23.ETH-NPC, Zürich June 2019

NPTI

New Periodic Emission Inspection of SCR + DPF equipped LD and HD-vehicles

A.Mayer / VERT

Th.Lutz, J.Czerwinski, H.Burtscher, G.Kadijk, V.Hensel

Modern «electronic» Engines provide much improved efficiency (CO_2) and power, but Emissions PN and NOx are still high

Petrol engines are high emitters and were only cleaned by the 3WC – John J.Mooney 1970 – still they emit high PN and the TWC let PN pass – GPF or 4WC is needed

Diesel engines need DPF to «eliminate» PM/PN-emissions from combustion, lubrication oil packages and wear.

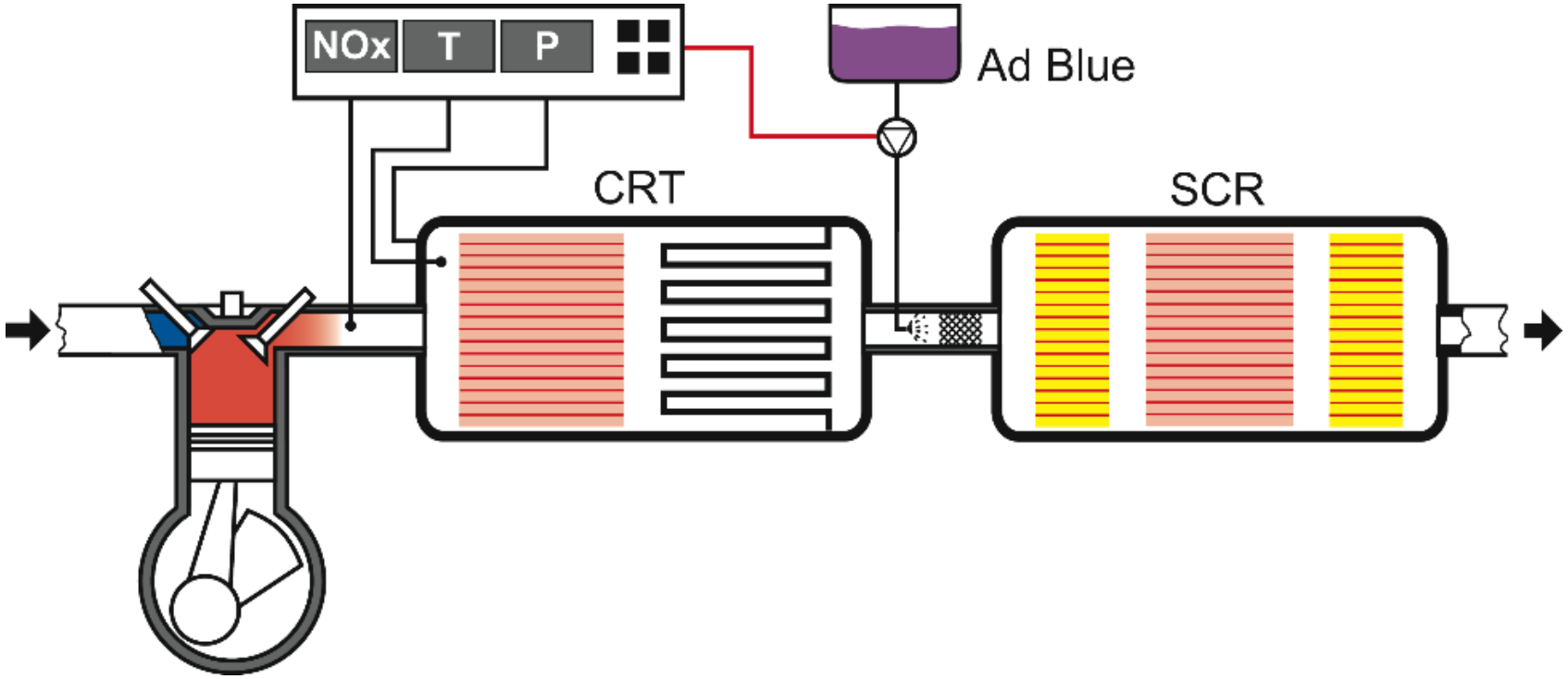
Diesel Engines also need oxidation catalysis DOC to eliminate PAH, Nitro PAH and other highly toxic substances

Diesel engines need DeNOx to reduce NO2 and NO → SCR+

Modern Engines have ideally **de-coupled** functions:

- The Engine operates at best Performance for CO2
- Aftertreatment EAC detoxifies perfectly the Exhaust Gas

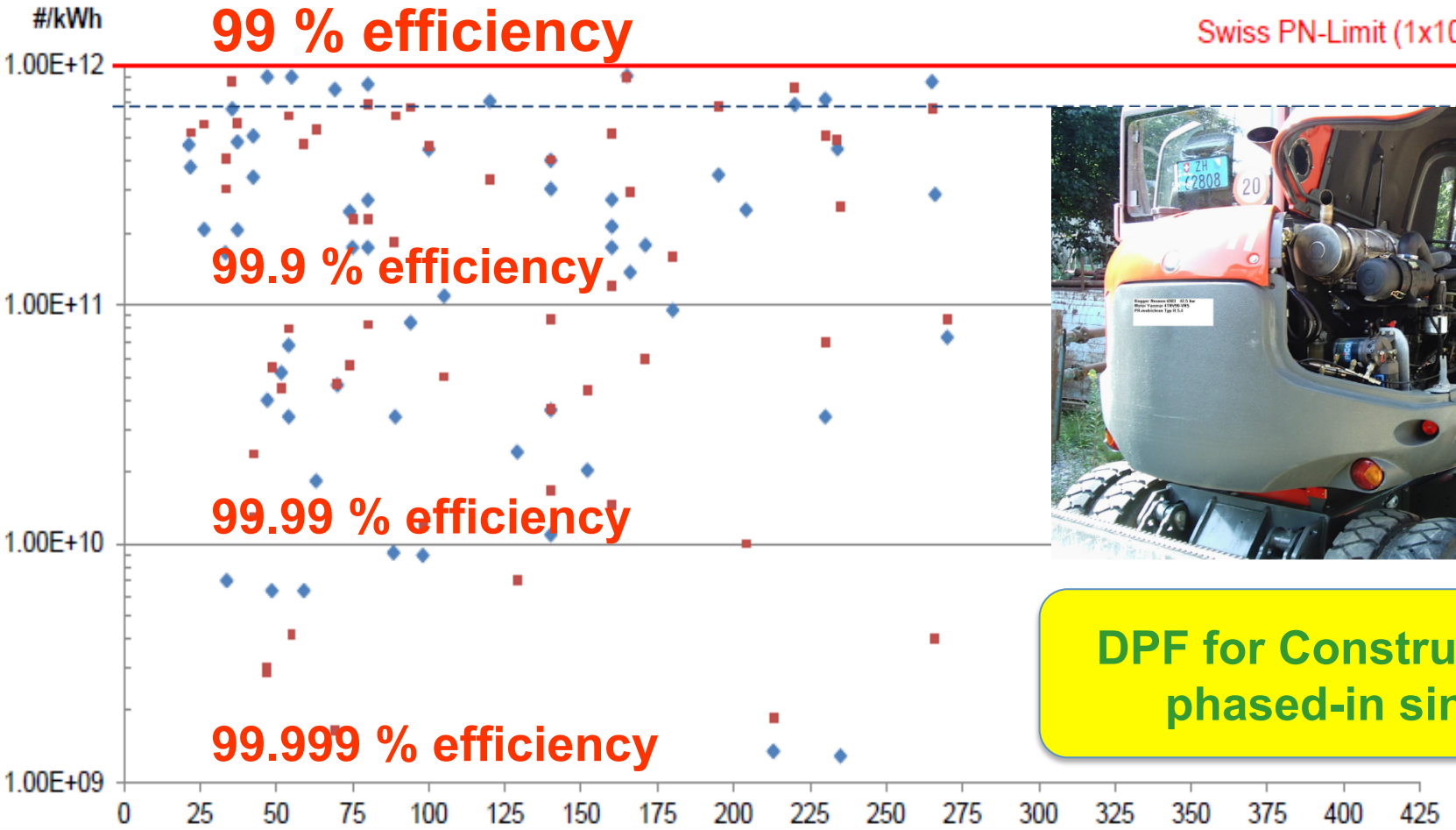
Emission Control by Aftertreatment EAS
now State of the Art



- very efficient - but no „plug and play“
- function depends on operation profile
- risk of wear, aging and poisoning, pollution
- **risk of manipulation** by manufacturer and operator

→ Control is required

PN-Test results



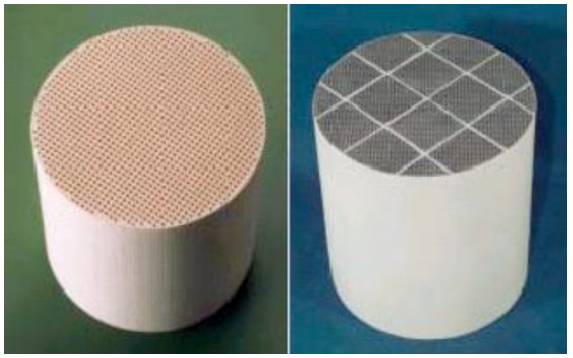
DPF for Construction in CH phased-in since 1998

Type approval of imported construction machines in stationary and transient cycle
In function of engine power [kW]

DPF Technology permits limit strengthening by one order of magnitude

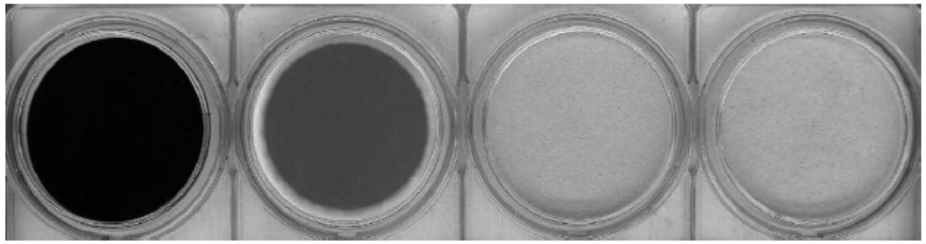
Number of Vehicles with/without DPF

for different immatriculation years in CH



Anzahl gemessene Fahrzeuge mit/ohne DPF nach Jahrgang

Peugeot 605 FAP rollout May 2000

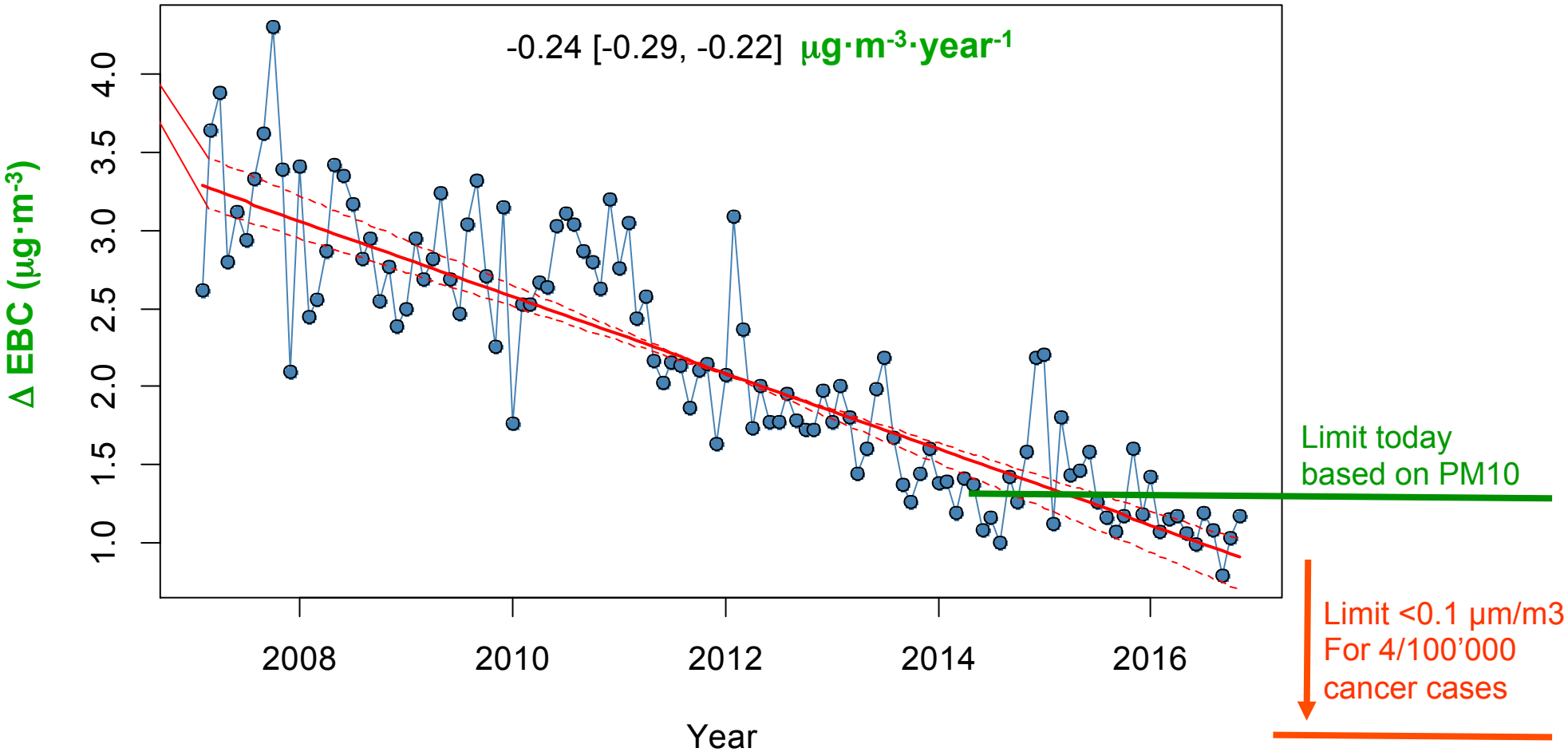


605-DK5	605-HDi	605-HDi+DPF	Air Dilution
Part 0,1 g/km	**Part 0,035 g/km**	**Part 0,004 g/km**	**Part 0,004 g/km**

today > 125 million vehicles with DPF In Europe

and the Result:
Cleaning the Air by DPF in Switzerland

Monitoring BC at the motorway crossing Härkingen



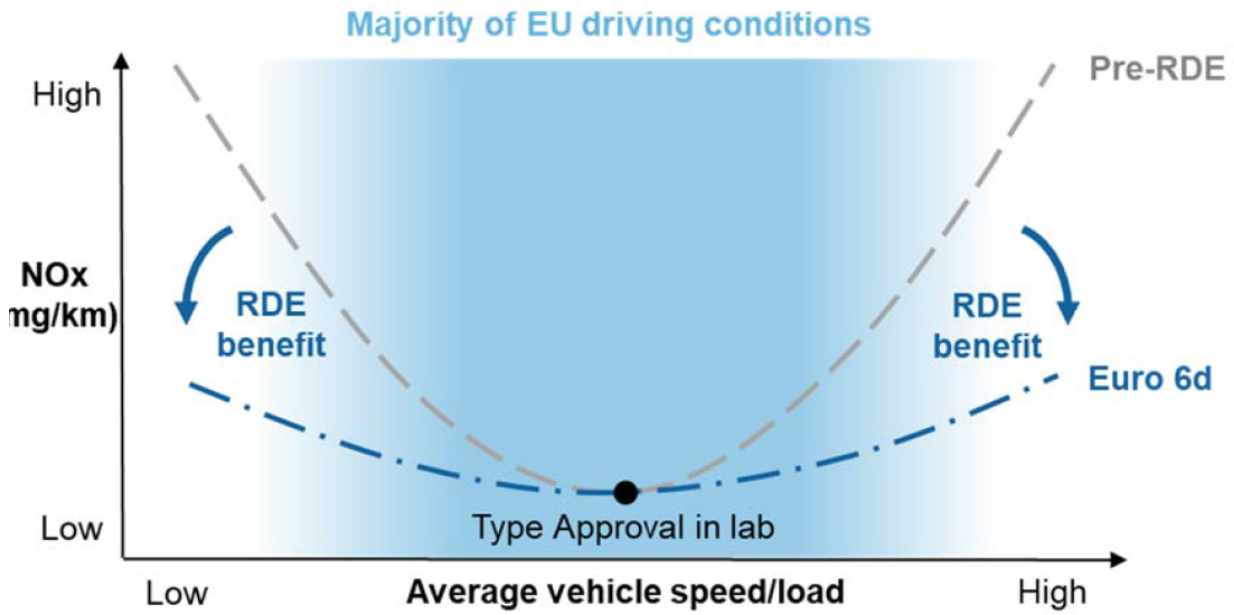
NOx Conversion as required by the modern Chinese Standards

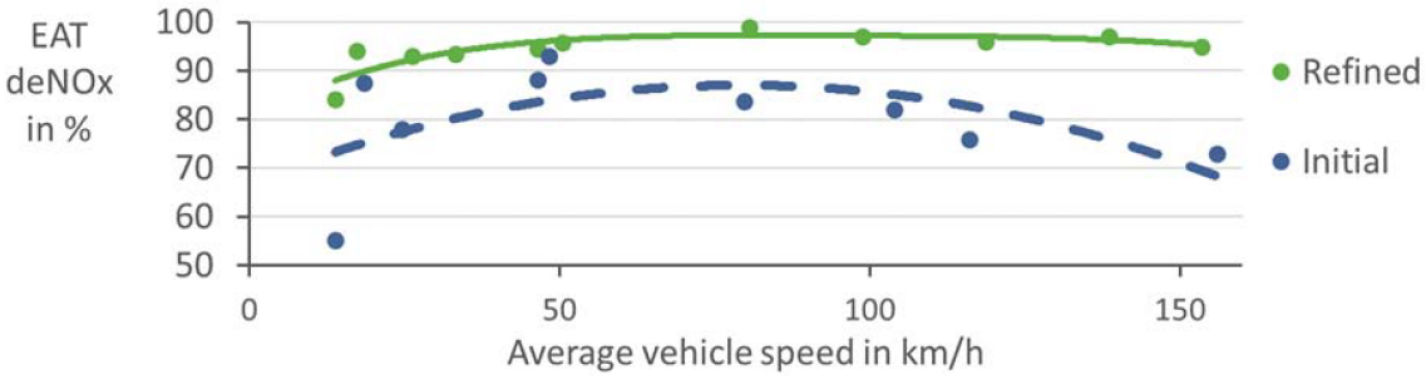
T/CAEPI 12. 2—2017

Table1 Fresh state conversion efficiency requirements

Temperature（℃） / Conversion efficiency（%）		200	250	450	500
Vanadium based SCR	Level I	40	60	90	80
	Level II	50	80	90	80
Copper-based molecular sieve SCR		80	90	90	85
Iron-based molecular sieve SCR		40	60	95	95

NOx-Conversion Strategy Improvement after Dieselgate due to RDE-Requirement





with EAS we have reached

Orders of Magnitude
of Emission Reduction S
to improve public health

but at the same time we are facing
a high risk for Emission Stability
due to serious flaws in Legislation
Implementation and Enforcement

Biggest Mistake of EU-Policy

Independent Control „delegated“ to OBD

invited car makers to fraudulent hard-and software

Quality Control (USA)

- **Type Approval**
- **COP** Conformity of Production
- **IUC** In Use Compliance
- **PTI** Periodic Techn. Inspection

EU Quality Control 2014/45

- **Type Approval**
- **COP**
- **IUC not implemented**
- **PTI abandoned** (CH:2013)

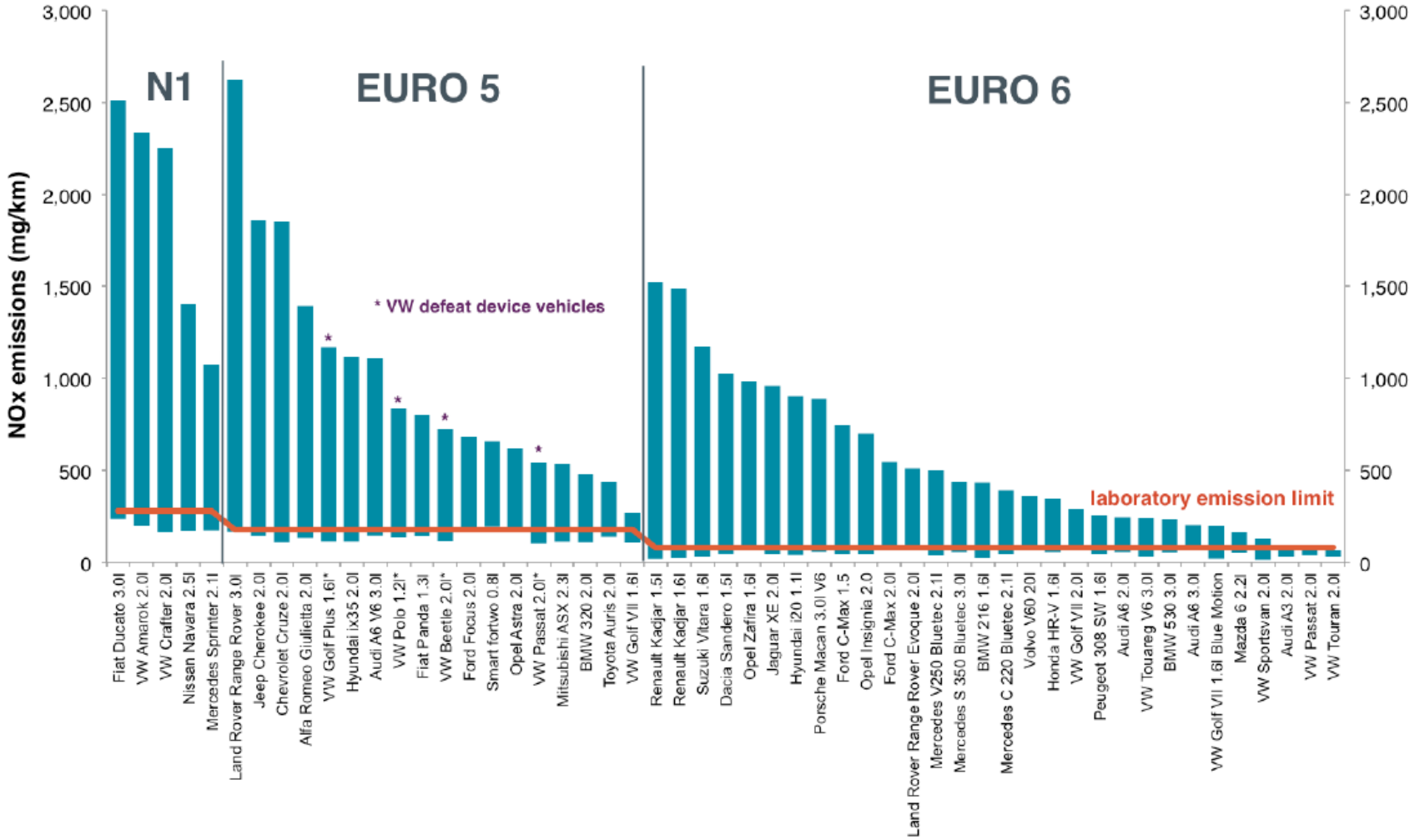
Control for Public Health must be independent

Montesquieu: De l'esprit des lois 1748 → la séparation des pouvoirs

NOx Exceedences

due to Emission Fraud by European Manufacturers

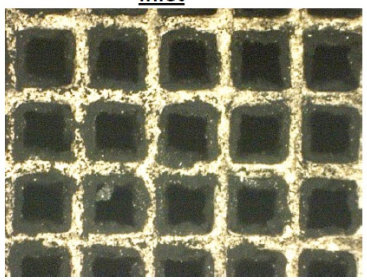
(defeat devices to limit emission technology to test cycle operation)

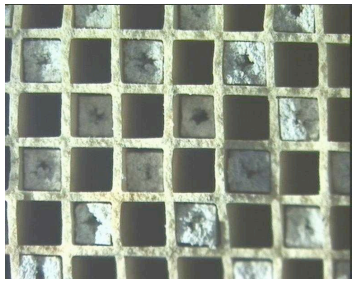


Source ICCT Sept 2016

DPF Damages we are finding – why?

Inlet





because they want to avoid cost for proper repair or cleaning

VERT at Expert Hearing Bundestag 5 PUA Berlin 22. Sept. 2016 on Dieselgate

→ **This must be reversed and Emission PTI must become EU-Regulation**

and here is my recommendation to the German government 9/2016

Deutscher Bundestag
5. Untersuchungsausschuss
der 18. Wahlperiode

Ausschussdrucksache
18(31)38

Beitrag zur Sachverständigenanhörung des 5.PUA (18/8273, 8932)

zur Frage erhöhter Schadstoffemissionen und Verbräuche von Fahrzeugmotoren durch Manipulation der elektronischen Motorsteuerung durch Hersteller und Betreiber, ungeeigneter Emissionsmessung, unzureichender Gesetzgebung und mangelhaften Vollzugs am 22.9.2016 in Berlin, Paul-Löbe-Haus, Sitzungssaal E 700

Emissionsstabilität von Fahrzeugmotoren

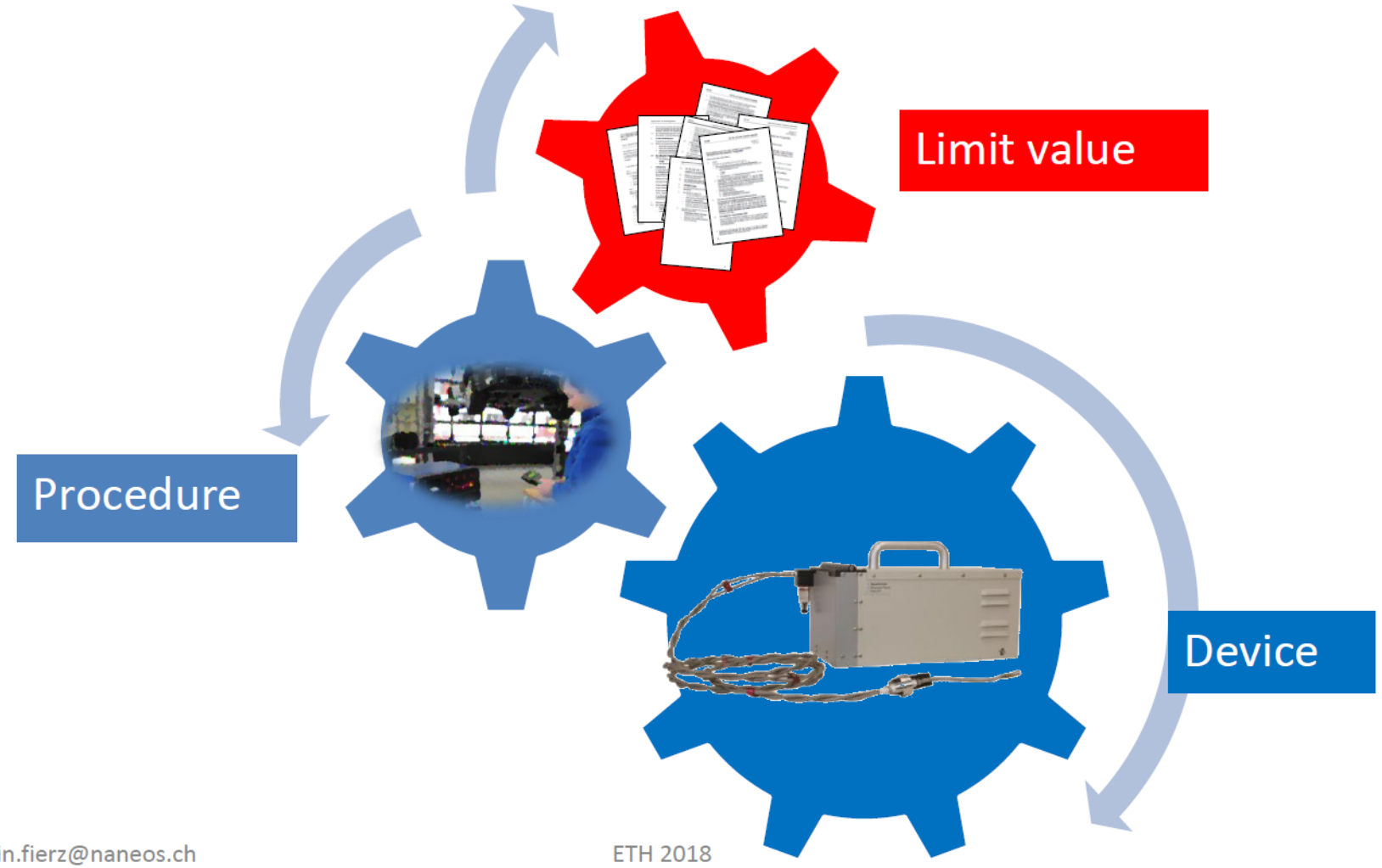
Der einzig sichere Weg zur Emissionsstabilität bestverfügbarer Abgastechnologie ist die flächendeckende unabhängige periodische Kontrolle nach einem neuen Testprotokoll

→ **Gemany Road Authority reacted immediately be re-activation of AU January 2017**

New PTI is a package with 3 elements

TNO and VERT started a private Initiative NPTI

Nov. 2016



Concept

for a very efficient and cost effective 100% in-use periodic emission control for DPF equipped vehicles

- **PN-Test at low idle**
- **PN with DPF; $< 10^3$**
- **PN with failure $> 10^6$**
- **Pass/Fail: 100'000 1/cc**

This Test is more than Pass/Fail

It supplies **quantiative diagnostic** information for the **functionality** of each emission control component and the engine as well and permits **preventive repair and maintenance.**

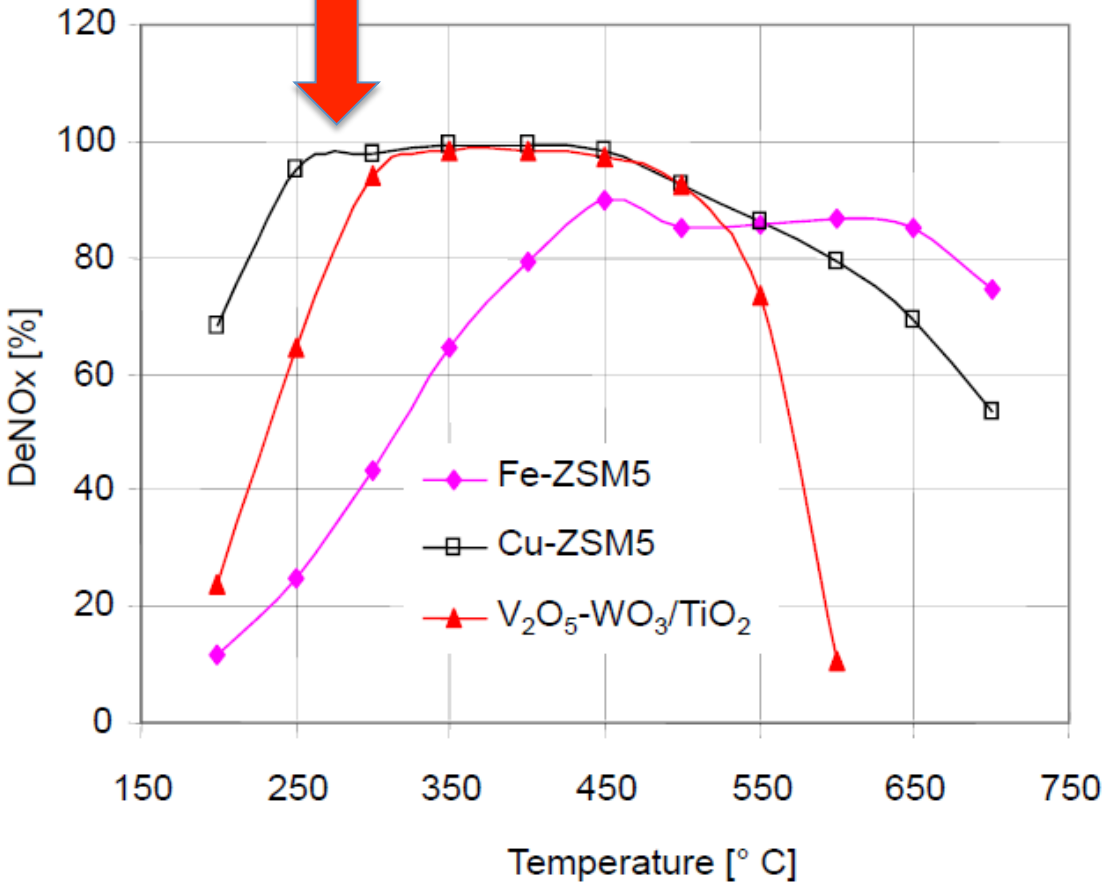
NPTI Mission for DPF is accomplished

- Netherlands will introduce NPTI in 2019, Belgium follows with the already Swiss-METAS certified instrument TSI NPET
- Germany has re-started AU in Jan. 2017, includes PN 2021
- Switzerland will follow as soon as instruments are available
- Spain, UK and France are in a similar process
- Six Instrument manufacturers will provide test samples 2019
- JRC performs instrument validation and reports to EU
- Instrument certification by NMI or METAS from end of 2019,

Repair Cost? → Liability of the manufacturers for emission stability within a period of 160'000 km (2005/78/EG)

But SCR deNOx is not active at idle or low load

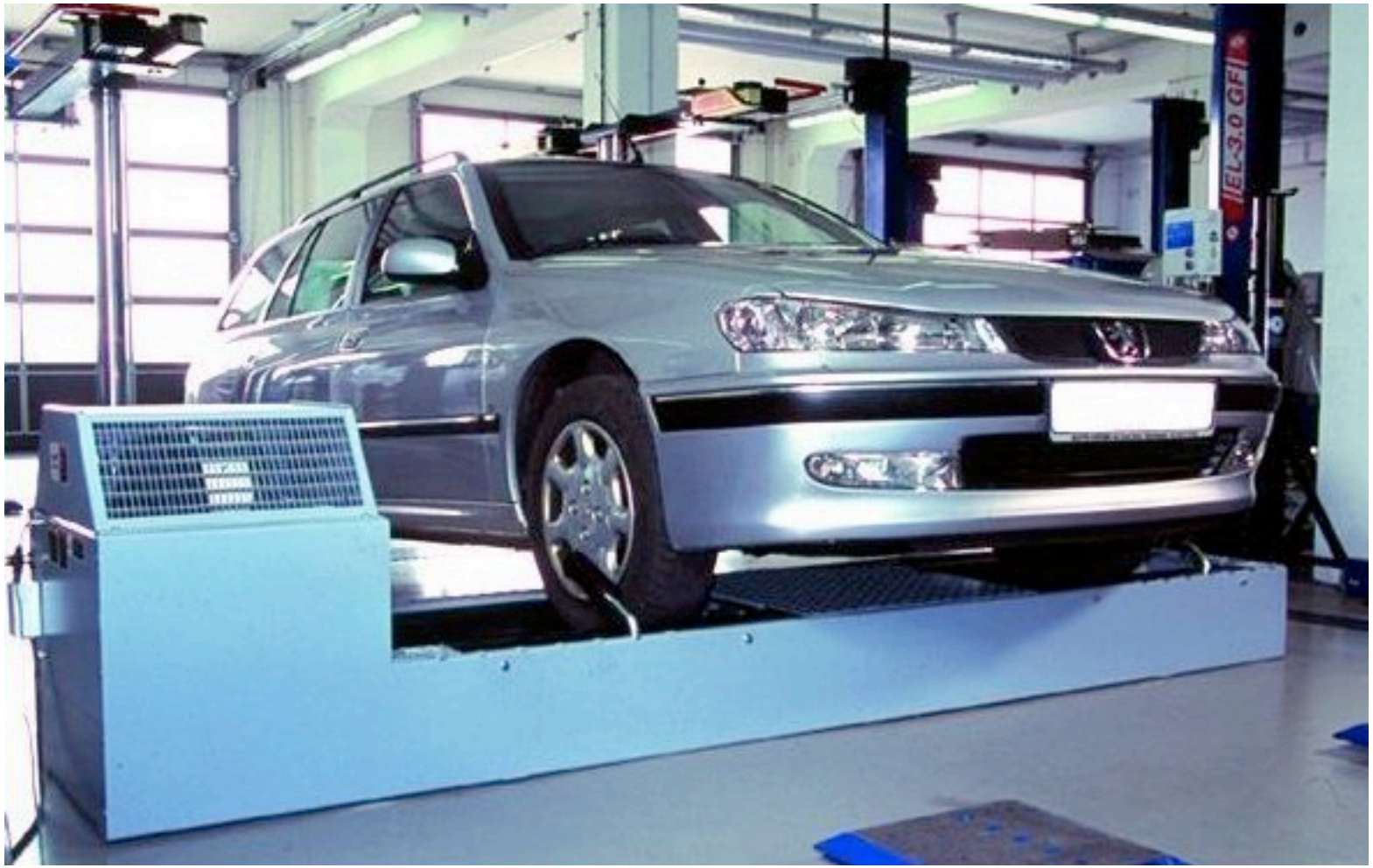
Adblue, the active agent cannot be injected below 220 °C



- Cu-ZSM-5 very active at T ≤ 300 °C.
- Fe-ZSM-5 very active at T > 550 °C.
- V_2O_5/WO_3-TiO_2 very active at intermediate temperatures.

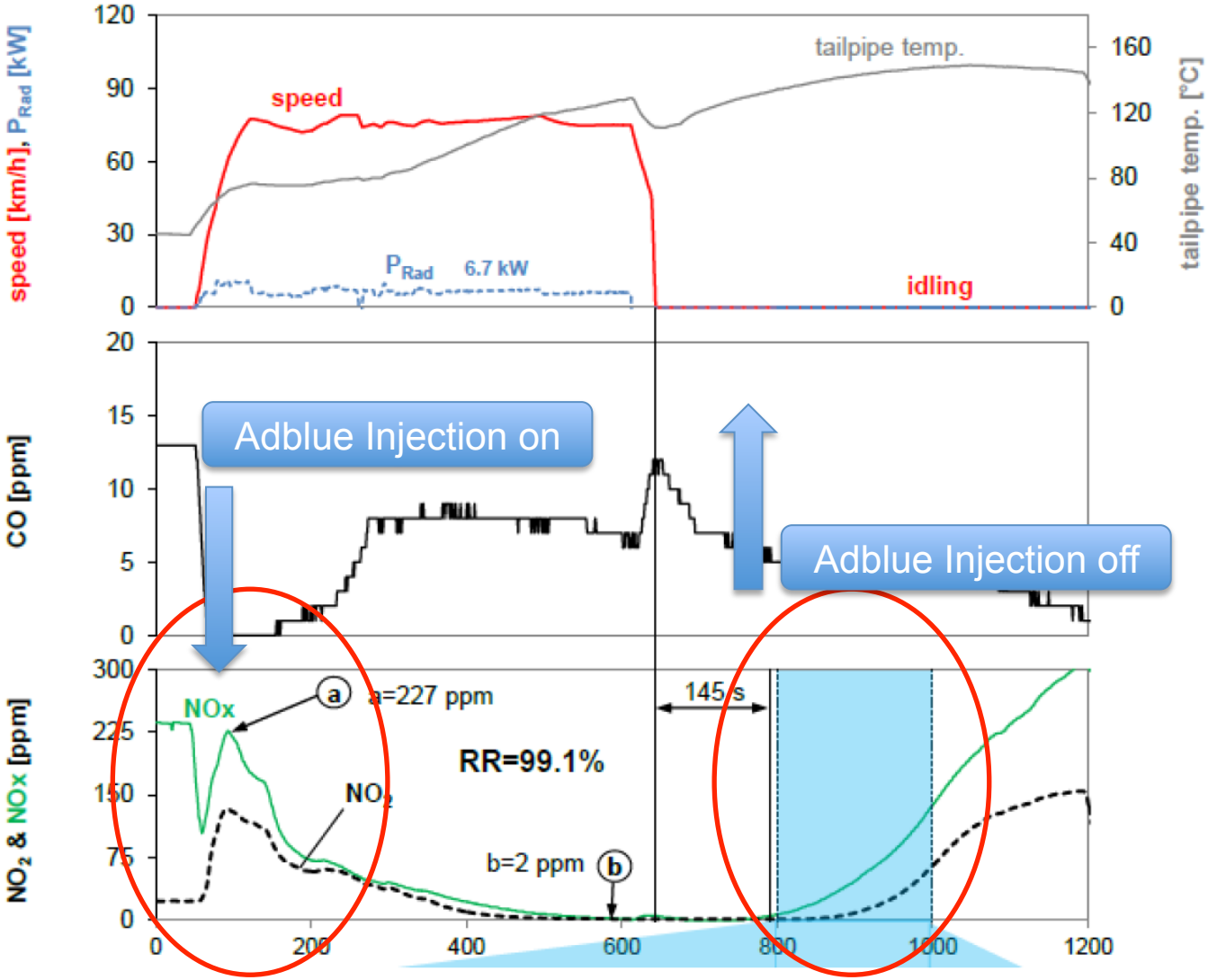
A Loadstep
(temperature 120 → 250°C)
is required to check the SCR function
after Adblue Injection

Load Step on a Floor Chassis Dyno



(Quelle: MAHA)

PTI- Load-Step Test to diagnose DOC and SCR Functions (Source AFHB)



Measurments
- Temp.
- RPM
- Load
- NO
- NO2
- CO
- NH3

This Chassis Dyno Test is possible and supplies all required Information to diagnose the system - see Poster 35

but takes too much time ?

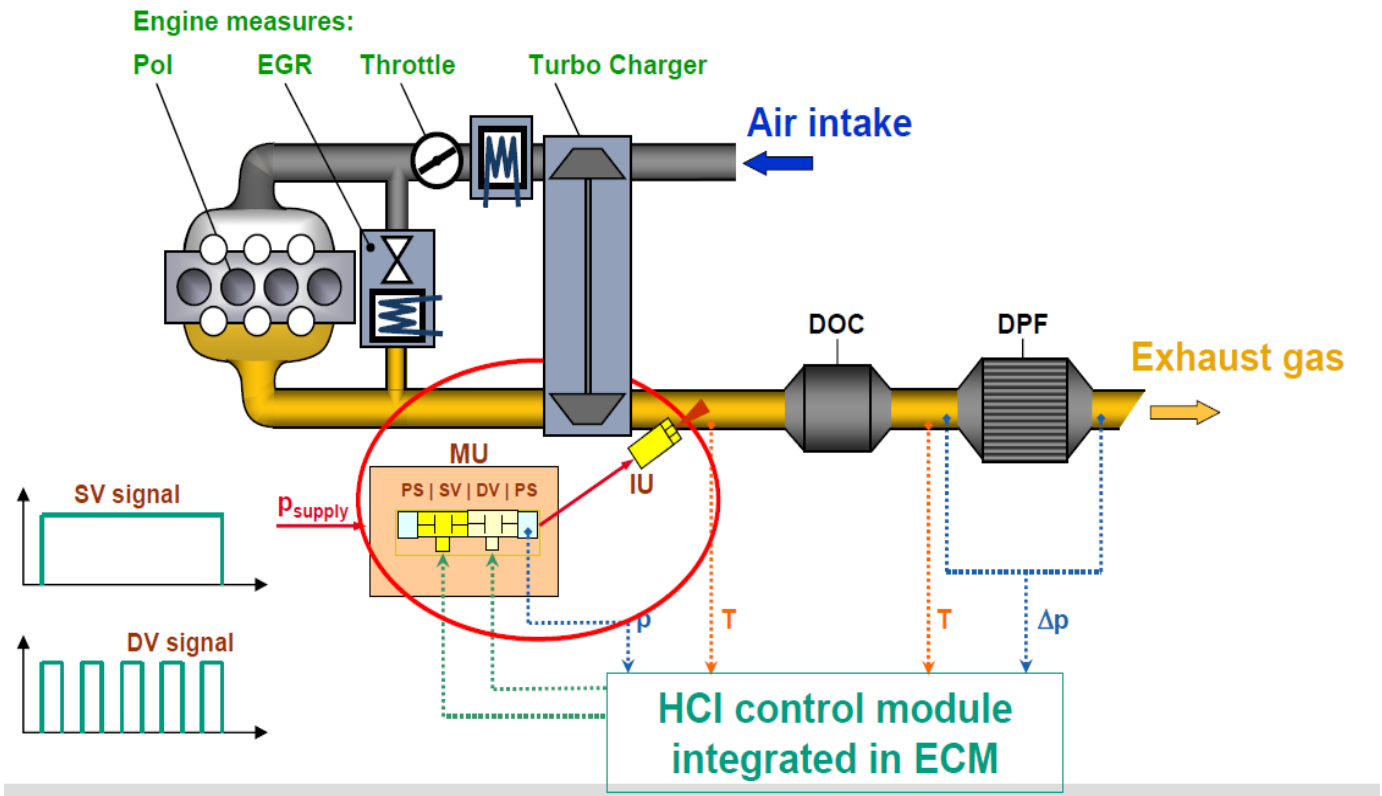
too expensive ?

not applicable for PTI ?

Alternatives available ?

Thermomanagment Tools are available in all modern vehicles

for DPF-Regeneration, SCR-Support, Deposit-Cleaning



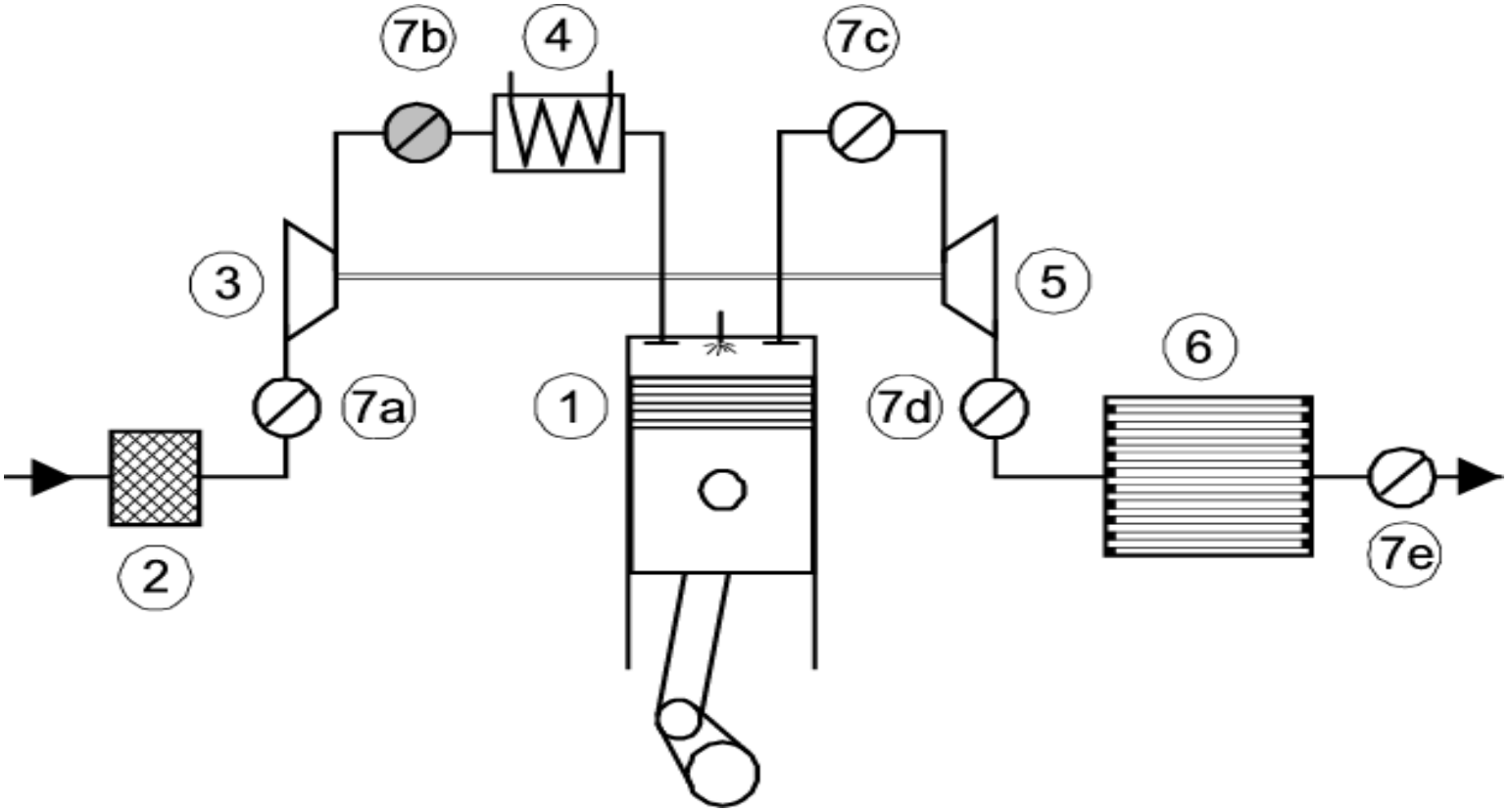
BOSCH

- **Intake Throttle**
- HC-injection
- Catalyt. Combustion
- Retarded injection
- Multiple Injection
- TC-Management
- EGR Managment
- Cooler Managment
- Electric Load

Each of these thermomanagement tools
permits a sudden increase of exhaust
temperature
even at (elevated) idle speed
and OBC knows exactly what to do

the inspector just pushes a button

Let’s look at Throttling – Intake or Exhaust



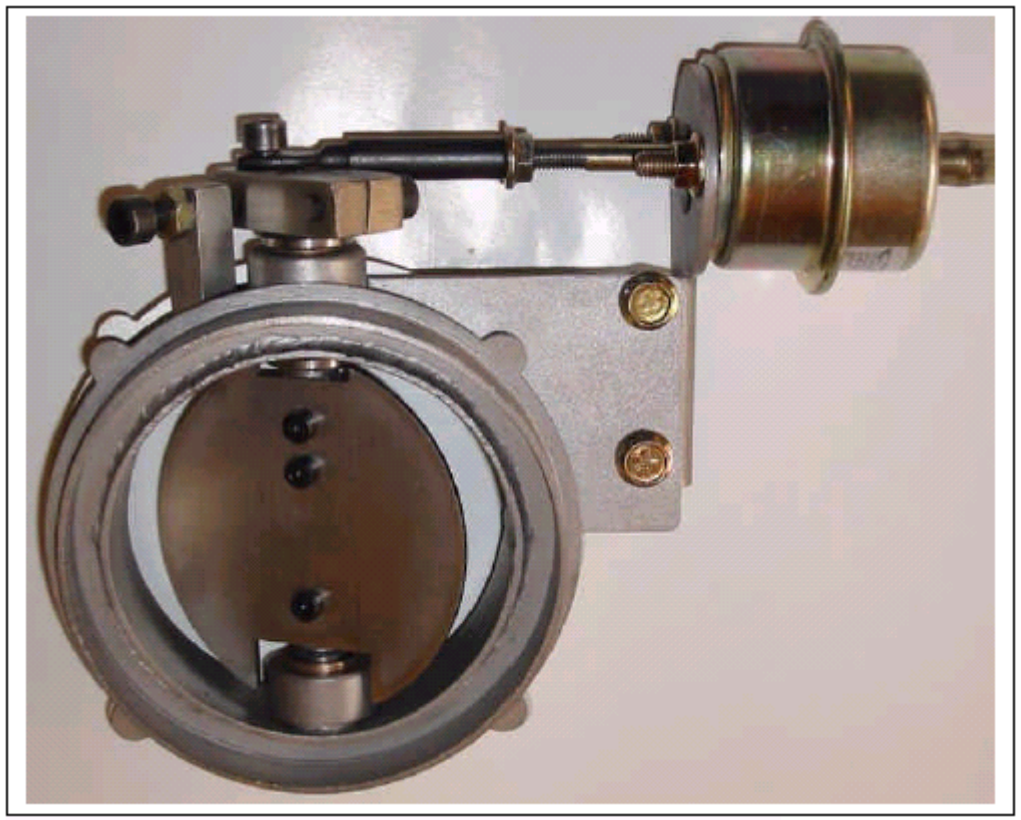
SAE 2003-01-0381
A.Mayer et al

Throttle valve (by PIERBURG) for automobile deployment

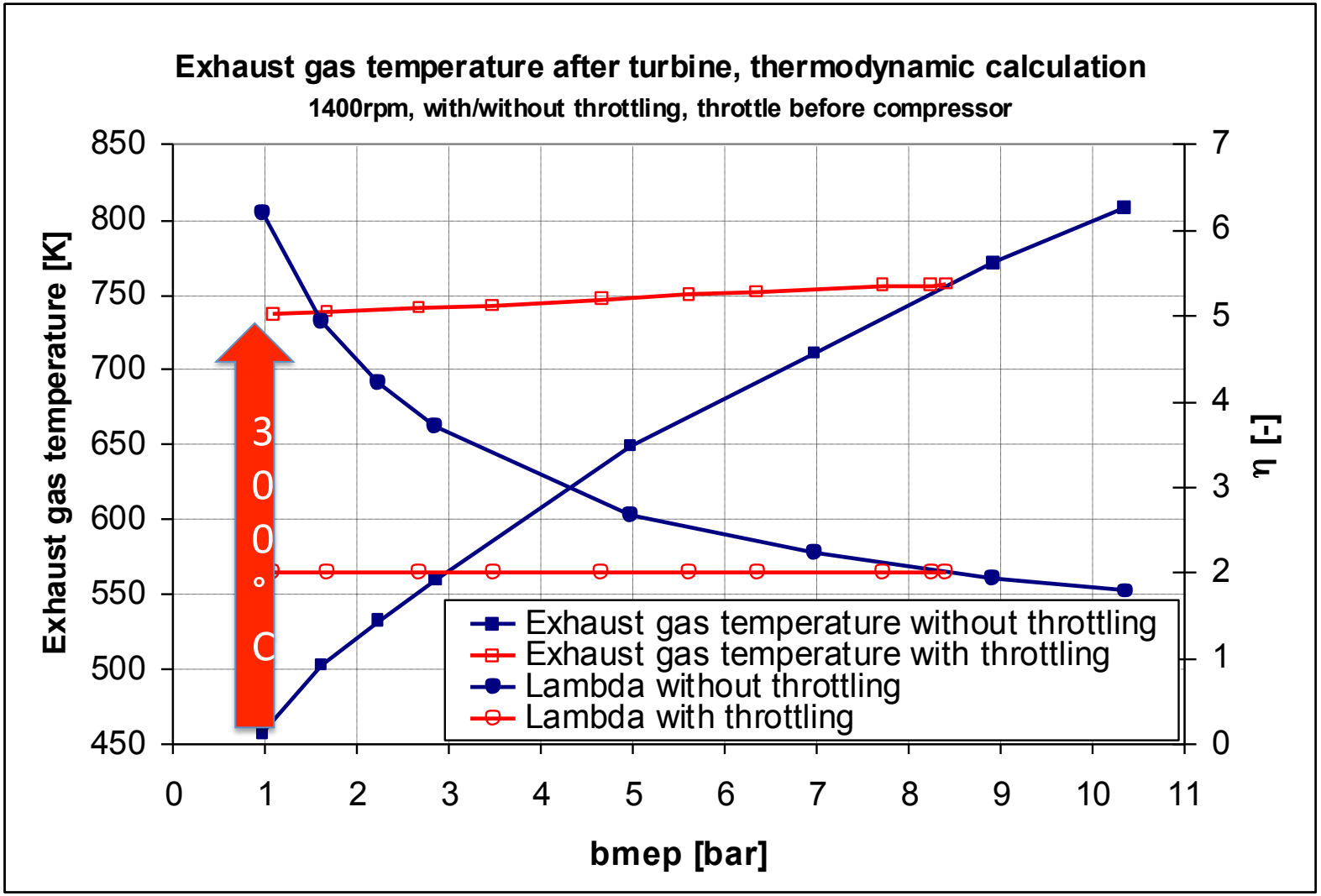
SAE 2003-01-0381

A.Mayer et al

Standard Exhaust brake used by Engelhard to support regeneration in public transport buses in Paris RATP



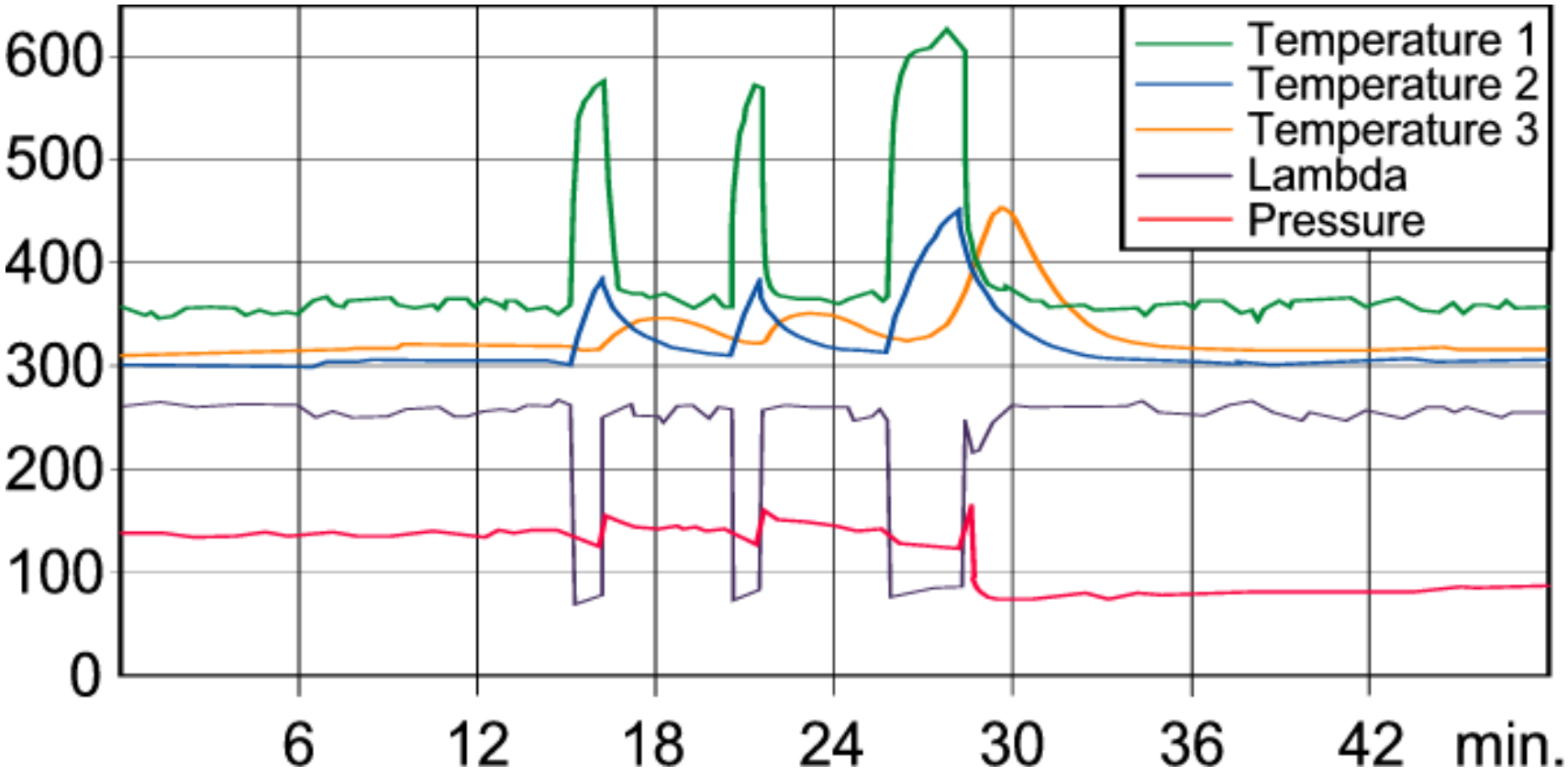
Exhaust gas temperatures with and w/o throttling for constant air excess



SAE 2003-01-0381

A.Mayer et al

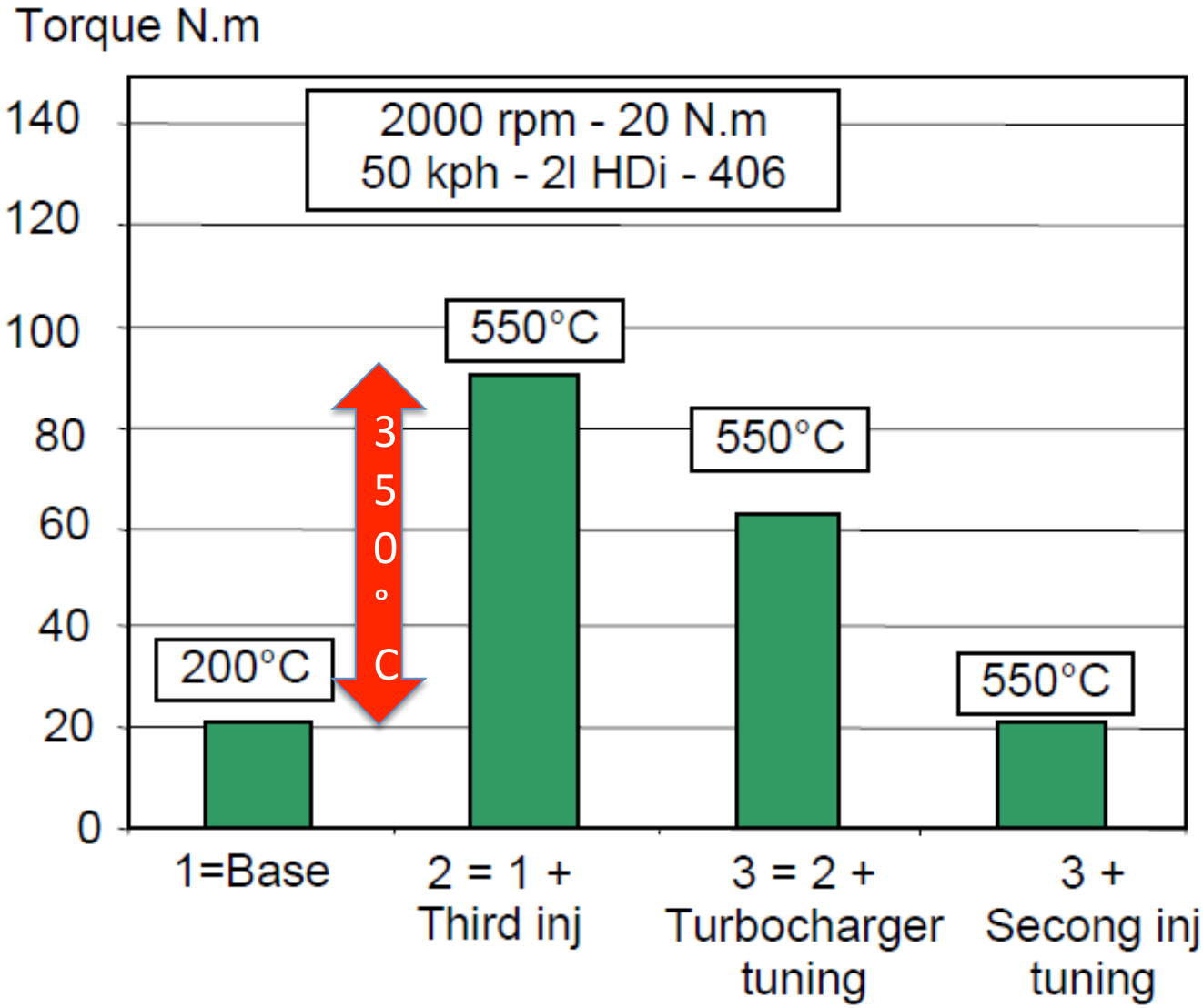
Dynamics of exhaust-gas temperature step by intake throttling for the automatic regeneration process



SAE 2005-01-0662

A.Mayer et al

This is a 20 years old result from Peugeot
using multiple injection and catalytic combustion



SAE 2000-01-0473
Belot et al

Summary of a 3 Years Development

- **For DPF quick and accurate PTI** is possible at low idle; new cost effective PN-instruments are already available and will be used in several European countries starting 2019 in NL, BE see Kadijk session 7 and exhibition
- **For SCR and DOC PTI** are possible by a load step anticipating that a simplyfied chassis dyno test is accepted - see poster 35 but may take too much time
- **A quick SCR test is also possible** by a temperature step 100→300 °C at low or elevated idle speed with standing still vehicle using the readily available temperature managment tools like intake throttling of modern vehicles but requires agreement with manufacturers and legislators