EUROPEAN UNION DEVELOPMENT OF IN USE EVALUATION METHOD FOR NON ROAD MOBILE MACHINERY

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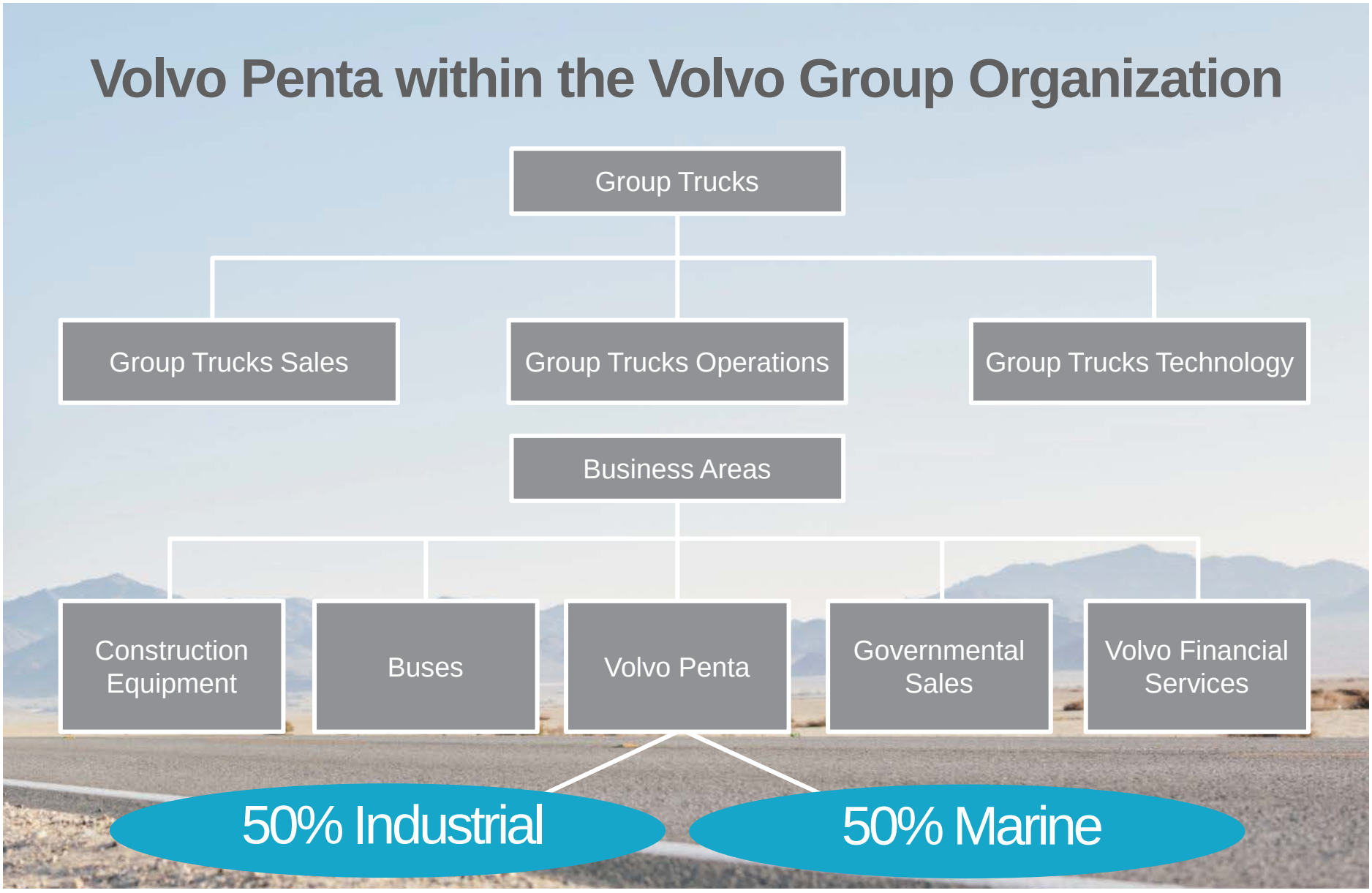
Agenda

1. Volvo Penta and Volvo Group Organization
2. Background to EU Non-Road PEMS
3. Likely future PEMS requirements for Non-Road in EU
4. Non-Road In Use Evaluation Development

Volvo Penta within the Volvo Group Organization



Background

- For Heavy-Duty On-Road in EU PEMS testing is mandatory.

- Non-Road gaseous PEMS pilot program goal:
  - The result (pass/fail) of the test shall give sufficient confidence that the engines - if extracted from the machine - would comply with the applicable emissions limits on the type approval transient cycle (NRTC).

- Existing evaluation methods were:
  - US Not-To-Exceed (NTE)
  - EU Heavy Duty On-Road, Work-Based-Window (WBW)

Background

US Not To Exceed method

- US NTE sets a limit for emissions during **≥30 seconds** with:
  - High enough torque
  - High enough engine speed
  - High enough engine power
  - …

For many non road applications there would be few or no NTE events. NTE does not reflect the overall emissions from the engine and it does not indicate whether the engine would pass a certification transient test cycle.

EU conclusion: NTE is not a suitable evaluation method for Non Road Mobile Machinery.

Background

EU Heavy Duty On Road WBW (Work-Based-Window)

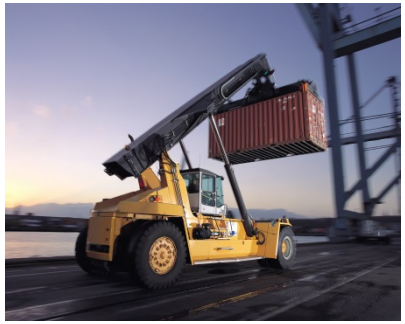
- Emissions in use averaged over the same work as in the transient certification test cycle used in test cell, called work window.
- In Use cycle defined by composition of:
  - city driving
  - rural driving
  - motorway driving

Likely future PEMS requirements for Non-Road in EU

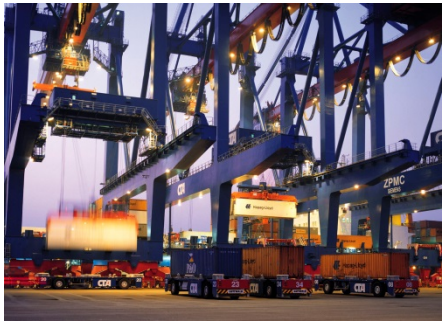
- Next emission step for Non-Road in EU is Stage V starting 2019.
- Variable engine speed Non-Road engines with power from 56 to 560kW in first scope.
- To be measured (per manufacturer) before end of 2024:
  - 9 engines with running hours <30% of full useful life
  - 9 engines with running hours >70% of full useful life
- Currently PM/PN is not in the scope.
- Reporting requirement but no emission limits that have to be met.

EU Non-Road In Use Evaluation Development

- Based on Heavy Duty On Road WBW but without predefined engine use composition. There is no equivalent to “city, rural and motorway driving” for Non Road.



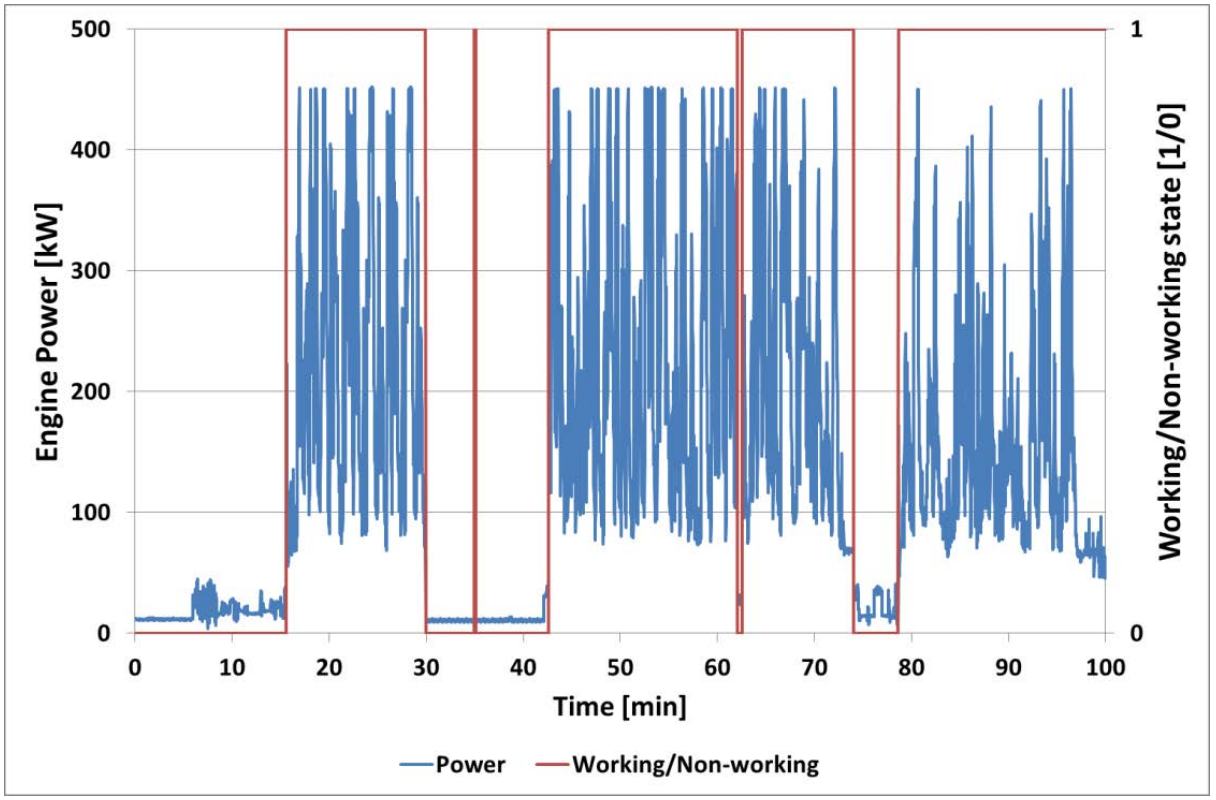





- Engine use not represented in the transient certification test cycle (NRTC) to be excluded.

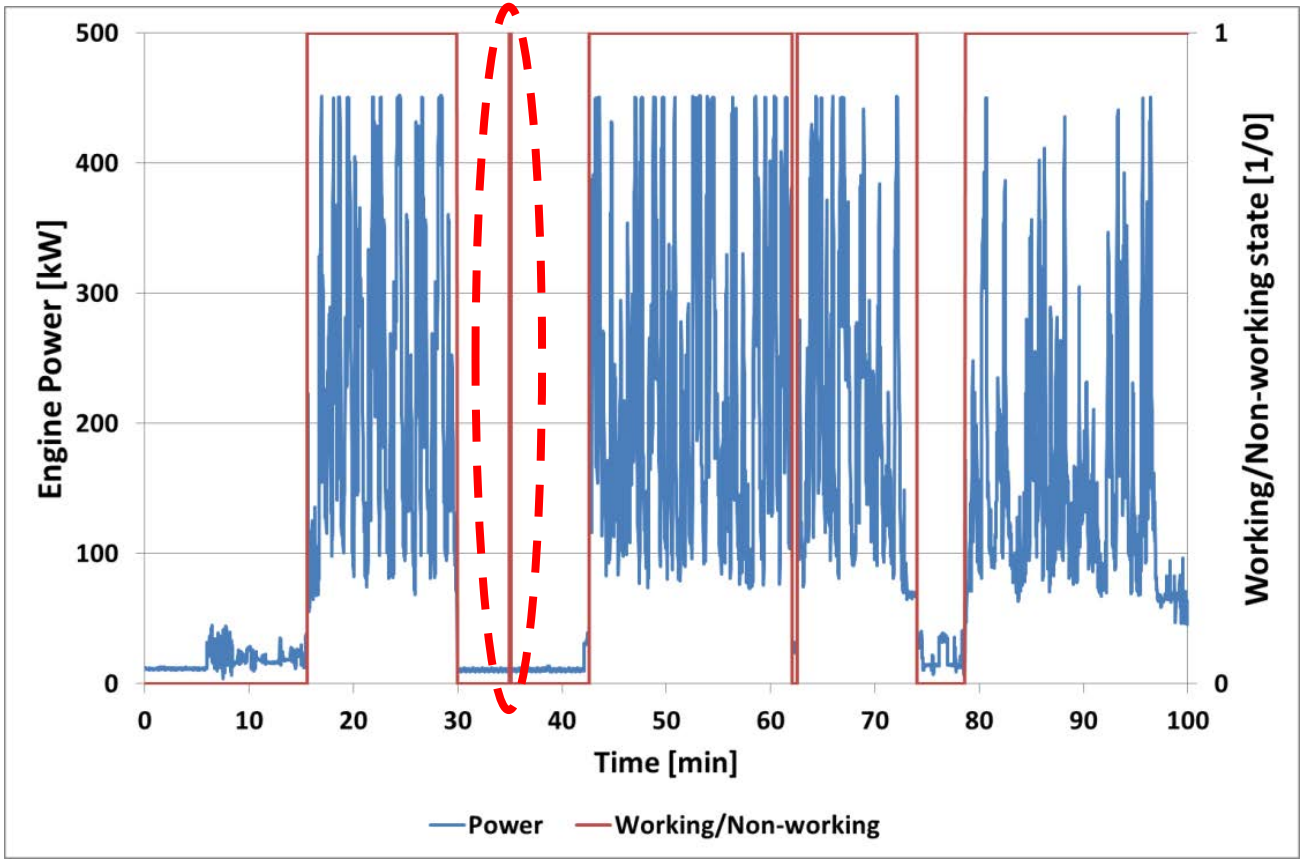
EU Non-Road In Use Evaluation Development

- "Working event" and "Non working event" defined as:
  - Working event: power≥10% of engine maximum power
  - Non working event: power <10% of engine maximum power



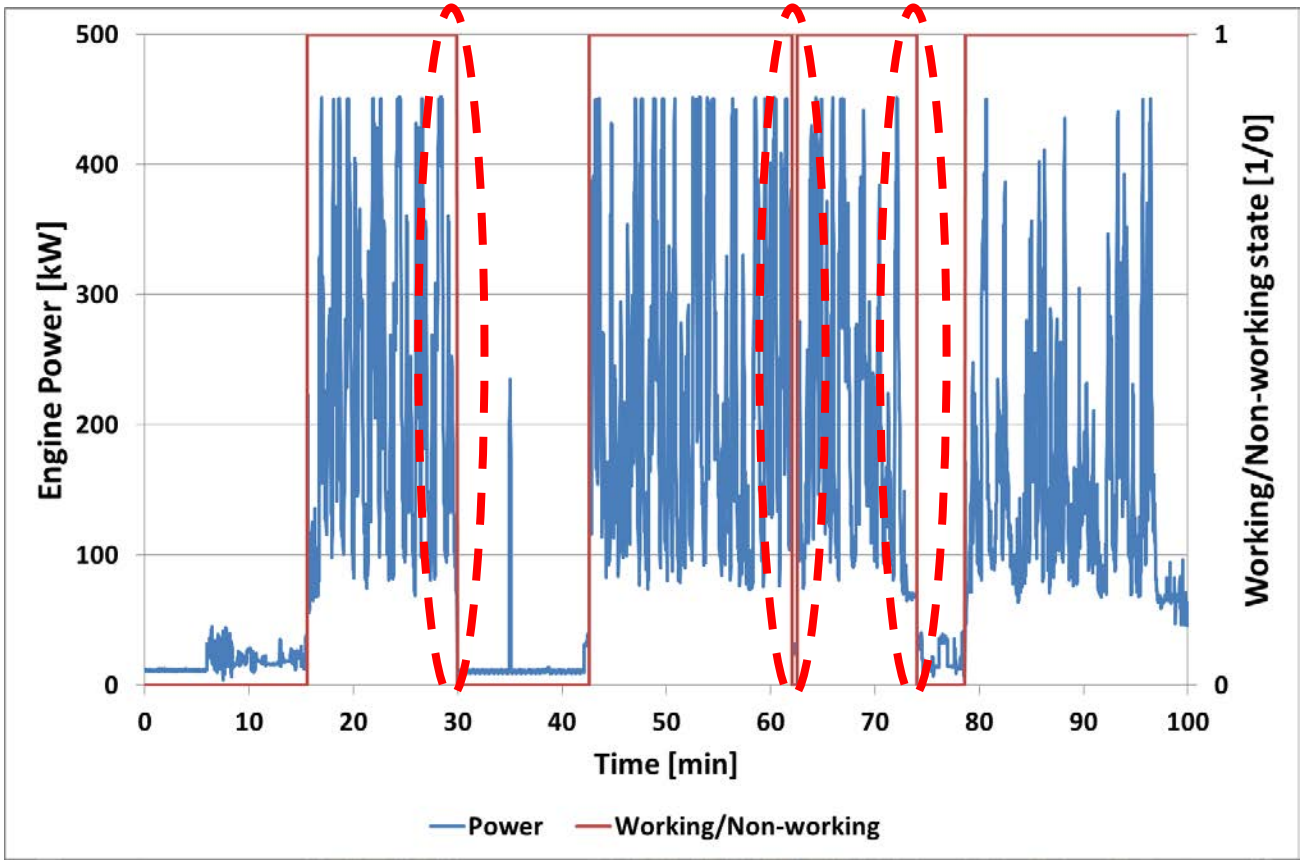
EU Non-Road In Use Evaluation Development

Working events shorter than 2 minutes are merged with surrounding non-working events longer than 2 minutes



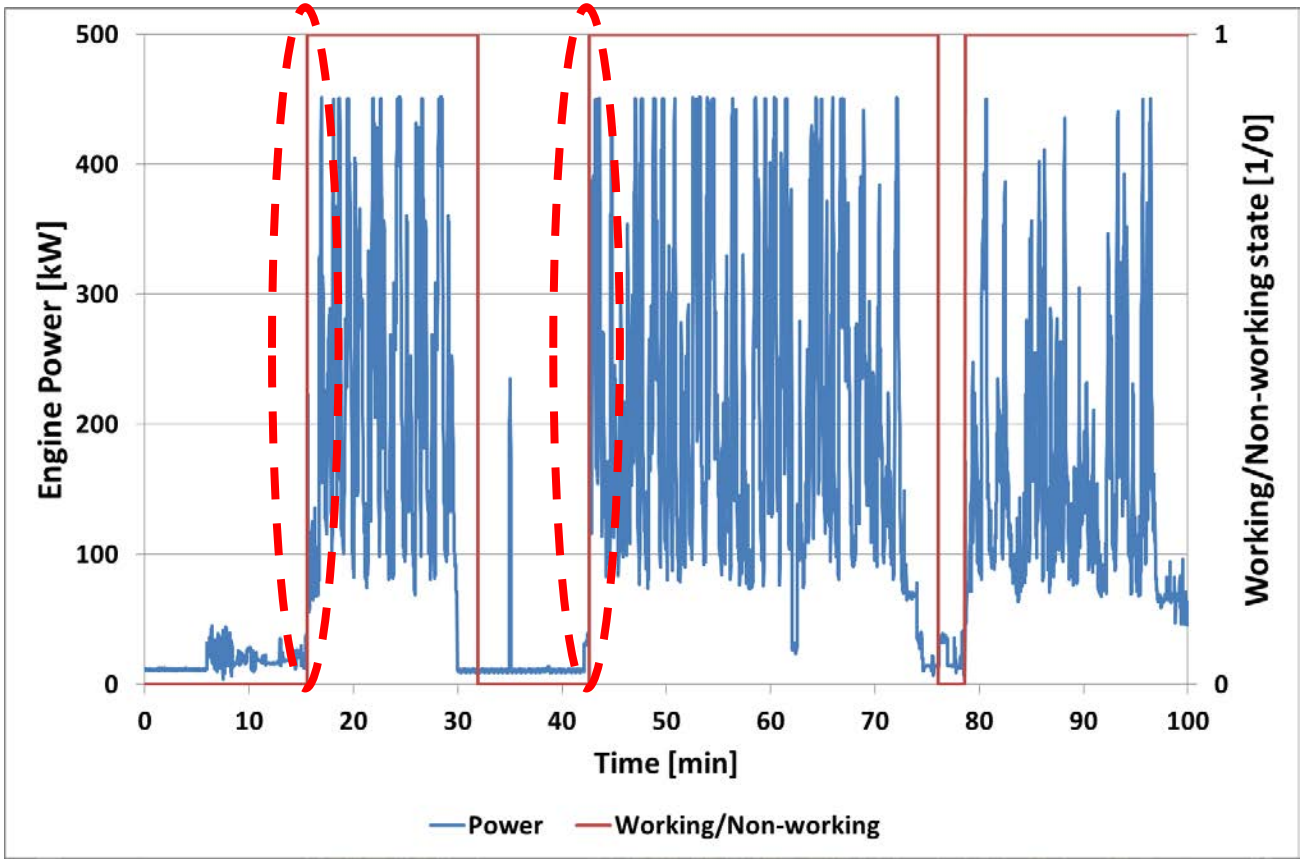
EU Non-Road In Use Evaluation Development

For all non-working events, the first 2 minutes of the events are valid (i.e. defined as working).



EU Non-Road In Use Evaluation Development

Exclude data following long non working events (>10 min) until the exhaust temperature reaches 250ºC or 4 min has passed, whatever occurs first.



EU Non-Road In Use Evaluation Development

Summary:

1. <10% power: Non working, ≥10% power: Working

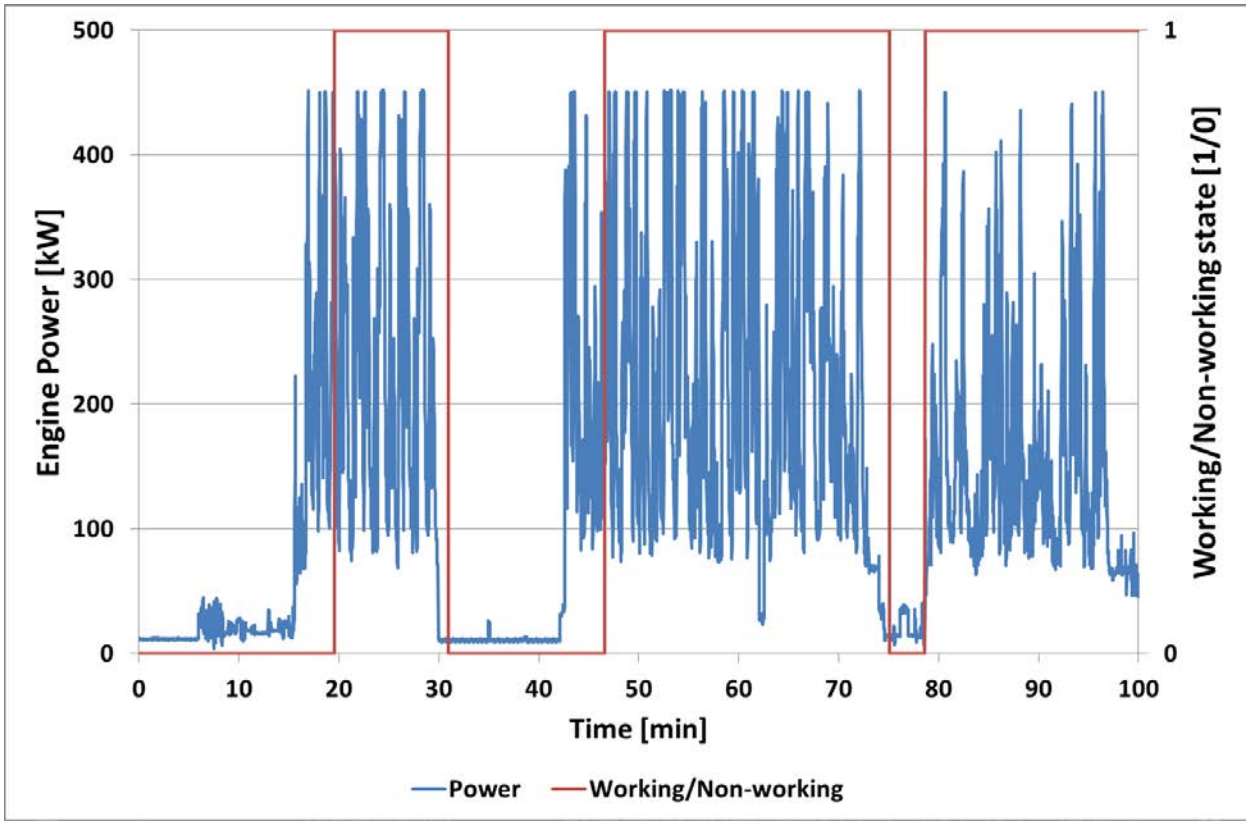
2. Working events shorter than 2 minutes are merged with surrounding non-working events that are longer than 2 minutes.

3. For all non-working events, the first 2 minutes of the events are valid.

4. After long non working events, >10 min, exclusion until the exhaust gas temperature downstream of exhaust aftertreatment system reaches 250ºC or maximum 4 minutes.

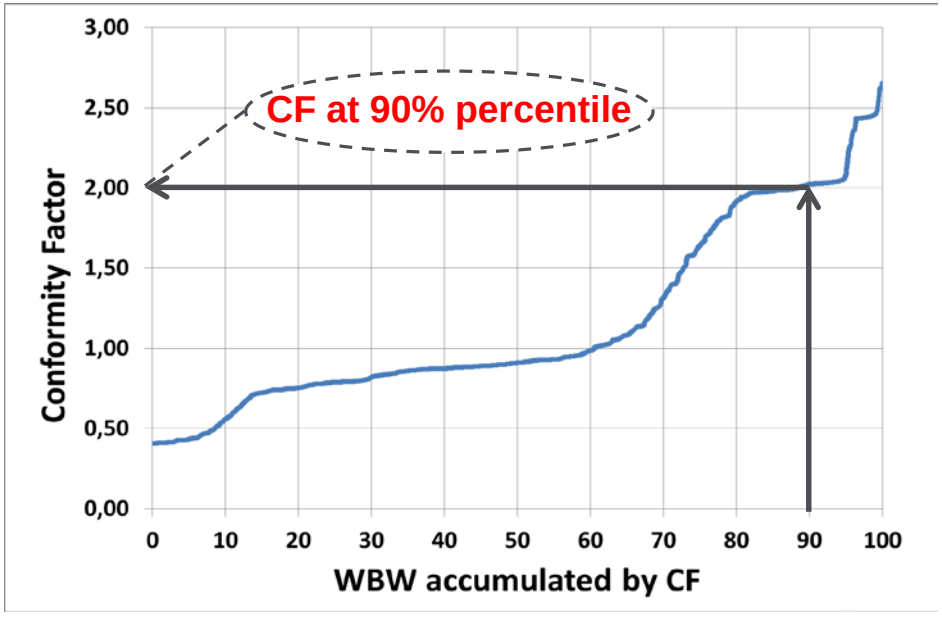
EU Non-Road In Use Evaluation Development

Work-Based-Window is calculated for the remaining working events.



EU Non-Road In Use Evaluation Development

- Only work-based-windows produced with average engine power >20% of maximum power used.
- Calculation of Conformity Factor (CF):
  - The 10% windows with highest brake specific emissions are excluded.
  - The emission value for the 90% percentile divided by the limit for the transient certification cycle -> Conformity Factor (CF)



EU Non-Road In Use Evaluation Development

Summary:

- **The evaluation tool for PEMS-testing of Non-Road engines in EU is available.**

Back-up slides, more detailed information

Ambient test conditions

- The Non Road PEMS tests shall be conducted under ambient conditions meeting the following conditions:
  - Coolant temperature, start evaluation when one of the following is fulfilled:
    - Coolant temp >70ºC or (~158F)
    - Coolant temp ±2ºC (~±4F) within 5 min or
    - Latest after 20min regardless of coolant temperature
  - Ambient temperature >-7ºC (~19F)
  - Ambient temperature <~29-37ºC (~84-99F) (altitude dependent)
  - Ambient pressure >82,5 kPa ambient pressure (~5570ft)

References

- For JRC (Joint Research Center) report on the EU NRMM evaluation method please see: http://publications.jrc.ec.europa.eu/repository/handle/JRC86958