An Introduction to Emission Control Technologies

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مقدمه ای بر نحوه تولید و فن آوری های کاهنده آلایندگی موتور با تاکید بر موتورهای دیزل

وحید حسینی

استادیار دانشکده مهندسی مکانیک دانشگاه صنعتی شریف

مقدمه ای بر احتراق دیزل و نحوه شکل گیری آلاینده ها

احتراق واقعی

$CH_4+2(O_2+3.76N_2) \rightarrow CO_2 + 2\ H_2O + 7.52\ N_2$

$C_xH_yN_zS_w...+2(O_2+3.76N_2) \rightarrow CO_2 + 2\ H_2O + 7.52\ N_2$

- سوخت مخلوط پیچیده ای از ترکیبات گوناگون شیمیایی است.

$C_xH_yN_zS_w...+n(O_2+3.76N_2) \rightarrow CO_2 + 2\ H_2O + 7.52\ N_2$

- ممکن است مقدار هوا دقیقا استوکیومتری نباشد.

$C_xH_yN_zS_w...+n(O_2+3.76N_2) \rightarrow$

$aCO_2 + b\ H_2O + d\ N_2 + e\ CO + f\ Cx'Hy' + g\ NO + h\ NO_2 + i\ N_2O + j\ C + k\ CN + ...$

- محصولات احتراقی نیز محصولات احتراق کامل نخواهند بود.

Diesel combustion model

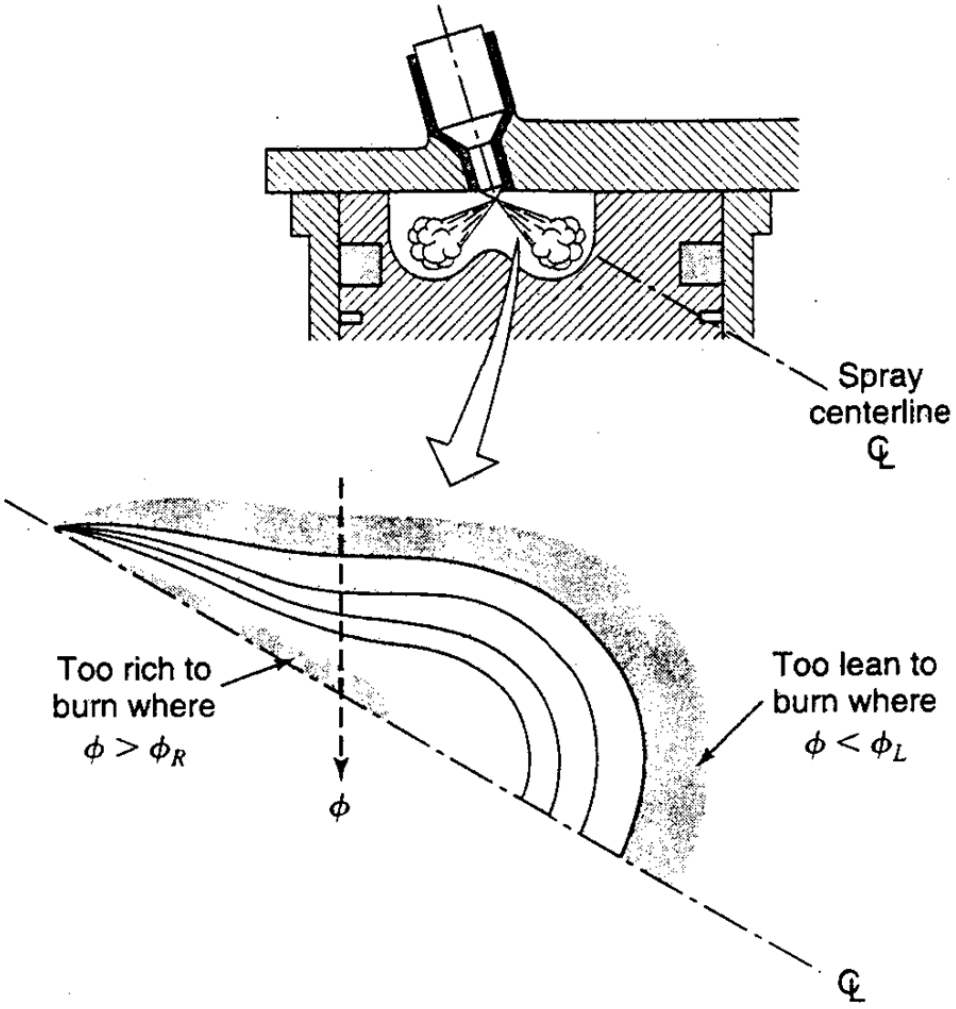


Figure 9-16 Simple model of diesel combustion.

Diesel combustion pictures

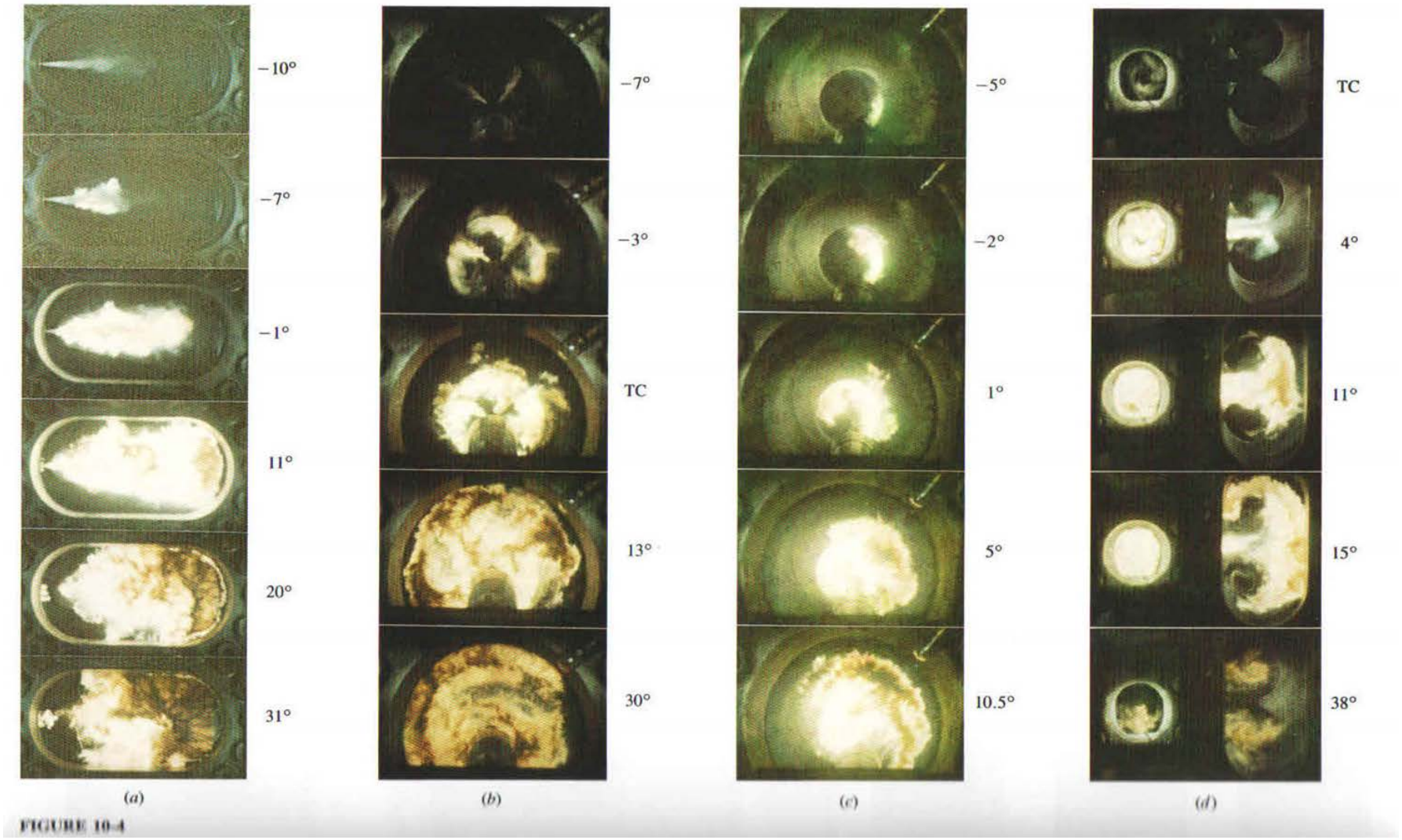


FIGURE 10-4

Diesel combustion heat release shape

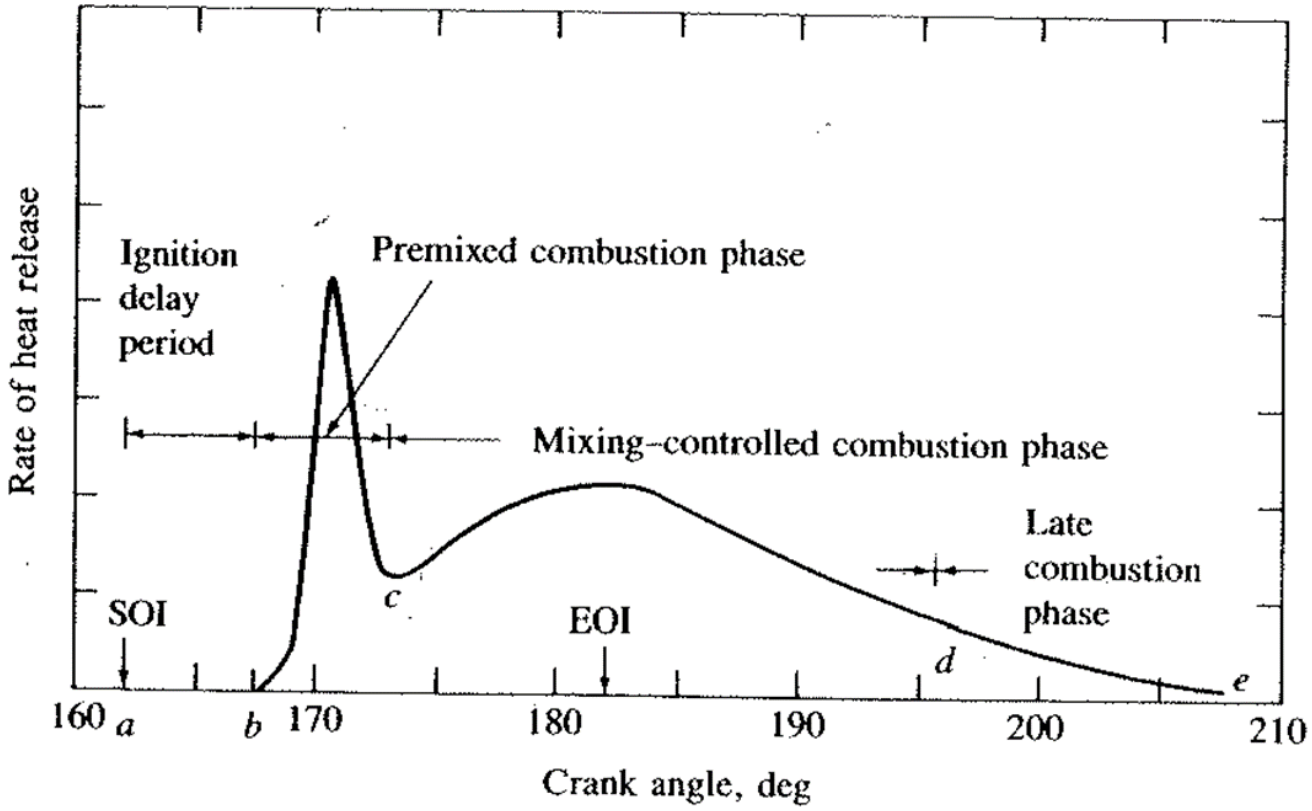


FIGURE 10-9
Typical DI engine heat-release-rate diagram identifying different diesel combustion phases.

Simplified vaporization, atomization, and mixing scheme

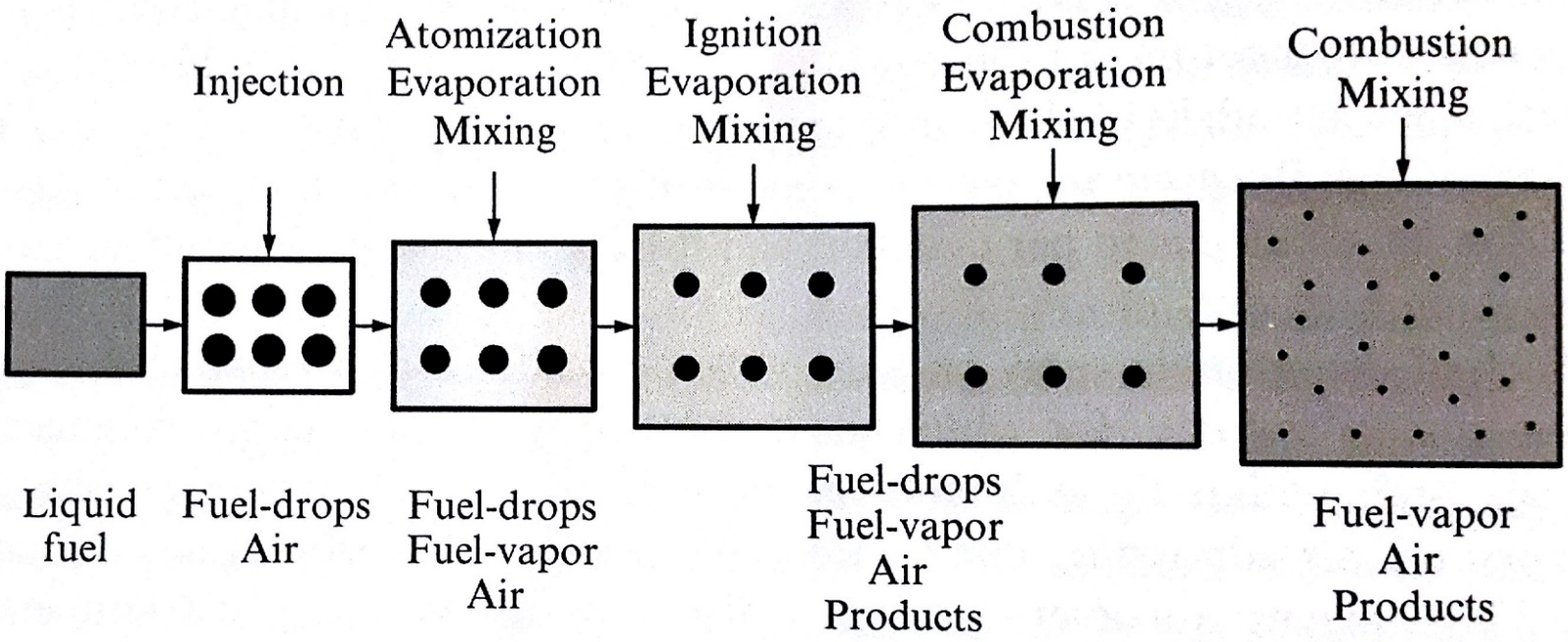


Fig. 11.7 Composition of spray packets

Details of diesel spray

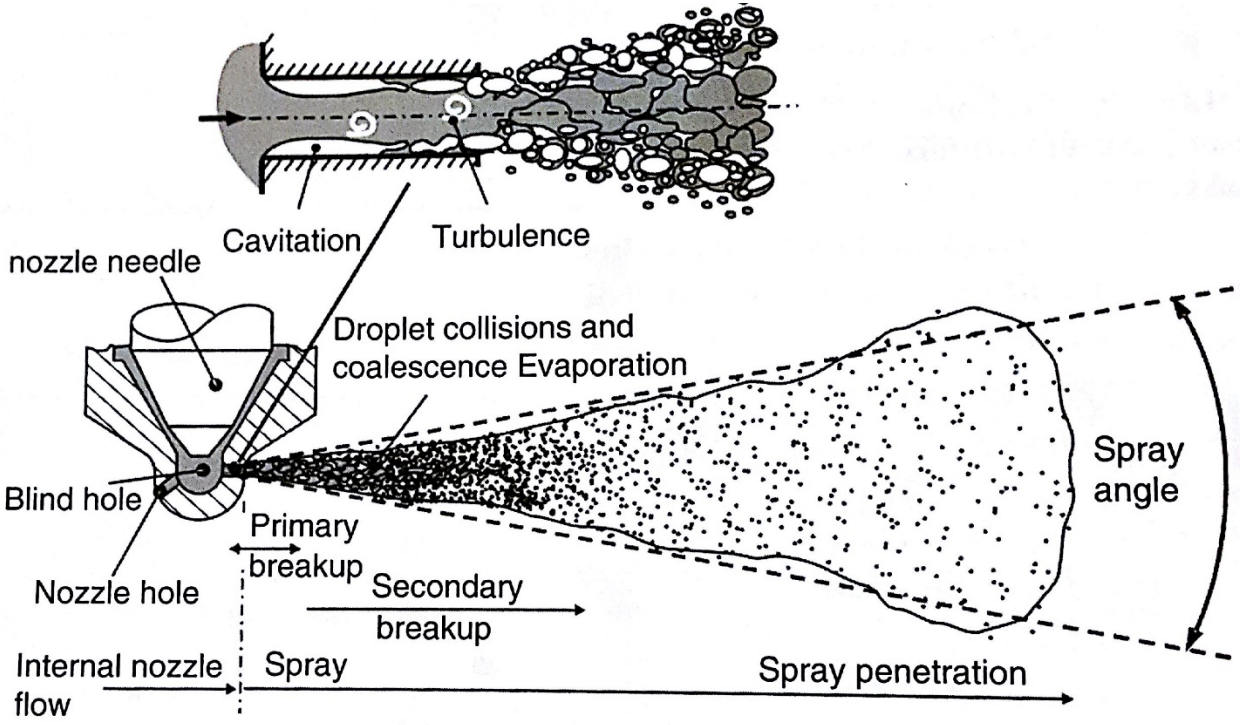
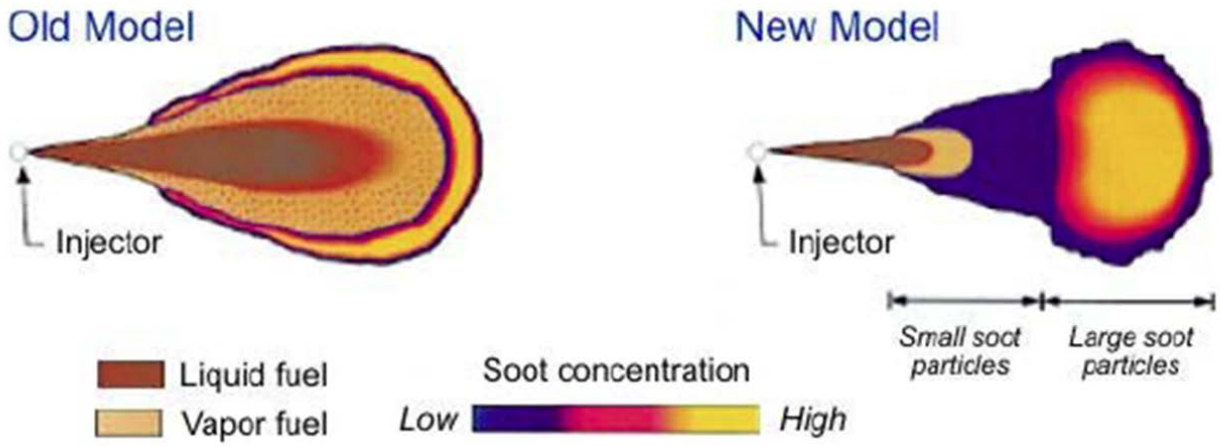
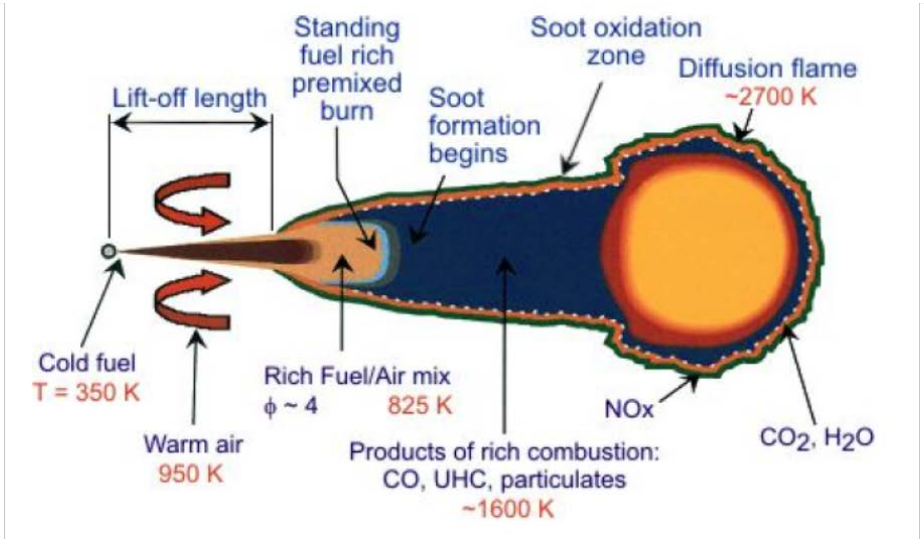


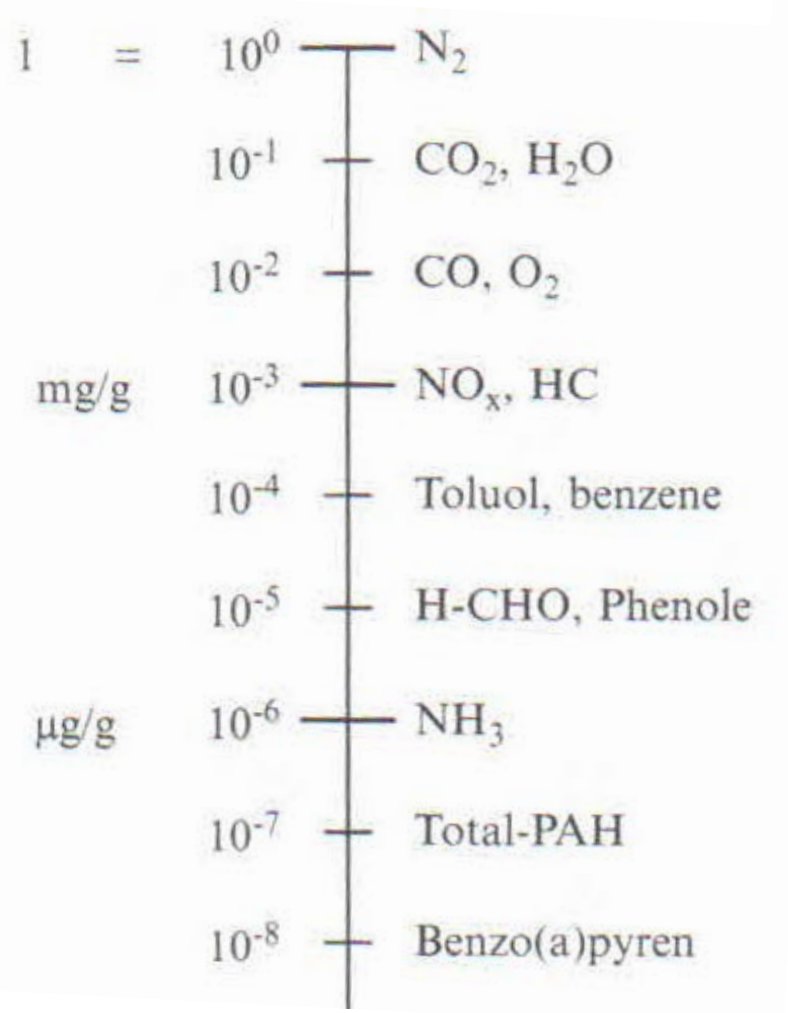
Fig. 4.18 Schematic representation of internal nozzle flow and spray propagation (Baumgarten 2006)

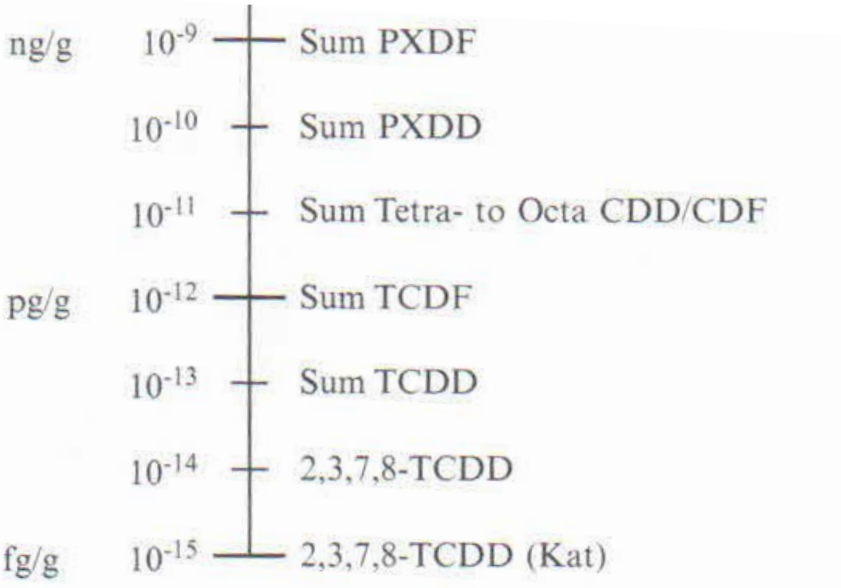
Old and new diesel combustion models





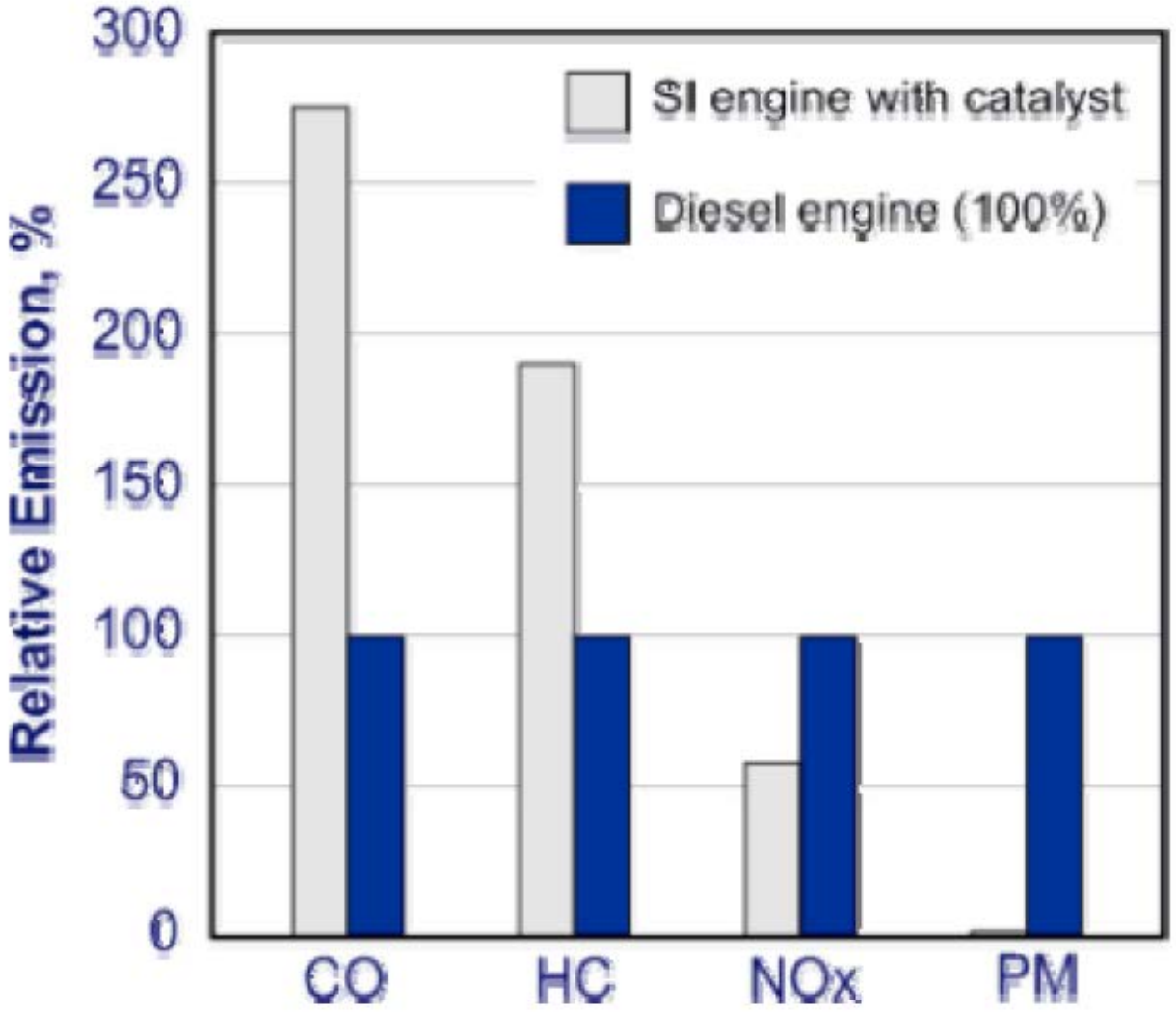
توزیع و مقایسه آلاینده های موتور





2,3,7,8- TCDD ≙ 2,3,7,8- Tetrachlordibenzo-p-dioxin
("Seveso-poison", 1976)

مقایسه آلایندگی نسبی موتورهای دیزلی و بنزینی



توزیع و مقایسه آلاینده های موتورهای SIو CI

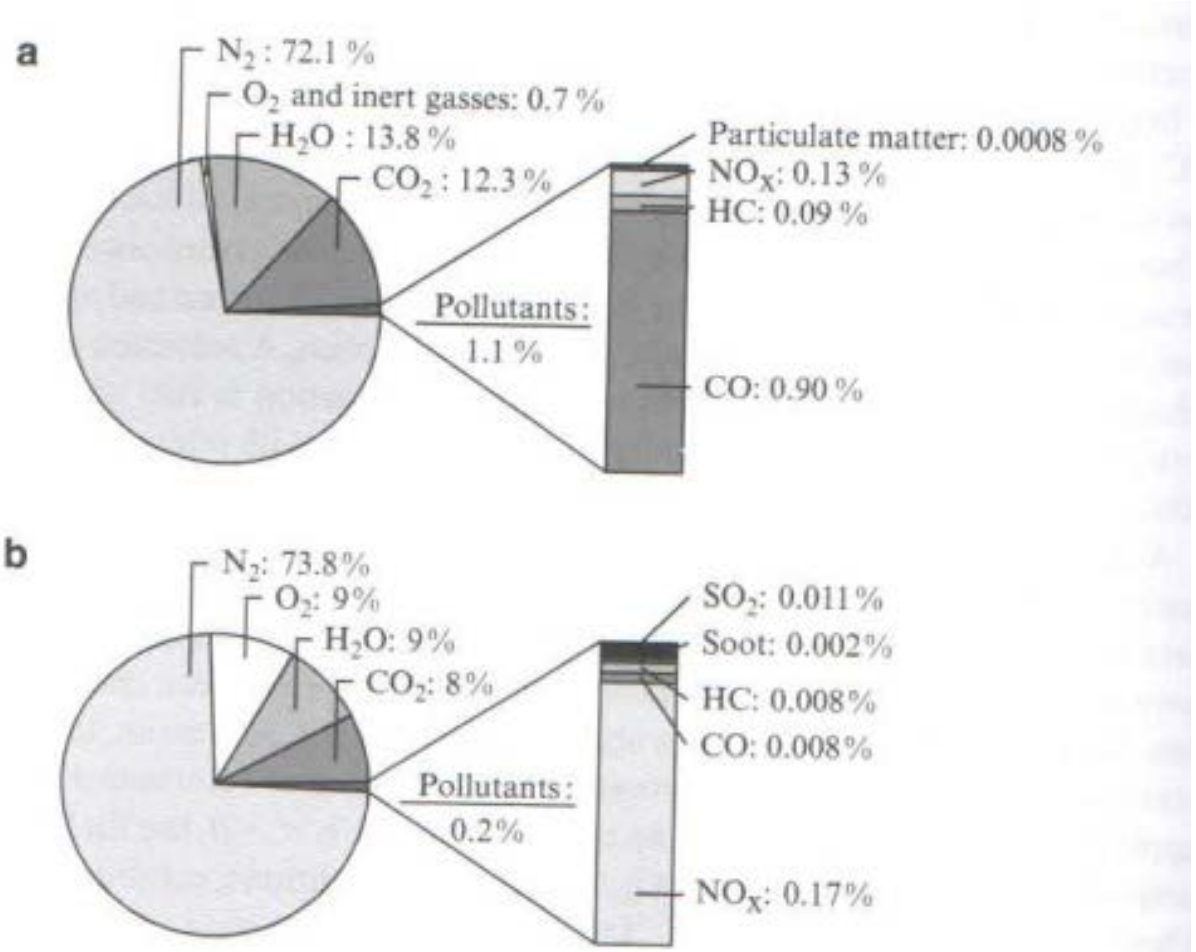
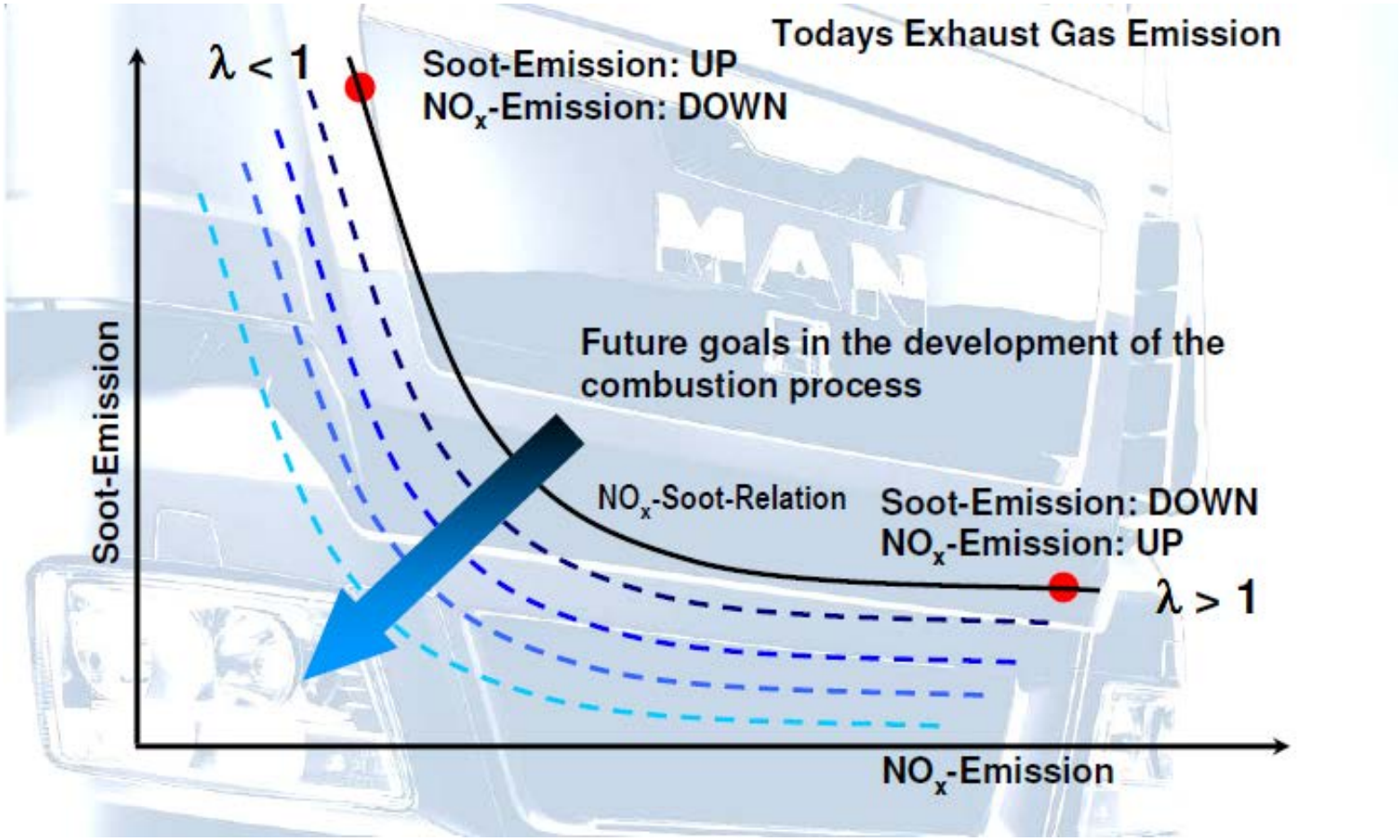


Fig. 6.2 Raw emissions (without catalyst) in percent by volume. (**a**) SI engine and (**b**) dies engine

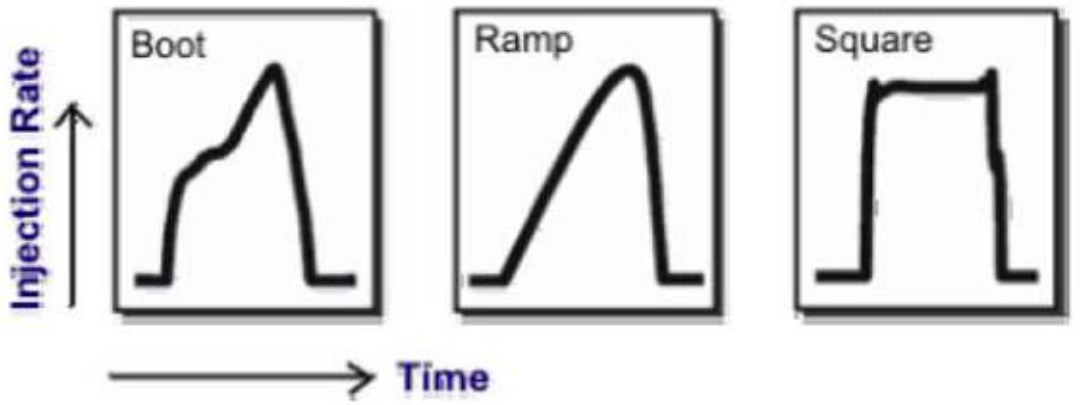
NOx- Soot trade-off

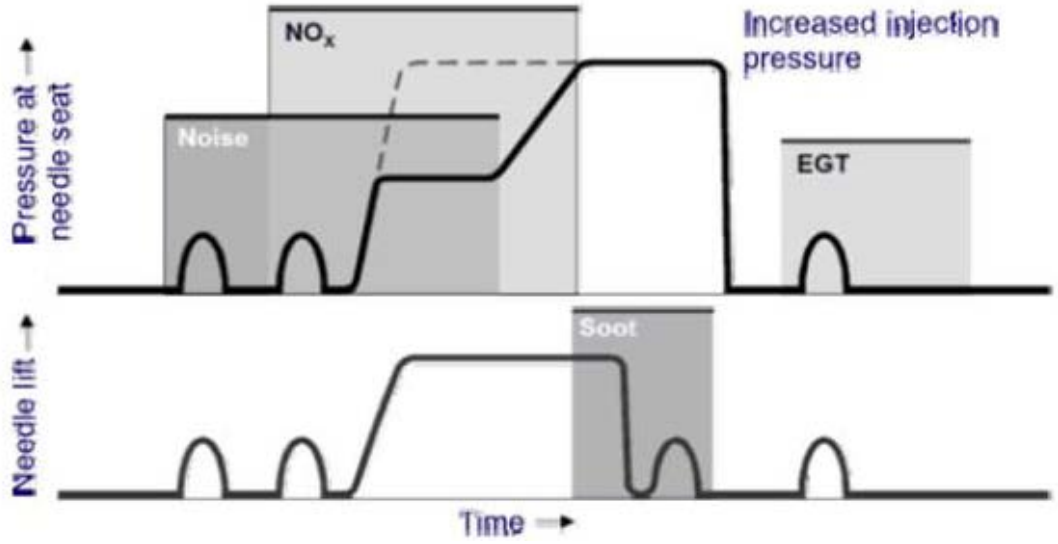
تقریبا هر اقدامی برای کاهش NOx در موتورهای دیزل به افزایش Soot منجر می شود و برعکس



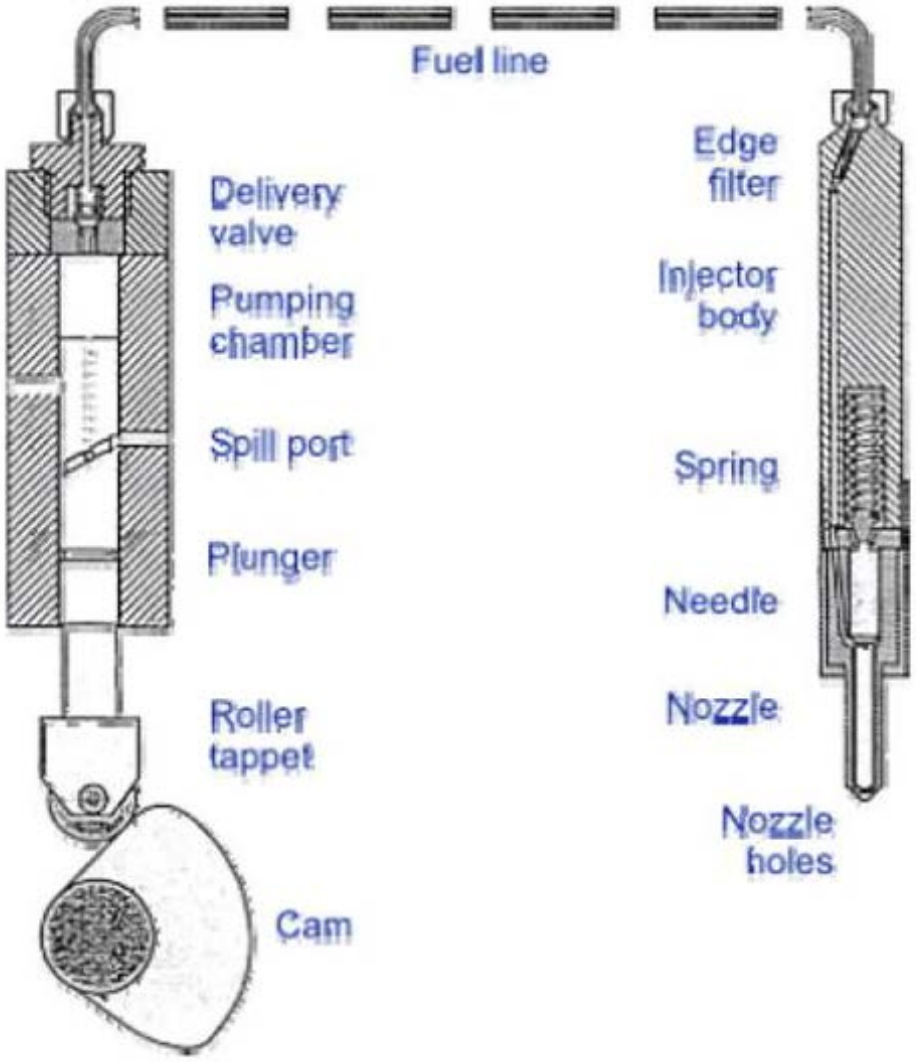
پاشش سوخت دیزل، مقدمه ای مهم بر کاهش آلودگی

Fuel injection patterns

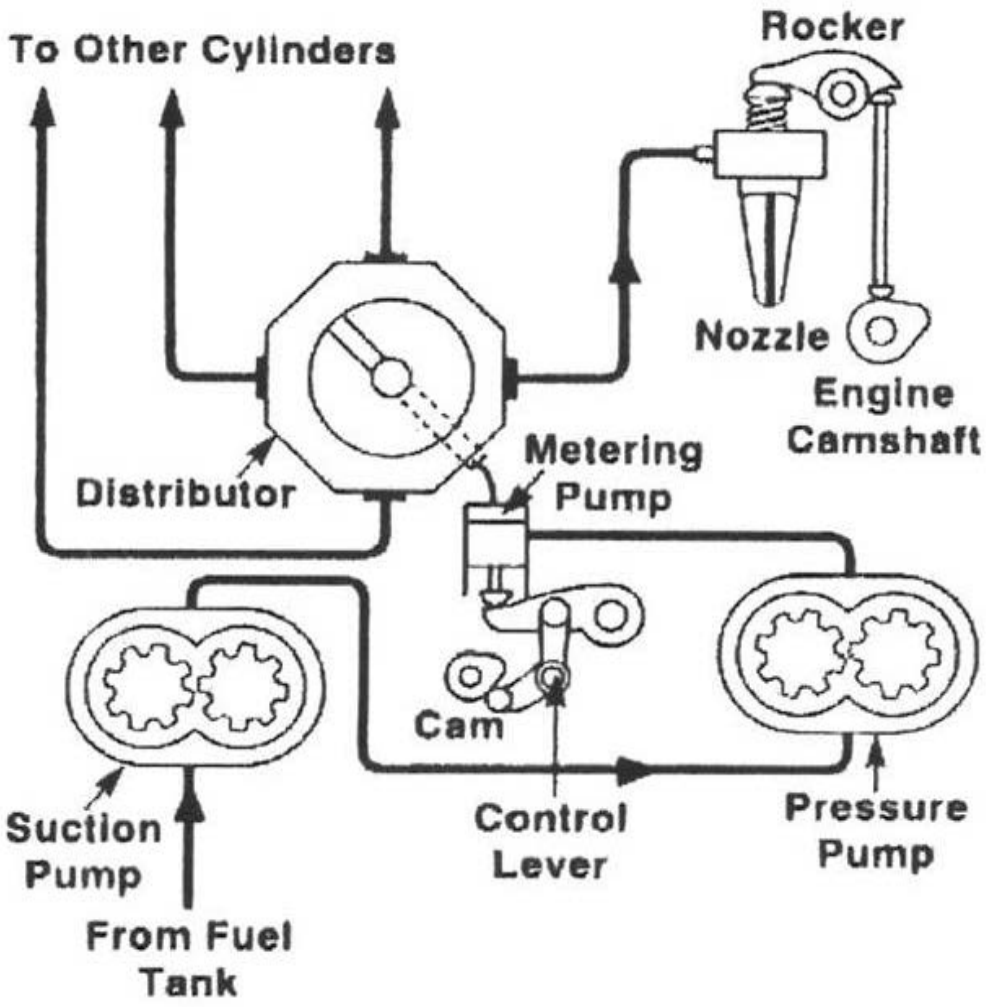




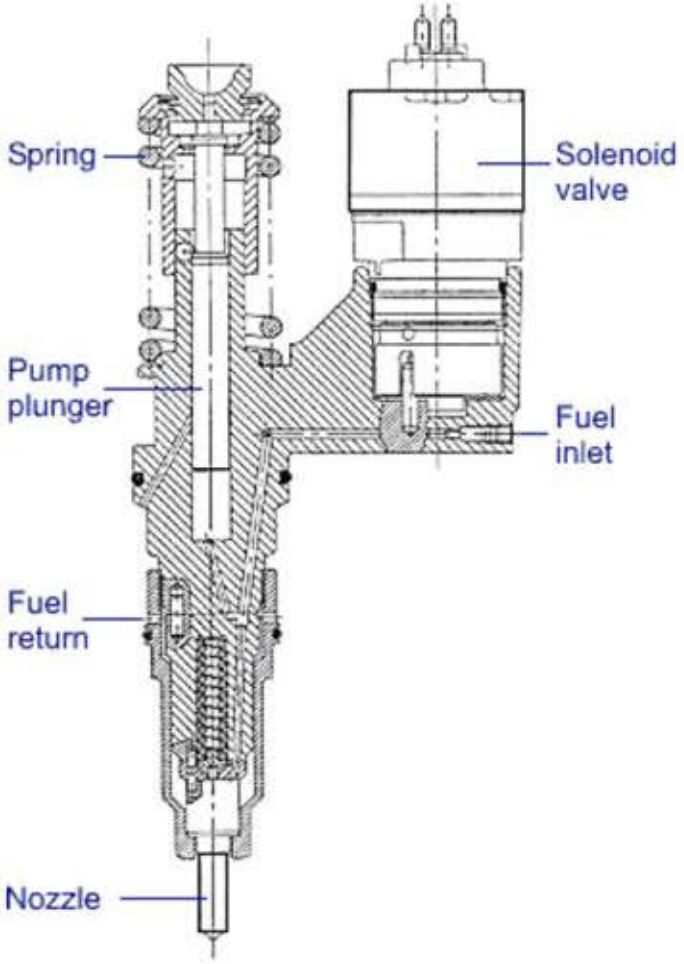
Pump-line-injector system

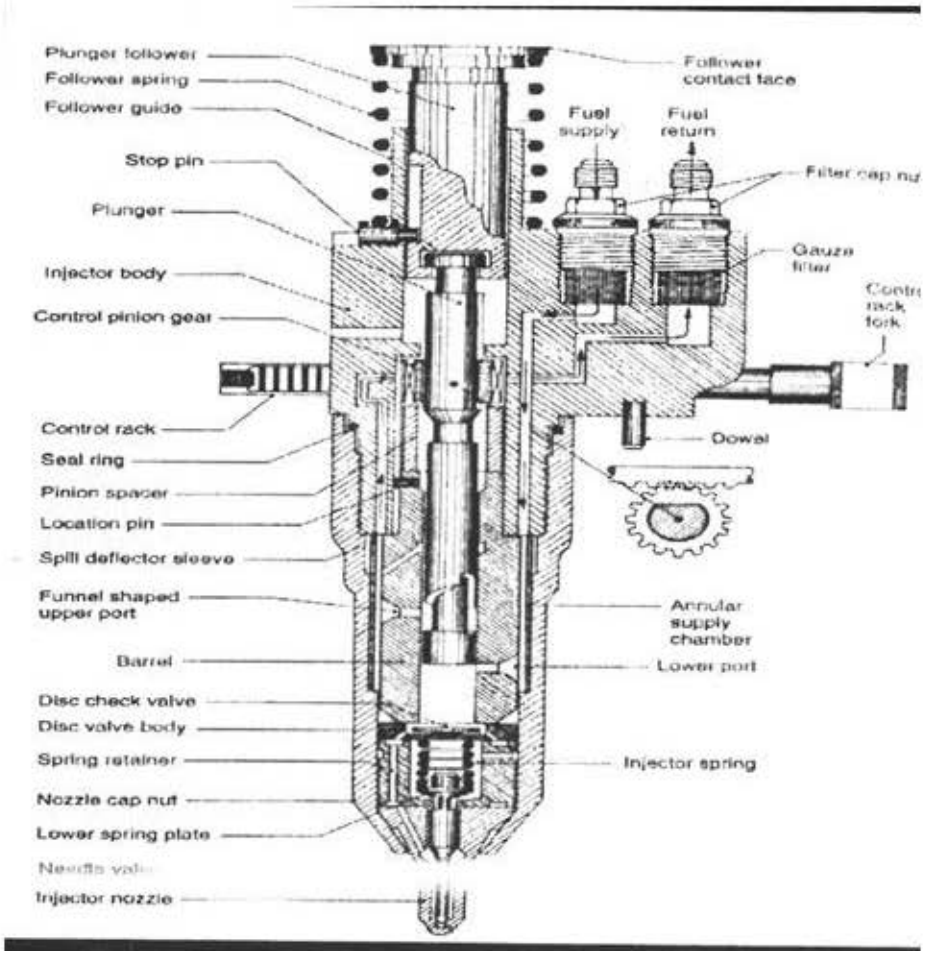


Schematic of distributor pump

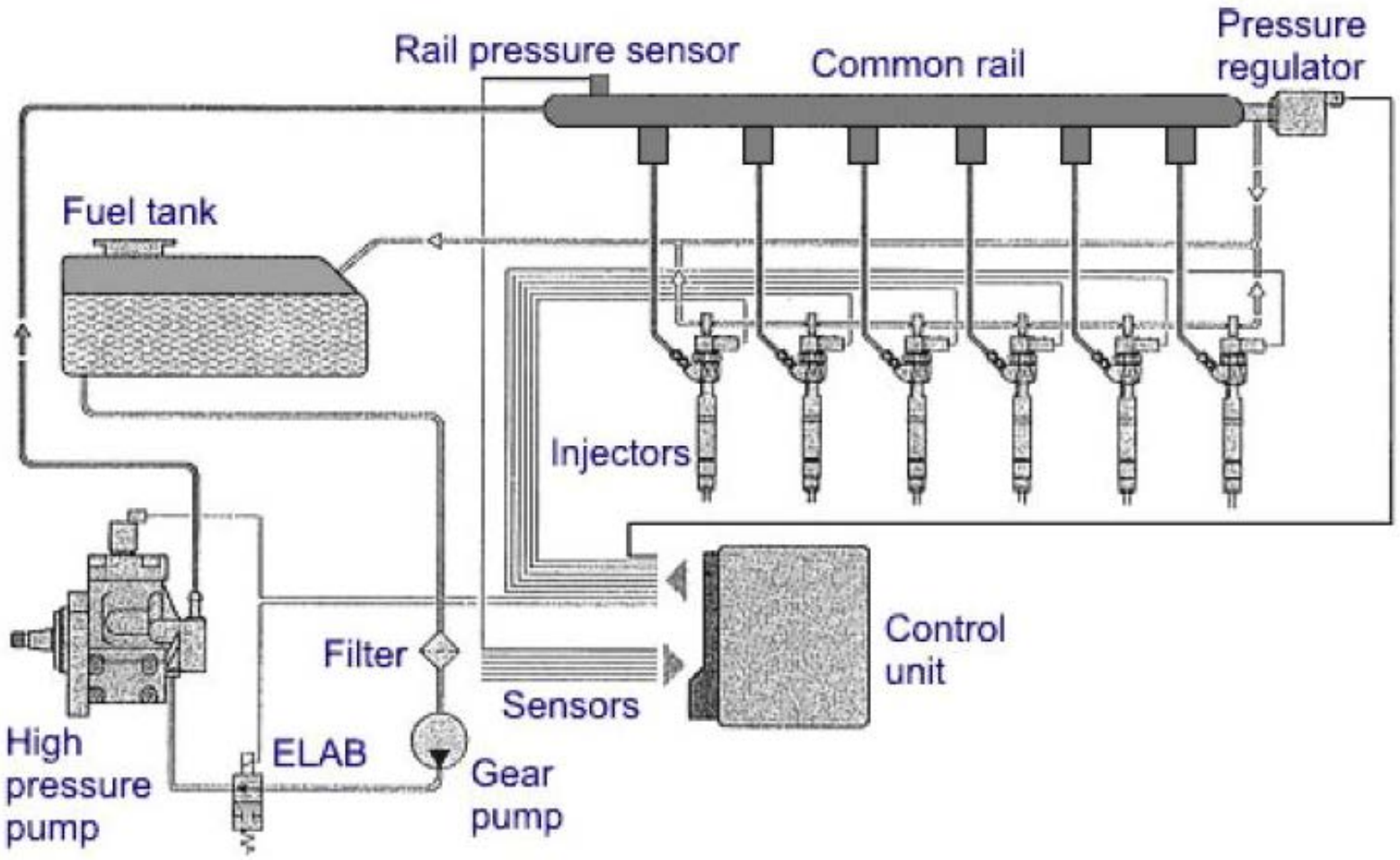


Unit injectors, mechanical and electronic



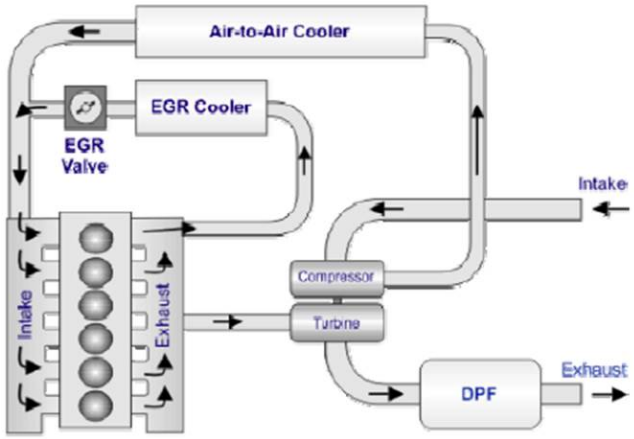


Bosch common rail fuel injection

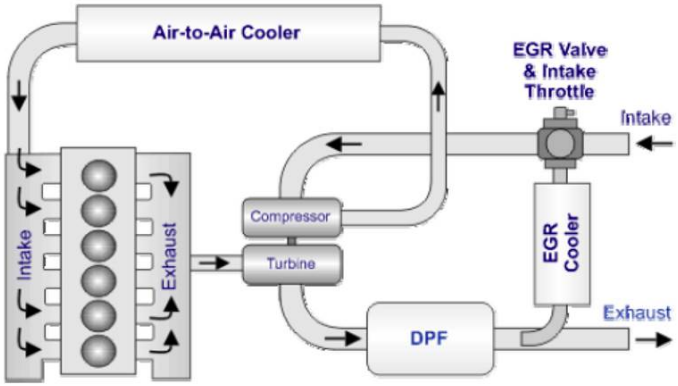


Diesel EGR system

High pressure EGR loop



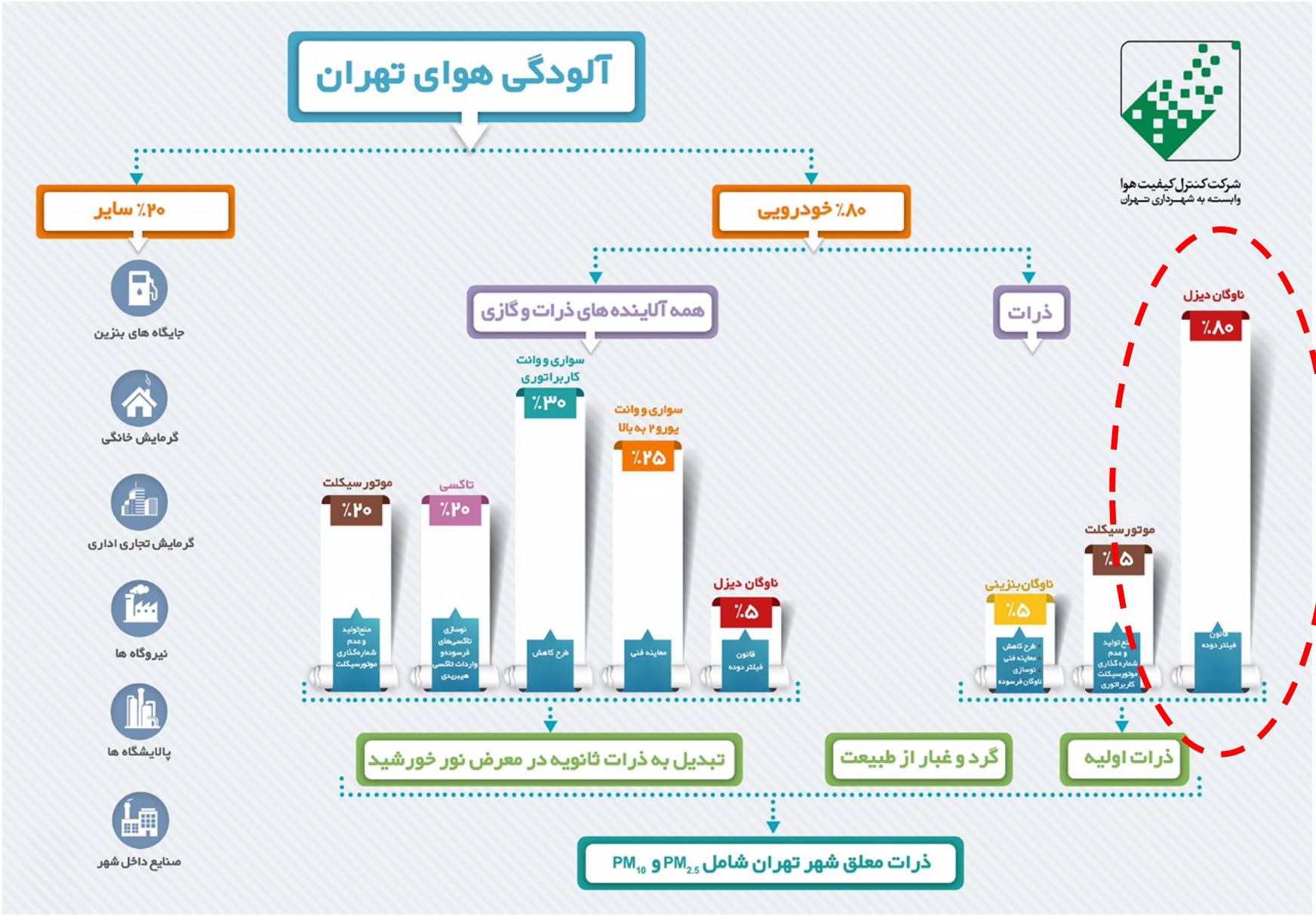
Low pressure EGR loop



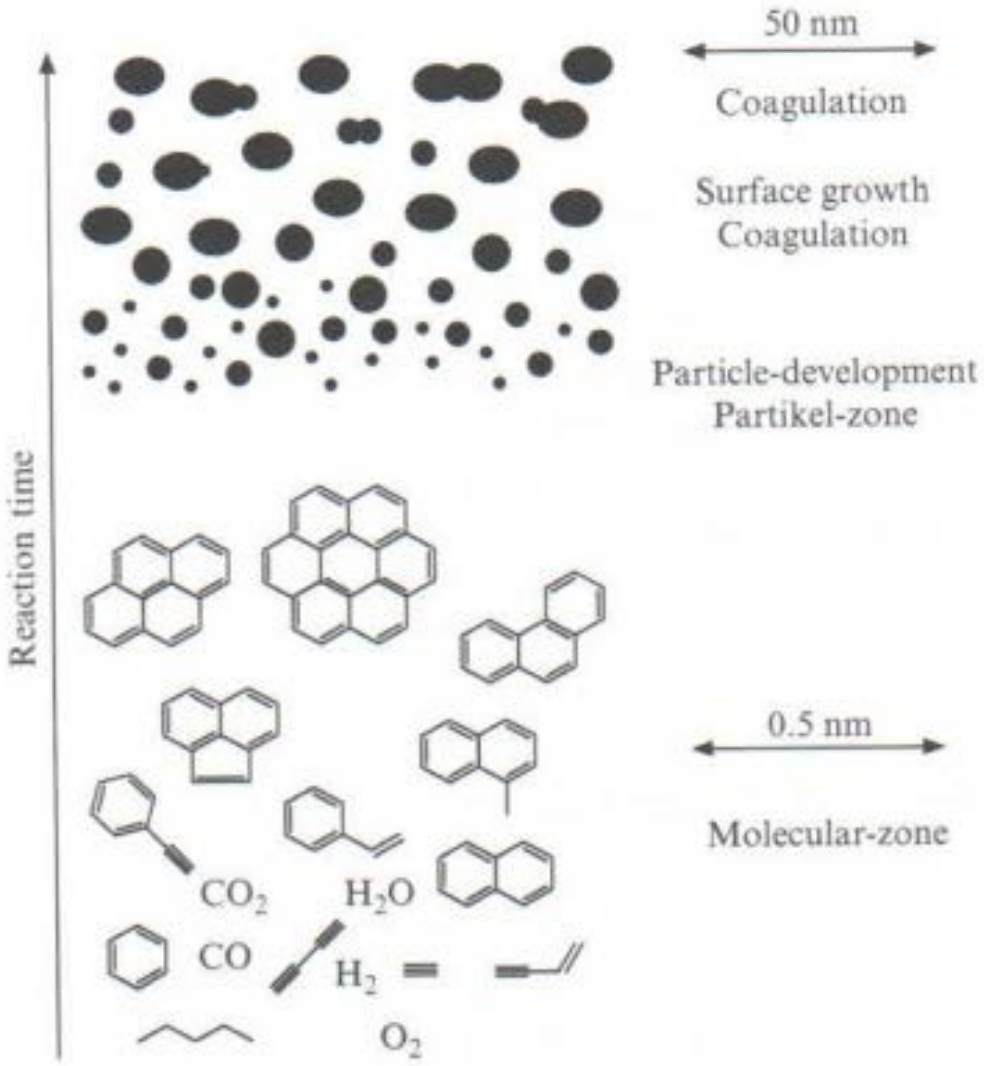
آلایندگی دوده دیزل

مفهوم جرم یا تعداد ذرات

ذرات تولیدی دیزل کجای آلودگی ذرات شهری است؟



نحوه تشکیل دوده در موتور دیزل



مدل تولید دوده

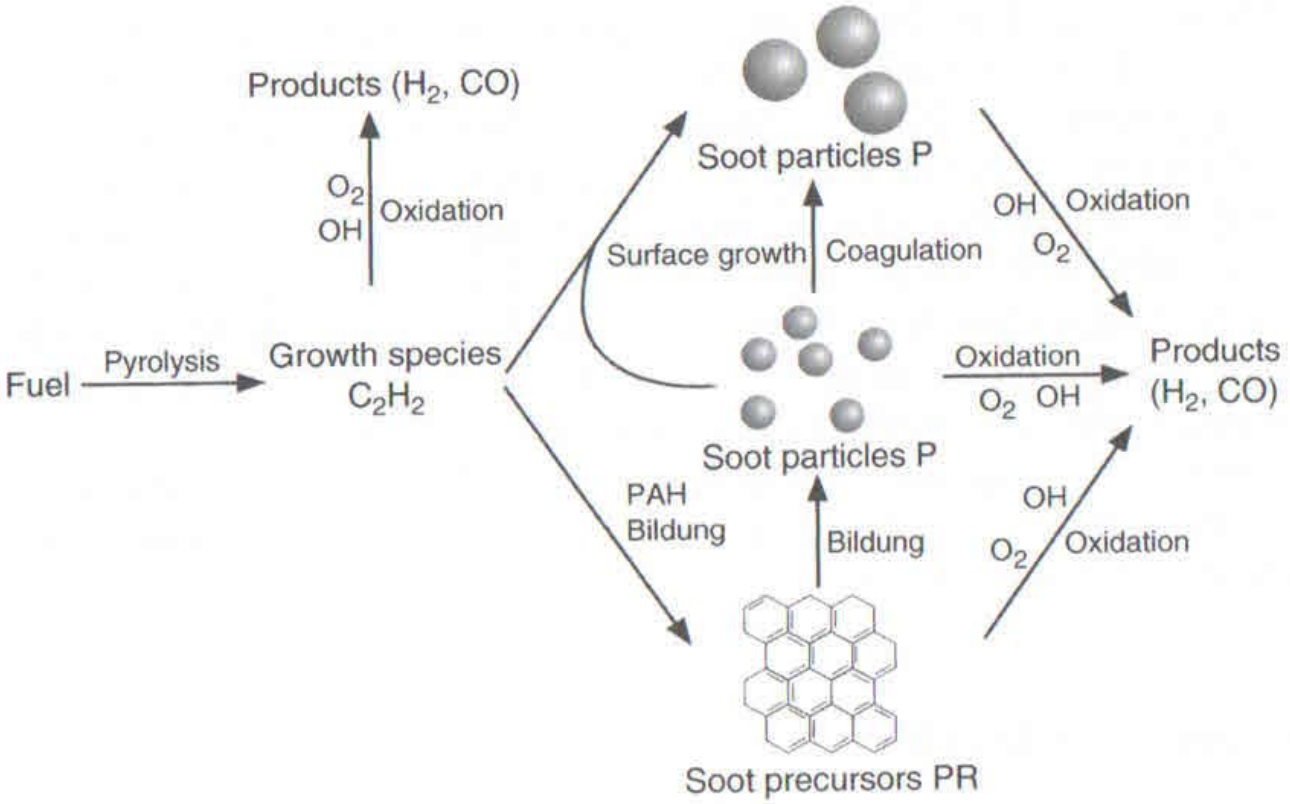
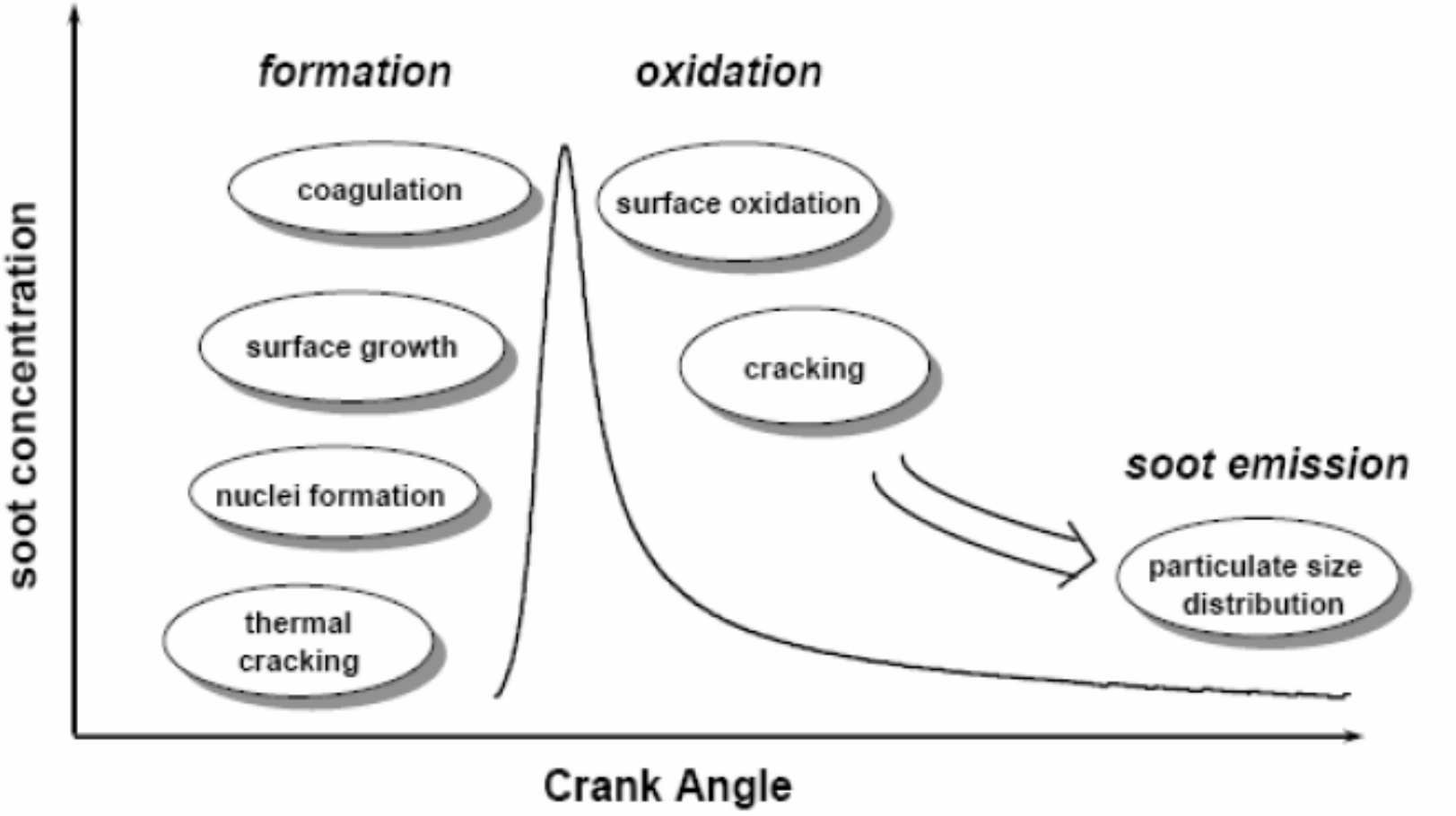
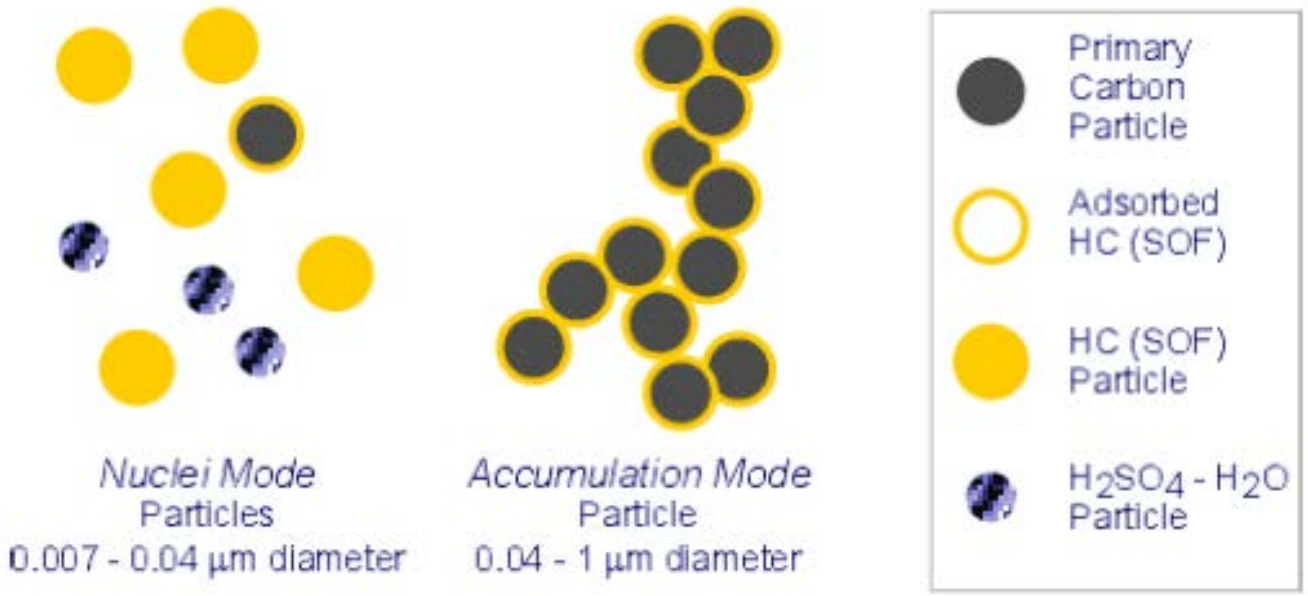


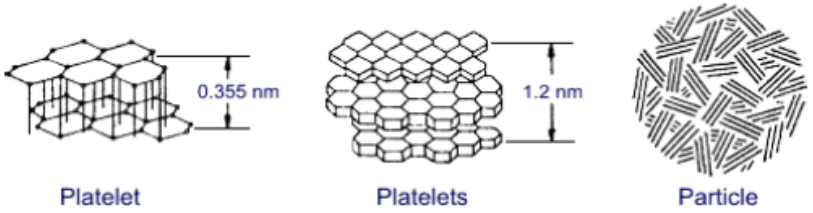
Fig. 6.21 Schematic representation of the phenomenological soot model, acc. to Tao et al. (2005)

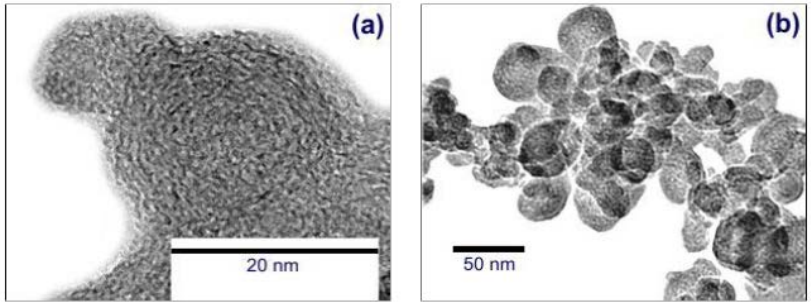
مدل تولید دوده



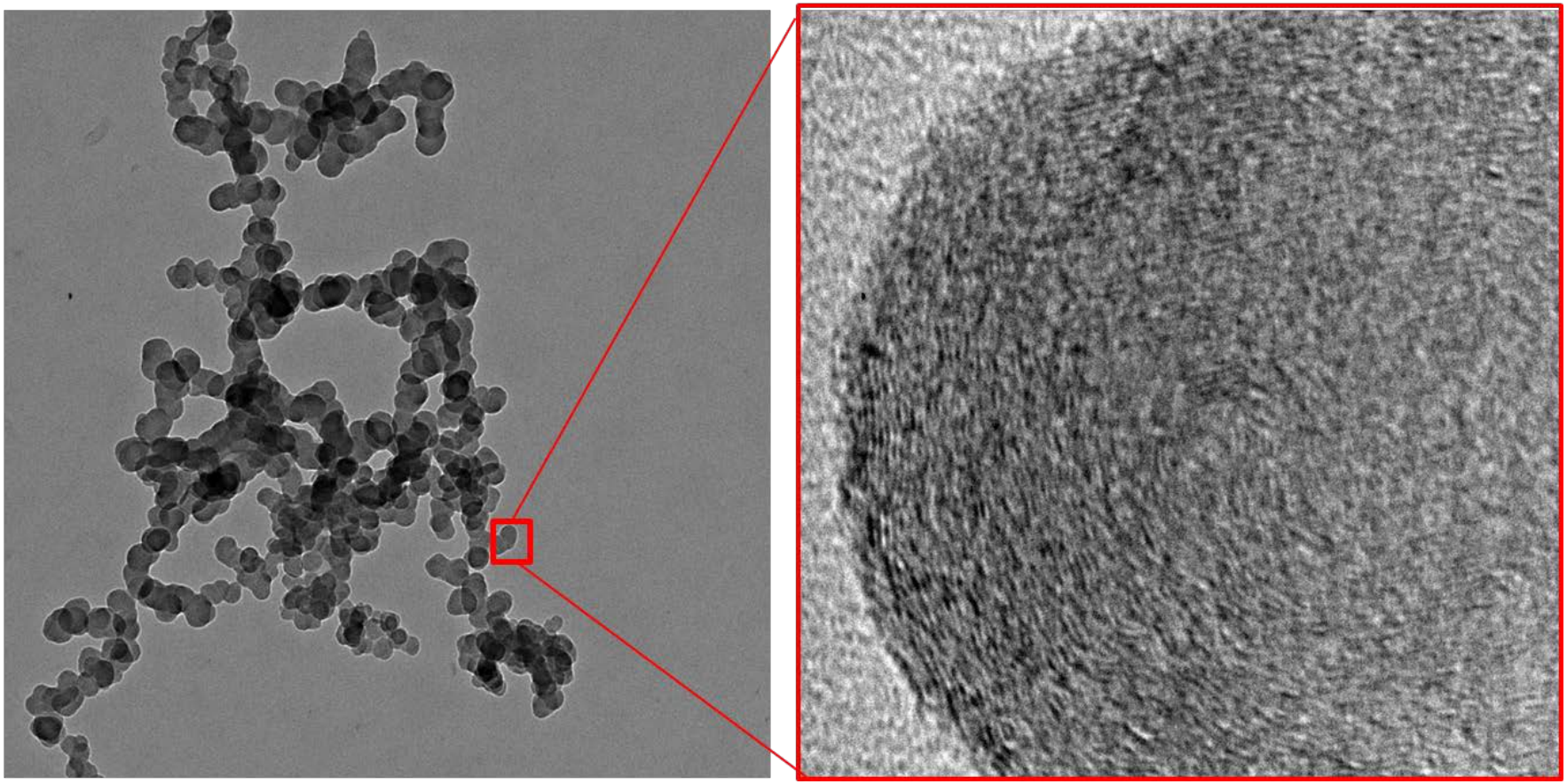
دوده دیزل و اجزا تشکیل دهنده آن



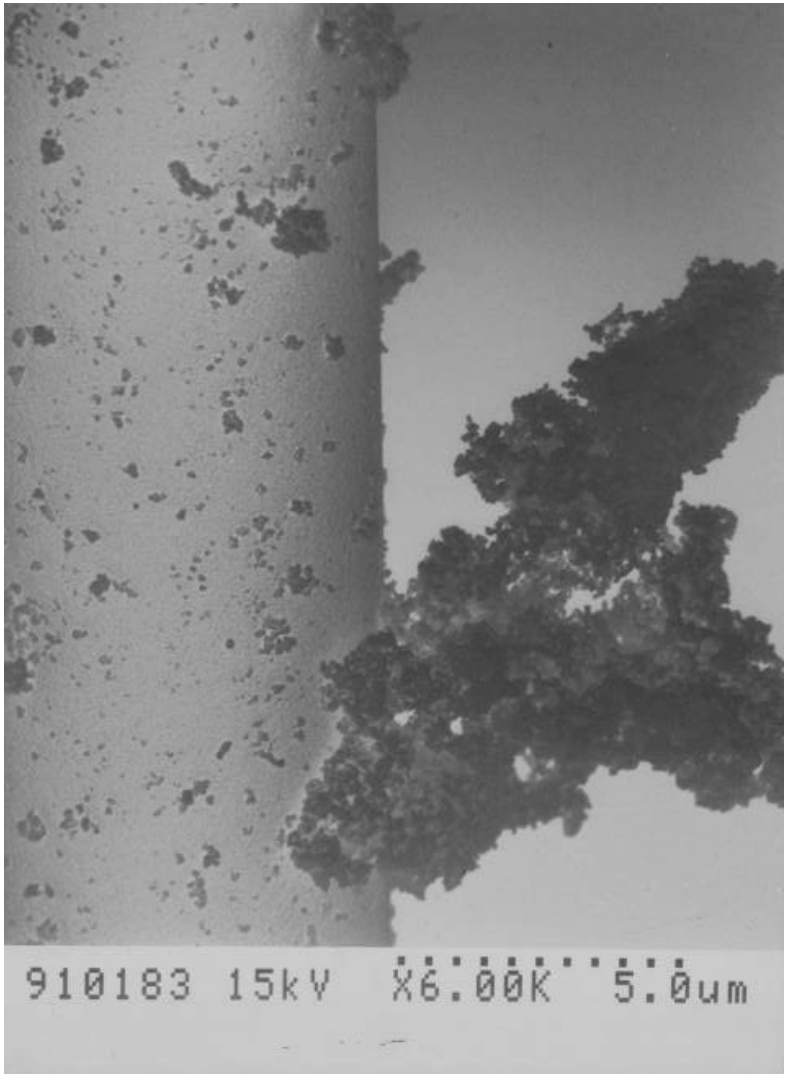


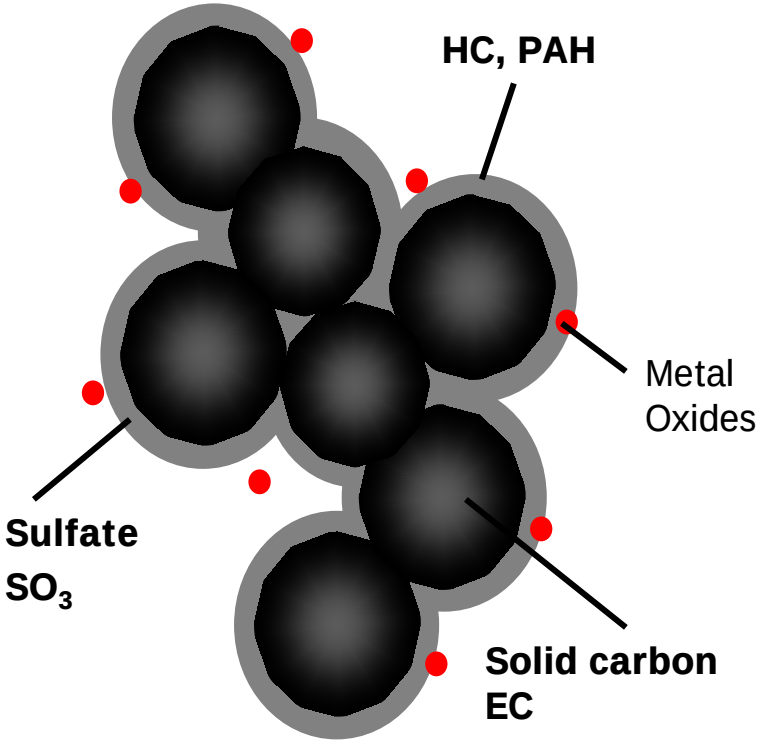


Soot aggregate and primary particle

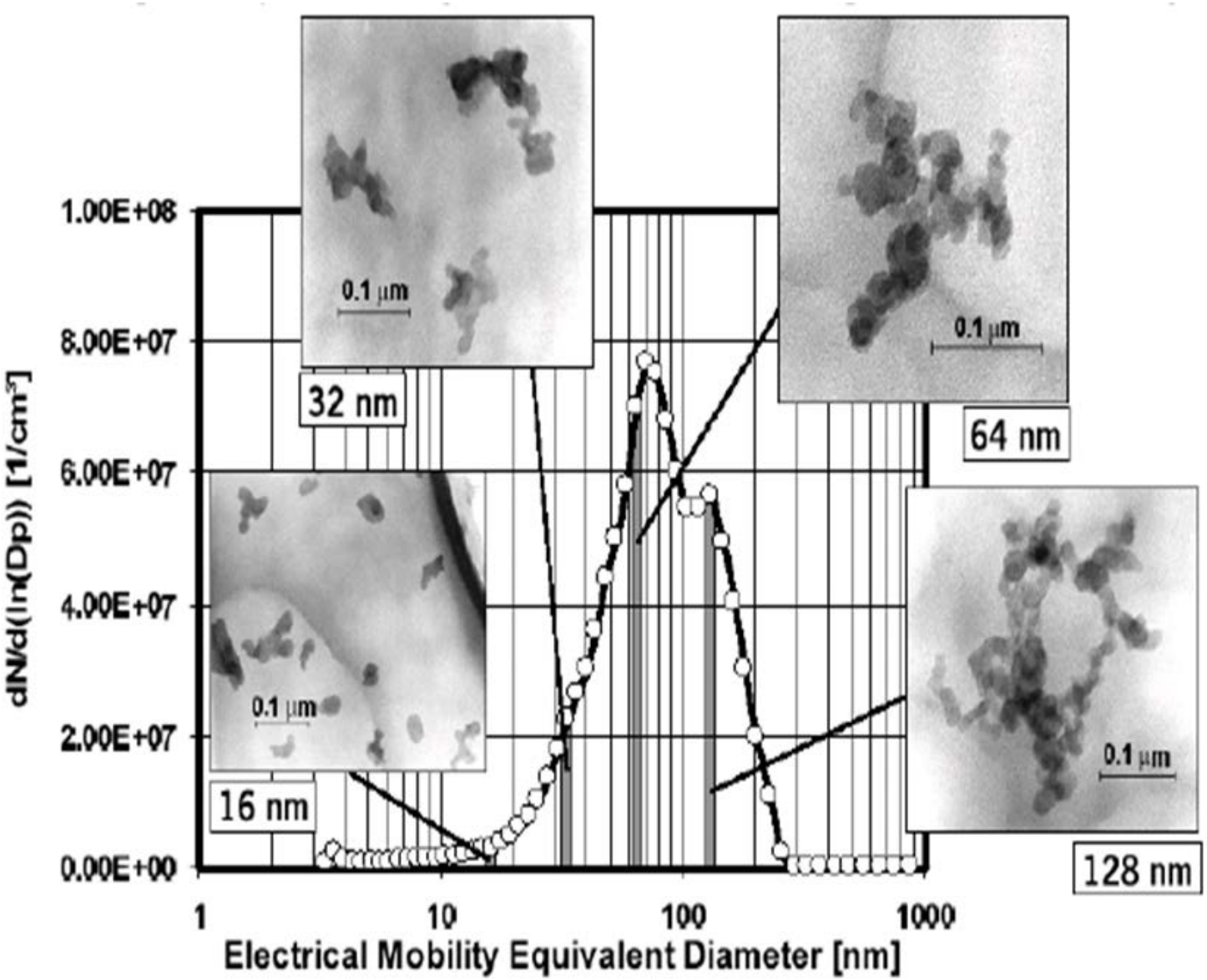


دوده دیزل و اجزا تشکیل دهنده آن





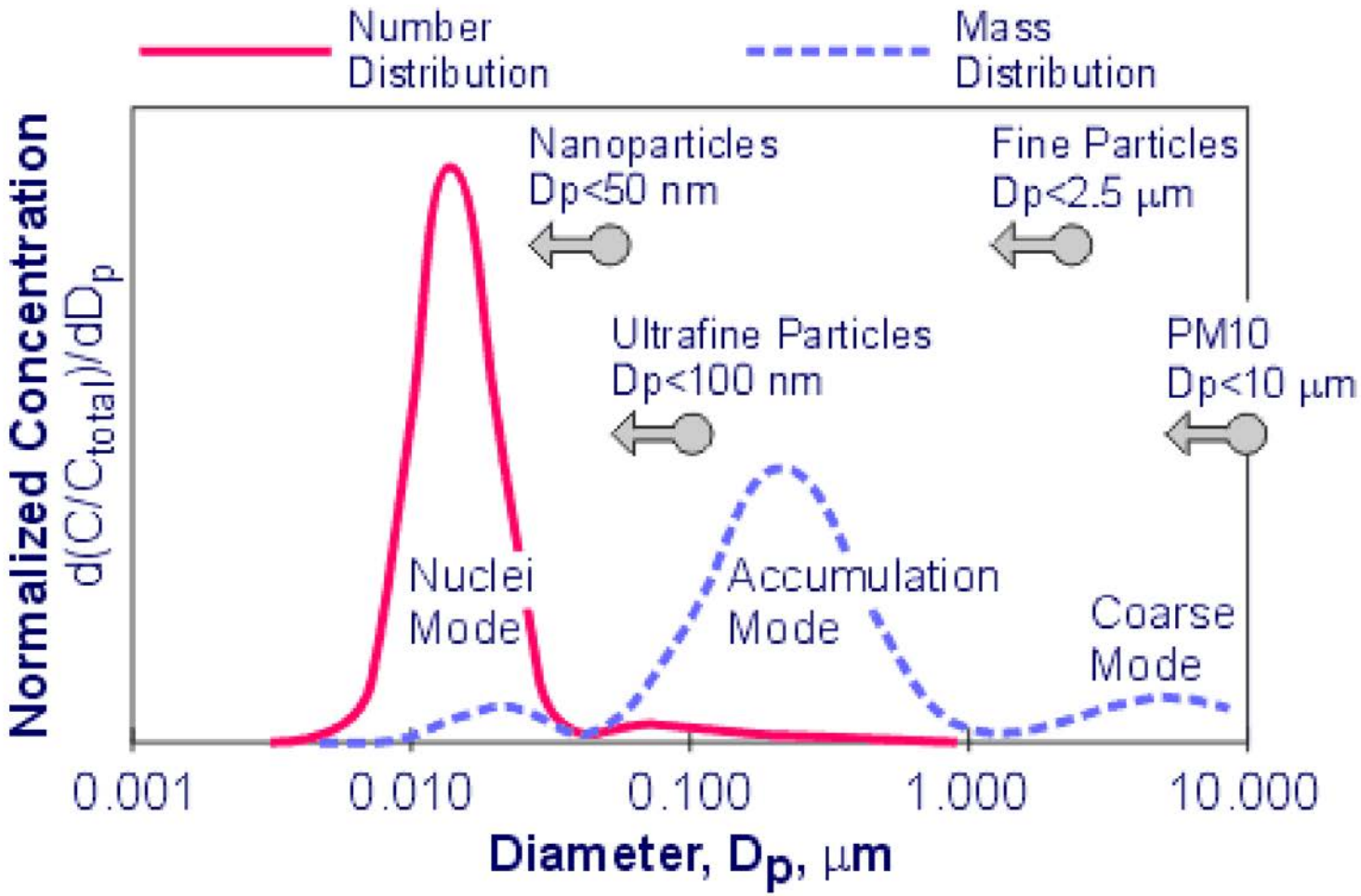
توزیع اندازه ذرات



PAH های شناسایی شده در PM دیزل

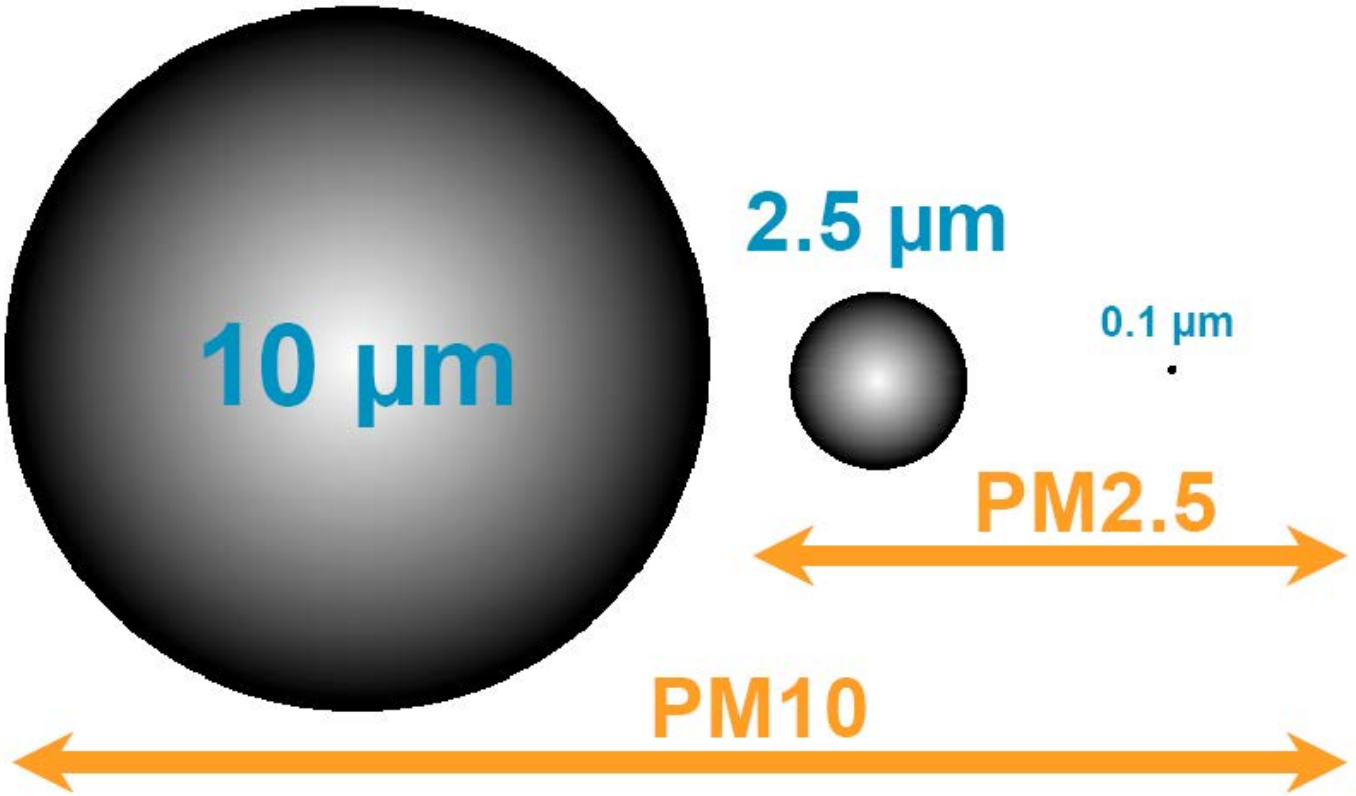
Compound	M*	Compound	M*
Acenaphthylene	152	Pyrene	202
Dibenzofuran	168	Ethylmethylphenanthrene	220
Fluorene	166	Methylfluoranthene	216
Methylfluorene	180	Ethylmethylphenanthrene	220
Methyldibenzofuran	182	Benzo(a)fluorene	216
Dibenzothiophene	184	Methylpyrene	216
Phenanthrene	178	Naphtobenzothiophene	234
Anthracene	178	Ethylpyrene	230
Benzo(h)quinoline	179	Benzo(g,h,i)fluoranthene	228
Acridine	179	Benz(a)anthracene	228
Dimethylfluorene	194	Chrysene	228
Methyldibenzothiophene	198	Methylnaphtobenzothiophene	248
Dimethylfluorene	190	Methylchrysene	242
Methyldibenzothiophene	198	Binaphtyl	254
Methylphenanthrene	192	Benzofluoranthene	252
4h-Cyclopenta(d,e,f)phenanthrene	190	Benzo(e)pyrene	252
Ethyldibenzothiofene	212	Benzo(a)pyrene	252
Ethylphenanthrene	206	Dibenz(a,h)anthracene	278
Fluoranthene	202	Benzo(b)chrysene	278
Benzacenaphthylene	202	Benzo(g,h,i)perylene	276
Benz(d,e,f)dibenzothiofene	208	Coronene	380
* M - Molecular Mass			

توزیع اندازه ذرات دیزل

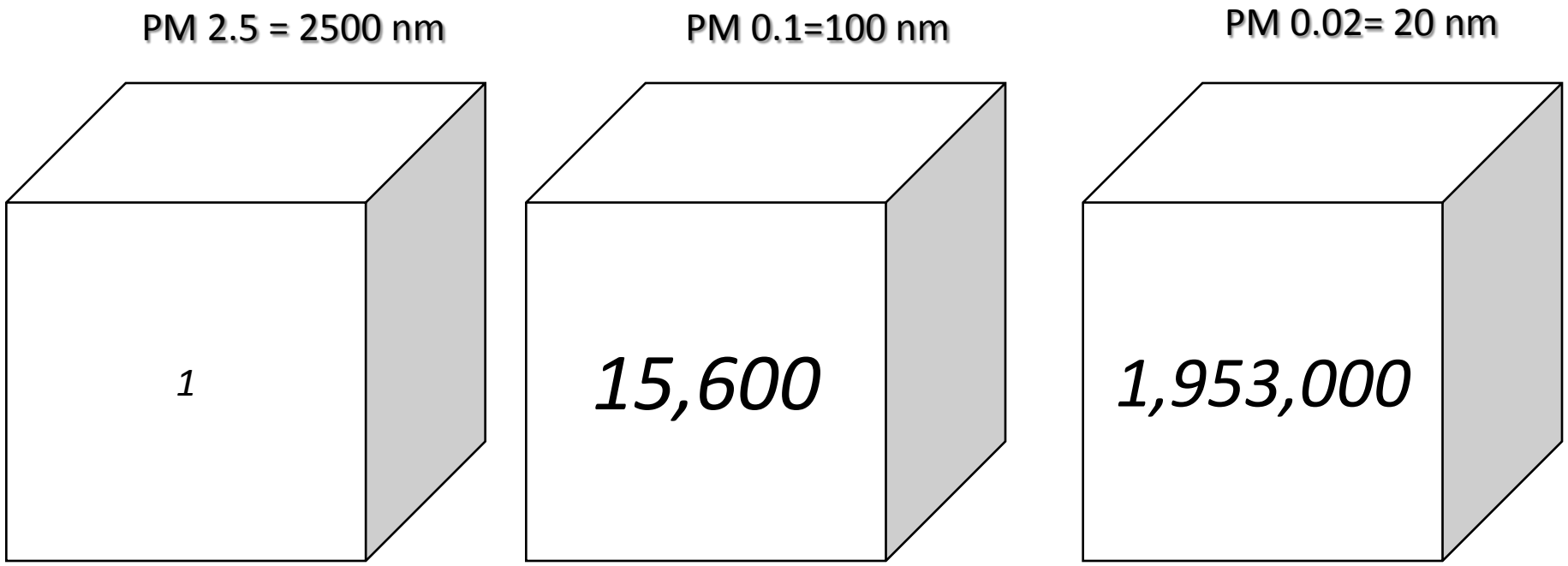


A new concept

- The mass is determined by large particles
- Small particles have the most health effects



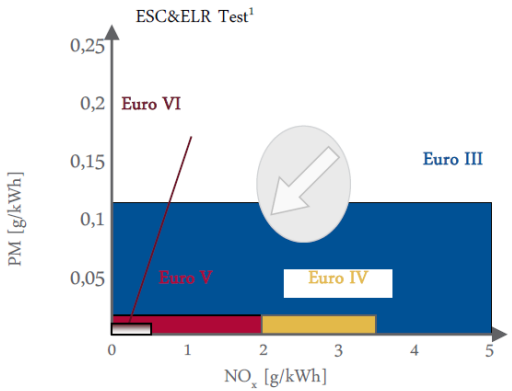
Number of particles per cm cube

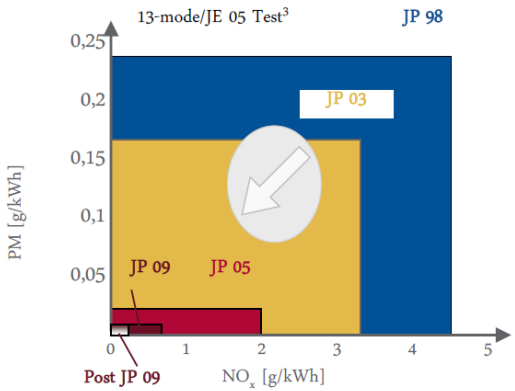


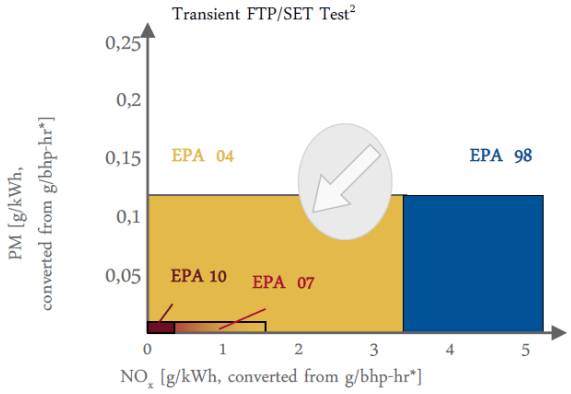
TSP= 8 µg/m³

استانداردهای آلایندگی

استانداردهای آلایندگی اروپا، امریکا و ژاپن



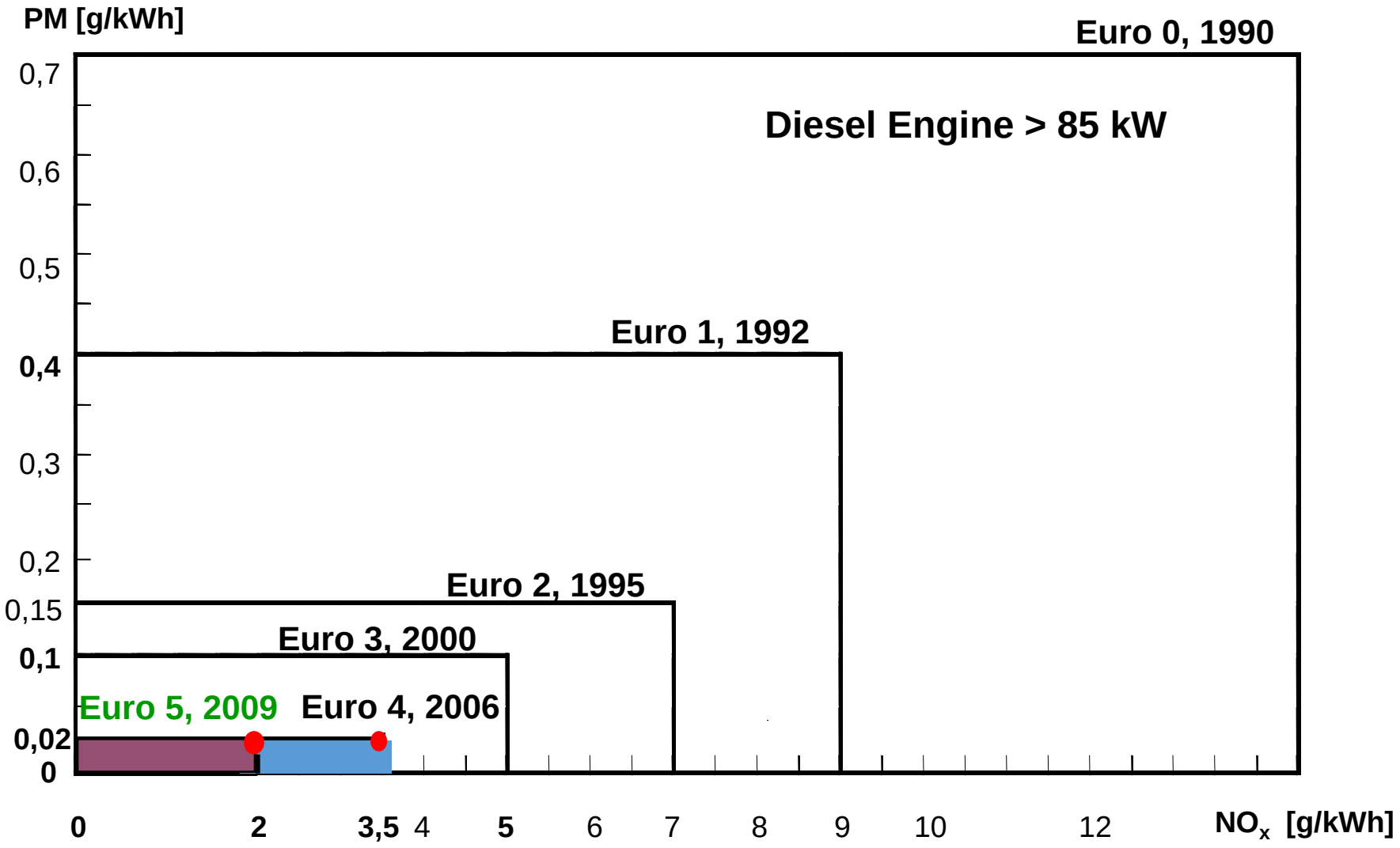




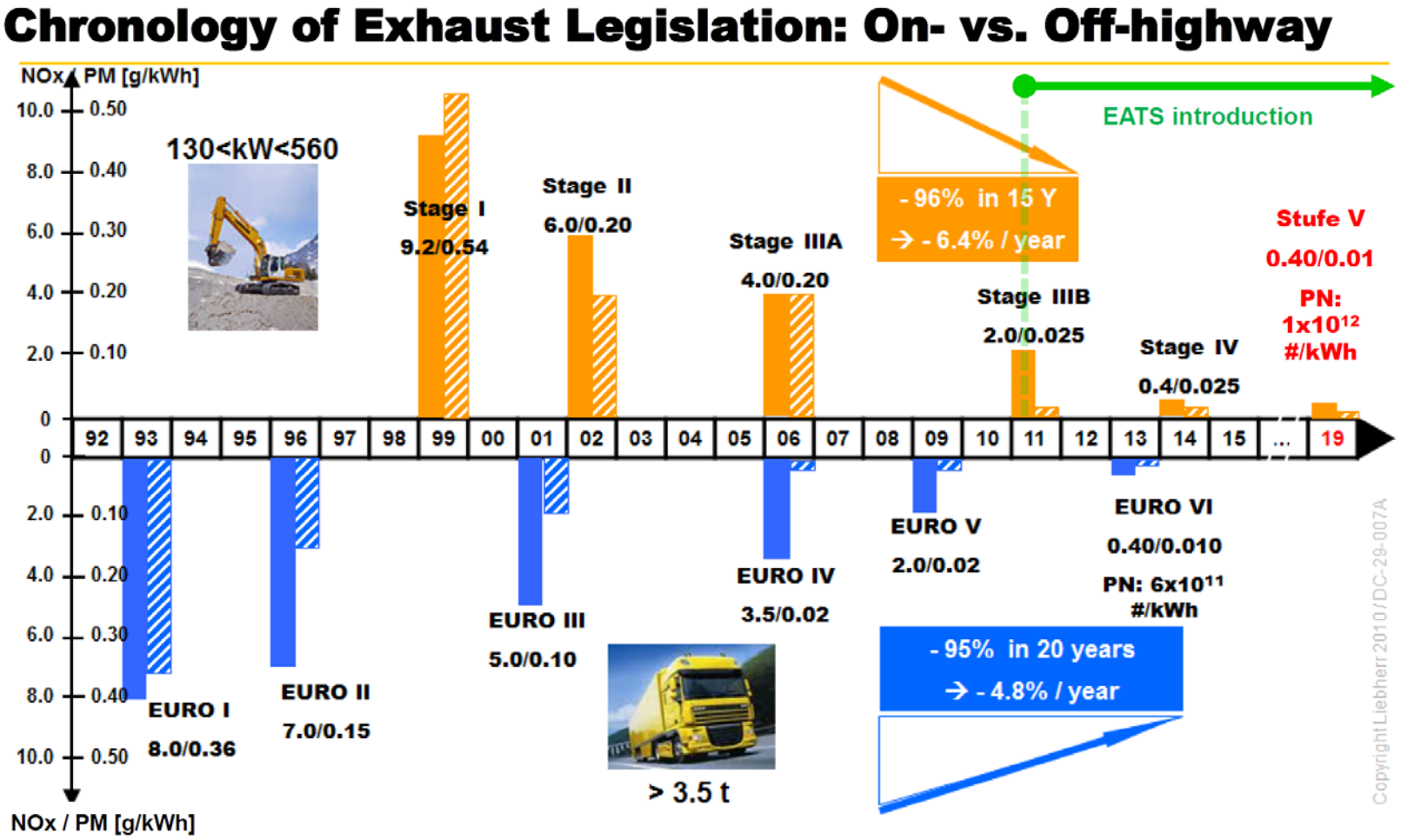
*Conversion: g/bhp-hr x 1.341 = g/kWh

[1]EU: WHTC/WHSC mandatory since Euro VI
[2]USA: WHTC/WHSC introduction not yet known
[3]Japan: WHTC mandatory as of Post JP09 (2016)

History of Euro emission standard

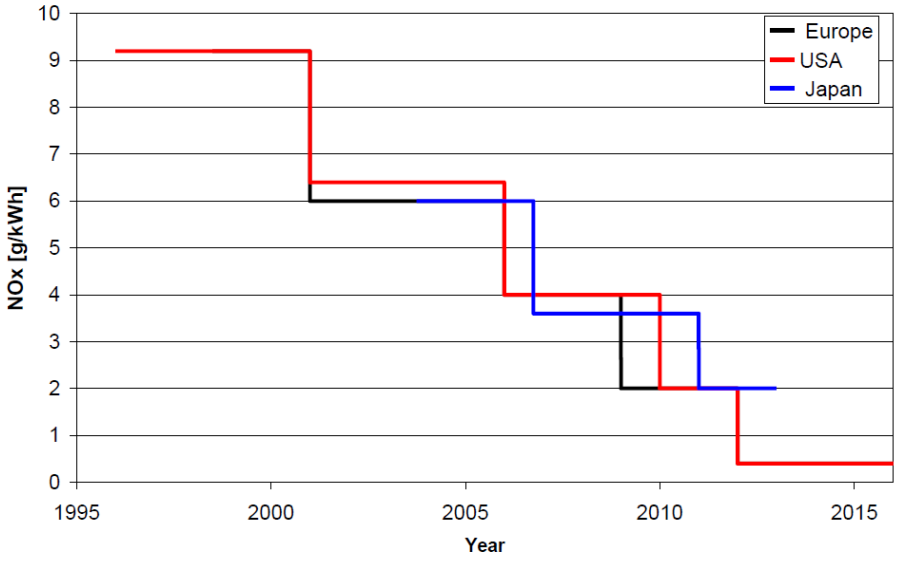


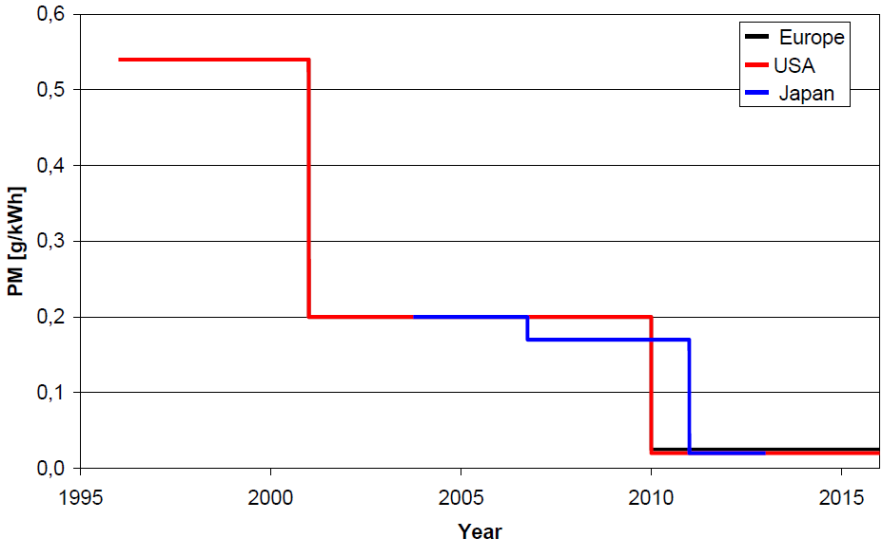
تاریخچه کاهش سطح آلایندگی استاندارد دیزل جاده ای و غیر جاده ای در اروپا



LIEBHERR

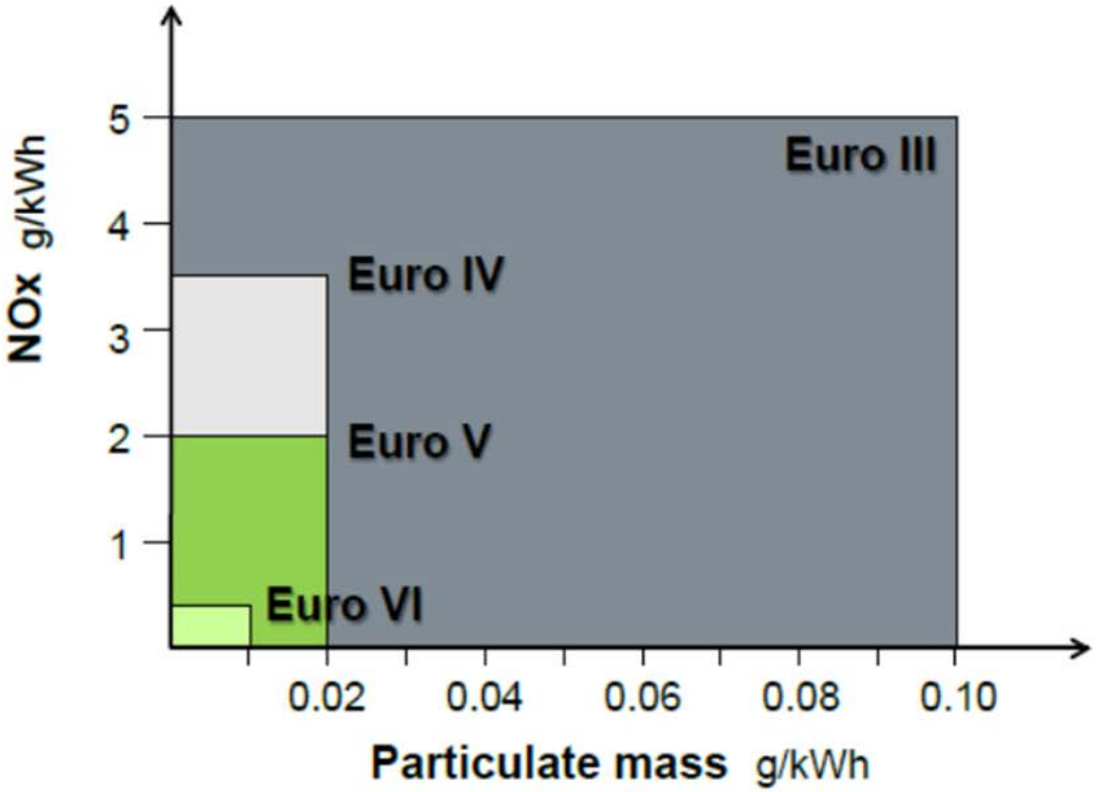
میزان کاهش در اروپا، ژاپن و امریکا برای NOx و PM





EU Emissions Regulation

– successively lower emissions in European legislation



Particle number

Regulated Fuel quality	
Euro III	300 ppm S
Euro IV	50 ppm S
Euro V Euro VI	10 ppm S

Emission standard Euro 5

Actually Euro 5 is the emission standard for vehicles brought into service in Europe

From 2014 on the stronger standard EURO 6 comes into force

- The required reduction in nitrogen oxide EURO 6 together correspond roughly to the magnitude of all five previous EURO-steps.
- This has inherently negative impact on consumption and CO2 emissions.
- Also for the first time a limit is set for the number of particles in order to limit the emission of small soot particles.

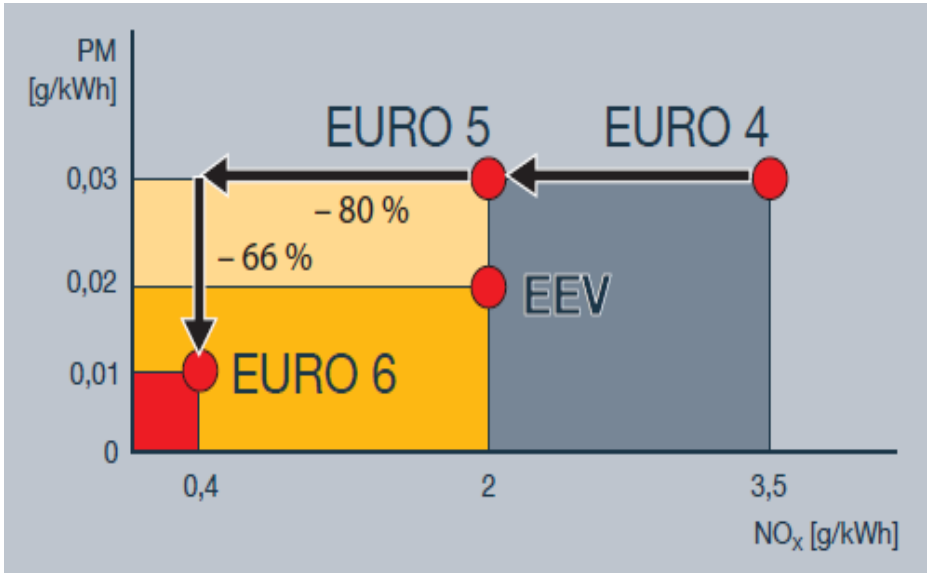


Table 1

EU Emission Standards for Heavy-Duty Diesel Engines: Steady-State Testing

Stage	Date	Test	CO	HC	NOx	PM	PN	Smoke
			g/kWh				*1/kWh*	*1/m*
Euro I	1992, ≤ 85 kW	ECE R-49	4.5	1.1	8.0	0.612		
	1992, > 85 kW		4.5	1.1	8.0	0.36		
Euro II	1996.10		4.0	1.1	7.0	0.25		
	1998.10		4.0	1.1	7.0	0.15		
Euro III	*1999.10 EEV only*	ESC & ELR	*1.5*	*0.25*	*2.0*	*0.02*		*0.15*
	2000.10		2.1	0.66	5.0	0.10[a]		0.8
Euro IV	2005.10		1.5	0.46	3.5	0.02		0.5
Euro V	2008.10		1.5	0.46	2.0	0.02		0.5
Euro VI	2013.01	WHSC	1.5	0.13	0.40	0.01	8.0×10^{11}	

a - PM = 0.13 g/kWh for engines < 0.75 dm^3 swept volume per cylinder and a rated power speed > 3000 min^{-1}

Table 2

EU Emission Standards for Heavy-Duty Diesel and Gas Engines: Transient Testing

Stage	Date	Test	CO	NMHC	CH_4[a]	NOx	PM[b]	PN[e]
			g/kWh					*1/kWh*
Euro III	*1999.10 EEV only*	ETC	*3.0*	*0.40*	*0.65*	*2.0*	*0.02*	
	2000.10		5.45	0.78	1.6	5.0	0.16[c]	
Euro IV	2005.10		4.0	0.55	1.1	3.5	0.03	
Euro V	2008.10		4.0	0.55	1.1	2.0	0.03	
Euro VI	2013.01	WHTC	4.0	0.16[d]	0.5	0.46	0.01	6.0×10^{11}

a - for gas engines only (Euro III-V: NG only; Euro VI: NG + LPG)
b - not applicable for gas fueled engines at the Euro III-IV stages
c - PM = 0.21 g/kWh for engines < 0.75 dm^3 swept volume per cylinder and a rated power speed > 3000 min^{-1}
d - THC for diesel engines
e - for diesel engines; PN limit for positive ignition engines TBD

نمونه هایی از سیکل های قدیم و جدید

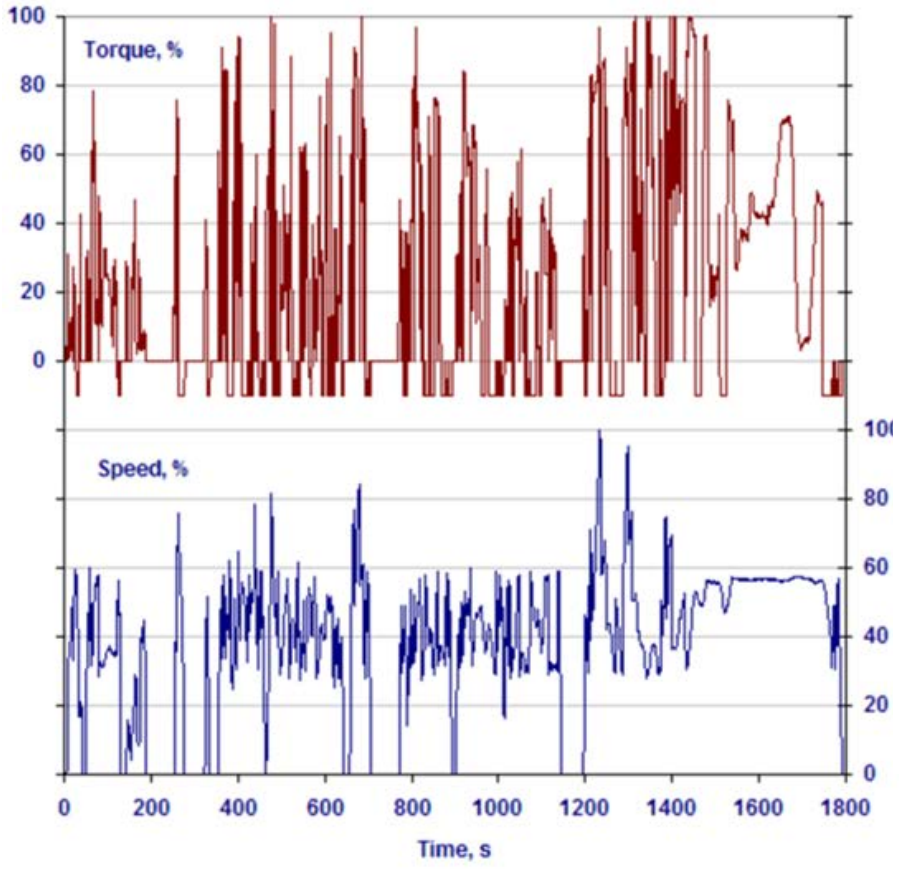


Figure 1. World Harmonized Transient Cycle (WHTC)

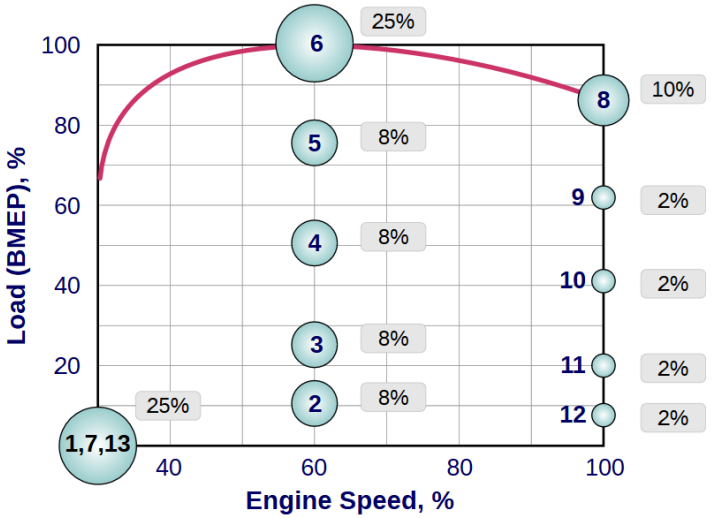


Figure 1. ECE R49 Cycle

روش های کاهش NOx و PM دیزل

Exhaust Gas Recirculation (EGR) – بازخوران

کاهش NOx به دلیل EGR

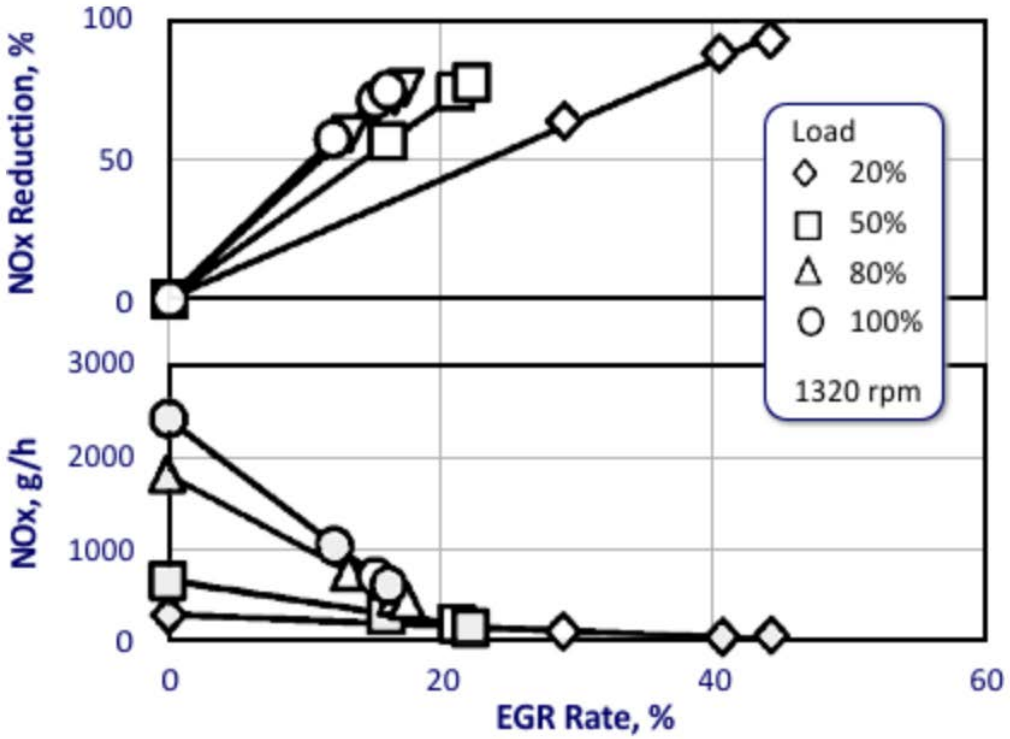


Figure 1. Effect of EGR rate on NOx reduction at various engine loads

NOx-Soot trade-off بر EGR اثر

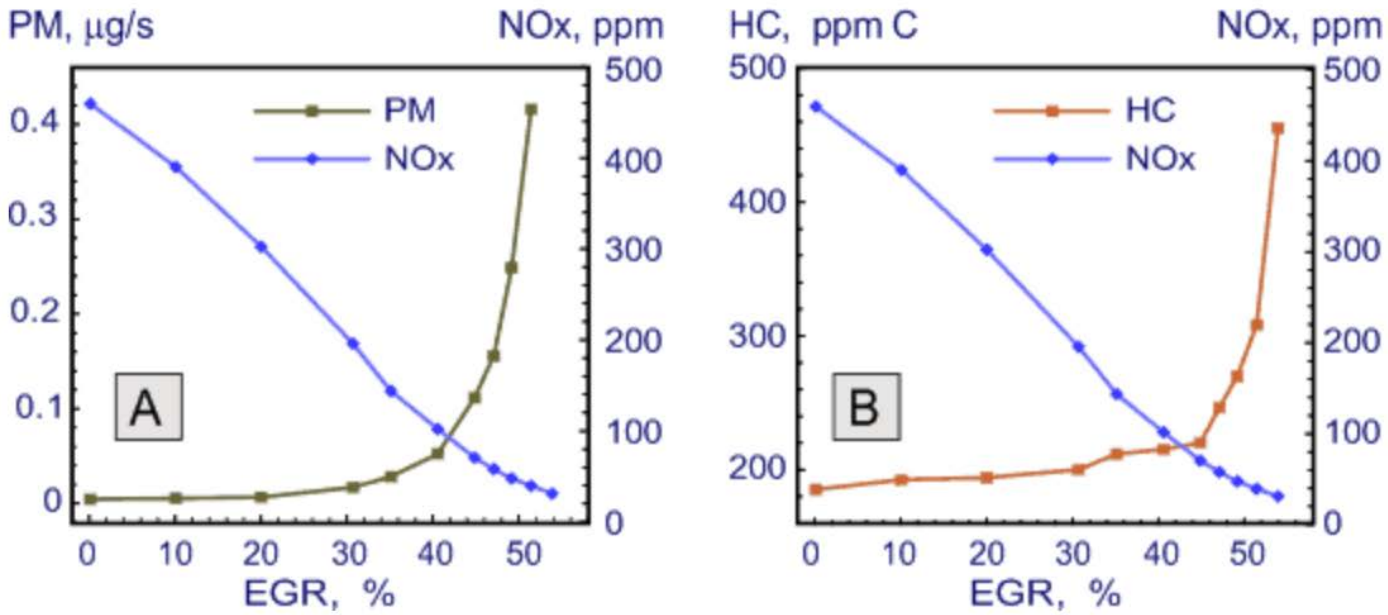


Figure 5. Effect of EGR ratio on NOx/PM (A) and NOx/HC (B) emission trade-off

1.9 liter VW TDI engine, 1200 rpm, 30% load, HPL EGR

نمونه ای از سیستم EGR

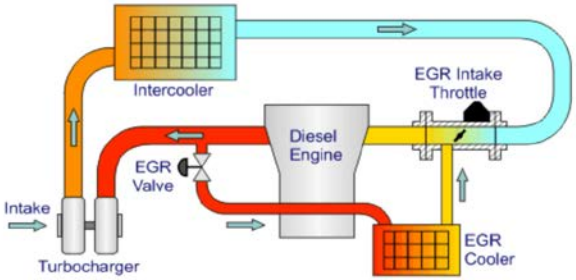


Figure 3. Schematic Representation of a High-Speed Passenger Car EGR/Intake Throttle System for Euro 3 Application

Audi 3.3 L V8 TDI engine

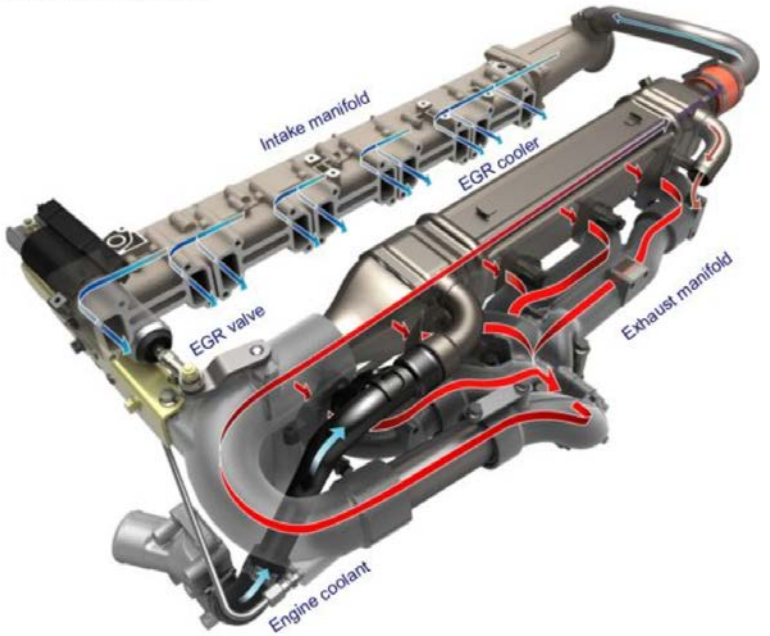
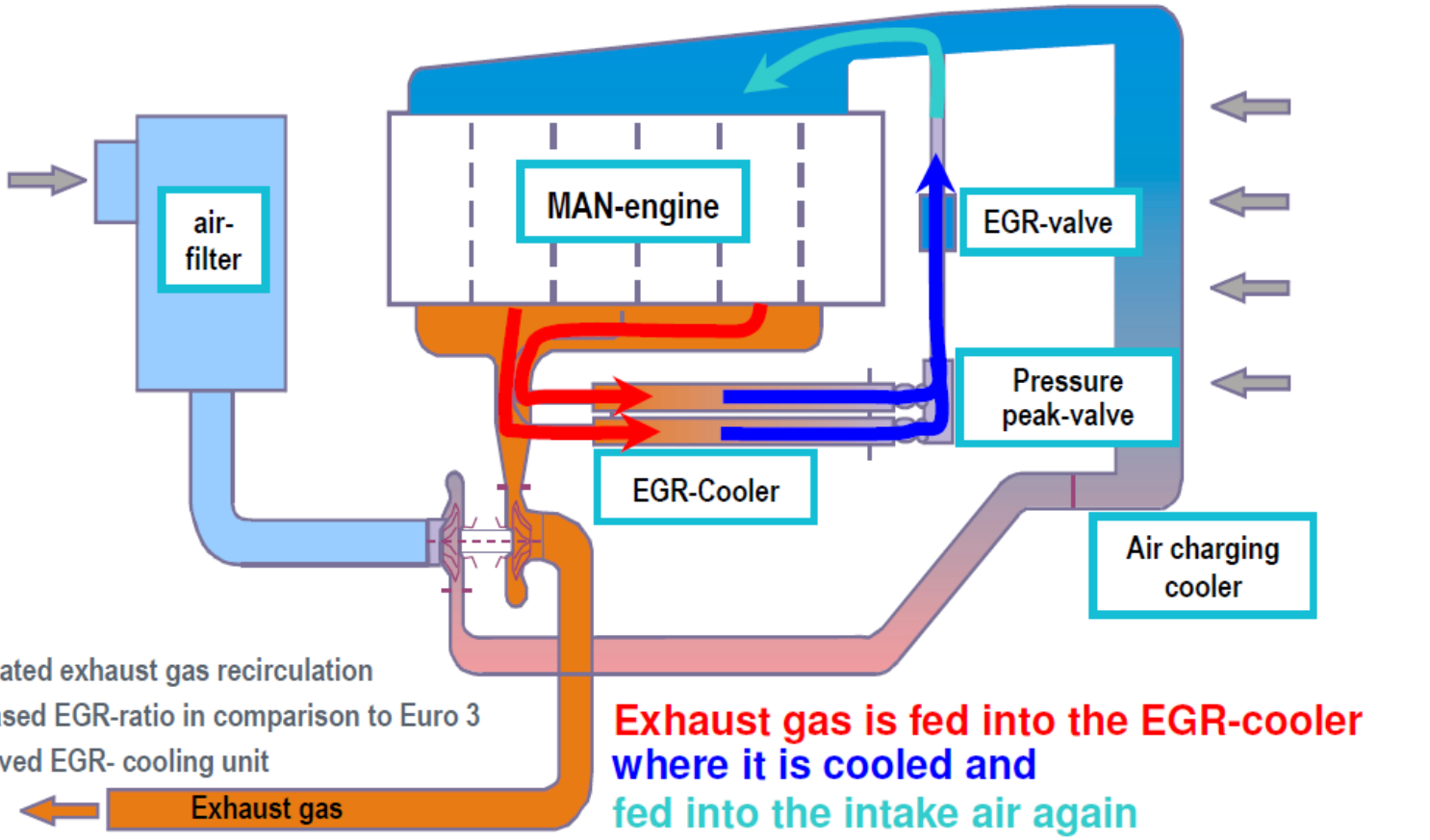


Figure 2. EGR System with One-Stage Cooling for Scania Euro IV Engines

(Source: Scania)

نمونه ای از سیستم EGR



- Regulated exhaust gas recirculation
- increased EGR-ratio in comparison to Euro 3
- improved EGR- cooling unit

Exhaust gas is fed into the EGR-cooler where it is cooled and fed into the intake air again

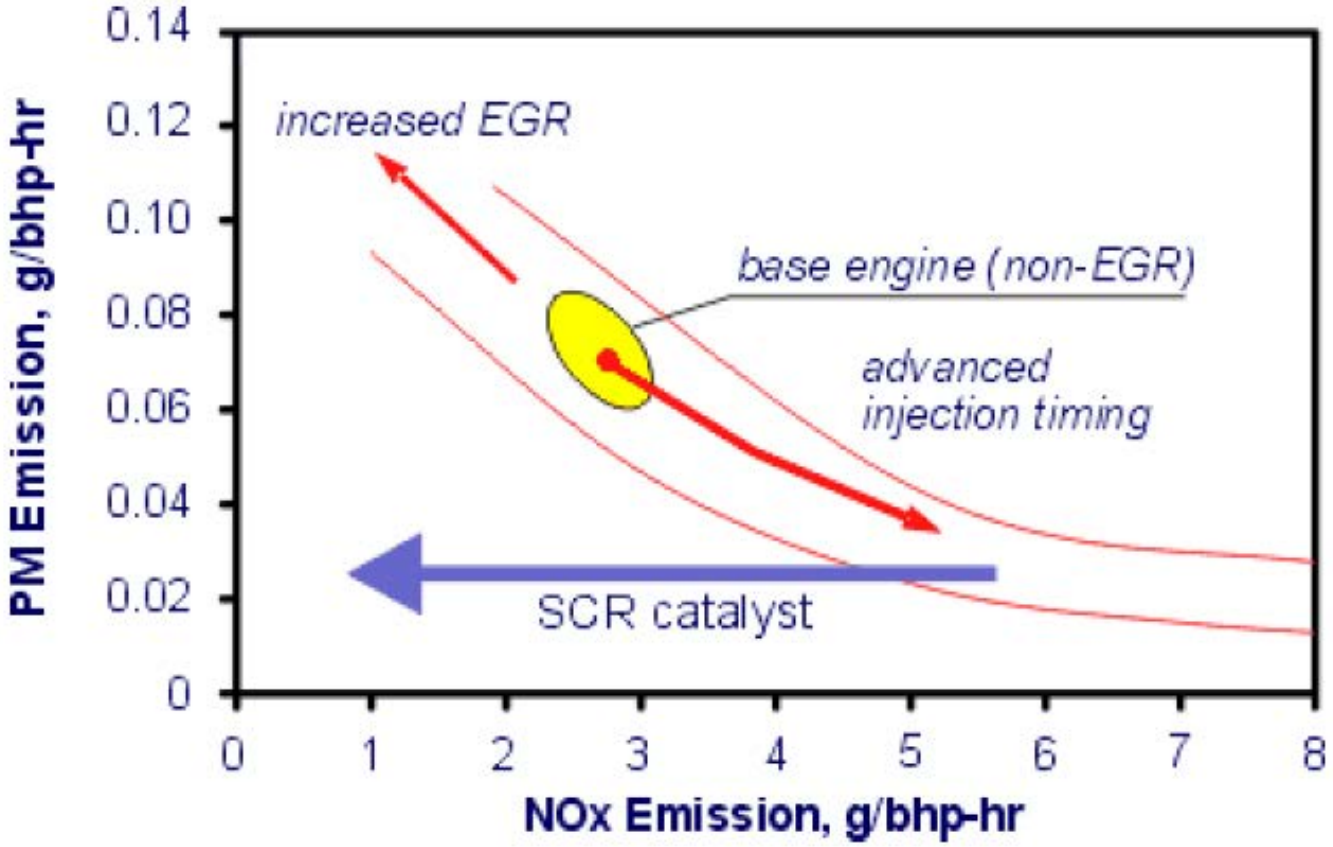
Effect: Lower combustion temperature and thus less NOx

روش های کاهش NOx و PM دیزل

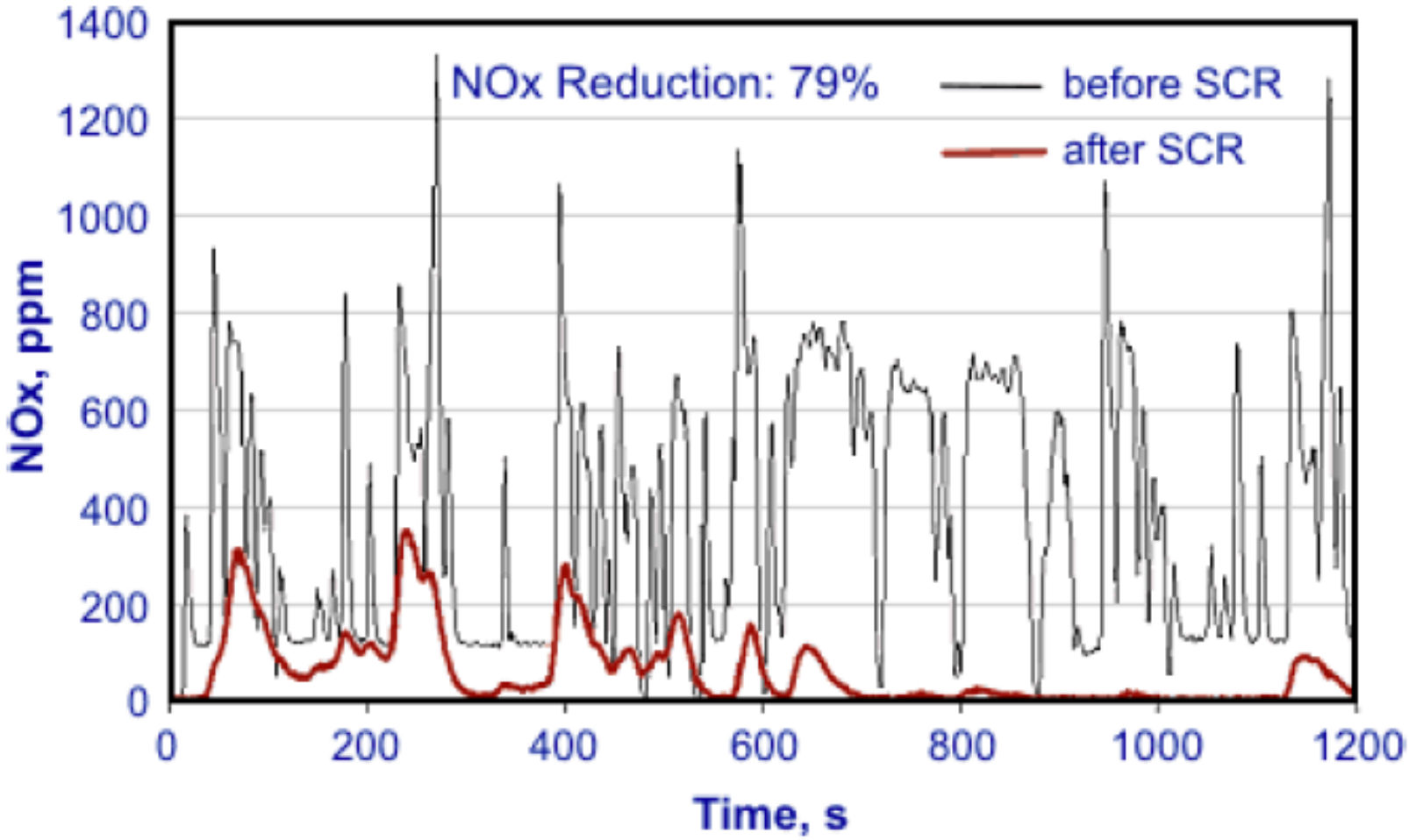
Selective Catalytic Reduction of NOx (SCR)

فیلتر کاهنده انتخابی اکسیدهای نیتروژن

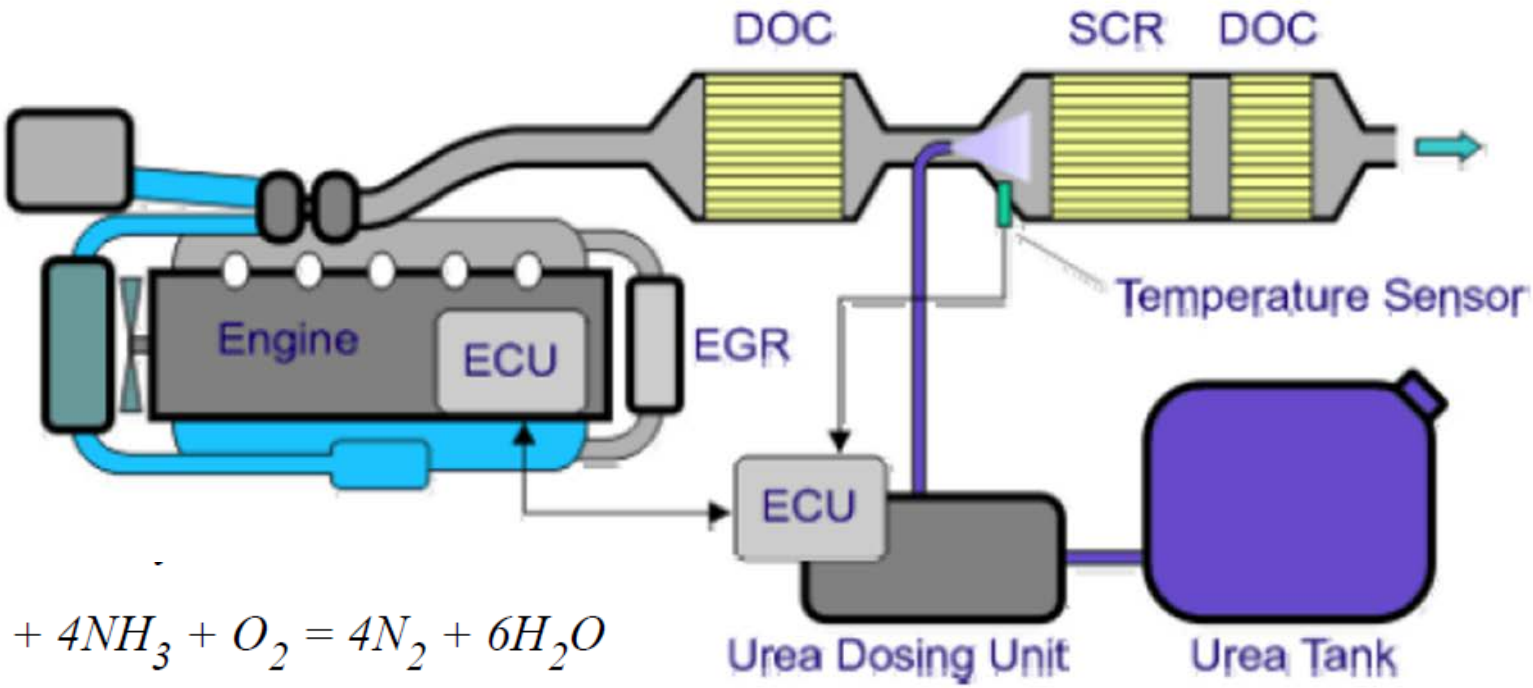
Emission strategy for SCR



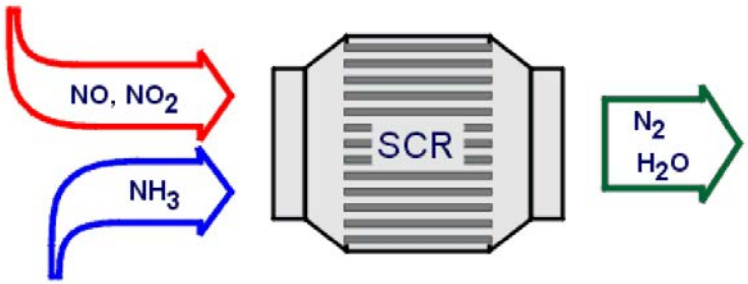
کاهش NOx توسط SCR در چرخه FTP



Selective Catalytic Reduction (SCR) by Ammonia



$$4NO + 4NH_3 + O_2 = 4N_2 + 6H_2O$$



Emission strategy for SCR

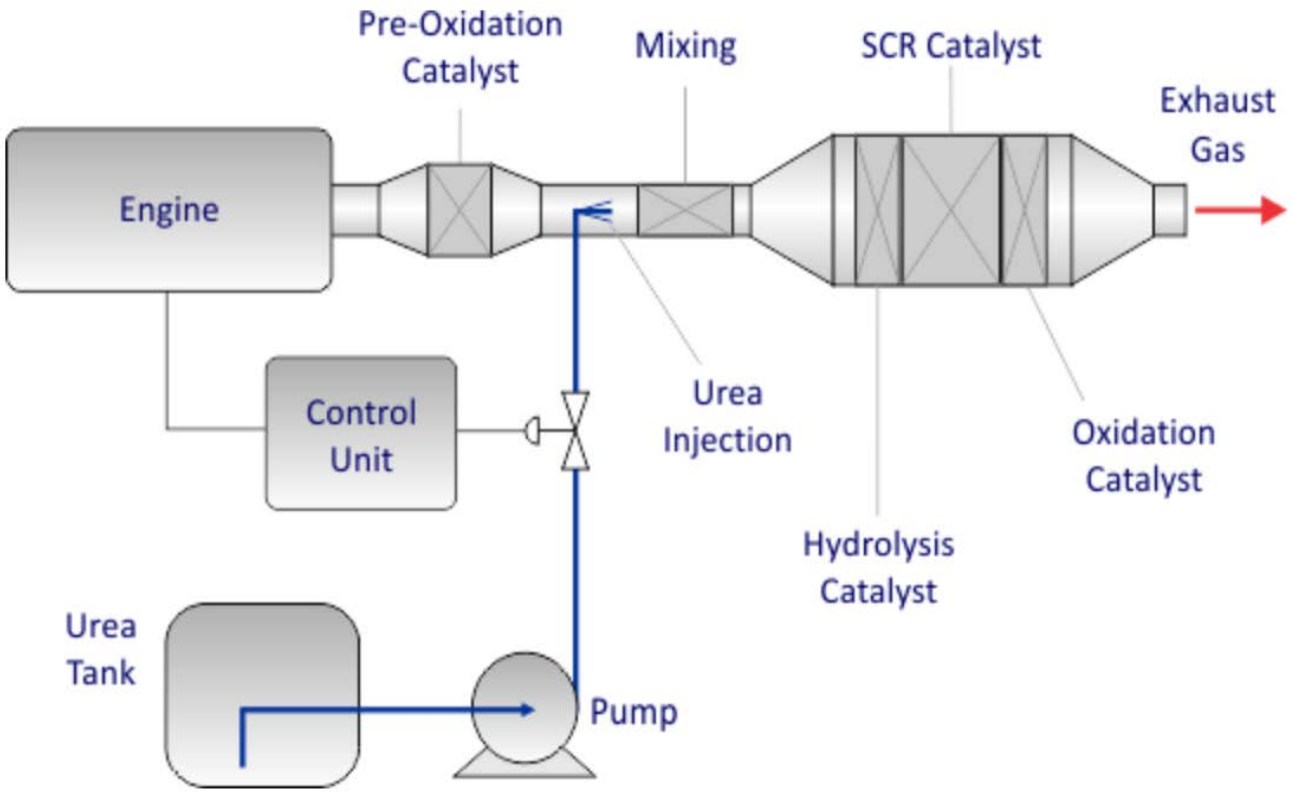
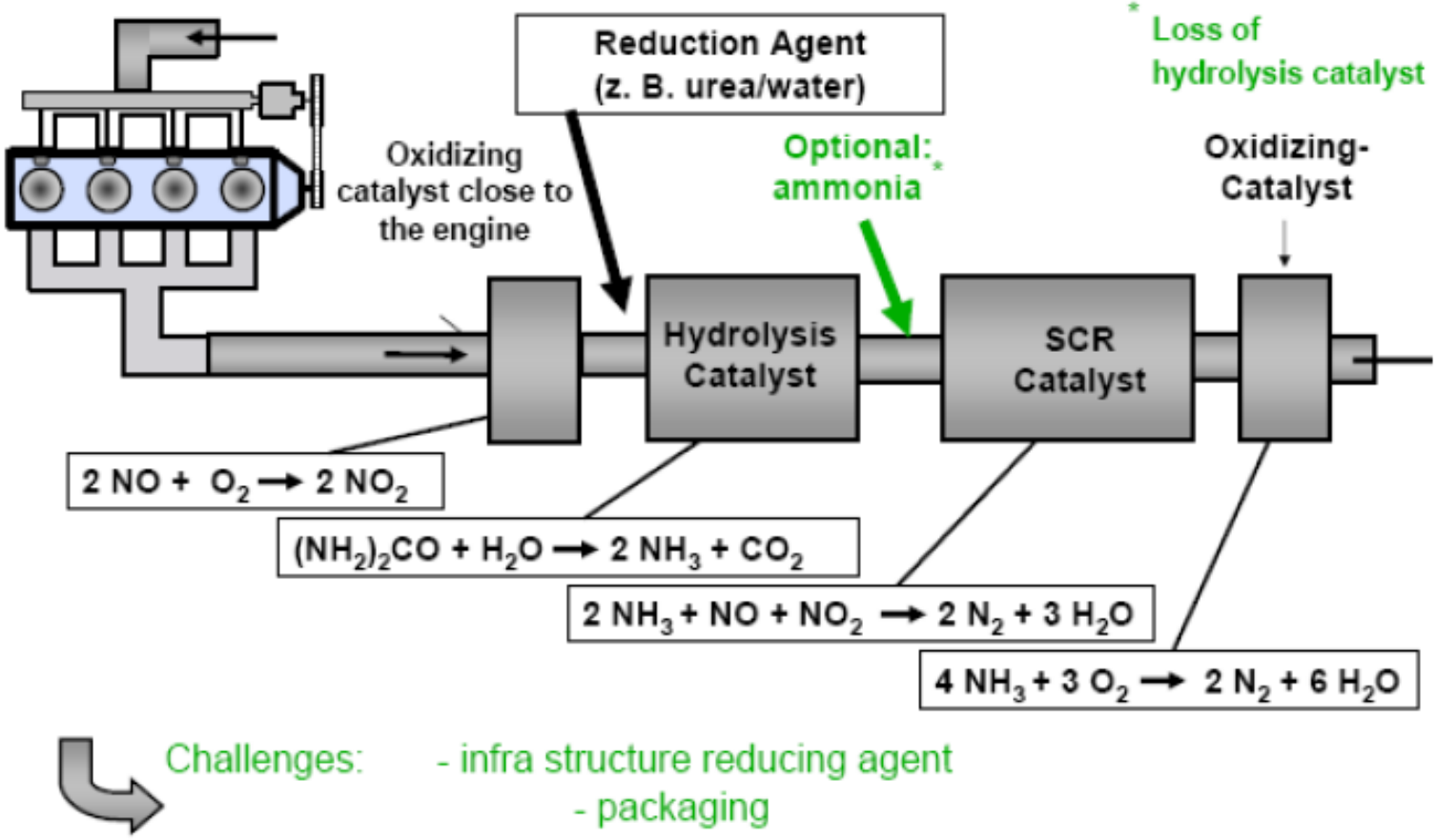


Figure 4. Open Loop Urea SCR System for Mobile Diesel Engines

Selective Catalytic Reduction (SCR) by Ammonia



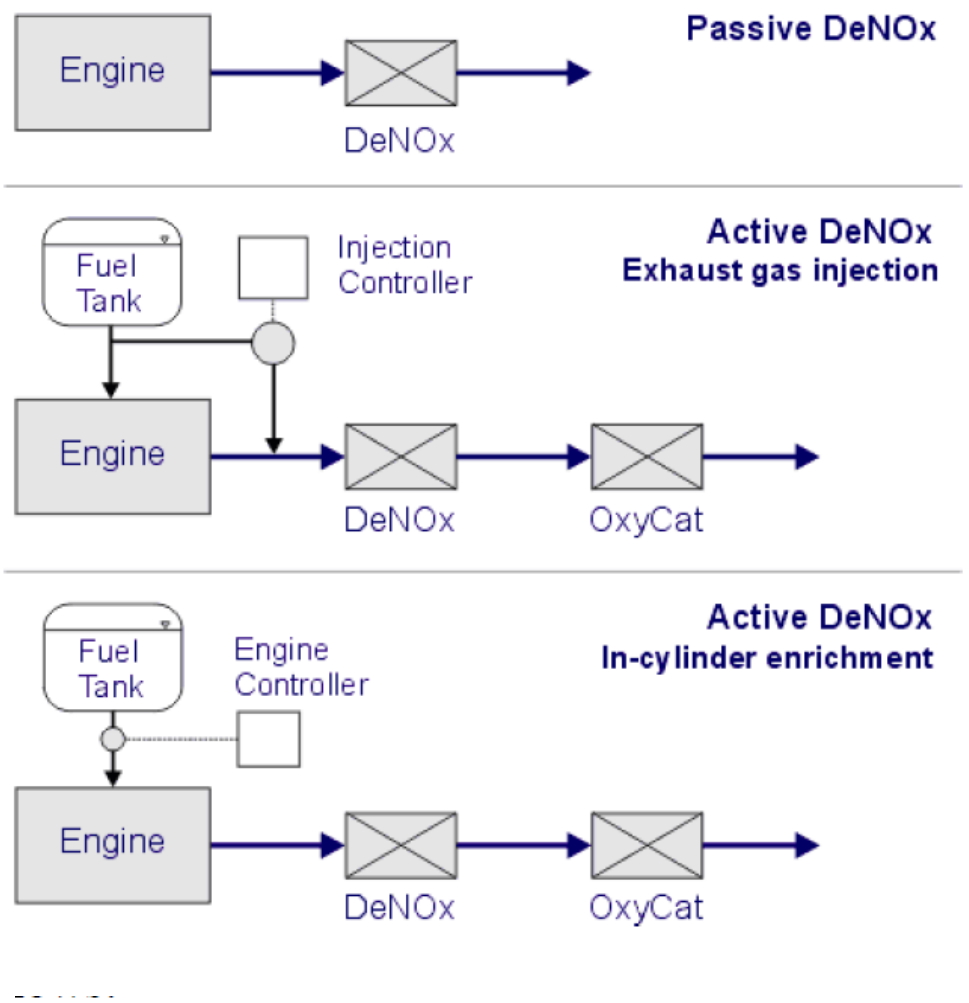
Selective Catalytic Reduction (SCR) by Ammonia

Figure 13. SCR System on US 2010 Mack MP7 Truck Engine

1 – Urea tank; 2 – Urea supply pump; 3 – Injector; 4 – Muffler/SCR converter unit; 5 – Aftertreatment control module.

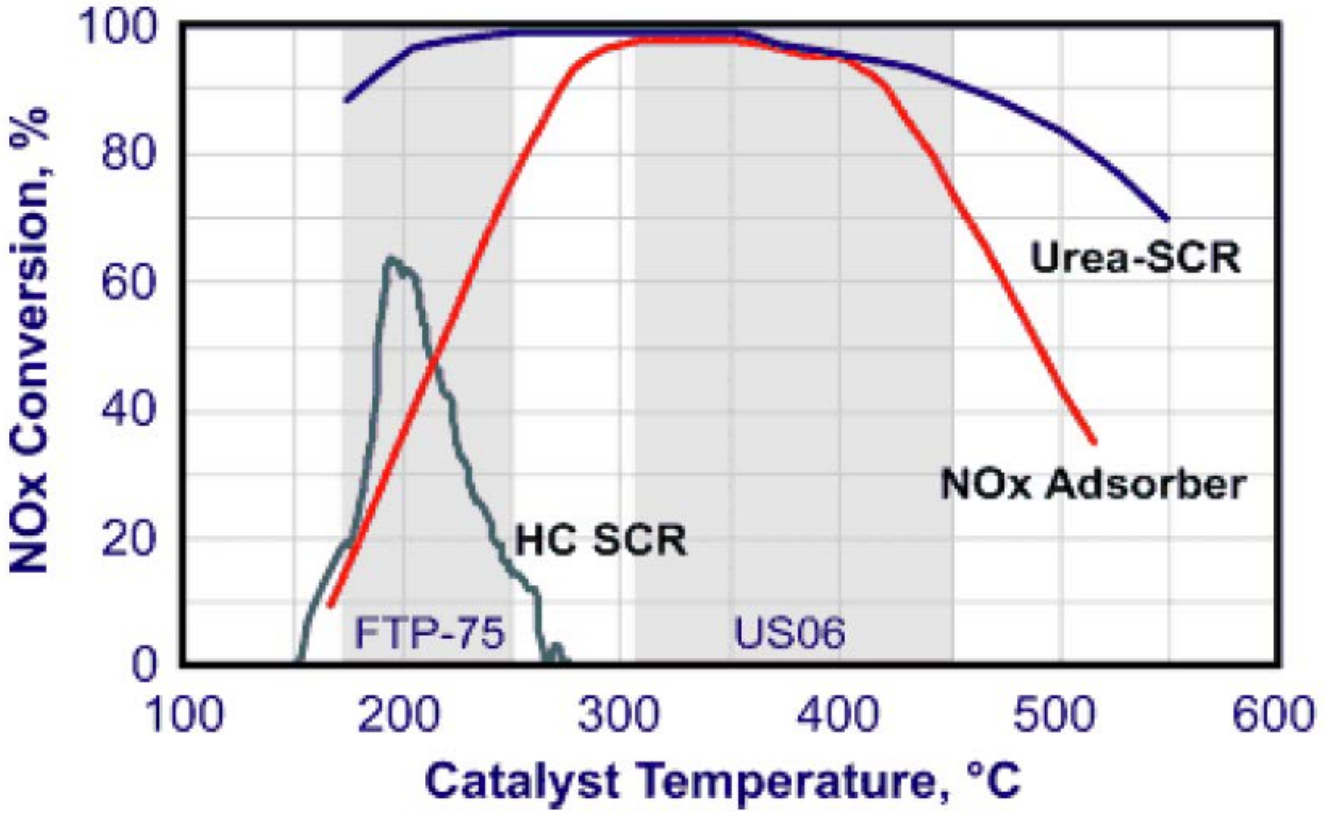
(Courtesy of Volvo Trucks)

Lean NOx Catalyst



$$10NO + C_3H_8 = 5N_2 + 3CO_2 + 4H_2O$$

مقایسه انواع تکنولوژی های کاهنده NOx در دیزل



مخاطرات – فرار آمونیوم

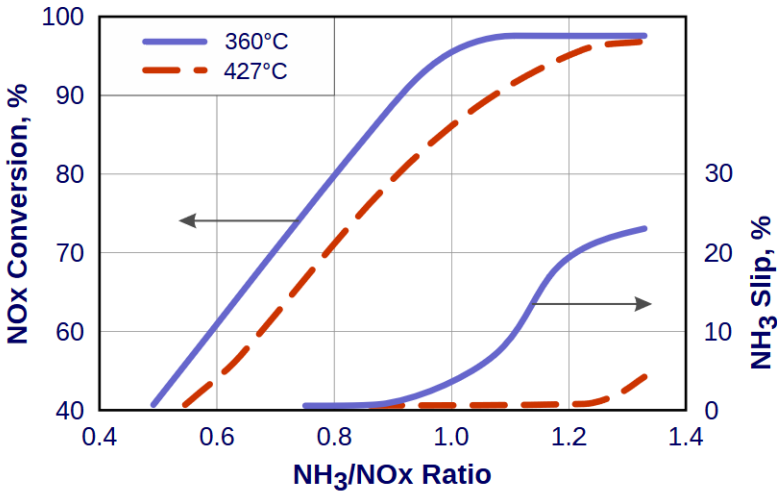


Figure 1. NOx conversion and ammonia slip for different NH_3/NOx ratios

V_2O_5/TiO_2 SCR catalyst, 200 cpsi

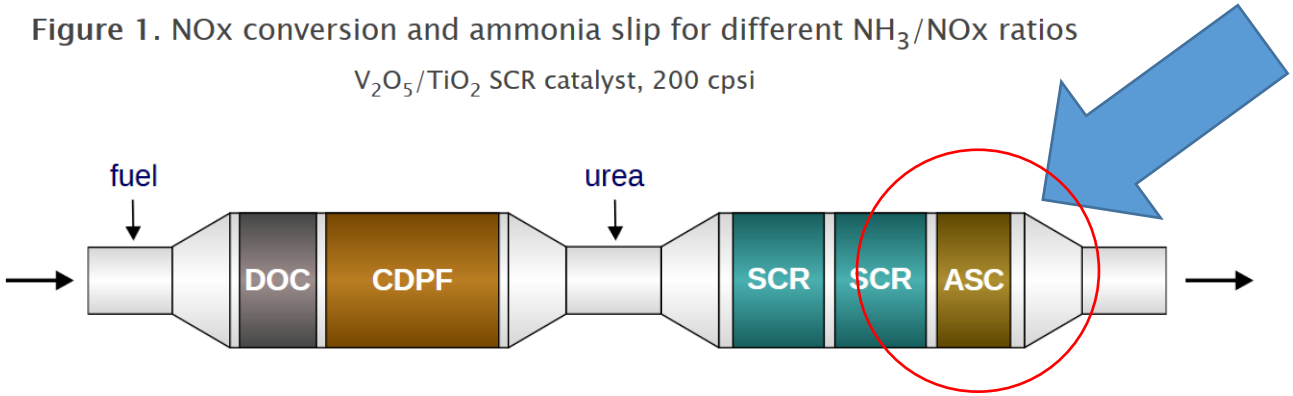


Figure 11. Schematic of typical US 2010 aftertreatment system

مخاطرات – کریستالایز شدن آمونیوم در فیلتر

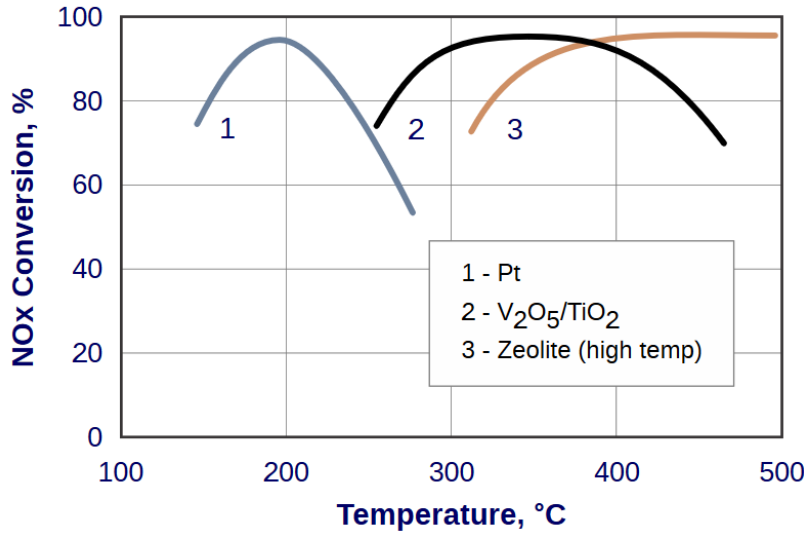


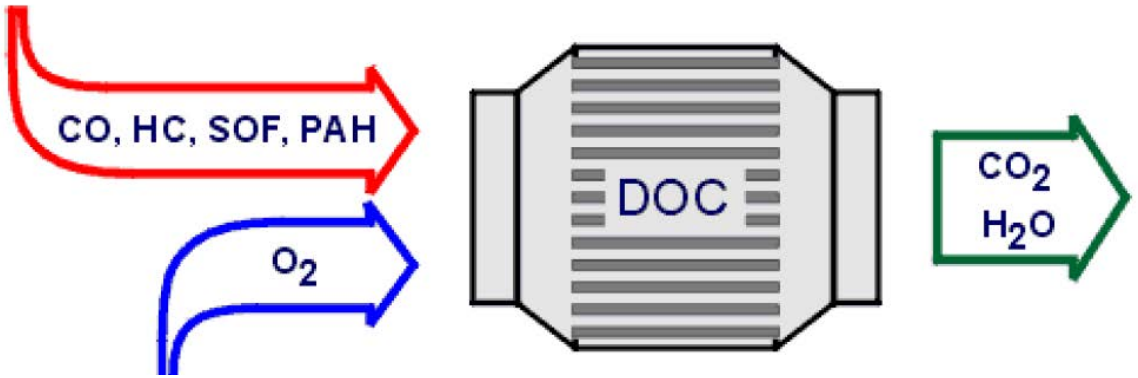
Figure 4. Operating temperature windows for different SCR catalysts

روش های کاهش NOx و PM دیزل

Diesel particulate filter (DPF)

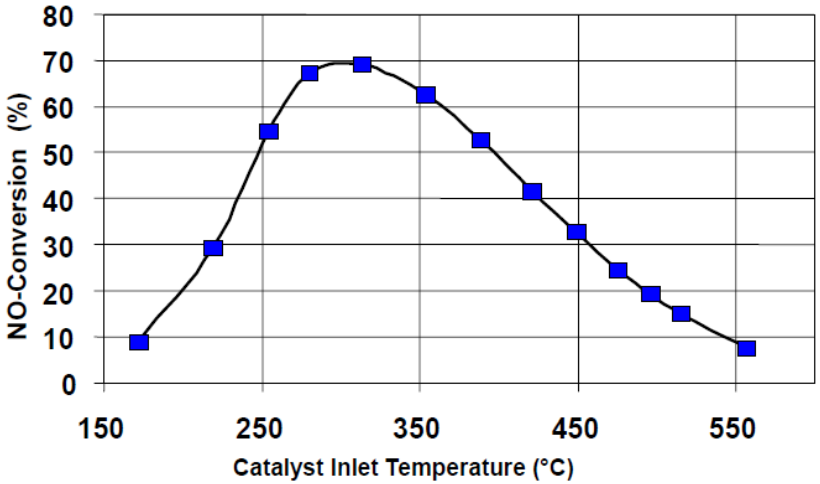
فیلتر تله ذرات

Diesel oxidation catalyst (DOC)

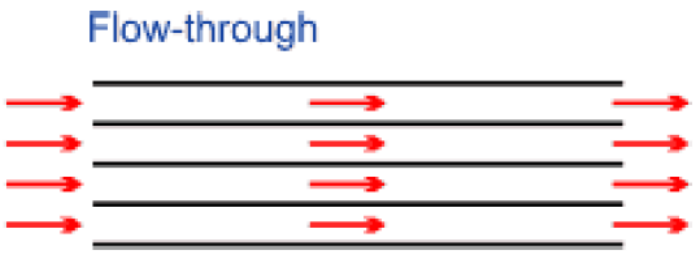


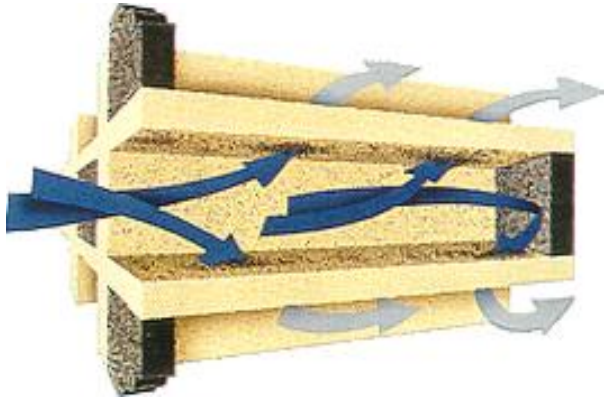
DOC converts NO→ NO2

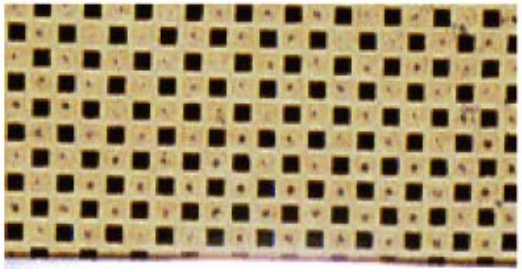
→ If NO2 is a problem DOC is not helpful

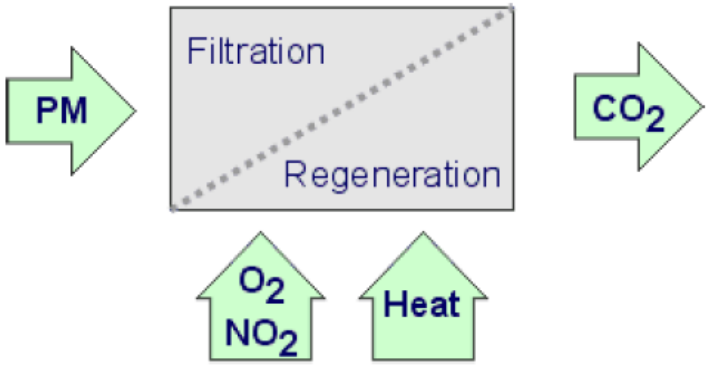


Diesel particulate filter (DPF)

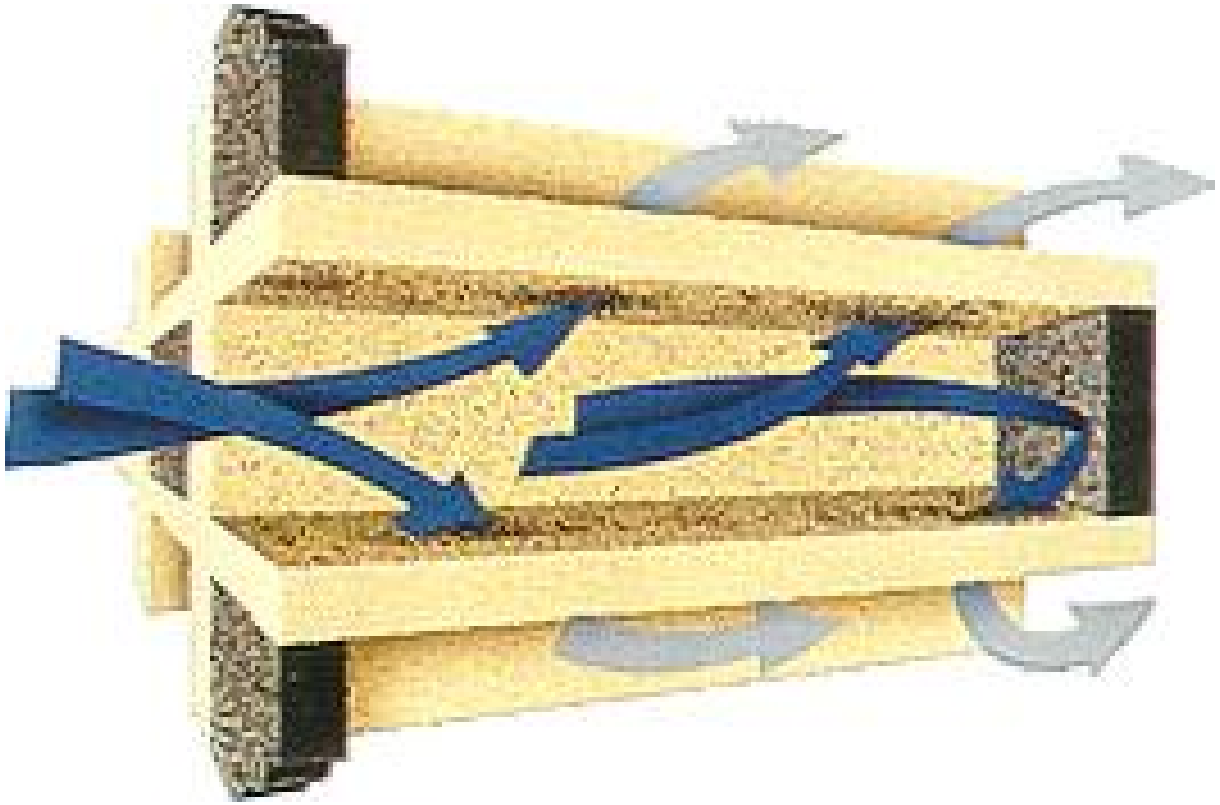






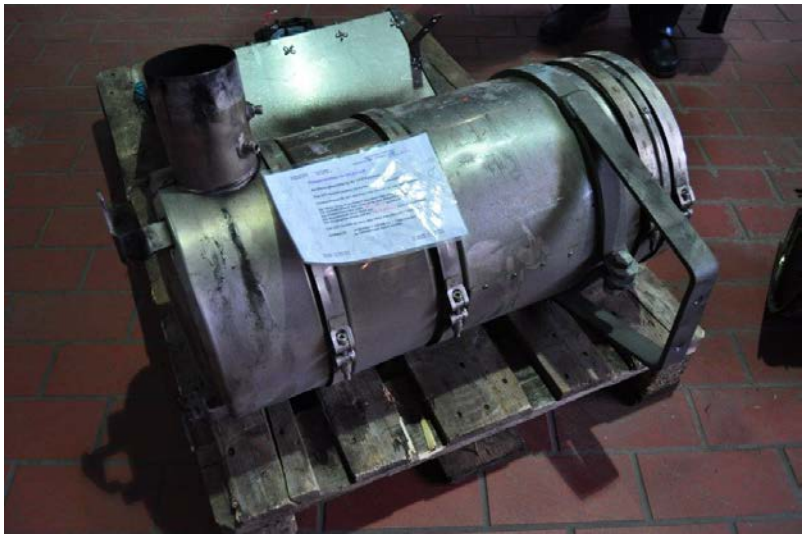


Wall-Flow Particle Filters available since 1982

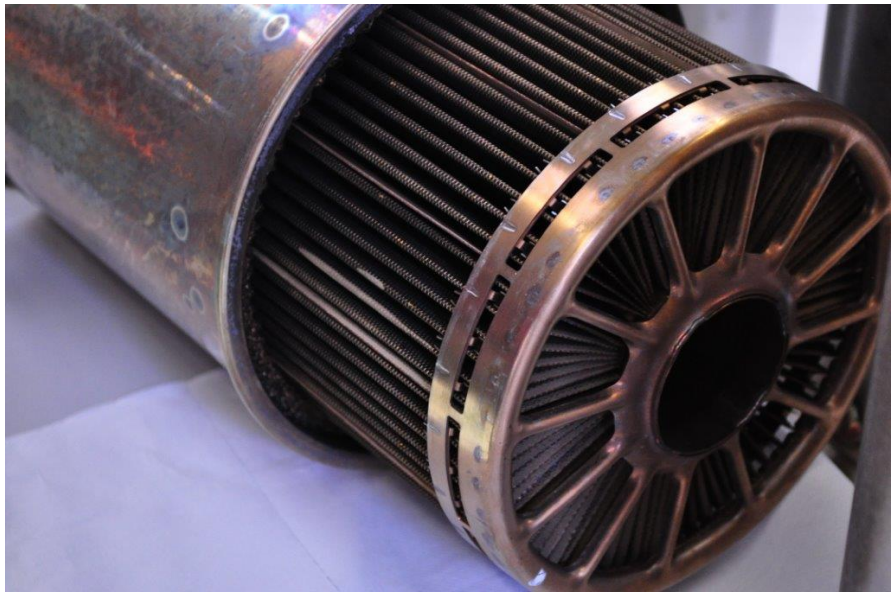


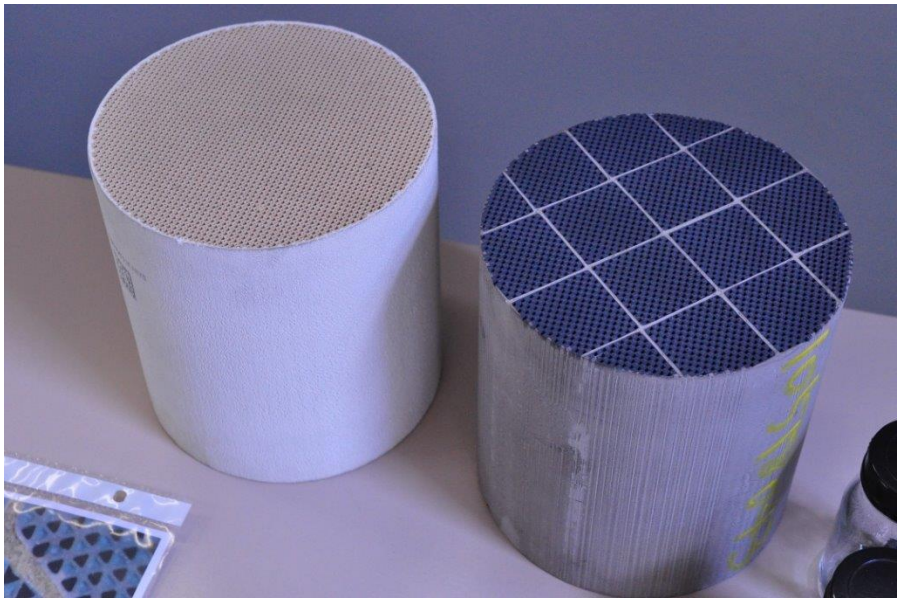
- Filtration Effectiveness > 99.9 % if pore size < 15 µm
- can be used for all Diesel Engines – new and in-use

Different types of diesel particulate filters



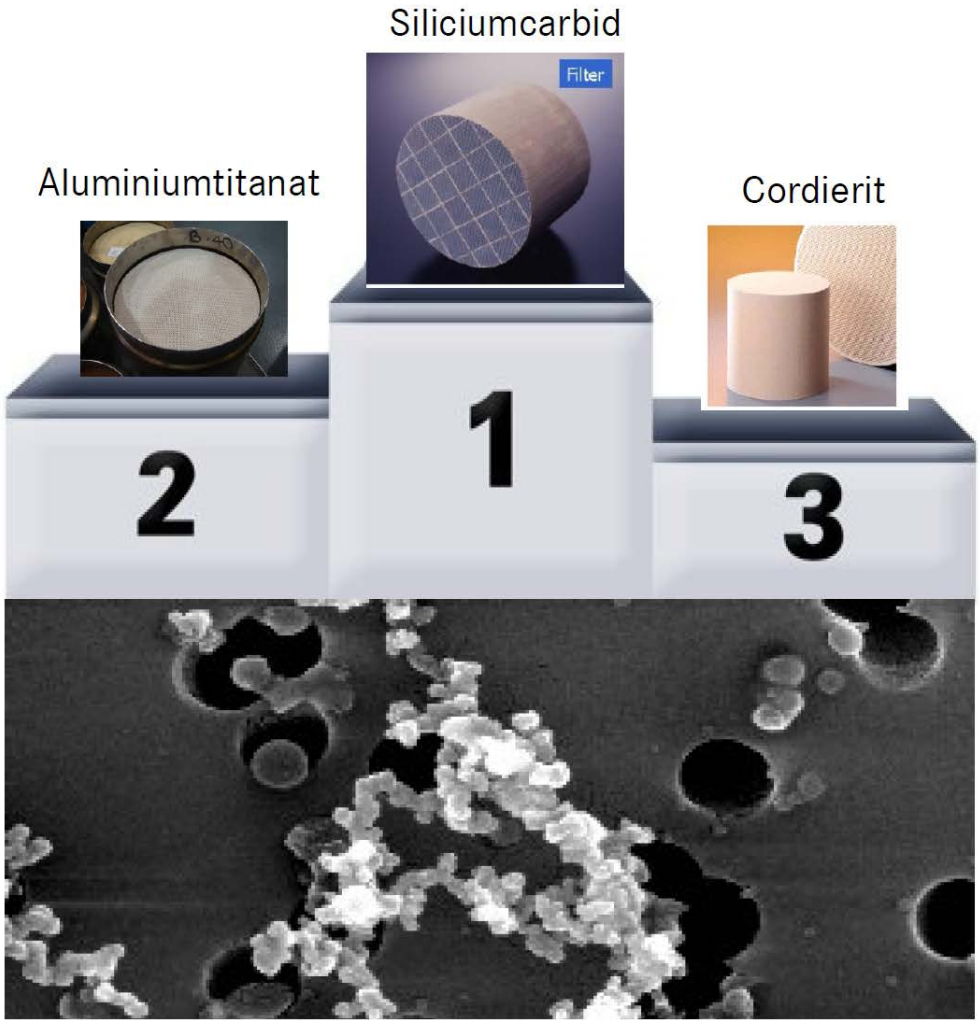
Different types of diesel particulate filters





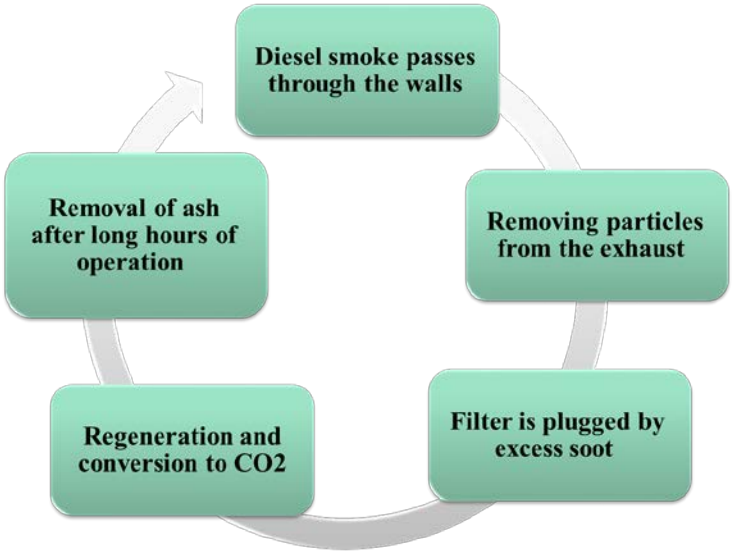
Different types of diesel particulate filters

مواد پایه برای استفاده در فیلتر دوده – تناسب با استاندارد یورو ۶

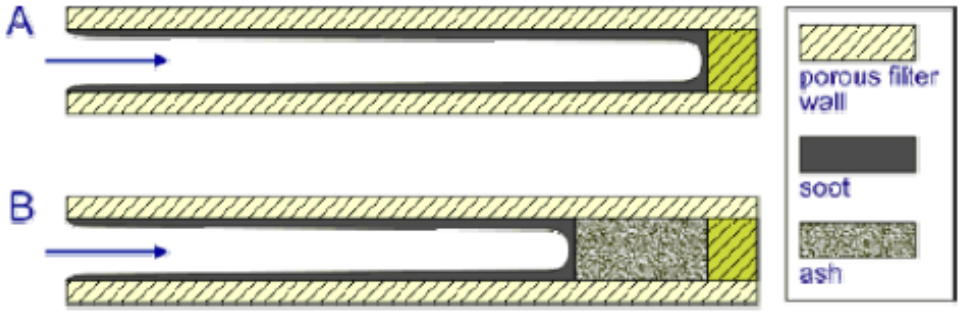


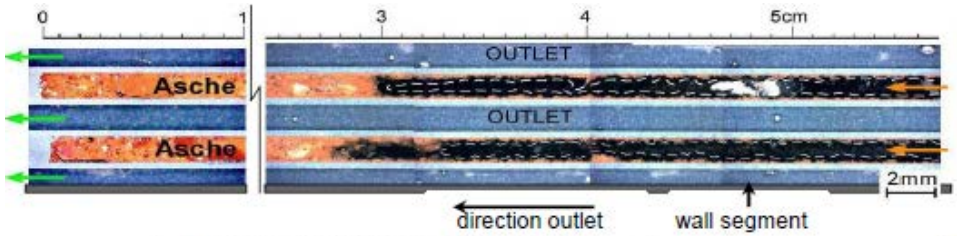
Wall-Flow Particle Filters
Basics of the operation

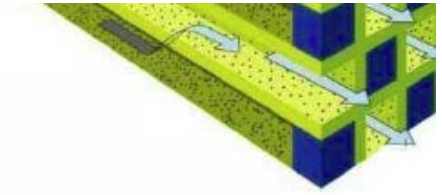
- Exhaust gas is forced through porous walls
- Soot particles are trapped in the wall and stick to the surfaces by Van der Walls force
- The filter gets gradually filled and needs to be regenerated
- The filter gets regenerated by active or passive methods

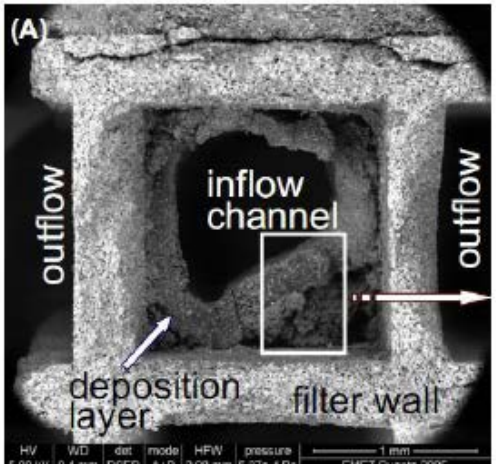


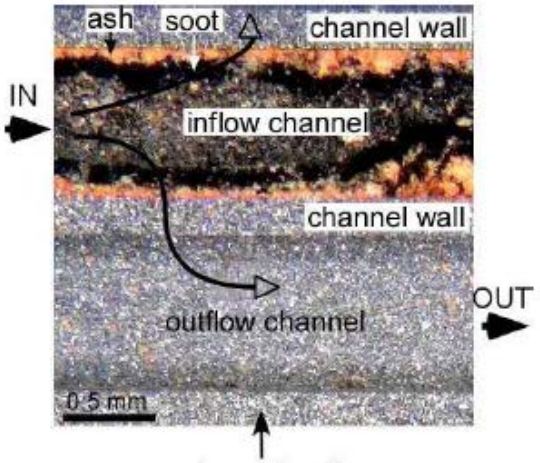
جمع شدن دوده و خاکستر در فیلتر



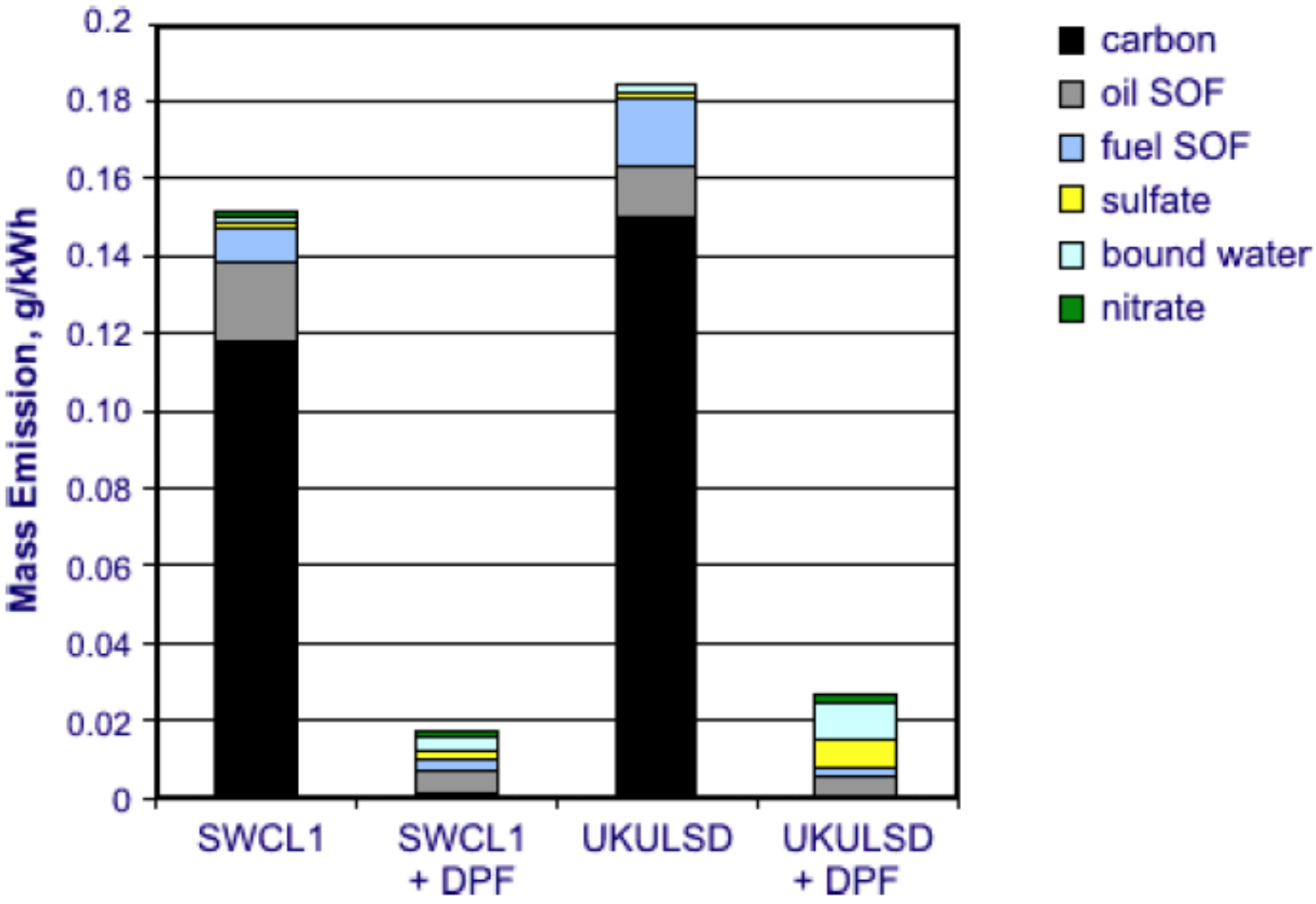




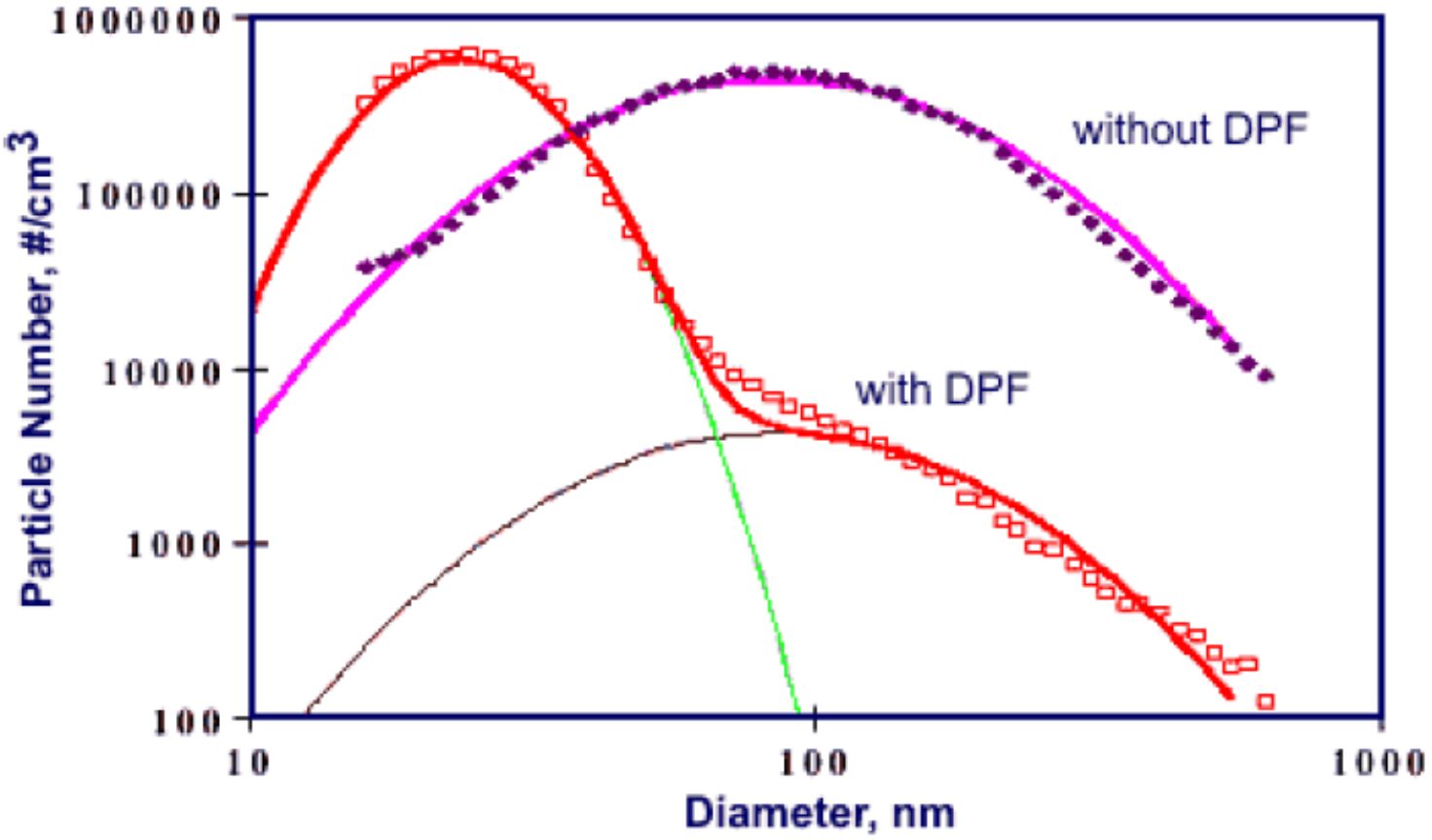




اثر استفاده از DPF بر جرم دوده تولیدی با دو نوع سوخت دیزل

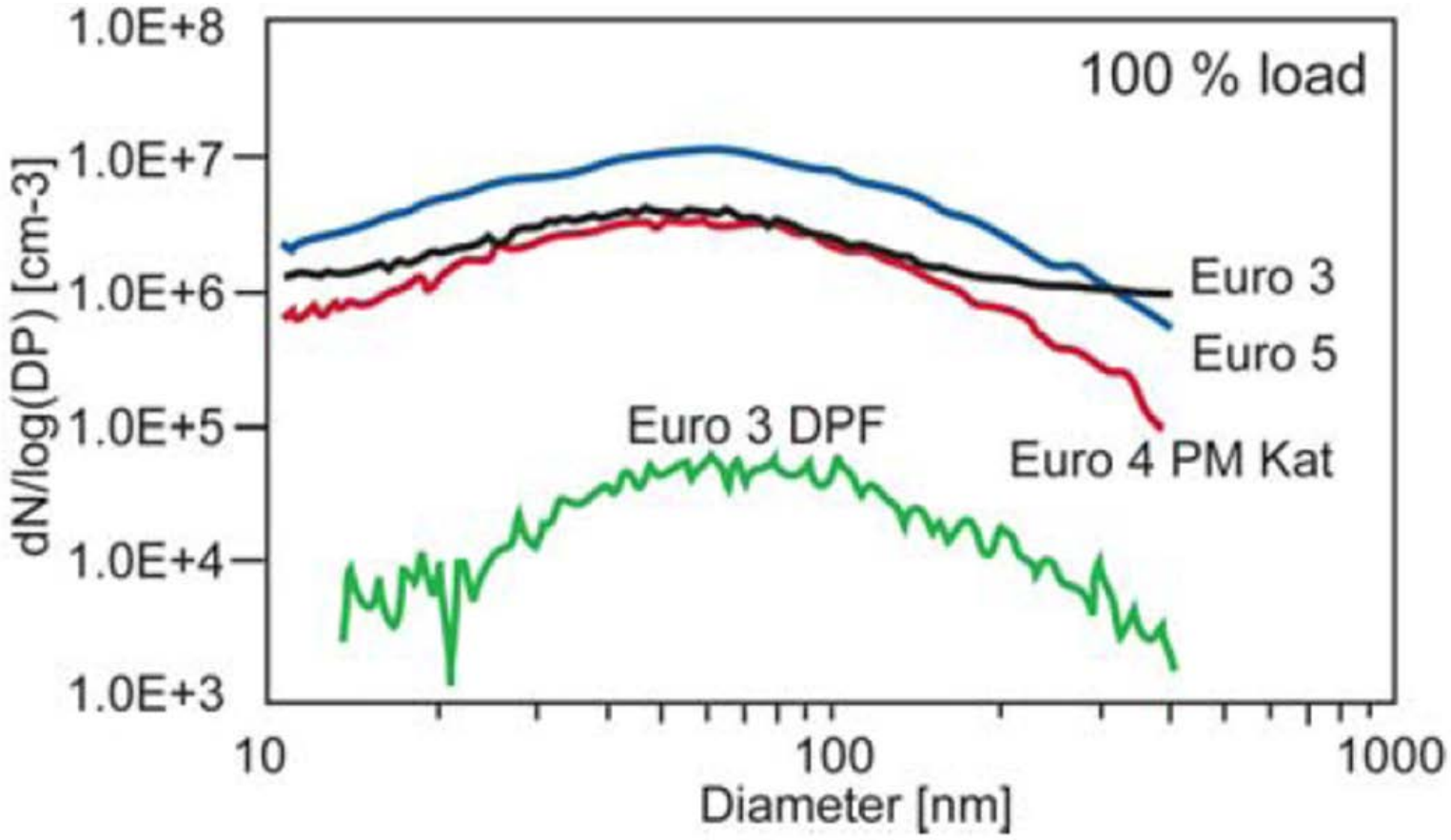


اثر استفاده از DPF بر سایز و تعداد ذرات



Effect of implementation of DPF on soot emissions of various emission standards

Euro V is as bad as Euro II in terms of particles

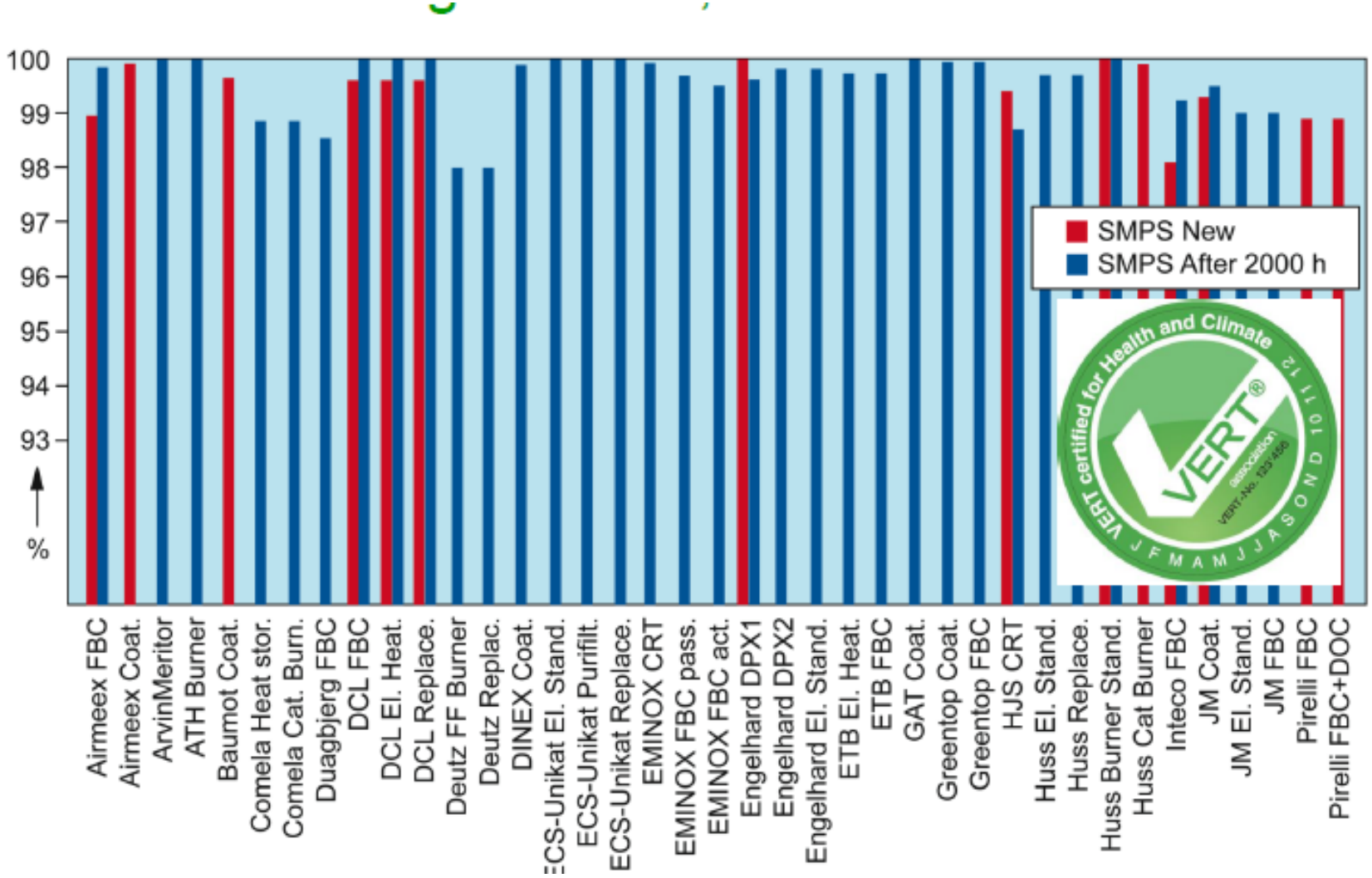


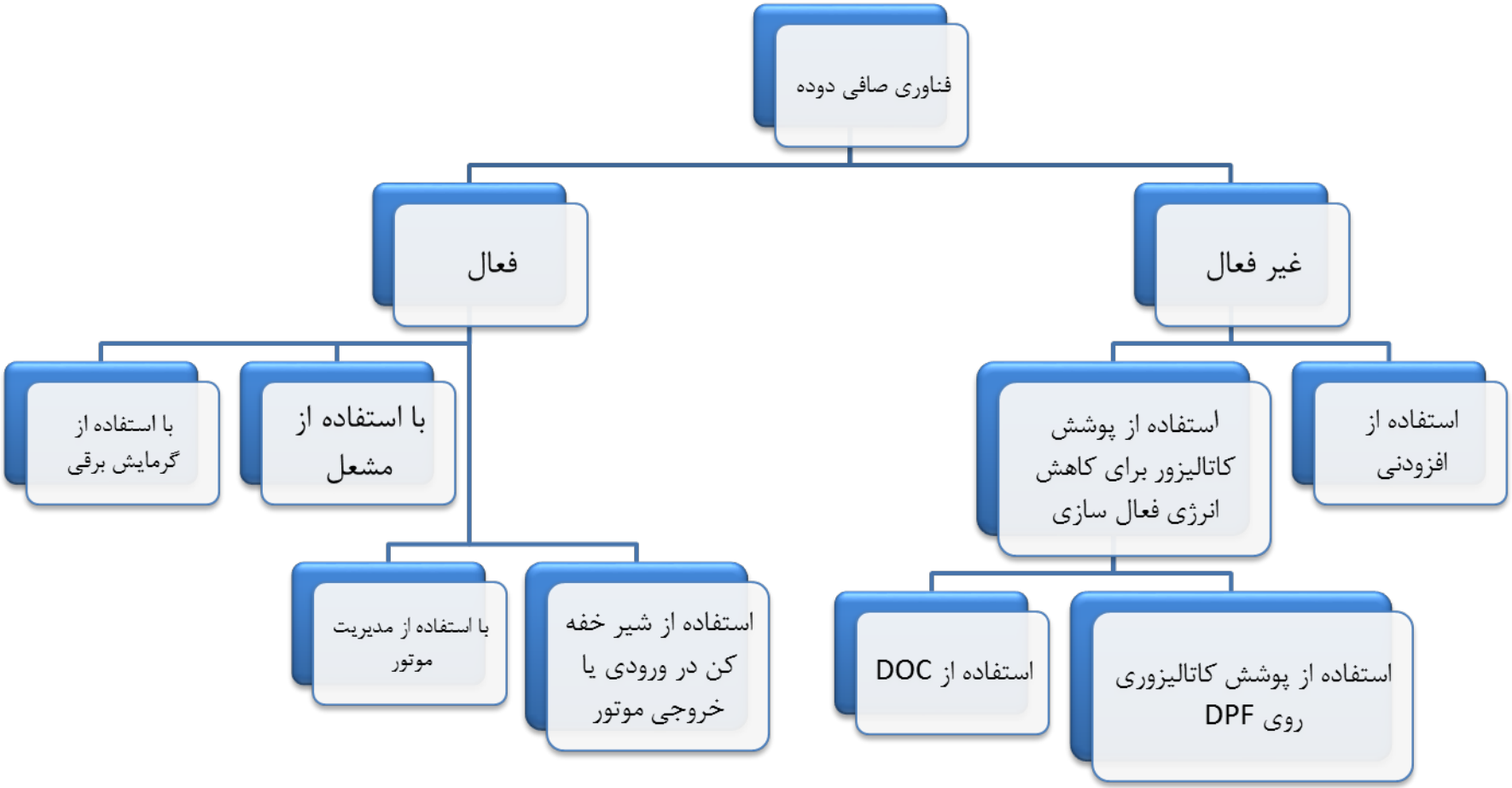
A.Mayer et al.,Nanoparticle-Emission of EURO 4 and EURO 5 HDV Compared to EURO 3 With and Without DPF , SAE Paper 2007-01-112

راندمان حذف دوده

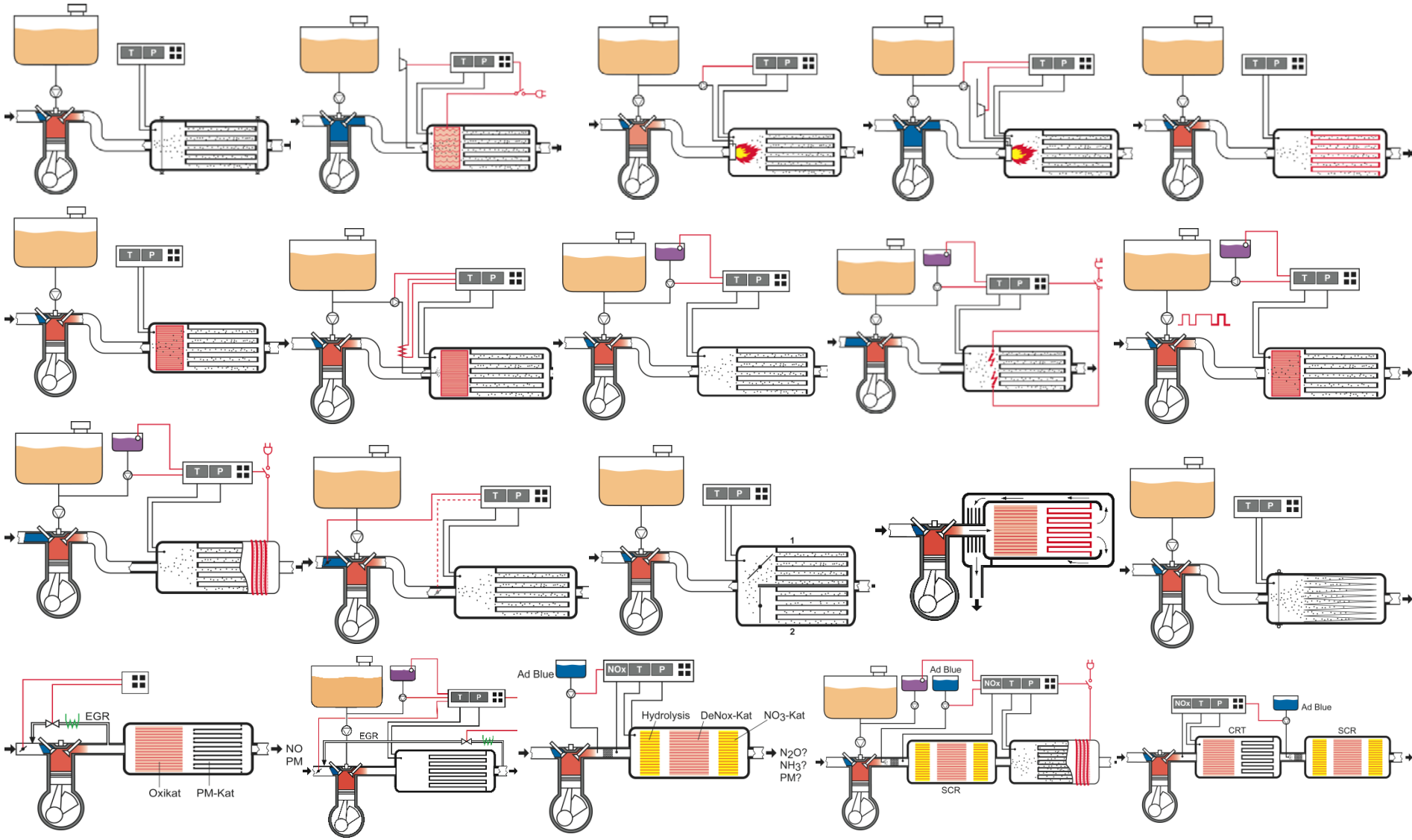
DPF-Efficiency can be very high

تعدادی راندمان حذف دوده




فناوری صافی دوده
فعال
غیر فعال
با استفاده از گرمایش برقی
با استفاده از مشعل
با استفاده از مدیریت موتور
استفاده از شیر خفه کن در ورودی یا خروجی موتور
استفاده از پوشش کاتالیزور برای کاهش انرژی فعال سازی
استفاده از افزودنی
استفاده از DOC
استفاده از پوشش کاتالیزوری روی DPF

Various technologies are available



فرایند احیا فیلتر

Why and How Regenerate the DPF

- An efficient filter stores all soot in it‘s cells – the exhaust gas exits clean, particles eliminated

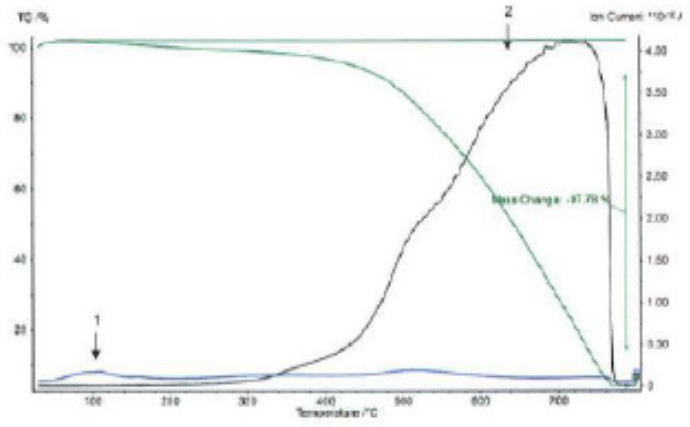
→ **the filter gets plugged soon**

- but by combustion solid soot can be converted into gaseous CO2 – leaving the filter

„Regeneration“ is controlled combustion of stored soot

→**Problem:**

combustion temperature must be very high and oxygen > 6 %

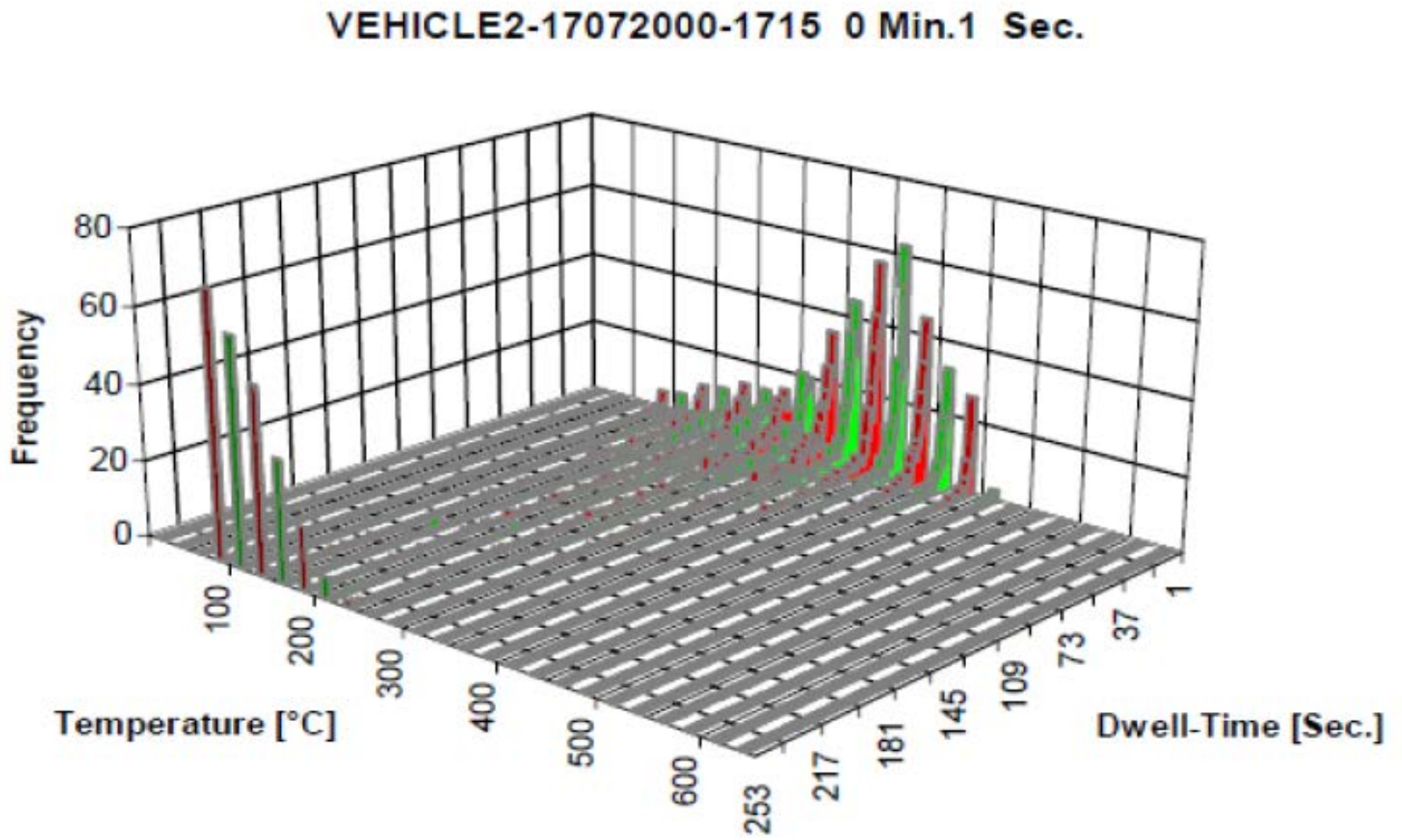


Soot combustion starts at 500°C and needs 700°C to become complete (TGA-combust.analysis)

This high temperature is rarely availabel in engine exhaust gas

High temperature episodes are short

SAE 2001-01-0187



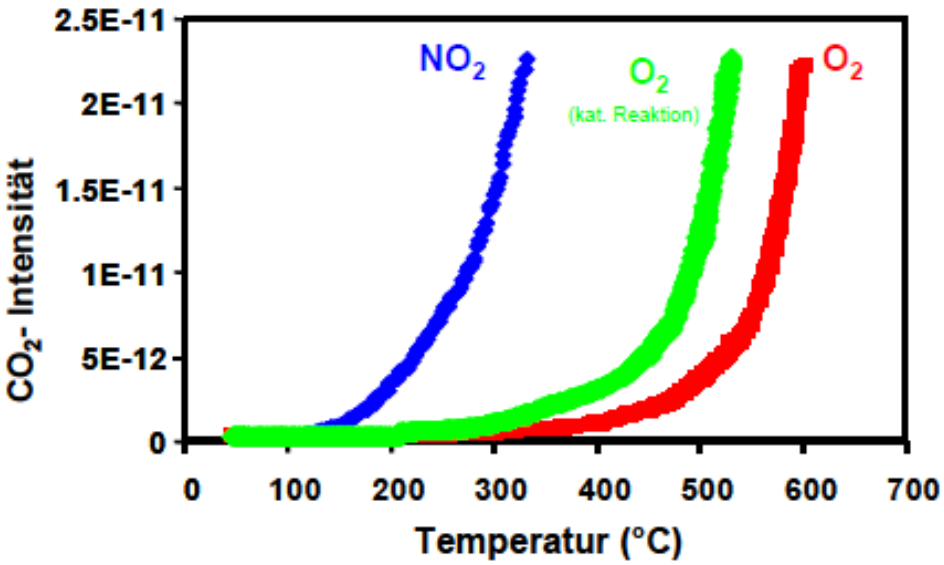
Soot-Reactions with O_2 und NO_2

- $C+O_2 = CO_2$

and the CRT-Process (JM)

- $C+2\ NO_2 = CO_2+2\ NO$

this CRT-process needs NO_2 which is not available in engine exhaust but can be provided by catalysis

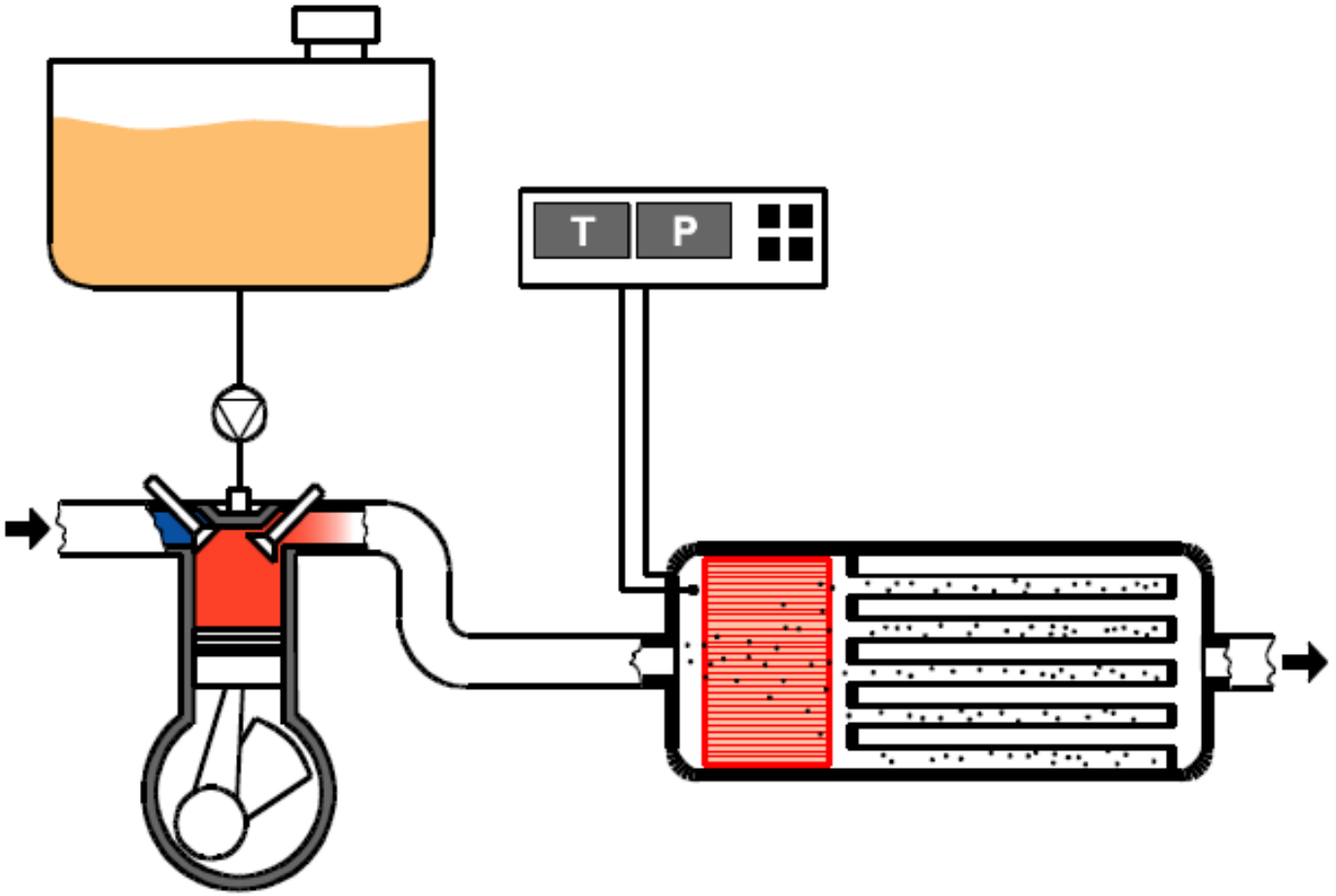


NO2-Rection is very attractive because of low temperatur

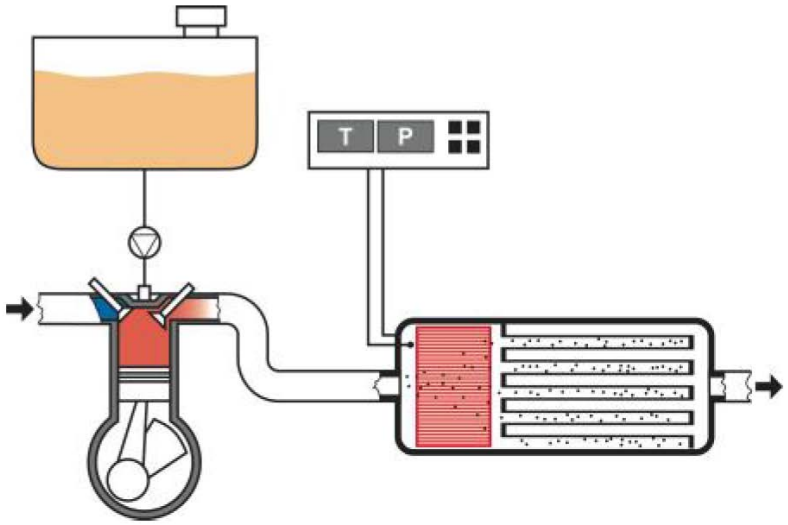
→ but requires Pt-Catalysis, which is not Sulfur-tolerant

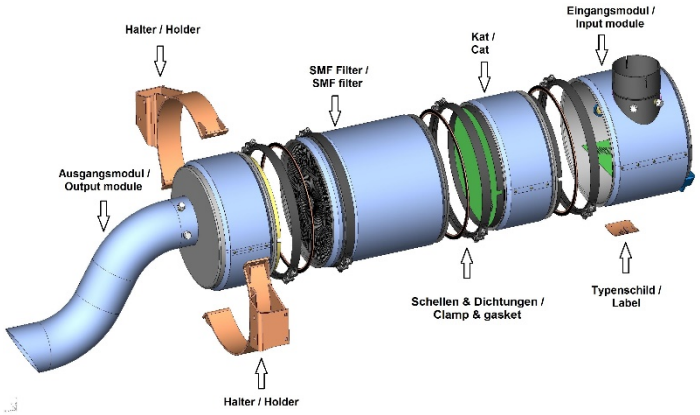
CRT: Passive Regeneration with Pt-Catalysis to generate NO_2 > 230 °C

JOHNSON MATTHEY / HJS-DES / EMINOX



CRT Systems | passive regenerating

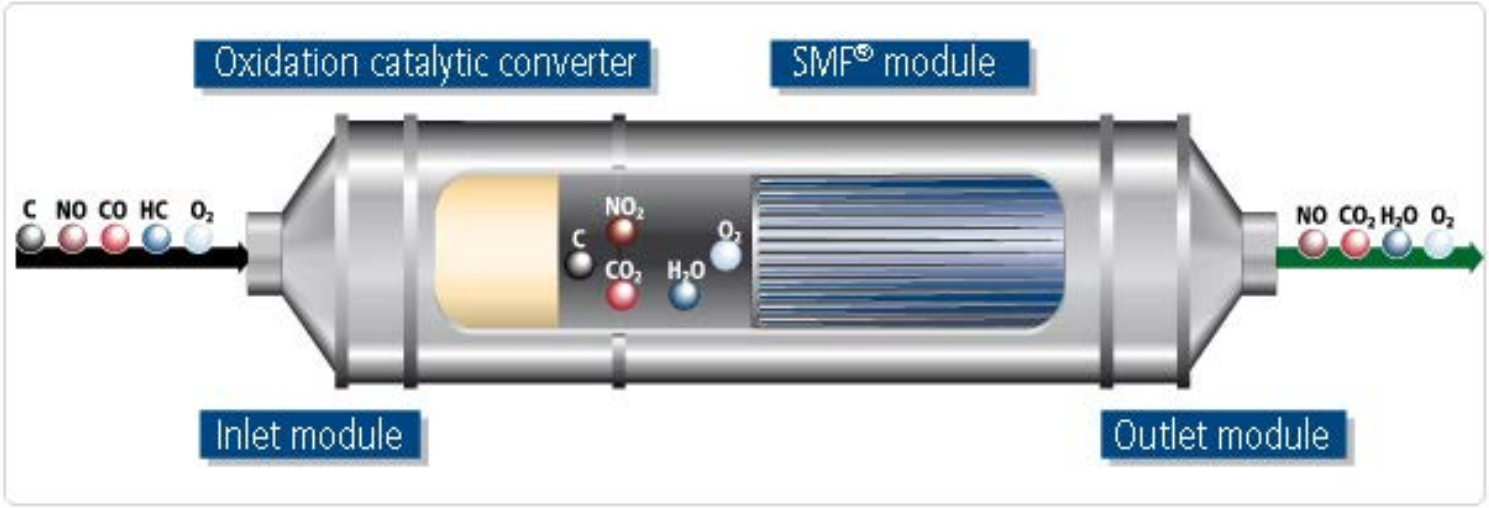




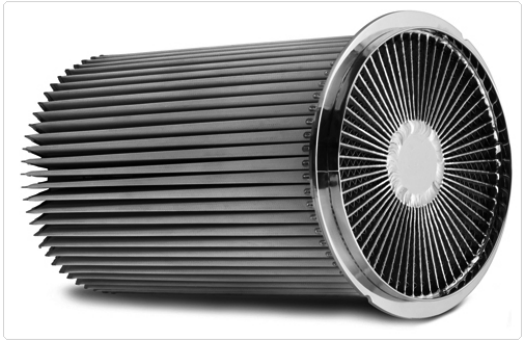
- **Catalytic converter upstream of the filter coated with precious metal**
- **Uses NO_2 for the regeneration**
- **Function of regeneration is depending on temperature cycles of the vehicles**
- **Sensitive against high sulfur (250 ppm)**
- **Robustness against 230 ppm sulfur has to be tested on engine test bench under Iranian circumstances**
- **Most used technology in city busses world wide**

- Example: HJS CRT filter

An example: CRT (Catalytic Reduction technology)

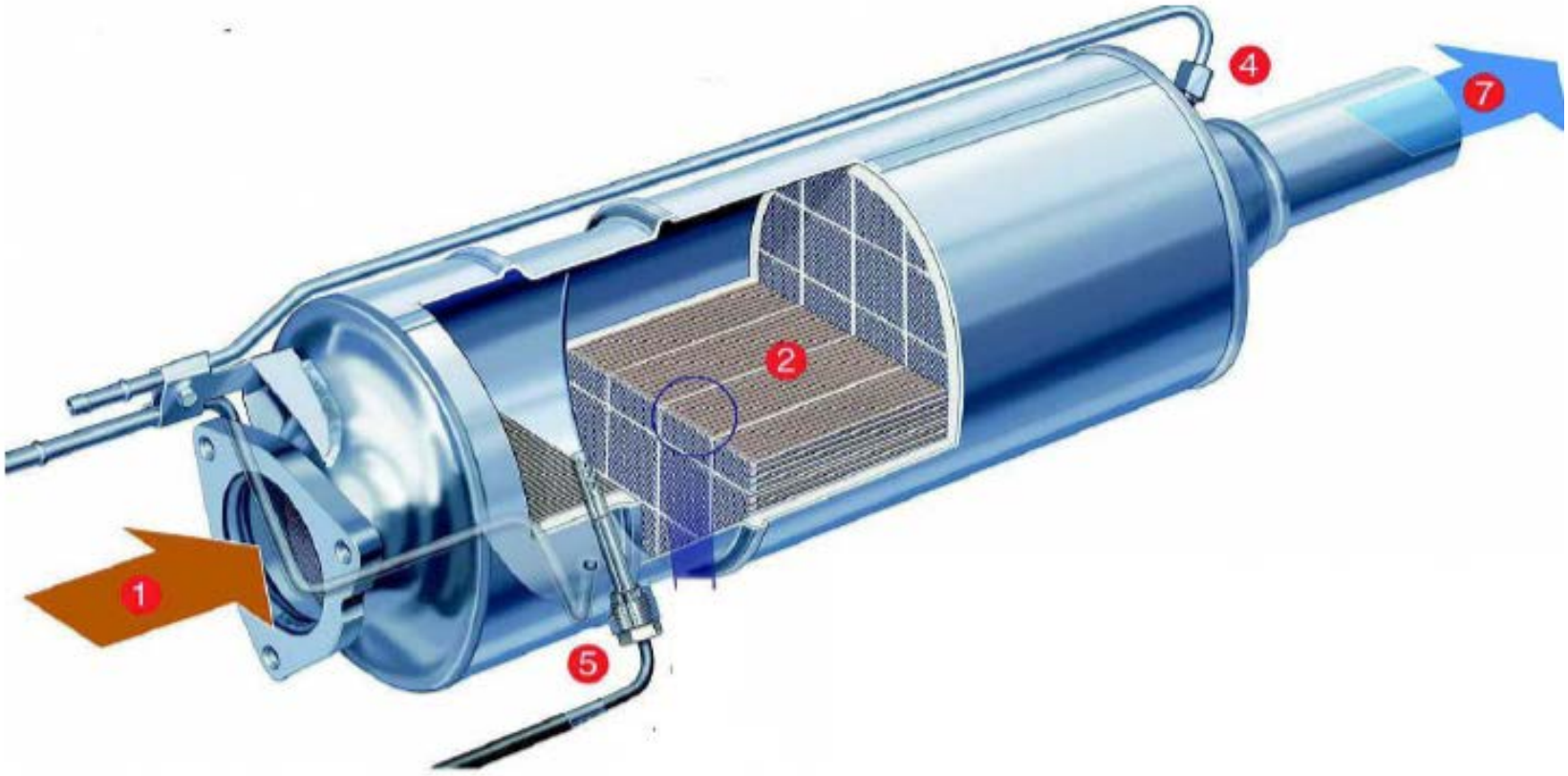


- **Over 99% reduction of soot particles, including fine particulate matter**
- **Over 95% reduction of gaseous pollutants (CO / HC)**

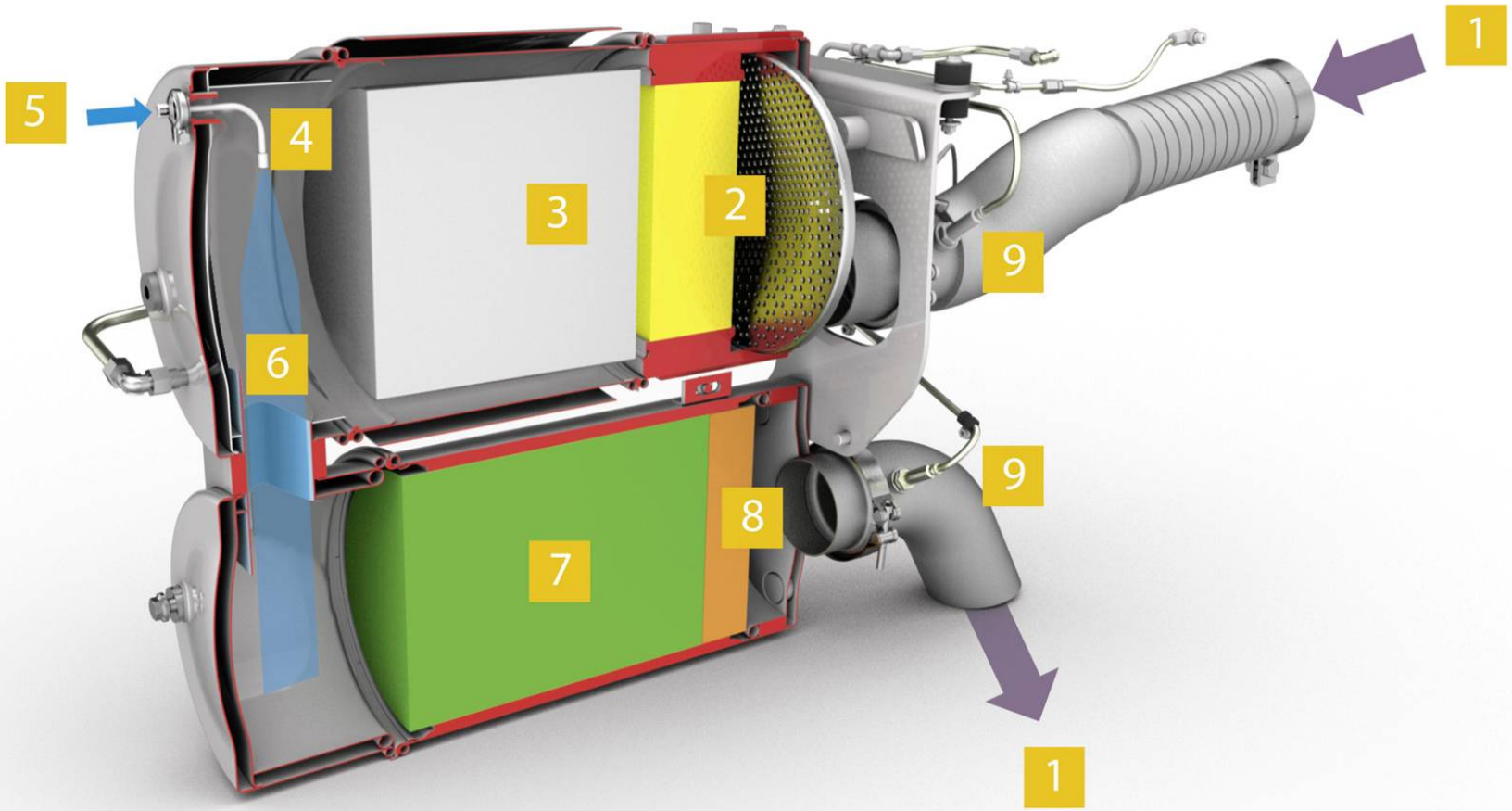


CRT-Filter System

Johnson Matthey Patent 1988



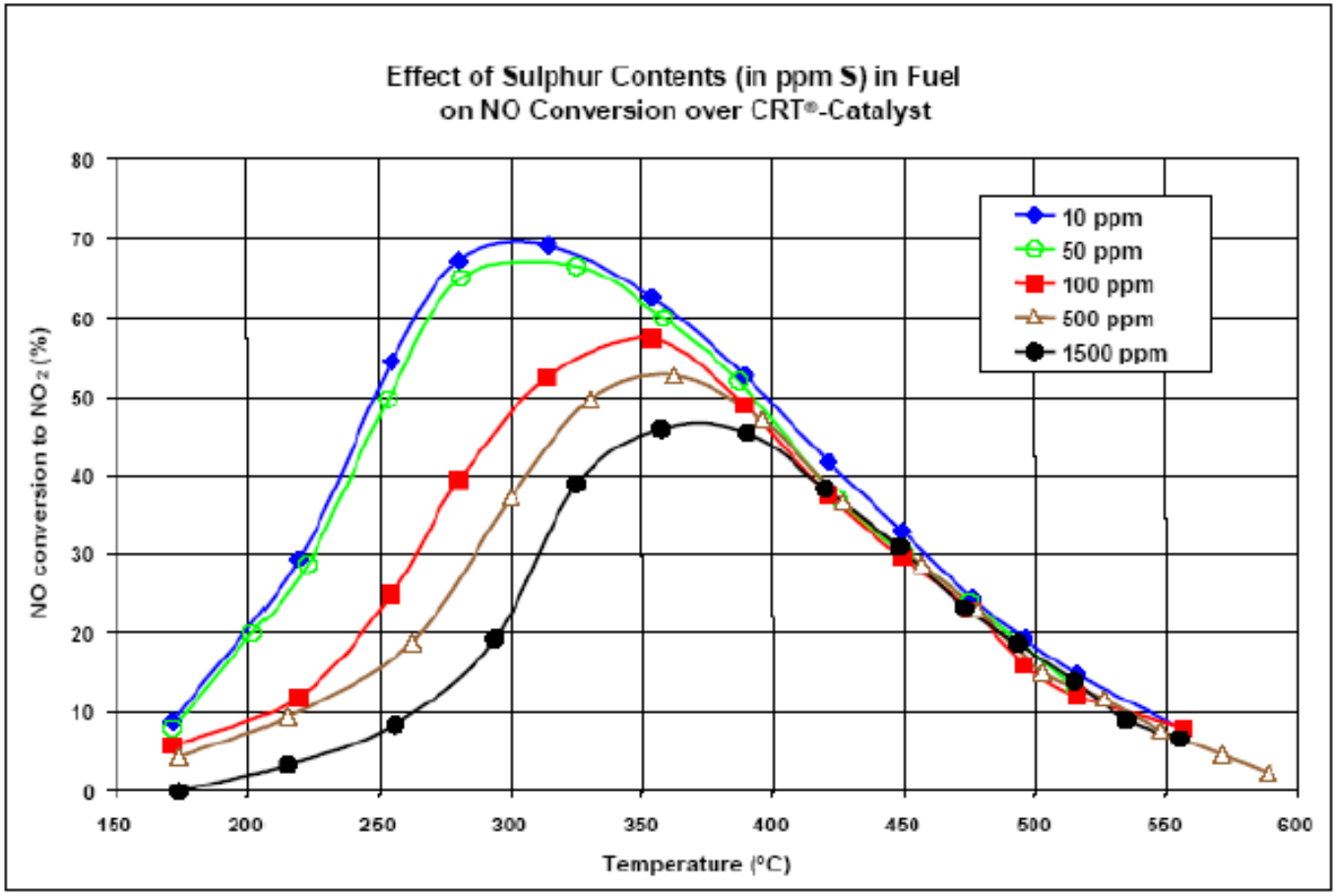
CRT (Catalytic Reduction technology)



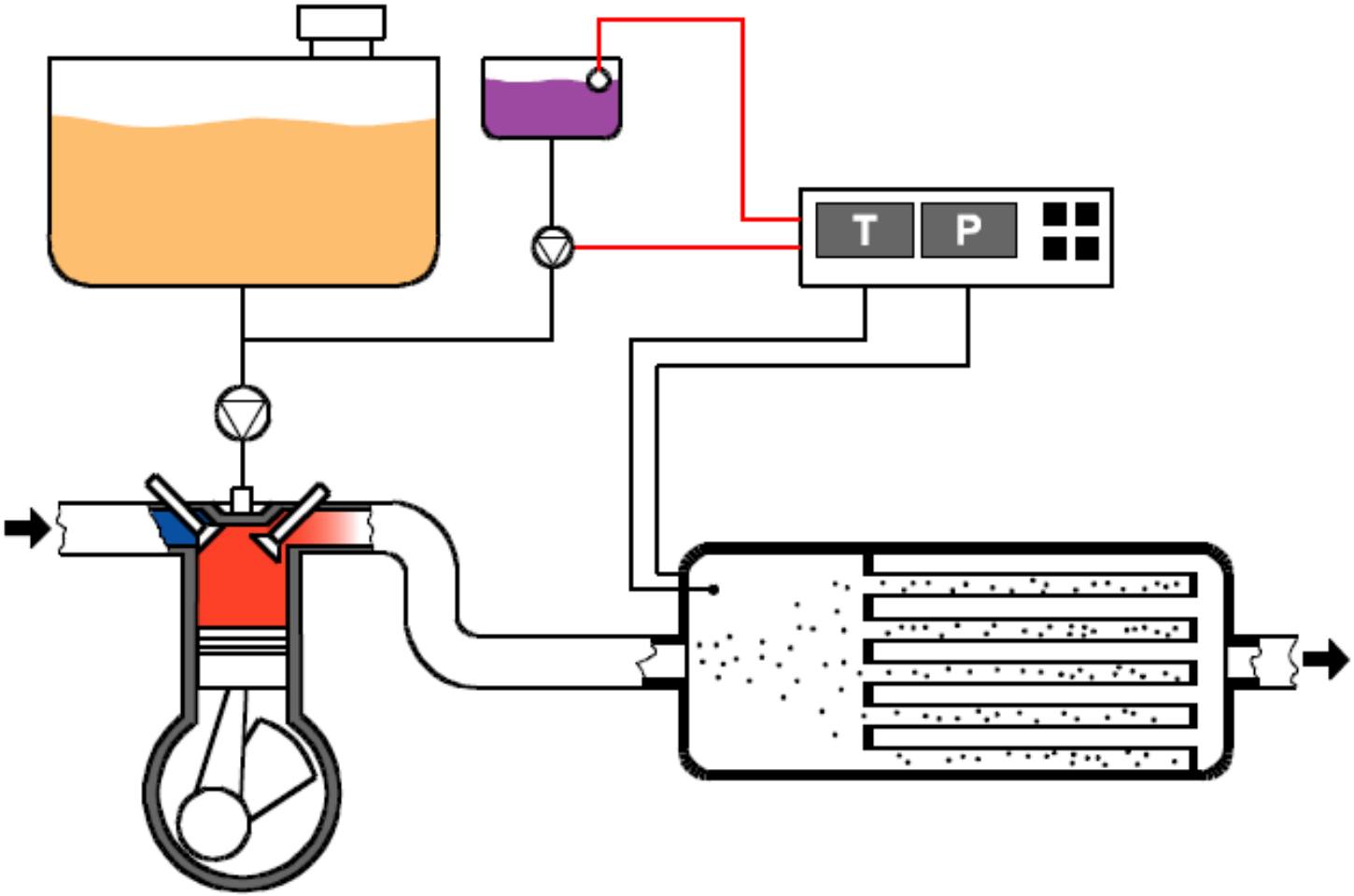
- **[1] Abgasstrom**
- **[2] Diesel-Oxidationskatalysator**
- **[3] Geschlossenes Partikelfiltersystem CRT**
- **[4] Eindüsung AdBlue®**
- **[5] Zuleitung AdBlue®**
- [6] AdBlue® Umwandlungsstrecke
- [7] SCR-Katalysatormodul
- [8] Ammoniak-Sperrkatalysator
- [9] NOx-Sensoren

NO_2-generation is inhibited by Sulfur in the Fuel – Filter gets plugged

Source: Johnson Matthey



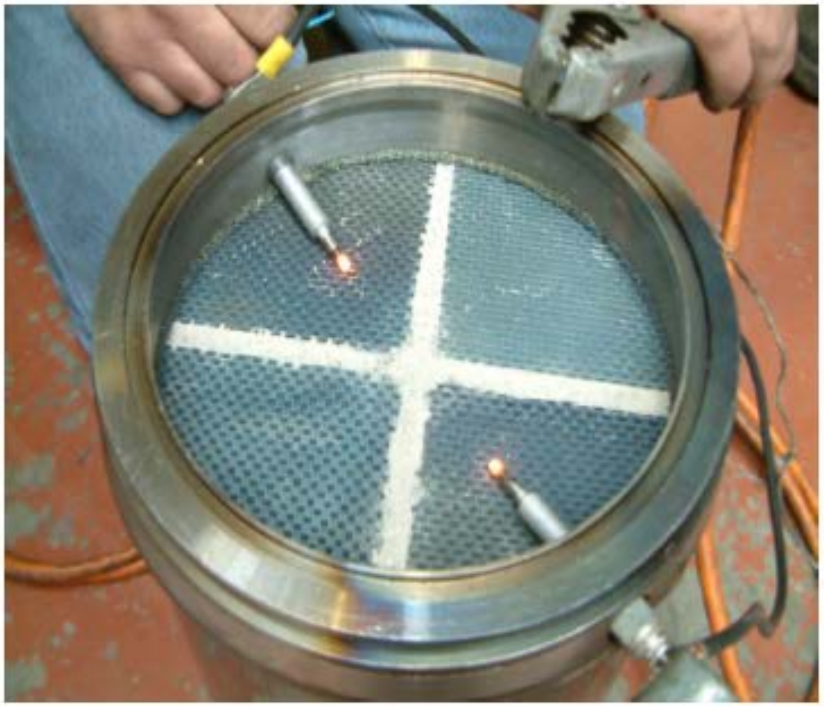
Passive Regeneration with FBC > 340 °C



Active Regeneration with FBC

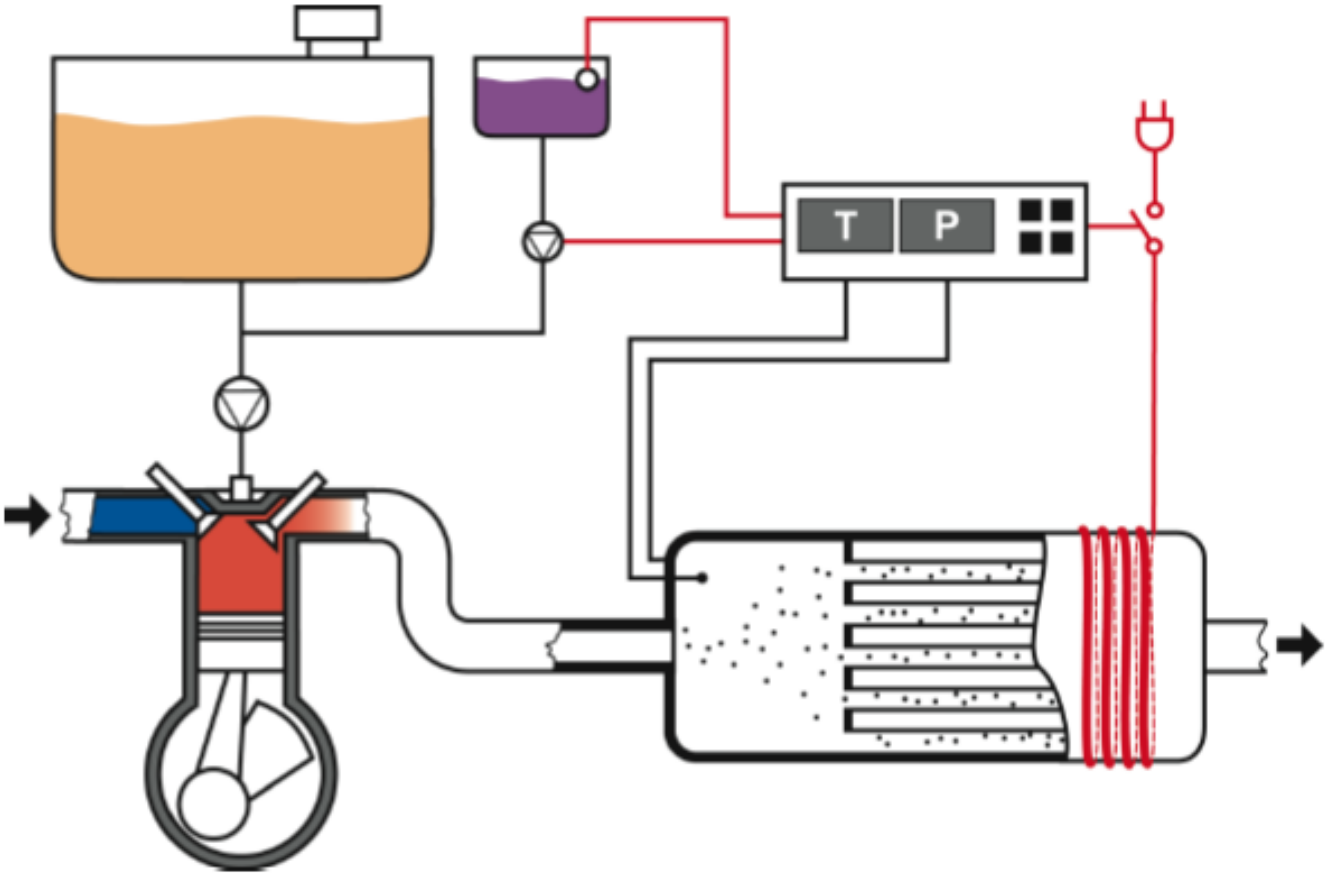
triggered by glow plugs

- Active Regeneration to suit
  - Older engine technology
  - Off highway applications
  - Low temperature
  - High sulfur fuel
- Requires robust SiC filters (heat conductivity)



Active Regeneration with FBC

triggered by electric heat

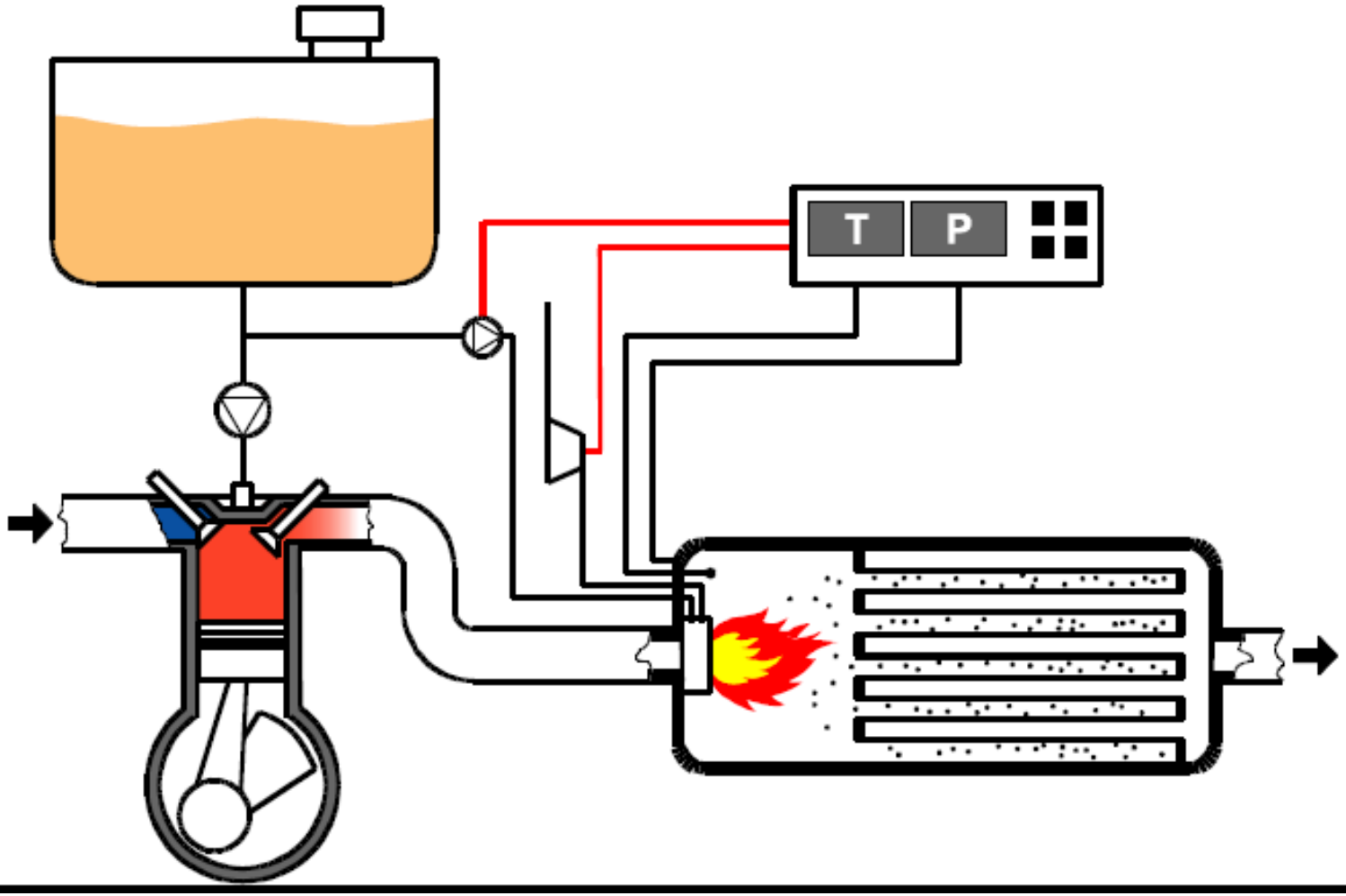


Regeneration triggered by electric Heating
combined with FBC-Catalysis

HJS Fahrzeugtechnik GmbH & Co KG

HJS SMF® – System mit autarker Regeneration

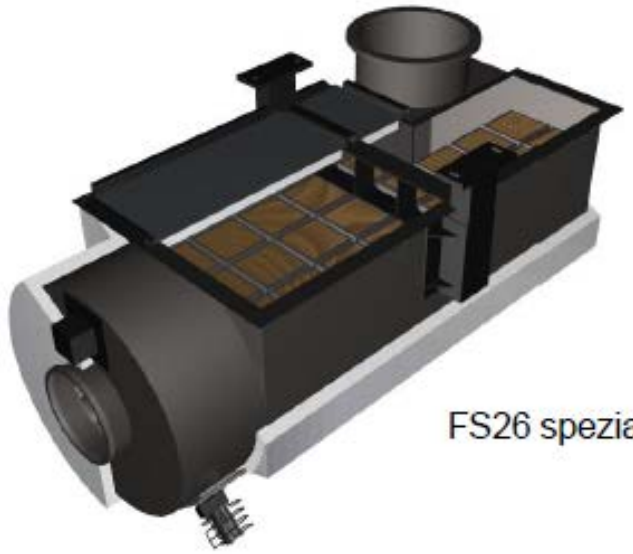
Solution 2: Full Flow – Diesel-Burner



Full Flow Burner combined with Base Metal-Catalyst

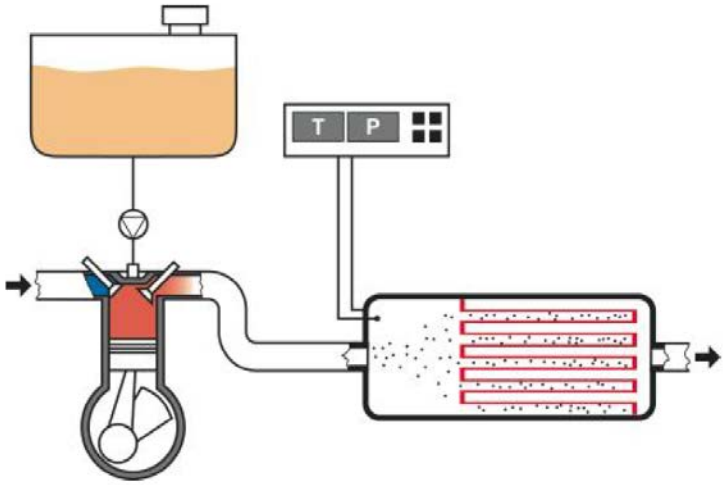
Standard Filtermodul

Restsauerstoff im Abgas:	> 8%
Heizleistungen:	30 – 400 kW
Druckluft > 5 bar:	20 Nm^3/h
Dieselkraftstoff:	3 – 40 l/h
Stromversorgung:	24 VDC



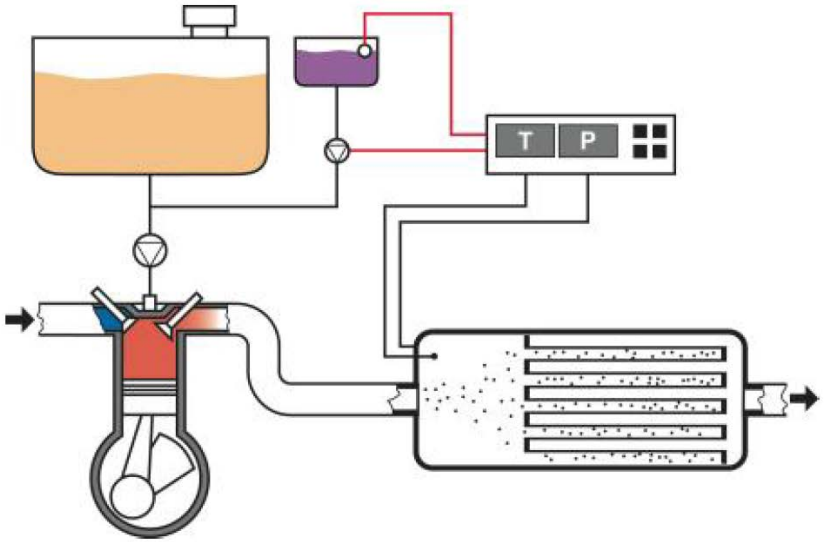
FS26 spezial

Catalytic Coated Filters| passive regenerating



- Catalytic coated ceramic filter element
- Uses NO2 and/or O2 for the regeneration
- Function of regeneration is depending on temperature cycles of the vehicles
- Sensitive against high sulfur (> 250 ppm) Depending on kind of coating
- Robustness against 230 ppm sulfur has to be tested on engine test bench under Iranian circumstances
- Easy to install

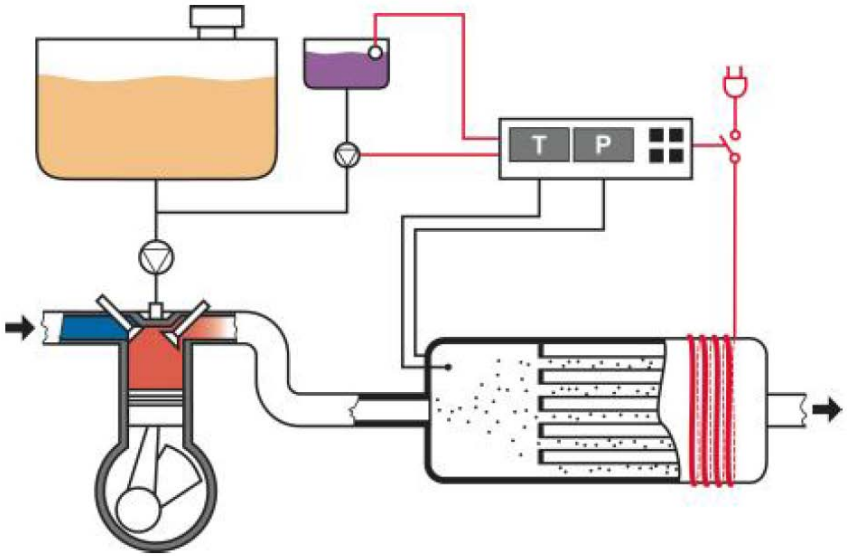
FBC = Fuel Borne Catalyst| passive regenerating



- **No catalytic coating, the additive is the catalyst and comes always fresh to the filter**
- **Need additive on the vehicle, 1 Liter is needed for 1.500 – 2.000 Liter fuel**
- **Reduces significantly NO_2**
- **Robust against high sulfur in diesel (up to 7.000 ppm tested in Tabriz)**
- **Function of regeneration is depending on temperature cycles of the vehicles. Short high temperature peaks are sufficient**

Example: Dinex and Puritech filters

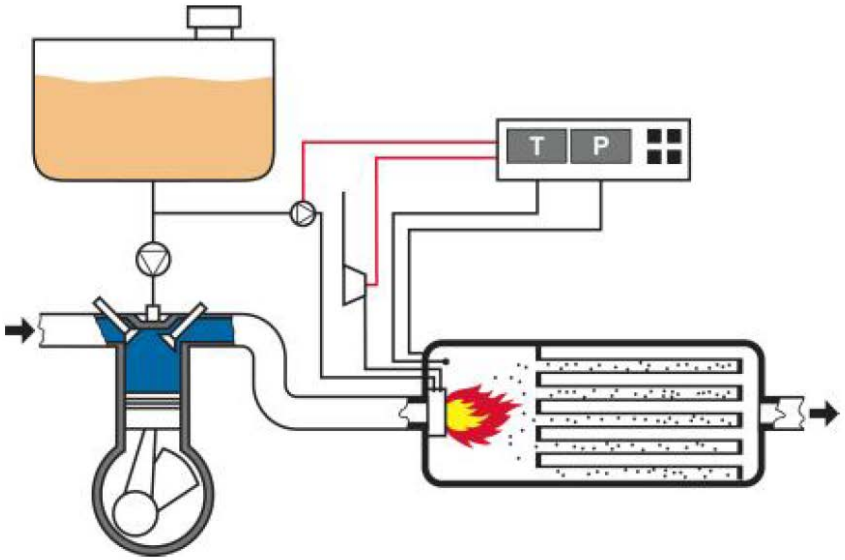
FBC = Fuel Borne Catalyst with electrical ignition (SMF-AR) | active regenerating



- **No catalytic coating, the additive is the catalyst and comes always fresh to the filter**
- **Need additive on the vehicle, 1 Liter is needed for 1.500 – 2.000 Liter fuel**
- **Reduces significantly NO_2**
- **Robust against high sulfur in diesel (up to 7.000 ppm tested in Tabriz)**
- **Works with every temperature profile of the vehicle**
- **Needs power from the vehicle for the regeneration for about 5-7 minutes.**

Example: HJS SMF-AR

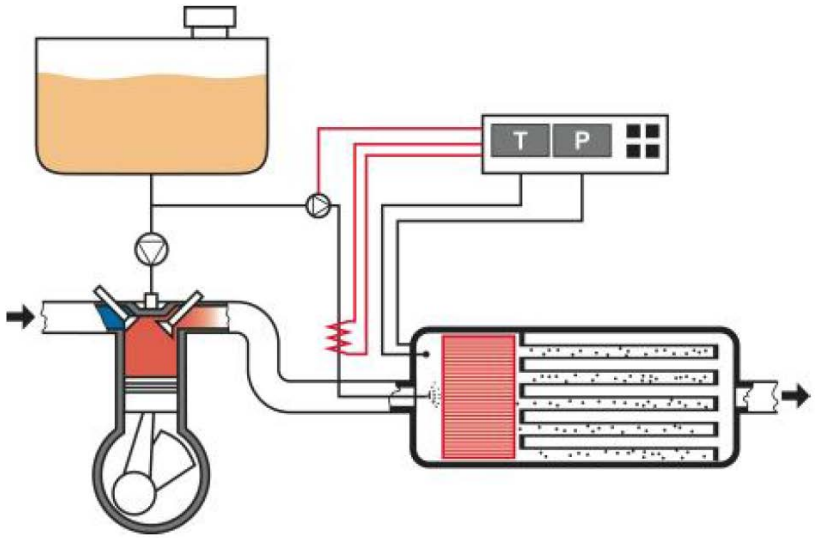
Stand Still Burner| active regenerating



- **Burns the soot of with a flame**
- **Robust against high sulfur in diesel (up to 7.000 ppm tested in Tabriz)**
- **Need downtime (apr. 30 min) when the filter needs to regenerate the soot which can be aligned with driver shift change**
- **Works with every temperature profile of the vehicle**
- **Needs a fuel line from the vehicle to the burner**

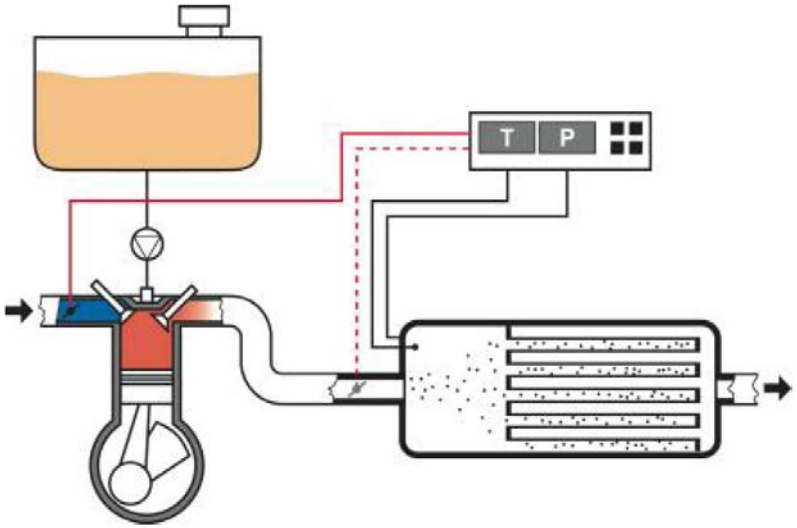
Example: HUSS MK System

Catalytic Fuel Burner| active regenerating



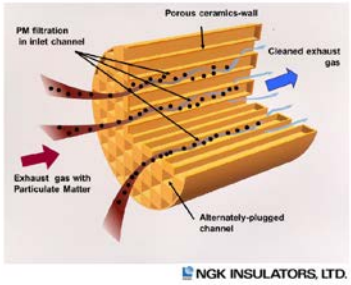
- Burns the soot of over 600 °C by injection diesel on a catalytic converter
- Robust against sulfur up to 230 ppm in diesel
- Probably not robust against high sulfur diesel > 250 ppm
- No downtime, the burner works under normal operation
- Works with every temperature profile of the vehicle
- Needs a fuel line from the vehicle to the burner

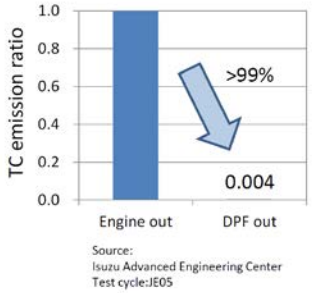
Temperature Management by Throttling



- An option for passive systems is a temperature (optional)
- Exhaust temperature can be increased up to 80 °C
- Support a broader application
- Makes passive systems more independent from bus routes
- Reduces additional maintenance due to blocked passive filters

Is DPF an effective solution?





Source:
Isuzu Advanced Engineering Center
Test cycle:JE05

Yes, However ....

Key points for „DPF into market"

- ✓ **Fuel quality**
  - **Low sulphur fuel is mandatory**
- ✓ **Low ash engine oil**
- ✓ **Low speed, low load operation and frequent engine stop**
- ✓ **DPF system information to market**

نمونه هایی از سامانه های کامل پس پالایش

Example: MAN solution for Euro-4

Combustion chamber and injection:

- Compression ratio raised from 19:1 to 20,5:1
- Optimization of combustion chamber
- Use of improved injection nozzles (7-hole) for optimised combustion
- Injection pressure was raised to 1600 bar
- Useage of postinjection to reduce formation of soot

Useage of an optimized EGR-system:

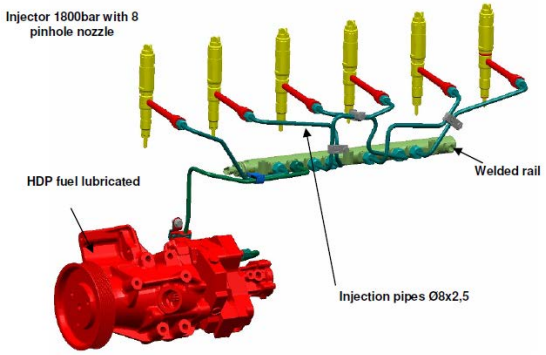
- EGR-rates of up to 20 %
- Lower temperatures of the recirculated exhaust gas
- The formation of NO_x is in-line with E4 regulations

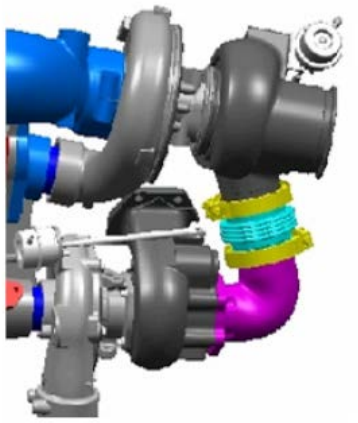
Useage of the PM-catalyzer to reduce the soot output

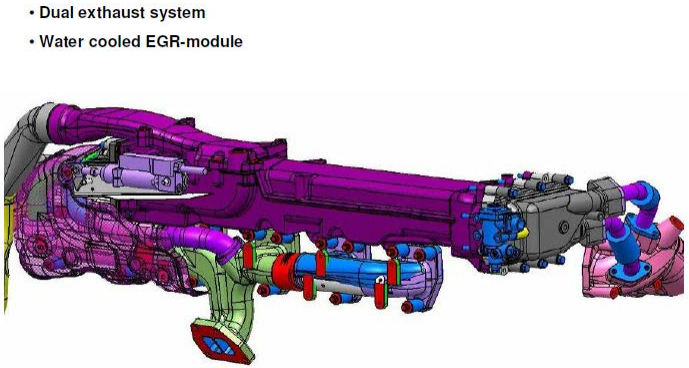
- Maintenance free, price-winning system that keeps the PM output in-line with E4 regulations

Example: MAN solution from Euro-4 to Euro-5

- Common Rail System 2nd generation
- Exhaust-gas recirculation system
- 2-stage turbo charging
- Indirect inter- and main charge air cooling
- PM-Kat







Example: MAN solution for Euro-5

Injection:

- Usage of 2nd generation CommonRail system
- Use of improved injection nozzles (8-hole) for optimised combustion
- Injection pressure was raised to 1800 bar (for E6 pressure of up to 2400 bar is planned)

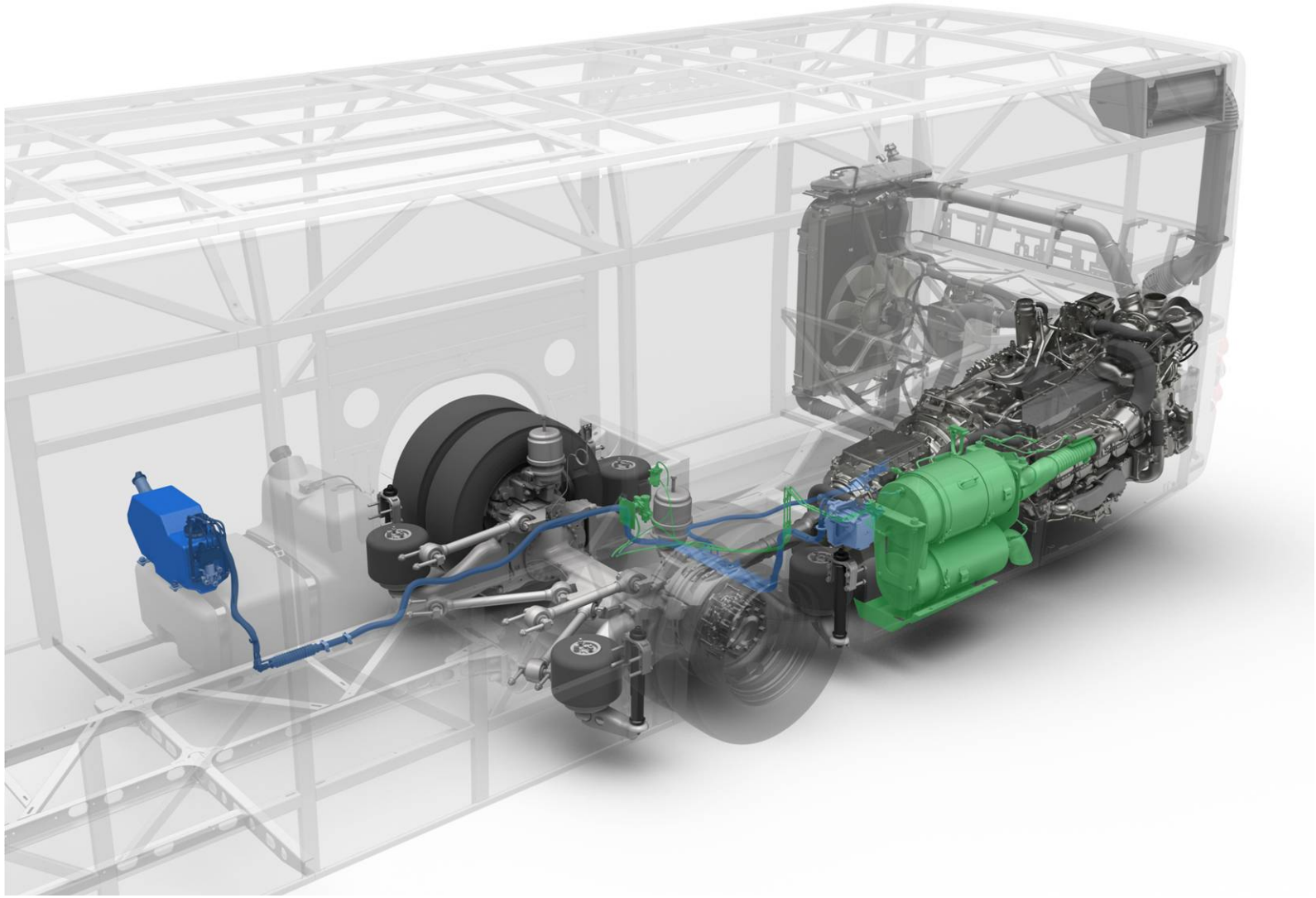
Further optimized EGR-system:

- EGR-rates of up to 30 %
- Double-fold exhaust system to achieve high EGR-rates
- Lower temperatures of the recirculated exhaust gas due to a better cooling unit
- The formation of NO_x is in-line with E5 regulations

Turbo charger and cooling system

- Double turbo charger
- Elaborate cooling system with air-water-intercooling for both turbos

MAN Euro-6 Solution



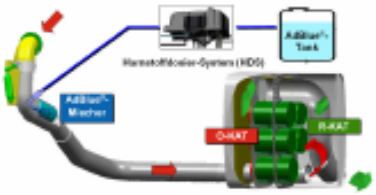
Example: MAN solution for Euro-6

EPA 2007

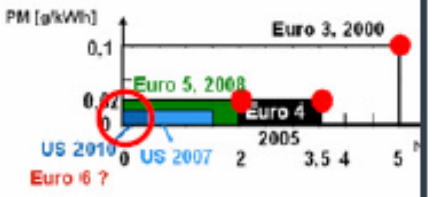
EGR-Technology
+
2-stage turbo charge
with
Carge air intercooling
+
Filter (PM-KAT®/CRTec®)

Euro 5

+



MAN AdBlue®



EPA 2010

Euro 6

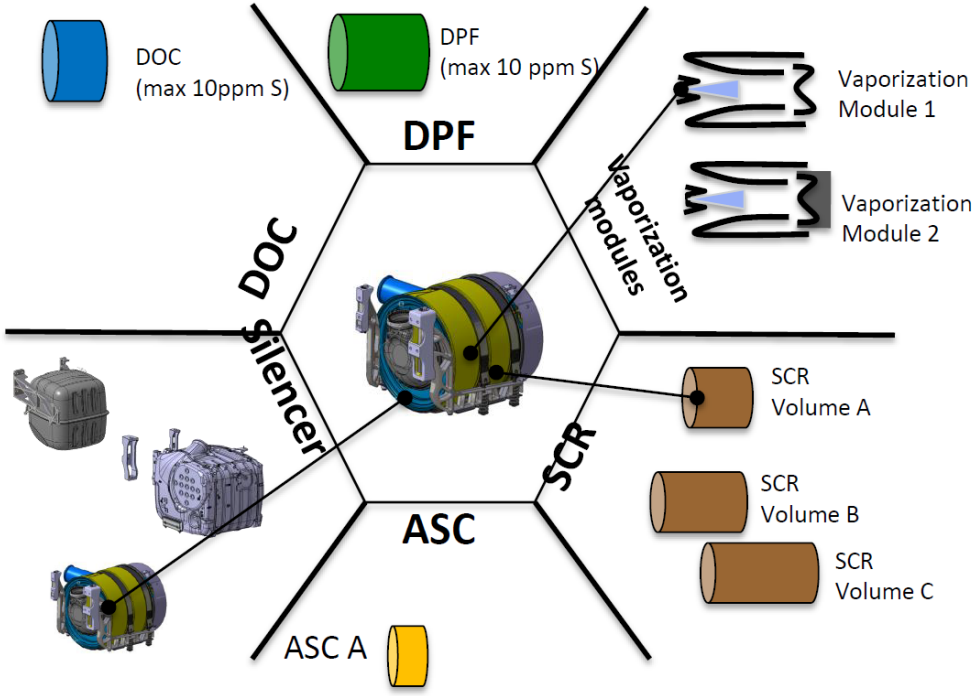
Exhaust treatment components

- **DOC – Diesel Oxidation Catalyst**
  - Oxidizes hydrocarbons and carbon monoxide to water and CO_2
- **DPF – Diesel Particulate Filter**
  - Removes particles from the exhaust. Breaks down PM to CO_2
- **UDS – Urea Dosing System**
  - Injects liquid Urea to exhaust
- **Vaporization module**
  - Turns liquid Urea to gaseous ammonia
- **SCR – Selective Catalytic Reduction**
  - Catalyst that breaks down NO_X using ammonia
- **ASC – Ammonia Slip Catalyst**
  - Removes excess ammonia from emissions

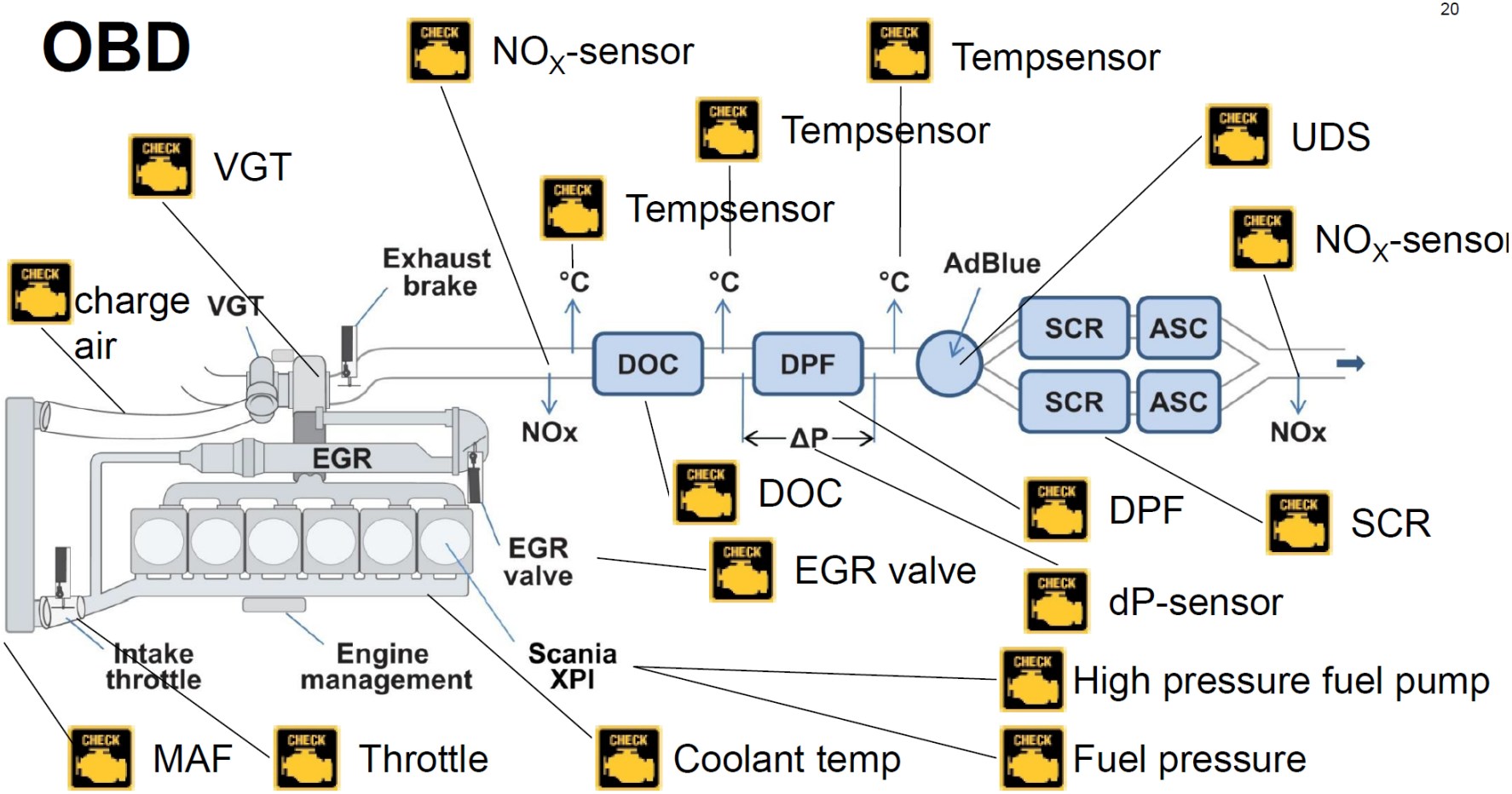
Scania Aftertreatment toolbox

Components with verified performance

Euro IV



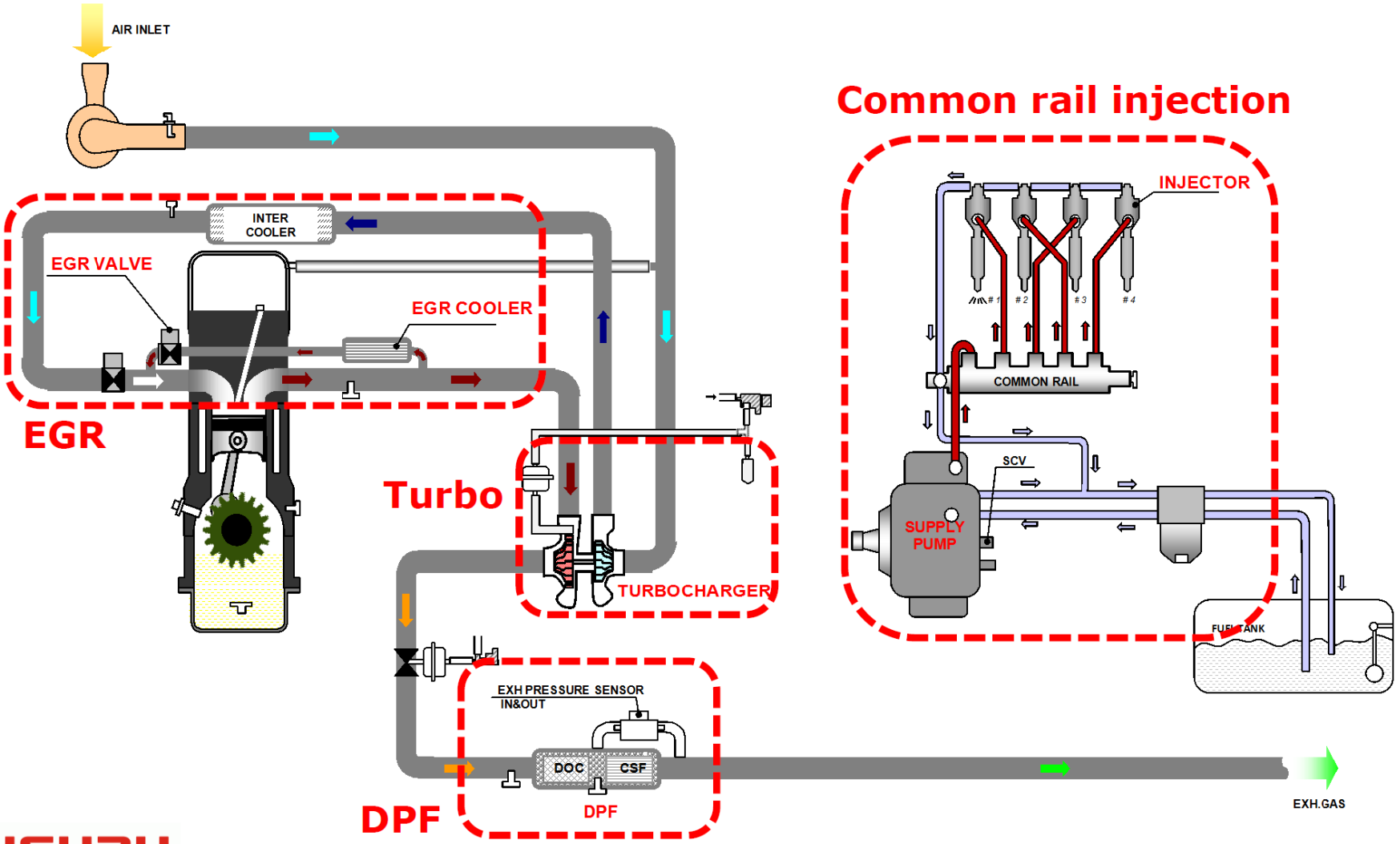
OBD



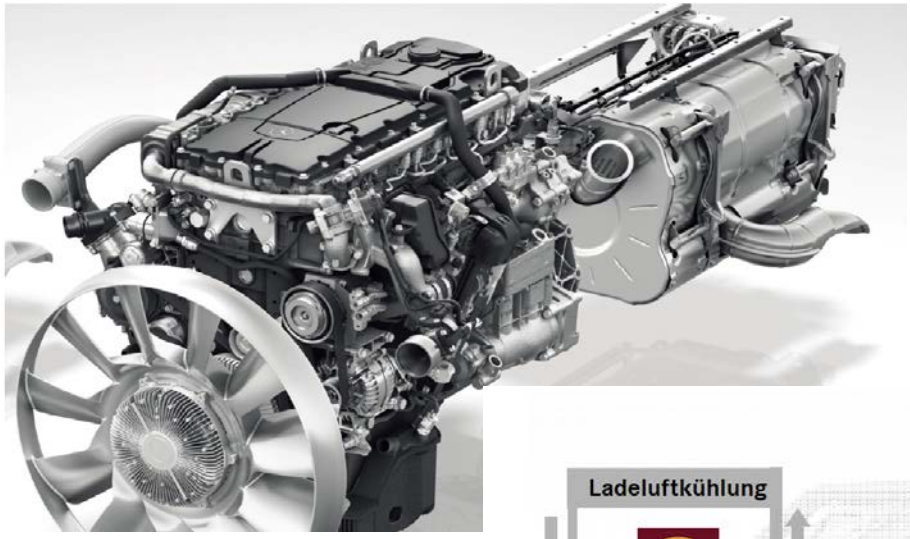
All components affecting emissions have to be monitored by OBD

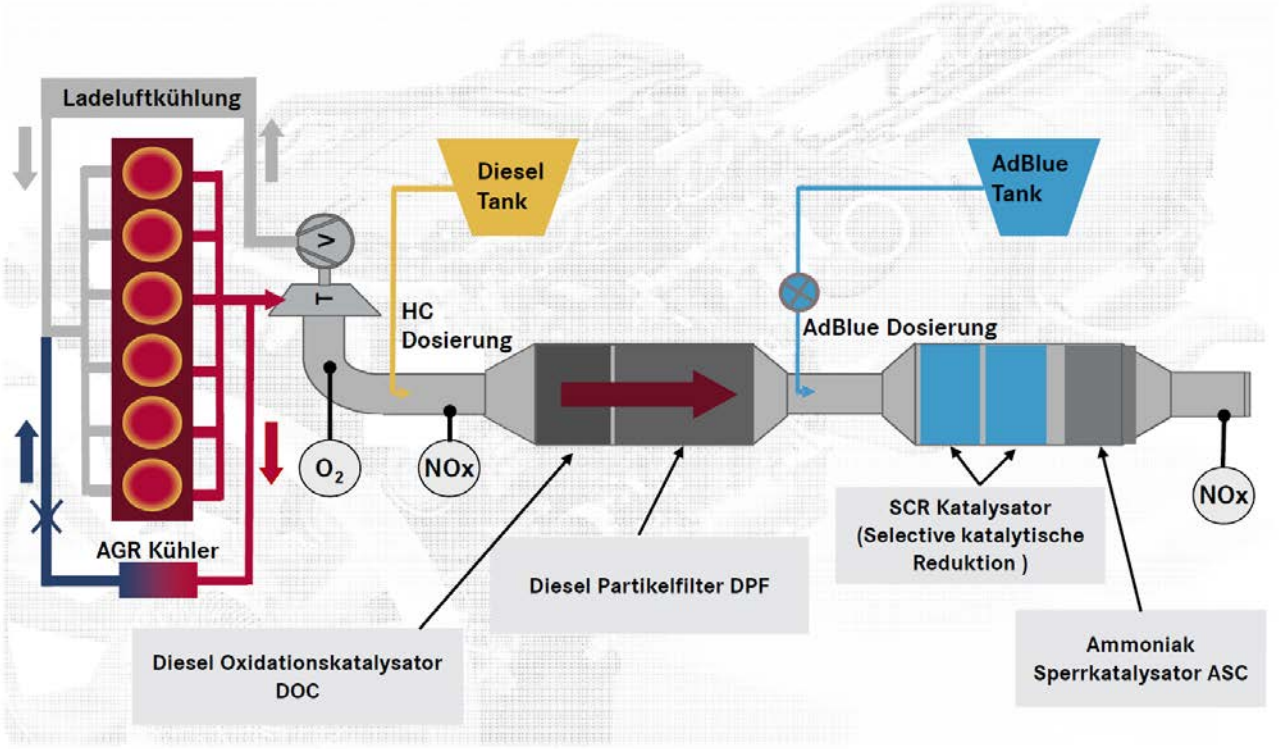
SCANIA

Potential system for proposed IranIVa



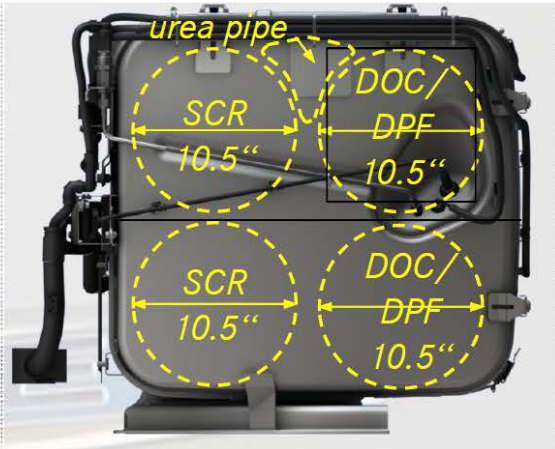
Daimler Euro 6





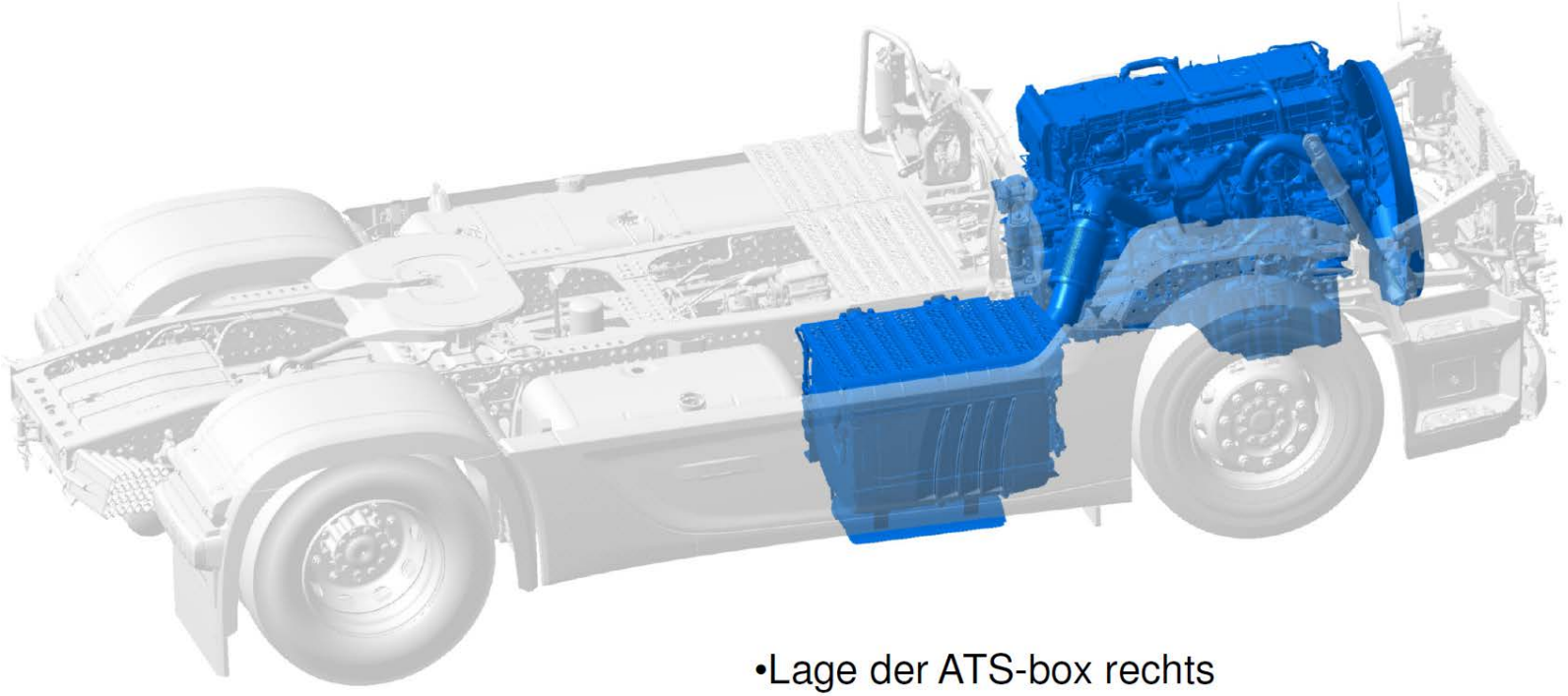
Daimler Euro 6 (Bluetec 6)

Motor	OM471 Euro 6, 12.8 l, 6 Zylinder Reihe
Leistungsstufen	310 / 330 / 350 / 375 kW
AGN Konzept	EGR / DOC-DPF-SCR/ASC
Abmessungen	[B x H x L] = 640 x 600 x 870
DOC/DPF Größe	Zweiflutig, 2x 10.5" Durchmesser
Gegendruck	auf minimalen Gegendruck ausgelegt
DPF Service Zugänglichkeit	Freier Zugang durch Wartungsklappe rechts
DPF Service Interval	450.000 km (long haul)[2]
SCR Größe	Zweiflutig, 2x 10.5" Durchmesser
Sensoren	5x T-, 2x NOx-, 2x p-sensor
Abgasauslässe	Verschiedene Auslassorientierungen incl. Temperaturreduzierungsmaßnahmen



Daimler Euro 6 (Bluetec 6)

Fahrzeugintegration ATS Box HDEP EURO 6



- Lage der ATS-box rechts
- Kurze Leitungsführung
- Niedriger Druckverluste
- Geringe Wärmeverluste

Acknowledgement

- Dr. Andreas Mayer for providing DPF slides
- ISUZU, MAN, DB, Scania for practical content
- http://www.dieselnet.com and Dr. Addy Majewski for the access to the website content

Thanks for your attention

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