2011 CSC
QUIETS' HPDI SNOWMOBILE

Outline

- Objectives/needs
- Design
  - HPDI system
  - Engine lubrification
  - Noise reduction
  - Catalyst
- Results
- Conclusion

- Objective: The EPA regulations require lower emission levels for snowmobile engines

- Problem: Stock carburated/semi-direct injected two-stroke engines are not passing today's EPA emissions level.

The consumer needs

- No performance loss.
- Affordable pricing.
- Low fuel consumption.

Landlords private propertys passage requirements:

- Lower emissions.
- Lower sound levels.

Dealer needs:

- Afordable (part wise)
- Easy installation
- Simple maintenance

Our Solution

- HPDI system
- ECU controlled electric oil pump
- Use of exhaust gas purification system
- Noise reduction muffler

High Pressure Direct Injection System

Bosch injector

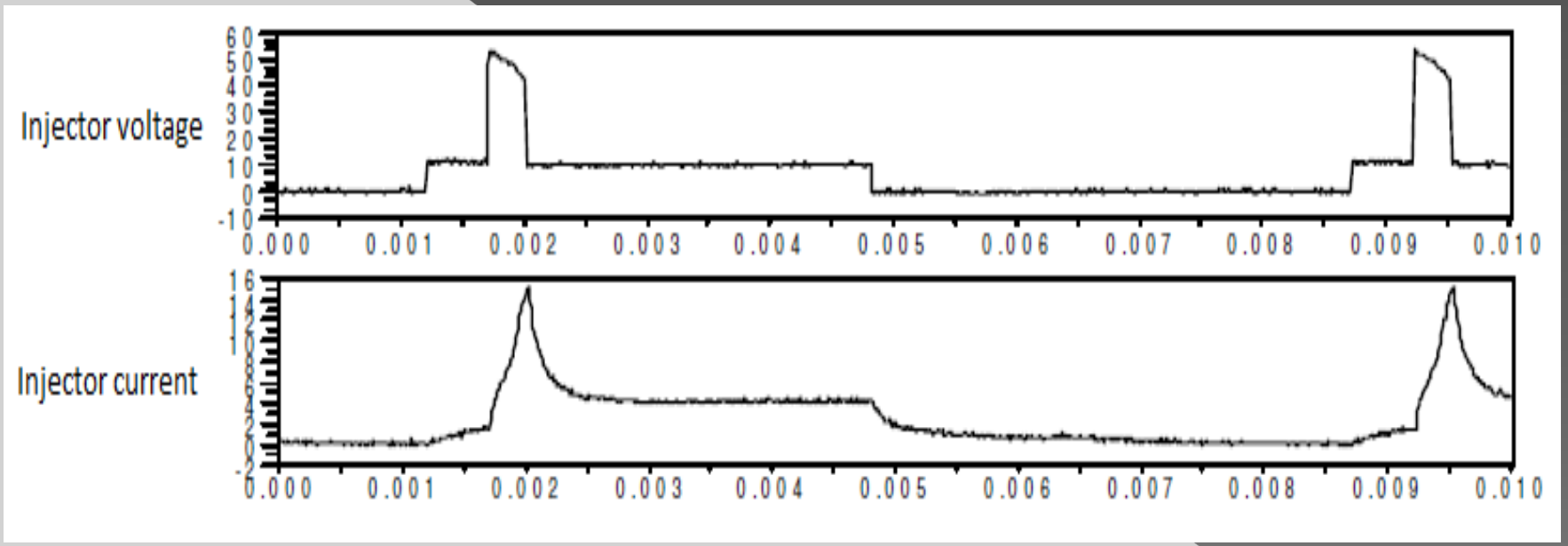
Static flow of 15,0 cm3/s (615g/min)

Nominal pressure of 100 bar (1500 PSI)

High Pressure Direct Injection System

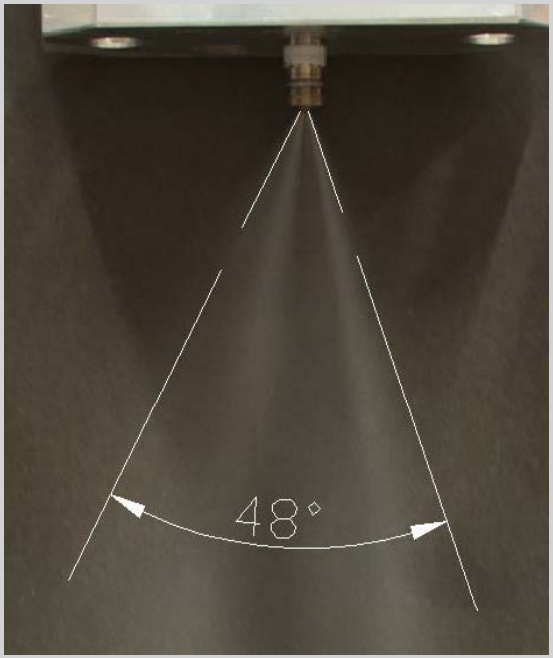
- Bosch injector power stage

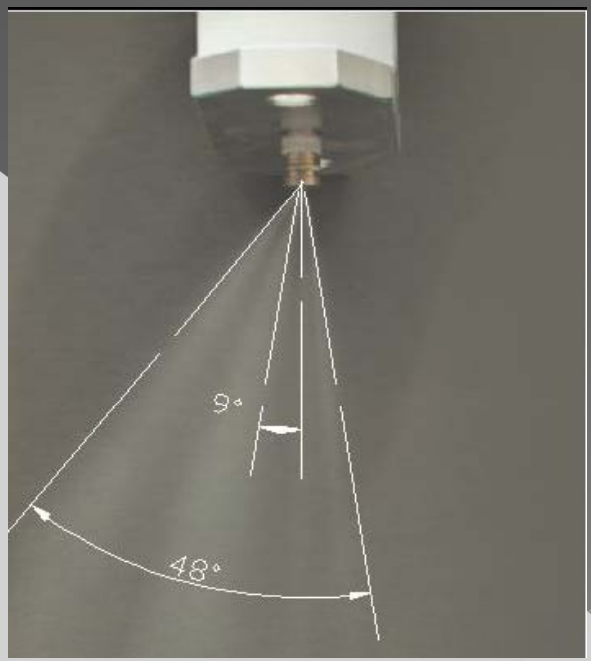
Injector driver electrical specifications



High Pressure Direct Injection System

- Injector cone angle

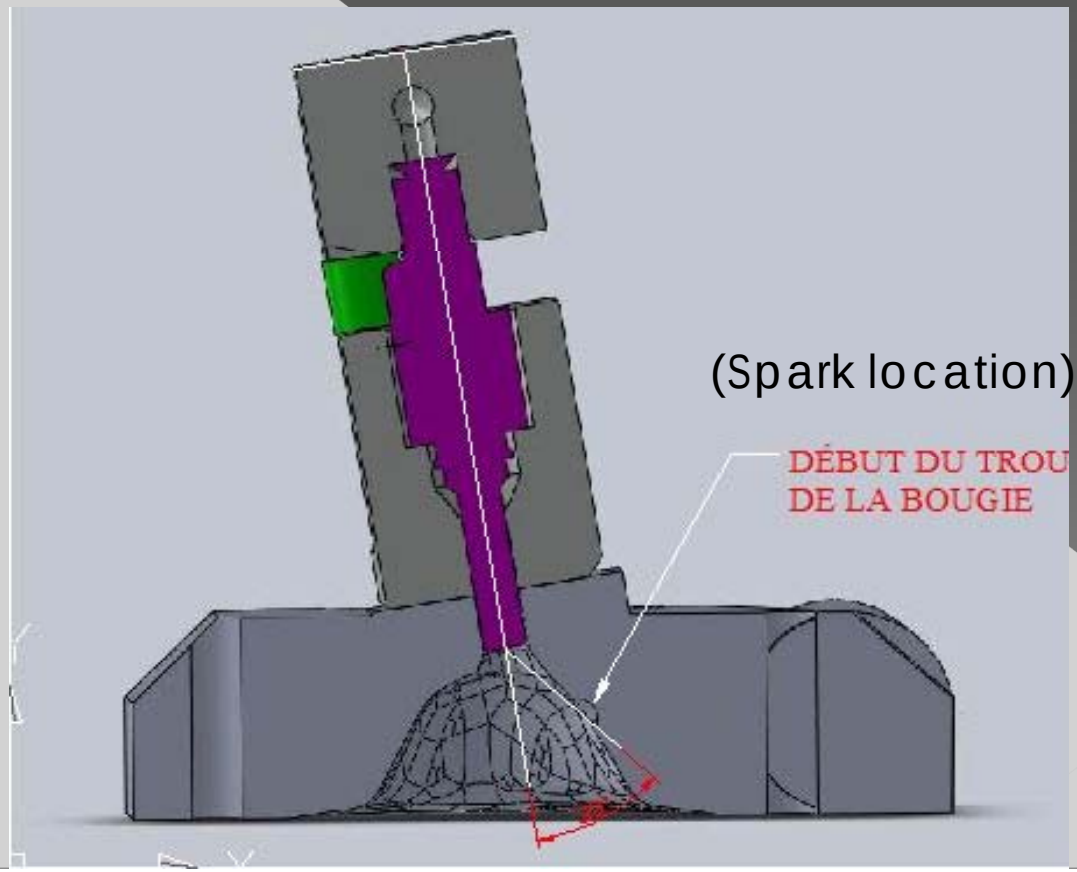




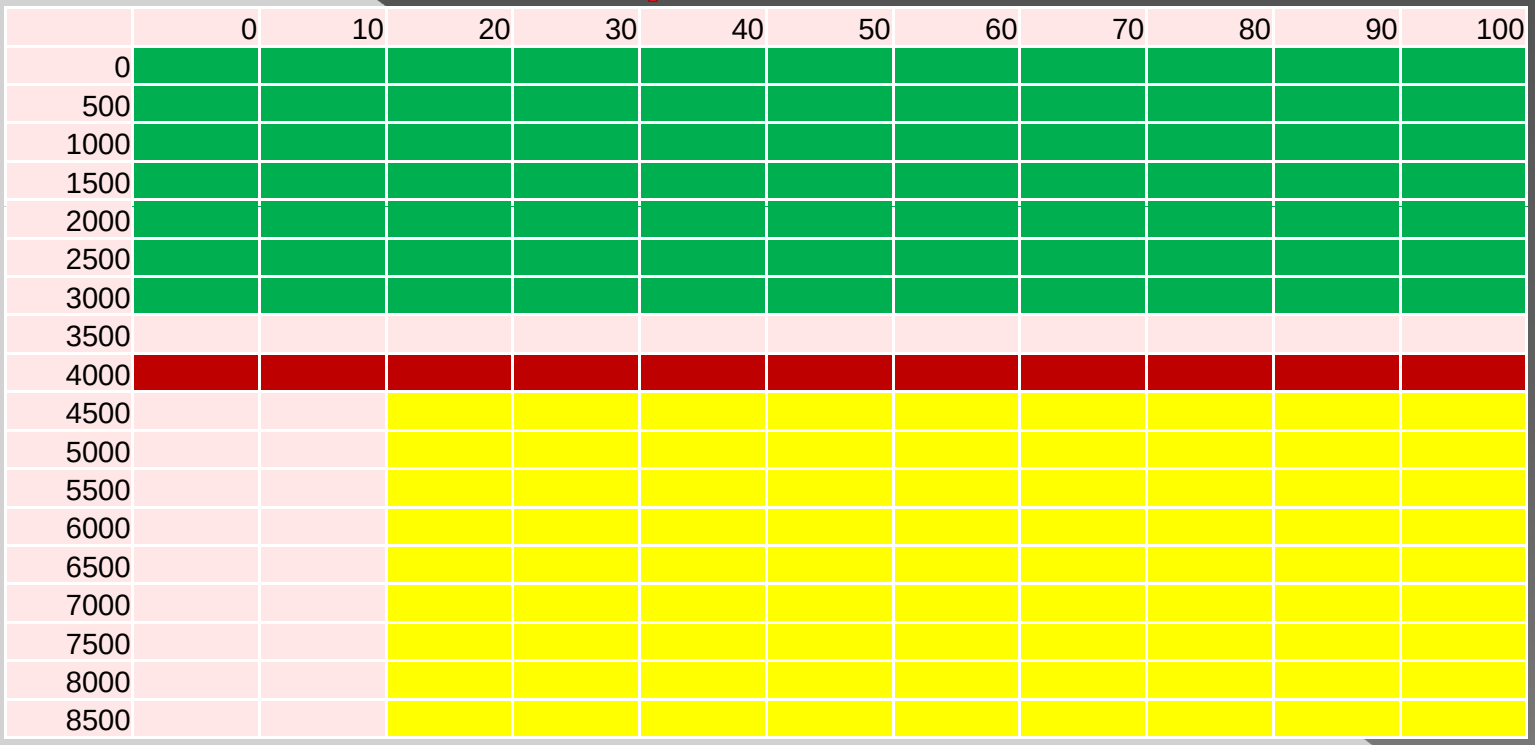
High Pressure Direct Injection System

Injection location:

Fuel spray characteristics as similar as possible to the E-TEC system



Stratified and Homogeneous modes of operation

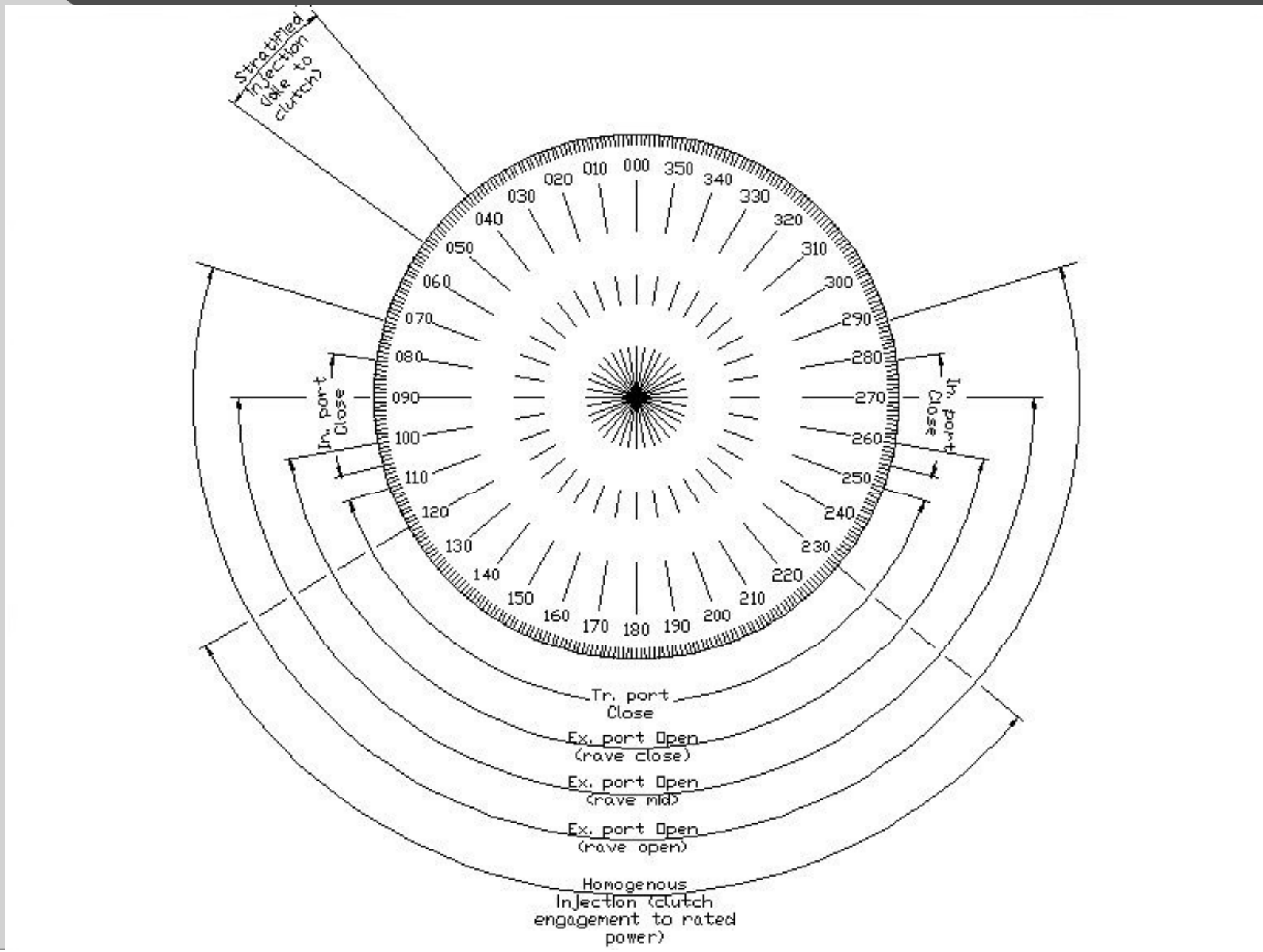


Stratified zone

Clutch engagement

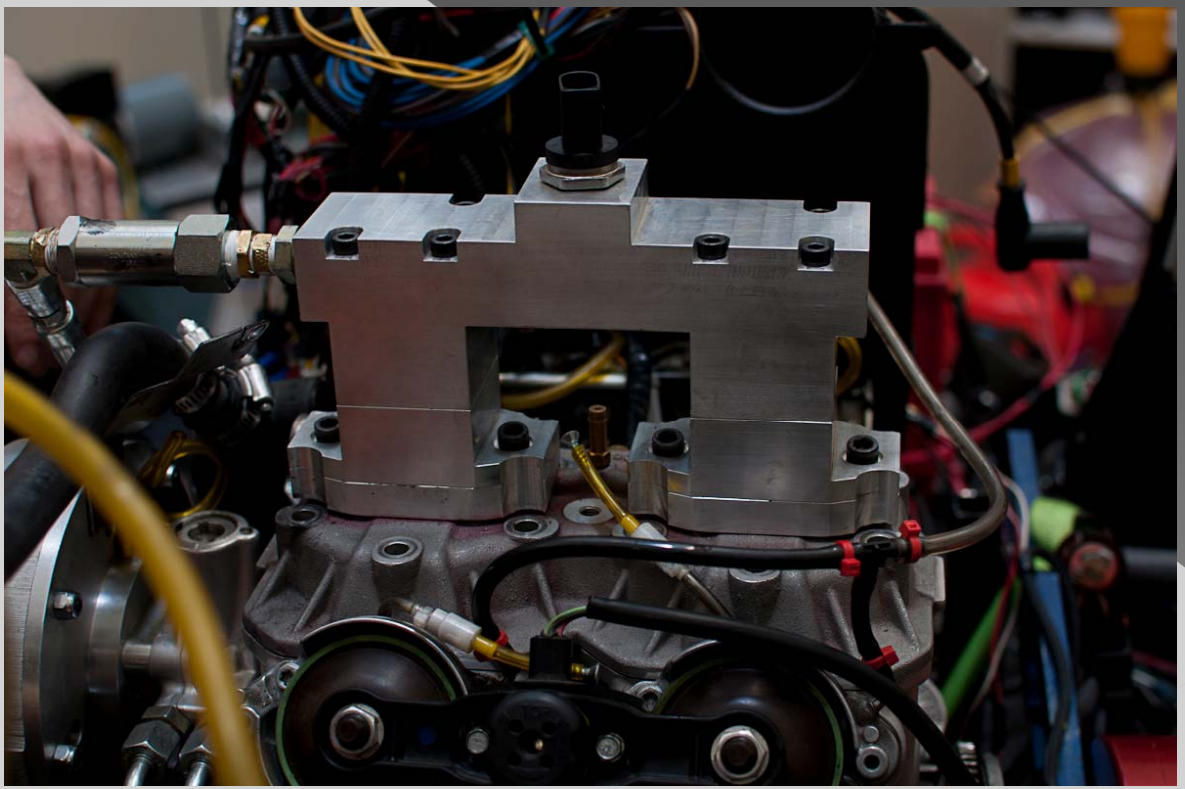
Homogeneous zone

Injection angle (Stratified/ homogeneous)



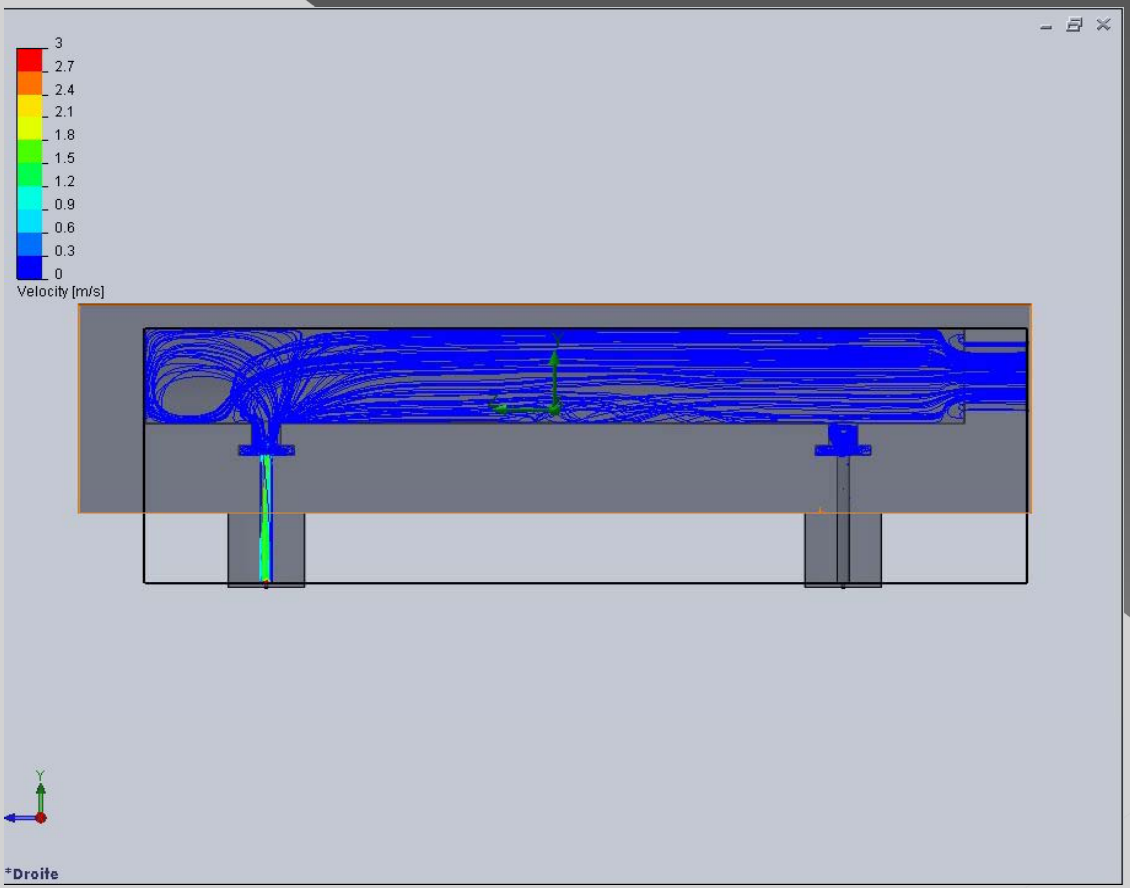
High Pressure Direct Injection System

Injector fuel rail installation



High Pressure Direct Injection System

Fuel rail fluid simulation



High Pressure Fuel Pump

Gas Pressure:

HDP 1.1 Bosch fuel pump 1500 PSI

Fuel pump driving system

Mechanical belt driving system

Fuel delivery of 0.66cm3 per revolution

Crankshaft driven with a 1:2 gear ratio (half of the engine speed)

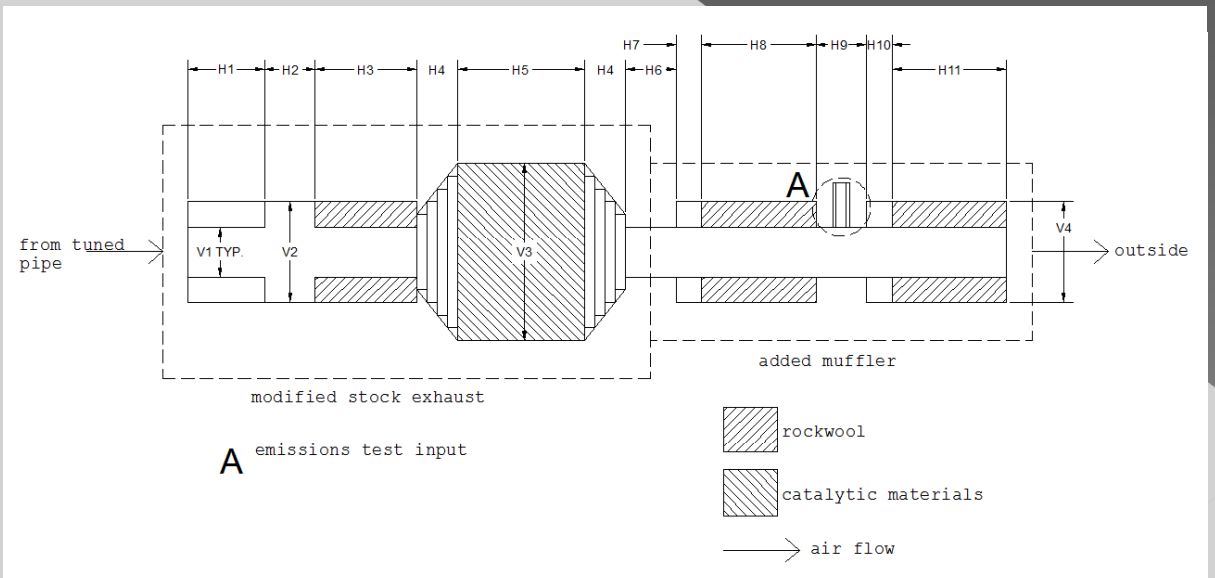
Operating pressure 100 bars (1500 PSI)

Engine lubrification

- Electrical oil pump allows the modification of the oil flow according to the engine speed and throttle. (Oil flow mapping)

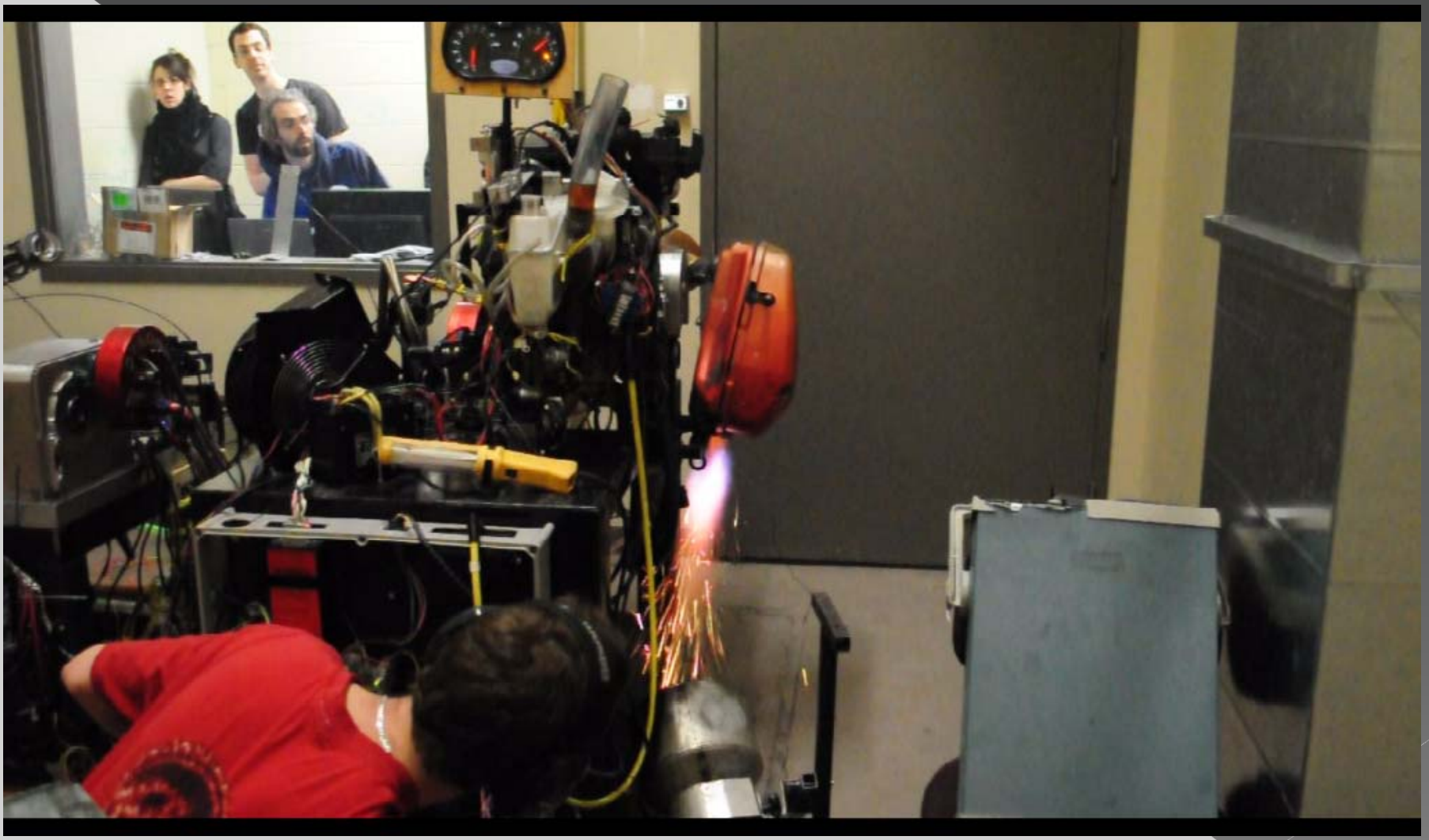
Noise reduction

- New muffler design:
  - 2 resonators
  - 2 expansions chambers

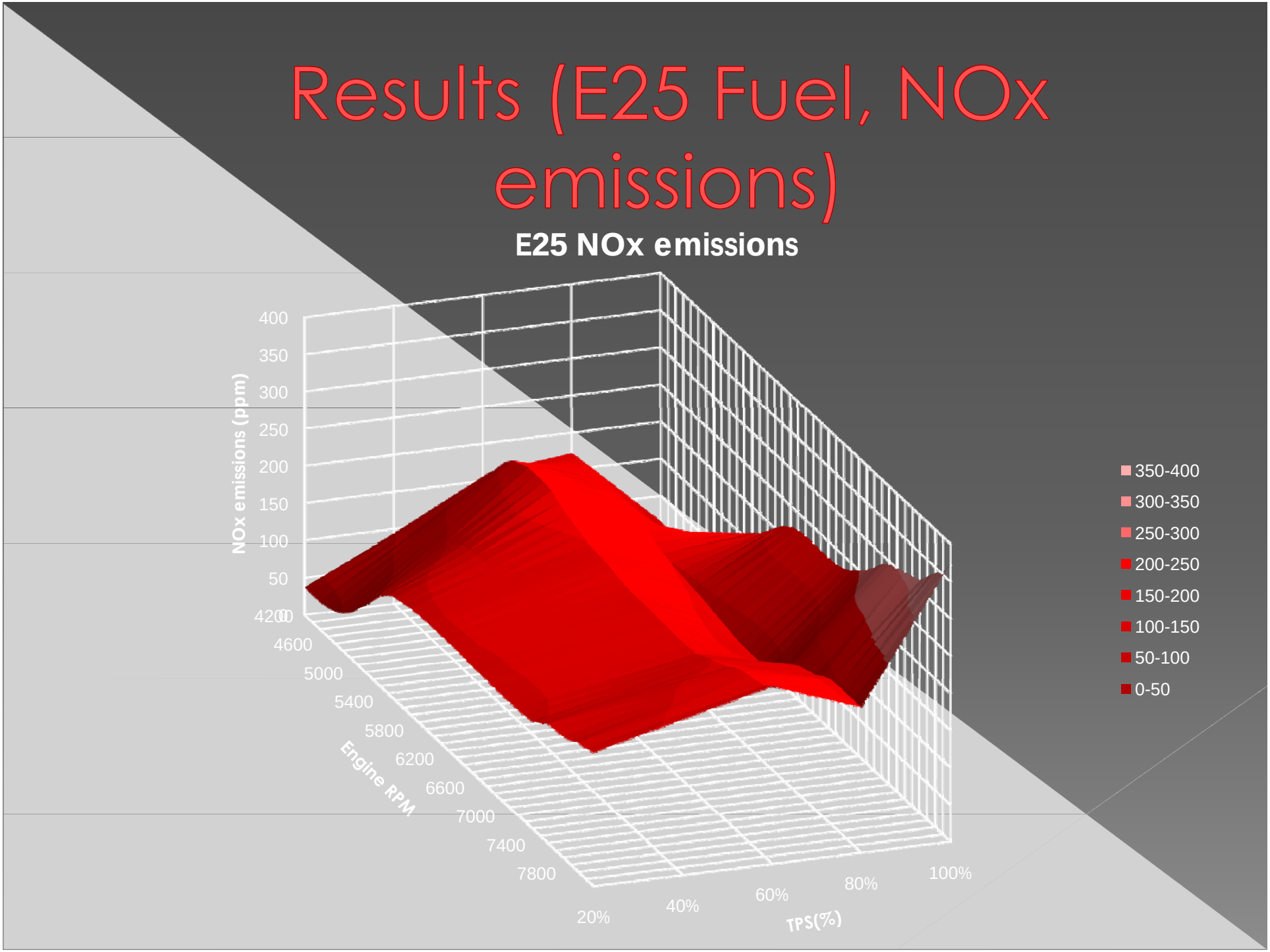


Catalyst intergration attempt

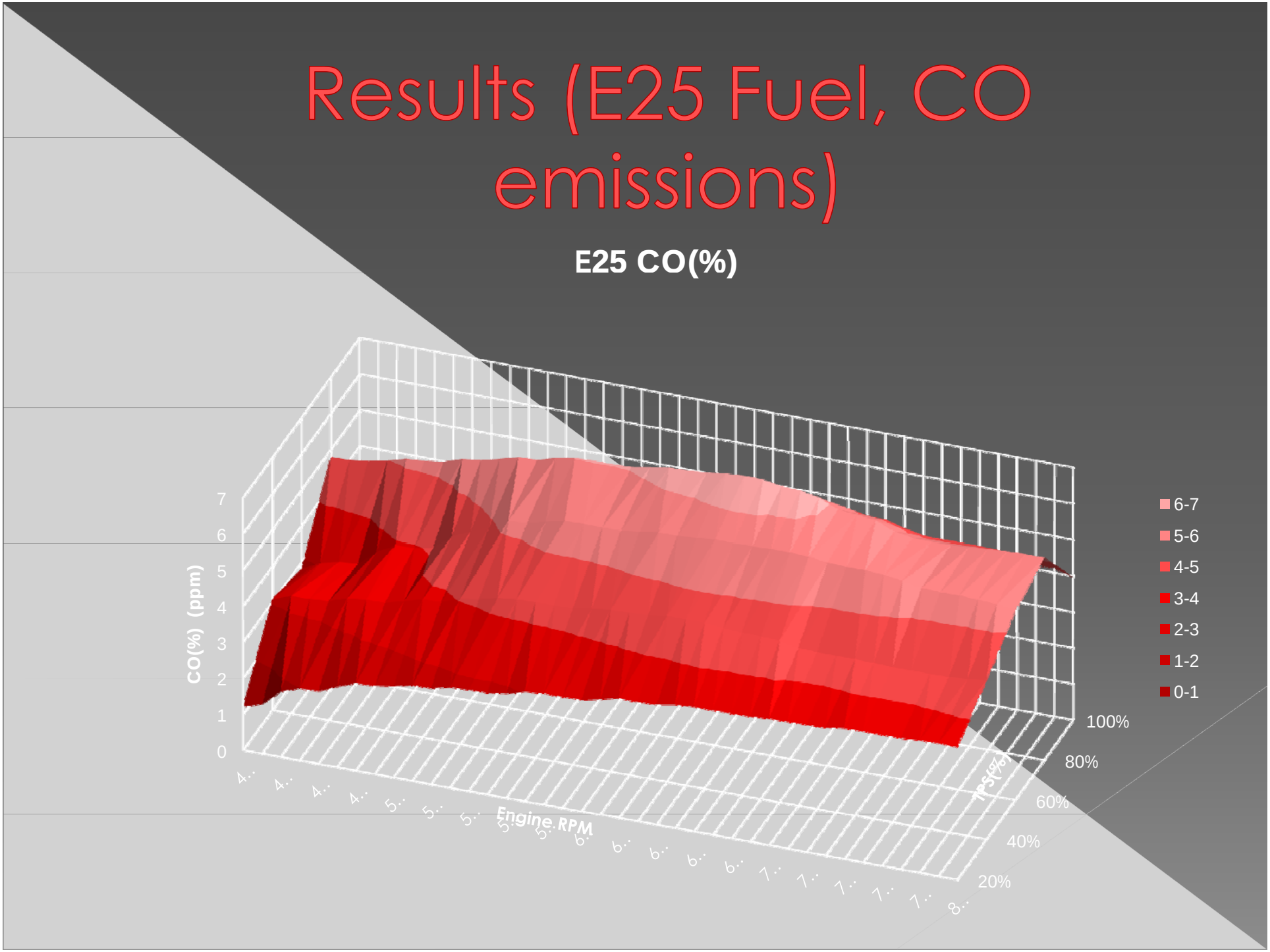
- Catalyst intergration into low frequency resonance chambers.



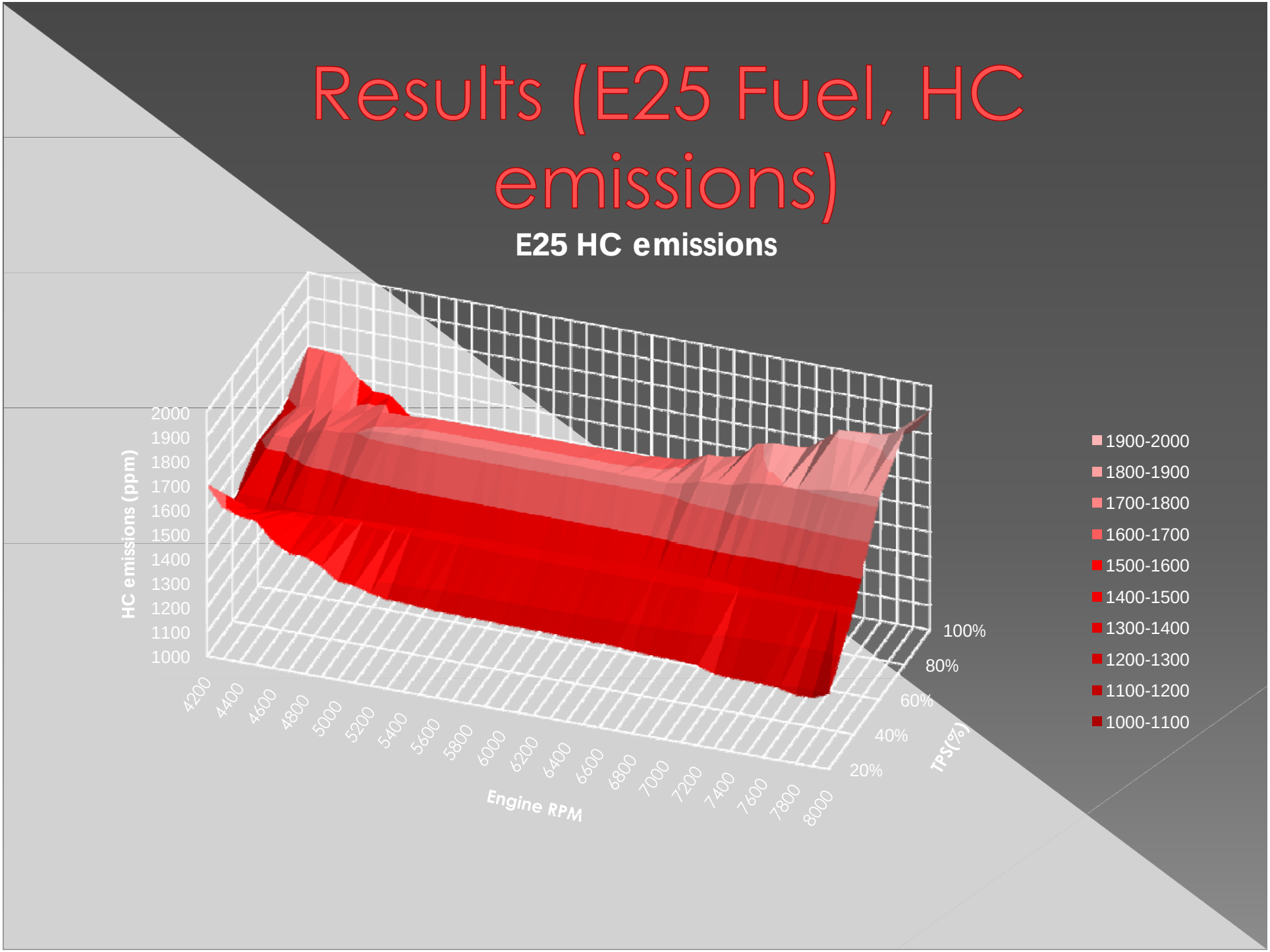
Results (E25 Fuel, NOx emissions)



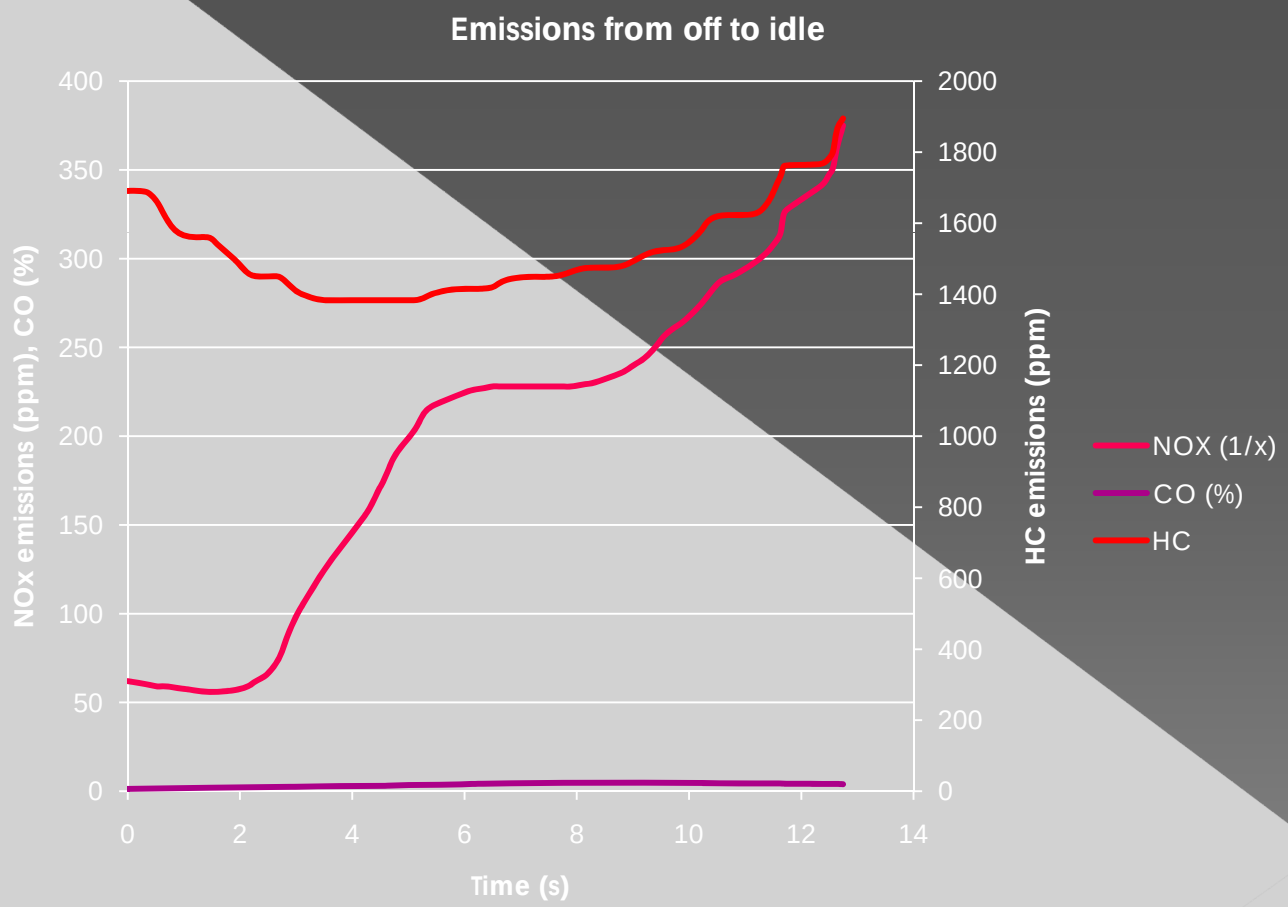
Results (E25 Fuel, CO emissions)



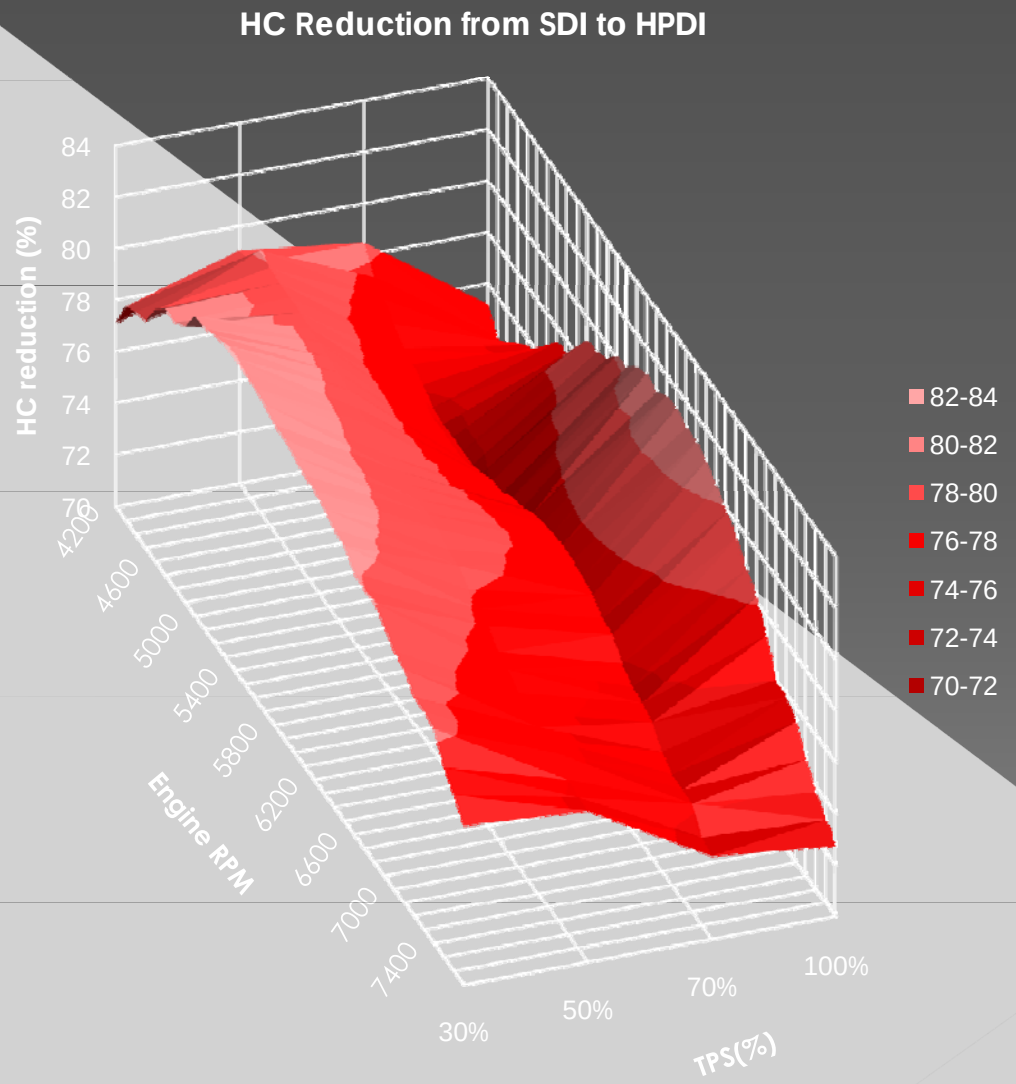
Results (E25 Fuel, HC emissions)



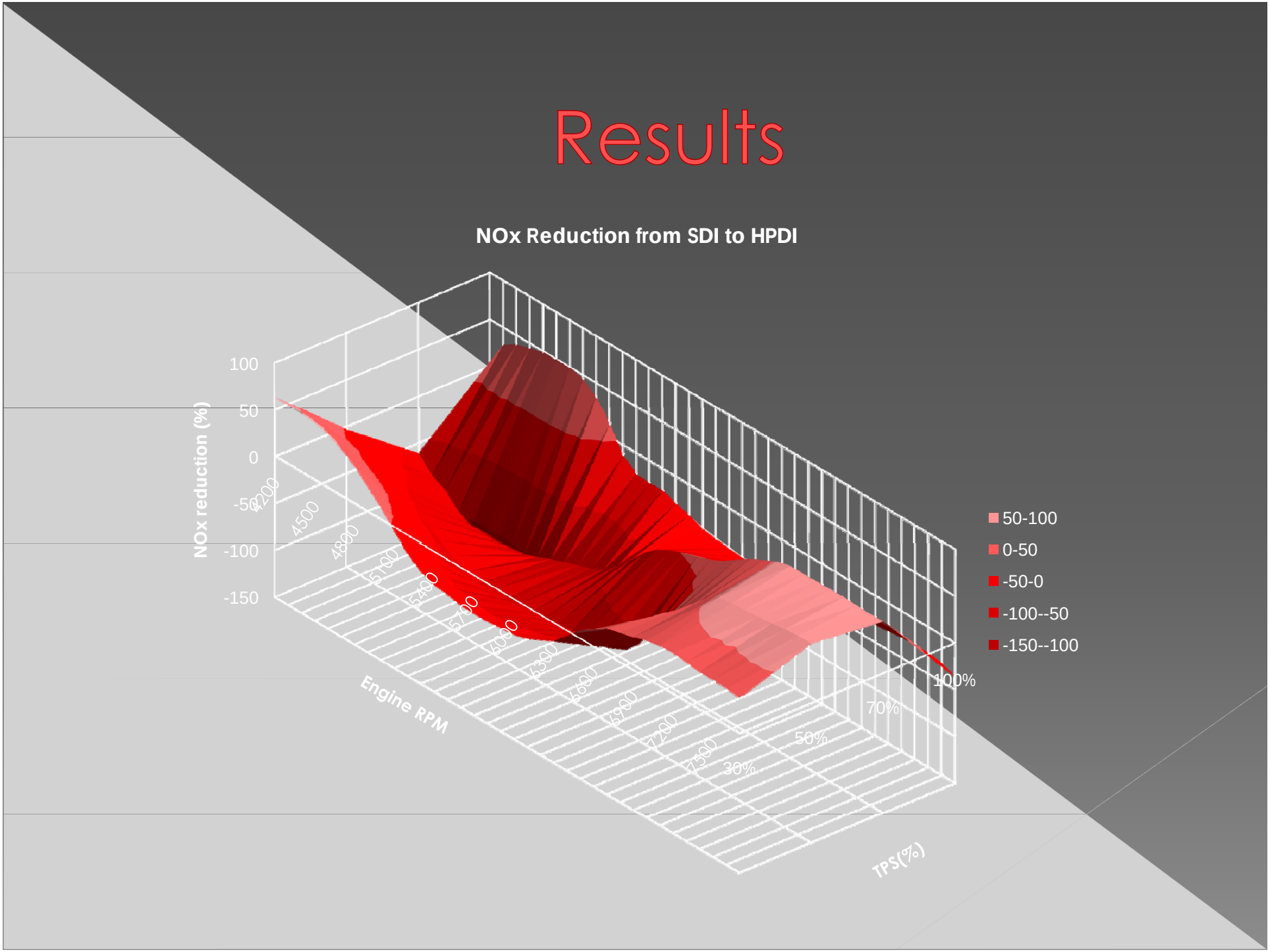
Results (Emissions stall to idle)



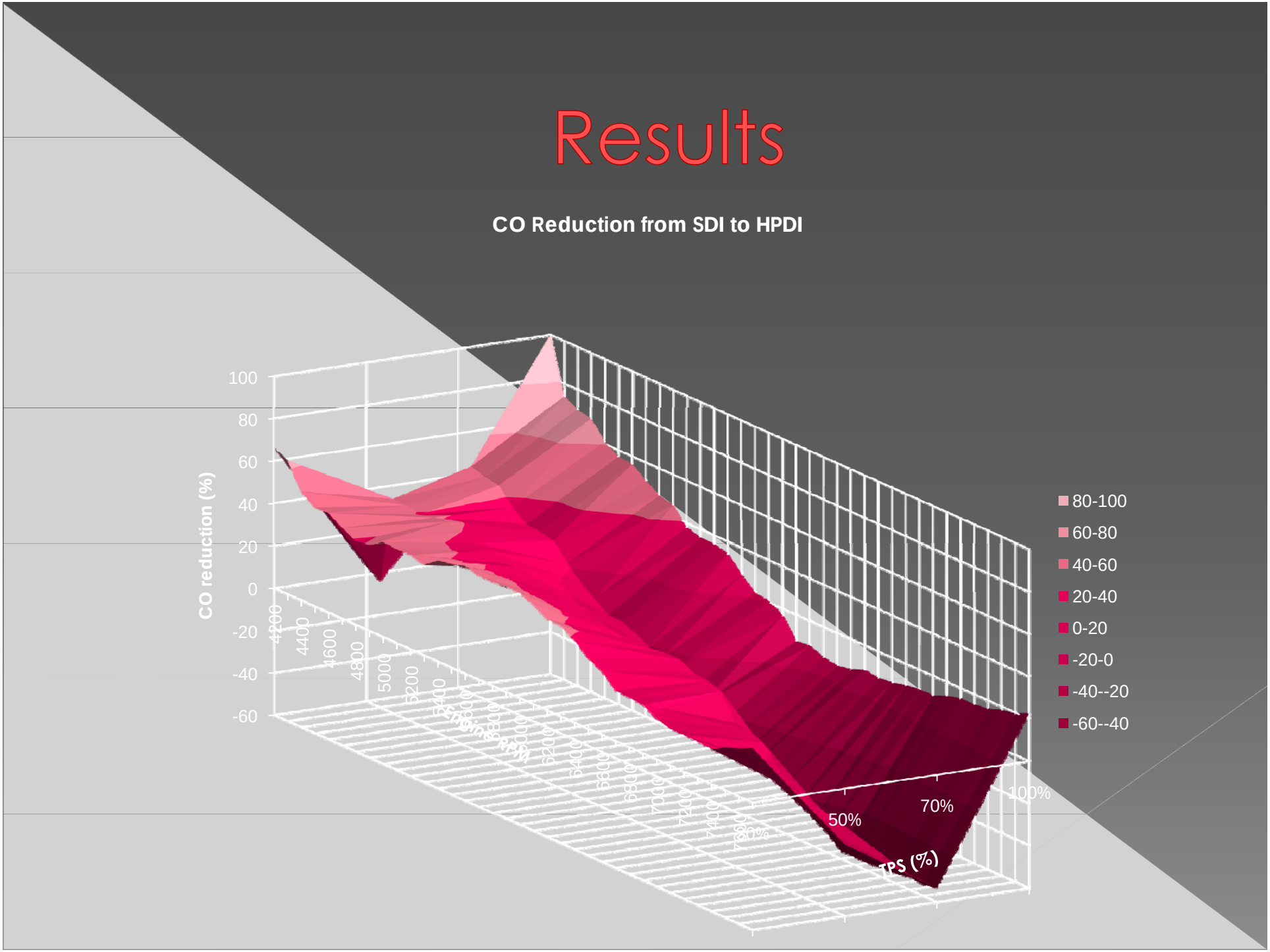
Results


HC Reduction from SDI to HPDI
HC reduction (%)
84
82
80
78
76
74
72
70
4200
4600
5000
5400
5800
6200
6600
7000
7400
Engine RPM
30%
50%
70%
100%
TPS(%)
82-84
80-82
78-80
76-78
74-76
72-74
70-72

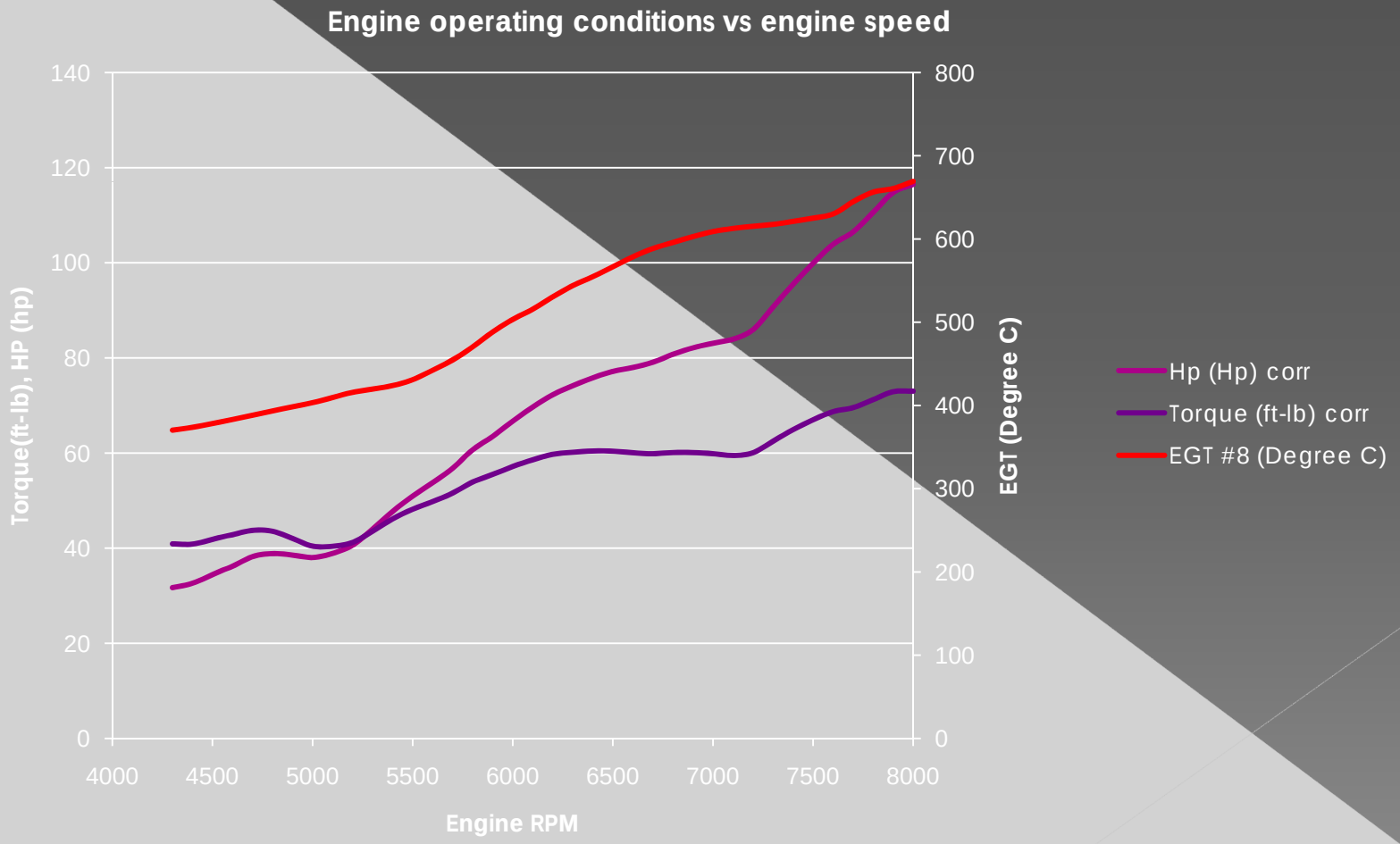
Results


NOx Reduction from SDI to HPDI
NOx reduction (%)
100
50
0
-50
-100
-150
4200
4500
4800
5100
5400
5700
6000
6300
6600
6900
7200
7500
Engine RPM
100%
70%
50%
30%
TPS(%)
50-100
0-50
-50-0
-100--50
-150--100

Results


CO Reduction from SDI to HPDI
CO reduction (%)
100
80
60
40
20
0
-20
-40
-60
4200
4400
4600
4800
5000
5200
5400
Engine RPM
50%
70%
100%
TPS (%)
80-100
60-80
40-60
20-40
0-20
-20-0
-40--20
-60--40

Results


Engine operating conditions vs engine speed
Torque(ft-lb), HP (hp)
EGT (Degree C)
Engine RPM
140
120
100
80
60
40
20
0
800
700
600
500
400
300
200
100
0
4000
4500
5000
5500
6000
6500
7000
7500
8000
Hp (Hp) corr
Torque (ft-lb) corr
EGT #8 (Degree C)

Thank you