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**Engine - management - supported after-treatment systems
for HDV and LDV**

Engine management supported aftertreatment systems for diesel powered vehicles

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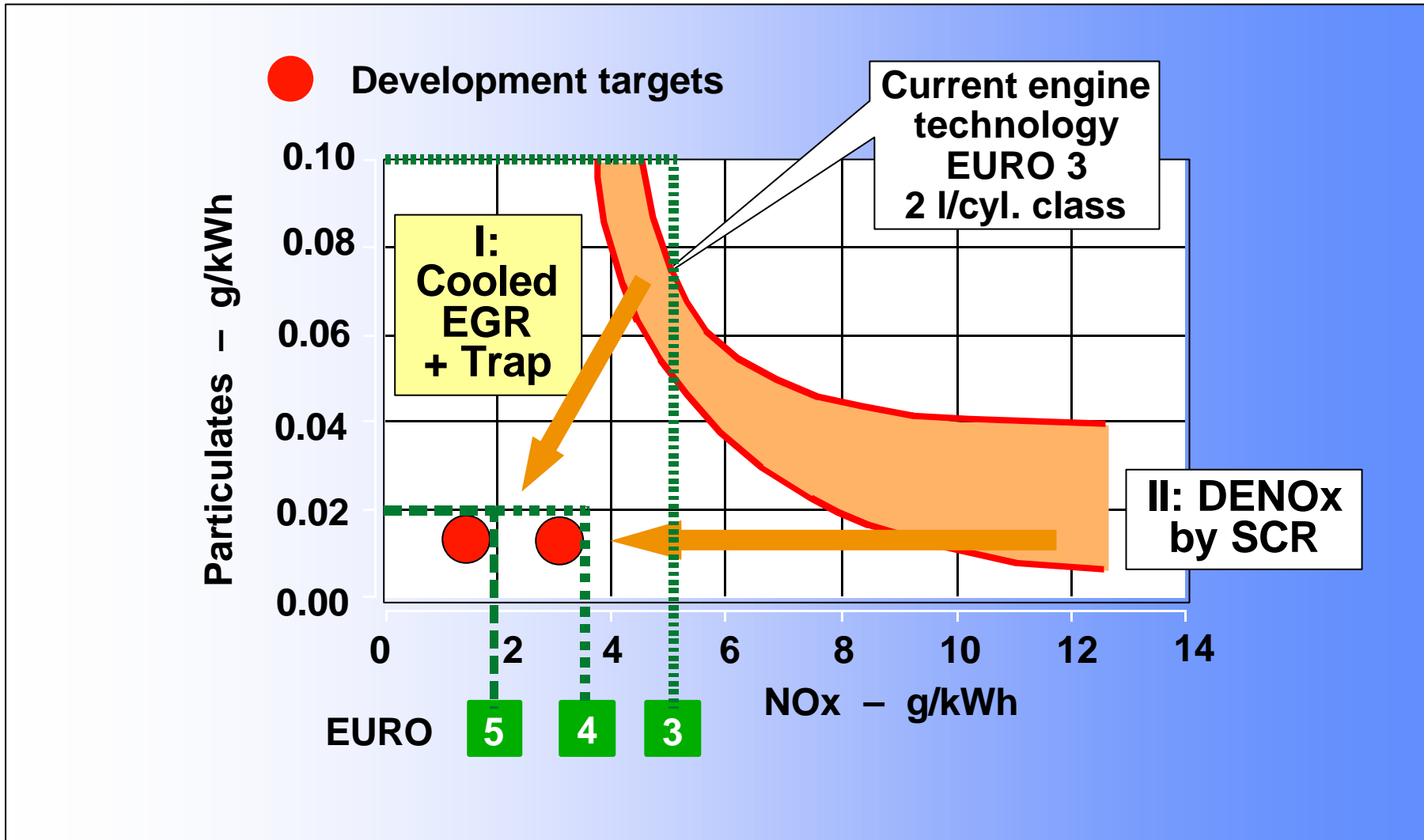
Zeuna Stärker GmbH & Co. KG, Augsburg

„4th Conference on Nanoparticle Measurement“
Zurich, August 7 - 9, 2000

Content of Presentation

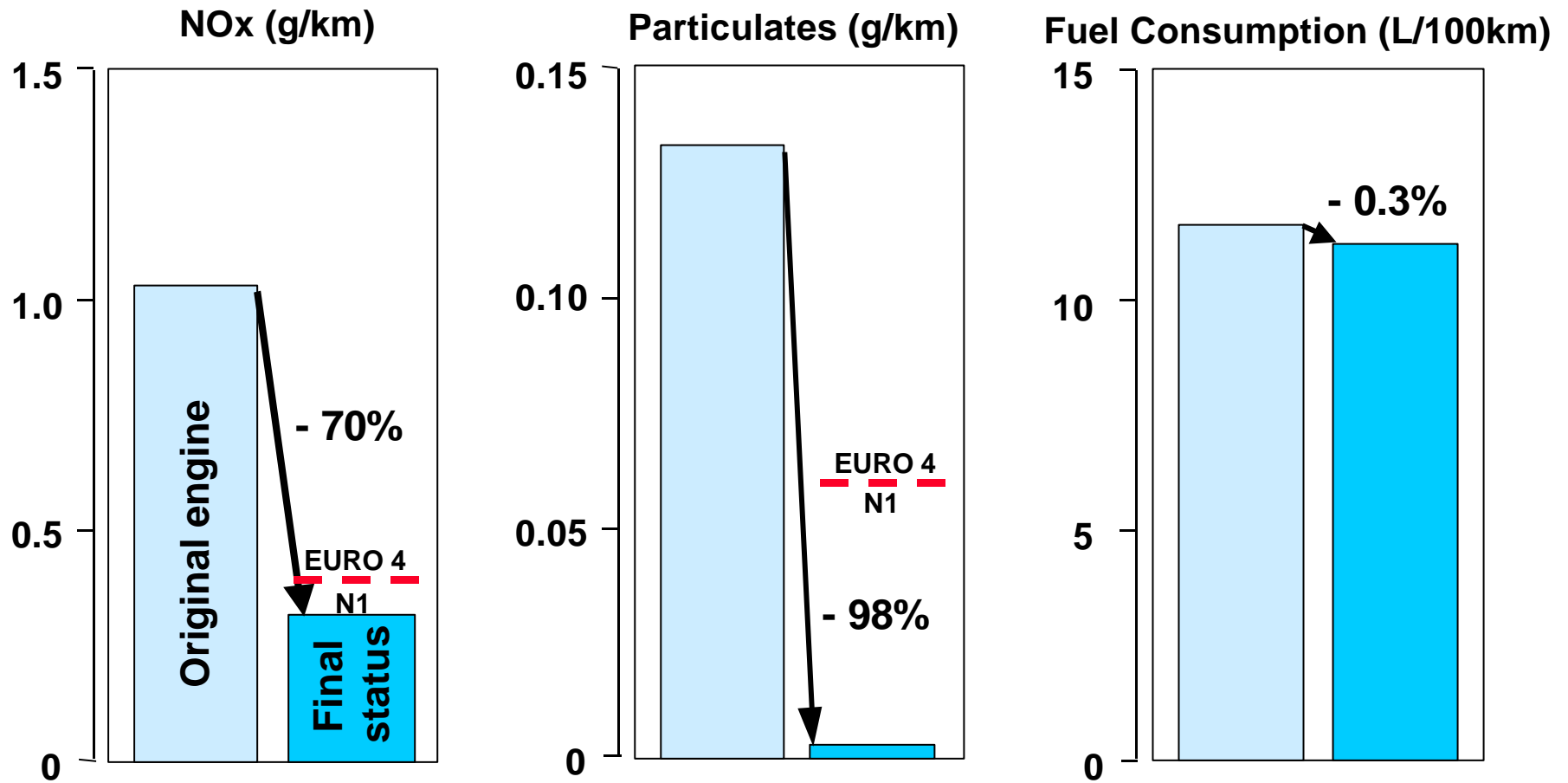
- **Strategies for Future Emission Standards**
- **Methods for Particulate Trap Regeneration**
- **Engine Management Control System**
- **Active Regeneration Supported by Engine Management**
- **Summary and Conclusions**

European Emission Reduction Strategies (Example for HDV)



NEDC Results

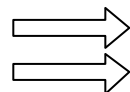
3 l DI/TCI Diesel Engine with EGR, ITW= 2150 kg



Aftertreatment system:

Original engine (EURO 2 - N1))

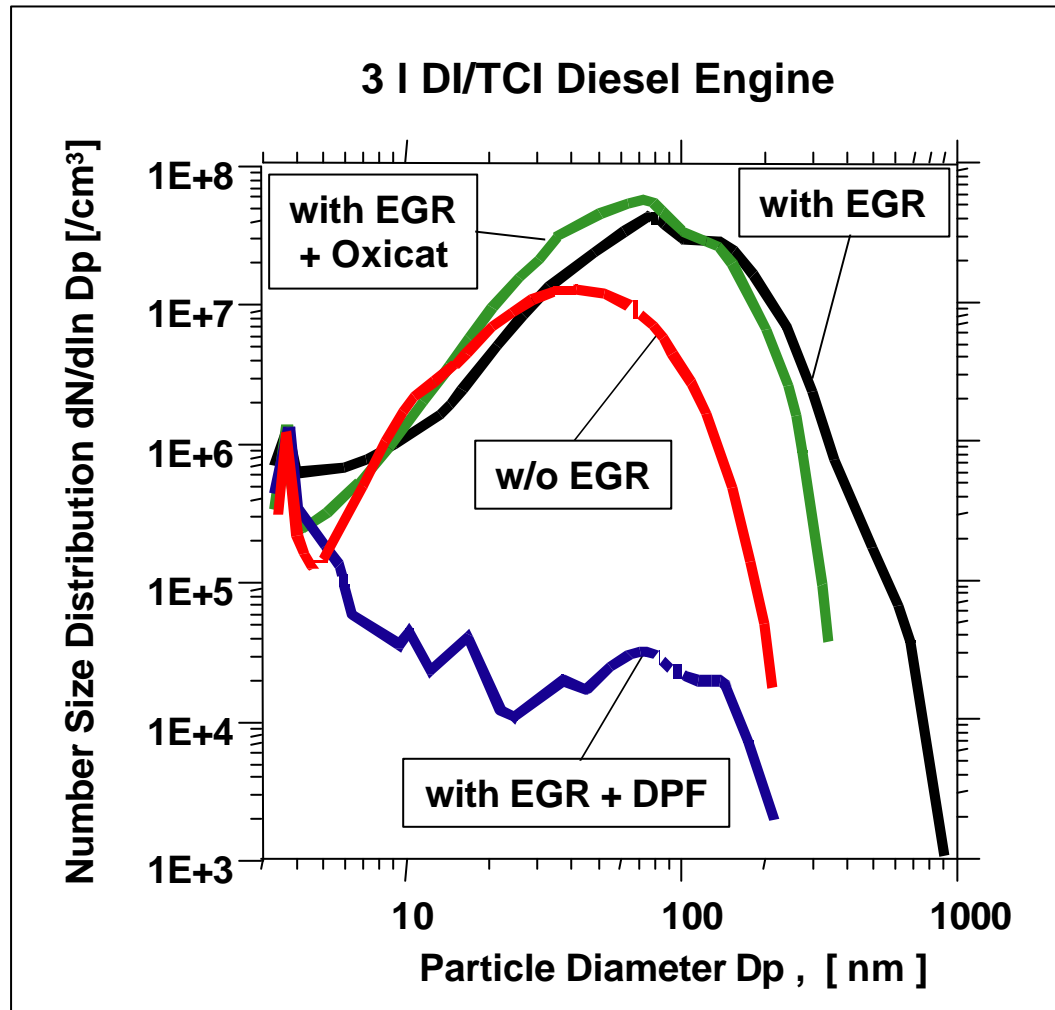
Final status (EURO 4 - N1)



Oxidation Catalyst

CRT™ System

PM Size Distribution of Different Diesel Engine Technologies in the NEDC



**NEDC Test
(weighted from
steady state calculation)
ITW = 2150 kg**

Low Sulphur Fuel
S < 10 wt.-ppm

**Measurement Equipment:
Dual Differential Mobility Particle
Spectrometer (DDMPS)**

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DPF Regeneration Methods

Fully Passive Regeneration above certain temperature level

- catalytic coating
- fuel additives (fuel-borne catalysts)
- CRT principle

Passive Regeneration supported by engine management

- temperature and NOx/Soot increase initiating start of regeneration

Active Regeneration Aid supported by engine management

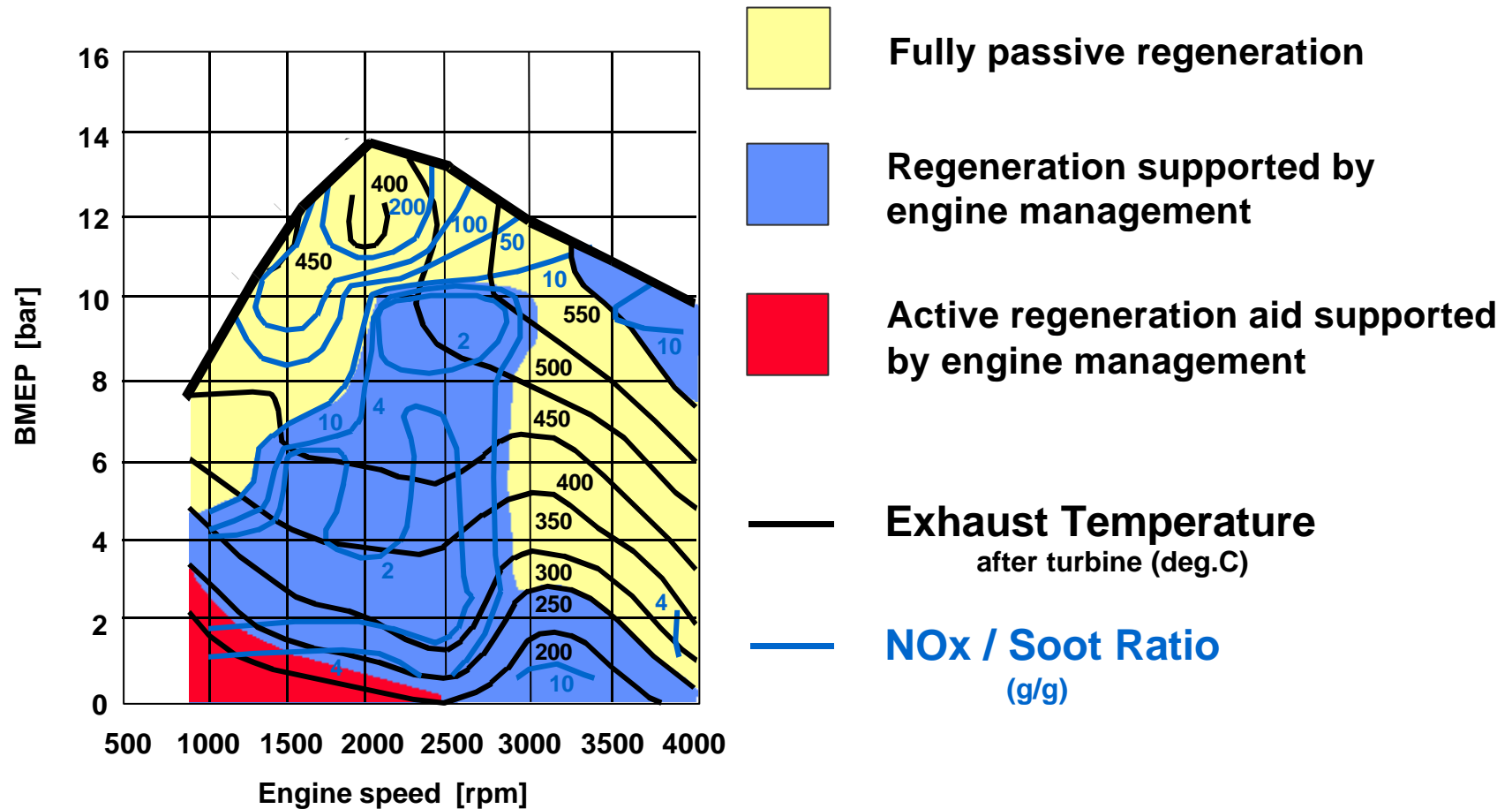
- electrical heaters or fuel burners together with additional exhaust temperature increase by engine management

Example for a DPF

- **CRT (Continuous Regeneration Trap)**
 - **Principle: oxidation of NO to NO₂ inside oxidation catalyst with subsequent conversion of stored soot (= carbon) inside trap by NO₂**
 - **Certain exhaust gas temperature level (>230 deg. C) and NO_x/Soot ratio (>8) necessary, otherwise trap would plug.**
 - **Additional engine management strategies necessary if longer engine operation outside these windows (e.g. EGR off).**
 - **requires diesel fuel with very low sulphur level (50 ppm or less) for sufficient NO₂ conversion**

Load / Speed Map with Different Regeneration Areas

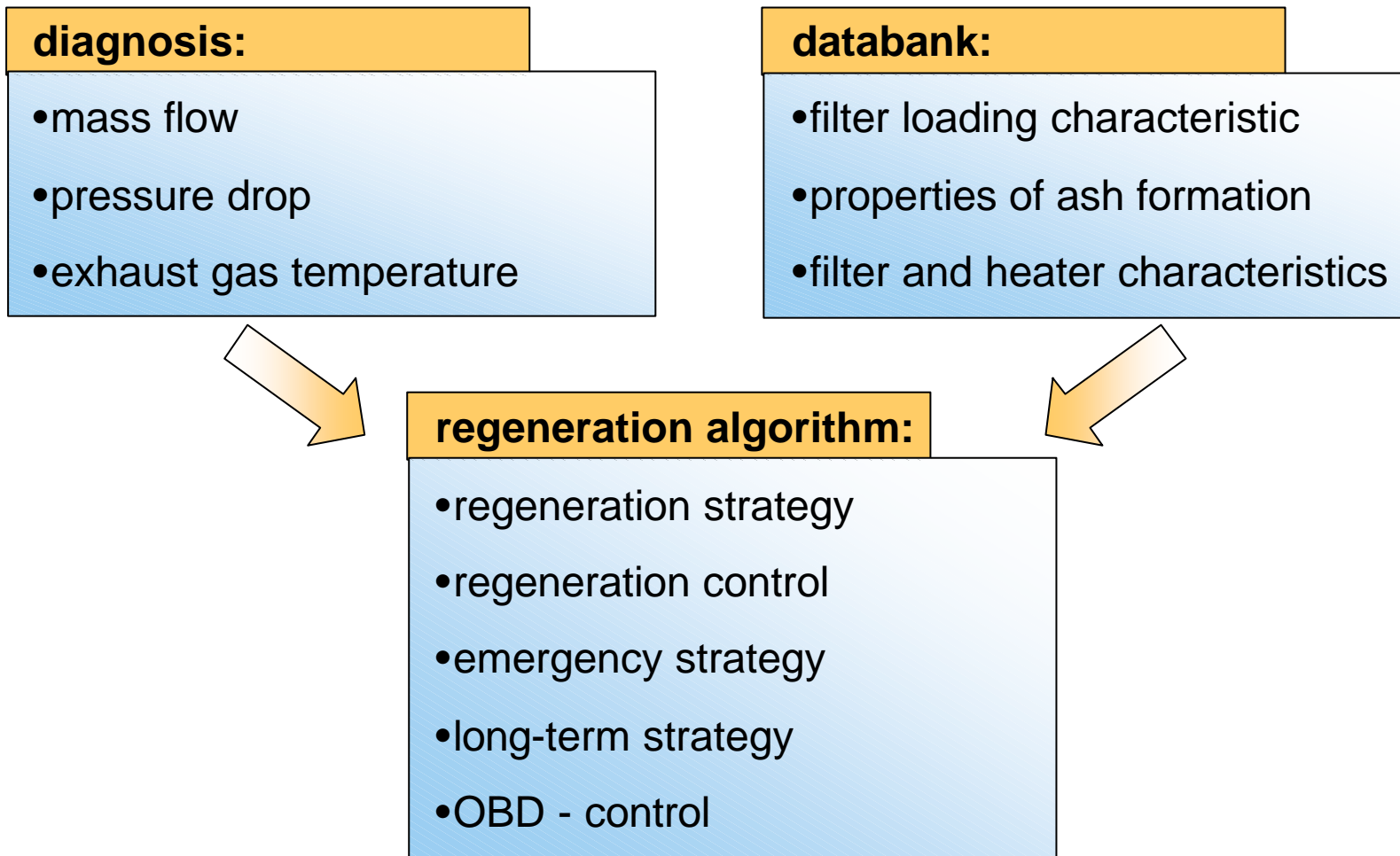
3 I DI/TCI Diesel Engine with cooled EGR (EURO 4 - N1)



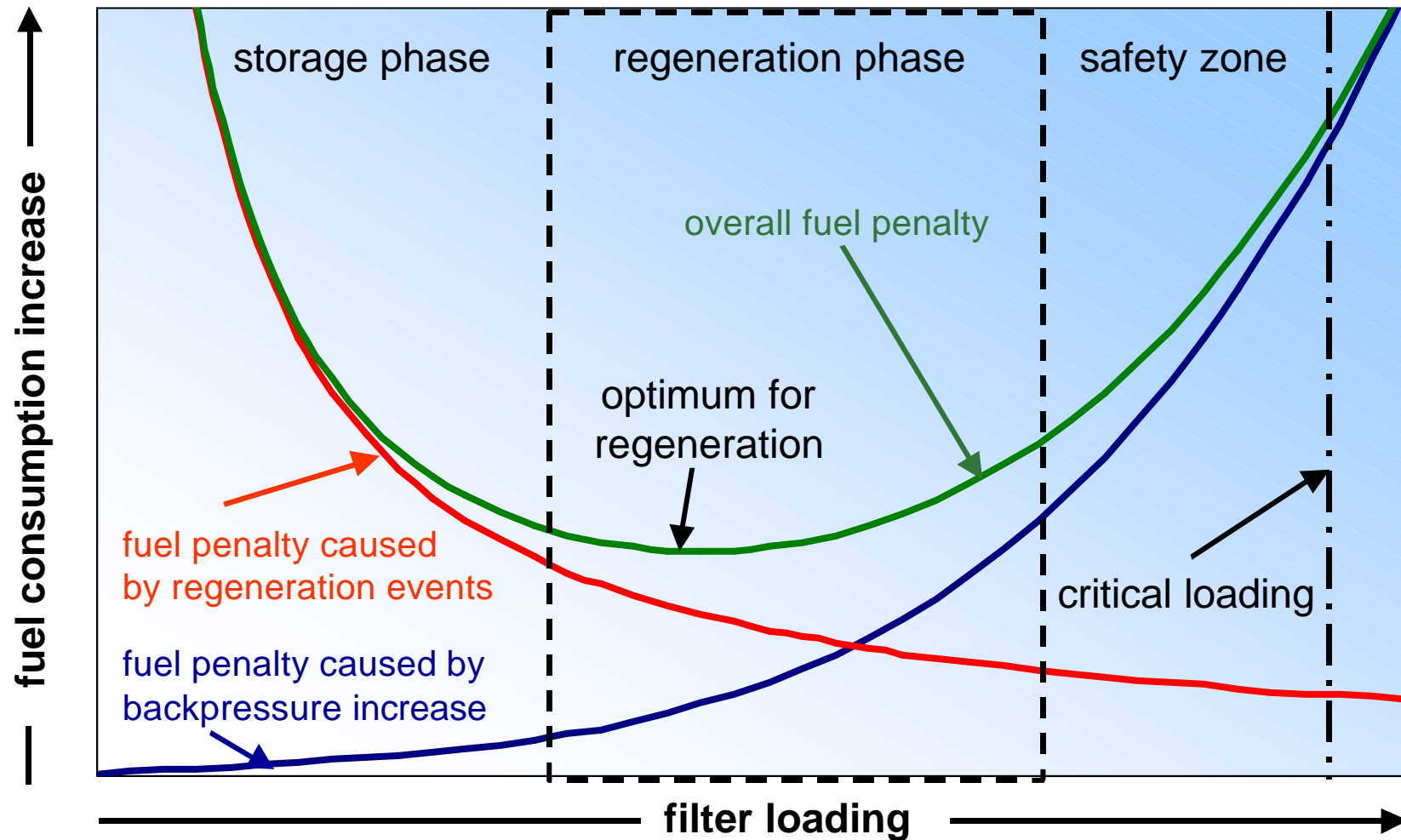
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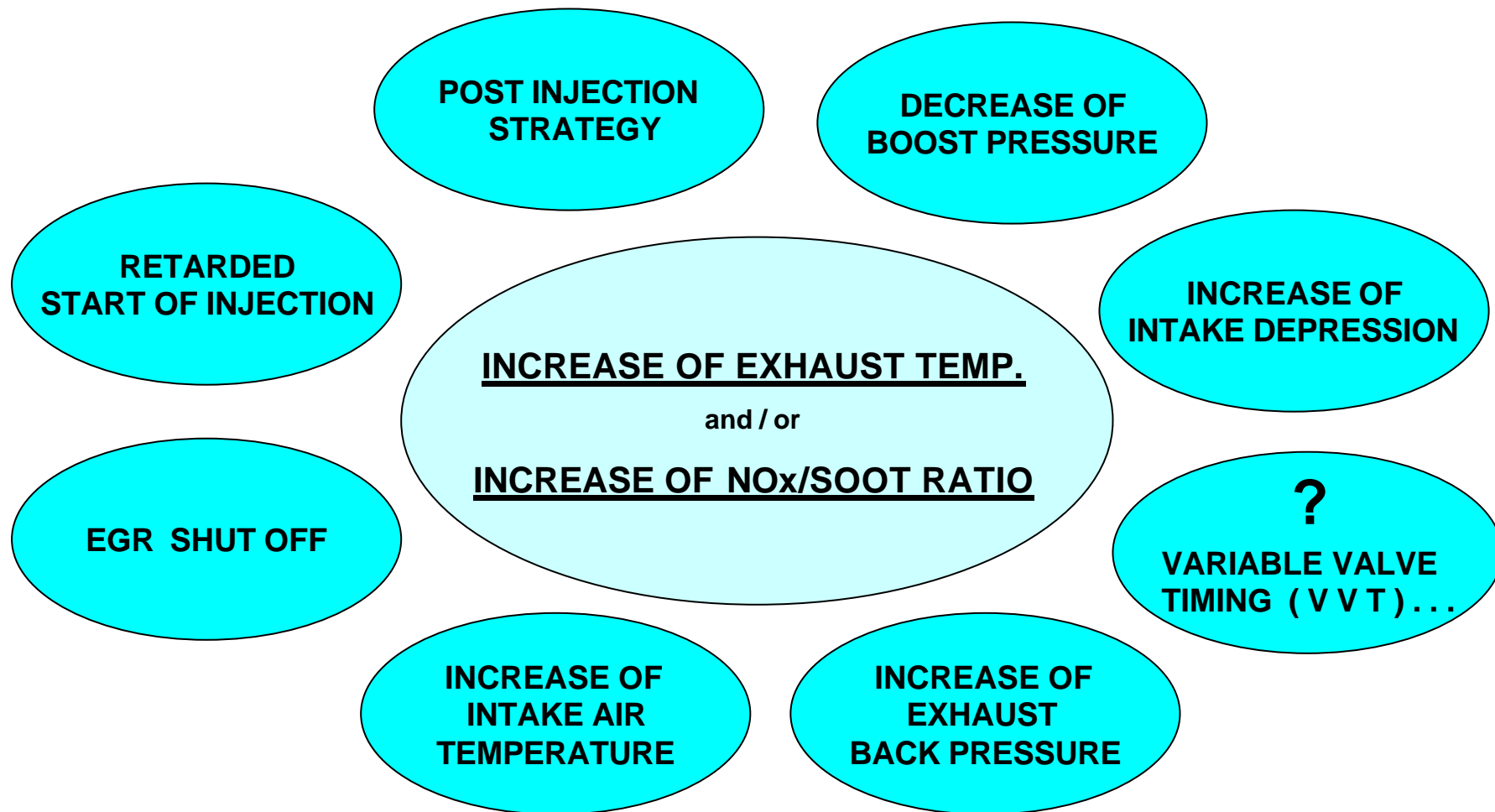
Control System



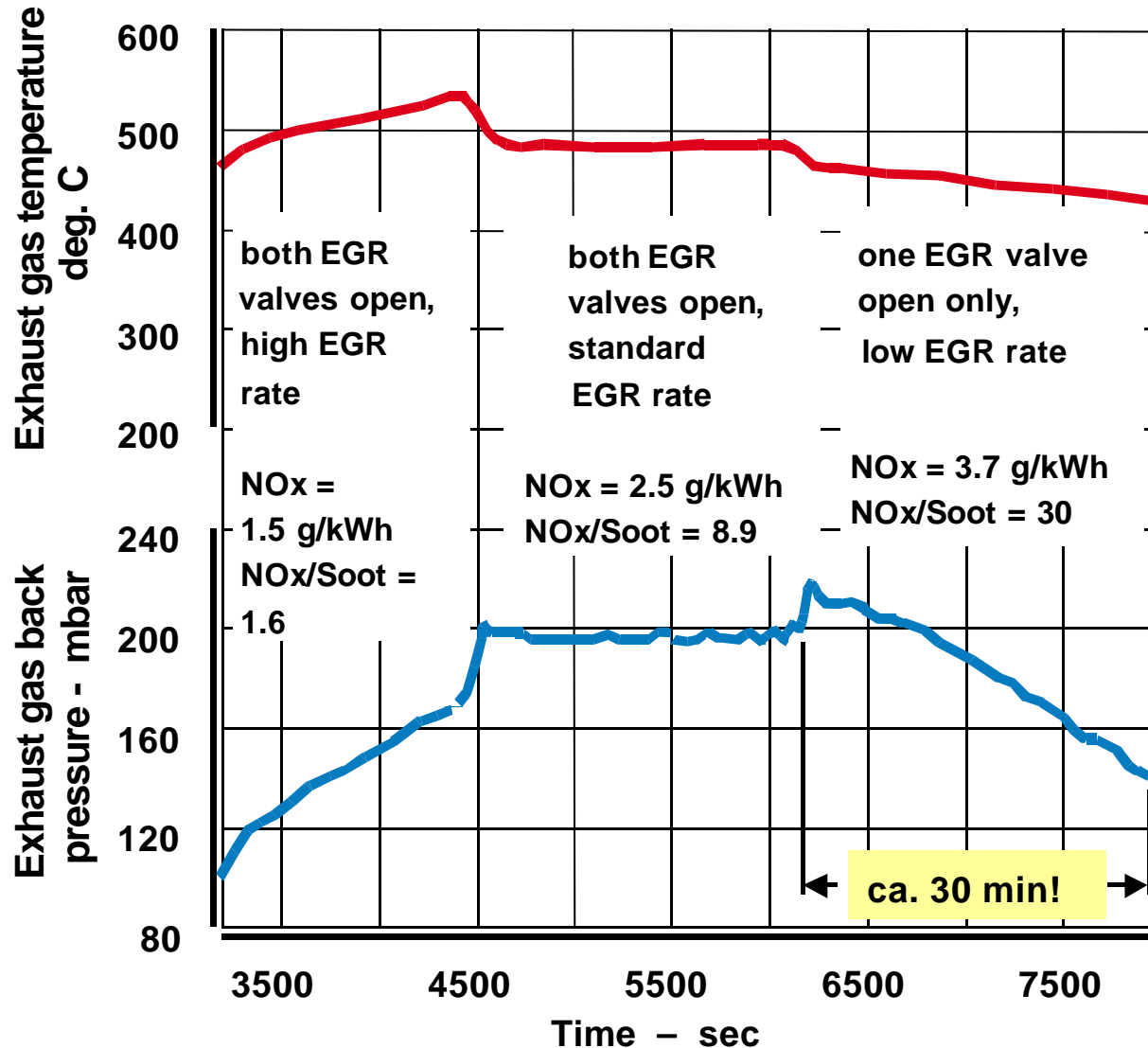
Strategy for Initiation of Regeneration



Methods to Support Regeneration of the CRT System



Loading and Regeneration Behaviour of a CRT System

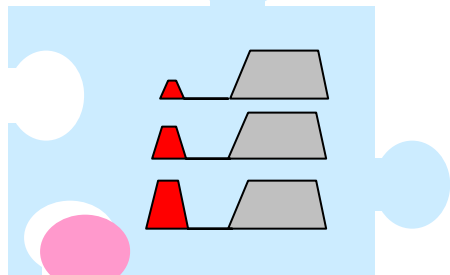


**HD DI / TCI
Diesel Engine
(1.5 l / cyl.)
EURO 4 Development
with cooled EGR**

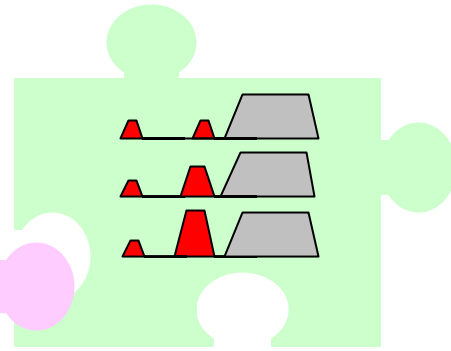
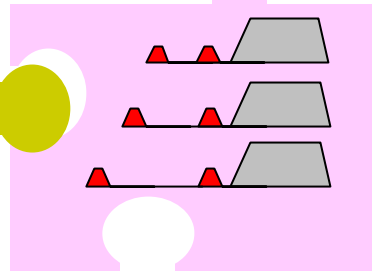
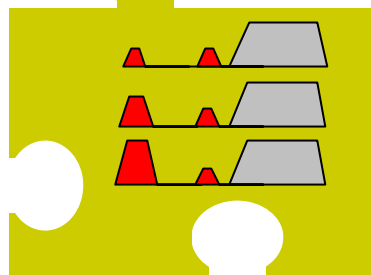
1700 rpm / Full load

Calibration Flexibility with HP-CR System

PILOT INJ. 1

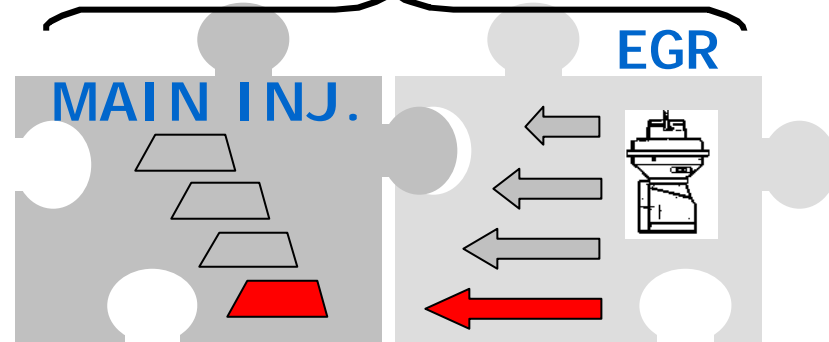


PILOT INJ. 2



RAIL PRESS.

STANDARD DEVELOPMENT PARAMETERS*



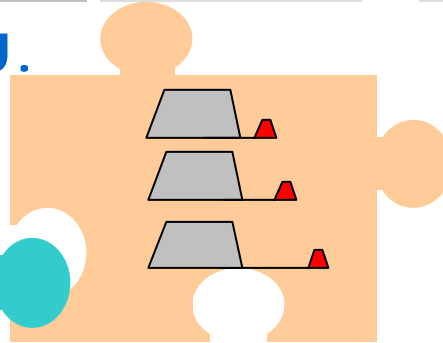
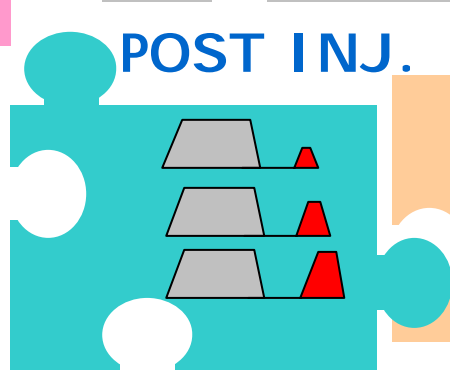
MAIN INJ.

EGR

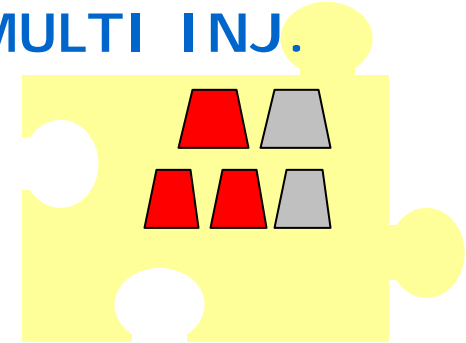


Excluding bowl geometry, injector design, air management etc.

POST INJ.



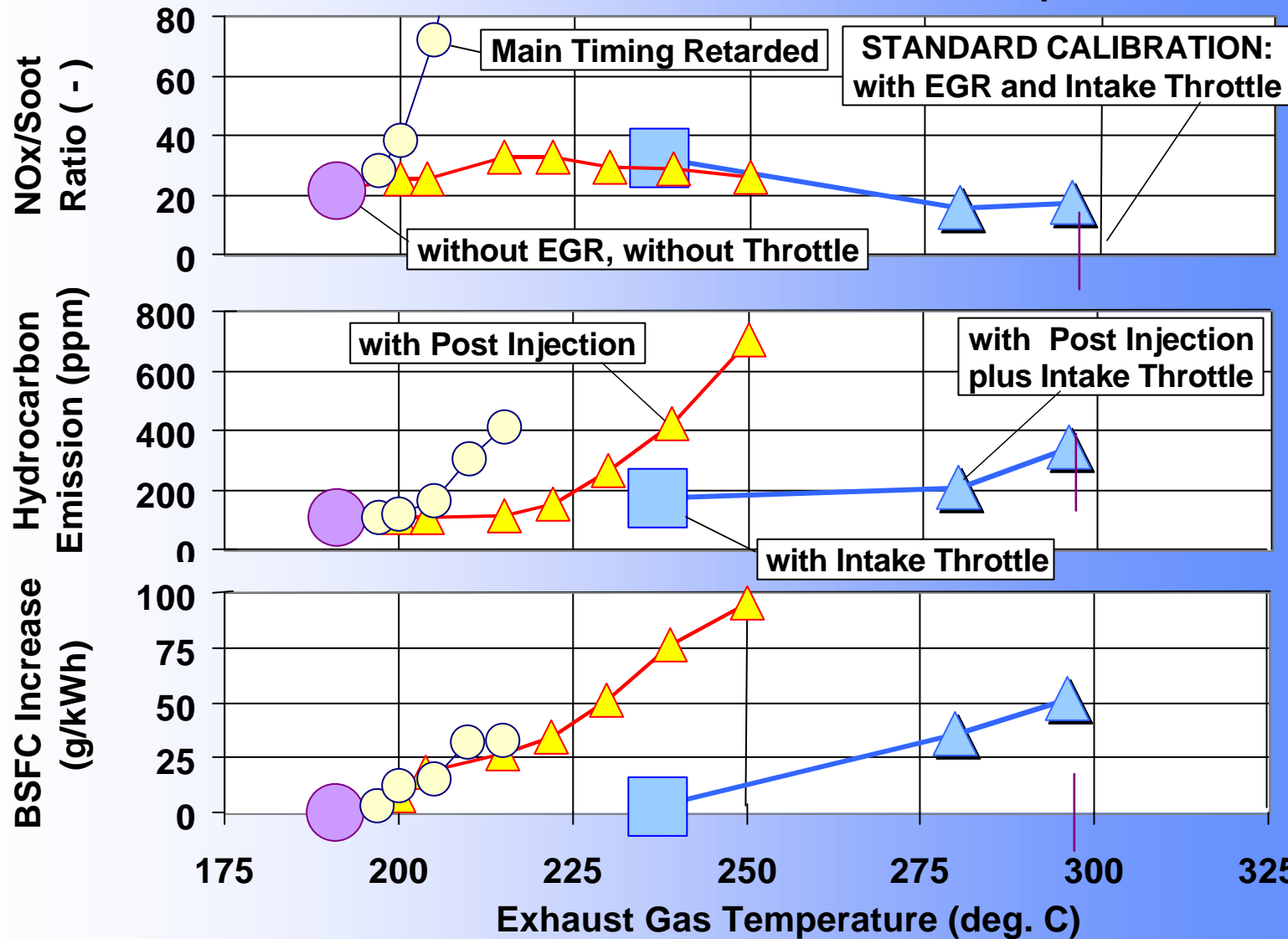
MULTI INJ.



Effect of different engine measures

EGR switched off (except ◆)

2000 rpm, 2.0 bar BMEP



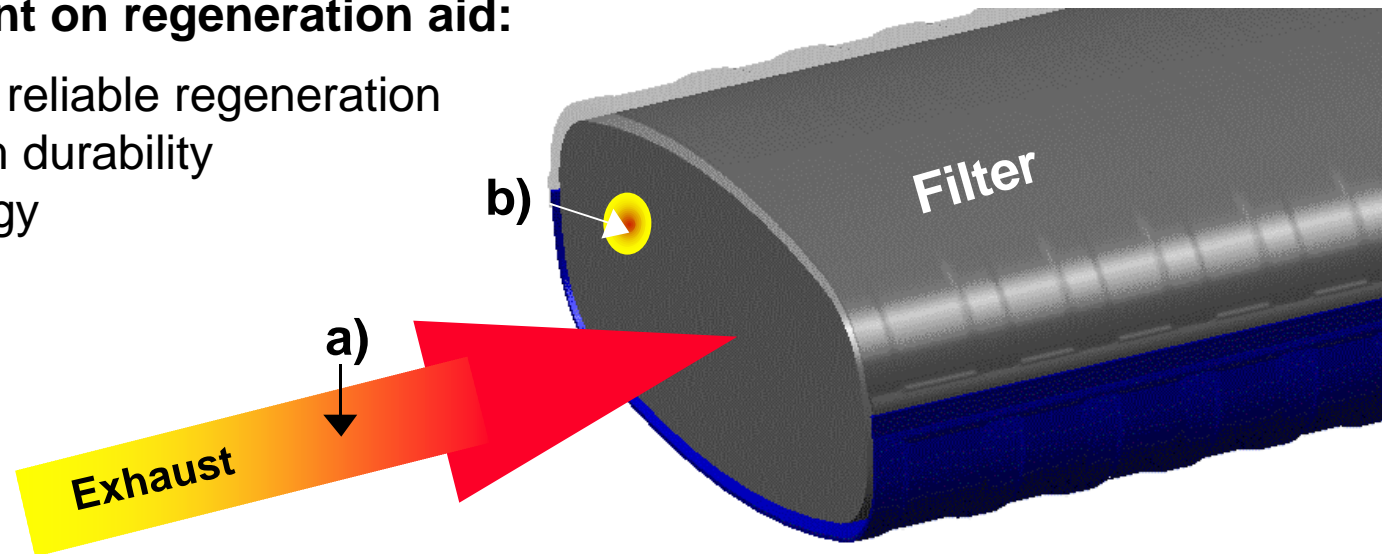
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Regeneration Aid

Requirement on regeneration aid:

- ☎ safe and reliable regeneration
- ☎ long term durability
- ☎ low energy



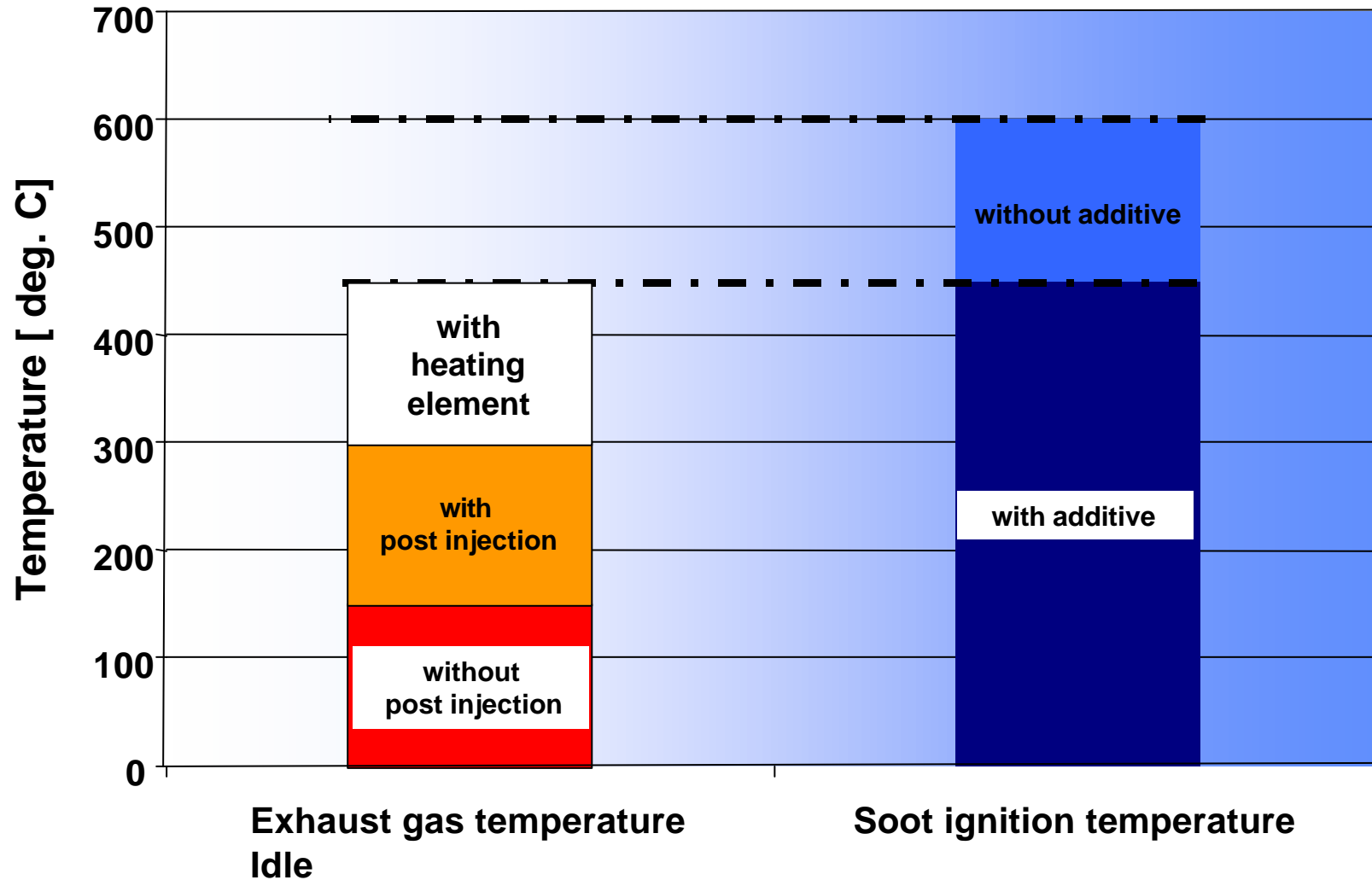
a) Exhaust Gas Heating

- ☎ ignition at any soot loading
- ☎ simultaneous ignition of the entire soot
- ☎ higher energy consumption

b) Direct Soot Ignition

- ☎ ignition at higher soot loading only
- ☎ slow expansion of the flame front
- ☎ low energy requirement

Heating Element



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Summary and Conclusions

- **Particulate traps will belong to standard aftertreatment systems for diesel engines in the near future.**
- **A combination of several regeneration methods for safe and reliable regeneration seems to be necessary to avoid any functional problems of the trap over the entire life of the diesel engine (e.g. > 200.000 km for passenger cars).**
- **Even the cost effective active regeneration aid as a “worst case solution” should be taken into account, particularly with respect to long time vehicle operation in the inner-city with its very low exhaust gas temperature level.**