New Approaches to Periodic Technical Inspection (PTI) Vehicle Emission Tests

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PTI Today

- PTI for exhaust emissions are mostly regulated by Directive 2014/45/EU:
  - Correct performance of complex exhaust after-treatment systems are verified only by visual inspection (absence, modification, leaks, etc.)
  - Different exhaust emission requirements for vehicle engine type:
    1. Positive ignition engines:
       a. CO emissions below specified thresholds
       b. Lambda coefficient within specified range
       c. OBD does not indicate significant malfunction
    2. Compression ignition engines:
       a. Opacity does not exceed specified thresholds

- Directive 2014/45/EU is out of date:
  - Not referenced to regulatory thresholds and measurements defined for type-approval testing, notably for NO_x and PN measurement/thresholds and CO or CO_2 thresholds
  - Existing PTI equipment cannot meet these requirements

PTI Tomorrow

- Post Dieselgate, European emission measurement is progressing:
  - EU has implemented PMP and RDE protocol for vehicle type-approval testing, with measurement of CO, NO_x, HC+NO_x, PM and, from EURO-5, measurement of PN
  - VERT (DPF manufacturers association) advocates PN measurement
  - Some member states are introducing new PTI regulations independently of EU regs
  - EU regulates OBM CO_2 monitoring for new vehicles from 2021, with PTI procedures to be defined

- Still work needed to implement emissions measurement at PTI:
  - Particulate protocol, measurement & threshold to be tested
  - NOx protocol, measurement & threshold to be developed and tested
  - CO and CO_2 protocol, measurement & threshold to be developed and tested
  - Advocating EU homogeneity and building future-proof systems

parSYNC® iPEMS Solution

- Next Generation: integrated PEMS
  - Easy to use and versatile
  - Rugged, light weight and mobile:
    <4 kg and >4 hours on battery
- Modular Sensor Cartridge for Particulates and Gases
  - GasMod cartridge measures
    NO (0-5000 ppm), NO_2 (0-300 ppm),
    CO (0-15%), and CO_2 (0-20%)
  - PM|PN cartridge measures Opacity
    Scattering and Ionisation
    and uses a matrix transform to calculate
    PM (ug/m^3) and PN ($\#/cm^3$)
  - Simplifies measurement and maintenance.

PTI Pilot at OPUS Sweden – Initial Findings

Test Location

This presentation covers Phase-1 data collected at the Borås site.

Vehicles Tested

Vehicle Summary

MAKE	Diesel	Petrol	2005	2006	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
AUDI	4	1	1	1				1	1	1						**5**
BMW	5					1		1		1	2					**5**
CITROEN	1						1									**1**
DACIA		2						1			1					**2**
FORD	4	1			1		1	2	1							**5**
HONDA	1	1									1		1			**2**
HYUNDAI	1	1						1			1					**2**
JEEP		1							1							**1**
KIA	4								2	1			1			**4**
MAZDA	2	2								1	1	1			1	**4**
MERCEDES-BENZ	1									1						**1**
MITSUBISHI	2				1			1								**2**
NISSAN		1									1					**1**
OPEL		1										1				**1**
RENAULT	1	2		1						1			1			**3**
SAAB	1	1		1		1										**2**
SKODA		2	1					1								**2**
SUBARU	1							1								**1**
TOYOTA	1						1									**1**
VOLKSWAGEN	2	1	1					1						1		**3**
VOLVO	10	1				1		1	1	1	3	2	2			**11**
VW	1								1							**1**
Total	**42**	**18**	**3**	**3**	**2**	**3**	**3**	**11**	**7**	**7**	**10**	**4**	**5**	**1**	**1**	**60**

Jan 21
to
Feb 18, 2021

Test Setup and Conditions

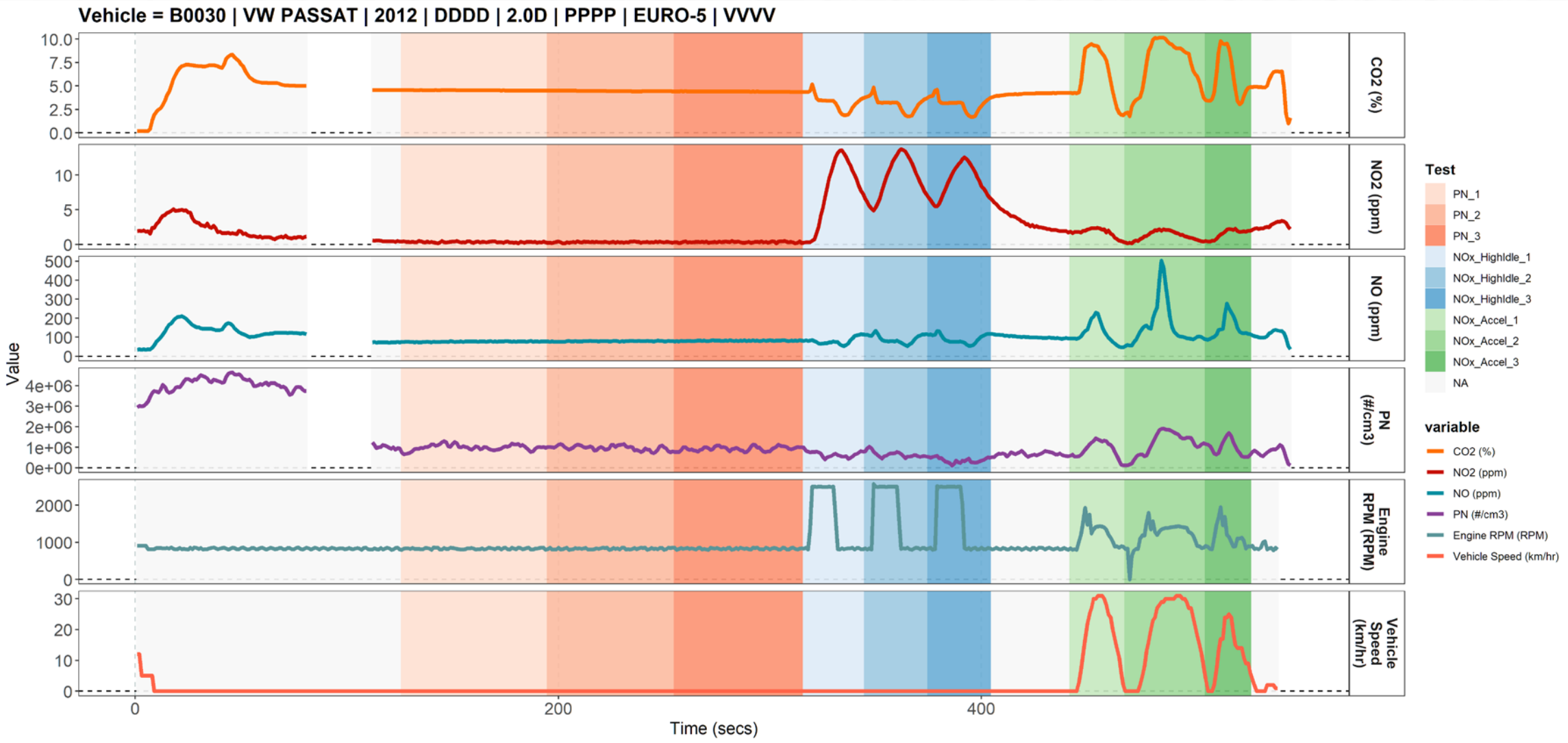
parSYNC warmup and zeroing while vehicle is being prepared

Test Protocol

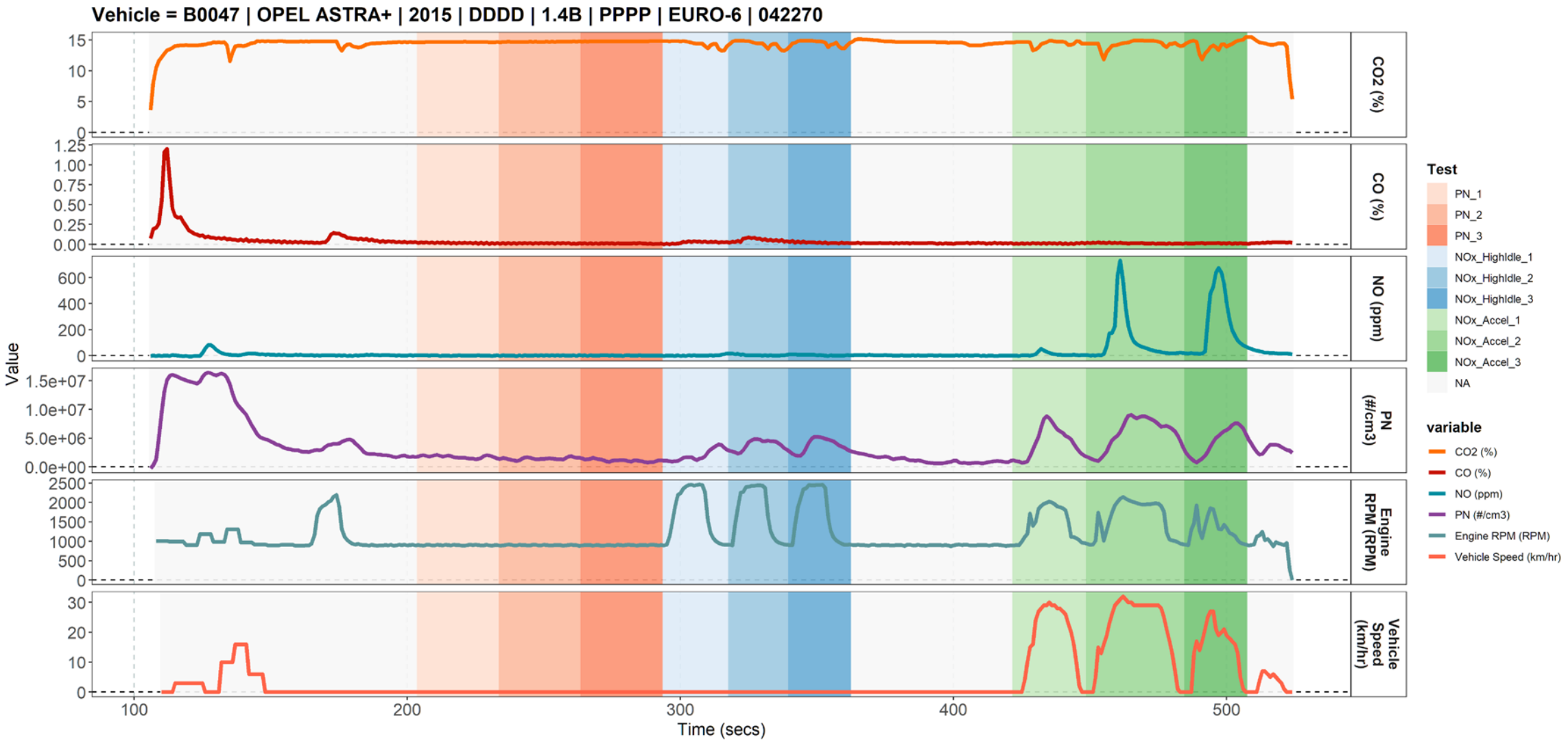
Prep	• Warmup (or dry-out) the parSYNC using wall power while sampling clean ambient air (use HEPA filter if available)
0	• Start test data file | Sample clean ambient air for ~60 seconds
Zero	• Run the zeroing procedure while parSYNC is on the bench
0	• With parSYNC running on battery power move it to the vehicle | Connect to tailpipe probe | Connect OBD reader to ECU port | Start the vehicle | Drive to parking lot position | Idle vehicle for 60 seconds
1-3	• PN – 30 seconds of idle | Repeat 3 times
4-6	• NO_x High Idle – Idle → ~2500 RPM, hold for 5 seconds → return to Idle and hold for 10 seconds | Repeat 3 times
7	• Idle for 60 seconds to allow NO_x emissions to stabilise
8-10	• NO_x Acceleration – Stationary → 30 kph → Stationary | Repeat 3 times
11	• Return vehicle to workshop/garage to uninstall | Disconnect parSYNC and place on bench and connect to wall power | Sample clean ambient air for 60 seconds
Zero	• Run zeroing procedure with parSYNC on the bench

Whole Test sequence completed within 15-20 minutes once equipment is warm

Example of a PTI Protocol Test – Diesel

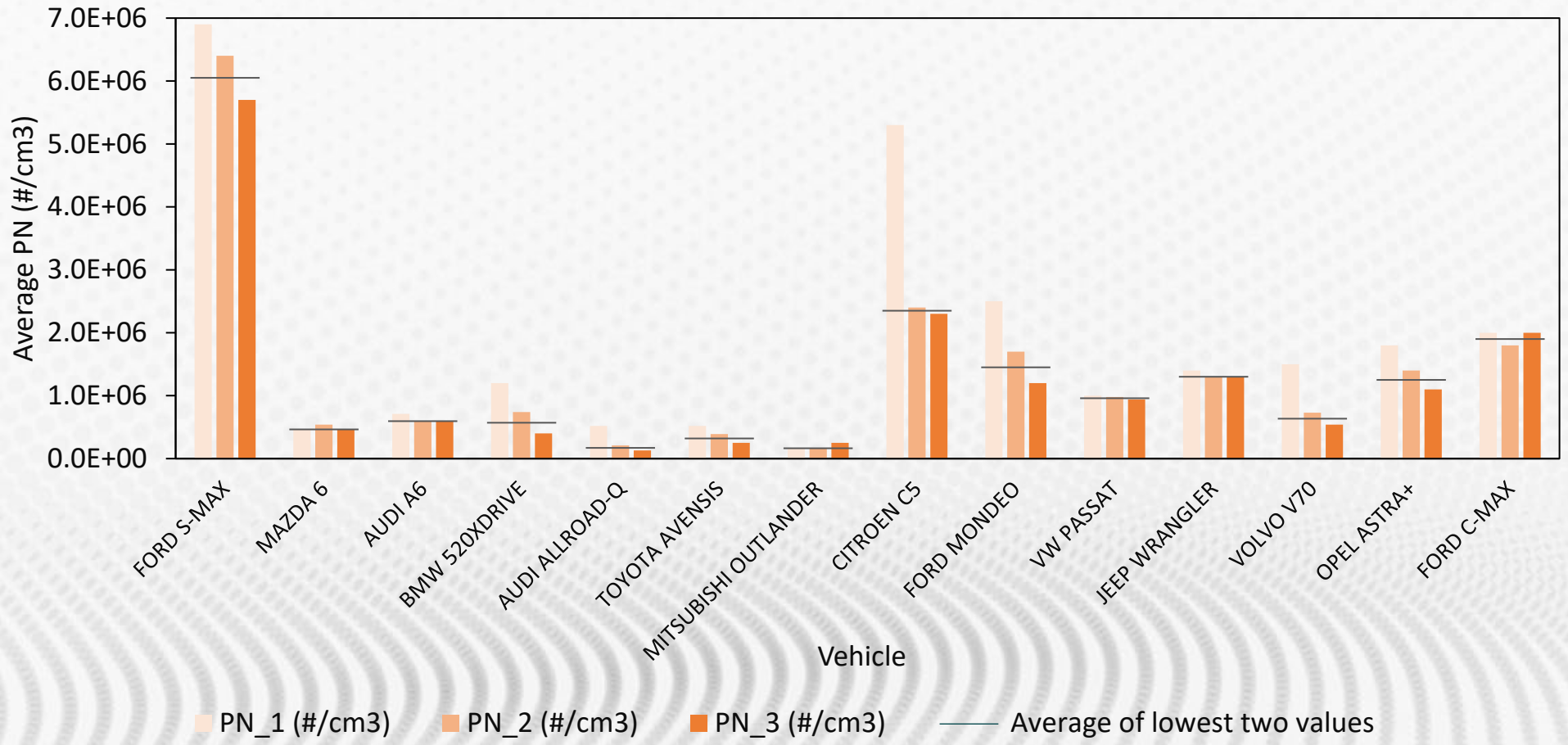


Example of a PTI Protocol Test – Petrol



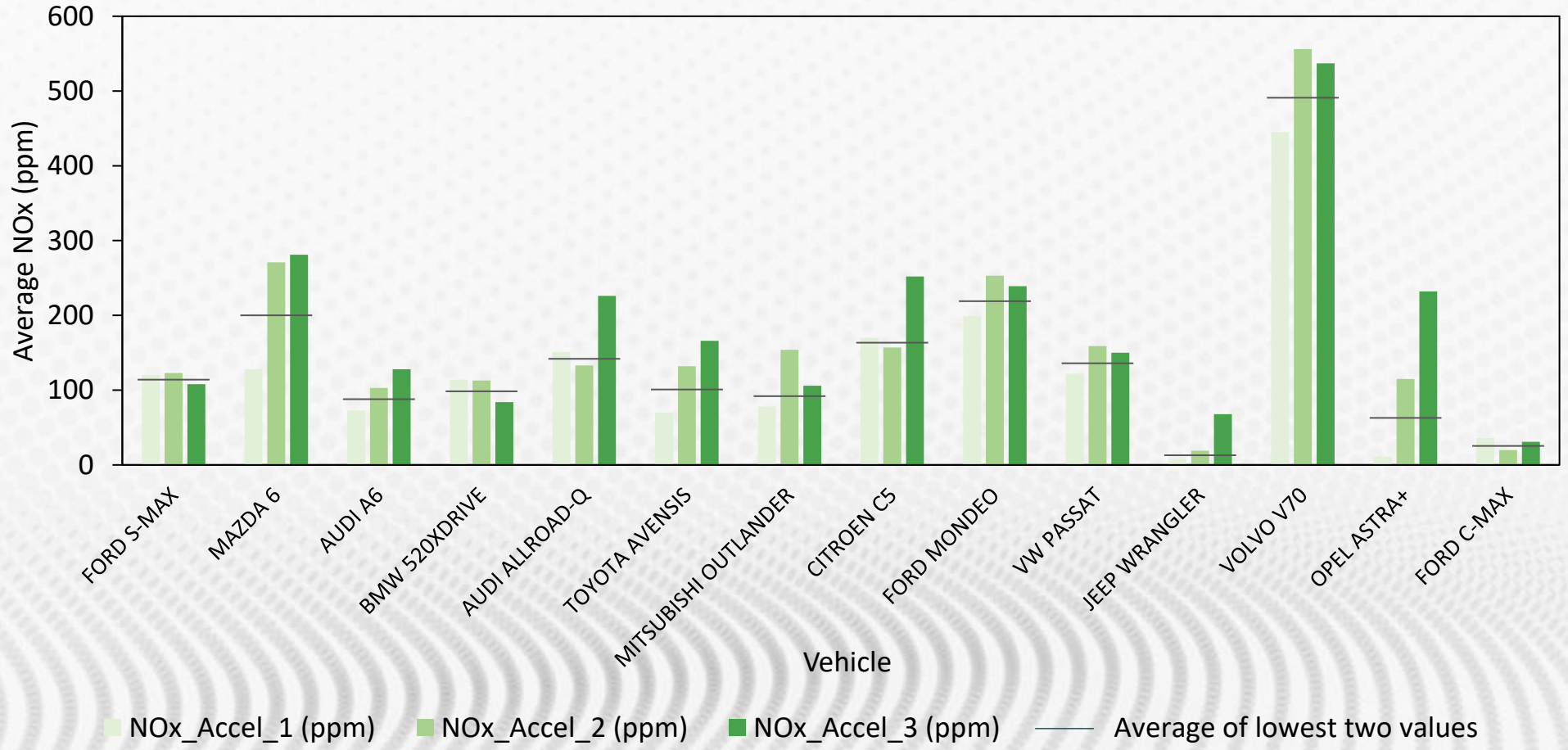
Preliminary PN Results – Idle Test

Initial findings from 14 trial PTI tests. Average PN concentrations are calculated from the PN engine idle test periods.



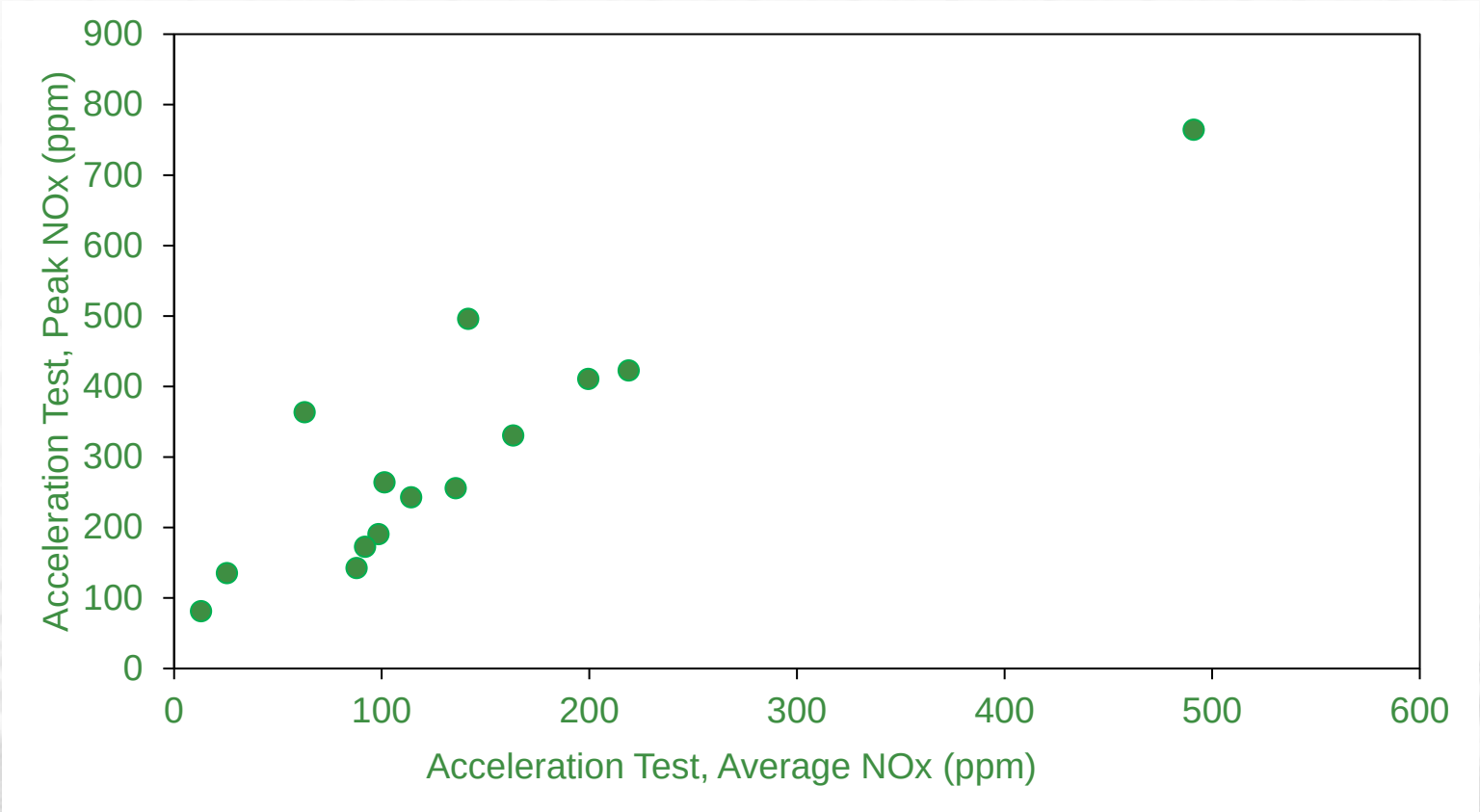
Preliminary NOx Results – Acceleration Test

Initial findings from 14 trial PTI tests. Average NOx concentrations are calculated from the NOx acceleration test periods.



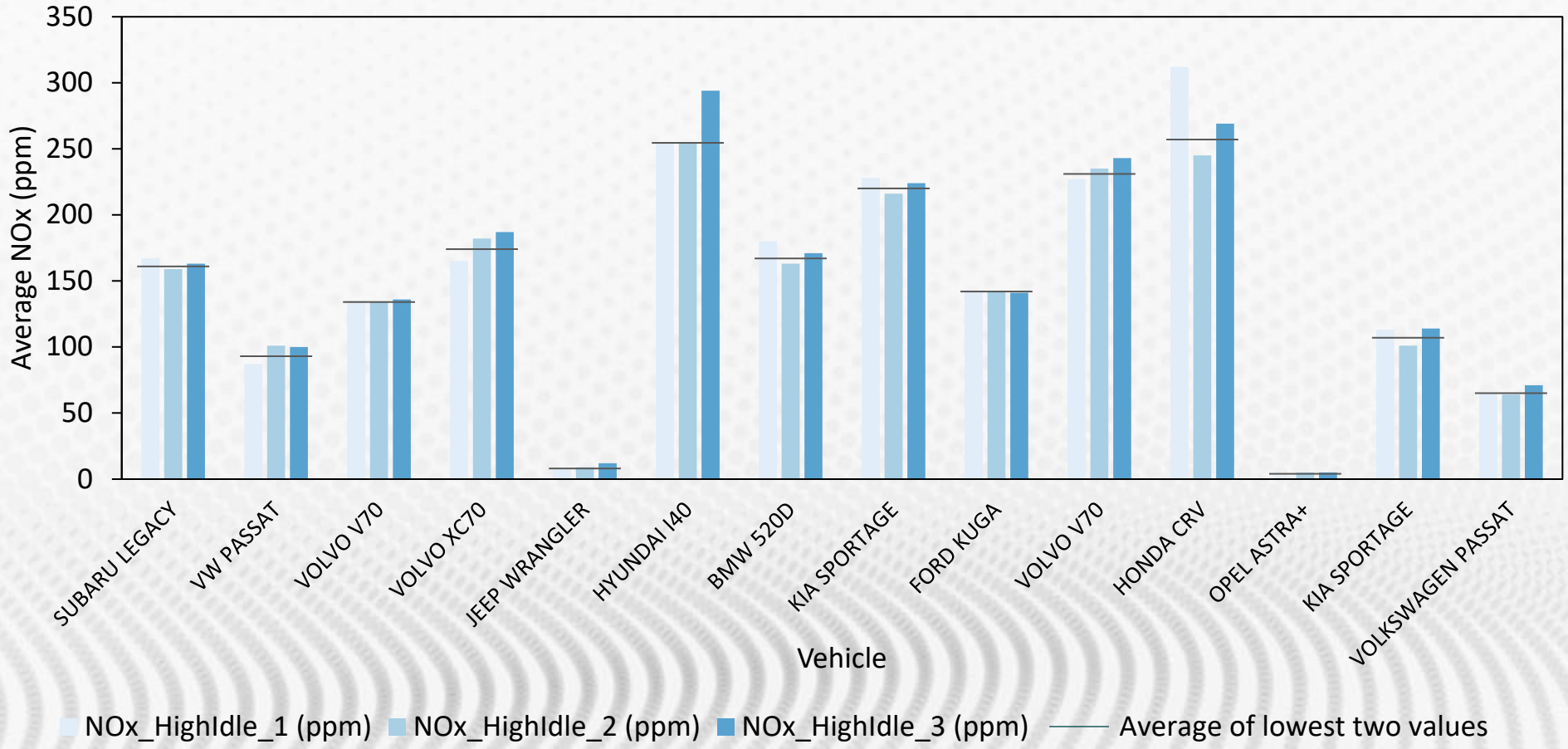
Relationship between Average and Peak Values

Positive correlation seen between the NO_x acceleration test's average NO_x value and peak NO_x value for individual vehicles.



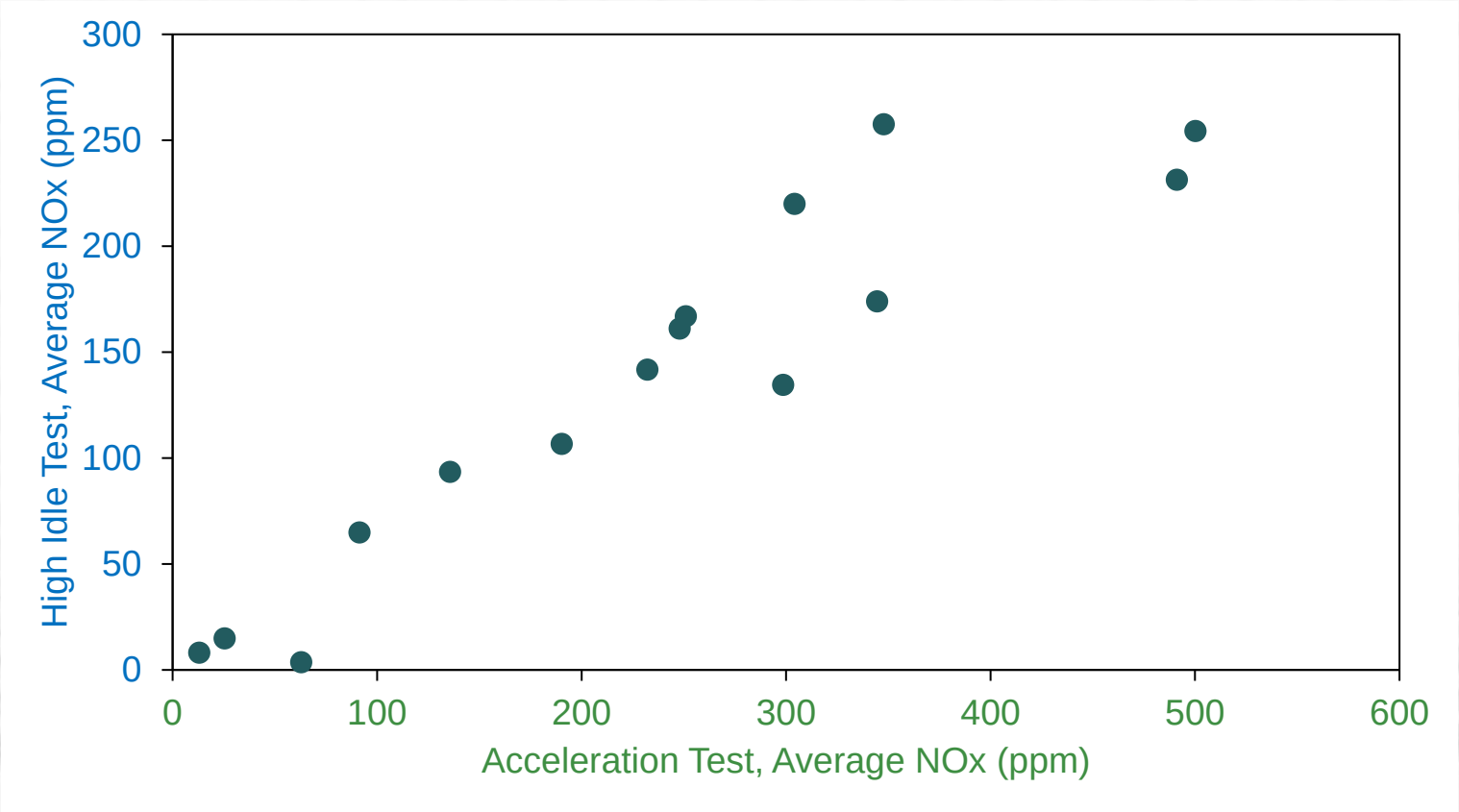
Preliminary NOx Results – High Idle Test

Initial findings from 14 trial PTI tests. Average NOx concentrations are calculated from the NOx High Idle test periods.



Relationship between Acceleration and High Idle Test Results

Positive correlation seen between the average NO_x high idle test results and acceleration test results for individual vehicles.



Preliminary Trial Conclusions and Next Steps

➢OPUS Trial Preliminary Conclusions:

- The PN Idle test works well, but an improved engine warming/conditioning procedure is required
- Both NOx tests appear promising, with good correlation between the two tests for individual vehicles

➢Phase 2 of PTI Pilot:

- Continue to refine the test protocol and pollutant metrics
- Expanded testing locations and including with additional partners
- Expanded scale of test vehicles

➢Database Development:

- Coordinate with suitable partners such as JRC
- Share vehicle emissions database with pilot partners
- Provide a web-based interface to extract emissions trends and reports from the database

Thank You for Listening!

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