



SCR Systems for Heavy Duty Trucks: Progress Towards Meeting Euro 4 Emission Standards in 2005

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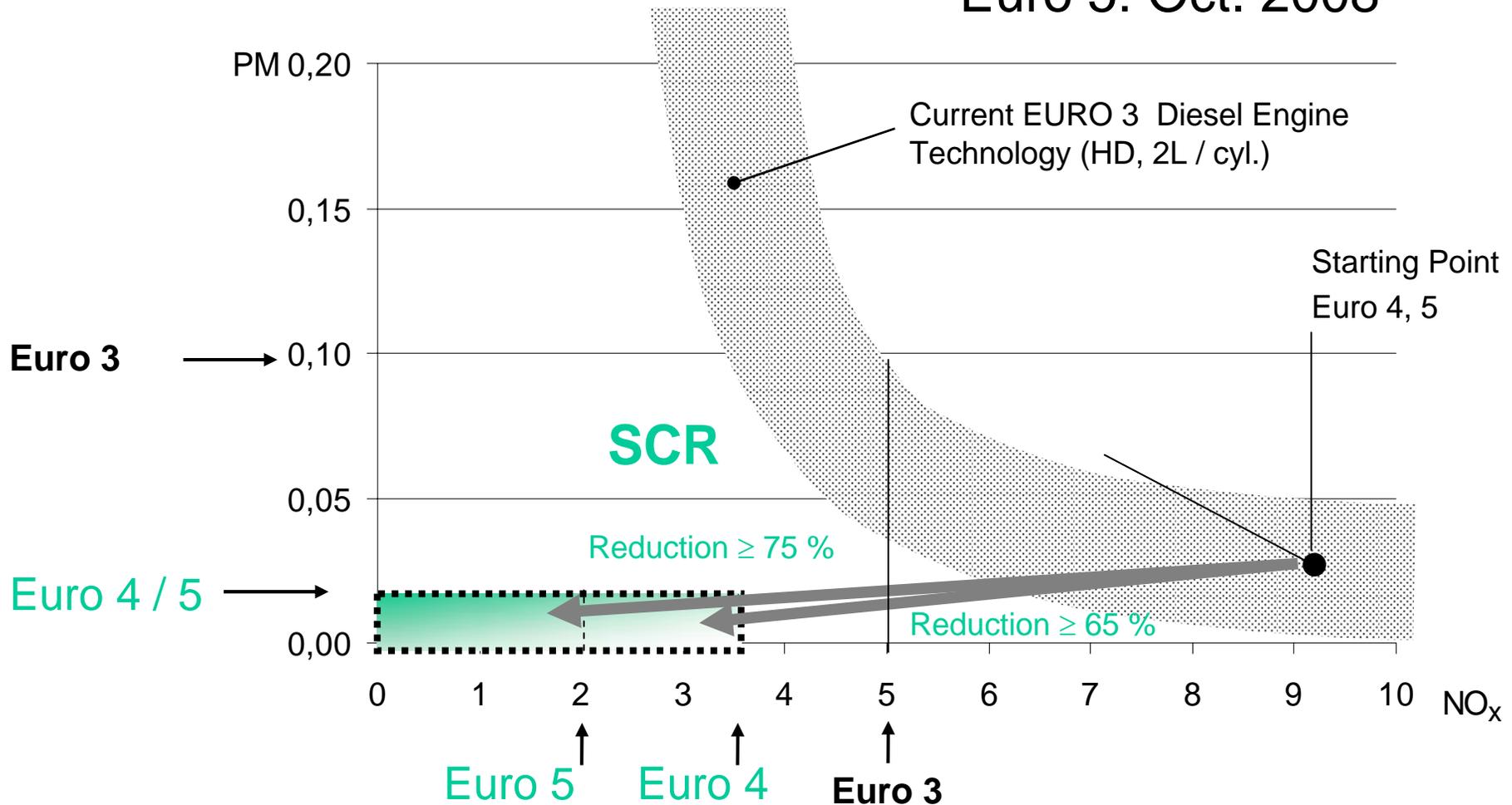
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Euro 4/5 Engine and Aftertreatment Technology Denoxation (SCR)

(Emissions: g/kWh, Test cycle ESC)

Euro 4: Oct. 2004
Euro 5: Oct. 2008



Getting Started: Urea based SCR-Systems for Commercial Vehicles

- The CEOs of the European truck manufacturers decided in September 2001 on UREA as the reductant for the implementation of SCR in Europe.
- Reasons:
 - » SCR DeNOx Technology opens further fuel efficiency improvement
 - » Experience of OEMs joint on-road testing since the 90's
 - » Urea is a non-hazardous product
 - » Short time for implementation recommends well known technology
 - » SCR catalyst production very likely to be extended to CV OEM demand
 - » Commitment of European Urea producers for supply of Special Grade Urea
- The focus of the European engine manufacturers is a joint infrastructure for Urea which has the potential to be extended to light duty vehicles and passenger car applications for meeting future legislation
- The CV industry will coordinate their view with the mineral oil industry, logistic companies and other stakeholders in developing an efficient Urea infrastructure

Aqueous Urea Solution as Reductant

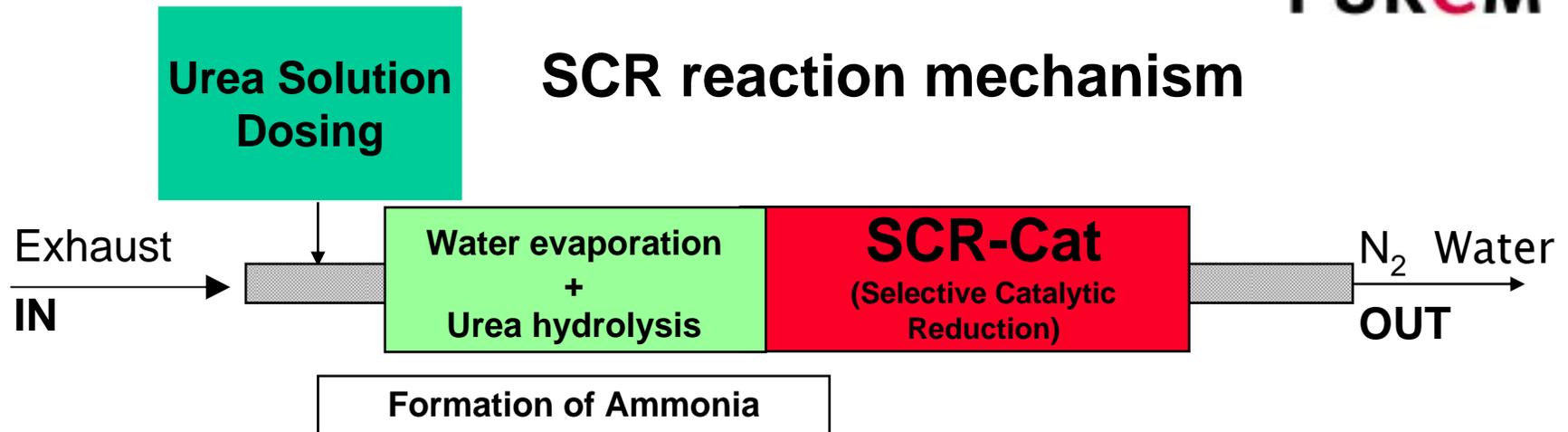
The European Trade name of aqueous Urea Solution for automotive application is

AdBlue

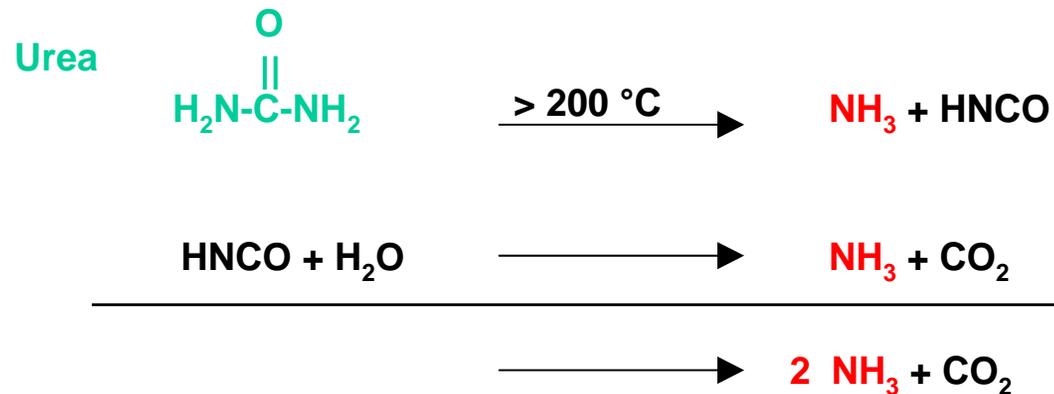
AdBlue is specified in the german standard

DIN 70070

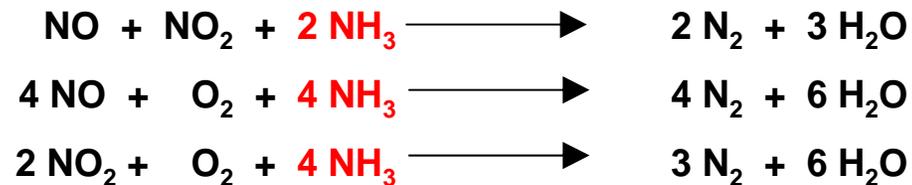
It will be submitted to ISO standardization shortly



1. **NH₃** generation
in exhaust pipe



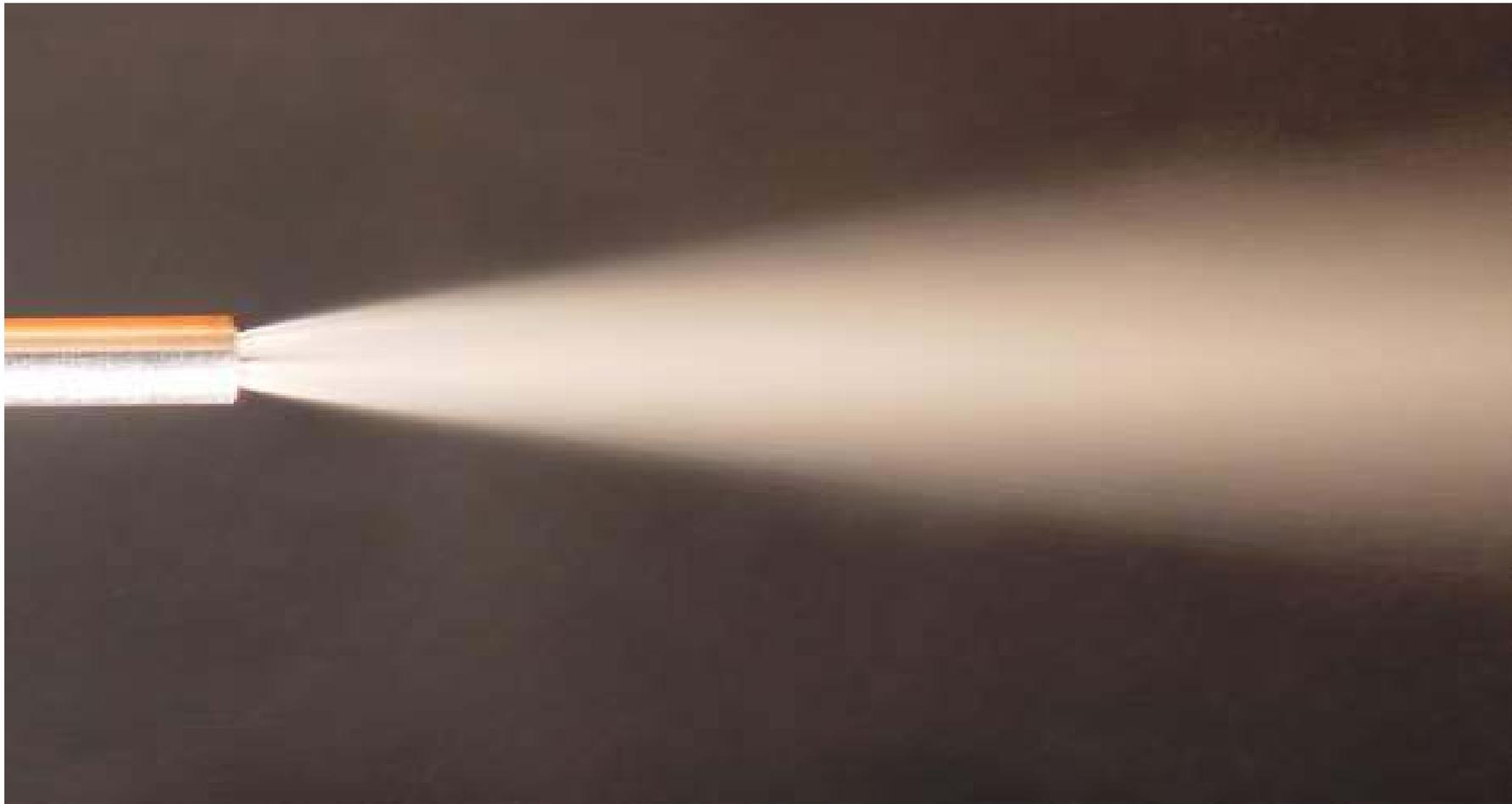
2. Reaction equations of
NO_x -Reduction



Key for SCR operation:

the Spray of Urea aerosol in the exhaust

→ definedly and reproducibly metered for less than
0.1 seconds dwell time



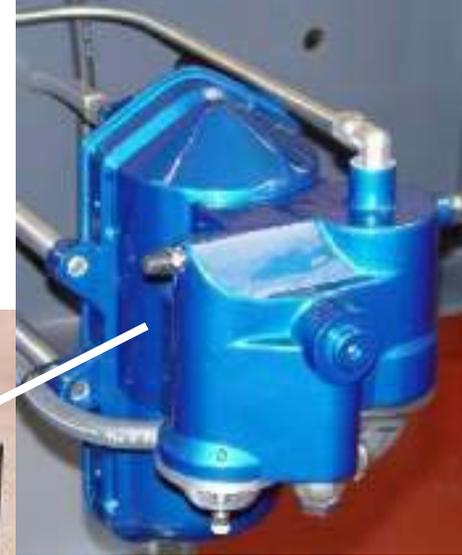
PUREM SCR System



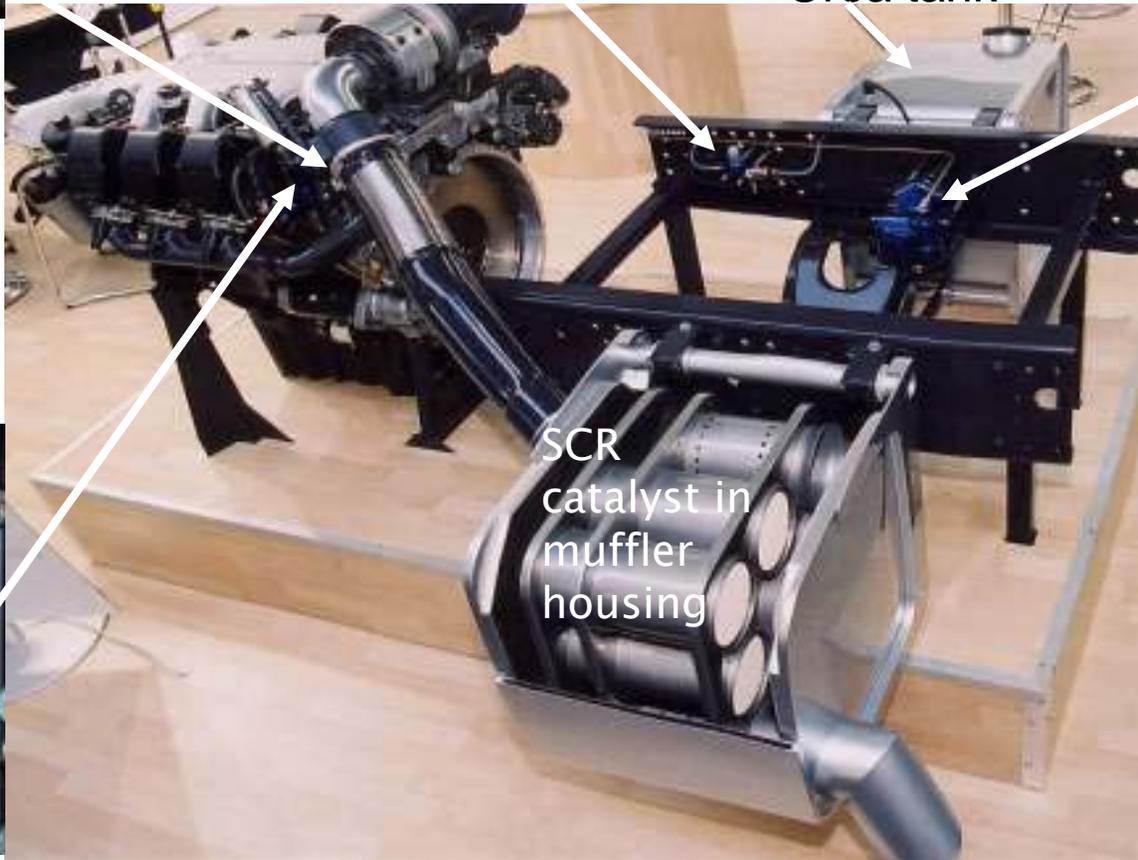
Injection nozzle



Air control unit



Urea tank



Dosing unit

AdBlue supply Unit

SCR catalyst in muffler housing



ECU

SCR System—Basic Components

- **Urea Aerosol Injection:**
 - » Urea Supply Unit, Compressed Air Controller, Dosing Unit
 - » Sensors
 - » Nozzle
 - » Electronic Control Unit
- **Muffler Unit:**
 - » Catalytic Converter, Temperature Sensors
 - » Housing optimized for
 - Mechanics, fixation to the vehicle frame
 - Flow Distribution
 - Acoustics
 - Material--Production technology
- **Urea on board storage, preparation and flow**
 - » Urea tank
 - » Urea pipes
 - » Heating of tank and pipes
 - » Level Sensor, Temperature Sensors

Key OEM Requirements to be met by the SCR System

» Durability:

- 1,000,000 km (620,000 mi)
- Truck setup Bad Road testing
- Component Shaker Testing

» Temperature:

- Components fixed to frame - 40 °C (-40 F) ... + 80 °C (+176 F)
- Components fixed to engine max. 140 °C (285 F)

» Dosing precision:

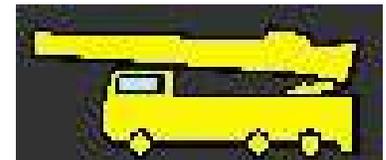
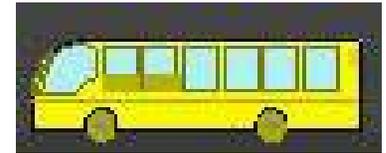
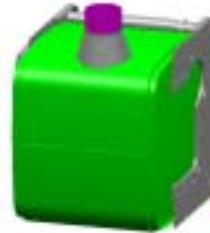
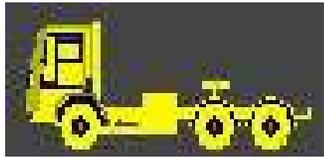
- +/- 5 weight %
- Static and dynamic operation

» Catalytic efficiency for Euro 4:

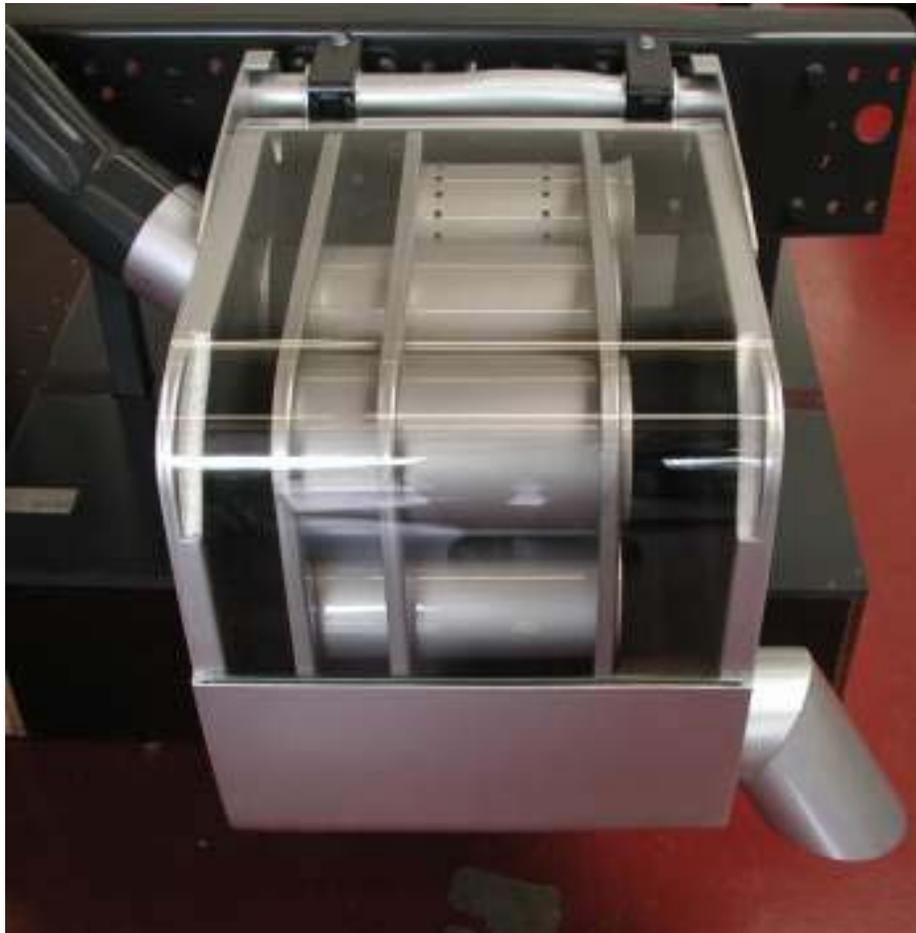
- >65% for 10,000 hr, equivalent 500,000 km (310,000 mi)

Key Requirement: Device Variability

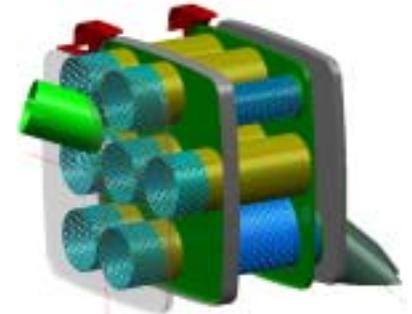
Design suitable for multiple application



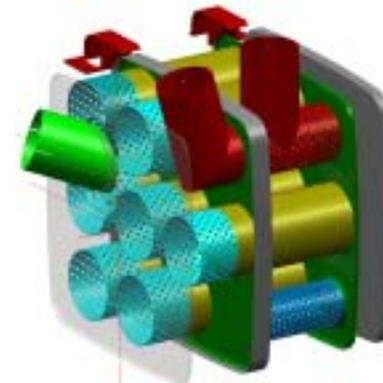
Key Requirement: Common Catalysts and Housing



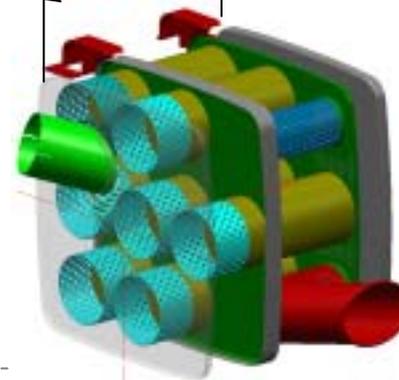
Straight through



Vertically out



Length1/
Length2



Side out

Key Requirement: Meet Design Constraints of Exhaust System

← Driving direction, left side view



Modification of Battery tray and Air tank placement provides the necessary space for the aftertreatment unit including Urea tank for Euro 4 and Euro 5 systems

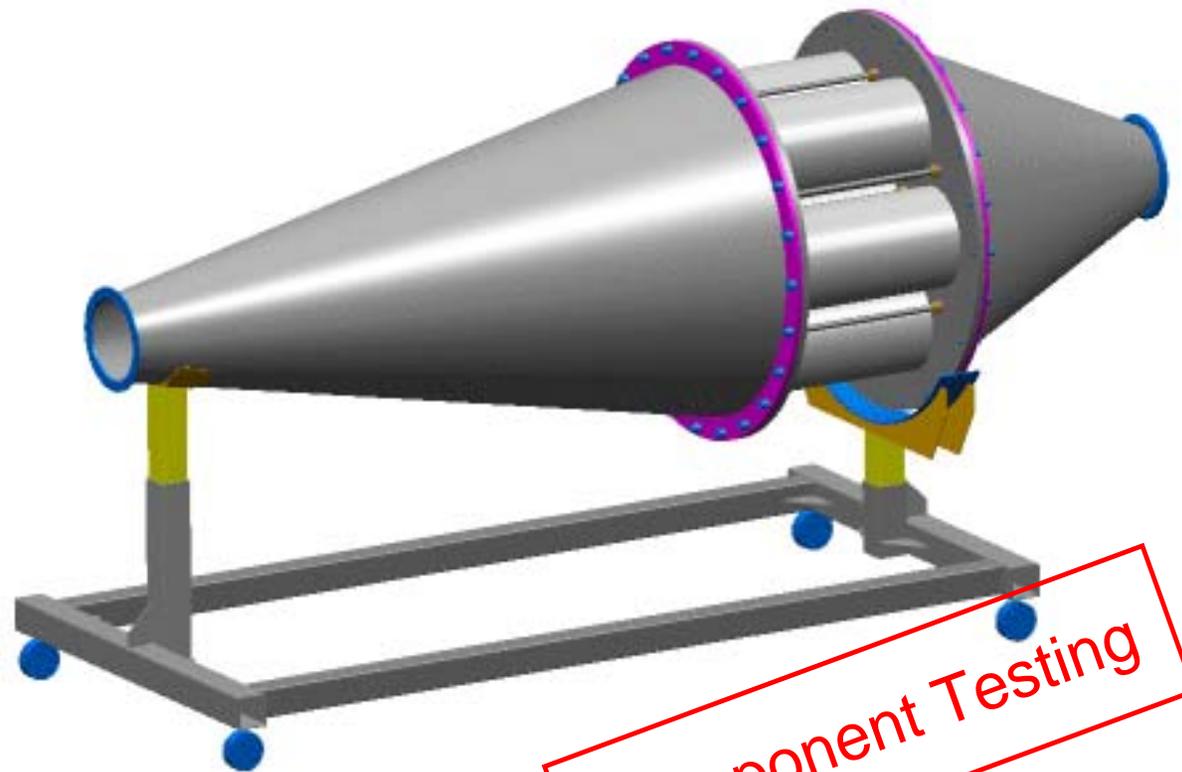
Testing Methodology: SCR System on 3-axis Hydro Pulse test bench (cold)

Simulation by Bad Road Test Course Acceleration pattern



Catalyst Testing (reference and aging test)

- Aging with 1,000, 6,000 and 10,000 hours



Component Testing

Argillon based design

Winter Testing - JAN. 2003, Rovaniemi Finland, -34 °C (-29 F)



Winter Testing

AdBlue Supply Unit mounted next to AdBlue Tank



Air Regulator and AdBlue Tank



Winter Testing

AdBlue filling stations' arctic experience



Winter Testing

Summer Testing - July 2003, Sierra Nevada, Spain



Summer Testing

Altitude range: From Sea level to 2,100 m (6,890 ft)

Temperature: 42 °C (108 F) Sea Level, 32 °C (90 F) Mountainside

Urea Solution
(AdBlue)
Filling Station



Summer Testing

Dosing Unit, Urea Solution Injection Nozzle



Dosing Unit



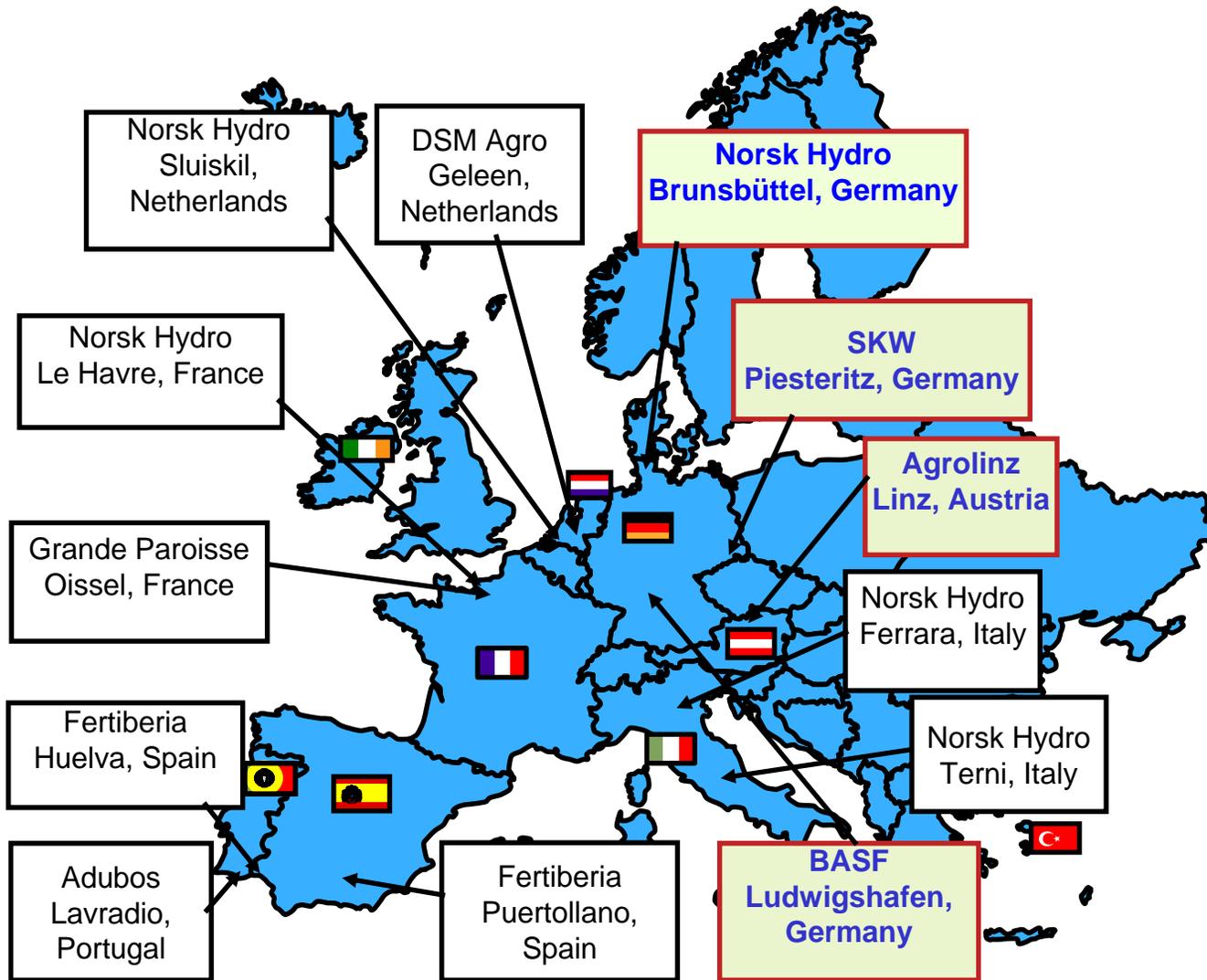
Urea Solution (AdBlue) Nozzle

Summer Testing

Testings Rationale and Outcome:

- Winter and Summer Tests provide Real-life Data as to the interaction of the SCR System and the vehicle: Climate, Air Flow turbulence, Dynamic/ Vibrational effects
- Basis for realistic, application specific test procedures
- Test bench provides weak spot detection and traceability in an accelerated timeframe
- SCR system design can be observed in detail and optimized as part of vehicle testing process
- **This contributes to real life development and testing and thus to an accelerated time frame**

2003 Western European Urea production locations



4 European sites are now prepared for AdBlue production of up to 1,000,000 tons/year - equivalent to 300,000 HD SCR equipped trucks' annual demand

Other production sites can be prepared for AdBlue production as the market develops

Source: HYDRO

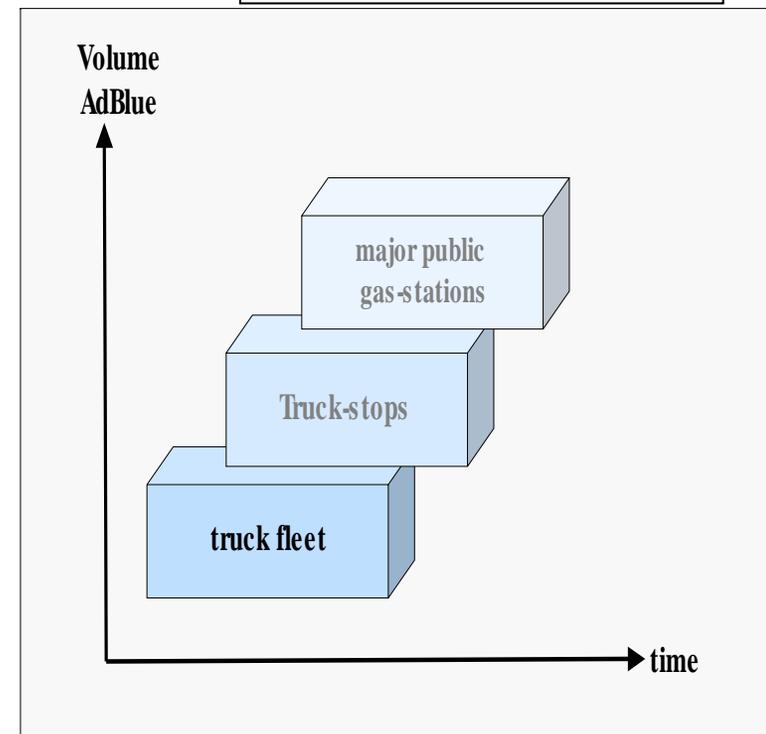
AdBlue Distribution in Europe

Univar, a large Chemical Distributor, has announced their proposed Distribution Plans. Univar provides Storage & Dispensing Units, European Wide Distribution Network, rational & Technical Support

Raiffeisen Cooperative, large distributor of Urea containing fertilizer liquids announced their proposed Distribution Concept. Agriculture Cooperatives provide Diesel fuel Filling stations with distribution to rural areas

German Mineral Oil Industry commissioned Scientific Association DGMK study (to be published in 09/03, Report #616-1). Decisions will be based on the findings of the report

3 step concept for Urea distribution



Public AdBlue Filling Station

Stations in Germany

Operator

OMV

Raiffeisen Cooperative

TotalFinaElf

TotalFinaElf

Location

Dingolfing/ Munich

Münster

Berlin (Oct. 2003)

Stuttgart (Dec. 2003)

Summary and Outlook

- Euro 4 SCR requires Leading Edge Solution
- SCR is on schedule to be launched for 2005 Series
- Euro 4 SCR Technology provides the basis for achieving stringent future emission targets
- The introduction of additional sensors allows for further optimization
- Sensors to detect NH₃, NO_x, Urea are currently under development
- Major International Producers are committed to supplying Quality Grade Urea (AdBlue)
- AdBlue Distribution is a Reality in Europe

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