



NDIR500 Fast CO&CO₂

*Real-time Millisecond Response Carbon Monoxide
and Carbon Dioxide Measurement*



Fast response time (8 *milliseconds*)
Continuous two channel sampling
Engine exhaust & inlet applications

Overview of fast response CO & CO₂ measurement

Cambustion specialise in the design and manufacture of fast response analyzers for engine and other applications. In addition to fast CO & CO₂, we also manufacture fast response HC, NOx and particulate instruments - all designed to aid engineers in transient emissions R&D. The data from these analyzers is usefully combined in many applications (e.g. transient fuelling calibration, NOx trap purging, cold start analysis) and although the instruments utilise the industry-standard measurement techniques for each component, they may be housed in a single cabinet if required.

Like our other analyzers, the NDIR500's fast response time is due to the detector being located in a remote sample head close to the sampling point in the engine. The sample gas is conveyed to the detector through heated capillaries thereby minimising the mixing of the sample gas and yielding a very fast response time.

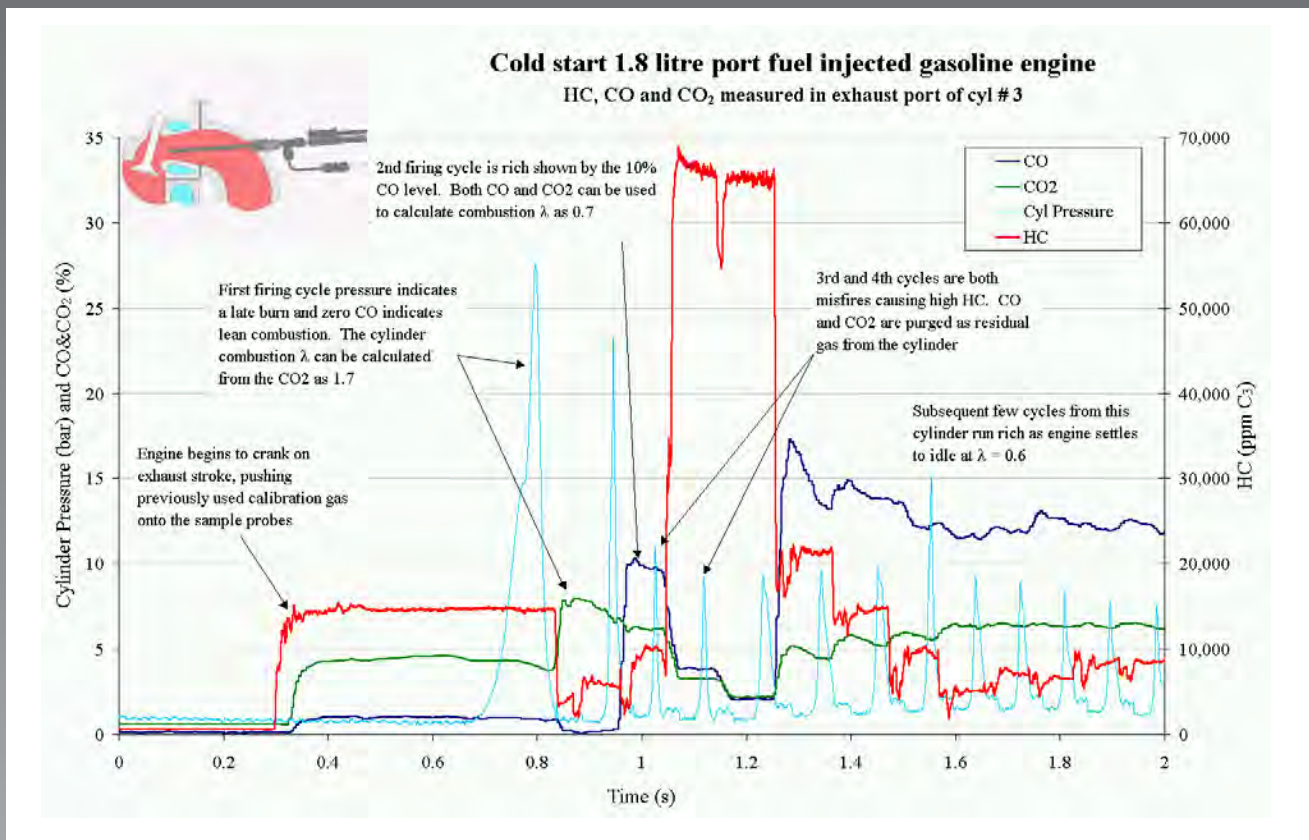
The analyzer can operate two independent sample heads supported by 10 metre conduits and delivers four channels of data {two x (CO and CO₂) simultaneously}. The mobile storage cabinet also contains a lockable drawer for tools and manuals, vacuum pump and circuit breakers.

The system is controlled via RS485 serial link from a computer user-interface with remote control as an option. Autocalibration, self testing and fault-finding with on-line help are included as standard.

Cold start combustion and fuelling analysis

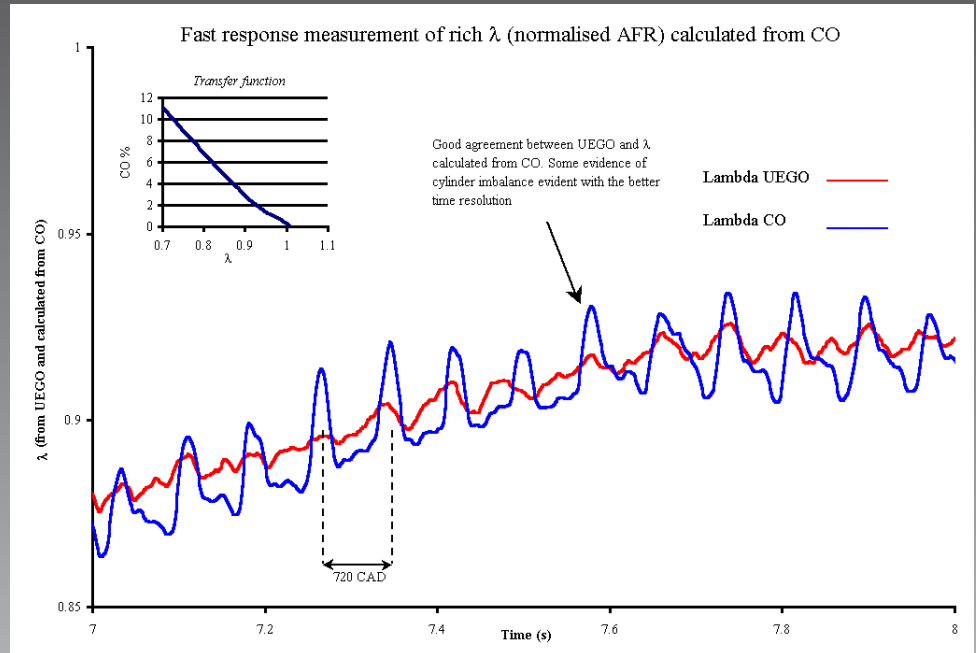
The transient fuelling during a cold start is crucial to reducing emissions and aid startability. Fast measurement of CO, CO₂ and other pollutants is a useful indicator of potential emissions problems and Air Fuel Ratio (AFR) control.

The relationship between CO, CO₂ and λ mean that instantaneous combustion AFR can be calculated from the NDIR500's output at cold start. This differs significantly from the AFR measured via an Exhaust Gas Oxygen sensor (UEGO) because unburned HCs which are prevalent during cold starts can affect the UEGO's response. For crank fuelling calibration, engineers are most interested in the cylinder λ into which the spark is propagating.



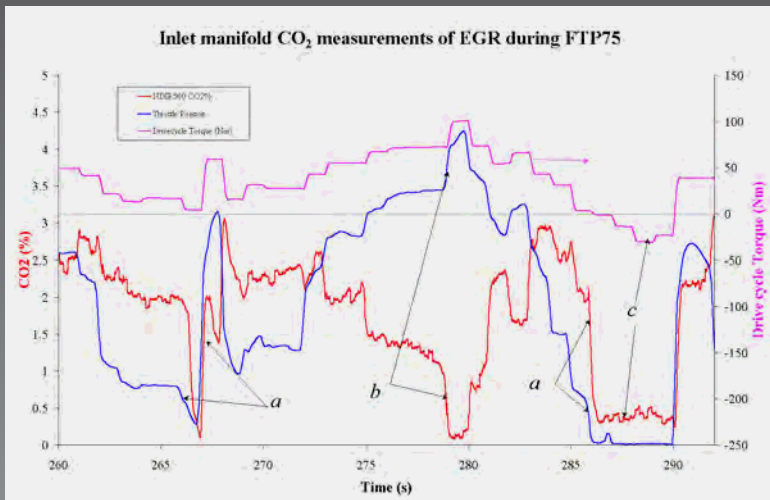
Fast AFR measurement via CO

CO rapidly increases with rich operation of the engine as can be seen from the transfer function in this graph. It is therefore a good indicator of changes in Air/Fuel Ratio (AFR) during rich engine operation and using the transfer function, AFR can be calculated with the NDIR500's time resolution of 8ms - approximately 10 times faster than currently available from a typical exhaust oxygen sensor. The graph shows the real-time λ (normalised AFR) recorded pre-catalyst on a 1.8-litre



gasoline engine during a drive cycle. In this engine, one of the cylinders is running slightly rich and a spike of CO is produced once per engine cycle (720 degrees of crank angle).

Measurement of real time EGR using CO₂



The chart shows the inlet manifold CO₂ measurement together with throttle position and drive-cycle torque. It is annotated as follows:

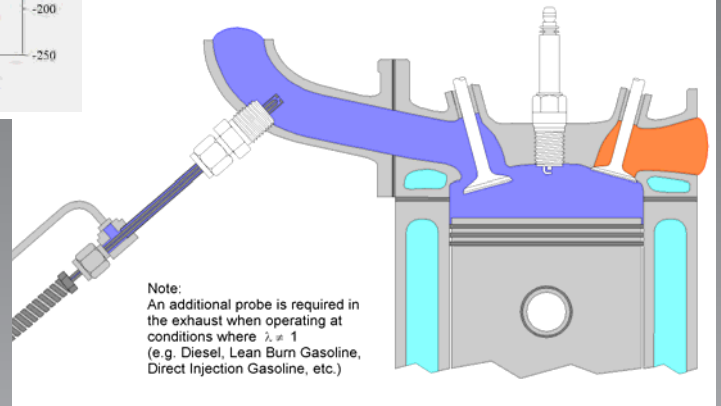
a) The EGR valve is closed by the ECU as the engine load reduces below a certain threshold and the throttle is closed.

The purging of CO₂ from the inlet manifold is initially very rapid.

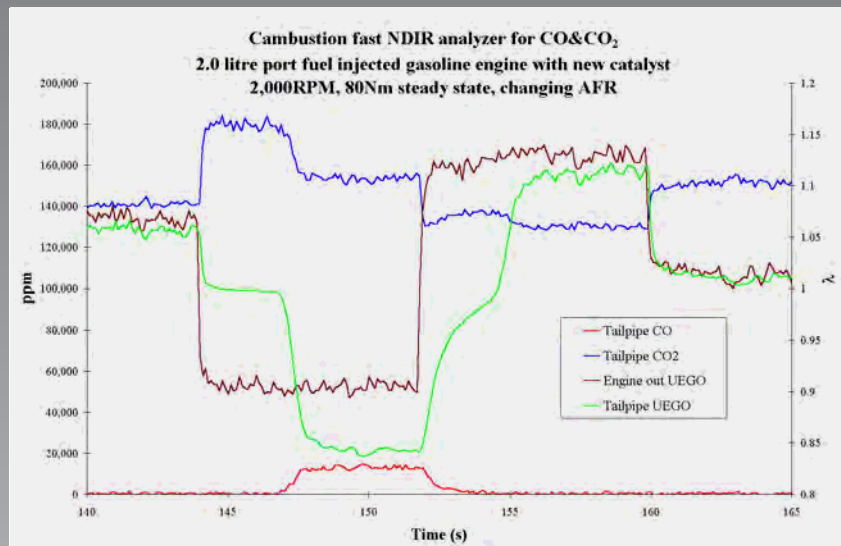
b) The EGR valve is closed by the ECU since the engine is demanding a high power output. Under these circumstances, the NO_x engine-out emissions will be very high.

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 CO₂ at the exhaust). The NDIR500 clearly shows a small level of CO₂ in the intake gases, indicating a slight leak through the closed EGR valve caused by poor sealing under the high pressure difference conditions.

System set up for EGR rate measurement
Probe in inlet manifold - downstream of throttle and EGR valves



NOx trap purging



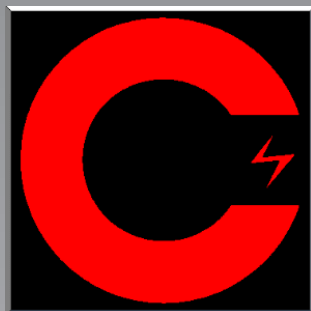
The purge profile of NO_x traps (where the engine is run rich for a short time to reduce the trapped NO_x) requires careful control of AFR. Operating rich for too long can produce CO from the tailpipe whereas too little purging can lower trap efficiency. The NDIR500, when measuring after the catalyst, can measure the first sign of CO breakthrough. The above data is from a standard, new 3-way catalyst on a port fuel injected gasoline engine during AFR transients and shows the NDIR500's fast response to post-catalyst changes in CO & CO₂ during the fuelling transient.

NDIR500 Specification

Measurement principle	-	Non-Dispersive Infra-Red (NDIR)
Components measured	-	Carbon Monoxide (CO) & Carbon Dioxide (CO ₂)
Number of channels	-	2
Measurement ranges	-	0-5% & 0-25%
Response Time T _{90-10%}	-	~ 8ms
Drift	-	< ±2% FS/hour
Linearity	-	< ±2% FS
Ambient sampling conditions	-	0 - 40°C
Sample gas flow	-	~5 litres/min (atmospheric sample pressure)
Output	-	0 - 10V, 47Ω
Power supply	-	AC 50/60 Hz, 110/230V
Gas supply pressure	-	2 bar (30psi) gauge

Cambustion Ltd reserve the right to change these specifications without notice

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