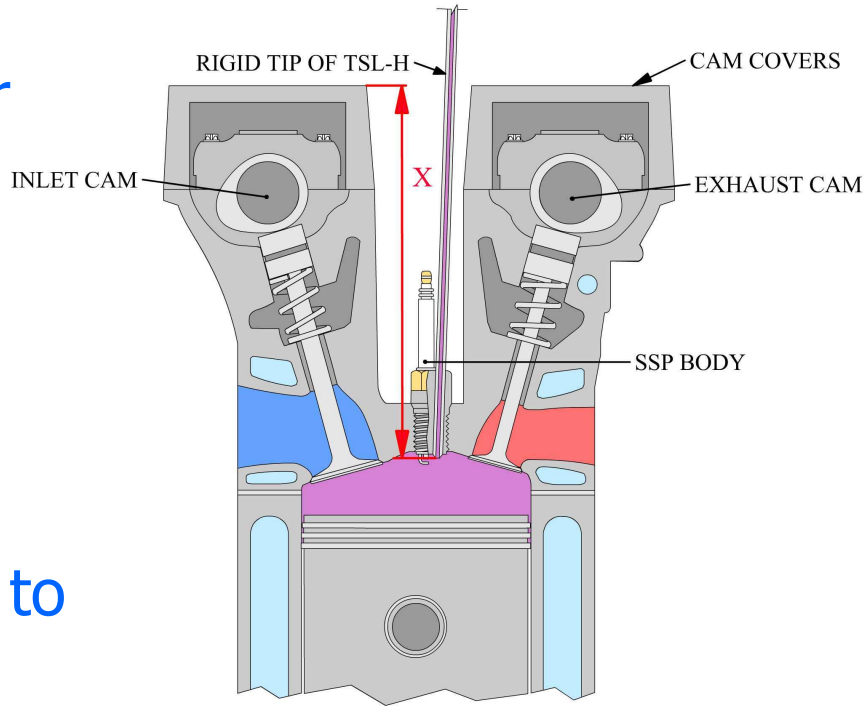
Cycle-by-cycle gasoline engine cold start measurement of residual gas and AFR using a fast response CO&CO_2 analyzer

Background

- Fast response gas analysers used extensively in exhaust to understand and control emissions
- To examine gas concentration inside the cylinder enables designers to understand better emission formation and combustion processes
- CO2 concentration inside the cylinder currently predicted by model or measured via optical techniques.
- Real-time in-cylinder data allows model validation, cyclic variability analysis as well as development of strategies for VVT, GDI and HCCI (CAI).

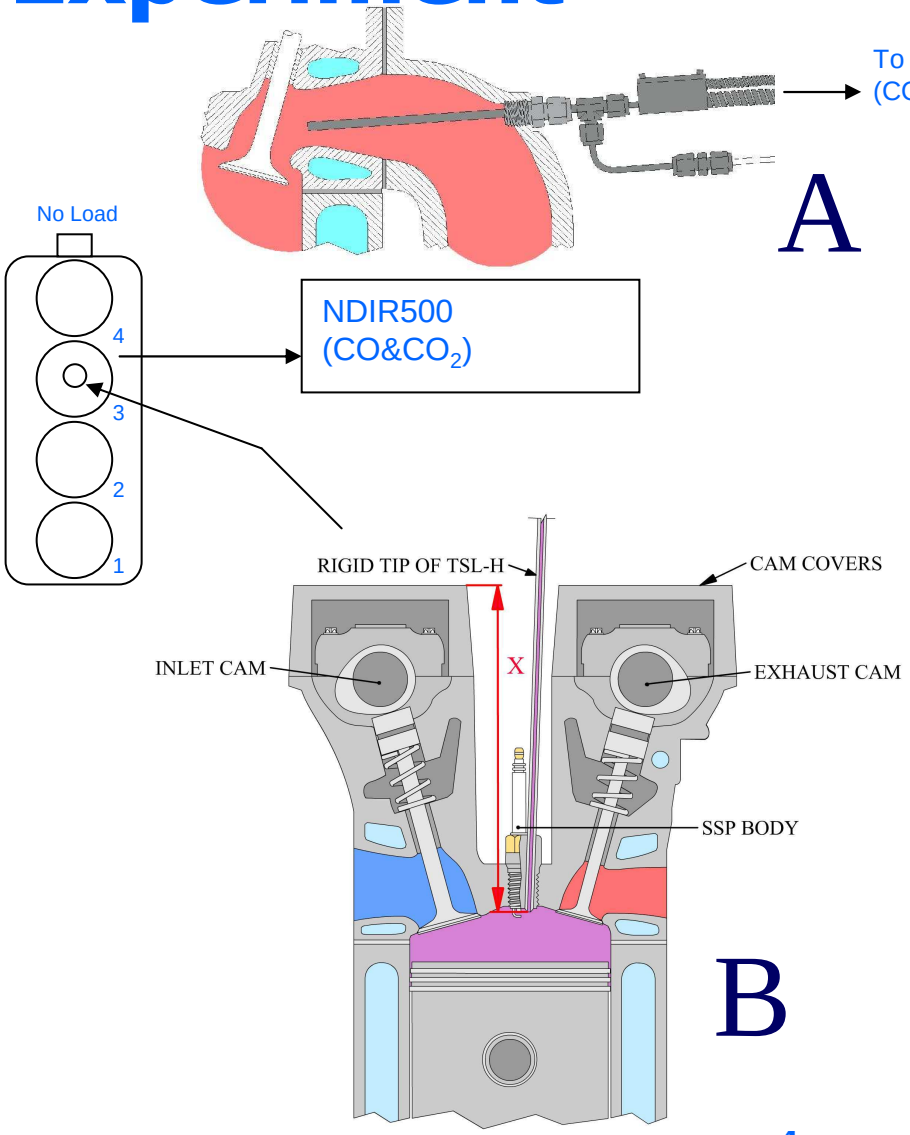
Experiment

Configuring the fast gas analyser for in-cylinder operation.



- Pressure Isolation: Narrow sampling capillary (0.015”). 150mbar pressure in sample cell to maintain STP flow hence time response, and allow sampling during intake stroke. Surge tank to attenuate pressure fluctuations.
- Sampling Spark Plug. Access to cylinder via a modified spark plug which passes a heated sample line.
- Quartz load washer to measure cylinder pressure

Experiment

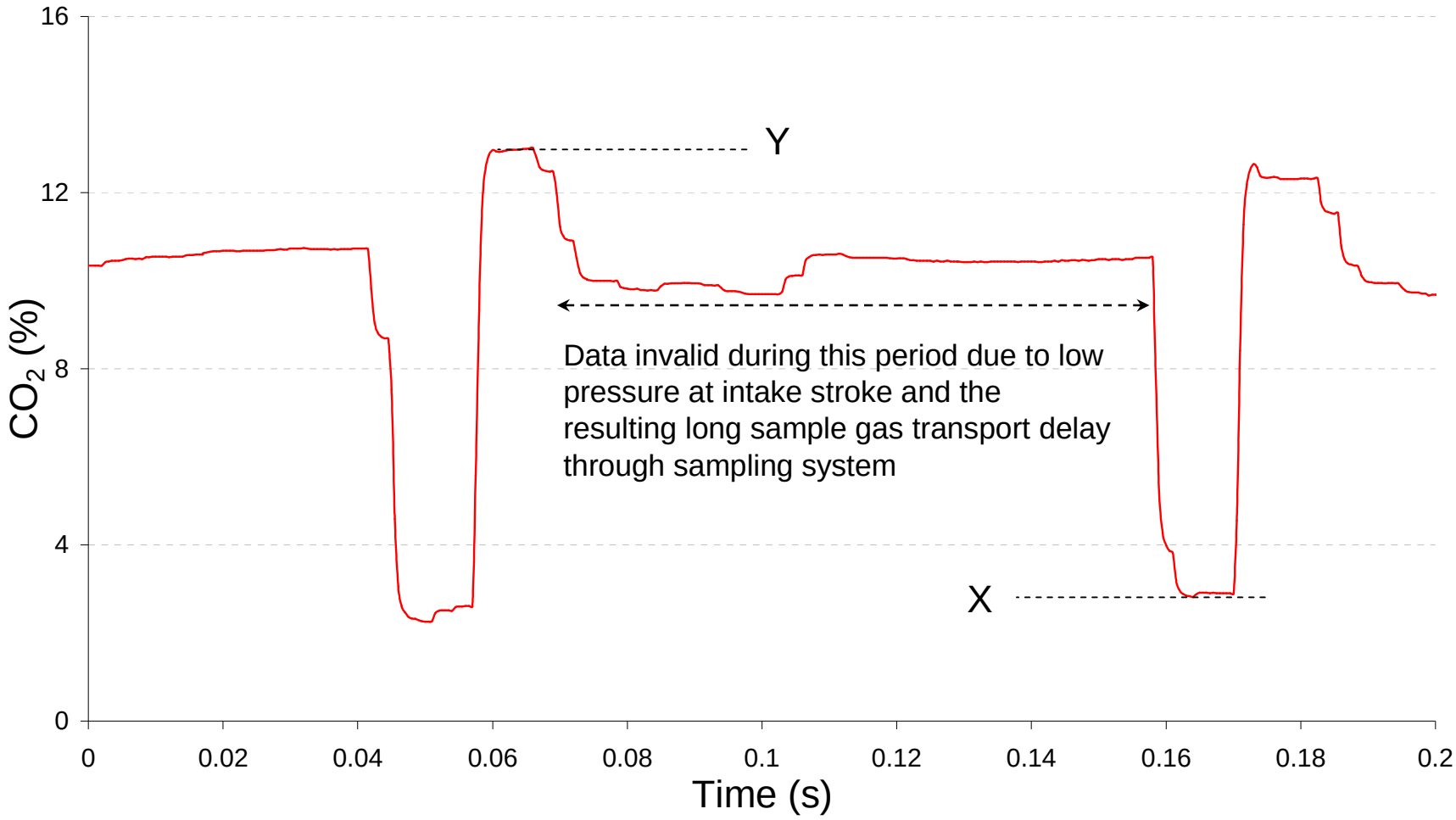


Equipment

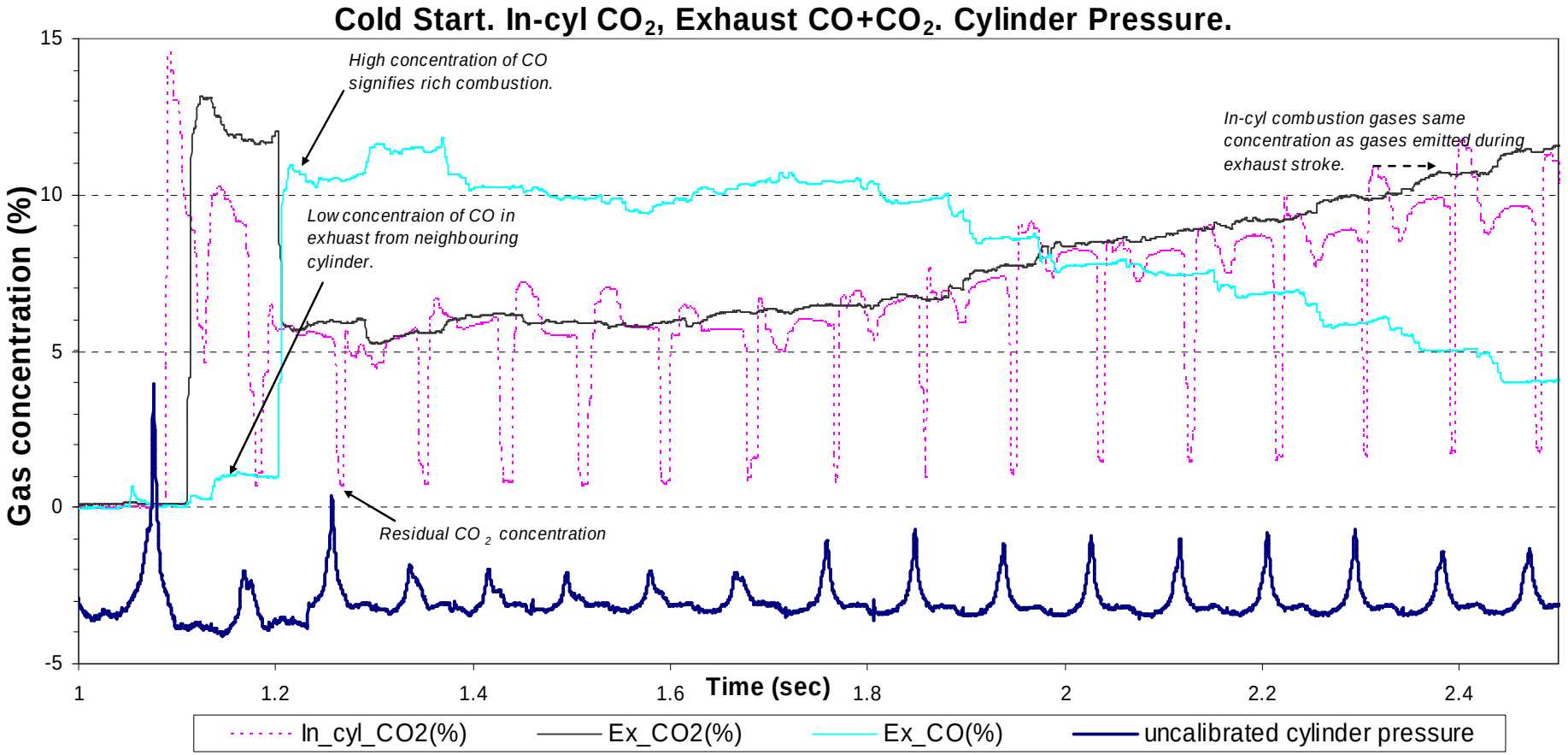
- 1.8L 4-cyl PFI engine. Engine mounted without dynomometer since experiment is start to idle (no load)
- NDIR500 2 channel fast CO&CO_2 analyser fitted in exhaust (A) and in-cylinder (B).
- Fast data acquisition system sampling at 1KHz.
- Quartz load washer for cylinder pressure

Results – Anatomy of in-cylinder trace

$$RGF\ (\%) = (X/Y)*100$$



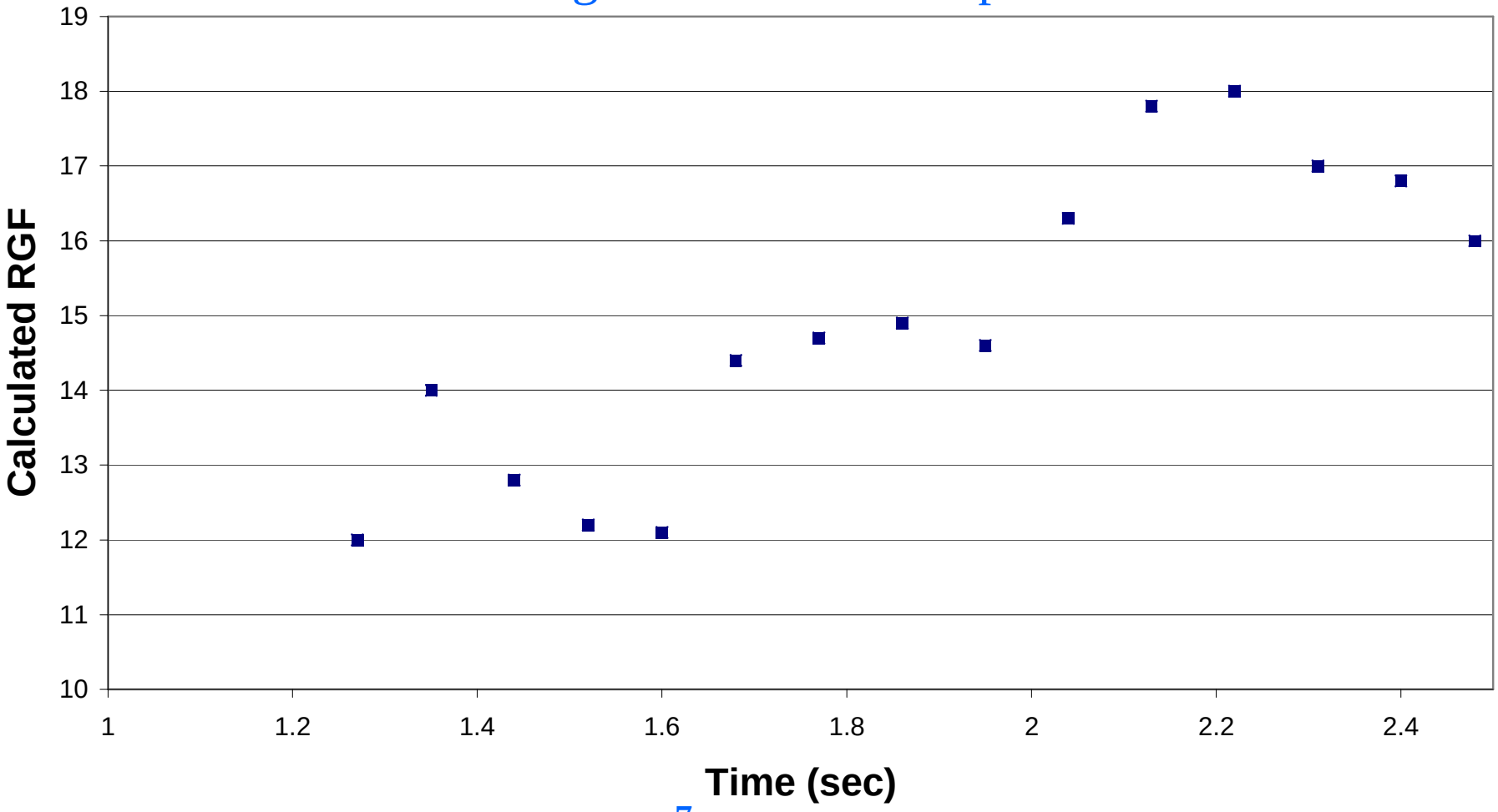
Results


Cold Start. In-cyl CO2, Exhaust CO+CO2. Cylinder Pressure.
High concentration of CO signifies rich combustion.
Low concentraion of CO in exhuast from neighbouring cylinder.
In-cyl combustion gases same concentration as gases emitted during exhaust stroke.
Residual CO 2 concentration
Gas concentration (%)
15
10
5
0
-5
1
1.2
1.4
1.6
1.8
2
2.2
2.4
Time (sec)
In_cyl_CO2(%)
Ex_CO2(%)
Ex_CO(%)
uncalibrated cylinder pressure

Results – RGF data

Data calculated cycle-by-cycle.

•RGF increases throughout start as inlet pressure falls



Conclusions

- RGF successfully measured during a cold start
- CO_2 measured in the cylinder shows good agreement with CO_2 measured in the exhaust for each cycle.
- Exhaust trace useful for examining combustion AFR considering CO and CO_2
- RGF measurement technique can provide experimental model validation as well as provide a basis for future engine calibration.