Real-time EGR measurement using Cambustion NDIR500

Real-Time EGR Measurement

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Real-time EGR observation

- Validate ECU model
- Observe very short but very important EGR events
  - (e.g. EGR valve leakage, internal EGR / spit-back)
- Sampling in inlet port of PFI engine.

Standard 2-channel system allows simultaneous exhaust and inlet sampling for EGR valve drive calibration and verification under transient engine conditions.

The NDIR500 system was installed on a 4 cylinder port fuel injected gasoline engine with EGR. The engine was run through bag 1 of the FTP75 drive cycle.

Inlet port sampling
Measurement of EGR

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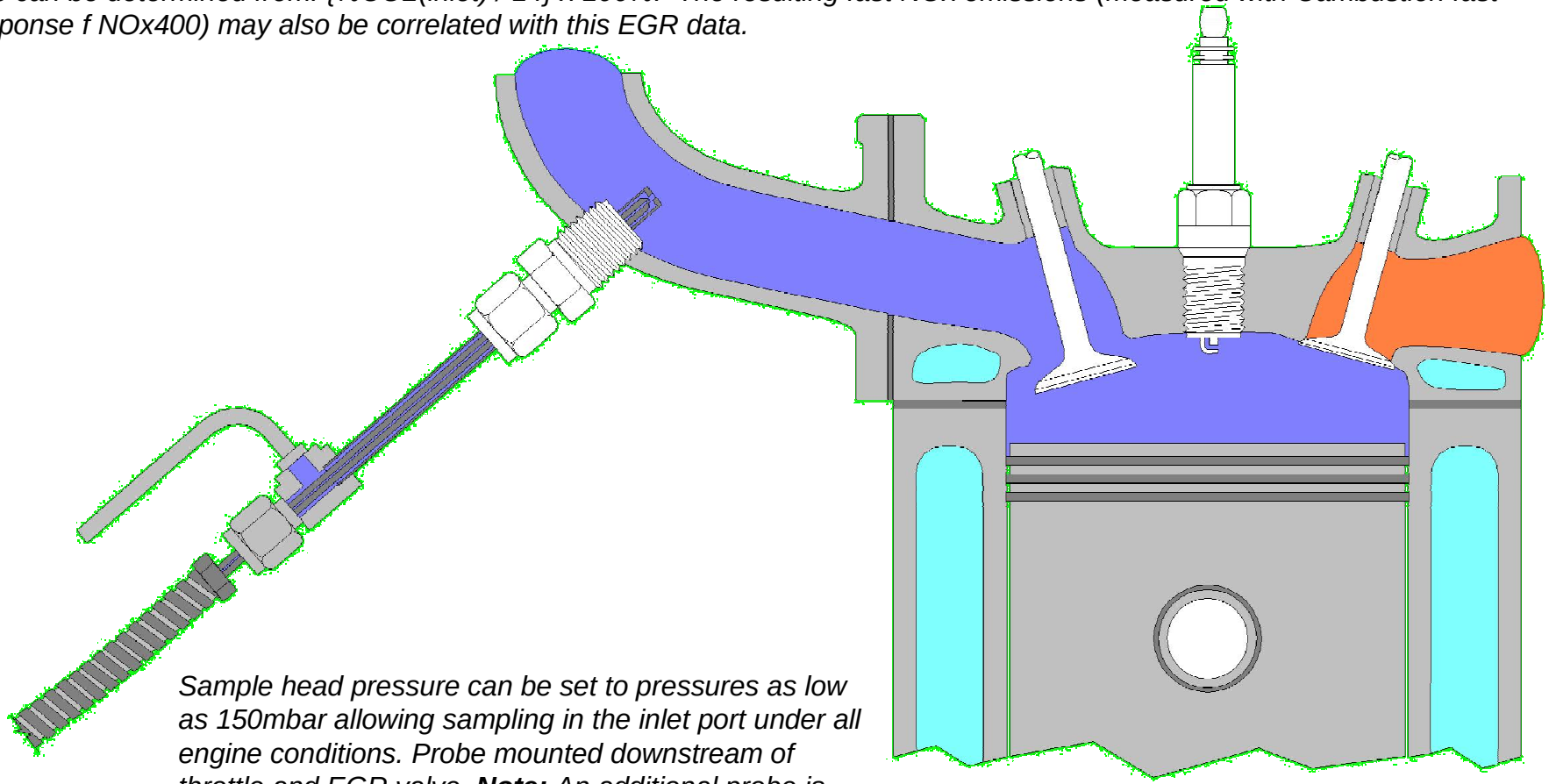
The attached figures show data which correspond to 260-290s (around mode 17) which is the period surrounding the highest vehicle speed during bag 1.

In general, fast transient CO2 features in the intake can be discerned from these graphs on "cycle-by-cycle" time-scales indicating the real-time levels of EGR. This is useful for rapid EGR valve control and assessment of effectiveness. The instantaneous EGR rate can be determined from: {%CO2(inlet) / 14} x 100%. The resulting fast NOx emissions (measured with Cambustion fast response f NOx400) may also be correlated with this EGR data.



Sample head pressure can be set to pressures as low as 150mbar allowing sampling in the inlet port under all engine conditions. Probe mounted downstream of throttle and EGR valve. ***Note:*** *An additional probe is required in the exhaust when operating at conditions where $\lambda \neq 1$*
(e.g. Diesel, Lean Burn Gasoline, GDI, etc.)

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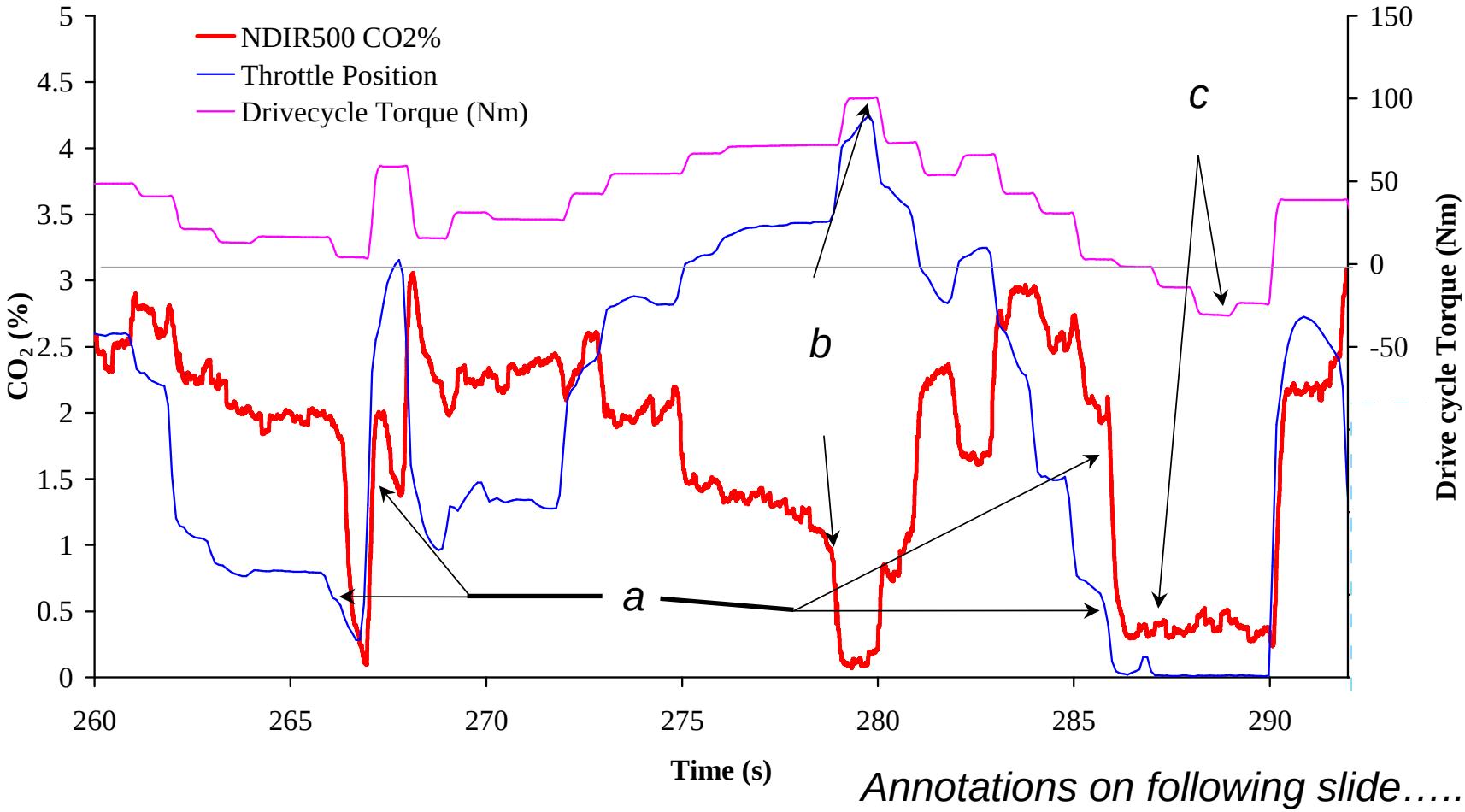
Drive-cycle CO_2 - inlet manifold

EGR measurements during FTP75



Annotations on following slide…..

Drive-cycle CO_2 - inlet manifold- annotations

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a) The EGR valve is closed by the Engine Control Unit (ECU) as the engine load reduces below a certain threshold and the throttle is closed. The purging of CO_2 from the inlet manifold is initially very rapid.

b) The EGR valve is closed by the ECU since the engine is demanding a high power output. Under these circumstances, the NO_x engine-out emissions will be very high.

c) The negative drive-cycle torque corresponds to engine braking as the required vehicle speed is reduced. This point is a closed-throttle engine deceleration where the EGR valve should be closed. The strategy is not operating deceleration fuel shut-off and so the engine continues to fire (producing CO_2 at the exhaust). The NDIR500 clearly shows a small level of CO_2 in the intake gases, indicating a slight leak through the closed EGR valve caused by poor sealing under the high pressure difference conditions.

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Drive-cycle CO_2 - inlet manifold

Model versus measured EGR rates

This data shows a comparison between the EGR rate calculated using the NDIR500 CO2 concentration and an EGR rate determined by a model in the ECU. The NDIR500 EGR rate is determined by assuming a constant exhaust CO2 concentration of 14% since the engine is operating at λ=1 at this point in the drive cycle. The ECU EGR rate model is based on EGR valve characteristics and modelled inlet and exhaust manifold pressures.

There is generally good agreement between the EGR rates. However, the leakage of the EGR valve at idle is clear. There is some indication that the model predictions are less than the measured EGR rate at higher engine loads.