# NOx measurements during the Periodic Technical Inspection (PTI)

Joint Research Centre

European Commission

# JRC Mission

As the science and knowledge service of the Commission
our mission is to support EU policies with independent evidence
throughout the whole policy cycle.

**Independent** of private, commercial or national interests

**Policy neutral**: has no policy agenda of its own

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Headquarters in **Brussels** and research facilities located in **5 Member States:**

Belgium (Geel)

Germany (Karlsruhe)

Italy (Ispra)

The Netherlands (Petten)

Spain (Seville)




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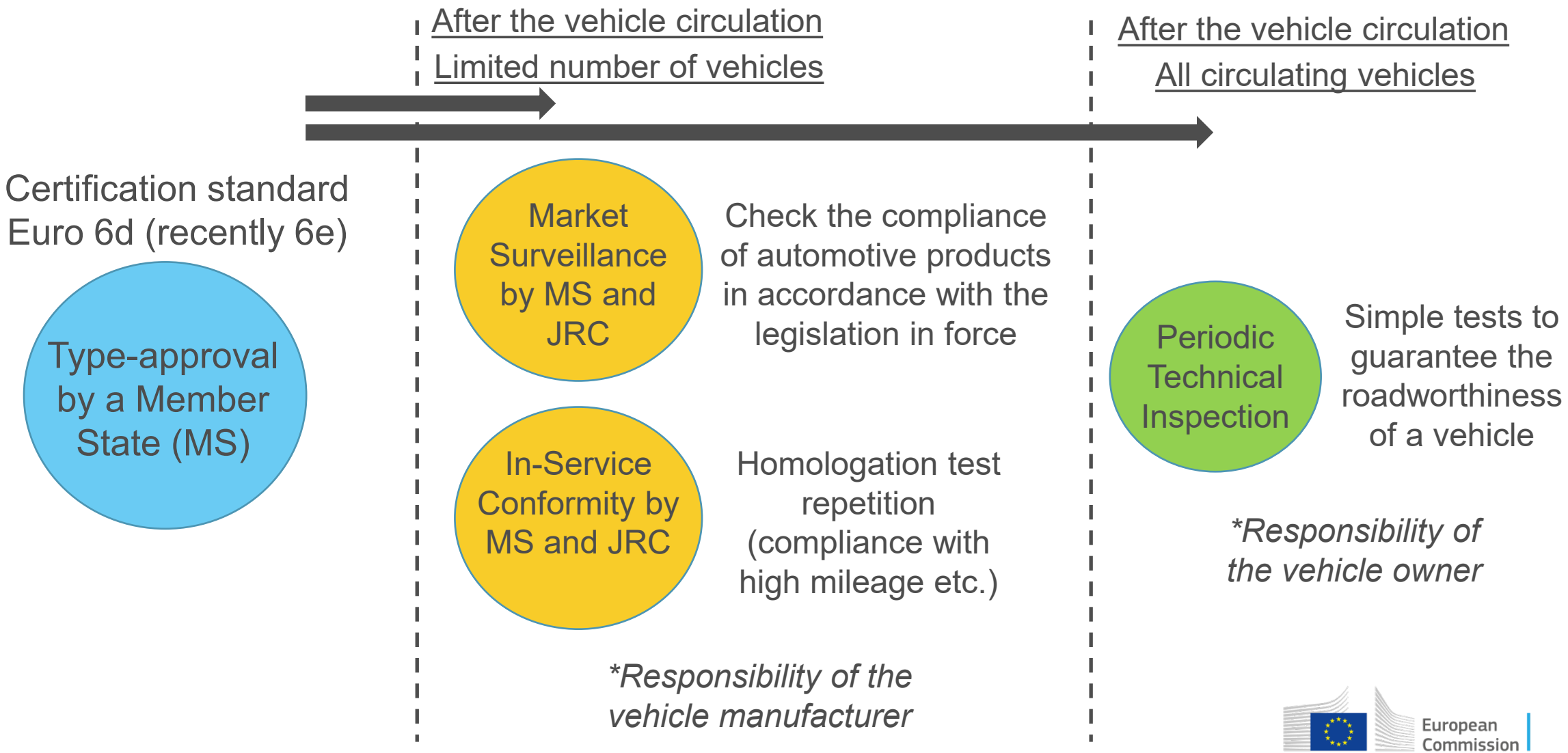
# Vehicle emission compliance in Europe



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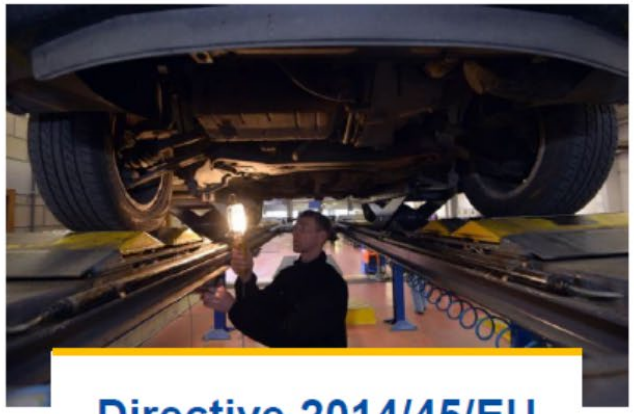
# EU legislative framework: Roadworthiness package



**Directive 2014/45/EU**

Periodic roadworthiness tests for motor vehicles and their trailers
*("PTI Directive")*

**Directive 2014/46/EU**

amending Directive 1999/37/EC

Registration documents of vehicles


**Directive 2014/47/EU**

Technical roadside inspection of the roadworthiness of commercial vehicles circulating in the EU
*("RSI Directive")*



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# NOx-PTI

# The scope

Dir. 2014/45/EU: *"Testing during the life cycle of a vehicle should be relatively **simple**, **quick** and **inexpensive**, while at the same time effective"*

**Identification of SCR malfunctioning in modern EU 6d+ Diesel LD- and Euro VI HD-vehicles or newer**

KEY ELEMENTS:

- Procedure
- Measurement devices
- Pass/Fail criteria



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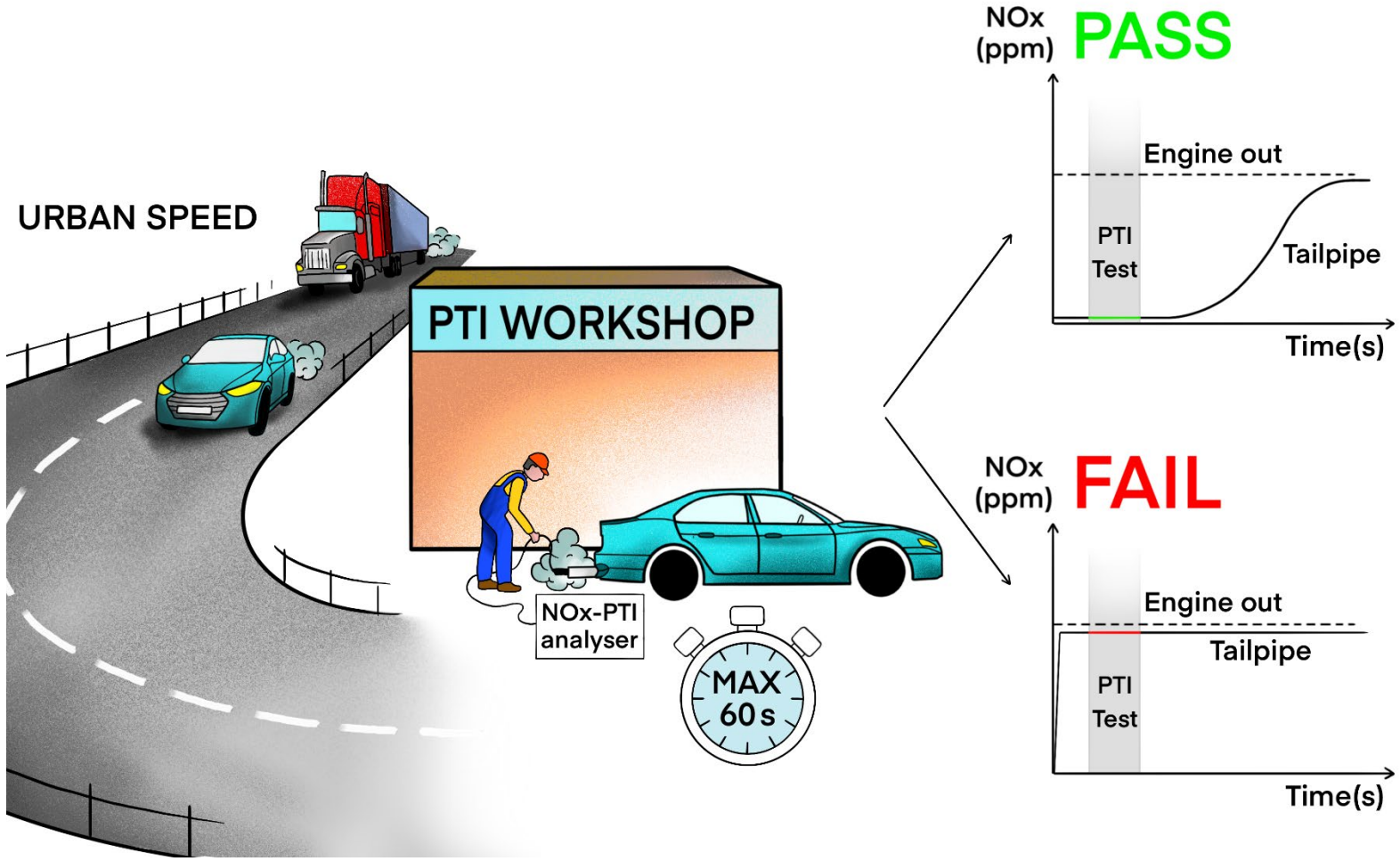
# The concept



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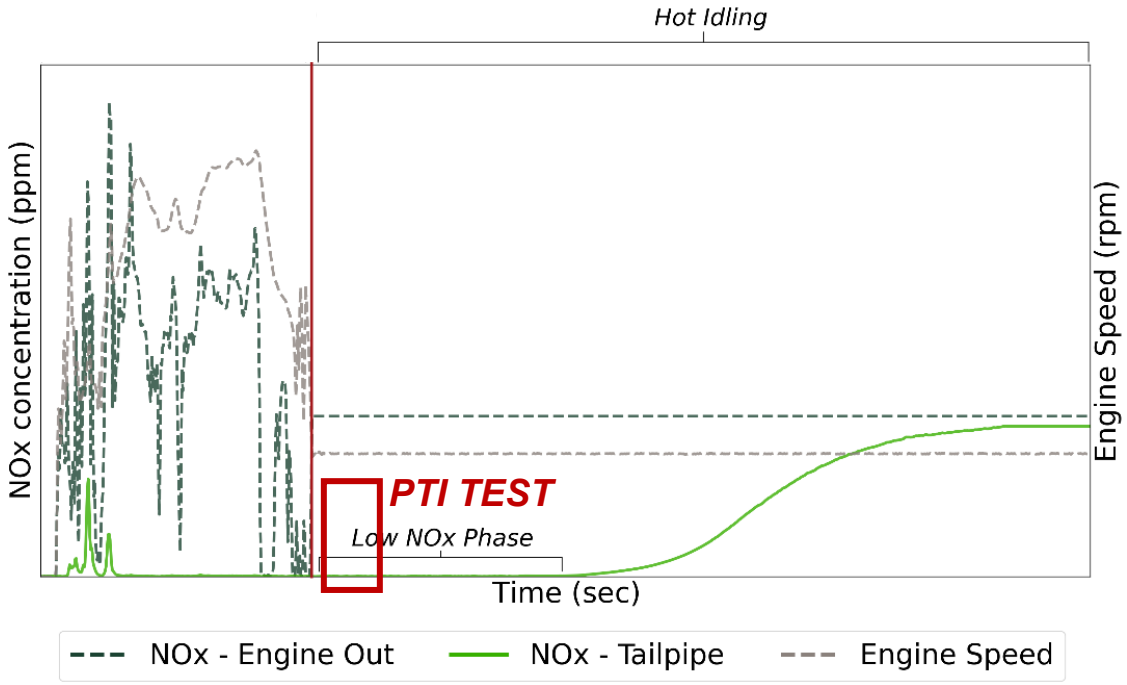
# The procedure

1) Engine in idle
2) NOx emissions are measured at tailpipe (15 s average NOx concentration)

Aftertreatment system **must be properly warmed-up**, ensuring that the SCR unit temperature is high enough to sustain NOx reduction activity



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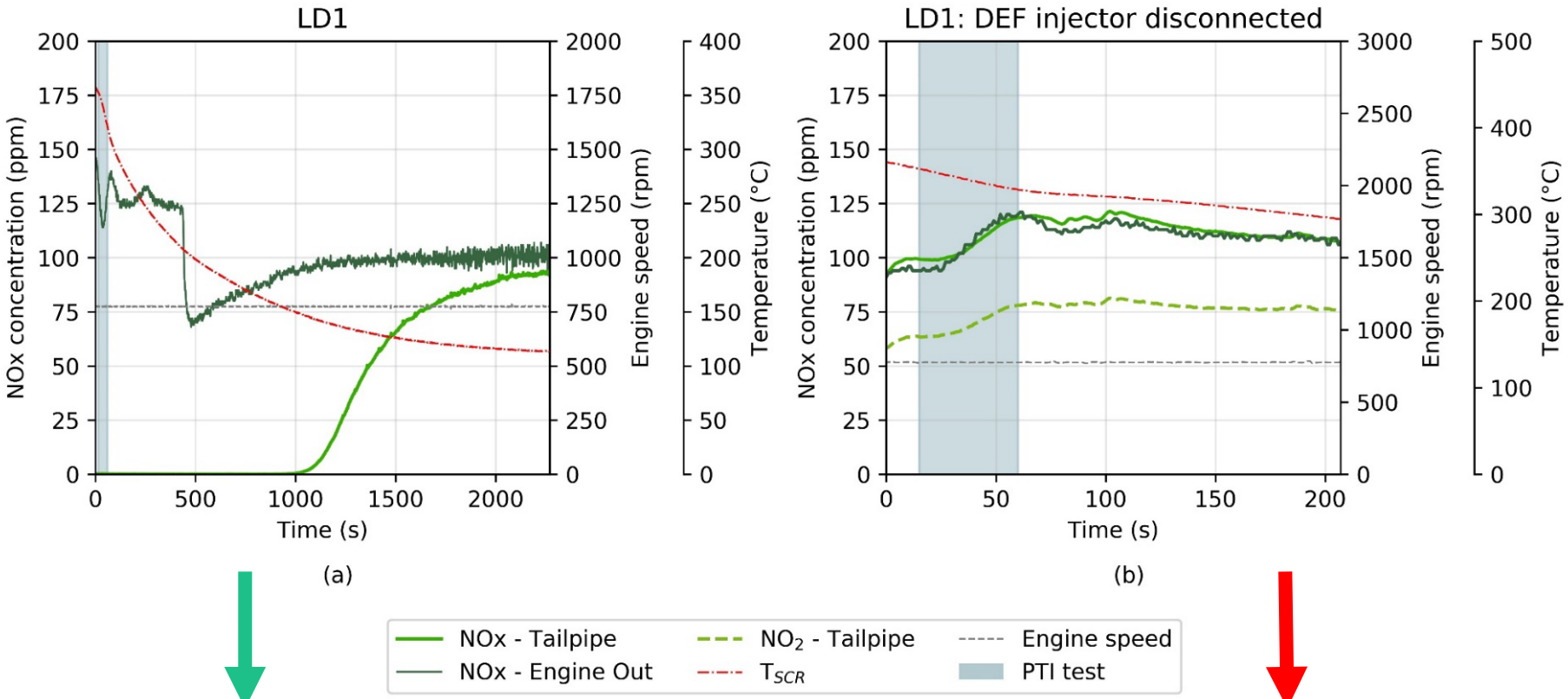
*Franzetti et al. https://doi.org/10.3390/en16145520

# Identification of SCR malfunction




**Properly functioning SCR unit**

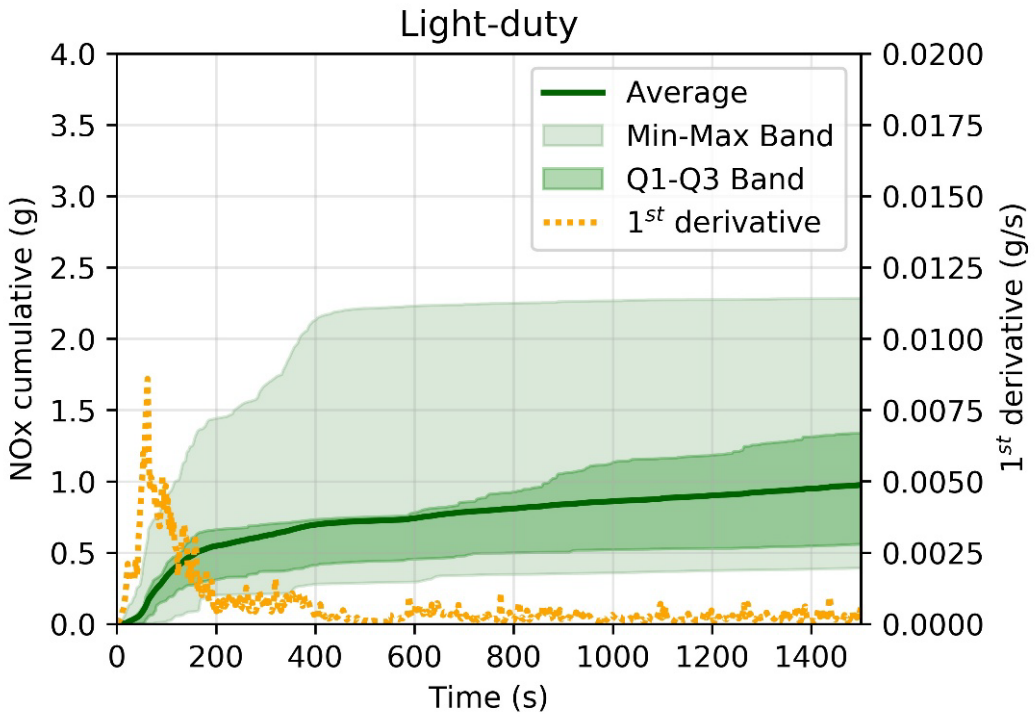
Low NOx tailpipe concentration

**Diesel exhaust fluid injection system not working**

High NOx emissions close to engine out levels since idling phase start.

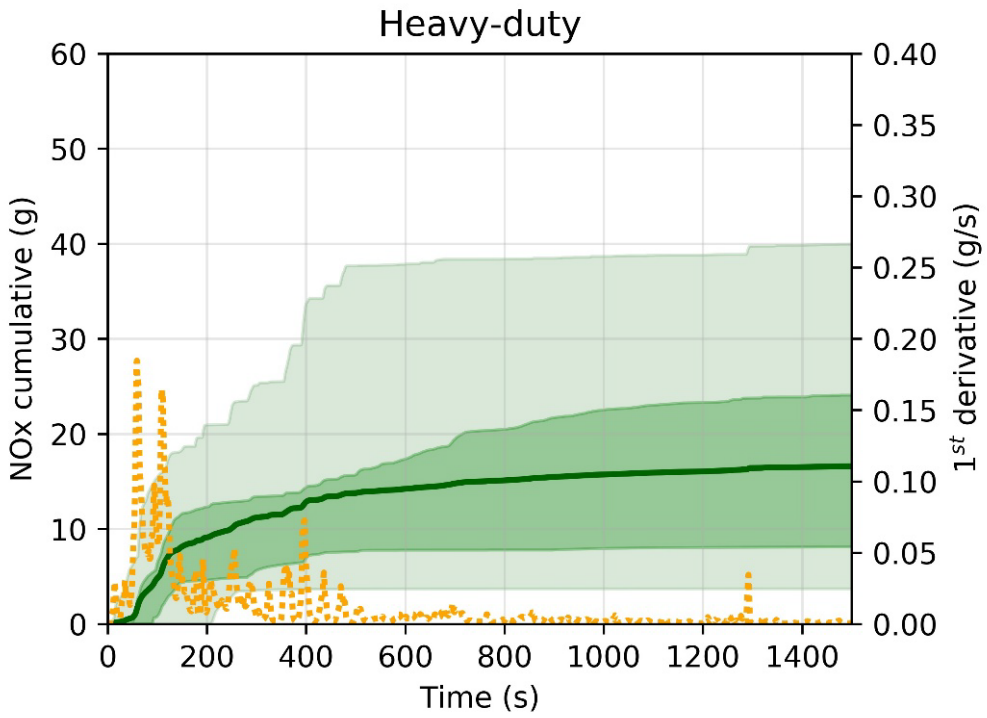
*Franzetti et al. https://doi.org/10.1186/s12302-024-01002-8

# ATS warm-up




*Data shows that **~5 minutes of urban driving** could suffice as aftertreatment warm-up for post-RDE Diesel light-duty vehicles.*

*19 vehicles, 30 RDE tests*




*Data shows that **~8 minutes of urban driving** could suffice as aftertreatment warm-up for Euro VI Diesel heavy-duty vehicles.*

*4 vehicles, 17 tests*



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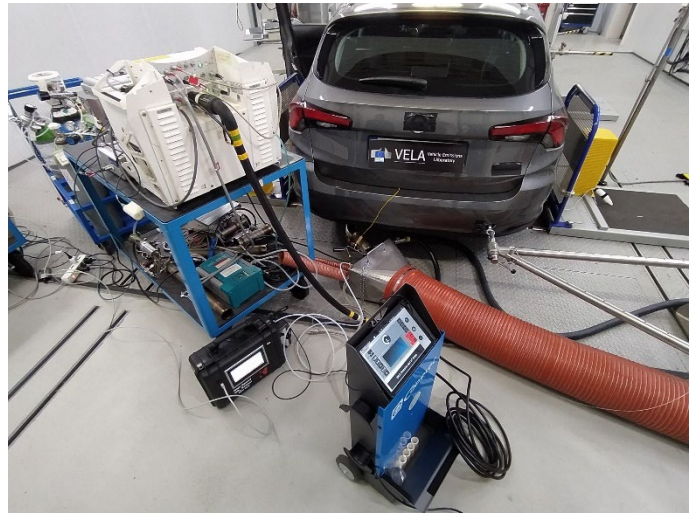
# The measurement devices

Experimental campaign with 5 instruments:

- 4 Electrochemical Sensors (ES)
- 1 Chemiluminescence Detector (CLD)
- Plus reference instruments (PEMS)




One Euro 6d Diesel vehicle and one Euro 5 Diesel vehicle (without any ATS present) were tested following the **hot idling test** procedure

*Can current NOx measurement devices be used for PTI purpose?*



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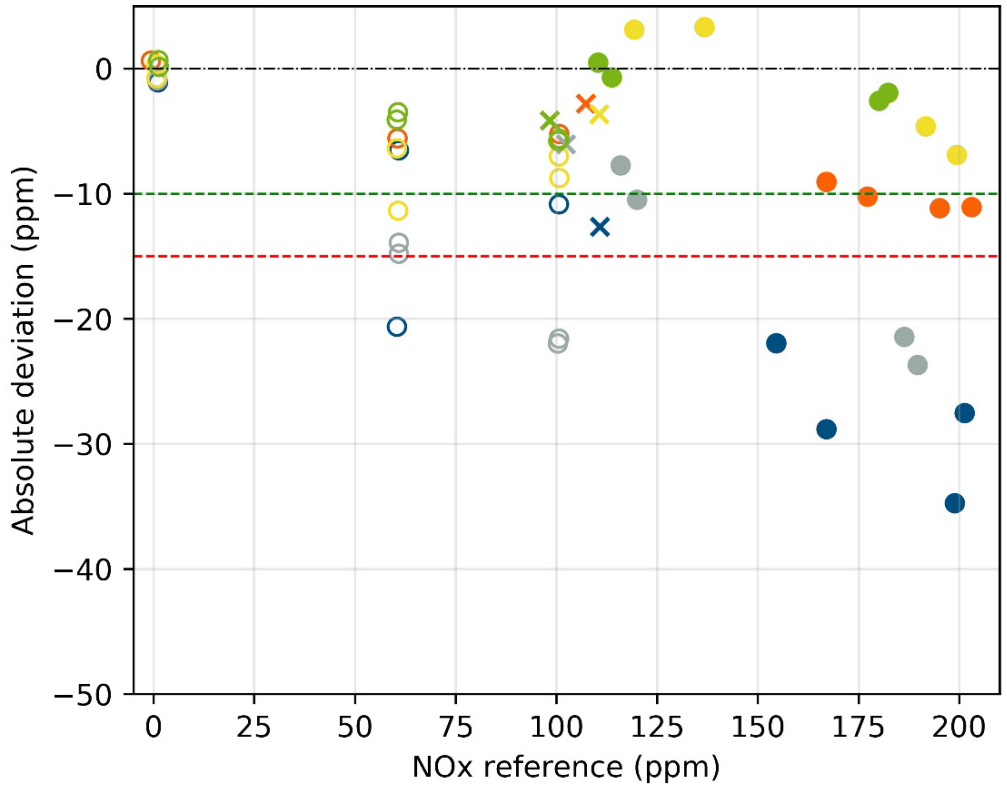
# Evaluation of measurement devices

*Equipment manufacturers provided commercially available instruments or close to the final stage of development.*

**RESULTS**:

- Good linearity with the reference NOx.
- Among five NOx analysers, three had <10 ppm and two had 20-30 ppm differences at 100-200 ppm.
- $t_{10\text{-}90}$ suggests that 15 s suffice to stabilize measurement.
- **<u>NOx must be measured (not only NO)</u>**




*LD6 = Euro 6d (with SCR)*
*LD7 = Euro 5 (without SCR)*



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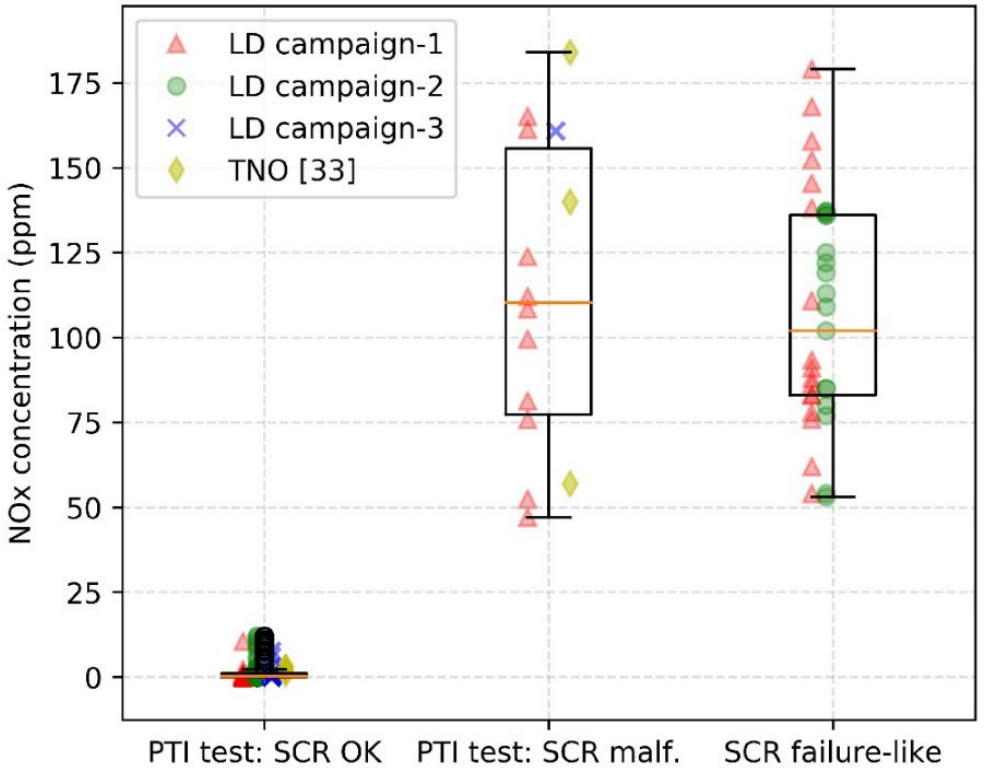
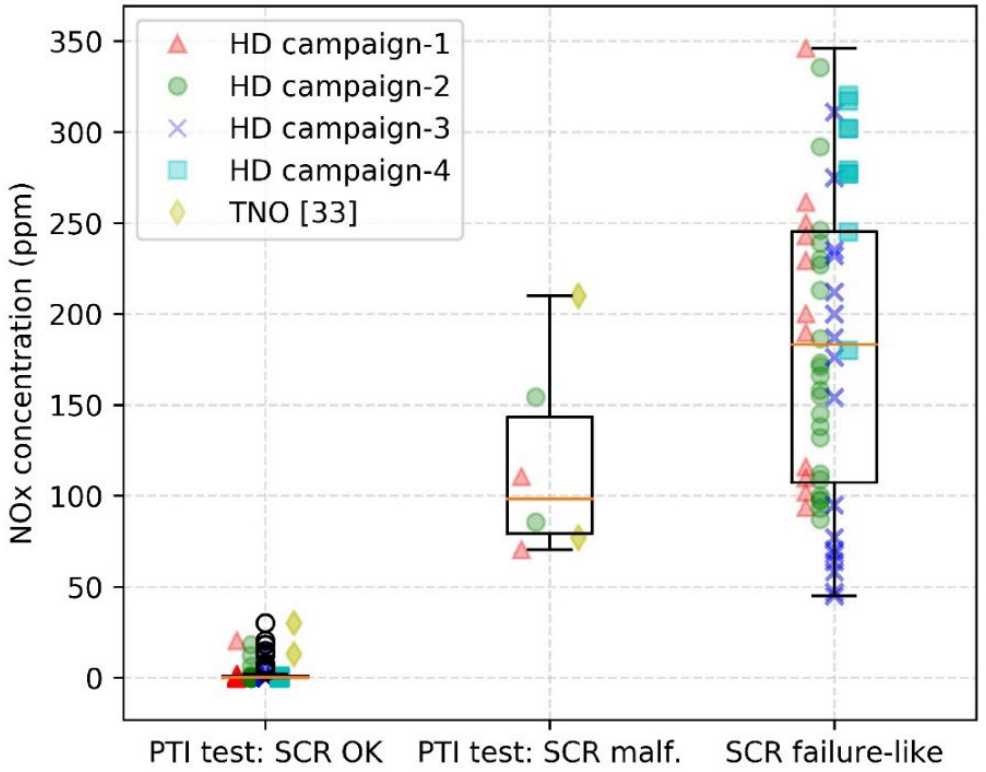
*Franzetti et al. '*Assessment of NOx concentration levels during periodic technical inspection of SCR-equipped Diesel vehicles*', submitted

# The Pass/Fail criteria

## Light-duty




## Heavy-duty




Best NOx Threshold range

- LD: **13 – 47 ppm**
- HD: **31 – 45 ppm**

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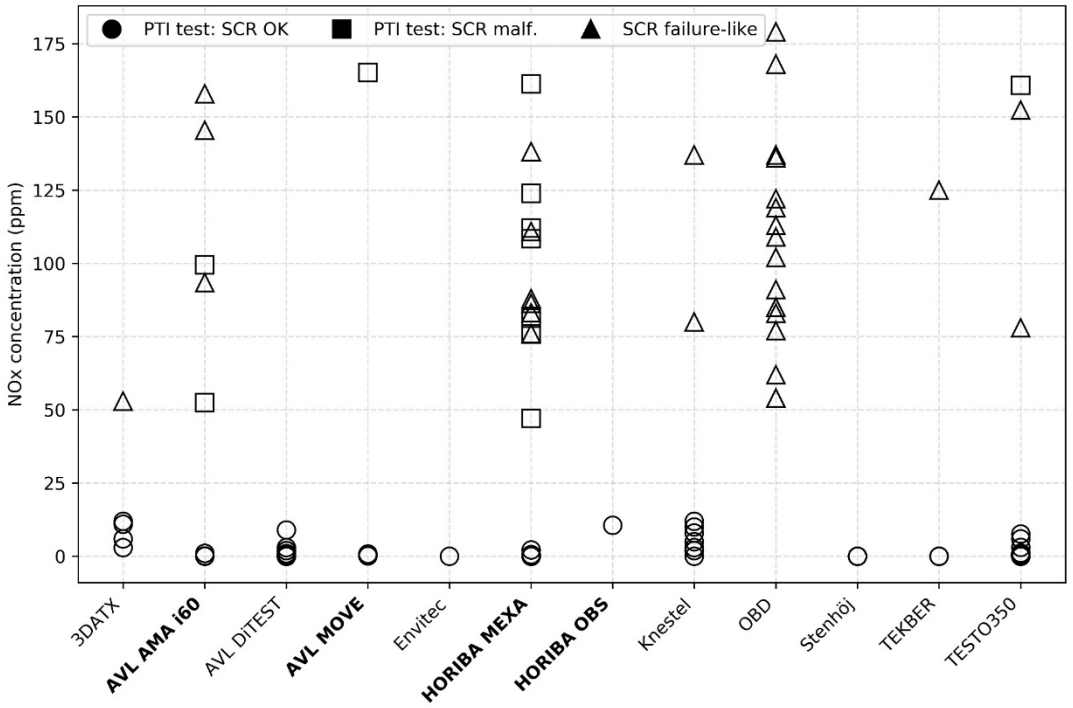
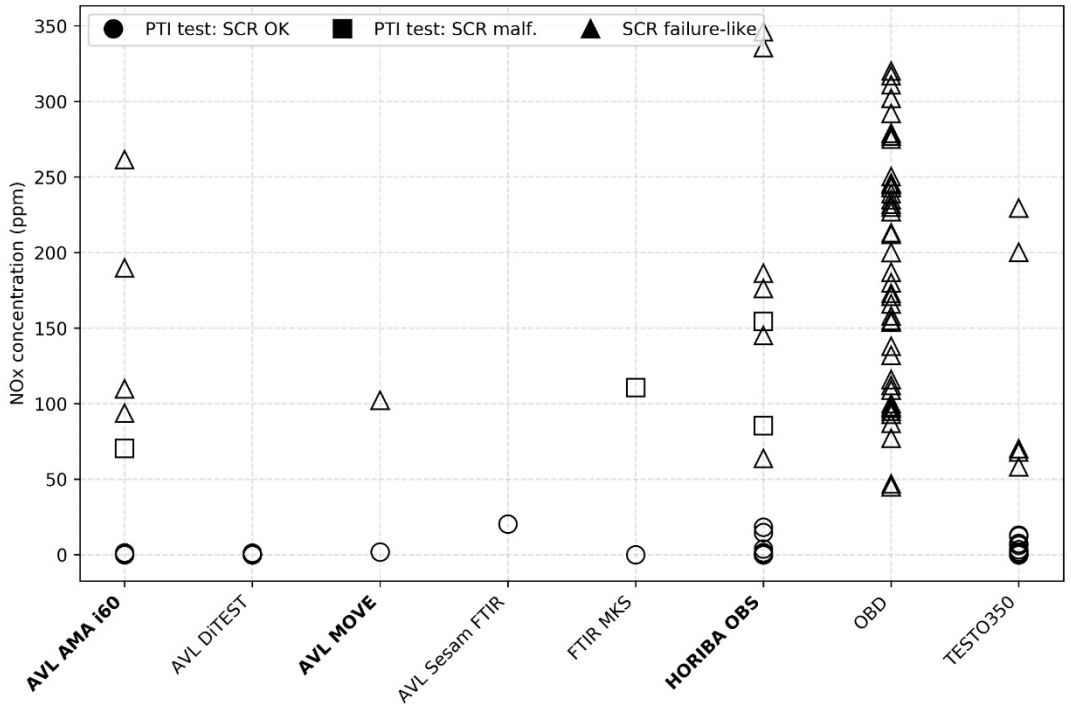
*Franzetti et al. '*Assessment of NOx concentration levels during periodic technical inspection of SCR-equipped Diesel vehicles*', submitted

# Devices and concentrations range

## Light-duty




## Heavy-duty




*'PTI test: SCR OK'* are scattered across all equipment types. *'PTI test: SCR malf.'* or *'SCR failure-like'* conditions were primarily obtained using high-precision laboratory-grade or PEMS equipment, as well as OBD NOx sensors.



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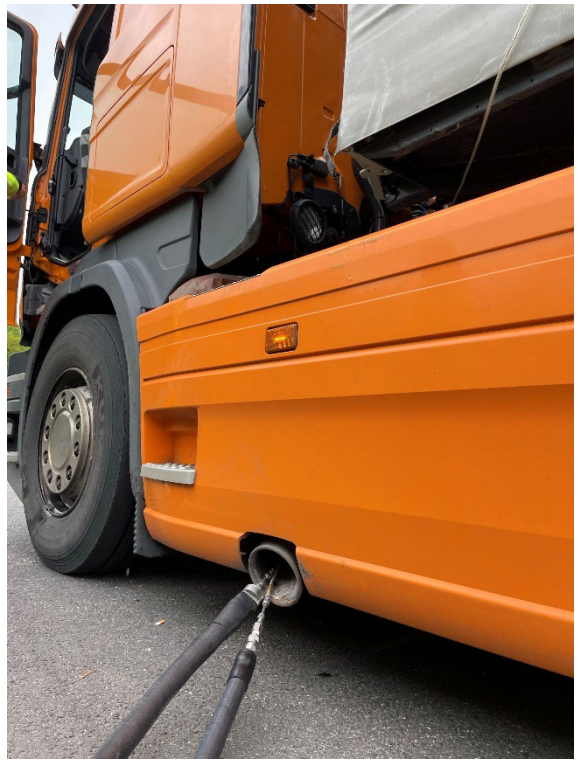
# The roadside inspection (RSI)

Joint exercise between the Færdselsstyrelsen (FSTYR – Danish Road Traffic Authority) and JRC during RSI

During RSI inspection FSTYR uses:

- Plume chasing (PC)
- OBD scan

From over 30 tested 2 had malfunctioning/tampered SCR system that was identified by the three methodologies **PC**, **OBD** and **Idle test**



NOx and PN testing at RSI



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# Thank you

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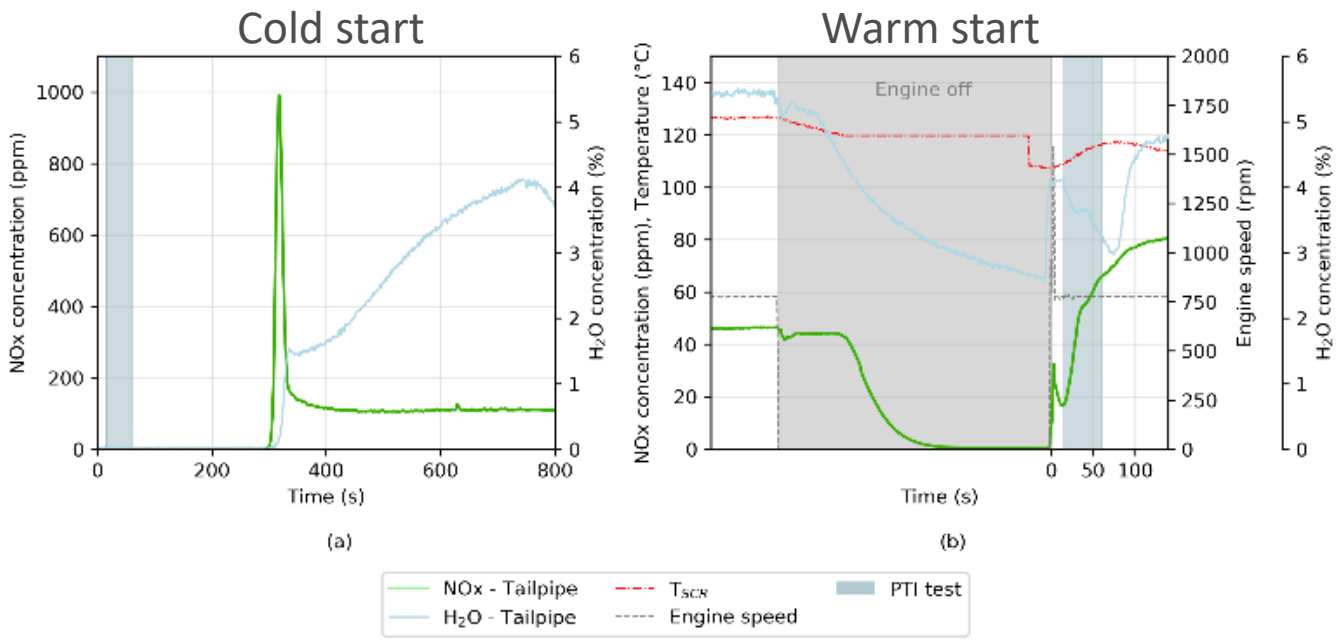
# AFTERTREATMENT SYSTEM WARM-UP : back up slide




Cold and warm start conditions must be avoided as the ATS has to be warmed-up before performing the idle test.



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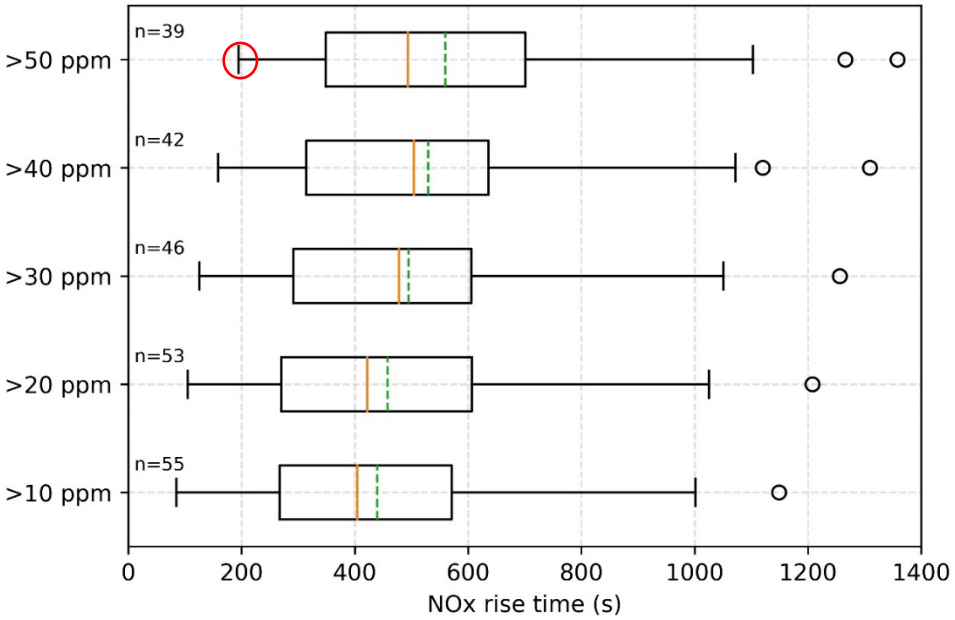
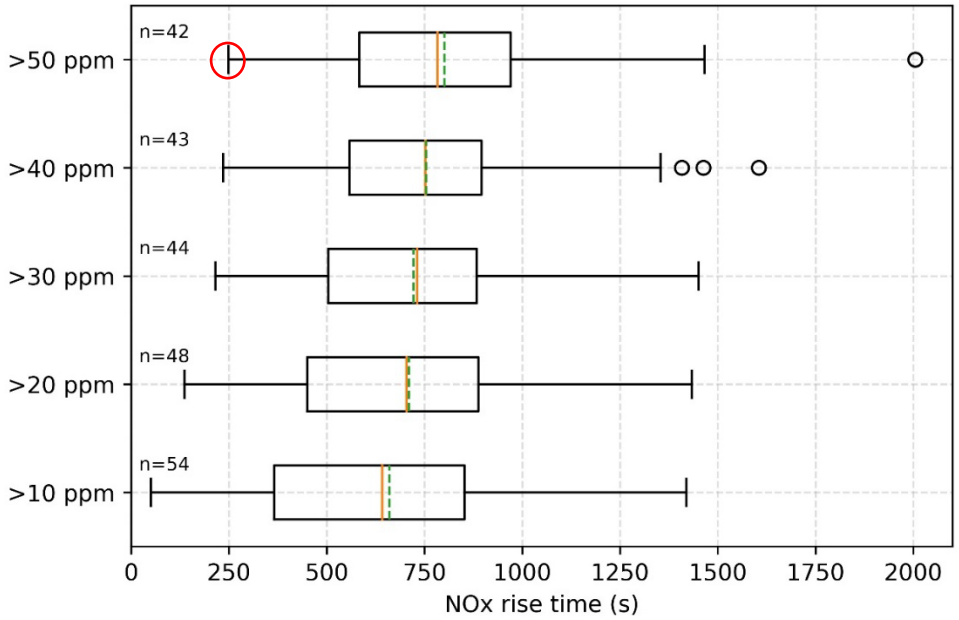
# NOx-PTI TEST TIME: back up slide

## Light-duty




## Heavy-duty




- 30 s idle test (15 s for equipment stabilisation and a 15 s average for NOx concentration) is feasible in a PTI workshop.
- PTI operator has a sufficient operational time buffer of approximately **~180 s** (LD) and **~230 s** (HD) seconds to prevent false failures caused by the SCR unit cooling down.



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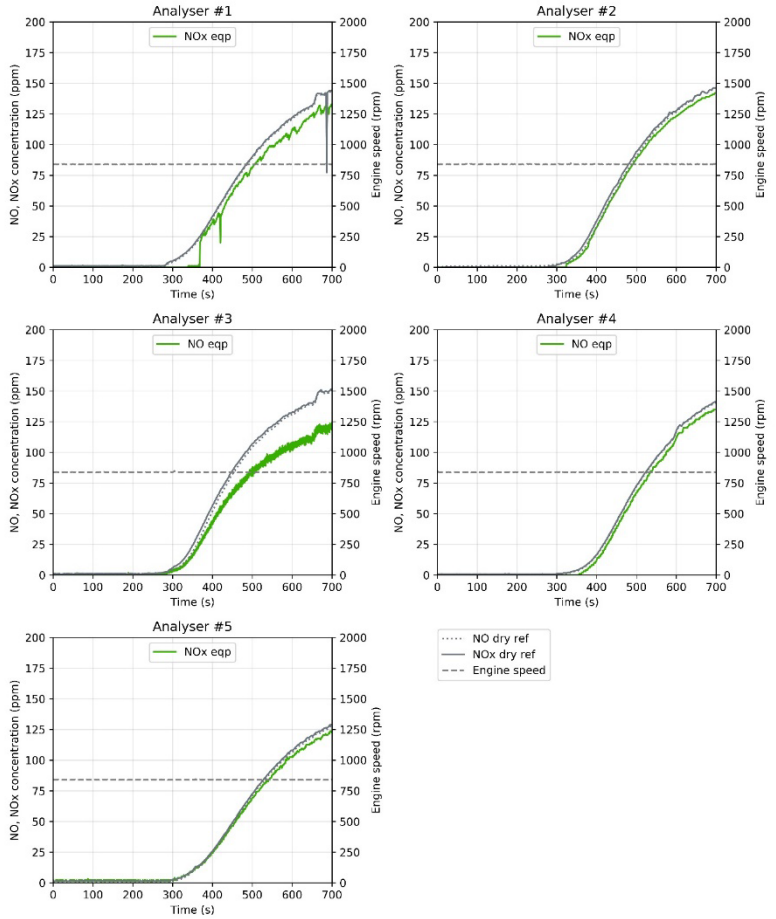
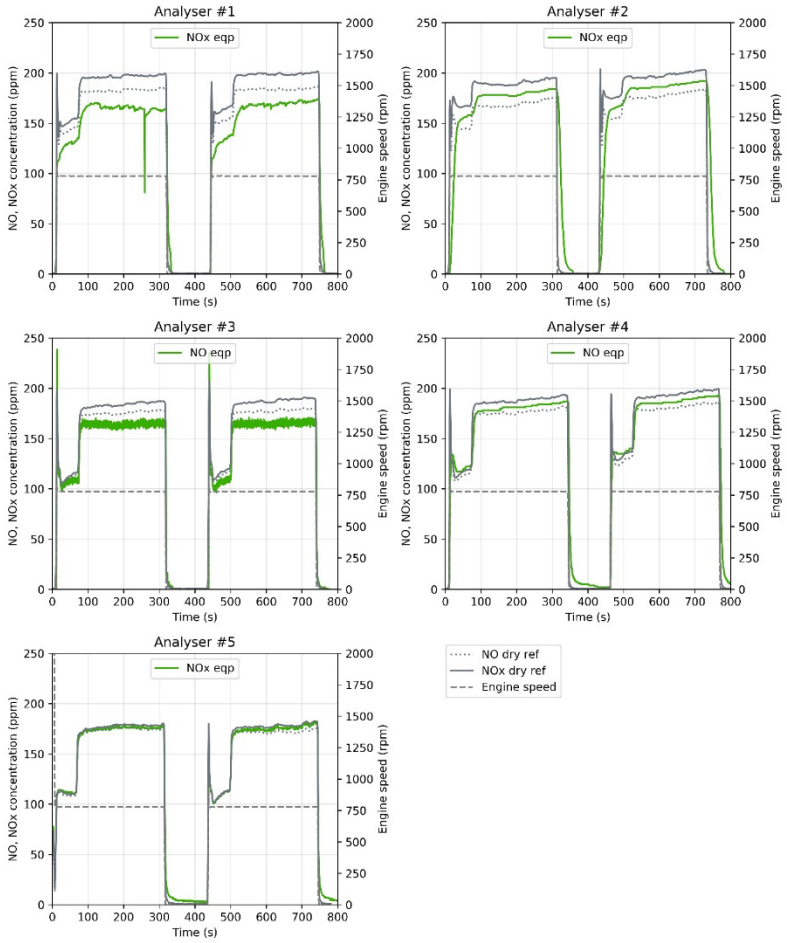
# EVALUATION OF NOX-PTI MEASUREMENT DEVICES: back up slide

## Euro 6




## Euro 5



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