Emission Testing under load for Pollutants e.g. NO_x and PN

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Transport and Air Quality

- Massive deviation – real world exhaust emission compared to limit values, even at modern diesel passenger cars
- Responsible authorities have to react effectively/fast
- About 50% of traffic based monitoring stations show exceedance of NO_2 concentration limit values in Germany, France, Italy, UK,…, leading to severe health damages
- Legal Basis EU Air Quality Directive 2008/50/EC (40 µg/m³ annual mean)
- Despite compliance with PM_{10} AQ-limits problem with ultrafine particles and corresponding health damage not accordingly addressed yet

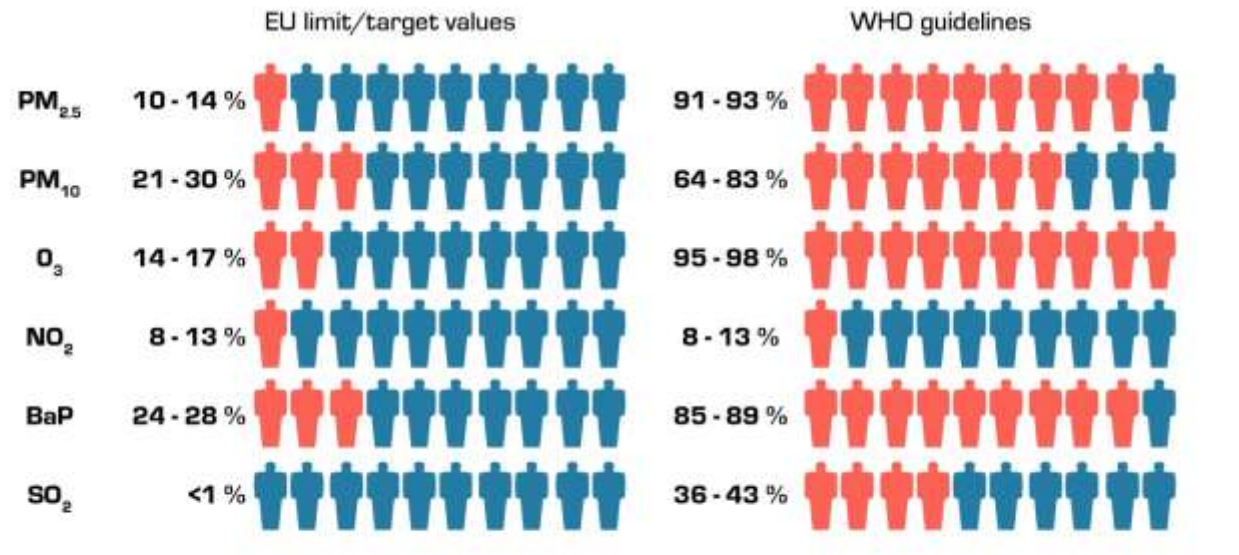
2018 Report: Exposure to harmful levels of air pollution

European Environment Agency

Many Europeans are exposed to harmful levels of air pollution

Up to 30 % of Europeans living in cities are exposed to air pollutant levels exceeding EU air quality standards. And around 95 % of Europeans living in cities are exposed to levels of air pollutants deemed damaging to health by the World Health Organization's more stringent guidelines.

EU urban population exposed to harmful levels of air pollution in 2010 - 2012, according to:



Read more: EEA Report 5/2014: Air quality in Europe - 2014

Source: https://www.eea.europa.eu/publications/air-quality-in-europe-2018

Reducing Vehicle Emissions with Chemistry

REDUCING VEHICLE EMISSIONS WITH CHEMISTRY

Millions of Volkswagen cars have been found to emit up to 40 times more nitrogen oxides in normal operation than they did during emissions testing, miring the company in controversy. This graphic looks at the devices present in a vehicle to help reduce pollution, and how they work.

POLLUTING COMPOUNDS

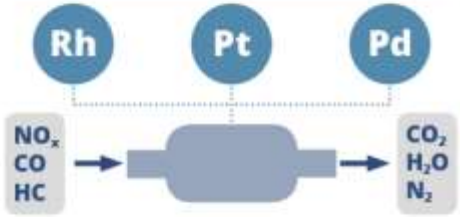
- NO_x — NITROGEN OXIDES (E.G. NITRIC OXIDE, NITROGEN DIOXIDE)
- CO — CARBON MONOXIDE
- HC — UNBURNT HYDROCARBONS (FROM FUEL)

THE 'DEFEAT DEVICE'

The 'defeat device' found in Volkswagen cars is not a physical device, but a piece of software that detects when the car is being tested. When it detected this, it tuned the engine's performance reducing the NO_x emissions. In normal driving conditions they were much higher.

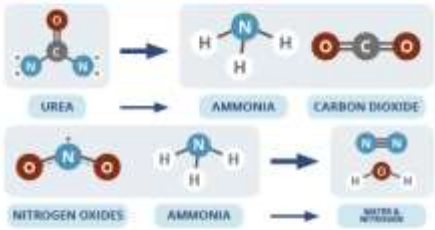
The car detected when it was in test conditions (potentially by monitoring steering wheel movement or traction control deactivation).

CATALYTIC CONVERTERS



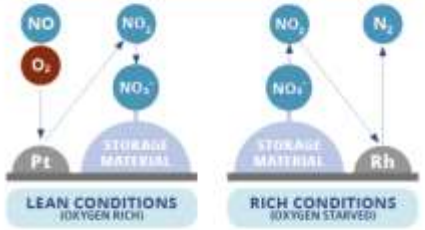
Three-way catalytic converters are present in all petrol-powered cars, and help remove carbon monoxide, unburnt hydrocarbons, and nitrogen oxides. They contain precious metals such as rhodium, platinum, and palladium to accomplish this. Three-way catalytic converters can't be used in diesel engines, as diesel's oxygen-rich exhaust gases make their removal of NO_x inefficient.

SELECTIVE CATALYTIC REDUCTION



Selective catalytic reduction (SCR) is a method for NO_x removal that is utilised in some diesel engines. It involves the injection of urea into the exhaust stream of the vehicle, where it produces ammonia, which is adsorbed onto a catalyst. The ammonia can then react with the nitrogen oxides in the exhaust stream to produce nitrogen and water. SCR is capable of achieving NO_x reductions of up to 90%.

NO_x ADSORBERS

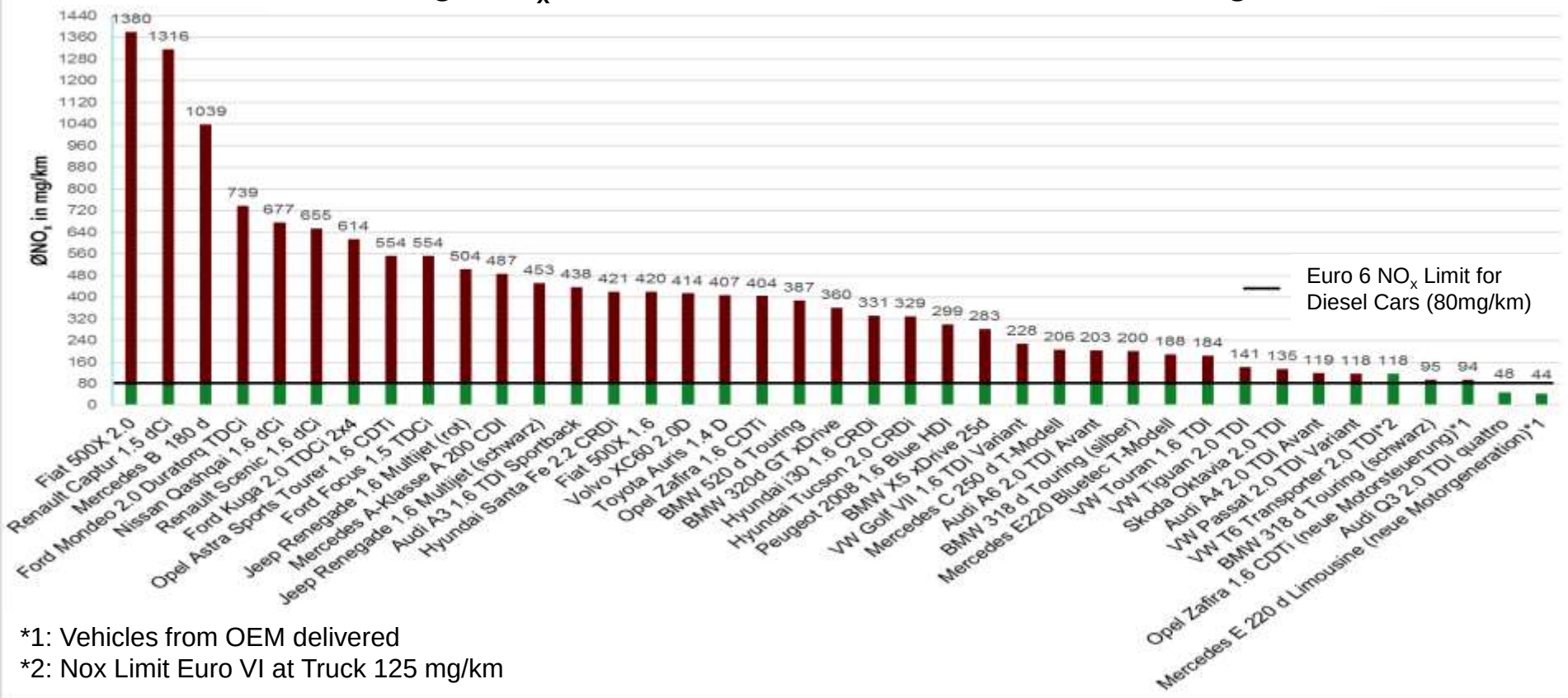


NO_x adsorbers can also be used in diesel engines. The majority of NO_x emissions from the diesel engines are NO, and this is converted to NO_2 by reaction with oxygen using a platinum catalyst. The NO_2 is then absorbed in the form of nitrates by the storage material (often barium oxide). Once the trap is full, the nitrate can be desorbed, converted to nitrogen over a rhodium catalyst, and released.

Source: www.compoundchem.com | Rh = Rhodium | Pt = Platimum | Pd = Palladium

PEMS- Road Measurements
Euro 6 Diesel Cars Exceeding the NO_x Limits

Average NO_x Emissions from Euro 6 Diesel Cars in mg/km

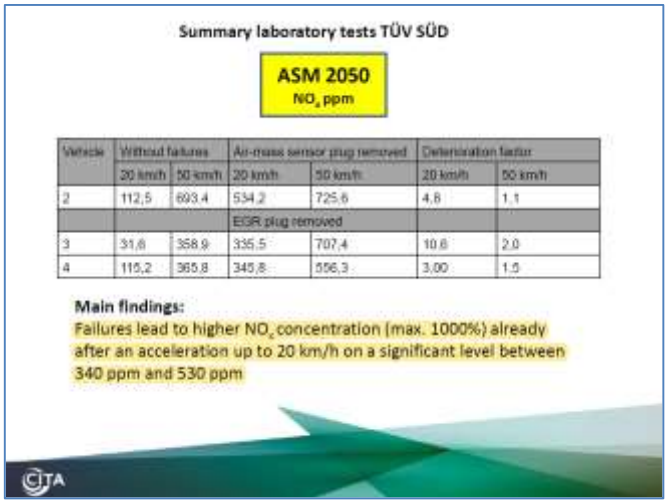


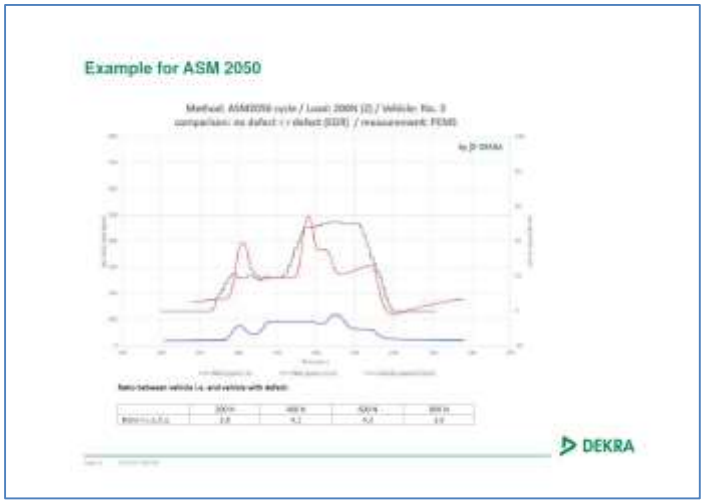
*1: Vehicles from OEM delivered
*2: Nox Limit Euro VI at Truck 125 mg/km

Source: PEMS Measurements, DUH (NGO), Germany

New Concept: Brake Tester combined with Emission Testing under load for Pollutants e.g. NO_x and PN

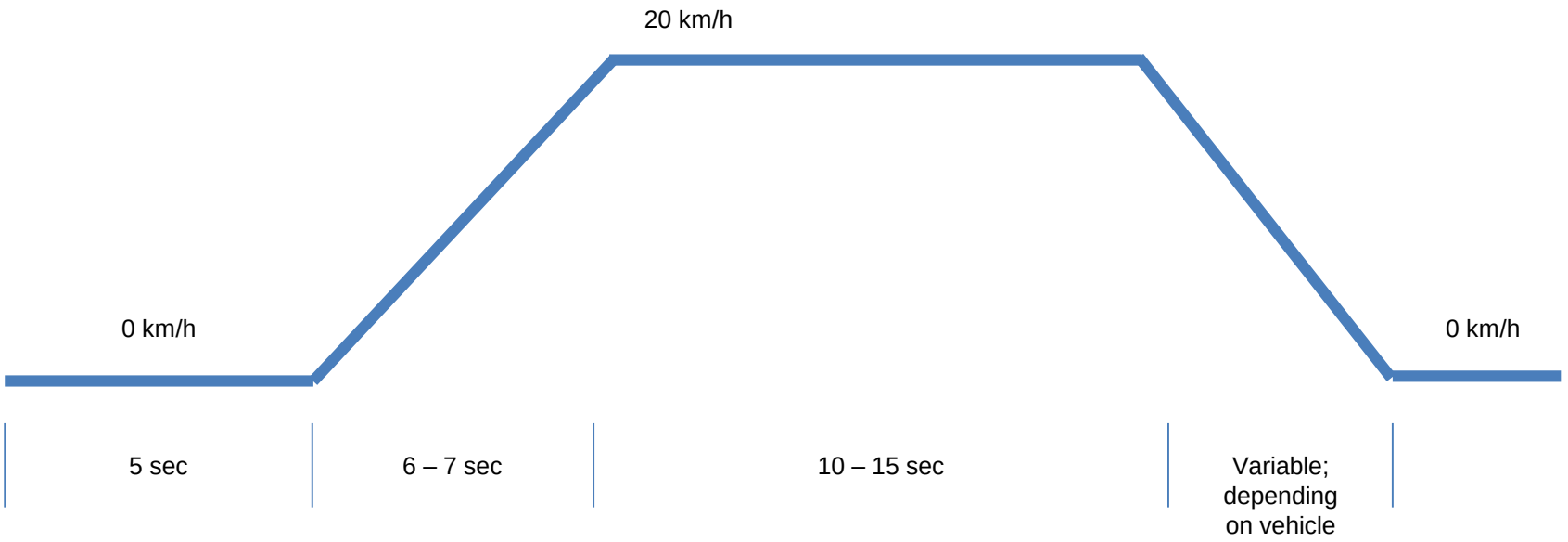
- ✓ using motors with different coils and better balancing
- ✓ frequency converters control motors
- ✓ using different frequencies and voltages, bench is able to accelerate the car to 20 km/h, and keep the car at this speed
- ✓ at 20 km/h we can still have a torque of 5 Nm, which corresponds to 1150 N per side = load is given to measure NO_x correctly
  ►important to see EGR and Ad blue activities





New Concept: Brake Tester combined with Emission Testing under load for Pollutants e.g. NO_x and PN

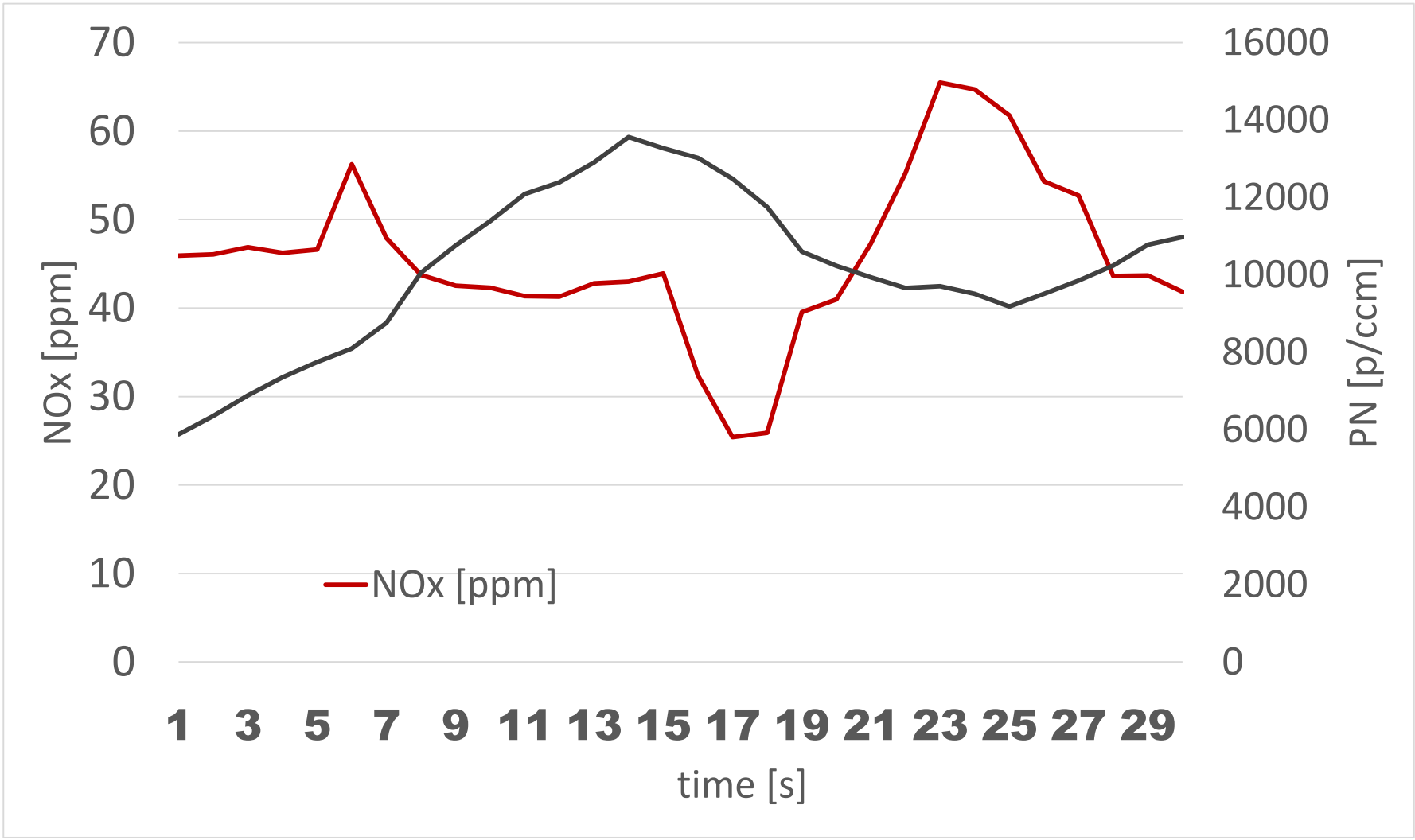
- Quick, Efficient and Reproducible Test Cycle < 2 Minutes



New Concept: Brake Tester combined with Emission Testing under load for Pollutants e.g. NO_x and PN

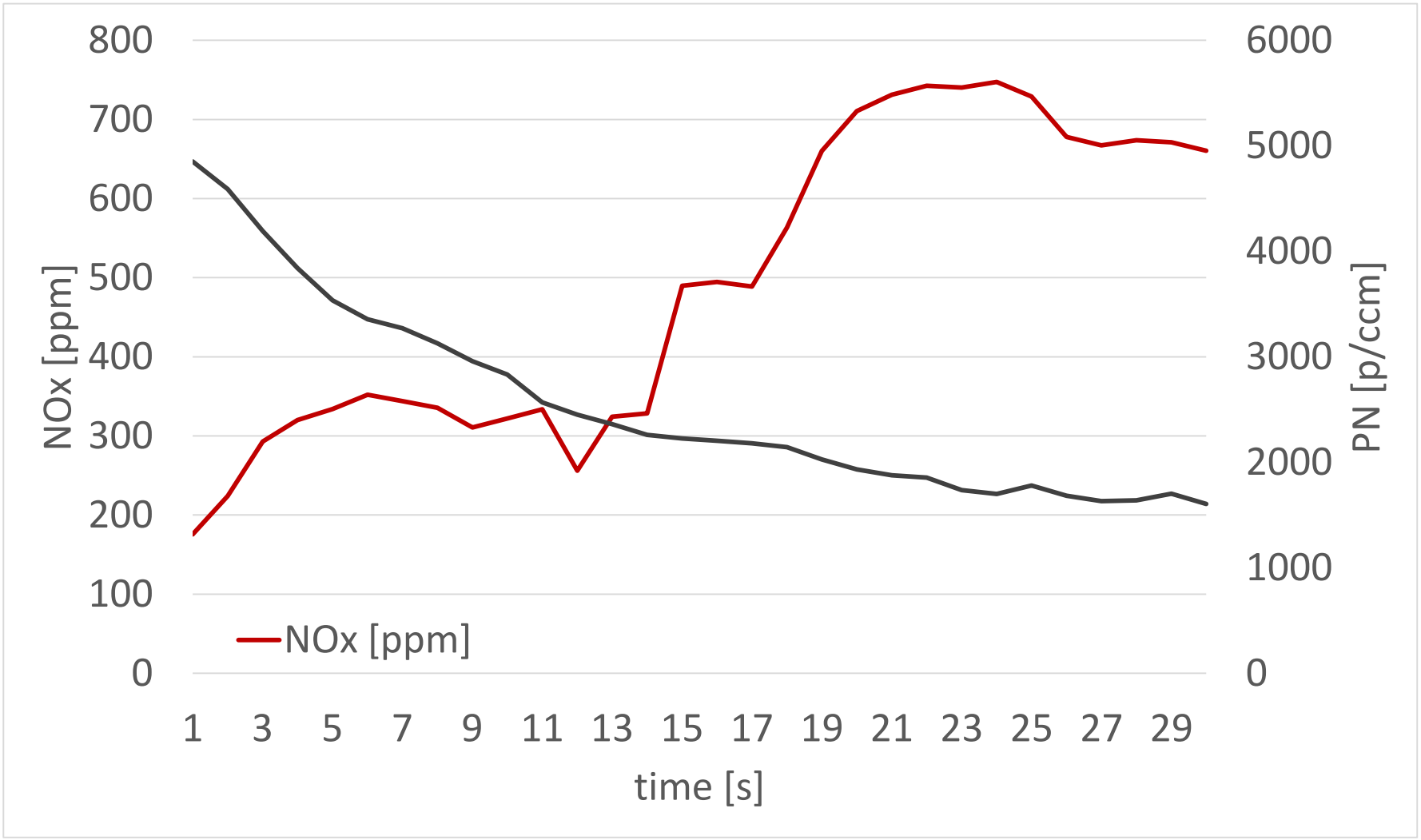
with electrochemical cells for NO_x measurement -
NO plus NO_2 separately

NO_x Concentration and Particle Number, Mercedes E220d



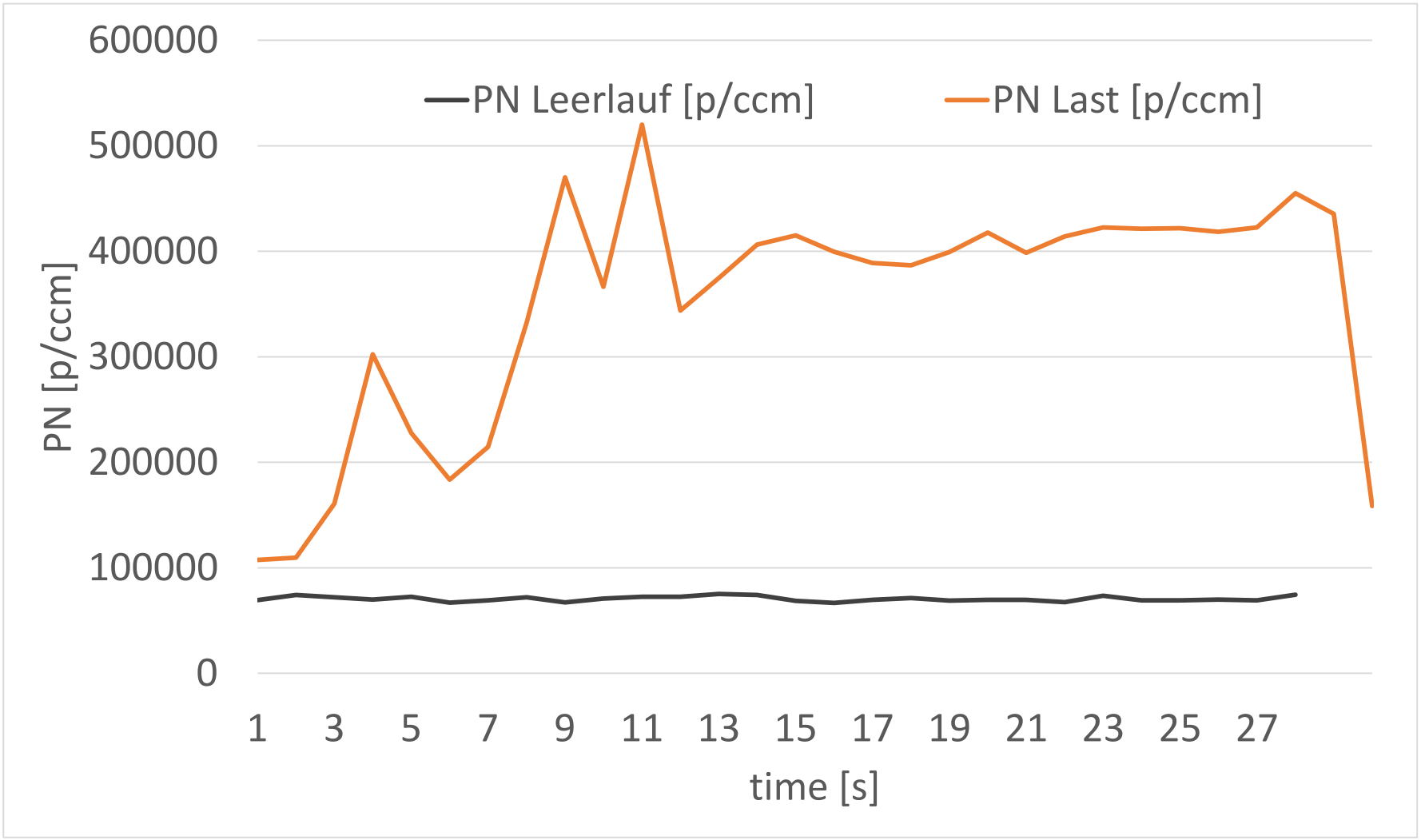
Source: DUH (NGO), Germany

NO_x- Concentration and Particle Number, Opel Insignia



Source: DUH (NGO), Germany

Particle Number Concentrations in Idle or under Load, Opel Zafira



Source: DUH (NGO), Germany

Passed // Failed with Limits of 200 ppm NO_x and 20,000 PN per (ccm) cm^3

BMW 318d

PN [p/ccm]	9.847	Passed
NO_x [ppm]	77	Passed
Result		**Passed**

Ford Focus 1.0 EcoBoost

PN [p/ccm]	19.150	Passed
NO_x [ppm]	136	Passed
Result		**Passed**

Mercedes E 220d

PN [p/ccm]	10.167	Passed
NO_x [ppm]	46	Passed
Result		**Passed**

Opel Insignia Sports Tourer

PN [p/ccm]	2.086	Passed
NO_x [ppm]	487	Failed
Result		**Failed**

Opel Zafira

PN under load [p/ccm]	349.854	Failed
PN Leerlauf [p/ccm]	70.533	Failed
NO_x [ppm]	166	Passed
Result		**Failed**

VW Passat 1.6 Cheap replacement catalyst

PN [p/ccm]	9.491	Passed
NO_x [ppm]	749	Failed
Result		**Failed**

Source: DUH (NGO), Germany

Test Limits for the Future PTI Test

- For Euro 6 vehicles a **PN limit value of 20,000 per cubic centimeter** is proposed for checking the functionality of particulate filters. If the particle filter is working, the test values are well below this test value.
- For the nitrogen oxide concentration, an average **NO_x concentration of 200 ppm** (parts per million) for **Euro 6 vehicles** is proposed on the basis of a large number of RDE measurements with PEMS measuring instruments.
- Based on these suggestions, some vehicles were assessed.

Source: DUH (NGO), Germany

Thank you for your attention!

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