Polyvinylidene fluoride (PVDF)
  - Polytetrafluoroethylene (PTFE)
  - Copolymers of PVDF and hexafluoropropylene (HFP)
DEF Packaging

- 10 L
- 20 L
- 200 L
- IBC – 1000 L
- Flexi Tanks 20 KL
Freezing of DEF

- DEF freeze at -11°C
- 32.5% urea concentration is optimum and provides lowest freezing point
- No anti-freeze agents to be added in AUS 32
- Quality of AUS 32 does not degrade due to freezing
- Solidified DEF has an approximately 7% larger volume than the liquid
- Packaging need to take care additional volume increase of AUS 32 in case of freezing (Freeze-proof design).
- Vehicles are generally equipped to handle freezing issues of AUS 32
IOC ClearBlue

• 1st DEF Plant commissioned at Manesar, haryana in Nov 2019.
• The capacity of the plant is 30,000 KLPA
• Three more such plants are being setup.
• Five more such plants have been planned.
• IOC ClearBlue meets the ISO Specifications and audited by VDA
• All the test facilities available with IOCL for quality assessment of DEF as per ISO 22241 requirements
IOC ClearBlue

Distribution

• From IOCL Stockiest to Bulk consumer sites (eg. MSRTC)
• From IOCL stockiest to Retail Outlets

Collaboration

• Technical grade urea suppliers
• Plant equipment manufacturers
• DEF suppliers
• Auto OEMs
Signing of Agreement with Cummins Technologies for bulk dispensing of IOC ClearBlue

Release of 1st batch of IOC CLEARBLUE from DEF Plant, Manesar
Fill Right Quality DEF while you fill Right Quality Diesel
COMPLETE FLUID SOLUTION @ YOUR DOORSTEP

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