Concept for particle filter and NOx-reduction retrofitting of commercial vehicle in urban service

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Content

- Driving force of retrofit projects
- Technical Funding Guideline
- Description of the development procedure

Extract of the development results

- Craftsman vehicles, Euro 4/5
- Municipal vehicles, Euro IV/V
- Municipal vehicles, Euro III

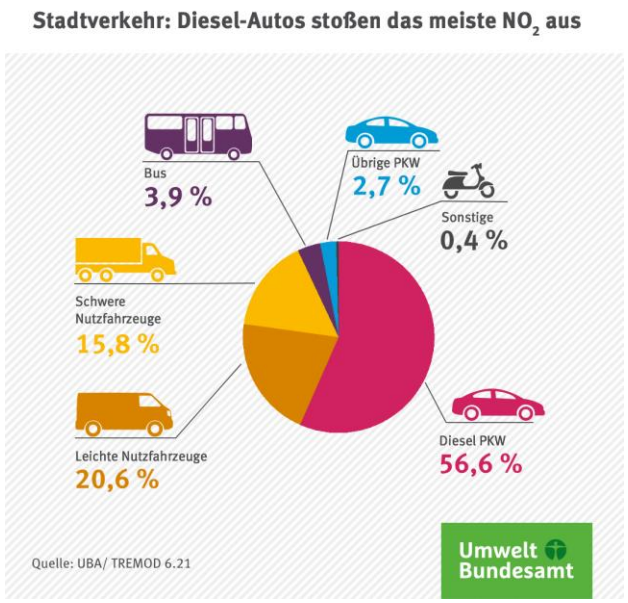
Air quality situation in Germany

Dirk Messner (President UBA): "For truly healthy air, **pollution levels must be reduced permanently and throughout Germany**.

There is an urgent **need for action beyond the measures already defined in the Clean Air Programme**: the goal must be to get our air as clean as possible.

Anteil der Stationen mit Überschreitung	Interim Target 1	Interim Target 2	Interim Target 3	Interim Target 4	WHO-Richtwert
$PM_{2.5}$: Jahresmittelwert	0% > 35 µg/m³	0% > 25 µg/m³	0% > 15 µg/m³	64% 36% > 10 µg/m³	1% 99% > 5 µg/m³
PM_{10}: Jahresmittelwert	0% > 70µg/m³	0% > 50 µg/m³	0% > 30 µg/m³	94% 6% > 20 µg/m³	60% 40% > 15 µg/m³
NO_2: Jahresmittelwert	99.5% 0.5% > 40 µg/m³	86% 14% > 30 µg/m³	61% 39% > 20 µg/m³	kein Interim Target	78% 22% > 10 µg/m³
Ozon: Max. tägl.8-Stunden-wert, 99. Perzentil	0% > 160 µg/m³	71% 29% > 120 µg/m³	kein Interim Target	kein Interim Target	99.6% 0.4% > 100 µg/m³

Quelle, UBA, 10.02.2022 - Luftqualitätsgrenzwerte in Deutschland 2021



Think about tomorrow.

Extract from the Budget of the Federal Republic of Germany 2022, Section 12, BMDV

Erläuterungen:

1. Die finanziellen Mittel sind vorgesehen für eine zeitnahe und effiziente Umsetzung von Forschungs-und Entwicklungstätigkeiten sowie die Herstellung der Marktreife von Abgasfiltern sowie technologieoffenen Nach- und Umrüstungssystemen für dieselbetriebene Nutzfahrzeuge und Maschinen mit einer hohen spezifischen Schadstoffemission und langer Lebensdauer wie vor allem Busse und Diesel-LKW im kommunalen und regionalen Einsatz, Bau- und Landmaschinen, Dieselloks, Binnenschiffen oder Stromgeneratoren.
2. Eine signifikante Elektrifizierungsrate durch Neuanschaffungen ist bei diesen Anwendungen kurz-und auch mittelfristig mangels Verfügbarkeit nicht zu erwarten. Durch den Einsatz technologisch fortschrittlicher Nach- und Umrüstsysteme wird dennoch auch für diese Anwendungen ein zusätzlicher, notwendiger und Beitrag zur Senkung von Emissionen (CO_2und / oder Schadstoffen) ermöglicht.
3. Die angestrebten FuE-Tätigkeiten und die daraus abgeleiteten marktreifen Nach- und Umrüstungssysteme stellen somit eine Brückentechnologie dar, die die unvermeidbare Weiternutzung von Bestandsmotoren auch unter ökologischen Aspekten ermöglicht.
4. Die Unterstützung ist unabdingbar zur Absicherung einer breiten Verfügbarmachung solcher Systeme für die genannten Anwendungen. Damit wird eine nachhaltige Transformationsstrategie umgesetzt, die sowohl ökologisch als auch ökonomisch die klimapolitischen Ziele fördert.

In the previous and existing budget, budgets are allocated for the development of diesel retrofit systems for commercial vehicles and machines with high pollutant emissions and a long service life.

- municipal trucks
- construction and agricultural machinery
- diesel locomotives
- inland vessels
- power generators

Extract from technical requirements for NOx reduction systems for retrofit systems (NOxMS-H-leicht, LDV)

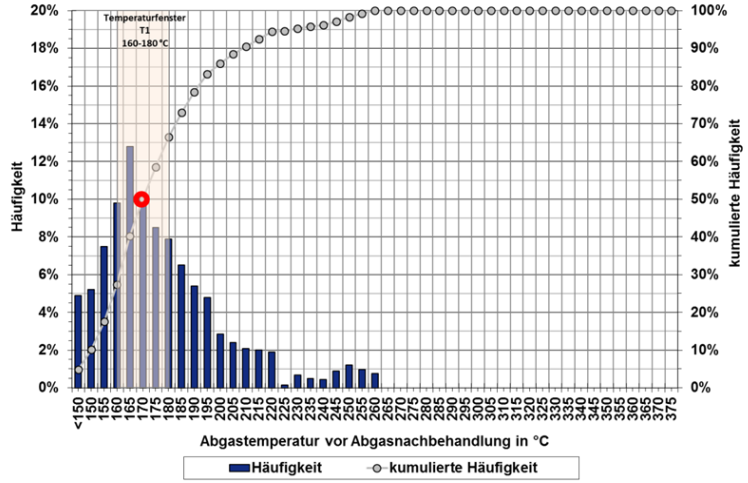
- Functionality starting at - 7 °C
- Lifetime 100,000 km or 5 years
- Functionality of original installed DOC/DPF must not be affected
- AdBlue tank level and quality control are mandatory
- Additional fuel consumption < 6%
- **NOx conversion in total: ≥ 75%**
- 2 Test runs
  - Test run according to “in Service Conformity Test” (ISC)
  - Test runs with different temperature distributions
- Vehicle load 50-60% of max. payload
- Annual inspection by a technical service of one field vehicle across 5 years

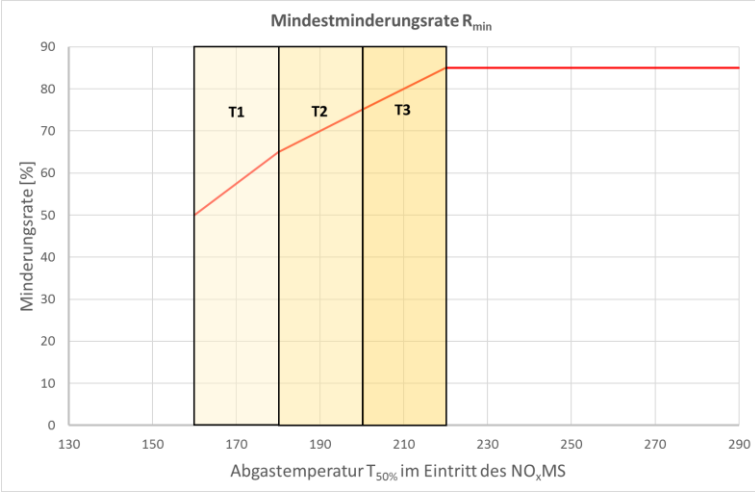
Passing the ISC test is a requirement for the operating permit. (Test cycle: e.g., on-road test LDV)

1. Test run according to “in Service Conformity Test” (ISC)
   - 34% urban (mean velocity 25 – 30 km/h)
   - 33% rural (mean velocity 60 – 90 km/h)
   - 33% highway (mean velocity > 90 km/h)
   - Cold start condition (coolant temperature max 30°C)
   - Data Analysis 15 min after start of measurement alternatively T(coolant) > 70°C
   - Load: 50 – 60% of max. payload
   - Test duration min. 120 min
   - **NOx conversion in total: ≥ 75%**

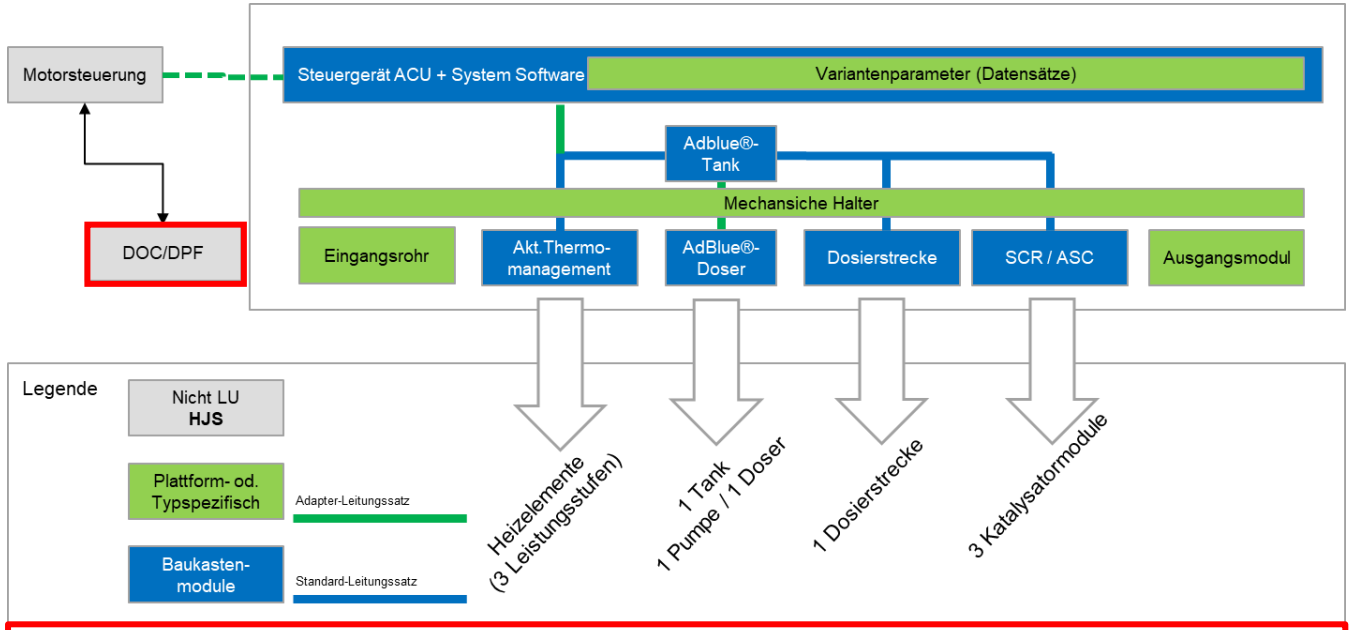
2. Test runs with different temperature distributions
   - 3 test runs 120 min each
   - Mean exhaust temperature (T50%, top right picture) within one of 3 Temperature windows defined
   - NOx conversion above red line (right picture)

The technical requirements for the other vehicle classes were adapted to their applications





Implementation Concept for Euro III/IV and V vehicles



In addition to the SCR system, a DOC and DPF were installed in the Euro III vehicles.

- The Concept is based on vehicle-specific and modular components
- Grey components are vehicle tied
  - Engine ECU
  - DOC/DPF
- Blue components are kit based
  - ACU and System Software
  - Thermo-Management
  - AdBlue Doser
  - Mixing device
  - SCR/ASC
- Green components are vehicle specific
  - Variants parameter data sets
  - In- and outlets
  - Brackets (SCR-System, ACU, Adblue-Tank,…)

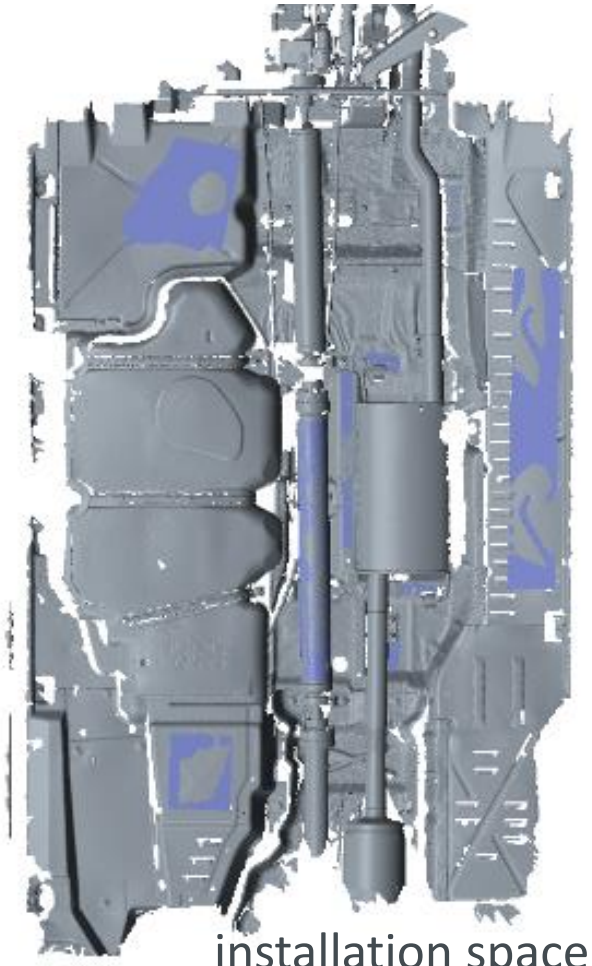
The concept is based on the following function steps

- Detection of engine operation
- Activation of the dosing system (pressure build-up in the line)
- Measurement of exhaust gas temperature, air mass and NOx concentration
- Control of the heating element
- Continuous calculation of the AdBlue dosing quantity to achieve the max. possible conversion rate
- Parallel continuous calculation of NH_3 storage level in the SCR catalyst
- Continuous measurement of AdBlue tank level and AdBlue quality
- Indication of service information and malfunctions on the display
- Initiation of inducement (emergency vehicle run), e.g. if no AdBlue is refilled despite repeated requests.
- Shutdown/deactivation of the system after switching off the engine.

Original installed exhaust system and installation position of VW T5 transporter (LDV)

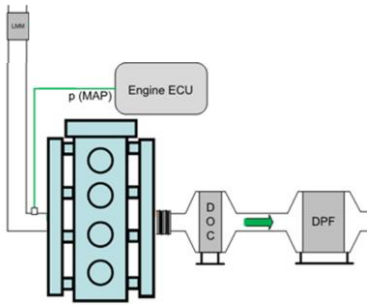
VW T5 2.0 TDI, Euro 5

Underbody view



installation space scan

Implementation & Effectiveness for Craftsman Vehicles of VW T5 Euro 5

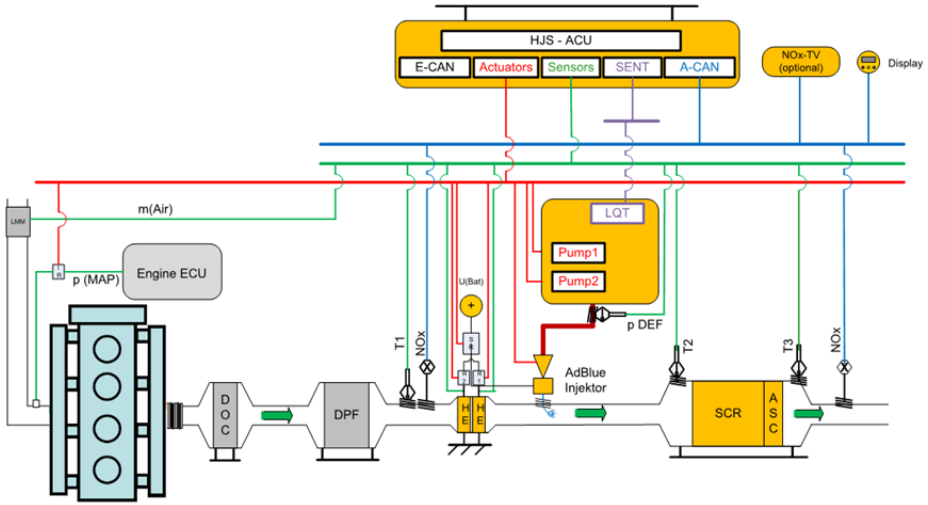


Original

AdBlue Injection

SCR-System incl. Slip Catalyst

Exhaust

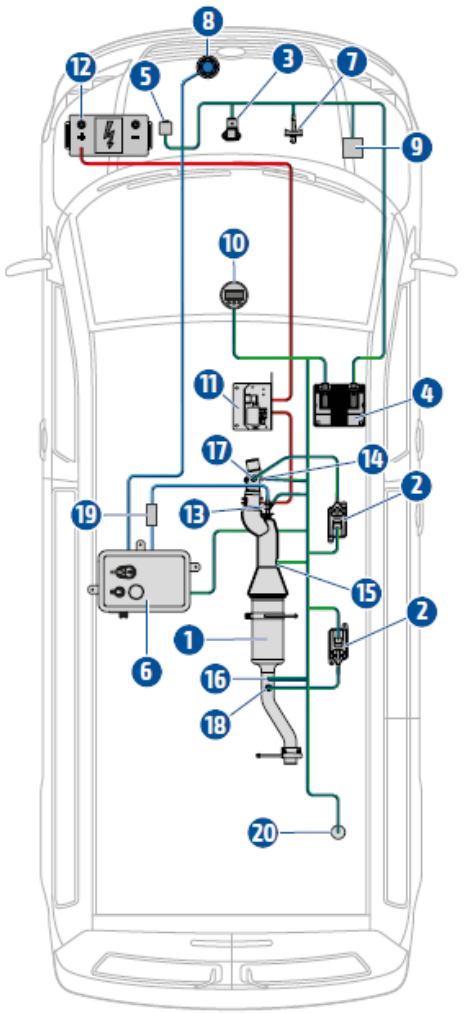


HJS system scope in yellow

AdBlue tank underbody

SCR-System + Heater

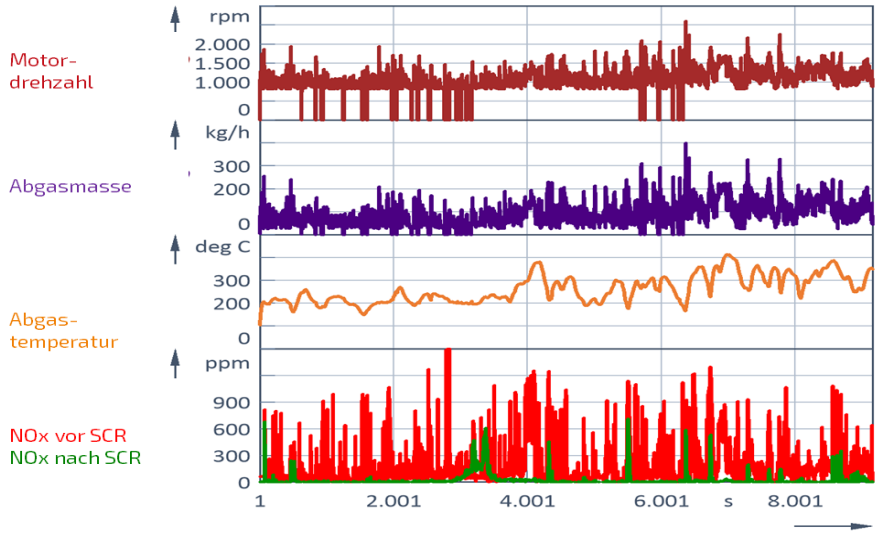
Implementation & Effectiveness for Craftsman Vehicles of VW T5 Euro 5



1. SCR catalyst
2. NOx sensor control unit
3. MAF sensor connection
4. ACU
5. Inducement relay
6. AdBlue®-tank
7. Boost pressure sensor
8. AdBlue®-filler
9. Fuse box
10. Service display
11. Relay plate LDV
12. Battery connection
13. AdBlue®-injector
14. Temperature sensor downstream CRT
15. Temperature sensor upstream SCR
16. Temperature sensor downstream SCR
17. NOx-sensor upstream SCR
18. NOx-sensor downstream SCR
19. AdBlue®- pressure sensor
20. Resistor

Key

- Heater power supply (battery box / underbody)
- HJS wiring loom (engine bay /vehicle interior / underbody)
- AdBlue® dosing line (underbody)



- Reduction of NOx emissions by 88 % in the VW T5 trial on an ISC test cycle.
- General operating permit has been issued.
- Other vehicles were realized
  - MB: Vito, Sprinter
  - VW: Crafter
  - Citroen: Jumper
  - Ford: Transit
  - Opel: Vivaro, Movano

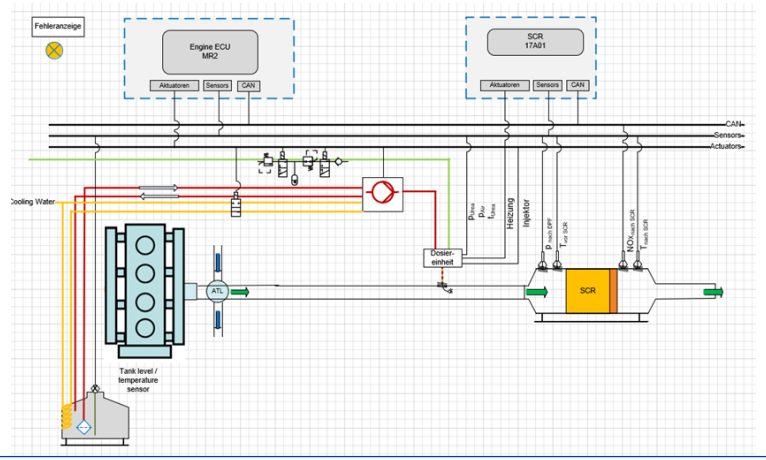
Original installed exhaust system and installation position of MB Econic Euro IV/V

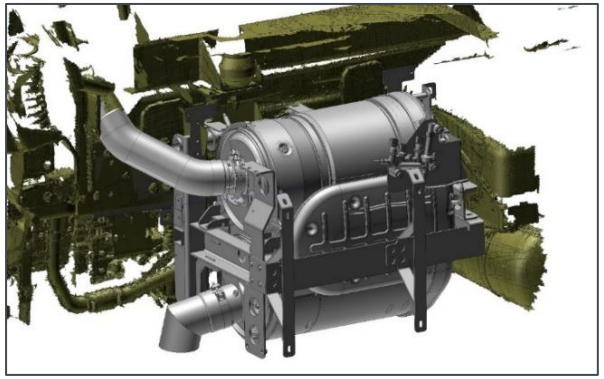
Econic Euro V

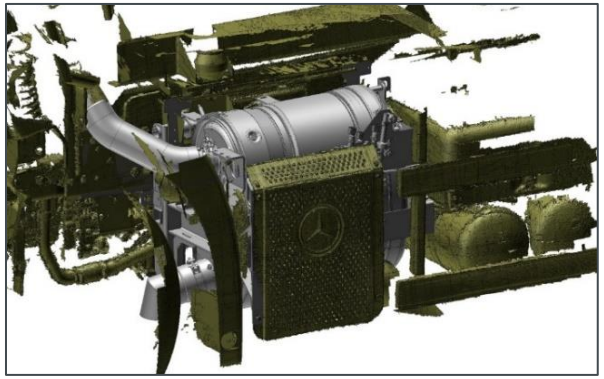
Installation space

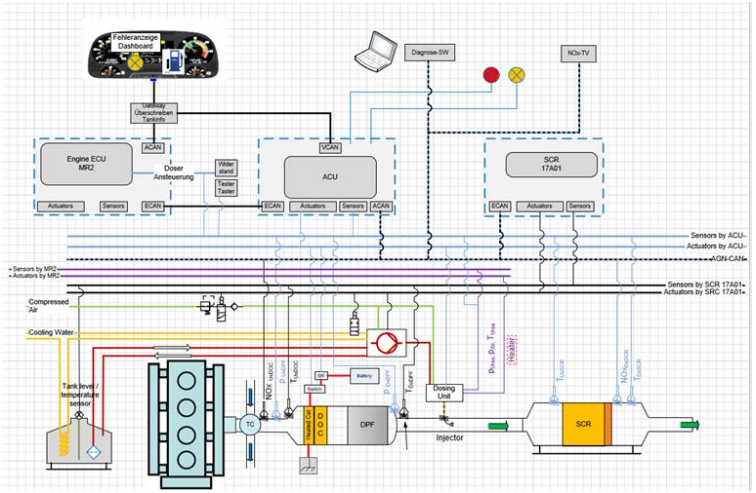
Original SCR System

Implementation & Effectiveness for Municipal Vehicles of Econic Euro IV/V

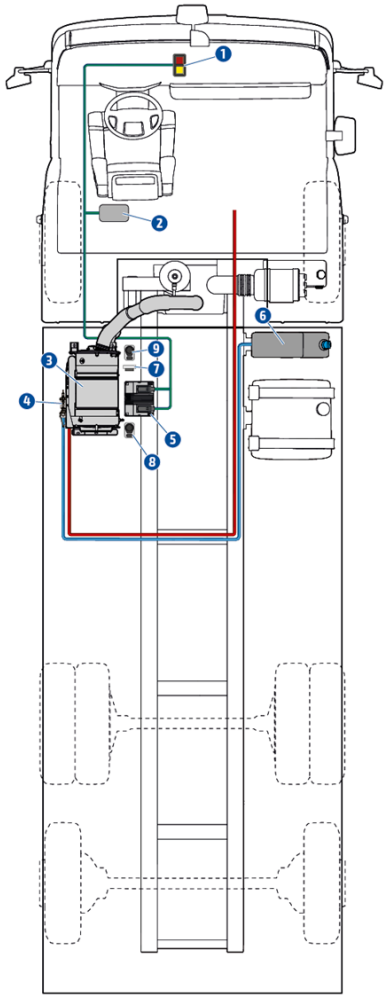








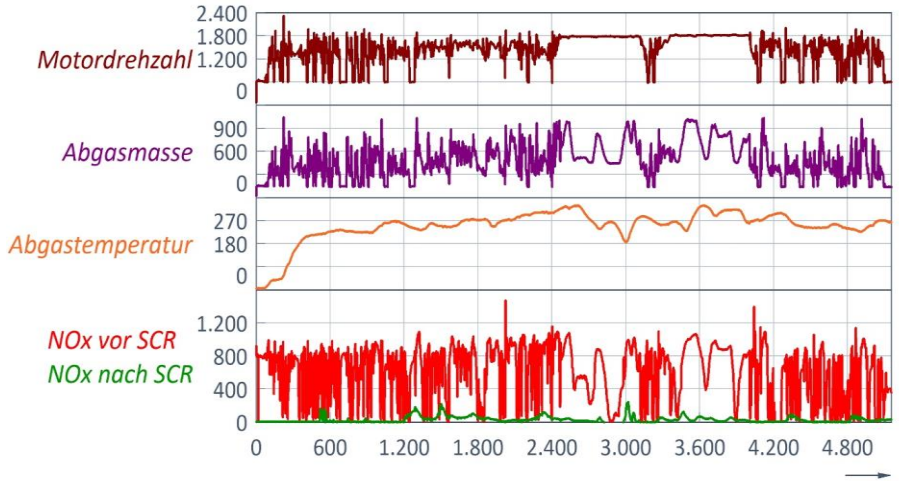
Implementation & Effectiveness for Municipal Vehicles of Econic Euro IV/V



1. HJS Kontrollleuchten
2. Dashgate Steuergerät CAN FPS2
3. SCRT®-System
4. Dosiereinheit
5. Aftertreatment control unit (ACU)
6. OE AdBlue® Tank
7. Steuergeräte NOx Sensoren
8. Drucksensor vor CRT-Einheit
9. Drucksensor nach CRT-Einheit

Key

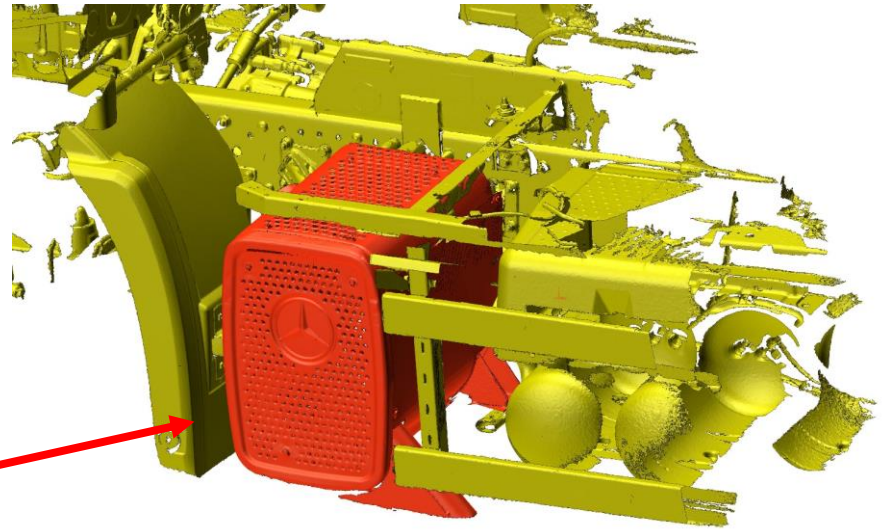
- Heater power supply (battery box / underbody)
- HJS wiring loom (engine bay / vehicle interior / underbody)
- AdBlue® dosing line (underbody)



- Reduction of NOx emissions by 94 % for the Econic Euro V on an ISC test cycle.
- General operating permit has been issued.
- Other vehicles were realized:
  - MB: Atego, Actros, Vario, Unimog
  - IVECO: Eurocargo, Stralis , Daily
  - Scania: L-, P- and G-Serie
  - MAN: TGL

Original installed exhaust system and installation position of MB Actros Euro III

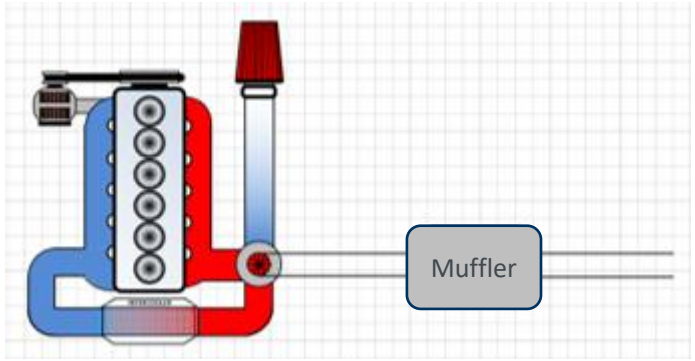
Actros Euro III

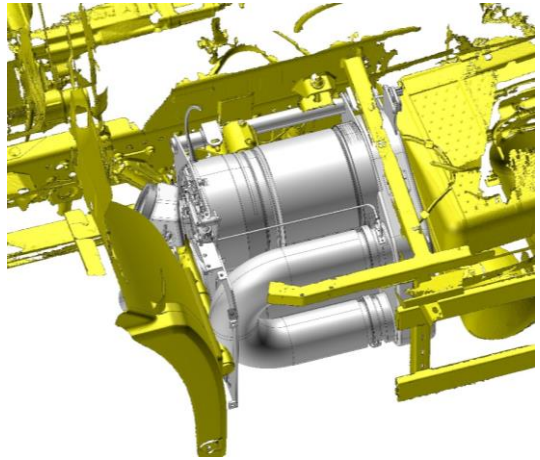


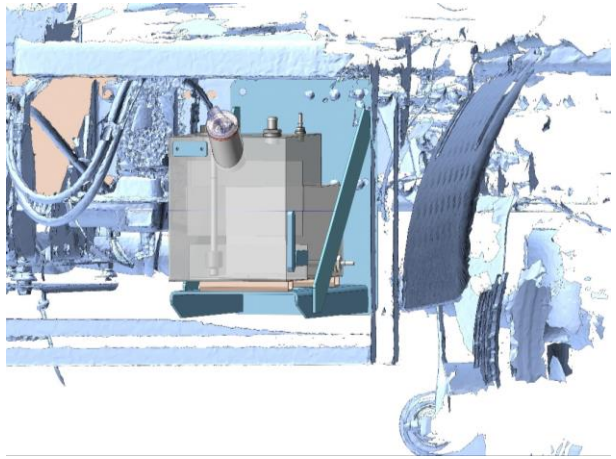
Muffler Position

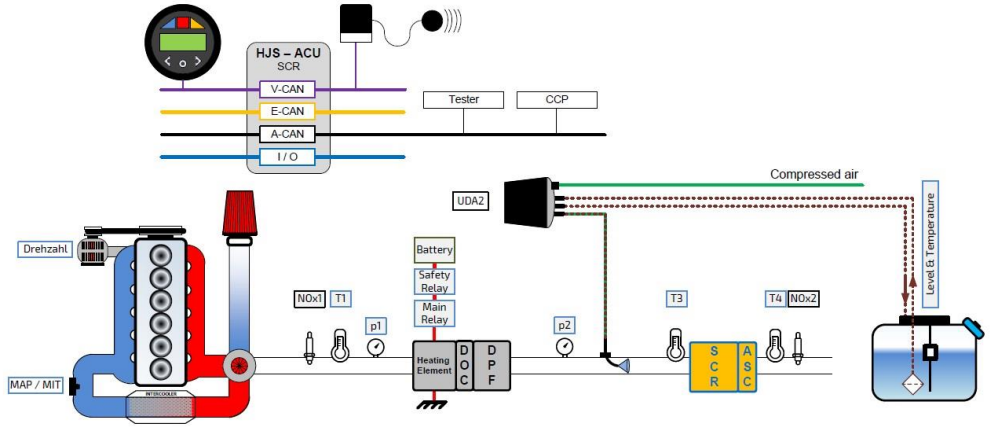
Muffler

Implementation & Effectiveness for Municipal Vehicles of Actros Euro III

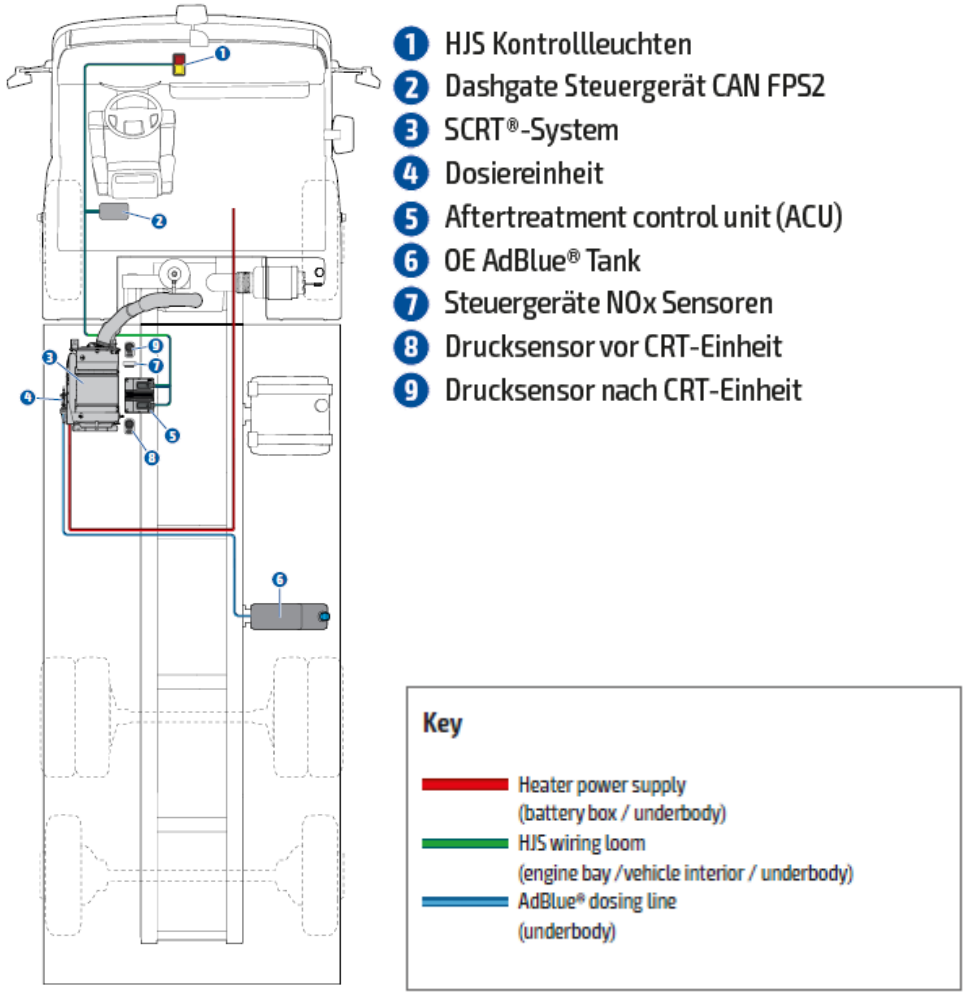








Implementation & Effectiveness for Municipal Vehicles of Actros Euro III



- Reduction of NOx emissions by 93 % for the Actros Euro III on an ISC test cycle.
- General operating permit has been issued.
- Other vehicles were realized
  - MB: Atego, Axor, Econic, Vario
  - MAN: L 2000, TGA
  - Scania: R420, 124G
  - Volvo: FH/420

Summary

- The results of the different development projects demonstrate that NOx Reduction > 75% can be realized in compliance with the requirements
- Even vehicles of emission class III could be successfully retrofitted using the HJS thermal management system
- The implementation concept designed to retrofit a wide variety of vehicles has proven its value.
- Kit systems for different vehicle classes allow the installation in various vehicles
- Parameter setting should not be underestimated

HJS will publish the results of the retrofit development projects which were funded by government in a detailed „White Paper“ by 1st of April 2023 on the following webpage

Link: https://www.hjs.com/luftnachoben

Thank you very much for your attention!

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Bundesministerium für Digitales und Verkehr

Funded by

Vehicle fleet 2021 and 2031

Segment	Emission Class	2021	2031
Passenger Car	Euro 5	4.300.000	37.500.00
	Euro 6d/t	1.800.000	
	Rest	41.800.000	
Urbane Logistic (bis 12 t)	Euro V	1.000.000	500.000
	Euro VI	1.187.867	500.000
Public transport buses & municipal	Euro V	61.000	15.250
	Euro VI	68.000	98.750
Long-distance logistics (> 12t) and buses	Euro V	108.000	25.000
	Euro VI	334.000	775.000
Construction machinery & stationary engines	Stufe III-IV	250.000	62.500
	Stufe V	50.000	237.500
Agricultural machinery	Gesamt	1.500.000	1.500.000
Railroad	Gesamt	~ 5.000	~ 5.000
Inland vessels	Gesamt	~ 5.000	~ 5.000

Source: HJS Investigation (Germany)