Sustainable Emission Testing SET II Project General Findings

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CITA SET II
Periodic NO_x-emission tests for passenger vehicles with diesel engine

1. Approach of the study

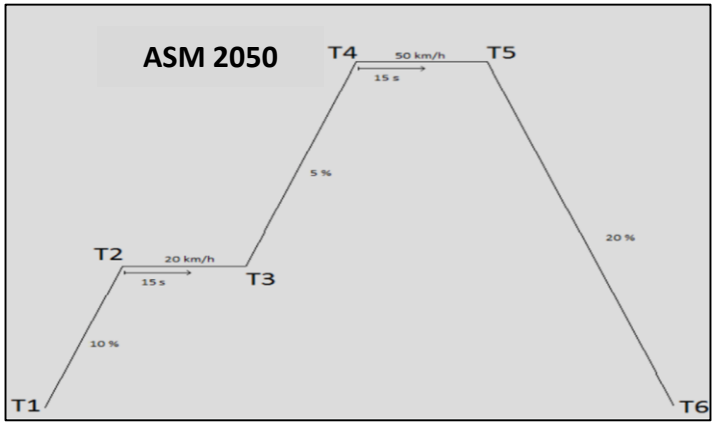
- ✓ **Performed comprehensive review** of the methods, instruments and research related to emission testing of NO_x during PTI;
- ✓ **Identified** generally applicable **test methods** for loaded and unloaded tests;
- ✓ **Performed laboratory investigation** of the test methods identified to derive meaningful **test methods for field tests;**
- ✓ **Performed** a large number of **field tests** in different countries
- ✓ **Evaluated results** of laboratory and field tests;
- ✓ **Made recommendations** for future PTI emission tests.

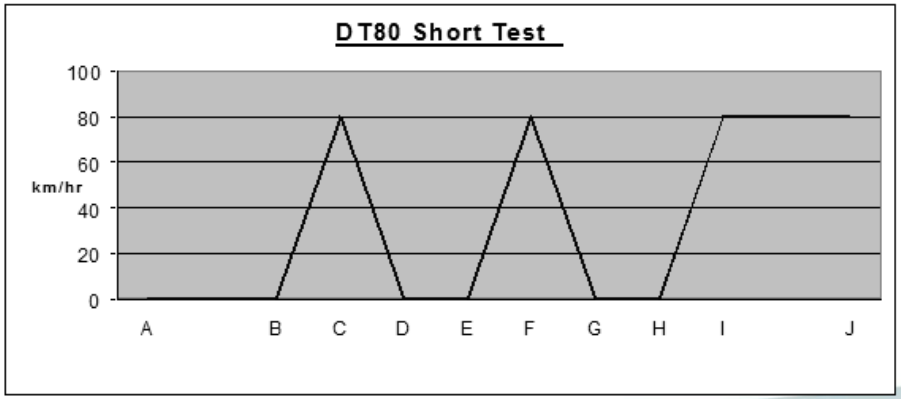
2. Laboratory test procedures

From the literature research the following procedures were selected

2.1 Loaded tests

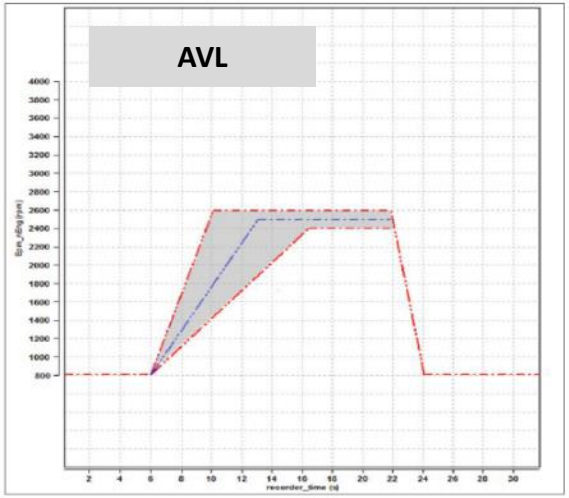
- DT80;
- ASM 2050;
- Short test drive.



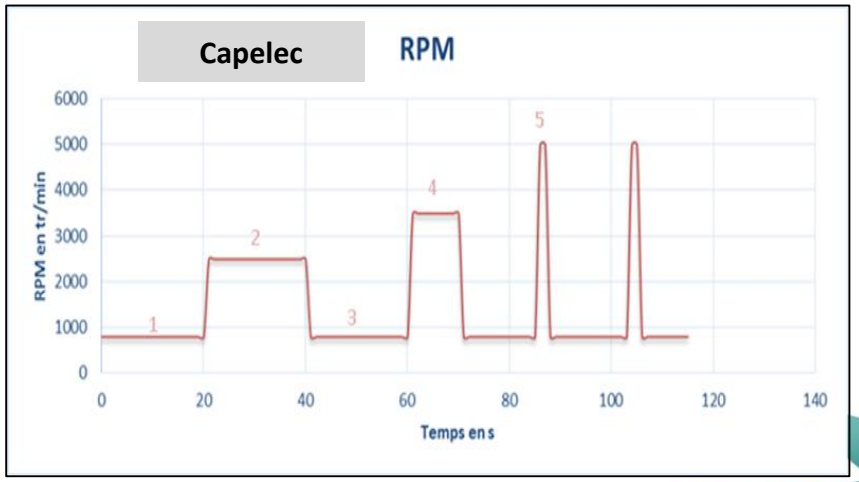


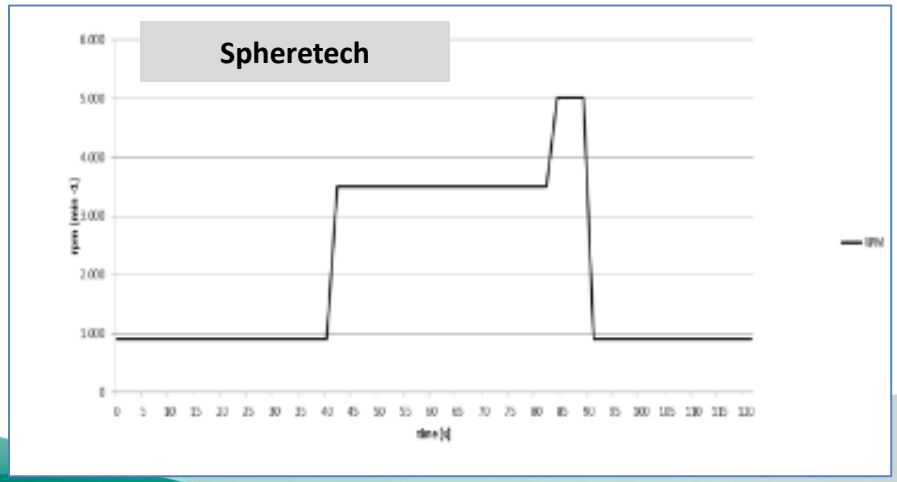
2. Laboratory test procedures

2.2 Unloaded tests



- **AVL** - a slow acceleration;
- **Capelec** - accelerations to different idling rpm;
- **Spheretech** - different measuremts using exhaust emissions as a kind of diagnostic scheme.





3. Main findings of laboratory tests

3.1 Loaded tests

- **DT80**:
  - Ability to detect failure related emissions is ok;
  - High speed and long cycle needs more time than ASM cycle.
- **ASM 2050:**
  - Ability to detect failure related emissions is already ok;
  - Good repeatability and accuracy.
- **Short test ride**:
  - Ability to detect failure related emissions is ok;
  - Need of distance (50 m or more), which is not available in all test houses;
  - Repeatability has to be improved.

3.2 Unloaded tests

- **AVL, Capelec, Spheretech:**
  - Ability to detect failure related emissions is less obvious;
  - Capelec focus on EGR system.

4. Laboratory tests and initial ranking of the methods

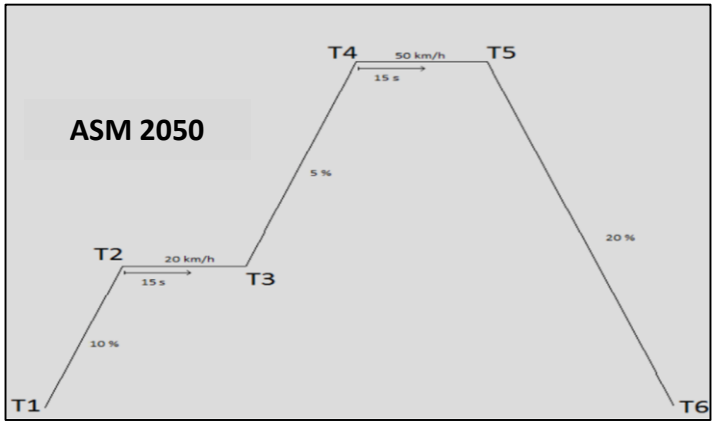
Criteria	Sphere-tech	Capelec	AVL	DT 80	ASM 2050	Short Test Ride
Ability to detect failures of different emission systems	X	X	X	XXX	XXX	XX
Over all accuracy of method	X	X	X	XX	XX	X
Applicable for all vehicles	XX	XX	XX	XXX	XXX	XX
Time and Investment needed	XXX	XXX	XXX	X	XX	XX

XXX = very positive XX = positive X = partly positive

5. Field test procedures selected

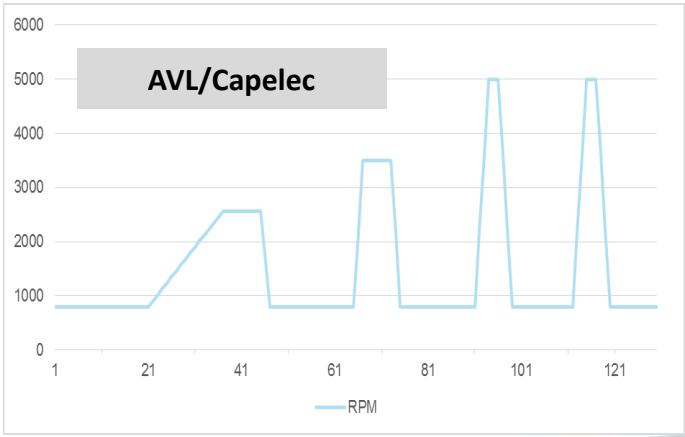
5.1 Loaded tests

- ASM 2050



5.2 Unloaded tests

- Combination AVL/Capelec



5.3 Field tests conducted

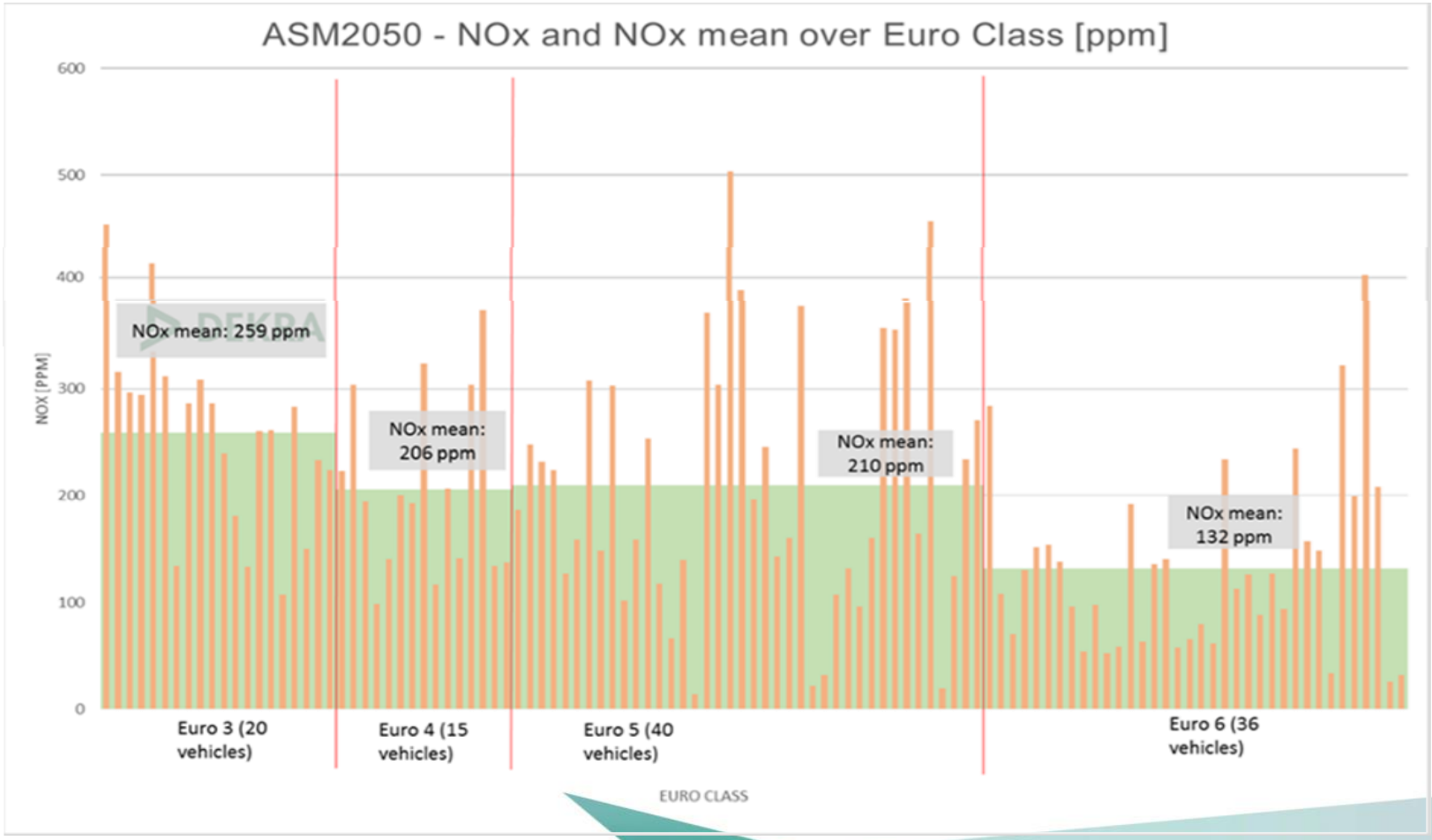
18 Participating companies (6 countries) and 826 diesel passenger cars tested

Company	Country	SETII Equipment
Bilprovningen	Sweden	AVL
ITVASA	Spain	AVL
Opus Bilprovning AB	Sweden	AVL
RDW	The Netherlands	AVL
AMSS-CMV	Serbia	CAPELEC
Applus+	Spain	CAPELEC
Certio ITV	Spain	CAPELEC
General de Servicicios ITV, S.A.	Spain	CAPELEC
TÜV NORD	Germany	SPHERETECH
Applus+	Spain	MAHA
CVH	Republic of Croatia	MAHA
FSD	Germany	MAHA
General de Servicicios ITV, S.A.	Spain	MAHA
Grupo Itevelesa	Spain	MAHA
SYC	Spain	MAHA
Veiasa	Spain	MAHA

Test Method	Equipment	# tested vehicles
AVL/CAPELEC	AVL	259
AVL/CAPELEC	Capelec	354
ASM2050	MAHA	213
Total		826

6. Main findings of field tests

6.1 Results of the loaded tests ASM 2050



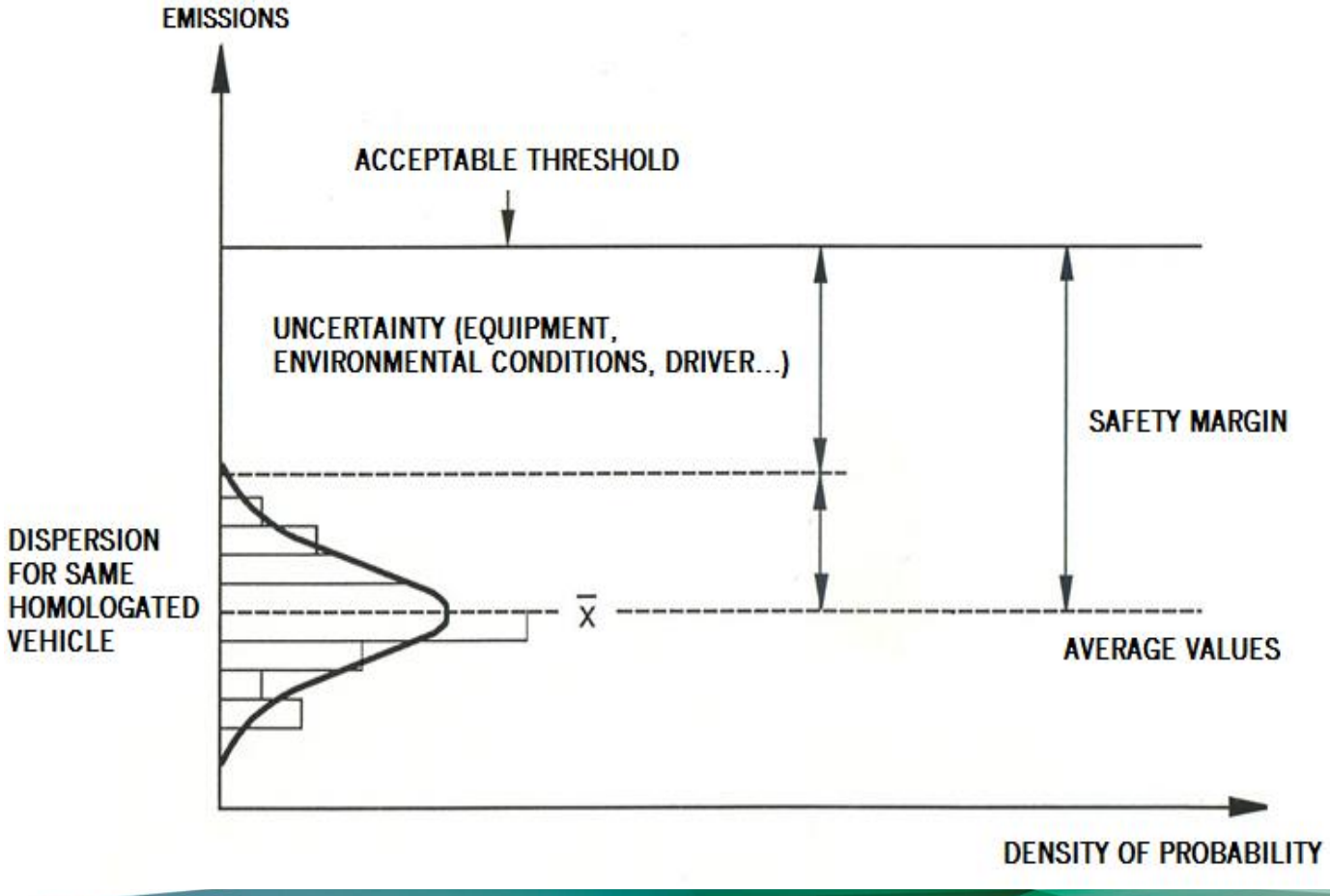
6.1.1 Main finding of the loaded tests ASM 2050

- Concentrations of NO_x between 50 ppm and 600 ppm;
- Average NO_x is decreasing from Euro 3 to Euro 6, but not in correlation with type approval
- Further analysis for appropriate thresholds is necessary

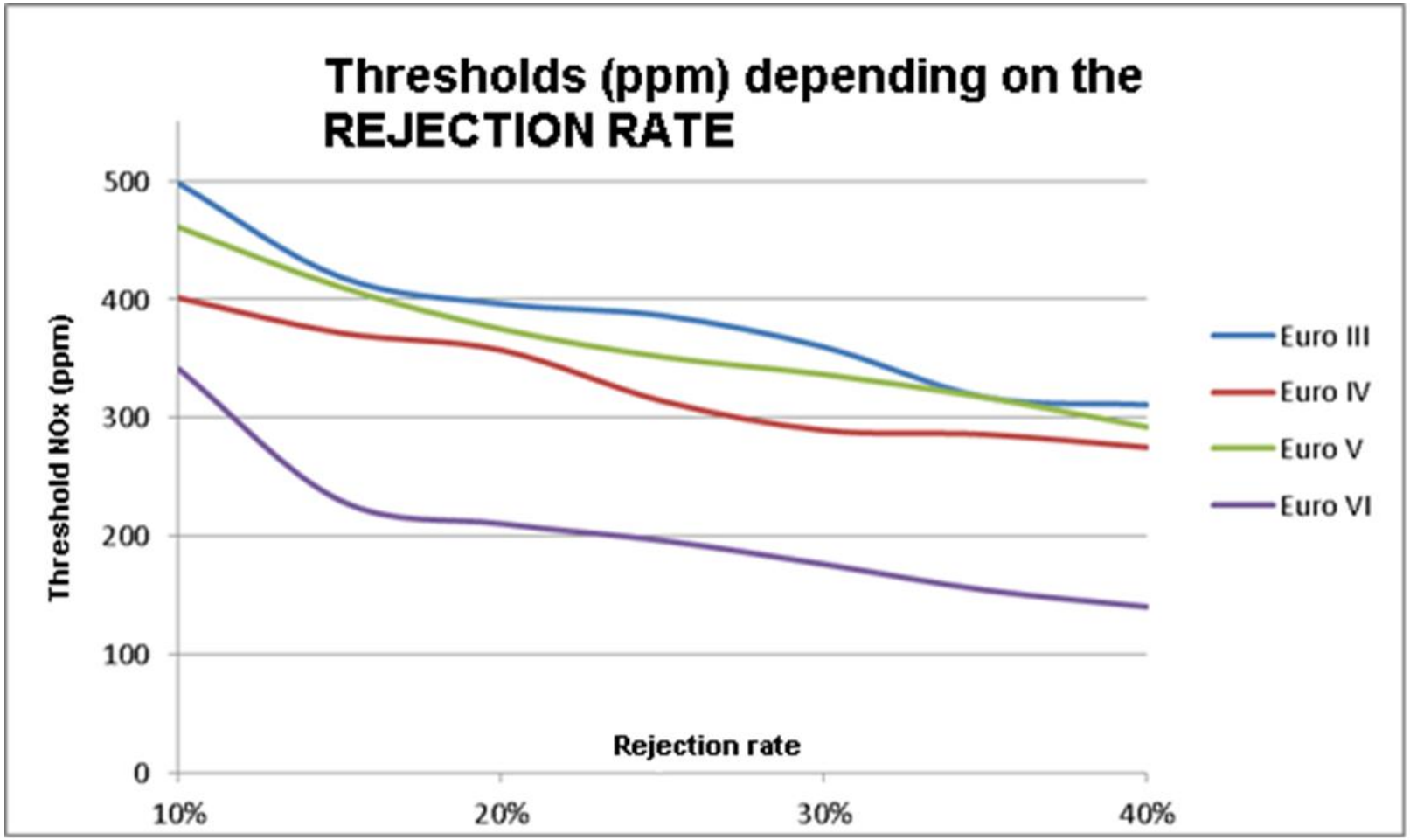
- Inherent to field tests is that the real condition of the vehicle is not known (e. g. software concept, SCR-temperature)
- Reasons for the wide spread of concentrations could be:
  - Failure condition of components or engine (deterioration or manipulation)
  - Legal reduction or switch off of the operation («thermo window»)
  - Vehicle not sufficient conditioned (e. g. temperature)
  - Regeneration phase

6.1.2 Possible approach to define thresholds for the loaded test ASM 2050

To define possible thresholds, as well as the dispersion of the vehicle values, it is necessary to take into account the uncertainties associated with the measure:

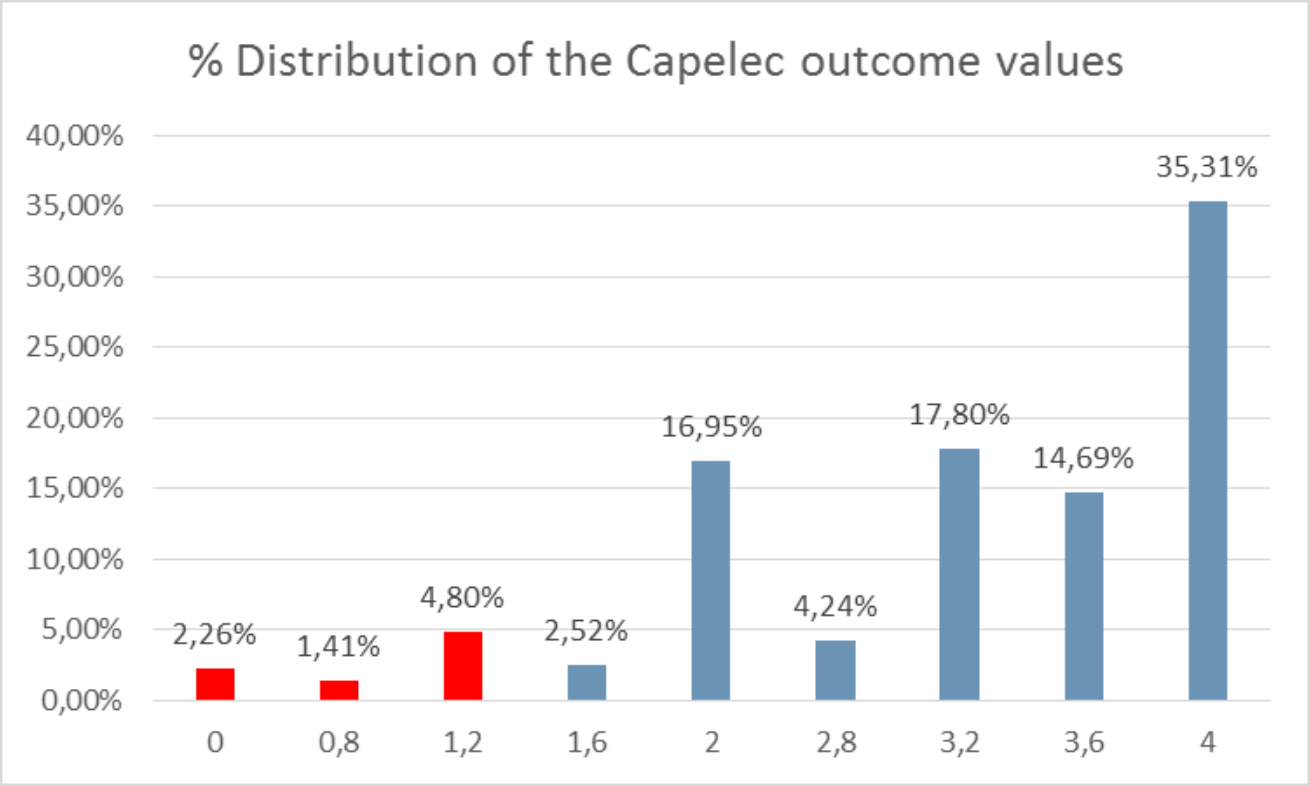


6.1.3 Possible thresholds based on the rejection rate required



6.2 Results of the un loaded tests

6.2.1 Results of the unloaded tests Capelec

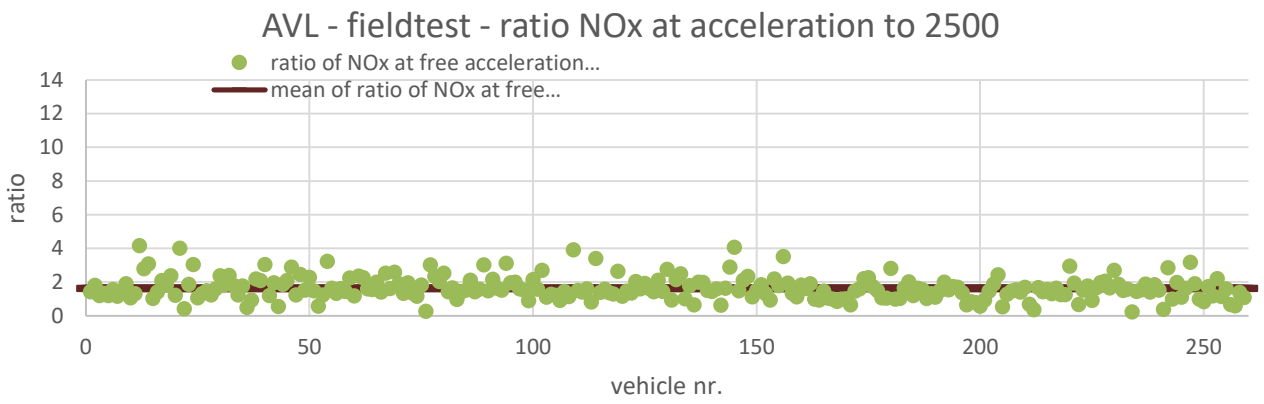


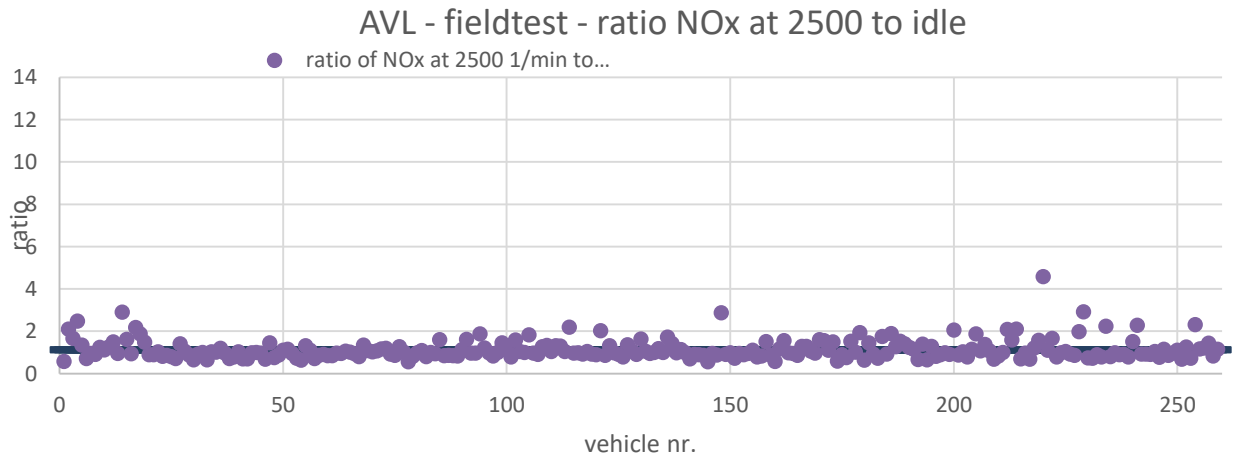
Values less than 1,5 are considered to indicate problems with the EGR system

6.2.2 Main finding of the unloaded Capelec test

- Capelec cycle focuses only on EGR-based after treatment systems;
- Results indicate 8,5% of the tested vehicles have problems with the EGR systems;
- Since the Capelec test is based on the evaluation of ratio’s, the influence of temperature is less important;

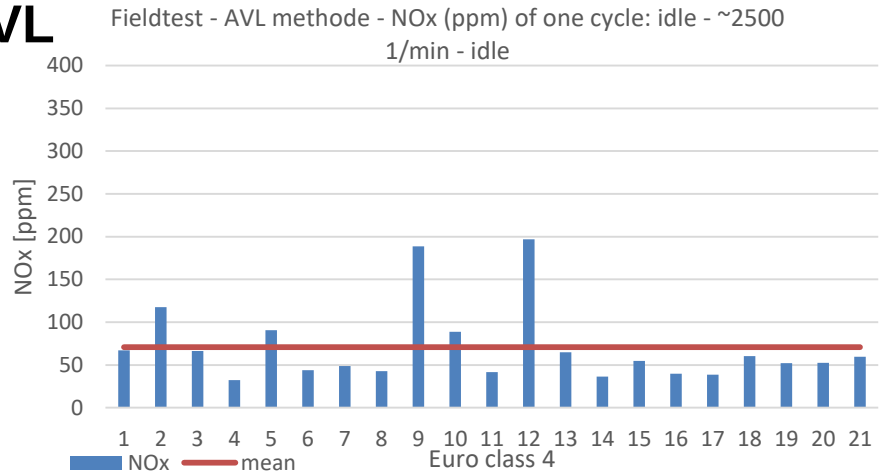
6.2.3 Results of the unloaded test AVL

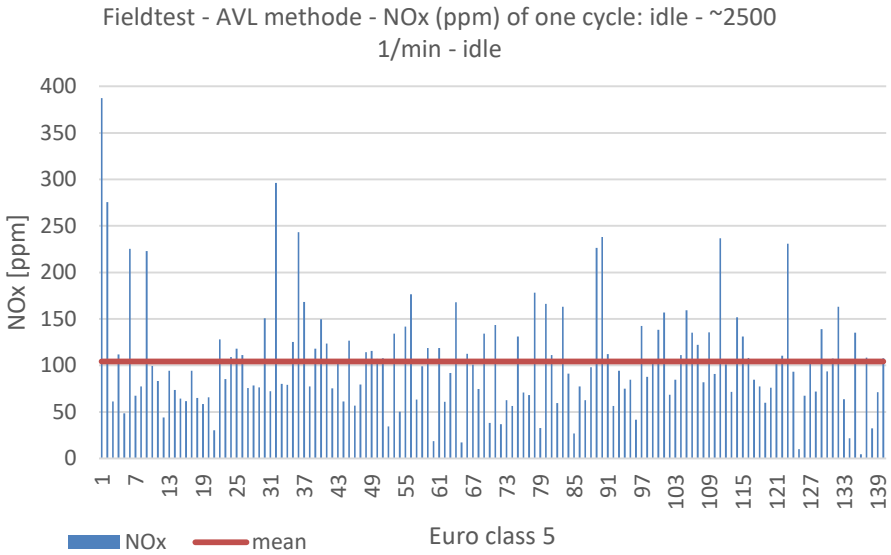


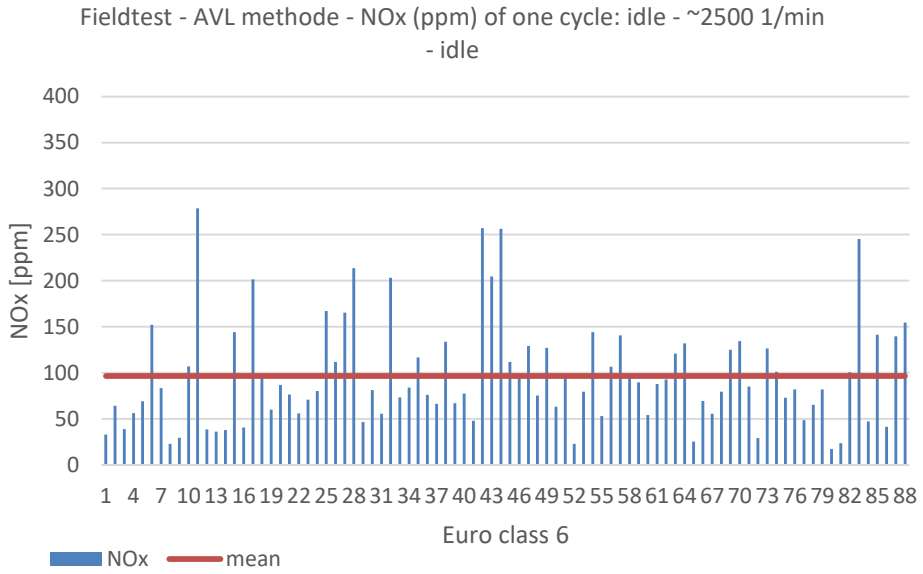


AVL – method based on the difference between NOx concentrations at different rpm conditions the ratio is estimated after certain number of acceleration compared an evaluated.

6.2.3 Results of the unloaded test AVL







6.2.4 Main findings of the unloaded AVL test methode

- AVL cycle focuses only on EGR-based after treatment systems
- Concentration NOx between 20 ppm and 370 ppm, average NOx concentration approx. 100 ppm
- NOx concentration even increasing from Euro 4 to Euro 6
- Further analysis for appropriate thresholds necessary

7. General findings

- Test methods **with load simulation** show a good potential to detect emission related failures: **the ratio** between **concentration values** between vehicles that pass and fail **is high (up to 4)**
- The test methods **without load simulation** show **lower ratios (less than 2)** between vehicles that pass and fail. High idle tests are sometimes not possible because of the limitation of the cut off speed.
- **Conditioning is important for a robust result of an emission test.** Especially for SCR systems the motor/catalyst temperature is very significant for the level of NO_X-concentration and the efficiency of the system in general
- It is important to have **information regarding the after treatment system** as well as on the software strategy and its function to evaluate possible interaction of several installed systems

8. Conclusion

- To be able to evaluate the NOx-behavior of diesel engine after treatment systems, there is a need for **specific technical information** for the vehicle:
  - After treatment systems installed
  - Software strategy (mode of operation)
- **Precondition of the vehicle** is crucial for a valid test result
- **Loaded tests are more meaningful** than unloaded tests
- The **combination** of **comprehensive OBD-information and emission tests** are necessary for a proper evaluation
- The tests conducted emphasize the **complexity of NOx measurement** in practice
- **Further tests are needed to give confidence in initial results**

9. Recommendations

- **Further tests are required**:
  - To define thresholds
  - To get better understanding of the behavior of after treatment systems
  - To elaborate practical procedures for periodic emission tests
- **Short test drive** as an alternative seems promising, but needs further investigation
- Further tests should include an **extended OBD-reading** (diagnostic tool) and **vehicle specific information** provided by the OEM
- **Specific reference values for later periodic emission** tests should be defined at the time of type approval (Euro 6 and further)
- It seems appropriate to **combine the loaded ASM method with unloaded test method for EGR assessment and OBD – read out** for better evaluation
- **Coordinated EU-wide approach** is necessary

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