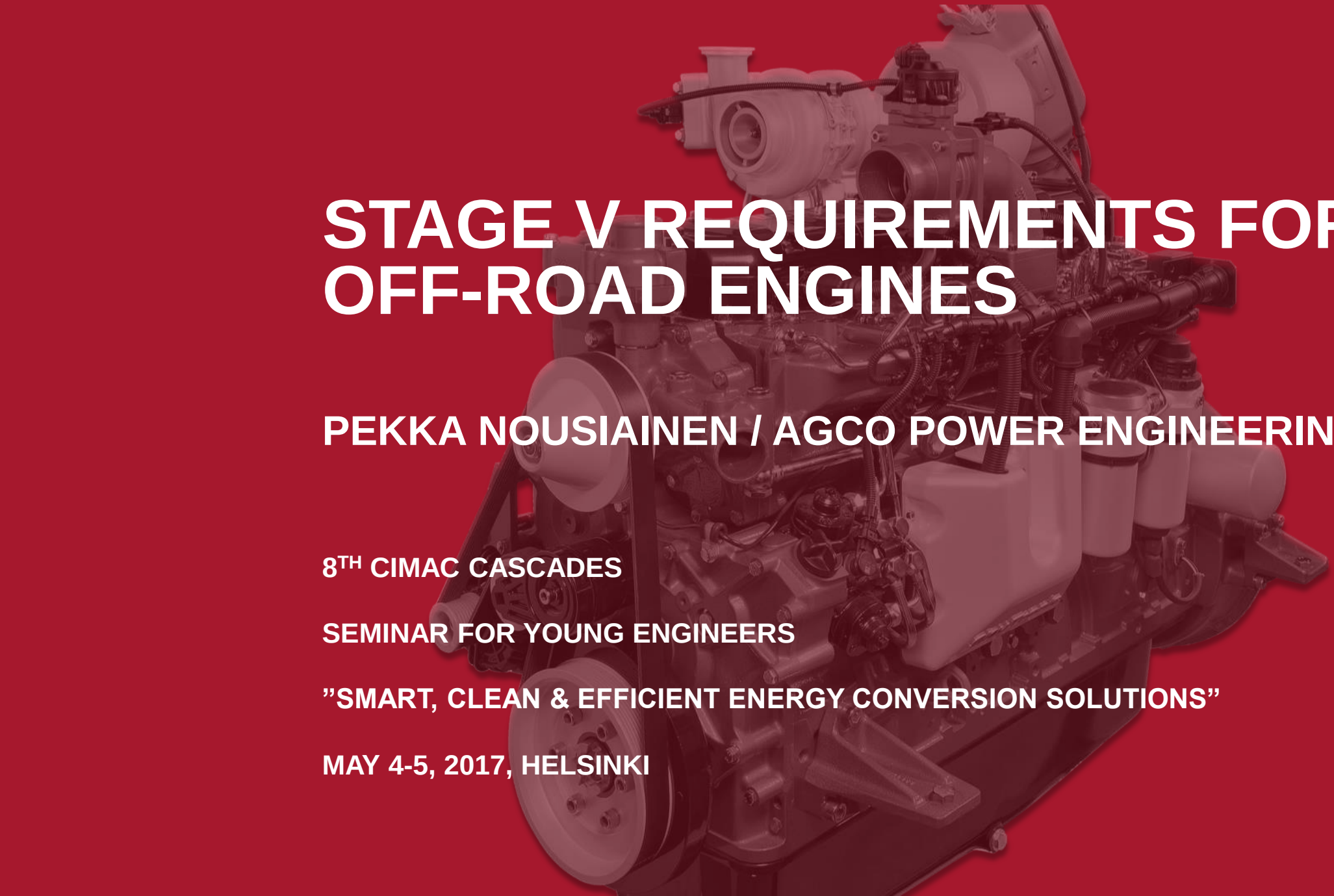


STAGE V REQUIREMENTS FOR OFF-ROAD ENGINES

PEKKA NOUSIAINEN / AGCO POWER ENGINEERING

8TH CIMAC CASCADES

SEMINAR FOR YOUNG ENGINEERS

”SMART, CLEAN & EFFICIENT ENERGY CONVERSION SOLUTIONS”

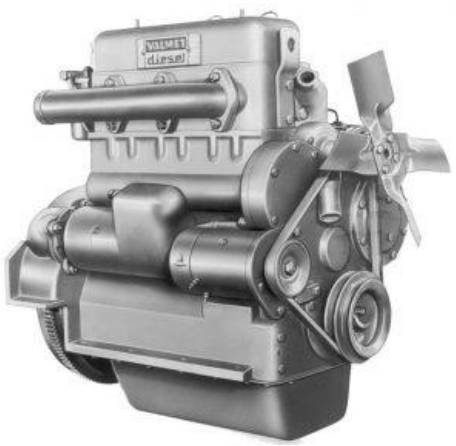
MAY 4-5, 2017, HELSINKI

AGCO POWER

TECHNOLOGY EVOLUTION

Off-road Diesel engine evolution from 50´s till today

- Power density (BMEP) increase, fuel consumption decrease
- Breakthrough for electronic control and aftertreatment systems in 2000´s



1957 - 2017

1942 Puolustusministeriö / Försvarsministeriet / Ministry of Defence

1946 VAMMT

1951 Valmet

1994 SISU

1997 PARTEK

2002 KONE

2004 AGCO

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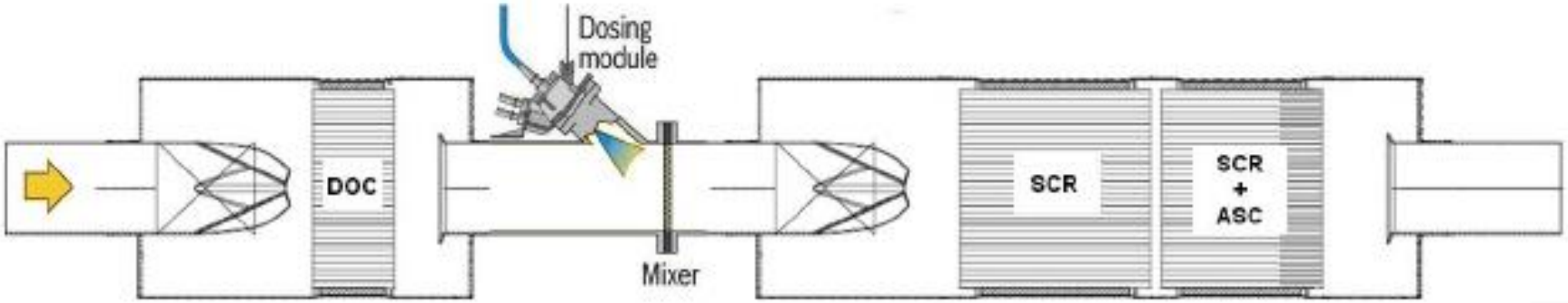
CURRENT TECHNOLOGY

Optimized base engine raw emissions & efficient DOC+SCR



DOC = Diesel Oxidation Catalyst
SCR = Selective Catalytic Reduction
ASC = Ammonia Slip Cat

1	**AGCO Corporation & AGCO Power**
2	Applications
3	Stage V legislation
4	Stage V technology
5	Summary

LEADING BRANDS

AGCO
Your Agriculture Company

VALTRA Challenger FENDT MASSEY FERGUSON® GSI® AGCO POWER

AGCO CORPORATION

AGCO POWER

AGCO POWER
FOUR ENGINE FACTORIES

Linnavuori, Finland

Changzhou, China

Mogi das Cruzes, Brazil

General Rodriguez, Argentina

- 3, 4, 6, 7 and 12 cylinders
- 50 – 500 kW
- Capacity 110 000 engines

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REFERENCES - TRACTORS

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REFERENCES – AGRICULTURAL APPLICATIONS

2.5.2017

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REFERENCES – OTHER OFF-ROAD APPLICATIONS

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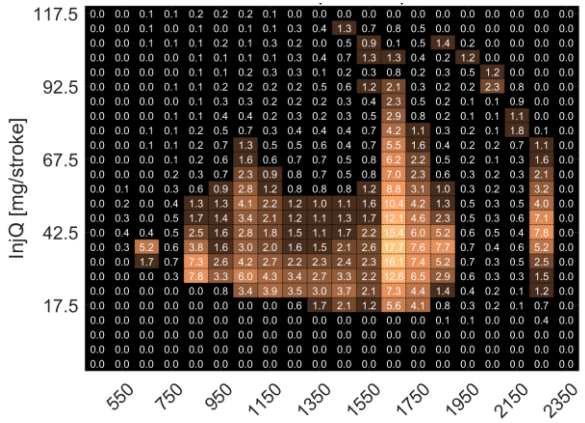
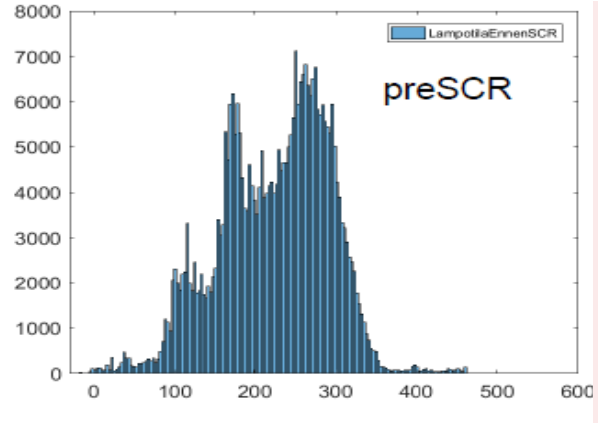
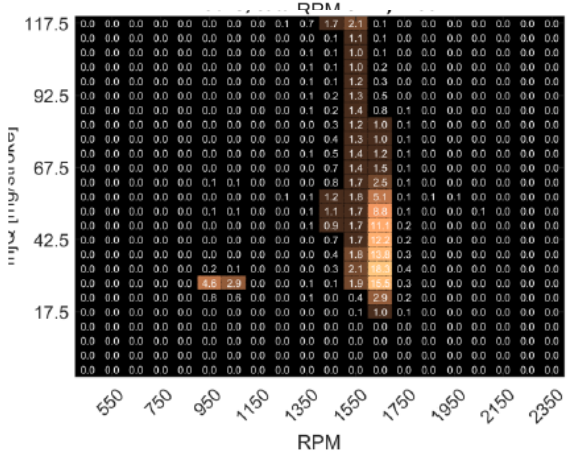
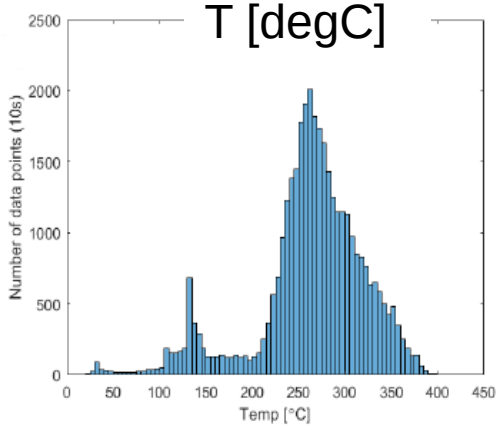
APPLICATIONS LOAD PROFILES

Huge variety in load profiles









- Exhaust gas temperature variations
- Challenge for optimization of base engine and aftertreatment systems

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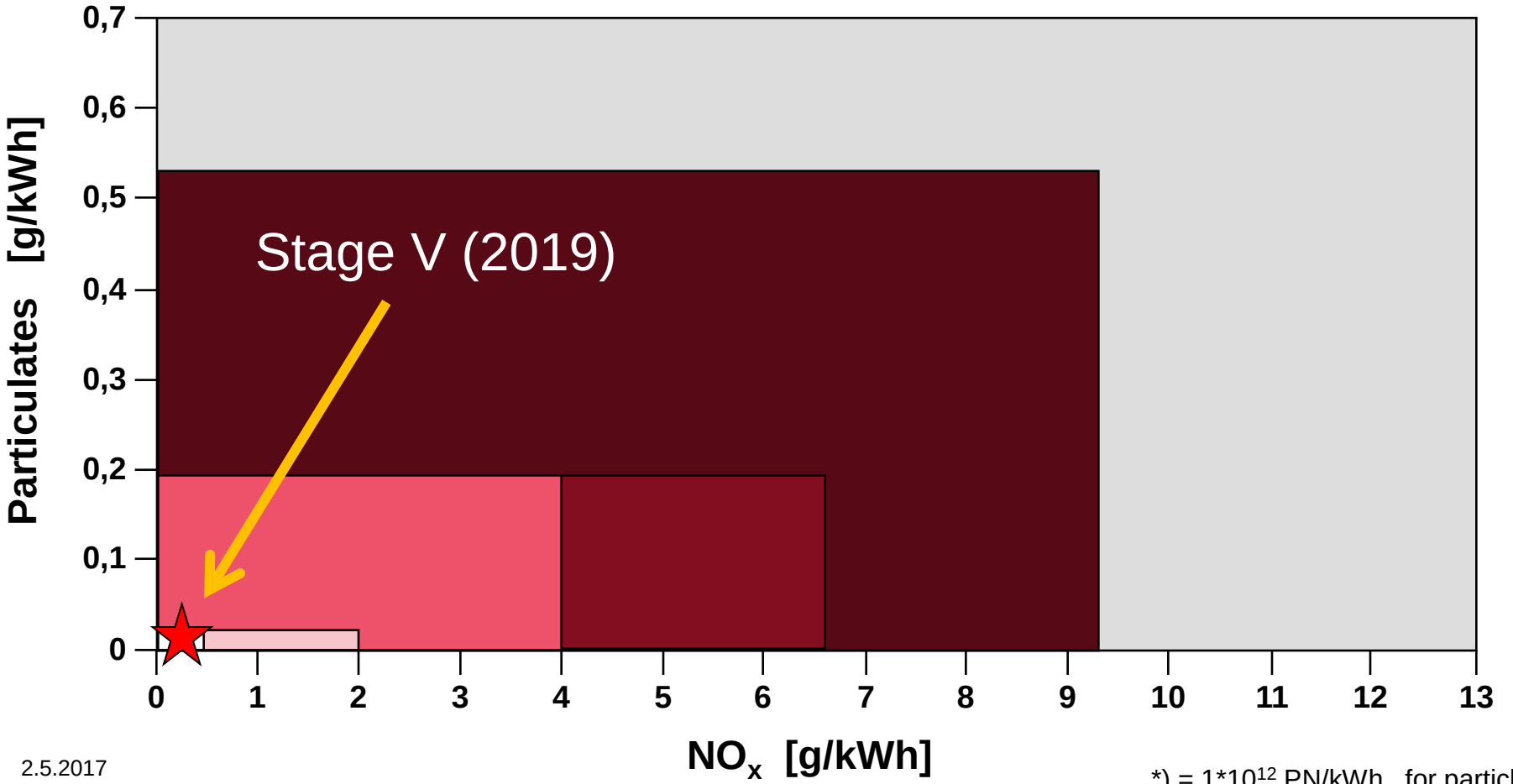
EXHAUST EMISSIONS LEGISLATION

Stage V particulate number (PN) limit *) forces to use Diesel Particulate Filter



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*) = $1*10^{12}$ PN/kWh, for particles > 23 nm

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EXHAUST EMISSIONS LEGISLATION

Real Driving Emissions (RDE) monitoring in the field

- Continuous monitoring via sensors and actuators

- Stage V In-Service Monitoring

  - Will be performed in the field as a separate campaigns, with customer vehicles
  - Measured with PEMS (NO_x, CO, CO_2 and HC) by the engine manufacturer
  - Collected data will be evaluated by European Commission, used as a guide for future legislation

PEMS = Portable Emissions Measurement System

AGCO POWER
ENGINEERING

Stage V engine – integration of sophisticated base engine and aftertreatment systems – and the <u>models</u>

+

https://www.proventia.com/index.php?63

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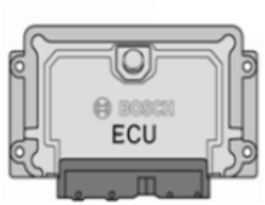
- Base control fuctions
- Raw emission models



- DOC models
- SCR models
- DPF models

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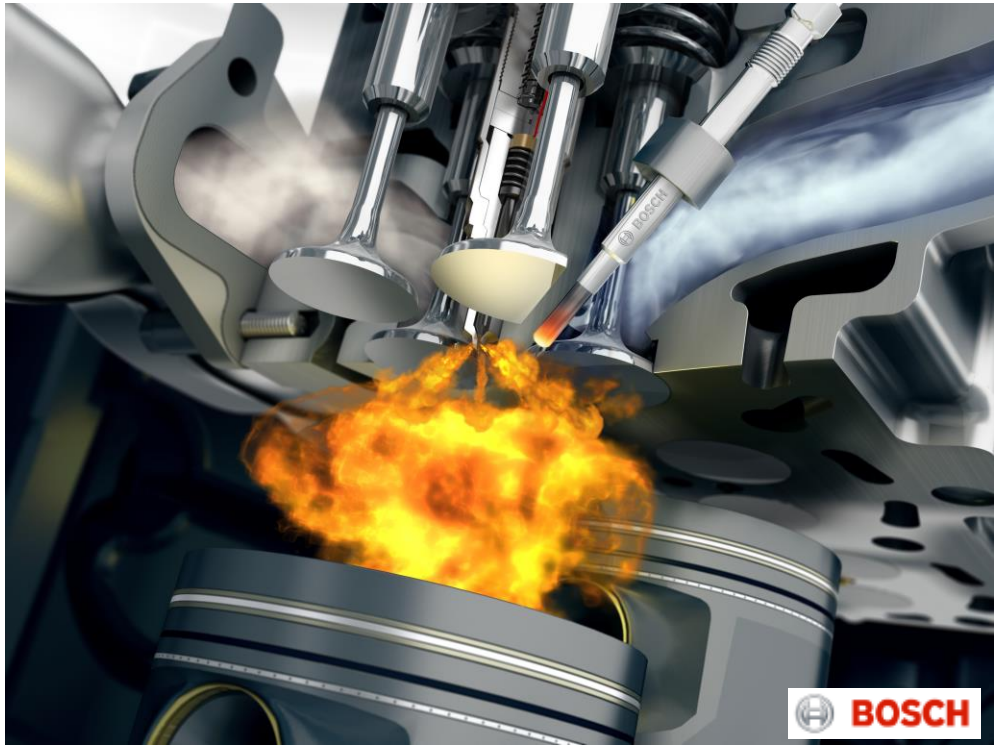
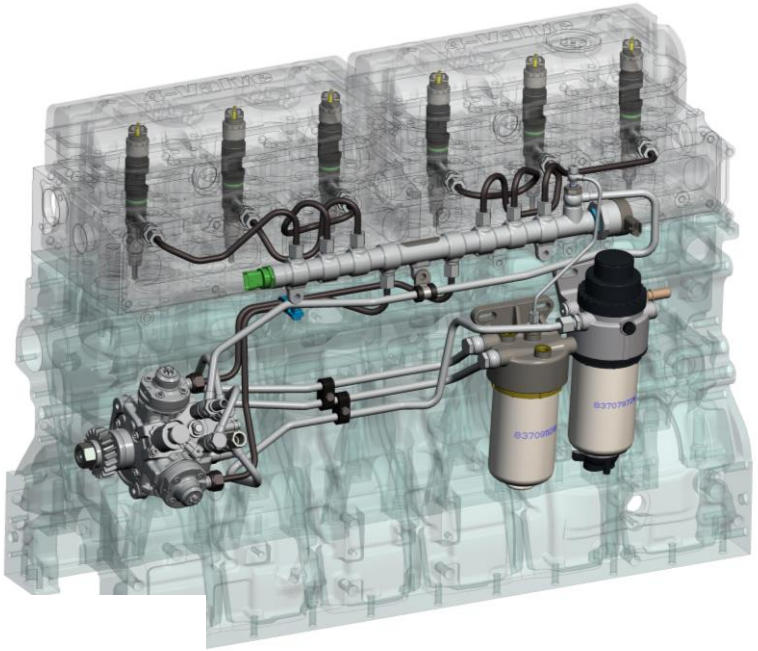
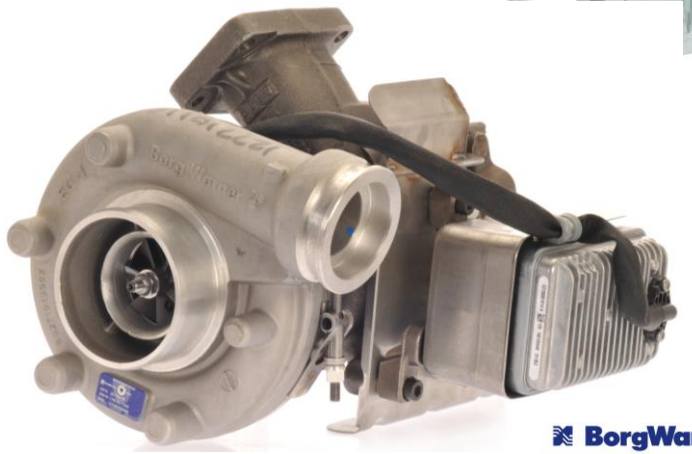
ENGINEERING / COMBUSTION DEVELOPMENT

New emission requirement – a new base engine combustion system development







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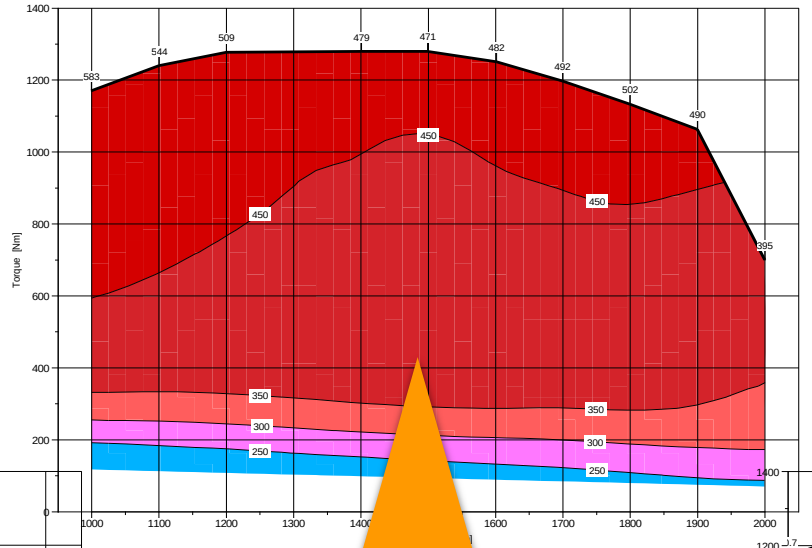
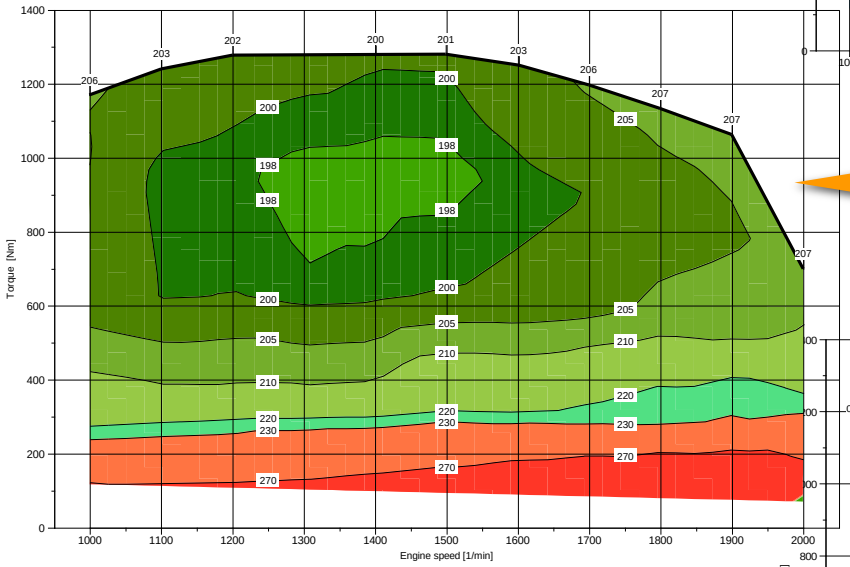
ENGINEERING / COMBUSTION DEVELOPMENT

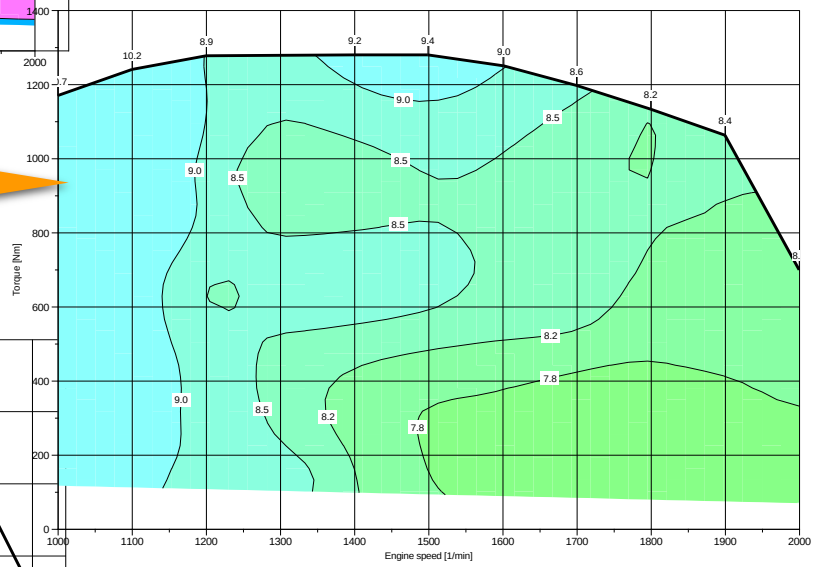
T exhaust gas after turbo



bSFC

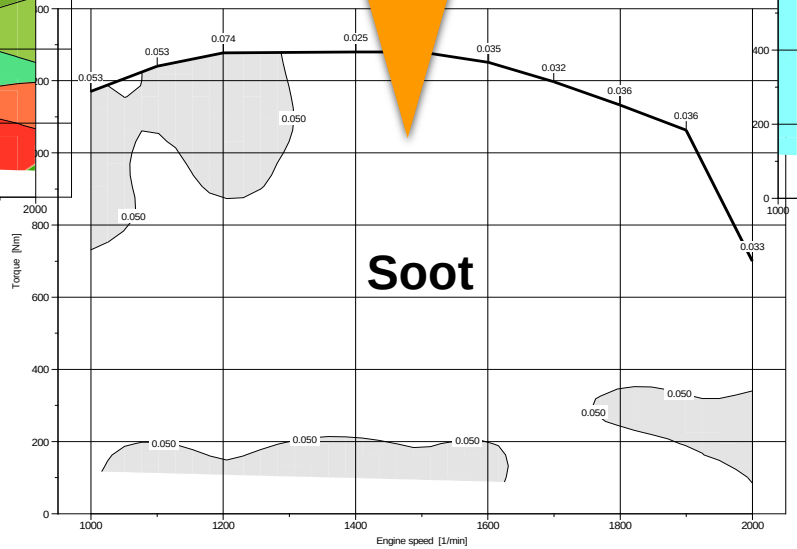


Raw NO_x



Calibration challenge

Soot



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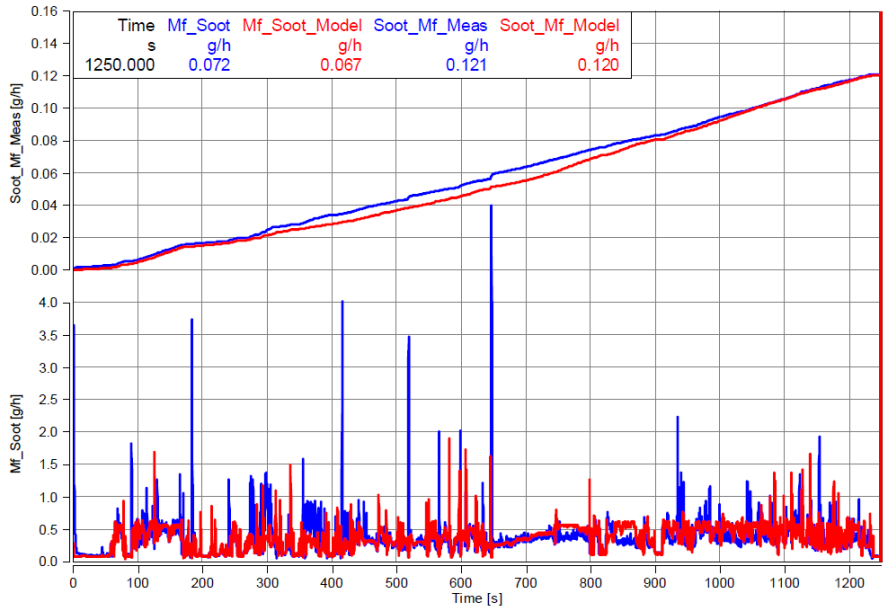
ENGINEERING / EXHAUST GAS AFTERTREATMENT

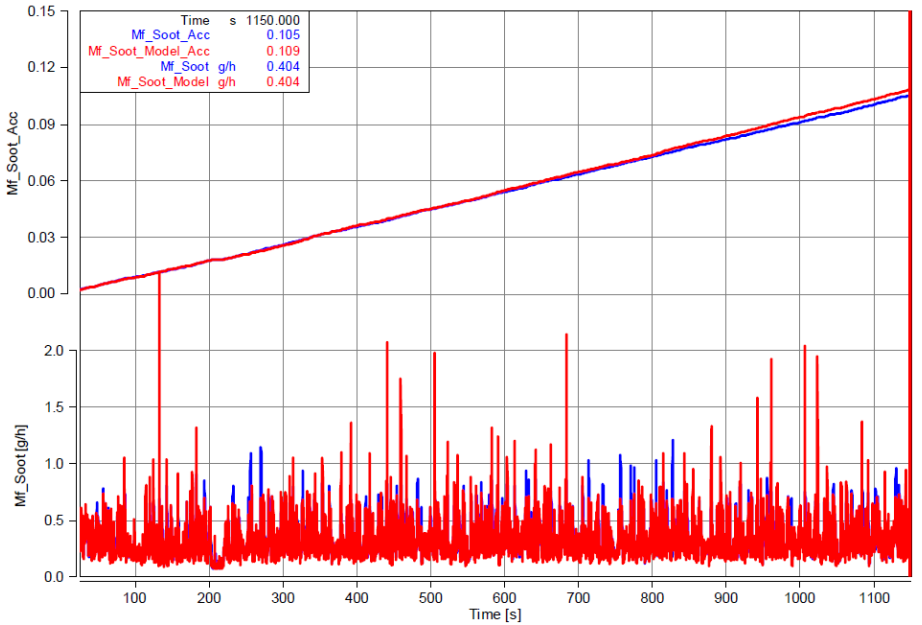
Exhaust Aftertreatment control requires state-of-the-art models

Example: Engine Raw Particulate emission model

NRTC cycle : Model vs. Measurement



Field cycle : Model vs. Measurement



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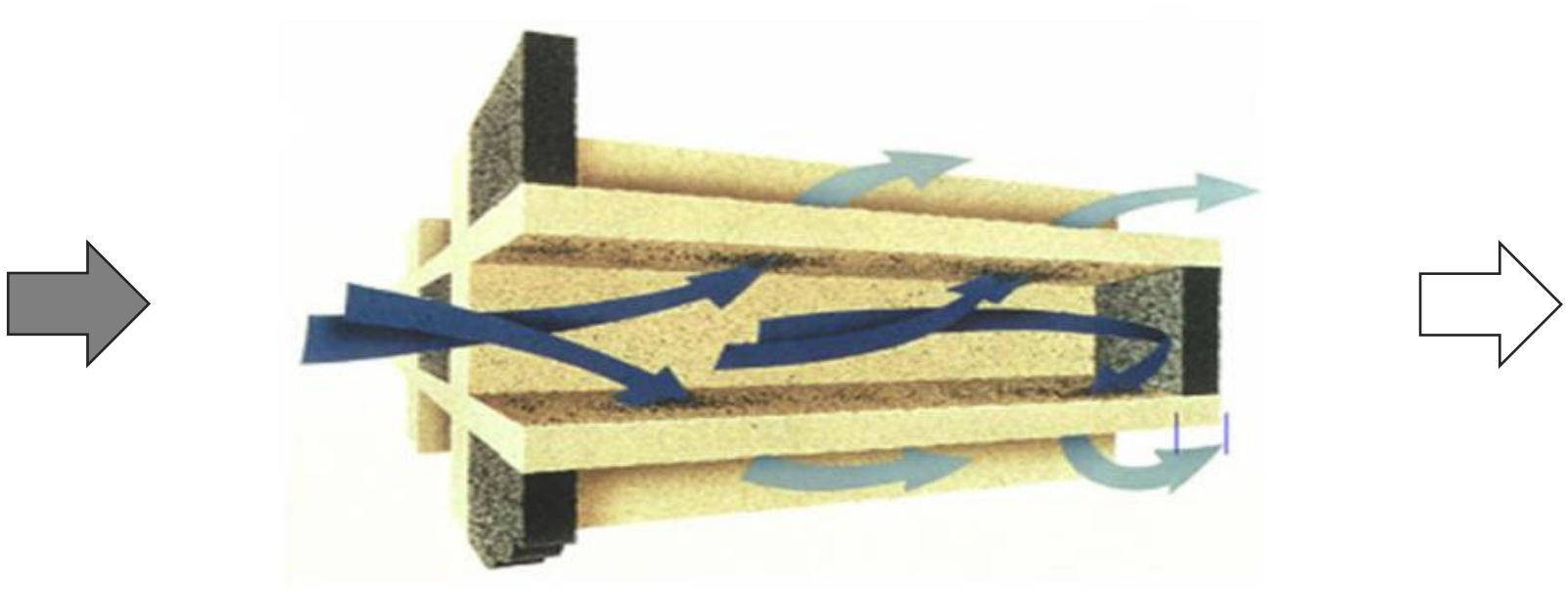
ENGINEERING / EXHAUST GAS AFTERTREATMENT

Diesel Particulate Filter operating principle

http://www.technology.matthey.com/wp-content/uploads/articles/53/1/Twigg-53-1-jan09-f4.jpg



1. Soot collection to walls of inlet channels

2. Soot regeneration

- Oxidation with NO_2 (> ≈ 250°C) = Passive regeneration
  - Takes place during normal operation
- Oxidation with O_2 (> ≈ 550°C) = Active regeneration
  - Needs fuel injection to increase temperature

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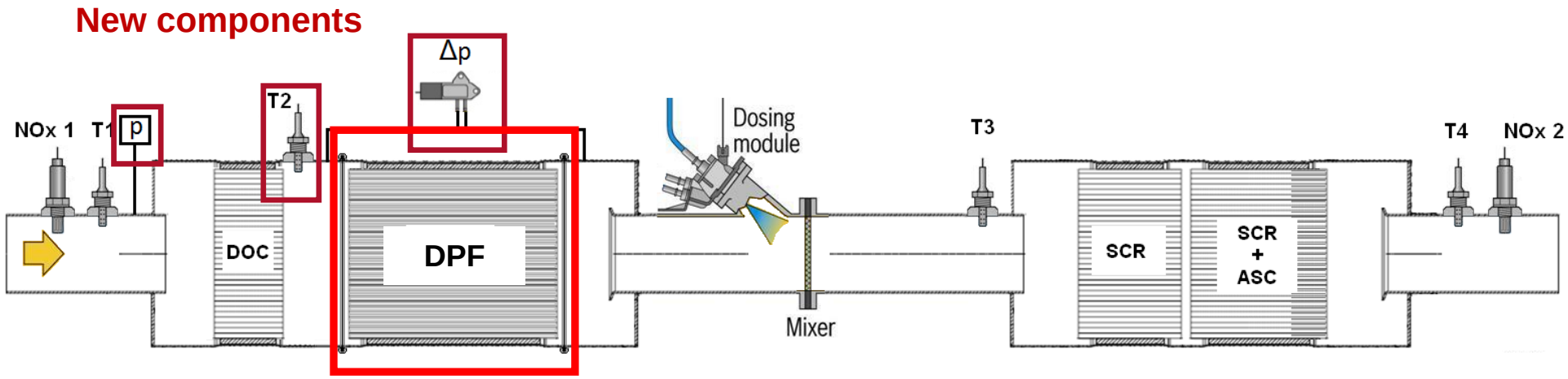
ENGINEERING / EXHAUST GAS AFTERTREATMENT

AGCO Power Stage V EAT system (> 56 kW)



DPF regeneration

- Primary method: Passive regeneration during normal vehicle operation (> 250 °)
- Secondary method: Stand-still active regeneration (> 550 °)
  - Trigger from Δp and modelled DPF soot loading

1	AGCO Corporation & AGCO Power
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5	**Summary**

SUMMARY

- AGCO Power develops and manufactures low emission diesel engines for global off-road use
- Todays aftertreatment solution is DOC + SCR
- Base engine calibration is partly done with DOE tools
- Next emissions step is StageV (Europe), 2019
- Diesel Particualte Filter will be mandatory
- Sophisticated DPF regeneration and SCR controls are key to success (variation of applications load profiles & exhaust temps)
- Lots of high-tech models are used in the ECU
- Stage V will require effective emissions field monitoring

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DOE = Design of Experiments


EXTREME
STRENGTH