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)

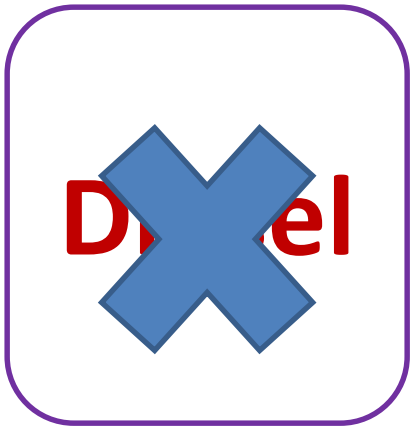
(ETC – Engine Transient Cycle)

Emission level	Test procedure	CO (g/kWh)	CH4 (g/kWh)	NMHC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	% Emission Reduction			
							CO	HC	NOx	PM
BS IV	ETC	4	1.1	0.55	3.5	0.03	0	55	87	67
BS VI	WHTC	4	0.5	0.16	0.46	0.01				

Other Limits introduced in BS VI: PN- 6.0 x 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)

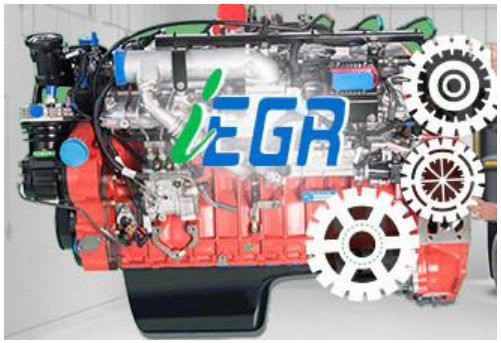
How to reduce NOx Emissions

N_2

O_2

In-cylinder Temperature

Exhaust Gas Recirculation (EGR)

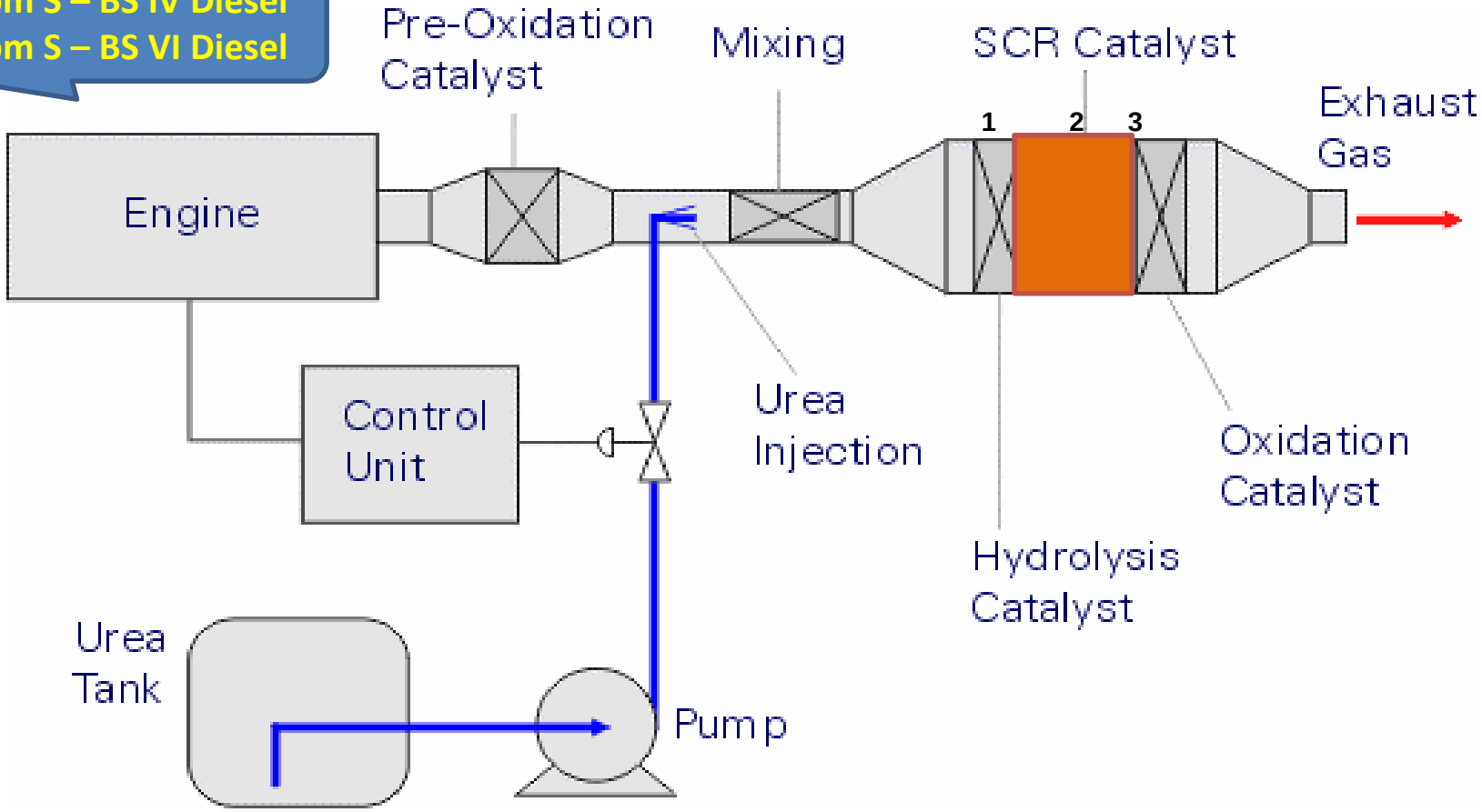


Issues with EGR alone NOx control technology in BS VI regime

- 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?

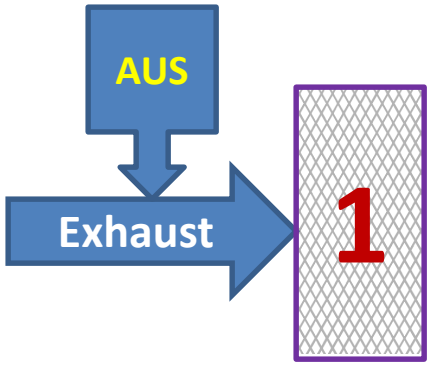
50 ppm S – BS IV Diesel
10 ppm S – BS VI Diesel



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.

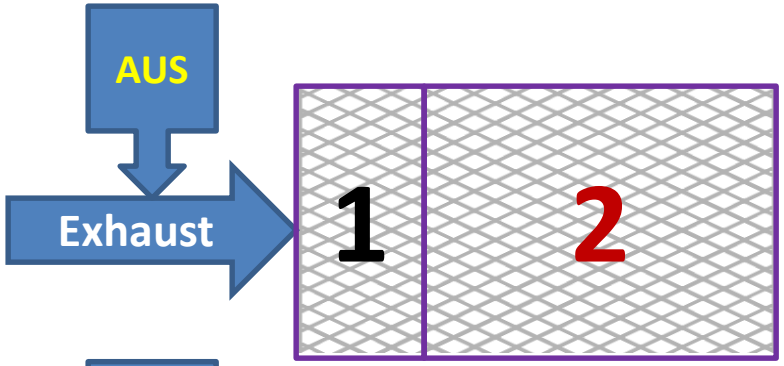
What is SCR?

Selective Catalytic Reduction - (Exhaust Gas After-treatment)



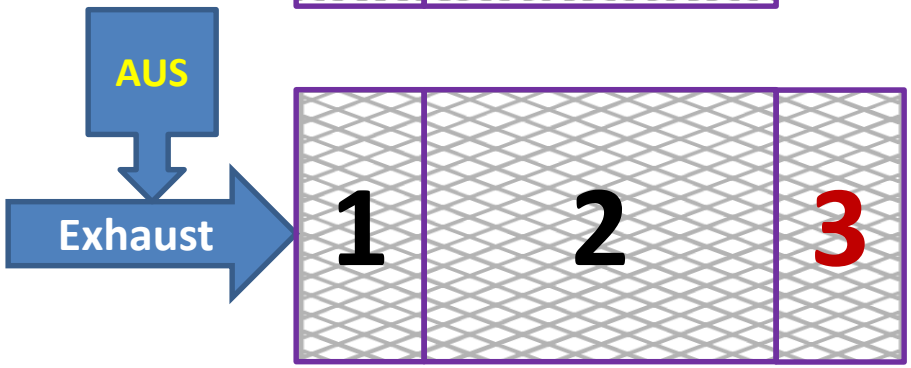
Hydrolysis Catalyst (Urea to Ammonia)

$(NH_2)_2CO + H_2O \rightarrow 2\,NH_3 + CO_2$



SCR Catalyst (NOx to N2)

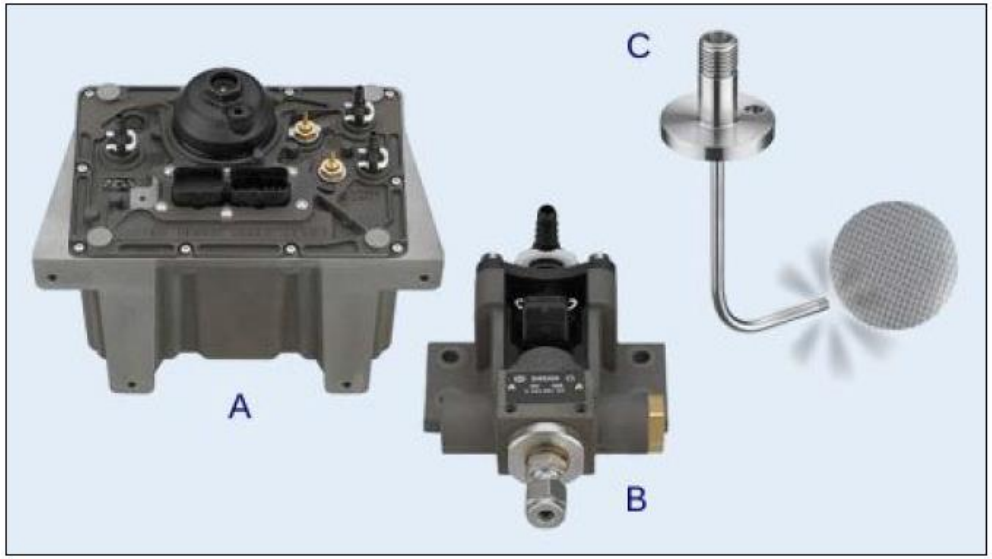
$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$



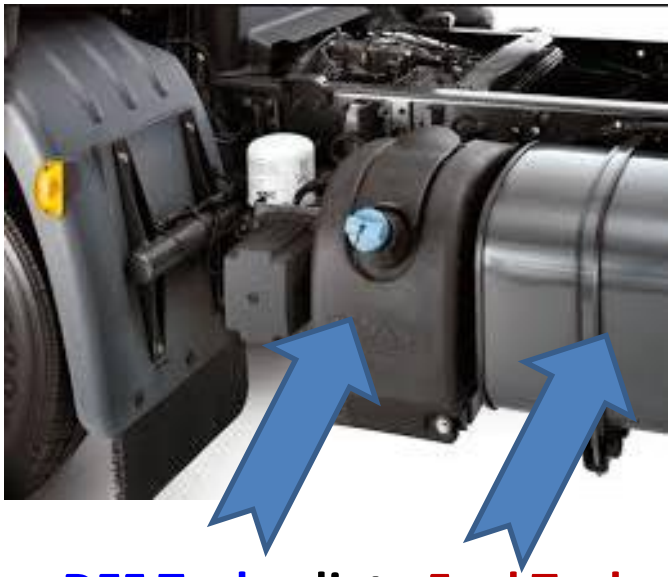
Ammonia Slip Catalyst

(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**

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AUS 32

Quality Requirements as per ISO 22241-1

Urea content		**31.8 – 33.2**	**% by weight**
Alkalinity as NH3	max.	0.2	% by weight
Biuret	**max.**	**0.3**	**% by weight**
Insolubles	max.	20	mg/kg
Aldehyde	max.	5	mg/kg
Phosphate (PO_4)	max.	0.5	mg/kg
Aluminum	max.	0.5	mg/kg
Calcium	max.	0.5	mg/kg
Iron	max.	0.5	mg/kg
Copper	max.	0.2	mg/kg
Zinc	max.	0.2	mg/kg
Chromium	max.	0.2	mg/kg
Nickel	max.	0.2	mg/kg
Magnesium	max.	0.5	mg/kg
Sodium	max.	0.5	mg/kg
Potassium	max.	0.5	mg/kg
Density at 20°C		1087.0 - 1093.0	kg/m3
Refractive index at 20°C		1.3814 - 1.3843	(-)
Identity		identical to reference	(-)

Why Quality of DEF is atmost important?

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?

Definition as per ISO 22241:2019

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

Characteristics	Test Method	Measurement Method	Equipment
Urea	ISO 22241-2 Annex B	Total nitrogen Method	Automatic nitrogen analyser
Density at 20°C	ISO 3675 or ISO 12185	Specific gravity method or Oscillation frequency method	Glass hydrometer or U-tube density meter
Refractive index at 20°C	ISO 22241-2 Annex C	Refractive index **	Refractometer
Alkalinity as NH3	ISO 22241-2 Annex D	Potentiometric titration of free ammonia	Potentiometer
Insolubles	ISO 22241-2 Annex G	Gravimetric method	Analytical balance
Biuret	ISO 22241-2 Annex E	Photometric method	Spectrophotometer
Aldehyde	ISO 22241-2 Annex F	Photometric method for Formaldehyde	
Phosphate (PO4)	ISO 22241-2 Annex H	Photometric method or Spectrometry Method	Spectrophotometer / ICP
Calcium	ISO 22241-2 Annex I	Spectrometry Method	Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES).
Iron			
Copper			
Zinc			
Chromium			
Nickel			
Aluminium			
Magnesium			
Sodium			
Potassium			
Identity	ISO 22241-2 Annex J	IR spectrometry	IR spectrometer or FTIR

**Refractive index method can also be used for urea content

On-site Quality Check

Handheld Digital Refractometers for on-site quality check

Storage of DEF

ISO 22241-3

Constant ambient storage temperature , °C	Minimum Shelf Life Months
≤ 10	36 (3 years)
≤ 25	18 (1 ½ years)
≤ 30	12 (1 year)
≤ 35	6
> 35	Significant loss of shelf. Check every batch before use

Storage of DEF

Material for DEF containers: Stainless Steel / HDPE

ISO 22241-3

- **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 popylene (PP)**
  - ✓ **Polyisobutylene (PIB)**
  - ✓ **Perfluoroalkoxy alkane (PFA)**
  - ✓ **Polyfluoroethylene (PFE)**
  - ✓ **Polyvinyllidene fluoride (PVDF)**
  - ✓ **Polytetrafluoroethylene (PTFE)**
  - ✓ **Copolymers of PVDF and hexafluropropylene (HFP)**

DEF Packaging

10 L

20 L

200 L

IBC – 1000 L

Flexi Tanks
20 KL

Storage of DEF

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

IOC ClearBlue

Signing of Agreement with Cummins Technologies for bulk dispensing of IOC ClearBlue

Release of 1st batch of IOC CLEARBLUE from DEF Plant, Manesar

IOC ClearBlue

Fill Right Quality DEF while you fill Right Quality Diesel


R&D
AVL-ZOLLNER

COMPLETE FLUID SOLUTION @ YOUR DOORSTEP

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