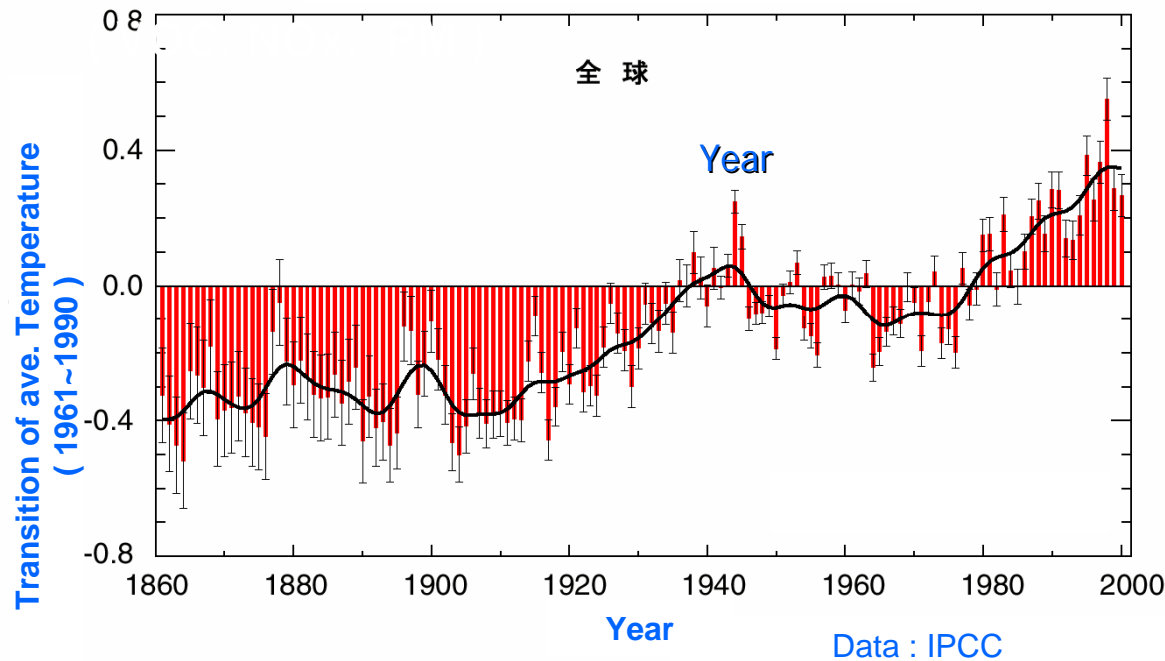


DEER Conference

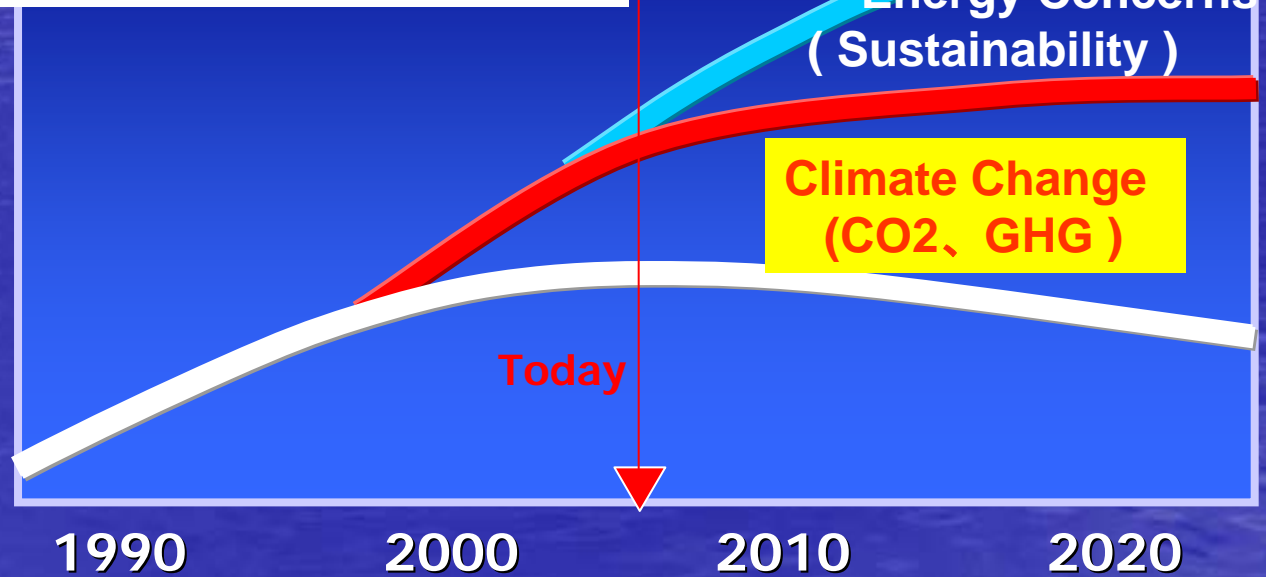
Clean Technology for Diesel Expansion

Yasuyuki Sando
Senior Manager
Honda R&D Co., Ltd.

Transition of Environmental Issues

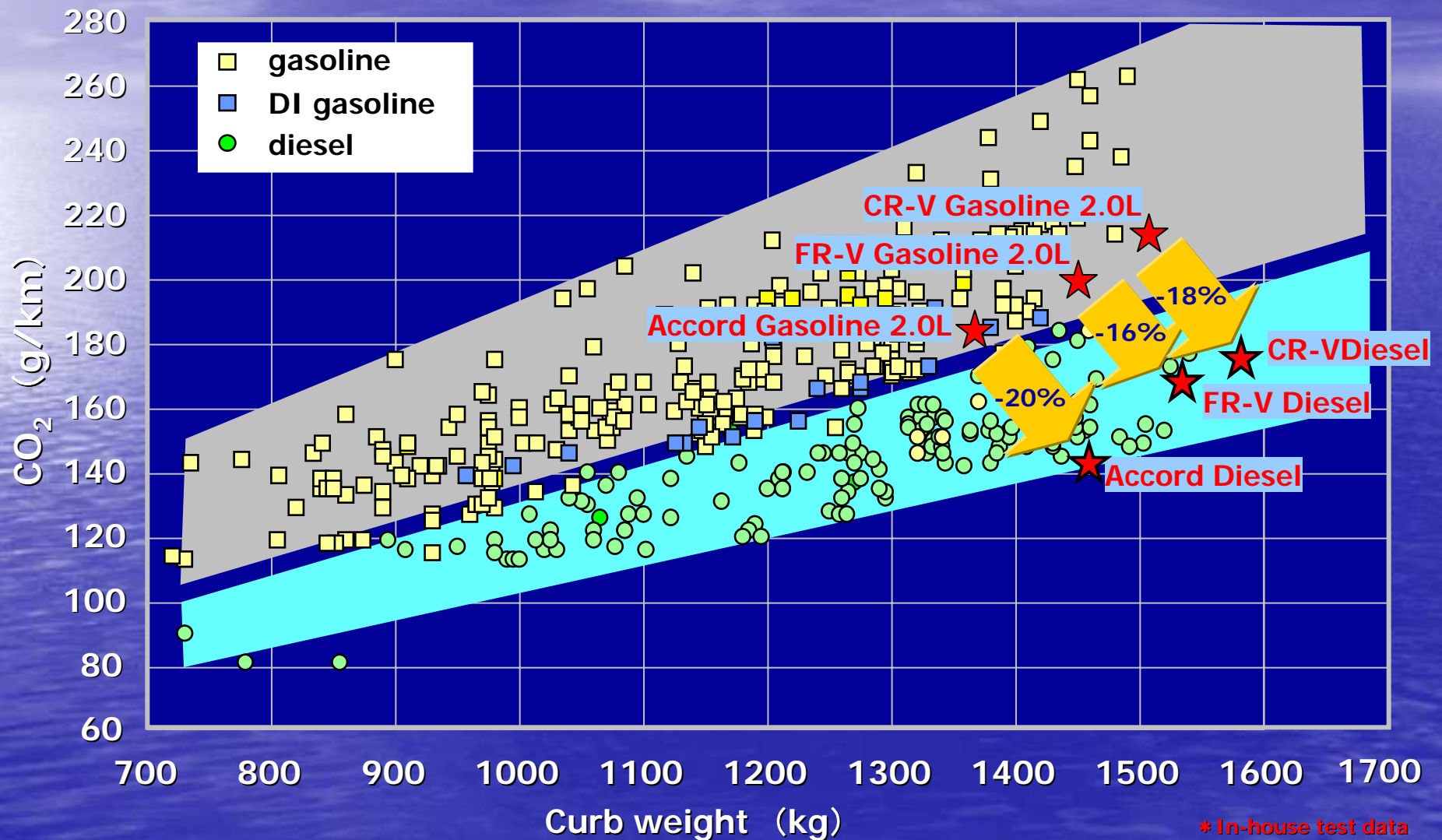


Intensity of Issue



Diesel contributes to CO2 reduction

CO2 Emission from European LDVs



Clean Diesel

1. Current Production EU Diesel
2. Clean Diesel Development Status
3. Diesel Fuel Status
4. Summary

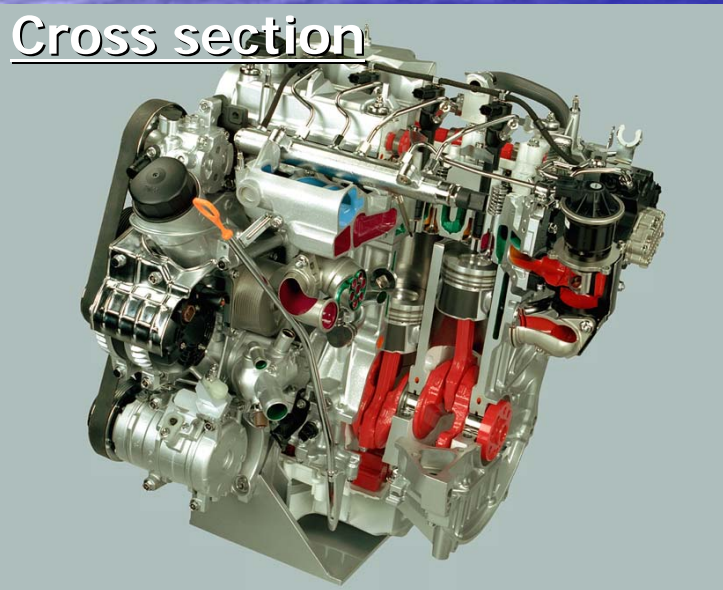
i-CTDi: HONDA Production Diesel Engine

HONDA
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External view



Cross section

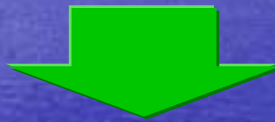


Main specification

| | |
|-----------------------|-------------------|
| Engine type | N22A |
| Cylinder number | Inline 4 cylinder |
| Displacement | 2.204 (L) |
| BoreXStroke | 85X97.1 (mm) |
| Valve configuration | DOHC-4v/v |
| Compression ratio | 16.7 |
| Fuel injection system | Common-rail |
| Maximum fuel pressure | 1600 (bar) |
| Emission category | EURO-IV |
| Maximum power | 103/4000 (kW/rpm) |
| Maximum torque | 340/2000 (Nm/rpm) |

Design Concept

Diesels
+ Torque / FE
- Noise / Vibration



Big Torque

Clean

Good FE

**"A first-class
diesel engine"**

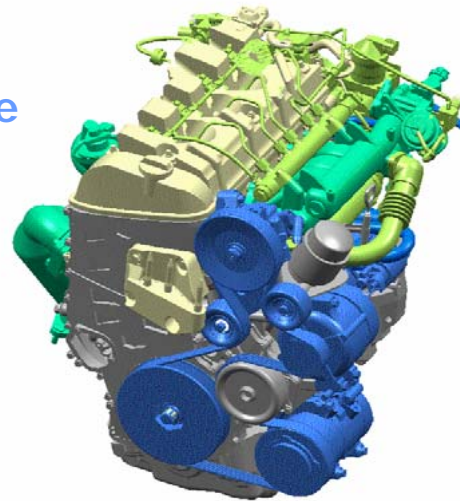
Low NV

Core Technologies

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High-precision combustion control

Optimized combustion chamber
1600bar common rail system
Pilot injection
Swirl control valve
Electric controlled EGR valve
EGR cooler
Variable geometry
turbocharger



Light-weight &

high-rigidity structure

ASCT aluminum cylinder block
Lower block construction
Top feed cooling circuit
Offset cylinder
2nd order balancer system
Roller chain system
Pendulum mount system

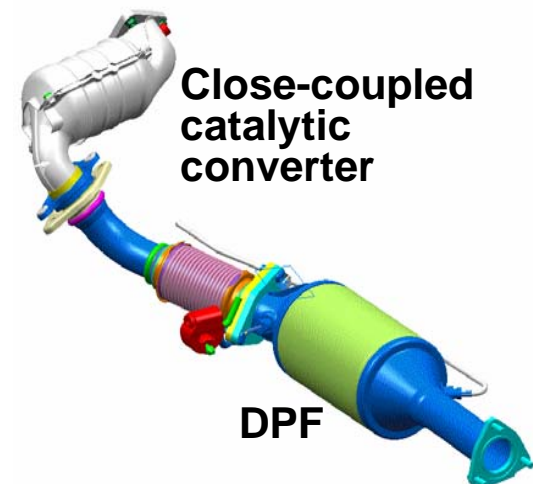
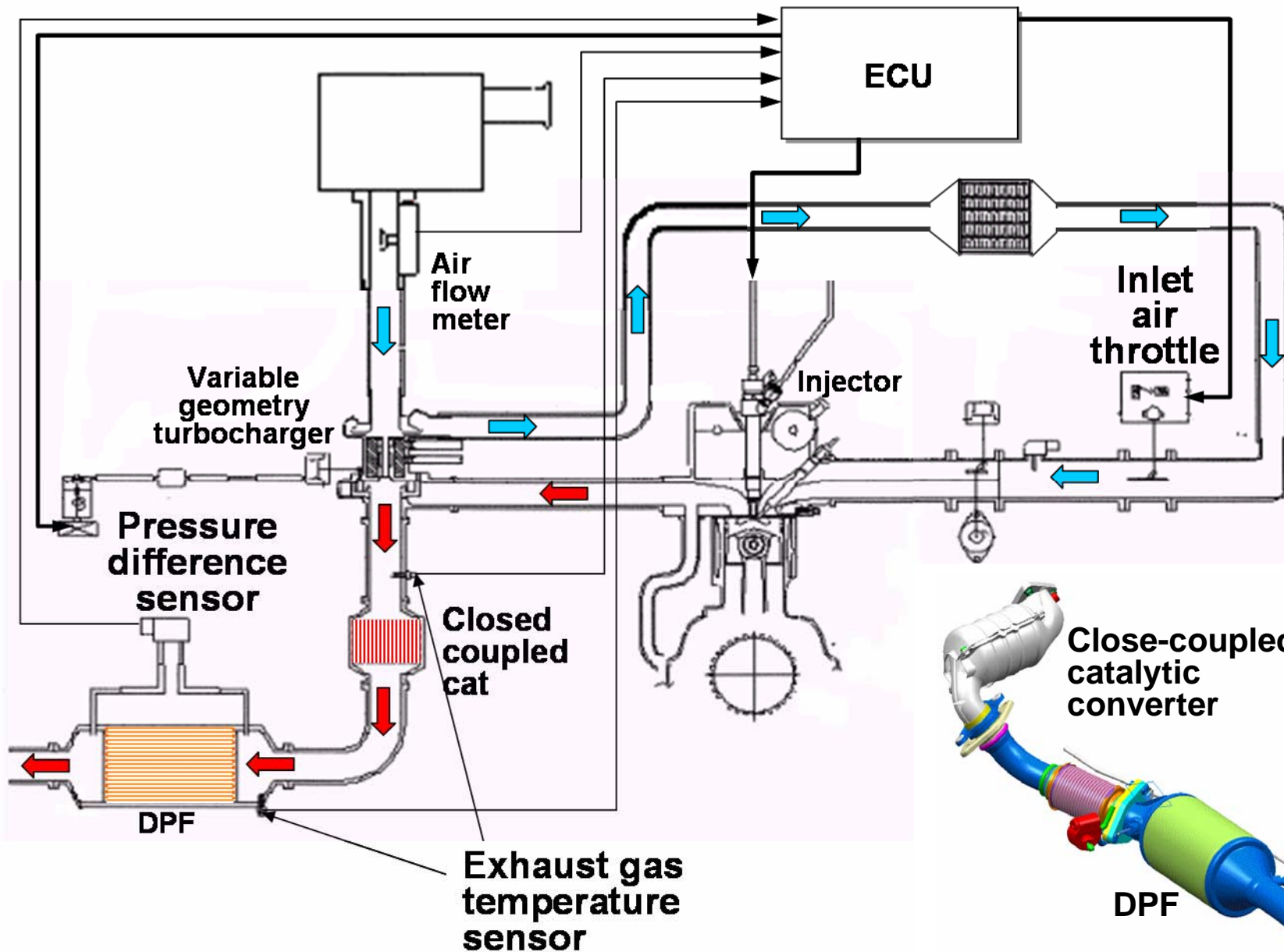
Exhaust after-treatment system

Oxidation & de-NOx catalyst
Metal foil substrate

SAE paper

**2004-01-1316 Development of New 2.2-liter Turbocharged Diesel Engine
for the EURO-IV Standards**

DPF System



i-CTDi Application in EU

HONDA
The Power of Dreams

i-CTDi : i Intelligent C Common rail
Turbocharged D Direct i injection

DPF : D Diesel P Particulate F Filter

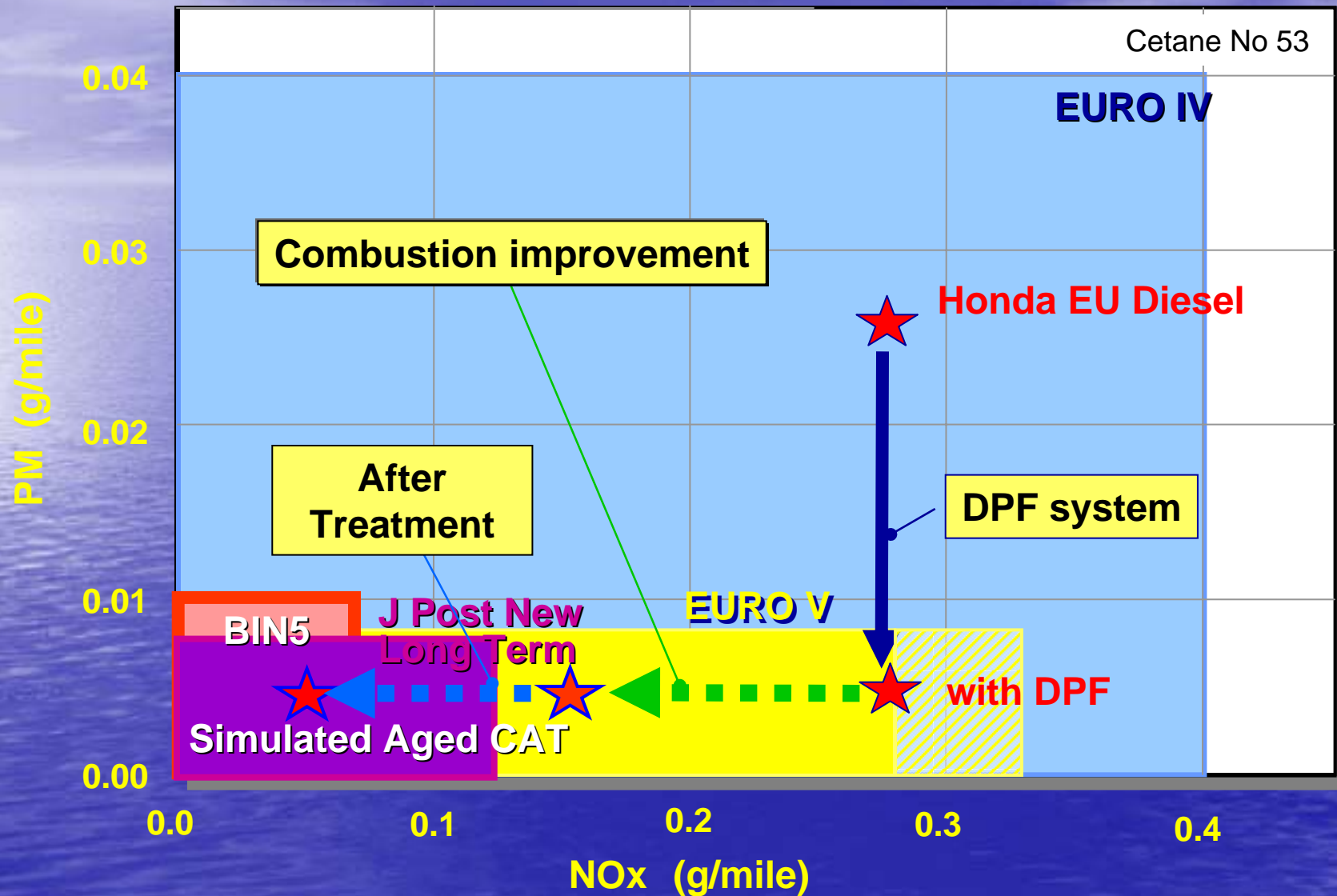


**Honda diesel series is expanding in EU
DPF series will be expanded quickly**

Clean Diesel

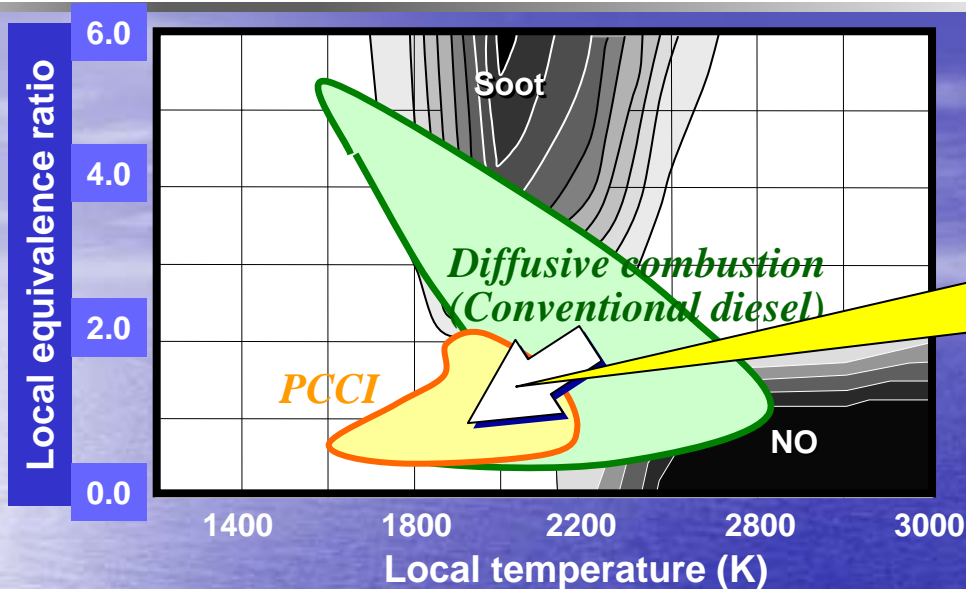
1. Current Production EU Diesel
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Strategy and Latest Achievement Level

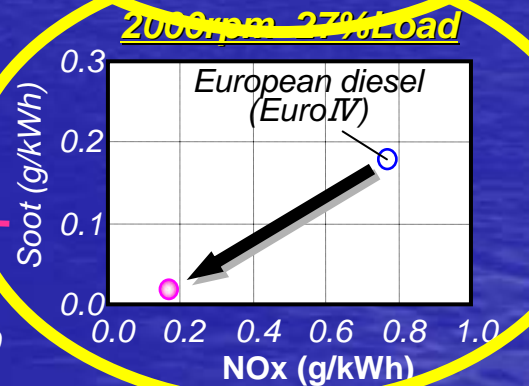
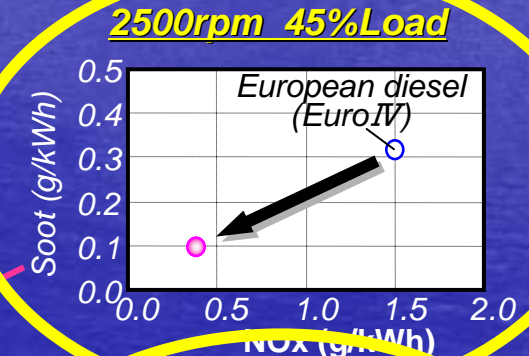
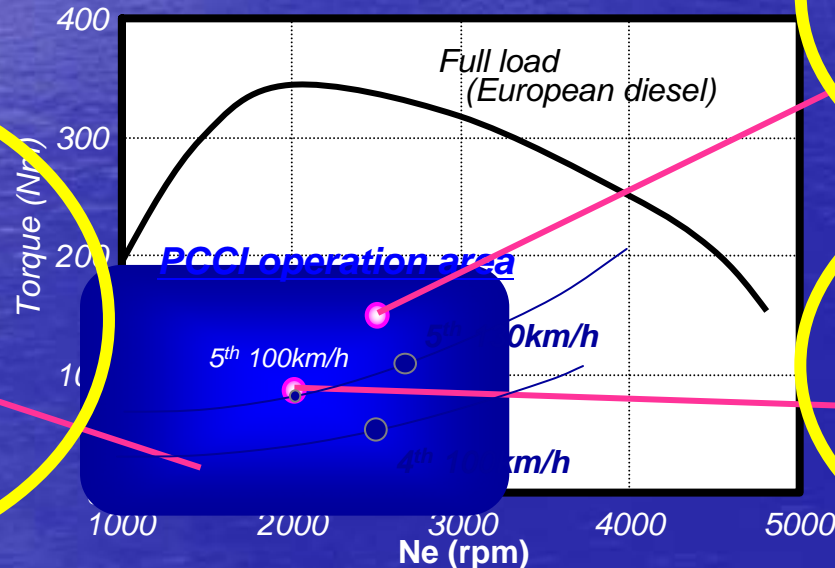
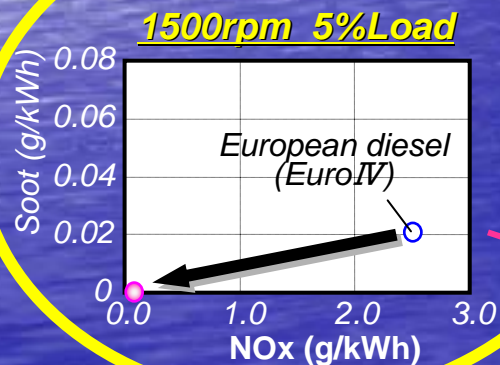


Clean diesel proto type has a potential to meet Bin5

Premixed Charge Compression Ignition



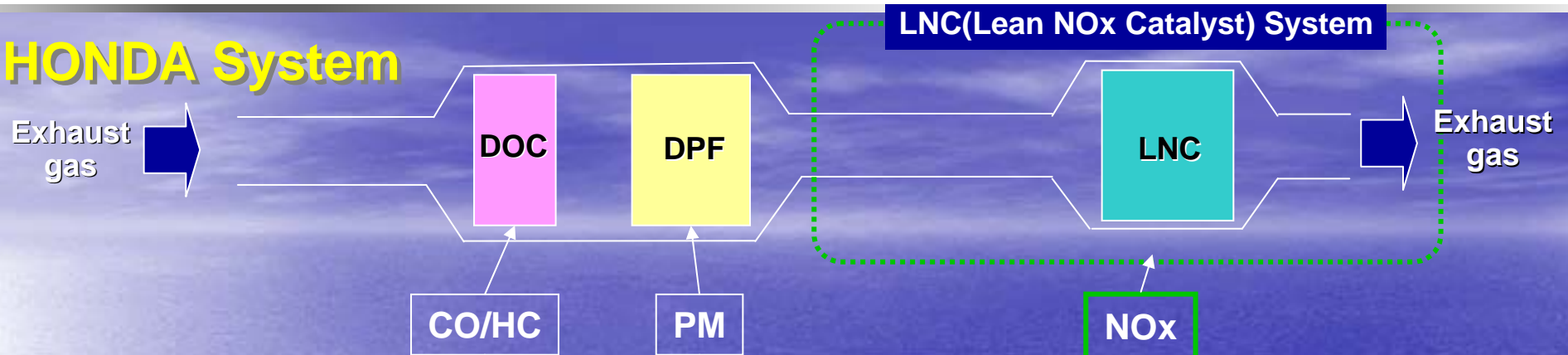
- *Piston bowl and nozzle optimization*
- *Further cooled EGR*
- *PCCI operation of fuel injection timing close to TDC*



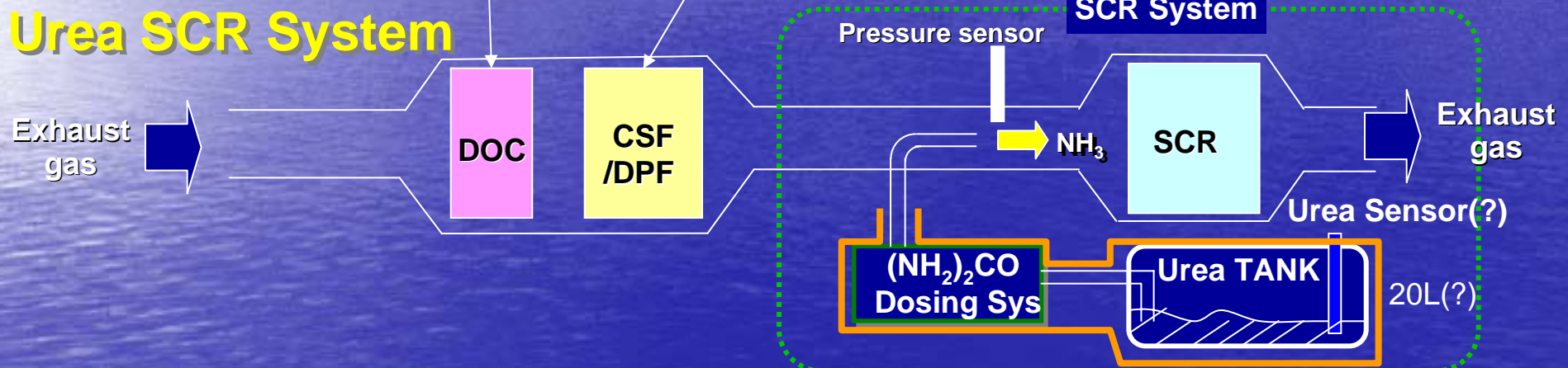
SAE papers 2005-01-0378 PCCI Operation with Early Injection of Conventional Diesel Fuel
2006-01-0920 PCCI Operation with Fuel Injection Timing set close to TDC

Comparison of After Treatment System

HONDA System



Urea SCR System



Technical assessment

○ : Good △ : Acceptable × : Not Acceptable

| | | System simplicity | FE penalty | Maintenance | Wide range applicability | for PC application |
|-----|--|-------------------|------------|-------------|--------------------------|--------------------|
| LNC | | ○ | △ | ○ | △ | ○ |
| SCR | | △ | ○ | △ | ○ | △ |

Diesel OBD-II System

EU OBD

- | | |
|---|------------------------------------|
| 1 | EGR system monitoring |
| 2 | DPF monitoring (blocked side only) |
| 3 | Air flow sensor monitoring |
| 4 | Water temp. sensor monitoring |



US OBD-II

- | | |
|---|------------------------------------|
| 1 | DOC monitoring |
| 2 | LNC monitoring |
| 3 | DPF monitoring (leakage side) |
| 4 | PCV system monitoring |
| 5 | Misfire monitoring |
| 6 | Fuel system monitoring |
| 7 | Comprehensive comp. monitoring |
| 8 | system guarantee in the real world |



Development items

- | | |
|---|---|
| 1 | Diesel LAF sensor |
| 2 | Very challenging |
| 3 | Very challenging |
| 4 | Pressure sensor very challenging |
| 5 | Combustion sensor or crank angle sensor |
| 6 | Combustion sensor |
| 7 | Comprehensive comp. monitoring |
| 8 | Rate base |

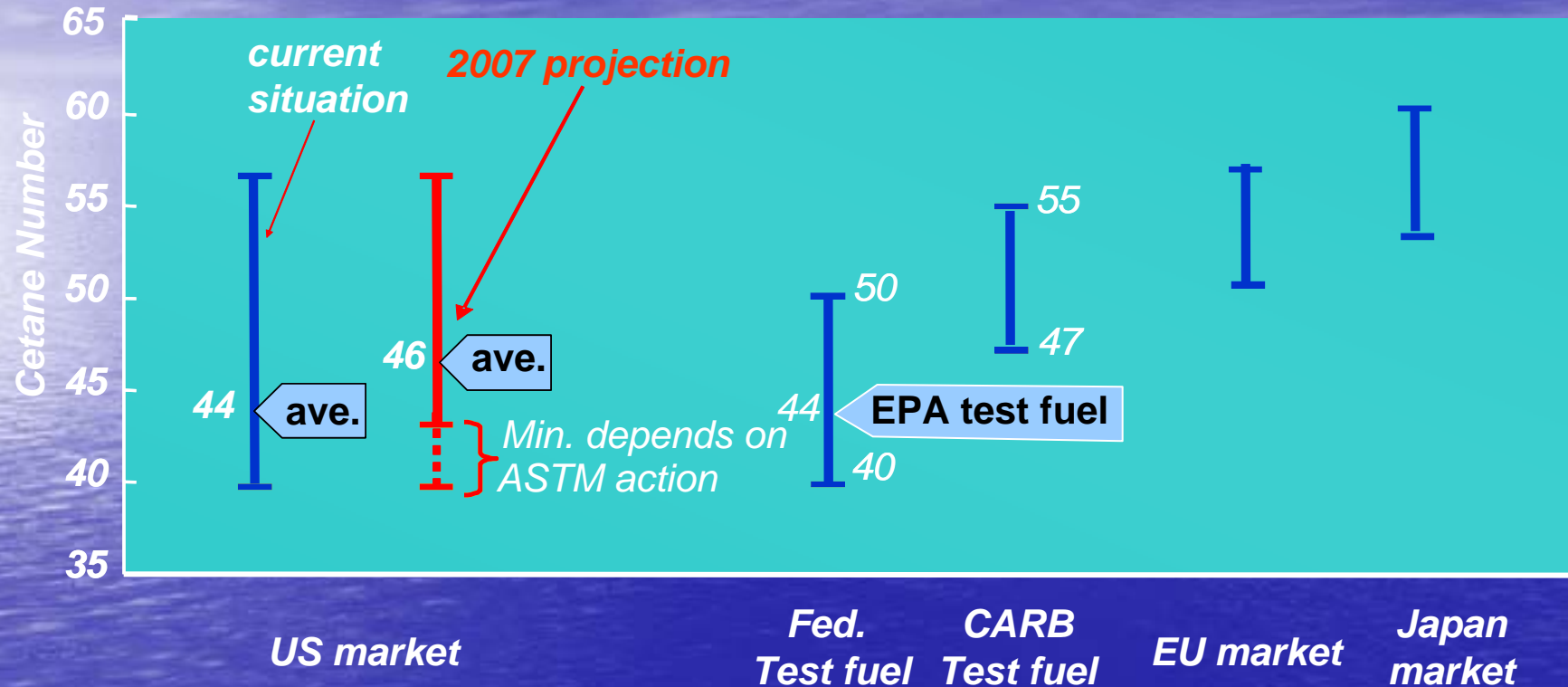
As development progresses, technological challenging points are identified

Clean Diesel

A horizontal line composed of a series of small, multi-colored diamond shapes in shades of yellow, green, and blue.

1. Production EU Diesel Update
2. Clean Diesel Development Status
3. Diesel Fuel Status
4. Summary

Status of US diesel fuel

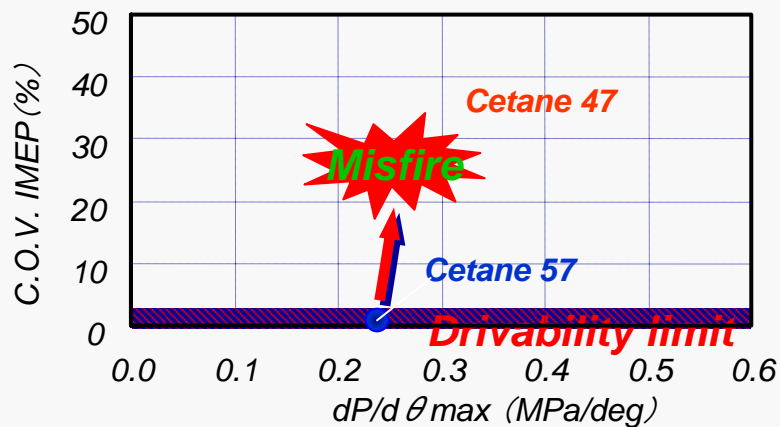
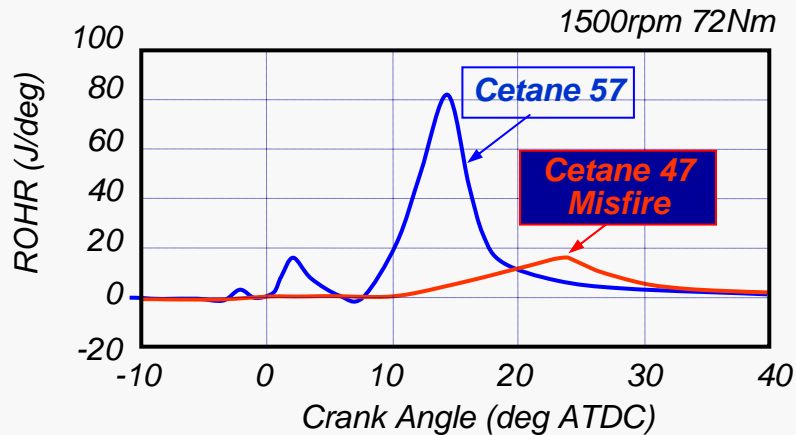


Low and wide variation of Cetane number compare to other market.

Influence of Cetane Number

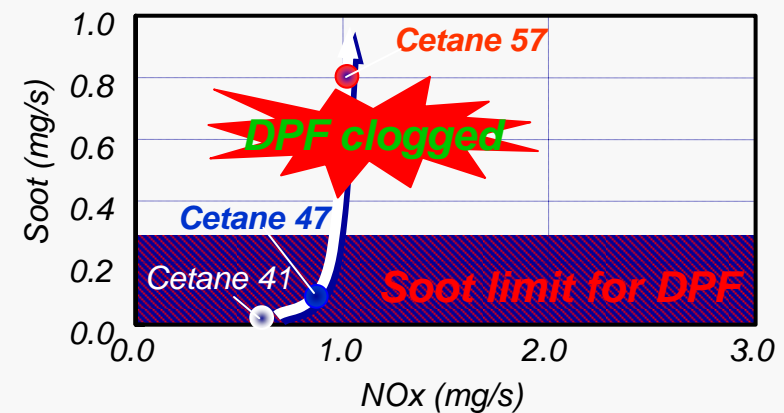
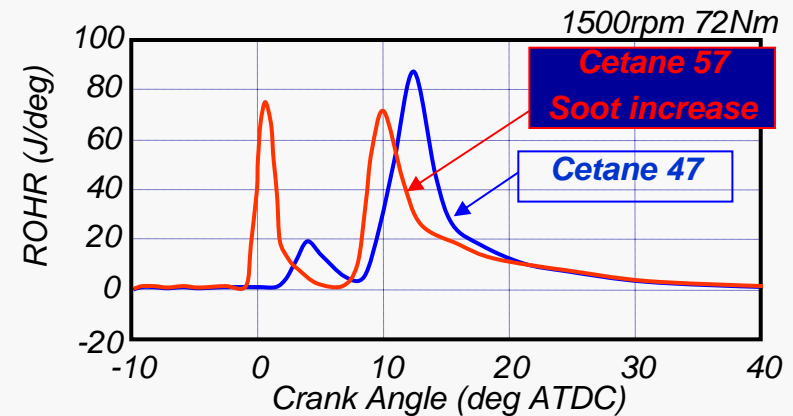
Variation of Cetane Number influence on high EGR rate combustion

Calibrate on 57 Cetane \Rightarrow Misfire on Cetane 47



Calibrate on 47 Cetane \Rightarrow

Soot increase on Cetane 57

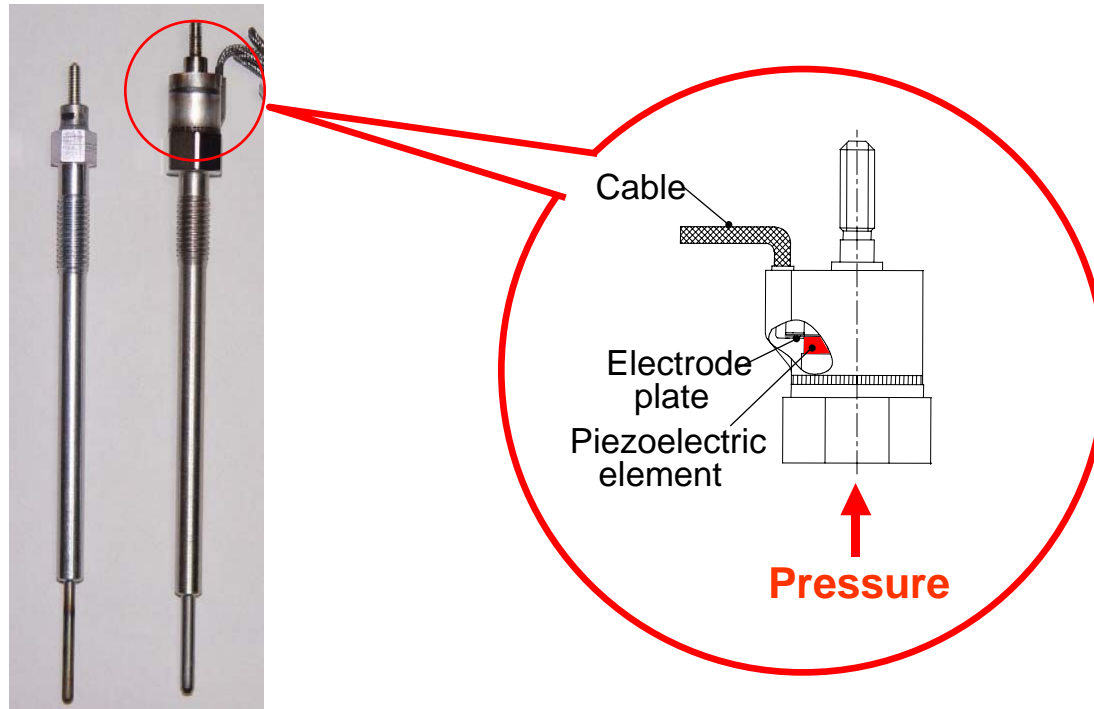


Control system for US Cetane No. variation would be required

Cylinder Pressure Sensor

HONDA
The Power of Dreams

Detection of Cetane number for Calibration



SAE paper : 2006-01-0180

Study on Ignition Timing Control for Diesel Engines using In-cylinder Pressure Sensor

Clean Diesel

A decorative horizontal line composed of a series of small, multi-colored diamond shapes in shades of yellow, green, and blue, positioned below the main title.

1. Production EU Diesel Update
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Summary

- Diesel clearly has a potential to reduce CO₂ emissions but is not as clean as current gasoline.
- Honda has made significant progress in the area of combustion enhancement and after-treatment technology for global expansion of Diesel.
- The improvement of LNC is ongoing. Still heat-resistance is main technological challenge.
- For US market, OBD still remains major technical hurdle.
- Improvement of diesel fuel quality is necessary to maintain good engine performance. European equivalent specification is preferred from developer's viewpoint.