

# Reactivity Controlled Compression Ignition Combustion in a Heavy-Duty Engine

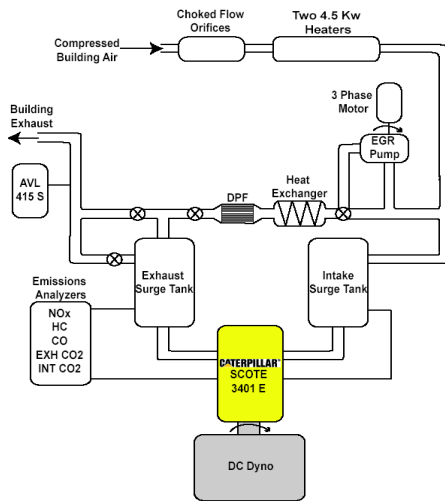
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Funding Sponsor : US Department of Energy



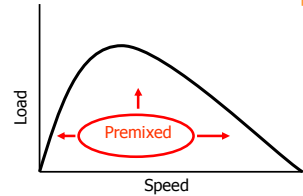
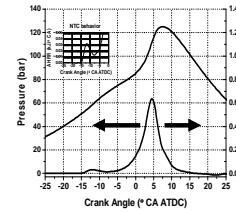
## 3401E SCOTE Geometry

Displacement (l)	2.44
Geometric Compression Ratio	16.1:1
Effective Compression Ratio	9.1:1
Bore (mm)	137.20
Stroke (mm)	165.10
Connecting Rod Length (mm)	261.60
Squish Height (mm)	1.57
Number of Valves	4
IVC (deg BTDC) (modified cam)	85.00
IVO (deg ATDC)	335.00
Swirl Ratio (stock)	0.7
Piston Type	Articulated
Piston Bowl Geometry	Stock



## RCCI Motivation

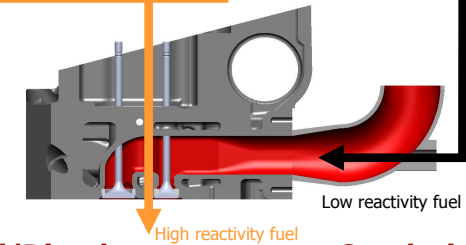
- Change fuel reactivity by blending fuels in-cylinder.
- Increase combustion duration via fuel reactivity gradient.
- Extend operating range of PCCI combustion.



## Injection Setup

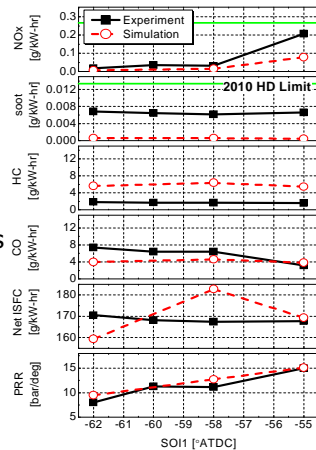
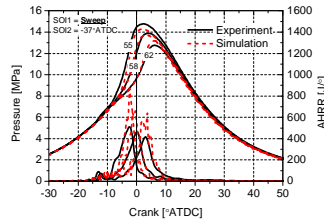
High Pressure Injector	
MFG	BOSCH
Body Type	Gen 2 Common Rail
Nozzle Part Number	DSL A95PV3387517
Injection Pressure [bar]	1500
Included Spray Angle	145°
Number of Holes	6
Hole Diameter [µm]	250
Steady Flowrate [cc/30 sec] at 100 bar	1000

Low Pressure Injector	
Manufacturer	BOSCH
Type	Port
Injection Pressure [MPa]	0.5
Included Spray Angle	15°
Number of Holes	3
Steady Flowrate	750 [cc/min]



## 9 bar SOI1 SWEEP

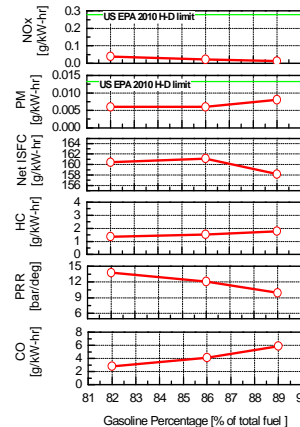
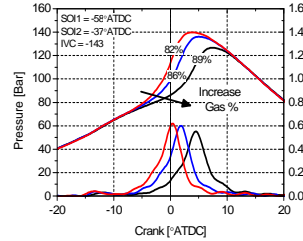
- Low NOx and PM emissions
- High efficiency (50%)
- NOx and PRR increase with retarded SOI1 timing



- Higher combustion temperatures with retarded SOI1
- Higher local equivalence ratio and reactivity advance combustion and increase NOx emissions
- Data from SAE 2010-01-0864 and Thiesel 2010

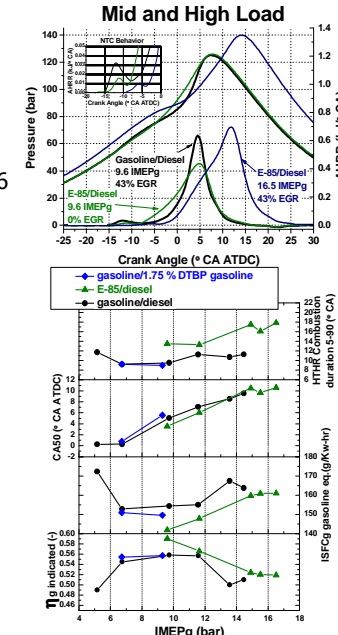
## 9 Bar Gas % Sweep

- Low NOx and PM emissions - Below EPA 2010
- High thermal efficiency of 53%
- PRR drop with additional gasoline due to delayed combustion phasing



## High Load Ethanol/Diesel

- High load operation (16.5 bar IMEPg) with Ethanol/Diesel blends was possible
- EGR not required for 9.6 or 11.5 bar IMEPg with E-85
- Longer combustion durations for ethanol blends
- CA50 linearly increases with load, keeps PRR and peak cylinder pressure within limits
- Greater than 50% thermal efficiency at nearly all operating conditions



## Conclusions

- Engine experiments showed RCCI combustion to be controlled by SOI timing and/or by the low reactivity-to-high reactivity fuel split.
- Thermal efficiencies over 50% were shown to be possible from 9 bar IMEP to 16 bar IMEP
- Over the same range, it was possible to achieve NOx and PM emissions below EPA 2010 heavy-duty limits.

