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

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Outline

- PTI Overview
  - PTI Today
  - PTI Tomorrow
- parSYNC iPEMS Solution
- PTI Pilot at Opus Sweden – Initial Findings
  - Pilot Info
  - Test Protocol
  - Initial Findings
- Preliminary Trial Conclusions and Next Steps
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Directive 2014/45/EU is out of date: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
Post Dieselgate, European emission measurement is progressing:
- EU has implemented PMP and RDE protocol for vehicle type-approval testing, with measurement of CO, NO\textsubscript{x}, HC+NO\textsubscript{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\textsubscript{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
- NO\textsubscript{x} protocol, measurement & threshold to be developed and tested
- CO and CO\textsubscript{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
This presentation covers Phase-1 data collected at the Borås site.
Vehicles Tested
# Vehicle Summary

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Jan 21 to Feb 18, 2021
Test Setup and Conditions

parSYNC warmup and zeroing while vehicle is being prepared

Tailpipe Sampling Probe

parSYNC iPEMS

OBD Logger

Test Vehicle
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\textsubscript{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\textsubscript{x} emissions to stabilise

- **8-10**
  - NO\textsubscript{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.
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\textsubscript{x} acceleration test’s average NO\textsubscript{x} value and peak NO\textsubscript{x} value for individual vehicles.

![Graph showing the relationship between average NO\textsubscript{x} and peak NO\textsubscript{x} values during acceleration tests.](image)
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.
Positive correlation seen between the average NO\textsubscript{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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Acknowledgements

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  ▪ Stefan Bjurkvist, Operation Managing Inspection Technician
  ▪ Jonas Lindén, Inspection Technician
  ▪ Natalie Wester, Inspection Technician

➢ 3DATX
  ▪ Ami Alderman, Ph.D., Director of Operations
  ▪ Larry Mattison, Director of Engineering
  ▪ Mike Dio, Lead – Customer Sales and Support
  ▪ Sean Dineen, Head Engineer of Production

➢ Other
  ▪ Claudia Toro, Ph.D., Data Analysis Scientist