



Homologation und Technik für land- und forstwirtschaftliche Fahrzeuge

Verordnung (EU) 2016/1628 Abgasstufe V Einführung, Anforderungen und Übergangsvorschriften

TÜV NORD Mobilität
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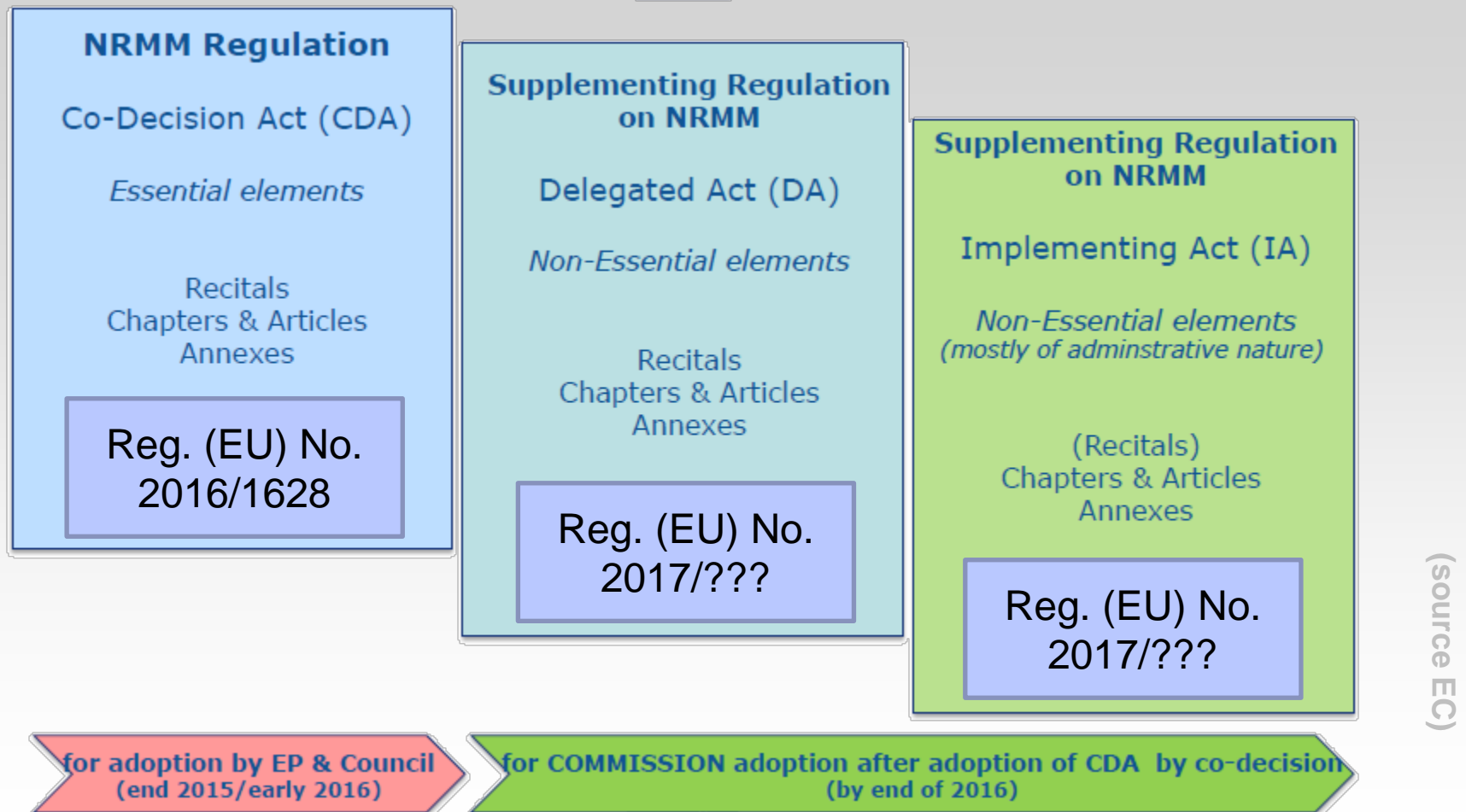


European Parliament adopted the proposal on 8 July 2016, and the final version of the regulation was published on 14 September 2016 .

The type approval for Stage V new non-road engines will start from 1 January 2018 to 1 January 2020, depending on engine types.

The timeline of market placement for the engines will be one year after the scheduled type approval. All new non-road engines entering the EU market have to meet Stage V from 1 January 2021 on.

Structure of legislation



Scope of legislation - Engines categories

NRE: CI and SI engines with constant and variable speed of all power ratings.

Engines with reference power < 560 kW as IWP, IWA RLL, RLR.

NRG: Mobile generating sets with reference power > 560 kW with reference power < 560 kW \rightarrow NRE.

NRSh: SI engines < 19 kW for use in hand-held applications.

NRS: SI engines < 56 kW being not included in NRSh

Scope of legislation - Engines categories

- IWP: engines exclusively for inland waterway vessels-propulsion, with reference power ≥ 19 kW
- IWA: auxiliary engines exclusively for inland waterway vessels with a reference power >19 kW
- RLL: Engines exclusively for locomotive propulsion
- RLR: Engines exclusively for railcar propulsion
- SMB: SI-Engines exclusively for snow mobiles. Others than SI engines \rightarrow NRE.
- ATS: SI-Engines exclusively for all terrain and side-by-side vehicles. Others than SI engines \rightarrow NRE.

Stage V - limits and implementation (NRE)

Engine sub-category	Speed mode	Swept volume [cm³]	Power range; [kW]	Ignition	CO [g/kWh]	HC [g/kWh]	NOx [g/kWh]	PM [g/kWh]	PN [# /kWh]	A	EU type-approval	Market placing
NRE-v-1	variable	-	0<P<8	CI	8,00	(HC+NOx≤7,50)		0,40 ¹⁾	-	1,1	01.01.2018	01.01.2019
NRE-c-1	constant	-										
NRE-v-2	variable	-	8≤P<19	CI	6,60	(HC+NOx≤7,50)		0,40	-	1,1	01.01.2018	01.01.2019
NRE-c-2	constant	-										
NRE-v-3	variable	-	19≤P<37	CI	5,00	(HC+NOx≤4,70)		0,015	1x10 ¹²	1,1	01.01.2018	01.01.2019
NRE-c-3	constant	-										
NRE-v-4	variable	-	37≤P<56	CI	5,00	(HC+NOx≤4,70)		0,015	1x10 ¹²	1,1	01.01.2018	01.01.2019
NRE-c-4	constant	-										
NRE-v-5	variable	-	56≤P<130	all	5,00	0,19	0,40	0,015	1x10 ¹²	1,1	01.01.2019	01.01.2020
NRE-c-5	constant	-										
NRE-v-6	variable	-	130≤P≤560	all	3,50	0,19	0,40	0,015	1x10 ¹²	1,1	01.01.2018	01.01.2019
NRE-c-6	constant	-										
NRE-v-7	variable	-	P>560	all	3,50	0,19	3,50	0,045	-	6,0	01.01.2018	01.01.2019
NRE-c-7	constant	-										

Emission limit NH₃: Mean value of 10 ppm

Transitional Provisions

7. Transitional provisions and exemptions (§ 58)

The regulation (EU) 2016/1628 replaces the flexibility scheme of 97/68/EC with a transition period of 24 months, allowing engines to be placed on the EU market which comply with the latest applicable emission limits prior to Stage V.

- The transition period starts with dates for placing on the market of Stage V engines.
- The transition period is applied to all engine categories.
- Transition engines must comply to the latest applicable emission Stage and must be produced until the dates for placing on the market of Stage V engine.
- The machinery in which the transition engine is installed must have a production date not later than 18 months following the start of the transition period.

Power range			2016	2017	2018	2019	2020	2021	2022
P < 56 kW & P ≥ 130 kW	Production	Engine	previous Stage			Stage V			
		Machine				with transition engine			
	Placing on the market	Engine				Transition period			
		Machine							
56 kW ≤ P < 130 kW	Production	Engine	Stage IV						
		Machine							
	Placing on the market	Engine							
		Machine							

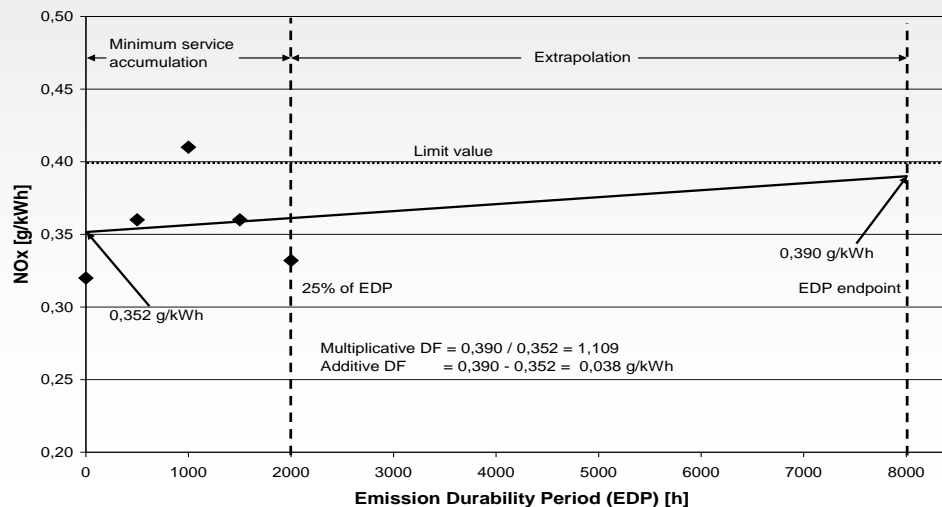
The following exemptions apply:

- For engines of category NRE, **OEMs with a total yearly production of less than 100 units** of non-road mobile machinery equipped with internal combustion engines get an extension of an additional 12 months for the above mentioned dates.
- For engines of category NRE used in **mobile cranes**, the above mentioned dates shall be extended by 12 months.
- For engines of category NRS with an engine power of less than 19 kW used in **snow throwers**, the above mentioned dates shall be extended by 24 months.

(source VDMA)

Stage V - Deterioration Factors (DF)

- DF run according service accumulation schedule
 - engine-aftertreatment system family (similar EAT)
 - service accumulation run with commercial fuel
 - min. 25% runtime of EDP (increased load)
 - NRSC and NRTC hot (variable speed)
 - additive or multiplicative DF per cycle



Stage V - Deterioration Factors (DF)

- alternative procedure on request to TAA
- assigned multiplicative deterioration factors
 - equal stage IV, new PN = 1,0
- existing DF values from stage IV may be used
 - same technology
 - DF results were part of type approval before
 - PN can be used by 0,0 additive or 1,0 multiplicative
- carry across possible for different technology
 - needs approval by type approval authority
- DF-run testing requires all criteria pollutants [3.2.3.2]



DF topics to be approved by authority prior to type approval testing. → non-formal application

Mandatory for: NRE*, NRG, IWP, IWA, RLL and RLR

The NO_x control strategy shall be operational under all environmental conditions regularly pertaining in the territory of the Union, especially at low ambient temperatures.

* also gas engines

AECS may apply outside:

NRE, NRG
and RLR:

- (i) atmospheric pressure greater than or equal to 82.5 kPa
- (ii) ambient temperature within the following range:
 - equal to or above 266 K (-7 °C),
 - less than or equal to the temperature determined by formula section 2.3.3
- (iii) the engine coolant temperature above 343 K (70 °C)

Stage V - NCD and DTC requirements

- **NCD operating conditions:**

- (i) ambient temperature between -7°C and 35°C;
- (ii) at all altitudes below 1600 m;
- (iii) the engine coolant temperature above 70 °C.

- **Standardized communication protocol only for ISM engines**

- (a) ISO 27145 with ISO 15765-4 (CAN-based) or
- (b) ISO 27145 with ISO 13400 (TCP/IP-based) or
- (c) SAE J1939-73.

- **Visual (and acoustic) signals for operator warning system**



solid or blinking, depending on warning or inducement level

Stage V - Warning and inducement – NRE and NRG

1. Warning

- Reagent level below 10 %
- Below CDmin for < 10 h
- Dosing interrupted for < 10h
- EGR / NCD failure, tampering

2. Low-level inducement

- Reagent level below 2,5 %
- Below CDmin for > 10 h but < 20 h
- Dosing interrupted > 10 h but < 20 h
- EGR / NCD failure, tampering > 36 h

3. Severe inducement

- Reagent level below 2,5 % AND no dosing
- Below CDmin for > 20 h
- Dosing interrupted > 20 h
- EGR / NCD failure, tampering > 100 h

Stage V - PCD requirements

“Particulate Control Diagnostic system (PCD)” means a system on-board the engine which has a capability of

- (a) detecting a Particulate Control Malfunction;
- (b) identifying the likely cause of particulate control malfunctions by means of information stored in computer memory and/or communicating that information off-board.

"Particulate Control Malfunction (PCM)" means an attempt to tamper with the diesel particulate filter (DPF) of an engine or a malfunction affecting the DPF that might be due to tampering, that is considered by this Regulation as requiring the activation of a warning once detected.

“PCD engine family” means a manufacturer’s grouping of engines having common methods of monitoring/diagnosing PCMs

Stage V - PCD requirements

- **Documentation requirements:**
 - **Specification of reagent (e.g. FBC) if applicable**
 - **Describe operation strategy to approval authority**
 - **Provide installation documents to OEM to ensure correct operation**
- **Operating conditions:**

The PCD system shall be operational at the following conditions:

- (a) ambient temperatures between 266 K and 308 K (– 7 °C and 35 °C);
- (b) all altitudes below 1600 m;
- (c) engine coolant temperatures above 343 K (70 °C).

Stage V - PCD requirements

- Detection and DTC storage

Monitor type	Period of accumulated running time within which a "confirmed and active" DTC shall be stored
Removal of DPF	60 minutes of non-idle engine operation
Loss of function of DPF	240 minutes of non-idle engine operation
Failures of the PCD system	60 minutes of engine operation

- Warning shall be applied visual; may be combined with NCD

- Erasing DTC

- DTCs shall not be erased by the PCD system itself
- the PCD system may erase DTCs upon request of a scan tool
- incidents of operation with DTC confirmed and active with warning are stored in non-volatile memory after max. 20 h

Stage V - PCD requirements

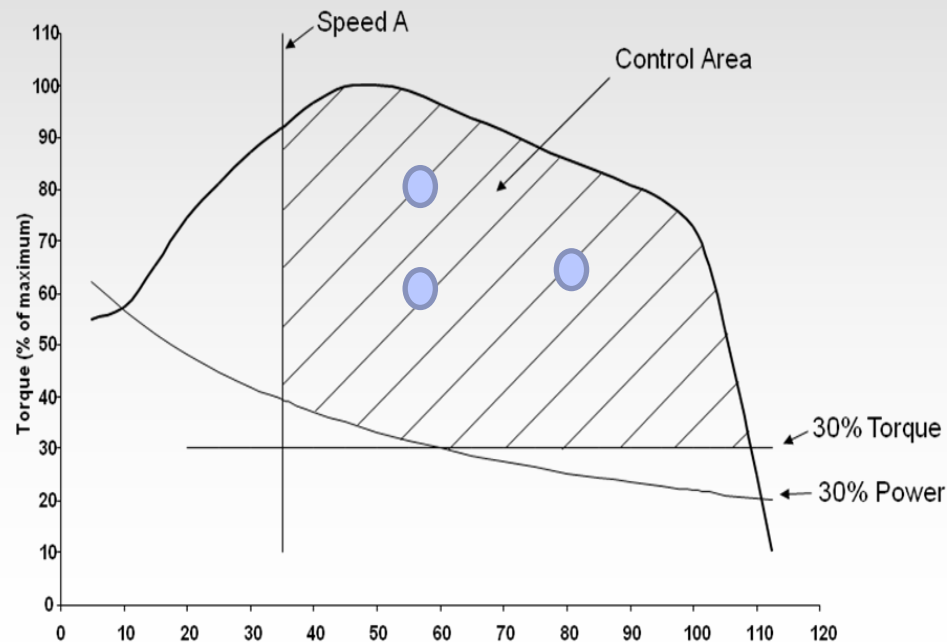
- PCD demonstration
 - Warning system activation on 2 tests incl. loss of function
 - Supplementary demonstration elements as appropriate

Monitor type	Number of PCD test cycles within which a "confirmed and active" DTC shall be stored
Removal of DPF	2
Loss of function of DPF	8
Failures of the PCD system	2

- PCD cycle
 - hot NRTC cycle for: NRE-v-3, NRE-v-4, NRE-v-5, NRE-v-6 and applicable NRSC for all other categories

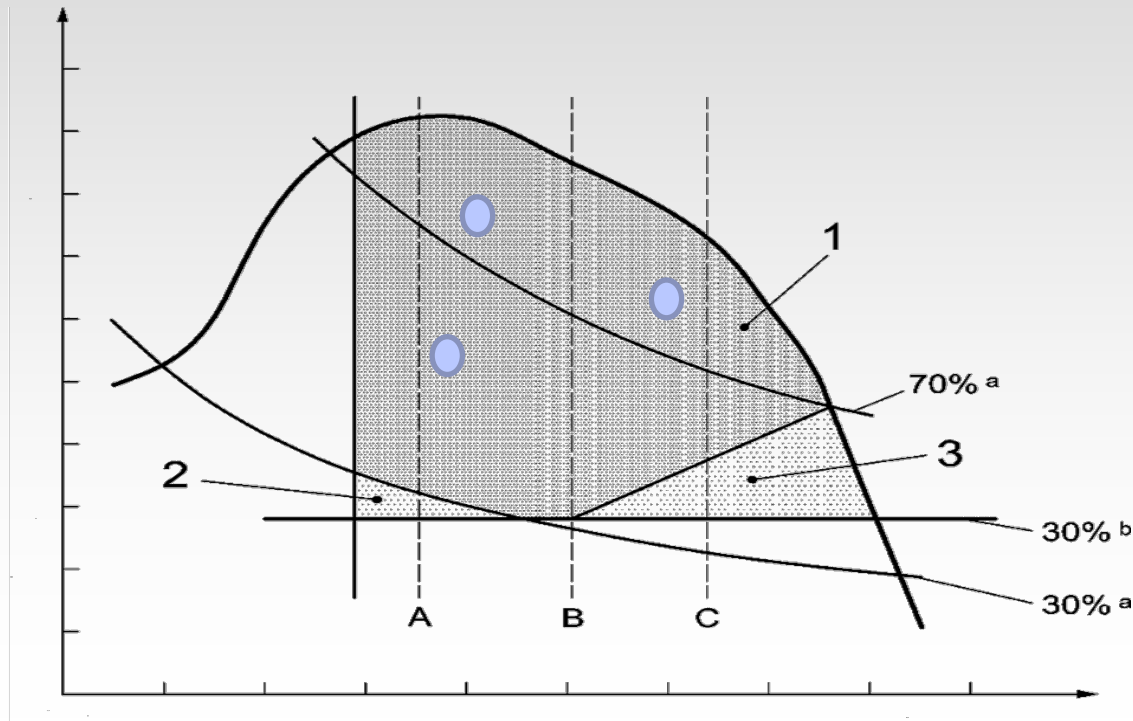
Stage V - NTE requirements

Control area for variable speed engines of category NRE with maximum net power ≥ 19 kW, variable speed engines of category IWA with maximum net power ≥ 300 kW and variable speed engines of category NRG



Stage V - NTE requirements

Control area for variable speed engines of category NRE with maximum net power < 19 kW and variable speed engines of category IWA with maximum net power < 300 kW, speed C < 2400 rpm



Article 19

Monitoring of emissions of in-service engines

1. The gaseous pollutant emissions from engines belonging to engine types or engine families of emission Stage V that have been type-approved in accordance with this Regulation shall be monitored by testing in-service engines installed in non-road mobile machinery and operated over their normal operating duty cycles. Such testing shall be conducted, under the responsibility of the manufacturer and in compliance with the requirements of the approval authority, on engines that have been correctly maintained, in compliance with the provisions on the selection of engines, test procedures and reporting of results for the different engine categories.

The Commission shall conduct pilot programmes with a view to developing appropriate test procedures for those engine categories and sub-categories in respect of which such test procedures are not in place.

The Commission shall conduct monitoring programmes for each engine category to determine to what extent the emissions measured from the test cycle correspond to the emissions measured in actual operation. Those programmes and their results shall, on a yearly basis, be the subject of a presentation to the Member States and, subsequently, of a communication to the public.

2. The Commission is empowered to adopt delegated acts in accordance with Article 55 for the purpose of supplementing this Regulation with detailed arrangements with regard to the selection of engines, test procedures and reporting of results referred to in paragraph 1 of this Article. Those delegated acts shall be adopted by 31 December 2016.

PEMS = Portable Emission Measurement System



Test equipment according to specific standards for the measurement of exhaust gas emissions from combustion engines in real world application on-road / off-road inclusive logger system for test relevant data

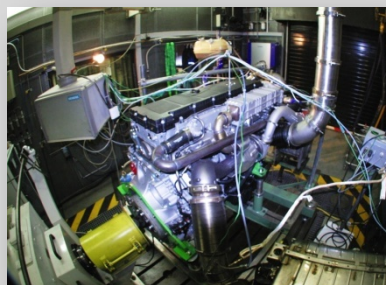
Mandatory parameters for Non-road mobile machinery testing:

- Gas concentration of HC, CO, NO_x, CO₂
- Exhaust gas flow
- Temperatures: intake air, exhaust gas, coolant
- Ambient conditions: temperature, humidity, pressure
- GPS data
- Engine speed and torque (ECU)
- Engine fuel flow (ECU)
- Particulate matter / number not yet fixed

Background and legislative implementation

HDV PEMS approach

Heavy duty vehicles (Euro VI, Regulation (EU) 595/2009 / 627/2014)



Engine dyno

+



Field testing

Standard emission
test cycles

PEMS at type approval*
incl. conformity factor (CF)

Engine type approval,
one test session



Field testing

In-service conformity*
(ISC) with PEMS
incl. CF

periodic testing

* since 01/2013, CF defined

Background and legislative implementation

LDV PEMS approach

Passenger cars / light duty vehicles (Euro 6, Regulation (EU) 715/2007 / 2016/427)



Chassis dyno

+



Field testing

Standard emission
test cycles

Real driving emissions *
(RDE)
without CF

Vehicle type approval,
one test session



Field testing

In-service monitoring **
(ISM) with PEMS
without CF

Monitoring,
periodic testing

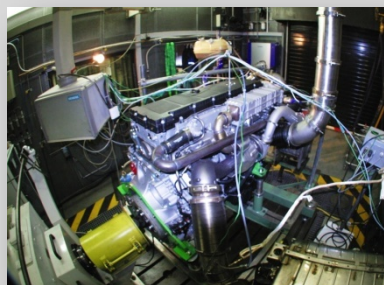
* since 04/2016, CF to be fixed

** provisions not yet adopted; implementing planned in 2017, CF to be fixed

Background and legislative implementation

NRMM PEMS approach

Non-road mobile machinery (Stage V, Regulation (EU) 2016/1628 replacing 97/68/EC)



Engine dyno

+



~~Field testing~~

Standard emission
test cycles

~~PEMS at type approval *~~

Engine type approval,
one test session



Field testing

In-service monitoring **
(ISM) with PEMS
without CF

Monitoring,
defined schedule

* not intended

** acc. specific testing scheme

Background and legislative implementation

Scope for the NRMM PEMS testing

Non-road mobile machinery (NRMM)



land based applications
(e.g. wheel loader, excavator, fork lifter, tractor)

engines of category NRE-v-5 and NRE-v-6 only
(compression engines with variable speed
and power bands between 56 - 560 kW)

future extension to further applications and engine categories likely,
as well as implementation of conformity factors

PEMS installation at NRMM

Challenges

Tractor



PEMS installation at NRMM

Challenges

Beet Harvester



PEMS installation at NRMM

Equipment arrangement

Example beet harvester

- 1) exhaust flow meter
- 2) heated sample line
- 3) gas analyzer (PEMS)
- 4) FID-fuel bottle for HC analyzer
- 5) battery pack and generator
- 6) vehicle interface / ECU data
- 7) (particulate sampling system)





Vielen Dank für Ihre Aufmerksamkeit!

