

Working Paper for discussion within the VERT-SCR-Group

VERTdeNOx-CERTIFICATION

| | Comments |
|---|----------|
| <p>Background and Trigger In the past years VERT has performed extensive research on SCR and SDPF-Systems on engine test benches and on HDV vehicles as well as supervised a pilot test fleet in Switzerland (with HTL Rapperswil). Most of this work has been published (Appendix A). VERT has also established a VERTdePN certification method and listed one certified SCR-system in 2012 with > 75% NOx-conversion. However, no large scale applications followed since public/legal pressure did not materialize. <u>Now time seems to change:</u> following the Diesel Scandal und due to stricter EU-enforcement of NO2 limits many cities are planning to use the chances of SCR-retrofit for public fleets. However, no list of independently tested BAT- quality systems is available, from which the cities can select appropriate systems according to their performance and quality criteria. VERT should use the opportunity to fill this gap and help to build up confidence in this technology.</p> <p>Target Elaborate a VERTdeNOx certification protocol until end of March 2018 and certify 5-6 retrofit-systems within the 6 following month such that 6 systems can be published in the VERT-List with the end of 2018 update. This VERTdeNOx certification protocol should reflect the VERT BAT-principles and be structured such that the cities will feel confident to select from this list mature technology with highest possible performance to clean the air from toxic contaminants at prices which are low compared to the health cost avoided. The elements of in-use compliance and independent supervision/auditing should be included as confidence building elements for this new market and a roll-out of this new certified technology should happen latest during VERT-Forum 2019.</p> | |

Test Object

Test object is a vehicle, which according to the declaration of the manufacturer is representative for the vehicle family the manufacturer intends to apply. This might be HDV or LDV and within these families it might be limited to city bus application or coaches or waste transporters – this remains up to the manufacturer commitment. The vehicle can be of any EU emission class but must be equipped with a VERT certified DPF and a complete SCR system in a technically final and ready-to-sell form including an on board control unit (OBC) with telemetry features.

It must be perfectly maintained regarding safety and emission relevant elements, degreased and operated with the system for not more than 10'000 km but not less than 1000 km and the manufacturer must provide his maintenance data (Appendix E) on emissions relevant elements at the time the vehicle is presented to the testing laboratory. For the emission testing the vehicle must be equipped with access elements for emission measurement (gases and particles) upstream and downstream of the after-treatment emission control elements (AEC) which are designed such that measurement during real world operation (RDE) of the vehicle is possible (Appendix B). Electronic access to the system sensor signals and the OBC must be provided for the testing direct at the vehicle and via the telemetric path on internet.

Manufacturer Data to be Disclosed

The manufacturer must disclose to the VERT-certification officer

- physical structure of the system – drawings, catalyst materials – see Appendix C.
- DeNOx-process strategy
- control and alert strategy
- operation and maintenance procedures
- target performance
- target life
- DPF-certification data
- system experience: number of systems retrofitted in the selected vehicle family
- hours (km) tested so far

Testing Protocol

The tests consists of 4 phases:

A. VERTdeNOx1: Steady state test on vehicle dynamometer

- Test on chassis dynamometer
- engine load ramp at two engine speeds in order to determine the exhaust temperature at which AdBlue injection starts and at which 80% conversion is reached
- full load and low idle should also be tested
- each operation point during 15 mins or until thermal stability is reached
- Measured operation data: velocity, RPM, power, temperatures of exhaust gas, engine water and lube oil, exhaust mass flow
- Measurement of emissions: CO, HC, CO₂, O₂, NO, NO₂, PN
- Measurement of NH₃ at tailpipe only
- Download system sensors data for NO, NO₂ at all operation points

No repetitions

B. VERTdeNOx2: Real drive emission (RDE)

- RDE-conform trajectory – see Appendix F
- 3 repetitions on different days
- Log operation data: velocity, RPM, ambient climate data
- PEMS-conform measurement of emissions: : CO, HC, CO₂, O₂, NO, NO₂, PN, NH₃
- Download system sensors data for NO, NO₂ during whole test, compare with PEMS

C. VERTdeNOx3: 10'000 km with telemetric data transfer to VERT laboratory

- System checked and sealed by the VERT certification inspector
- Operation of the vehicle under supervision of the manufacturer who must supply a logbook on all relevant observations to the VERT-laboratory
- Continuous access to OBC via internet telemetry
- AdBlue consumption to be measured
- Fuel consumption to be measured

The System must be checked by the VERT-inspector before release for VERTdeNOx4

D. VERTdeNOx4: Real Drive Emission Control

Download all System OBS data stored during VERTdeNOx3

Repetition of VERTdeNOx2 but only one test

VERT Secondary emission test is waived, if this test has already been successfully performed for the DPF-system used. This decision is based on extensive VSET data with SCR system research of all common catalytic configurations.

Metrology

Measurement "upstream/downstream"

And with/without AdBlue injection only during VERTdeNOx1

Metrology is in accordance with

- SN 277206
 - PMP/PEMS-Protocol
 - RDE-Protocol
 - Noise acc. to VTS, SR 741.41 and EU-70/157/EWG
- Noise measurement before installation by the manufacturer -- to be discussed

Swiss Accreditation STS 0561

Testing Conditions

- Testing at ambient conditions >10 °C
- Engine warmed up
- Engine maintained
- Air filter replaced
- Fuel: EN 590 – Swiss market quality
- Lubrication oil: changed, manufacturer specified quality
- DPF regenerated at start of the test
- AdBlue tank full filled by the VERT inspector

Testing Time

Dynamometer test: one day

Road Test on 3 different days

Reporting

- All data measured and downloaded
- Interpretation of all important findings
- Conclusions with respect to conformity criteria, operation and findings
- Document system design and strategy
- Compare OBC sensors data and test data
- Physical observation, pictures

See report structure Appendix D

VERT-Conformity Criteria

Certification is limited to the defined vehicle family and must fulfill the following criteria:

- PN filtration efficiency > 98% for solid particles 10-500 nm in all operation points
- Backpressure < 200 mbar
- NOx-conversion during RDE: 3 classes > 85% / 75-85 % / 65-75 %; < 65% rejected
- Light off (50% NOx-conversion) at 230°C after SCR
- NH3 < 20 ppm at all operation points
- CO, HC according to the EU emission class of the vehicle
- Fuel economy deterioration < 3 %
- Noise emission: no deterioration after replacement of muffler by AEC
- Aging during 10'000 km < 5%

VERT Certification is valid for 5 years if yearly failure rate remains < 3%

Accredited Testing Laboratories

Besides National Accreditation VERT approval required (see VERT-Filter list)

Overall Testing Cost

- < 50'000 CHF – to be confirmed by a detailed cost calculation
- Transfer of finances by the VERT finance department
- Payment in advance

Confidentiality of Data and Reports

All data and reports are confidential between the manufacturer, VERT and the testing laboratory. A respective NDA shall be signed

Harmonization with Political Bodies

VERT shall try to get approval for this procedure from political bodies
e.g. by Deutscher Städtetag

Documents to be Elaborated

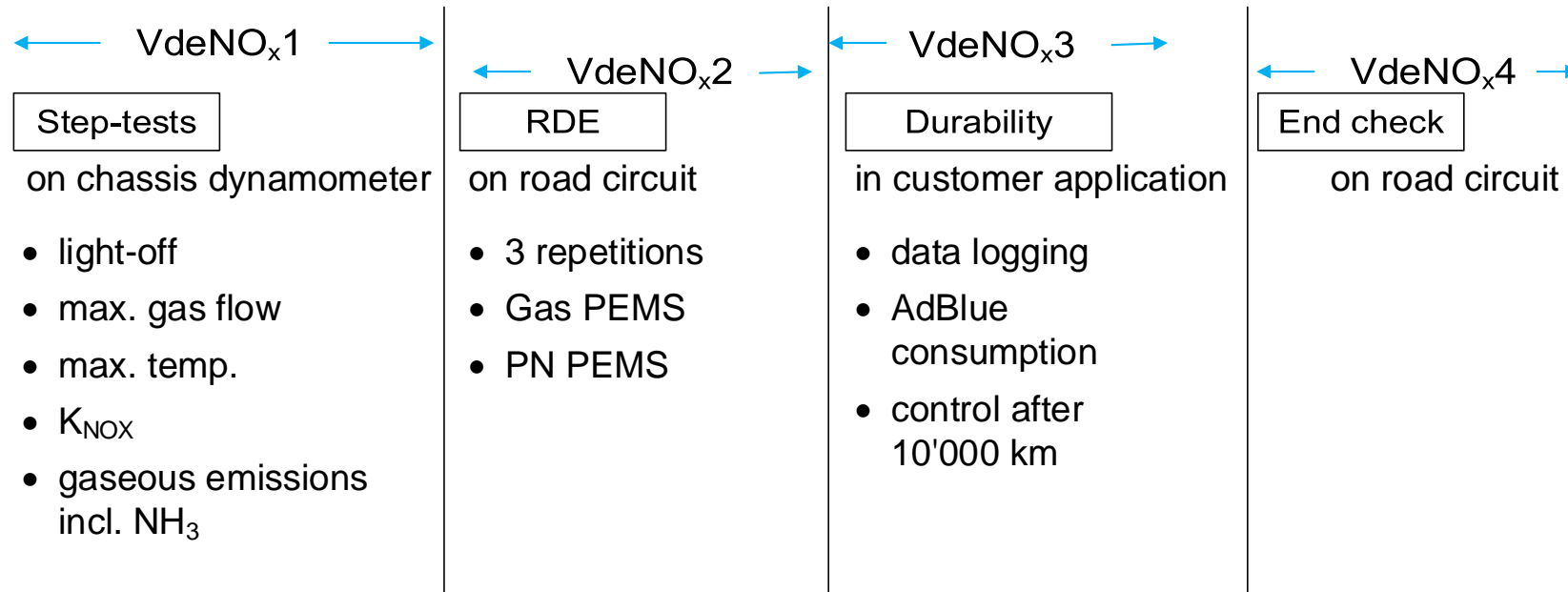
Appendix A : Literature
Appendix B : Real Driving Emission Procedure
Appendix C: Manufacturer Data similar to SN 277206 Tab.D
Appendix D: Report Structure similar to SN 277206
Appendix E: Maintenance report
Appendix F: RDE-test

Open Questions / Remarks

- How to handle already installed EGR → close ?
- How to handle LNT-systems → exclude ?
- How to handle test limitations by vehicle OBD → reject certification
- Freezing/Defreezing can not be controlled during this VERT certification
- Which further properties must be checked ?

VERTdeNOx Testing Procedures for HD/LD SCR-retrofit

Vehicle equipped with a VERT-conform DPF-system



Abbreviations

HD ... heavy duty

LD ... light duty

K_{NOX} ... NO_x conversion efficiency

PN ... particle number

RDE ... real driving emissions

PEMS ... portable emission measuring system