

Solid SCR Demonstration Truck Application



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DIRECTIONS IN ENGINE-EFFICIENCY
AND EMISSIONS RESEARCH CONFERENCE



U.S. DEPARTMENT OF
ENERGY

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FEV

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Solid SCR Demonstration Vehicle Presentation Outline

- Introduction**
- SCR and SSCR Basics**
- SSCR System Layout**
 - 1st Generation**
 - 2nd Generation**
- Test Results**
 - Bench Setup**
 - Vehicle**
- Summary**

Solid SCR Demonstration Vehicle Introduction

Project Objective

Demonstrate the feasibility and performance of the FEV Solid SCR (Ammonium Carbamate) Technology, retrofitting a 2004.5 Dodge Ram and measuring emissions reductions in steady state and transient conditions both in the lab and real-world environments



Solid SCR Demonstration Vehicle Introduction



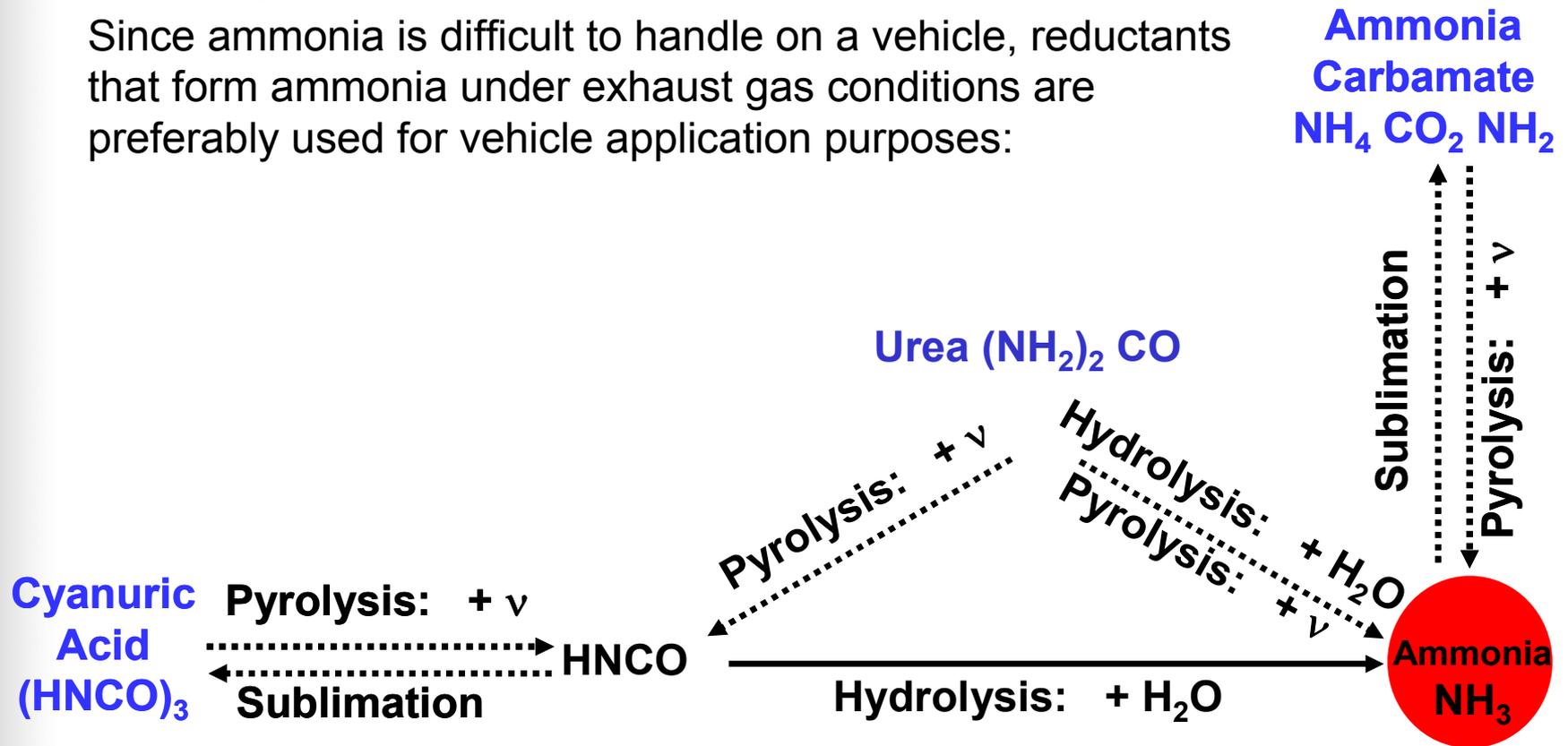
Solid SCR Demonstration Vehicle

SCR Basics

SCR Technology Basics

The designation SCR refers to Selective Catalytic Reduction technologies relying on ammonia as the reductant.

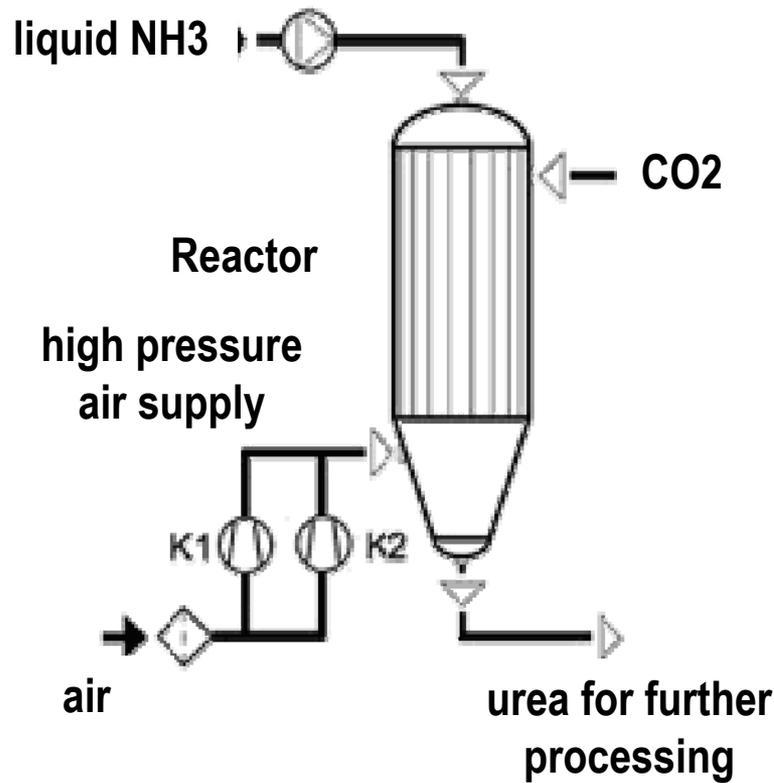
Since ammonia is difficult to handle on a vehicle, reductants that form ammonia under exhaust gas conditions are preferably used for vehicle application purposes:



Solid SCR Demonstration Vehicle

SCR Basics

Ammonium Carbamate



❑ Ammonium carbamate is produced directly from CO₂ and ammonia at about 180 bar and 230°C

❑ $2\text{NH}_3 + \text{CO}_2 \rightarrow (\text{NH}_2\text{-CO}_2)\text{-(NH}_4)$

❑ Ammonium carbamate is a byproduct of urea production. As base for the production of urea liquid ammonia and gaseous CO₂ are being used.

❑ Both products are introduced into a reactor. The reactor walls of this more than 27 m high tower consist basically out of two metals. The outer layer is made from carbon steel and the inner layer is stainless steel with a wall thickness of about 6 mm.

Solid SCR Demonstration Vehicle

SCR Basics

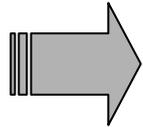
Ammonium Carbamate

Under heat (~ 230°C) and pressure (~ 180 bar) ammonium carbamate is formed. Utilizing dehydration in presence of acid and heat ammonia carbamate is converted in urea and water. Additional dehydration and processing produces a white granulate.



Solid SCR Demonstration Vehicle

SCR Basics



In order to fulfill the demand for AdBlue refill within reasonable (service) intervals and e.g. also fulfill legislative demands, quite large AdBlue storage volumes are required

	Mass / 1g NO	Volume @ Density
Pure Ammonia (liquid Phase):	0.57 g	0.93 cm ³ @ 0.61 g/cm ³
Solid Urea:	1 g	0.75 cm ³ @ 1.34 g/cm ³
Urea / Water Solution (34.4% / 65.6%):	2.9 g	3.0 cm ³ @ 0.97 g/cm ³
Ammonia Carbamate:	1.3 g	0.81 cm ³ @ 1.6 g/cm ³
Metal Ammine	1.2 g	1.0 cm ³ @ 1.2 g/cm ³

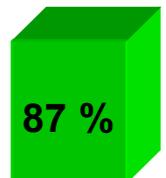
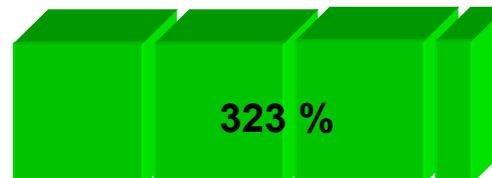
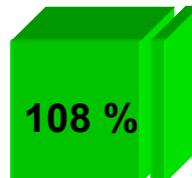
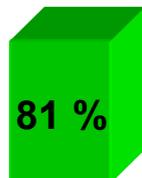
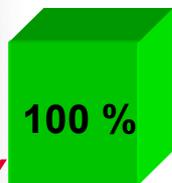
**Liquid
Ammonia**

Solid Urea

**Metal
Ammines**

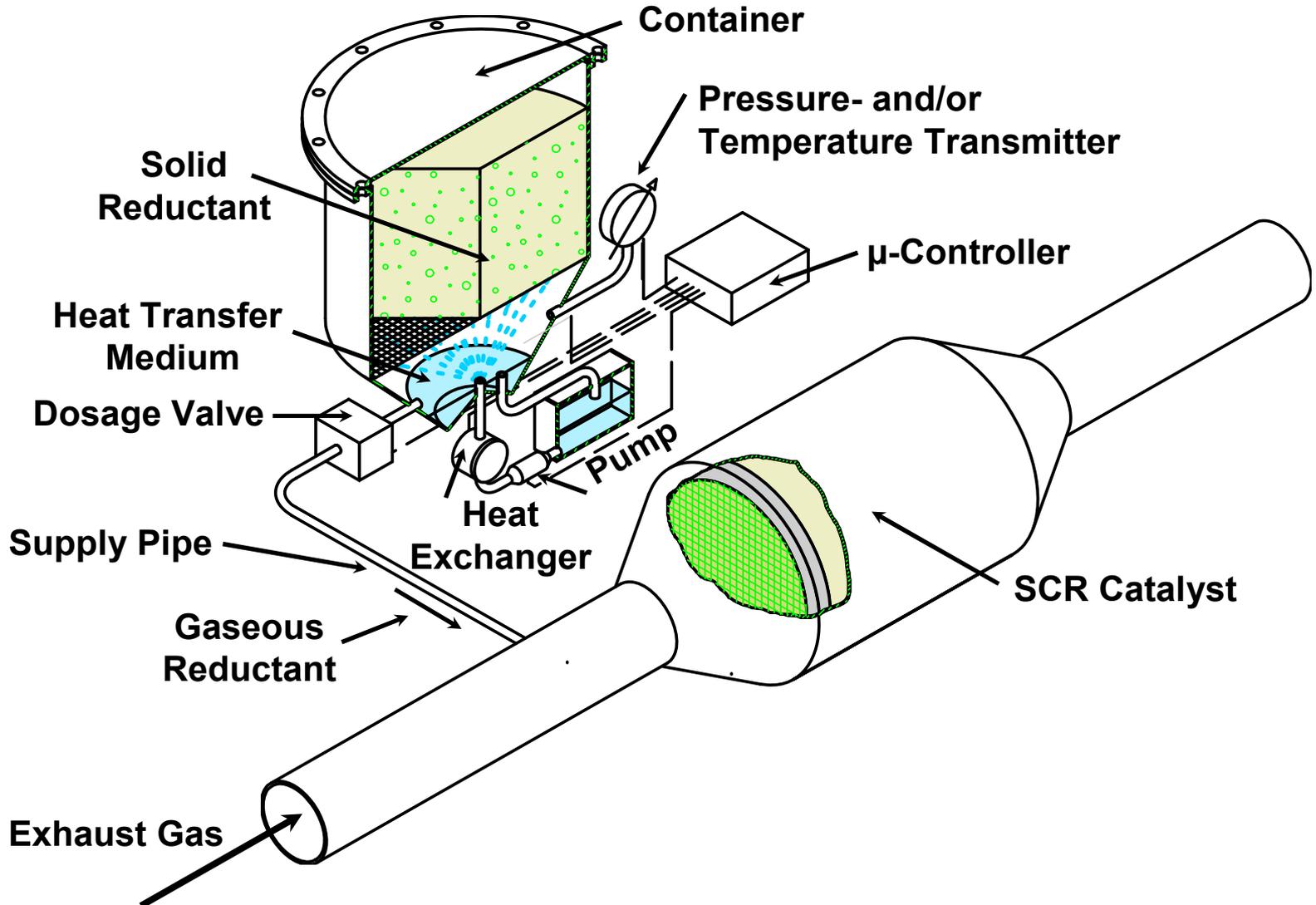
AdBlue

**Ammonia
Carbamate**



Solid SCR Demonstration Vehicle SSCR System Layout

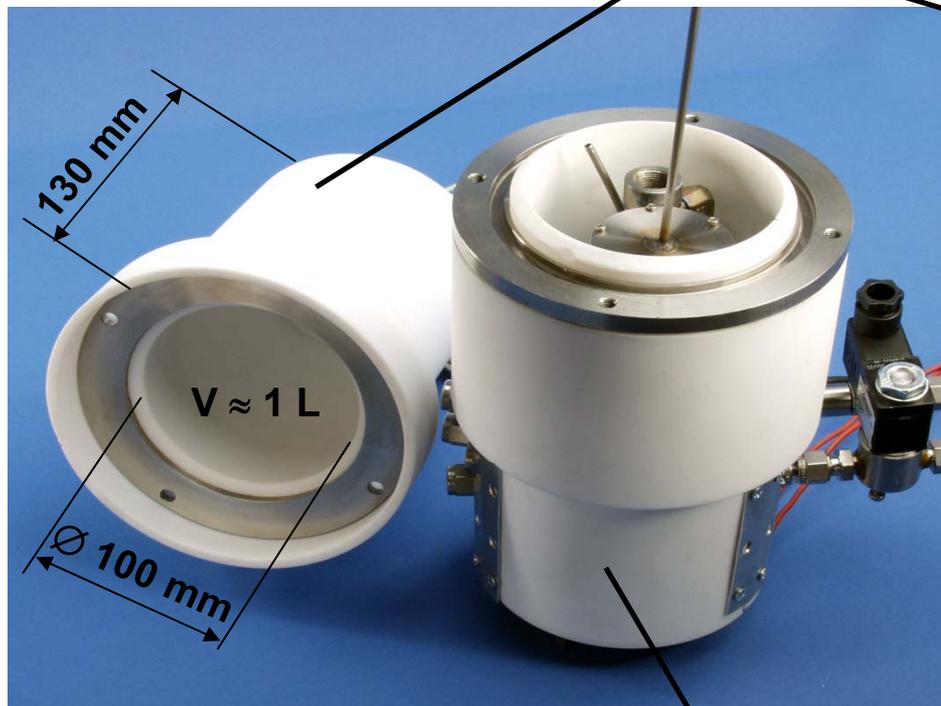
First Generation System



Solid SCR Demonstration Vehicle SSCR System Layout

System Comparison 1st Generation

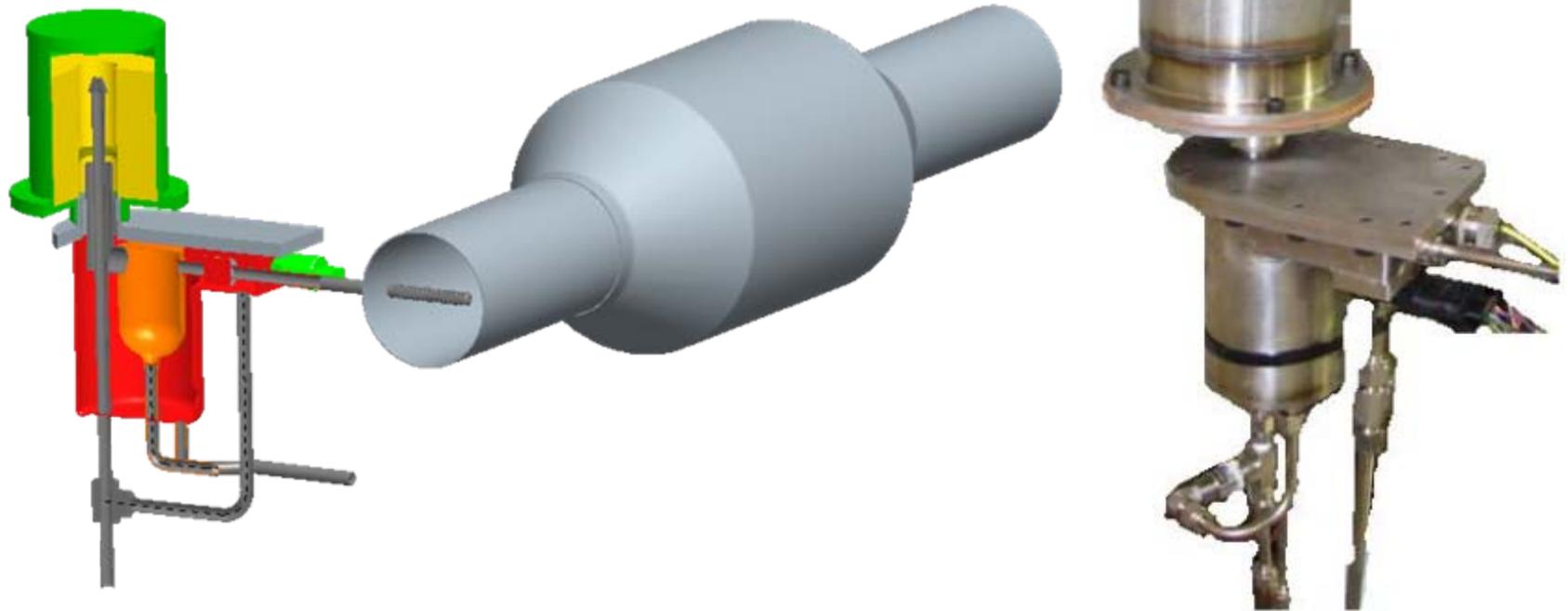
Solid Reductant Container w/ PTFE Isolation



Control Unit with PTFE Isolation

Solid SCR Demonstration Vehicle SSCR System Layout

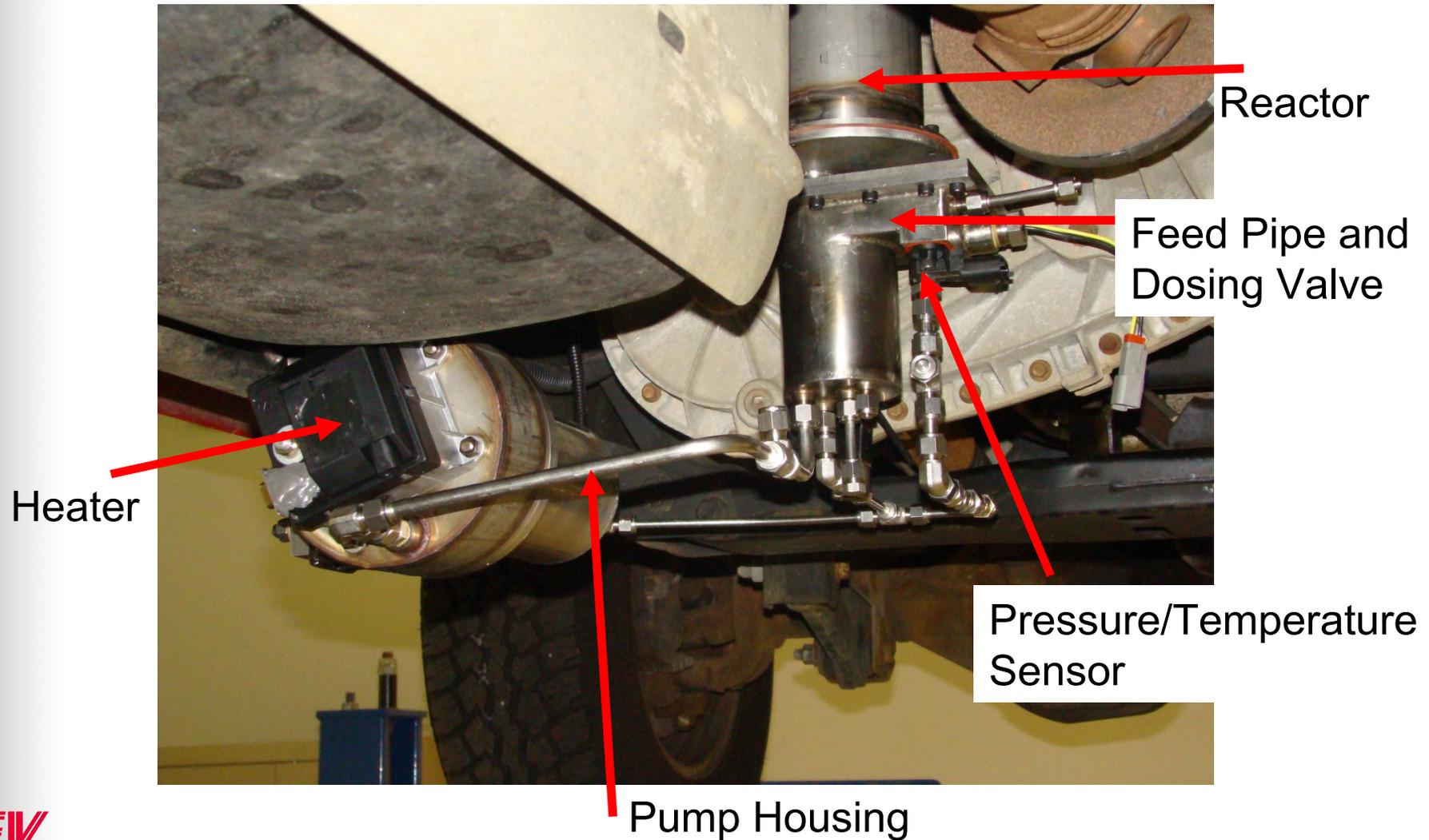
System Comparison 2nd Generation



All used sensing components are automotive production parts,
i.e. heater is cabin heater, temperature sensors are RTD's,
pressure sensors are differential pressure and boost pressure sensors

Solid SCR Demonstration Vehicle SSCR System Layout

System Installation 2nd Generation

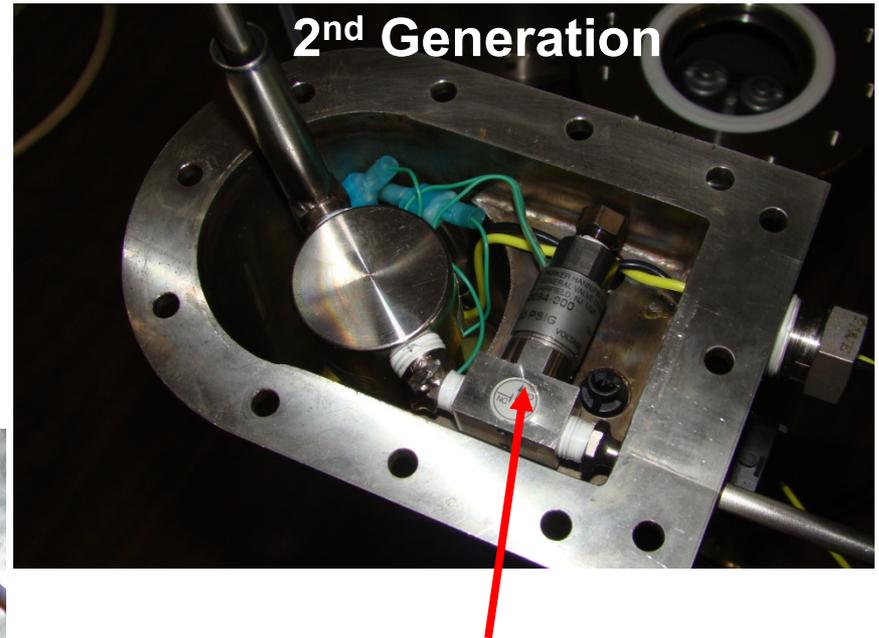
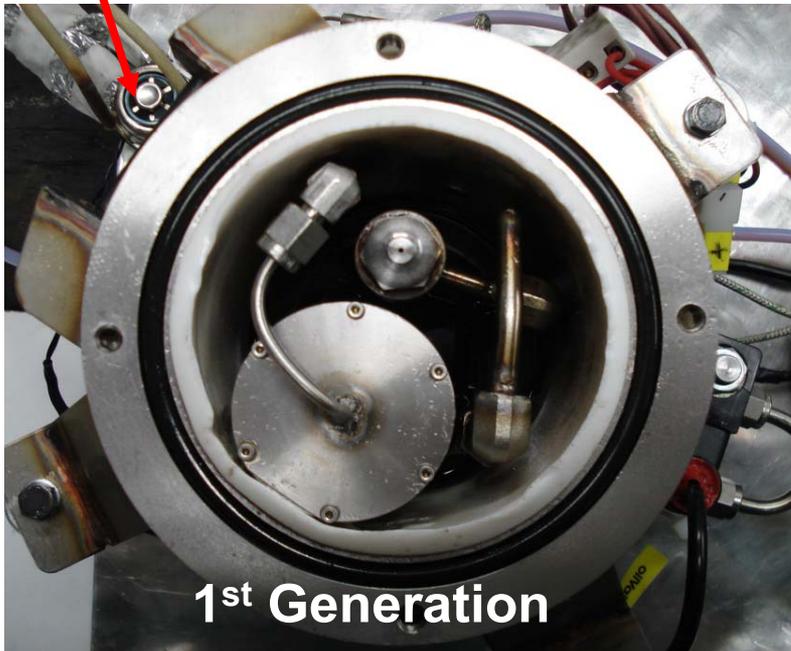


Solid SCR Demonstration Vehicle SSCR System Layout

System Comparison

Old dosing valve was outside the reactor

Extra dosing valve heater was necessary



New dosing valve is embedded in the heat transfer medium

Valve has the same temperature as the oil

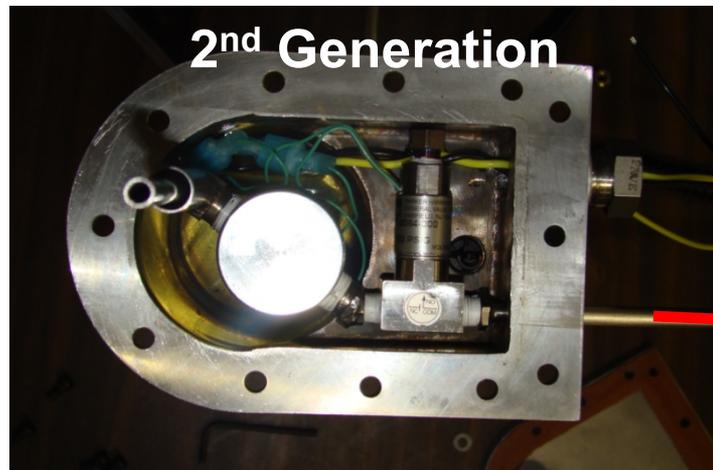
No dosing valve heater necessary

Solid SCR Demonstration Vehicle SSCR System Layout

System Comparison



Unheated spots and elbows can cause line plugging



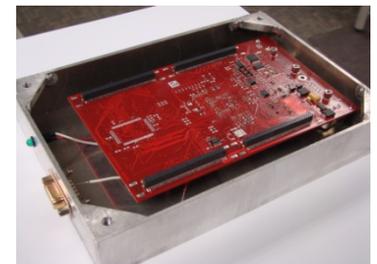
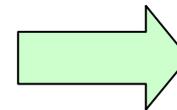
Straight lines, all heated
internals including valves
and lines

Solid SCR Demonstration Vehicle SSCR System Layout

System Comparison

**2nd Generation System
operates without:**

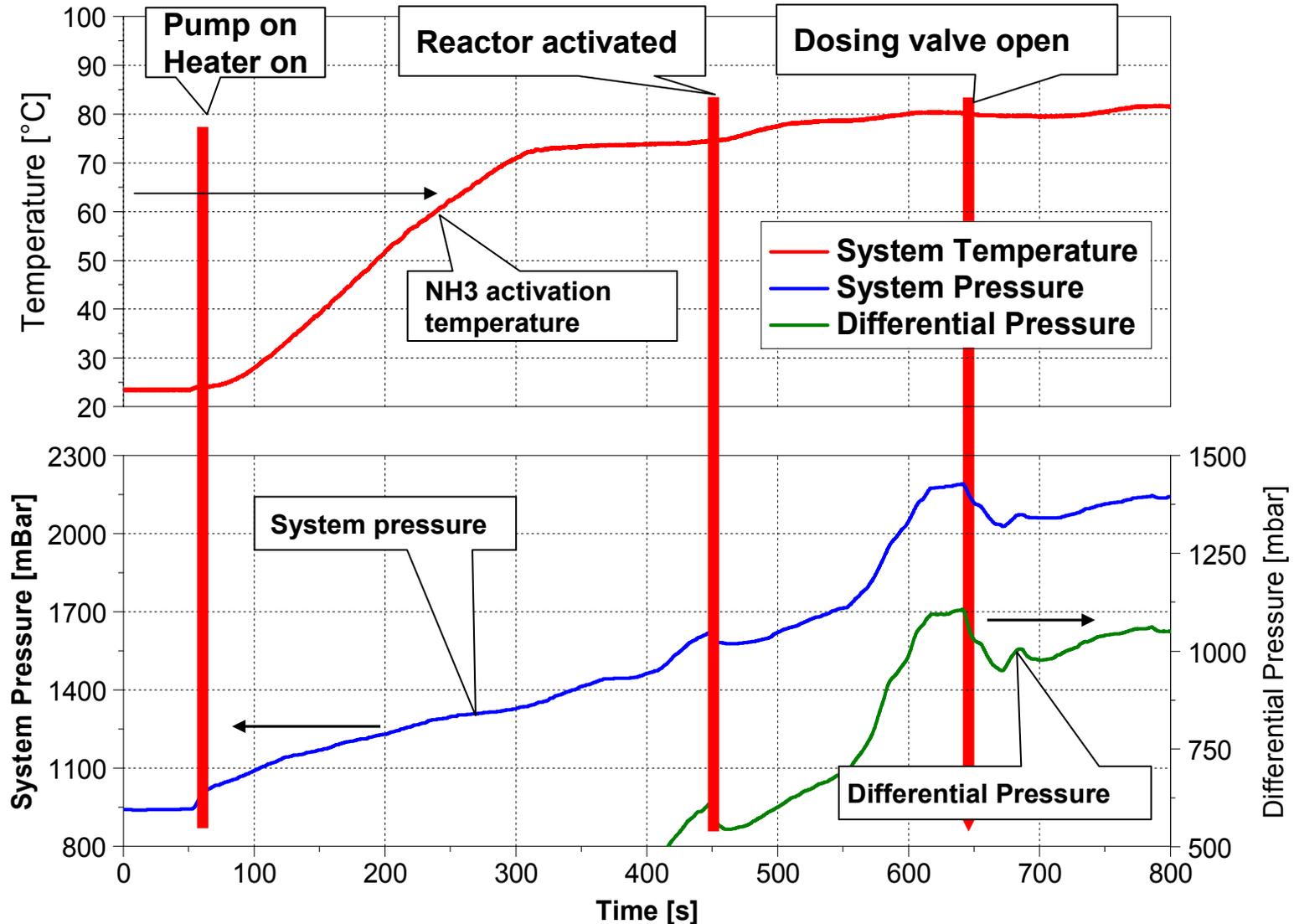
- Amplifier
- AADI Box
- Thermocouple
Transformer Unit
- ES 1000



Solid SCR Demonstration Vehicle

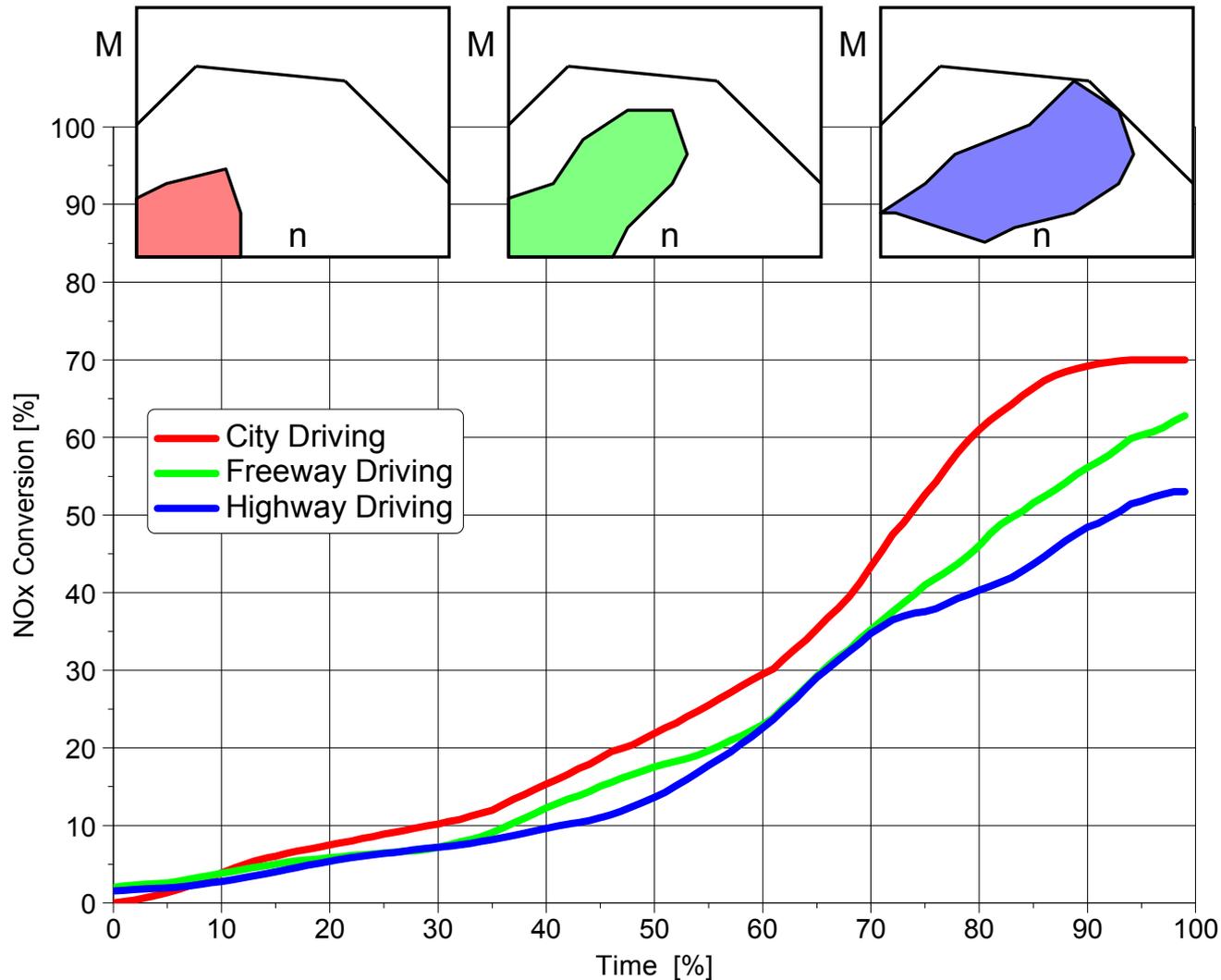
Test Results

Bench Test Results: warm up (working fluid: diesel)



Solid SCR Demonstration Vehicle Test Results

Initial Vehicle Results with 2nd Generation System



Solid SCR Demonstration Vehicle Summary

- ❑ SSCR system proved to be functional in vehicle environment**
- ❑ Transition from 1st to 2nd generation successfully completed**
 - ❑ Refinement of 2nd generation currently ongoing**
- ❑ First test data indicates acceptable conversion efficiencies with new hardware**
- ❑ Chassis dynamometer tests to validate the system performance**

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■
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moving working living
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