Fast response CO and CO2 sampling of a diesel engine.

Introduction

Diesel vehicles are increasing in popularity due to their fuel efficiency and recent improvements in performance. Concerns over the particulate matter (PM) produced by diesel engines has lead to the development of diesel oxidation catalysts (DOC) and diesel particulate filters (DPF). Control of these aftertreatment systems requires the engine to run under conditions that are not necessarily optimal for engine out emissions. For instance, regeneration of a DPF requires high temperature engine-out gas. Delayed injection coupled with post injection is a commonly implemented scheme to achieve this elevated exhaust gas temperature, but can have undesirable consequences for CO emissions.

Experiment

In this experiment a NDIR500 was used to examine CO and CO_2 output from a 2.2litre HDi engine. The aftertreatment system consisted of a DOC and DPF. Engine-out and tailpipe gasses were sampled simultaneously by using both channels of the NDIR500.

Engine-out gas can have very high concentrations of PM. This can cause contamination in the sample head which can lead to output drift. In this experiment the engine-out sample head was protected by a sintered metal filter. The tailpipe gas sampled through the HEPA filter accessory. The reduced time-response of 30 ms was not seen as an issue when sampling at this location.

The first 400 seconds of a New European Drive Cycle and 2 DPF regenerations are examined.

Results

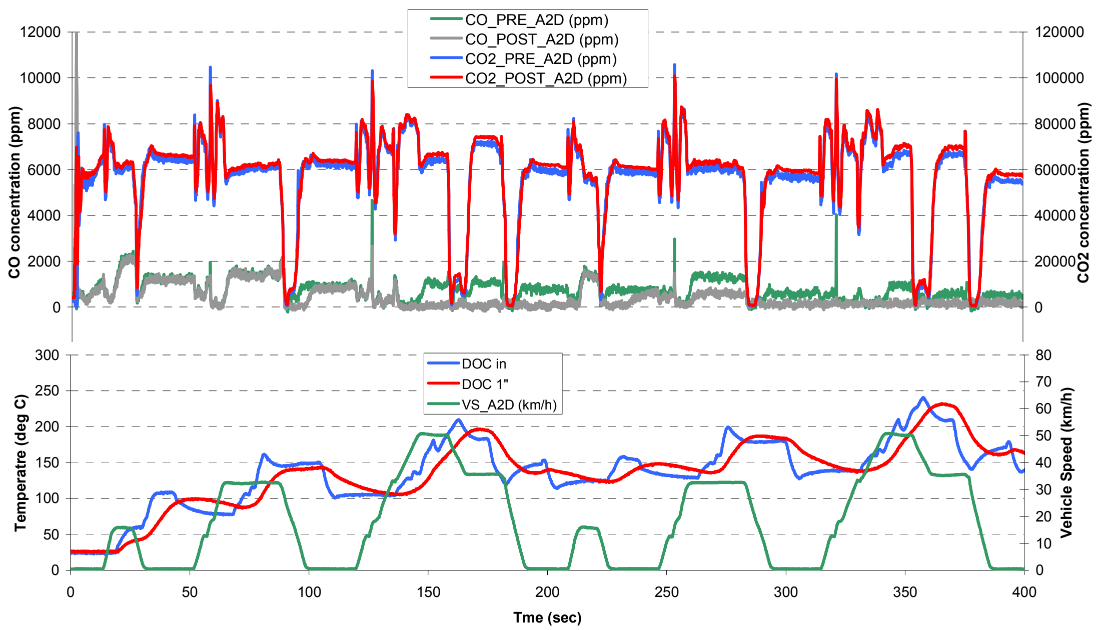

Chart 1. Diesel cold start.

The initial high concentration of 12,000ppm CO at cold start is only discernable via the use of this fast response emissions analyzer; lasting only a few seconds, but providing a significant contribution to the cycle emissions. High CO (2000ppm) concentrations are produced in the crank and run-up due to locally rich combustion, possibly from some surface burning effects or other cold burning flames on cold engine surfaces.

The oxidation catalyst then begins to convert CO at approximately 95 seconds indicated by the engine-out and tail-pipe traces diverging. This occurs when the DOC has reached light-off temperature; in this case around 140°C. However, the idle at 100 seconds causes engine-out temperatures to fall and shortly after the DOC ceases oxidation resulting in tailpipe CO once again following engine-out levels. The DOC again stops working at 215s but recovers gradually during the subsequent idle section of the cycle with partial conversion during the 250 second to 290 second period.

The CO_2 data clearly shows the transient events during the cycle: throttle movements and gear changes. It is also possible to observe the CO2 formation by the DOC since the tailpipe concentration is higher than the feed gas. The decel fuel shut-off scheme is also clearly evident in this data where the CO_2 levels fall considerably since there is no combustion.

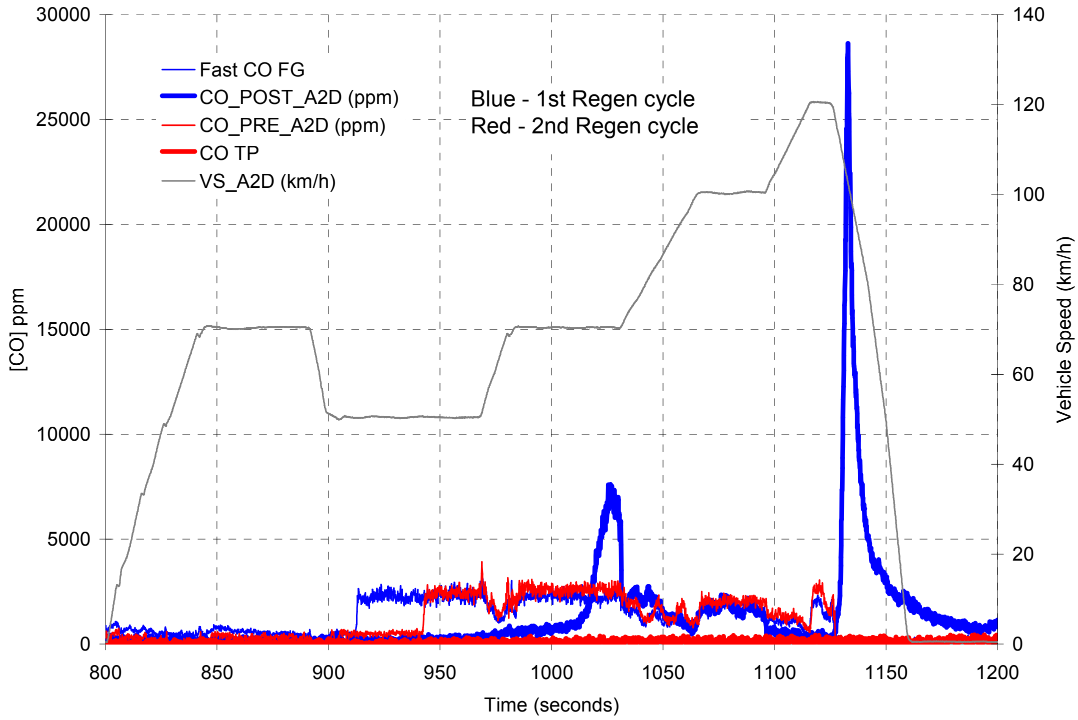

Chart 2. DPF Regeneration.

Regeneration Event

The ECU strategy triggers the regeneration at the same point in each EUDC drive cycle. Two regeneration events are examined: The first cycle was run after an extended 70km/h cruise to soot load the DPF. The second cycle run was run shortly after the first when there was no longer significant soot in the DPF.

The CO engine-out data indicates the onset of the regeneration process with the engine-out CO increasing sharply caused by partial oxidation of post-injected fuel at 915 seconds (run 1) and 940 seconds (run 2). The tailpipe traces indicate high conversion efficiencies initially but as the DPF exotherm progresses during the first regeneration event, the tailpipe CO begins to rise associated with partial oxidation of the soot/carbon to CO rather than to CO2. For the 2nd regeneration cycle, the CO conversion efficiency remains high throughout the regeneration due to the reduced levels of carbon being oxidised.