Using a forepump to boost cell measurement pressure

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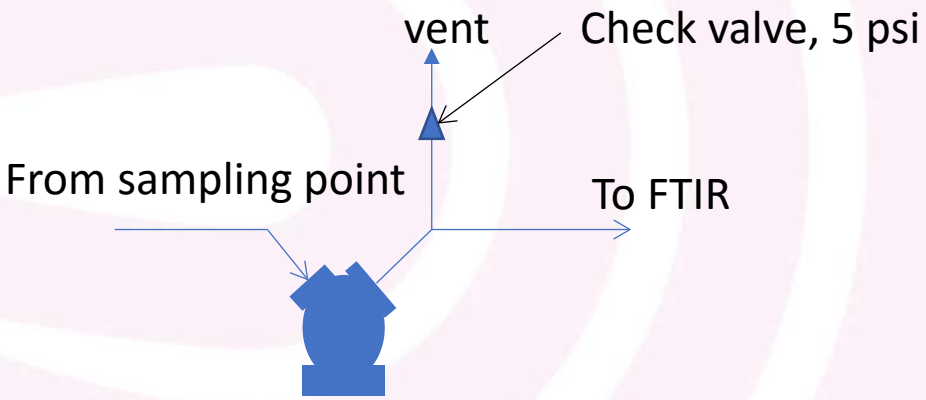
Aug 2018

Preamble

There is a pressure drop across the inlet system between the external pressure and the cell due to flow resistance mainly in the dryer. The drop is typically 20-50 hPa at 1 SLPM and may vary due to flow resistance in the dryer as the magnesium perchlorate packs with age. This limits the pressure for ambient air measurement to typically 950 hPa or less. More consistent measurements at higher cell pressure (with proportionally higher precision) can be achieved if the inlet gas is delivered at above ambient pressure and can adjust for increasing flow resistance in the dryer. For ambient air a forepump is required. Tank gas sample delivery pressure can be set by the tank pressure regulator.

Forepump implementation

The figure shows a schematic forepump setup. Ambient air is delivered to the inlet of a small clean diaphragm pump such as KNF Laboport N 86 KT series. At the outlet of the pump to the FTIR inlet a check valve maintains a constant delivery pressure to the FTIR at the cracking pressure of the check valve, typically 5 psi or ~ 450hPa overpressure. The FTIR pressure control can then operate the cell at typically 1100 hPa. Excess sample is vented via the checkvalve and serves the additional function of maintaining flow through the inlet sampling system.



Revision history

V1	2018	Original description

Appendix

The imperfect cancellation of water vapour features is due to the breakdown of Beer's Law at low resolution. Let τ_S and τ_B be the optical depth of the sample and background spectra at some frequency. Here $\tau > 0$ due to water vapour concentrations in the sample and background: $\tau = \alpha C$ is proportional to C, the water vapour concentration. The sample and background spectra are

$I_S = I_0 \exp(-\tau_S)$ and $I_B = I_0 \exp(-\tau_B)$

The true, or monochromatic, transmission is

$T_{true} = I_S/I_B = \exp(-(\tau_S-\tau_B)) = \exp(-\alpha(C_S - C_B))$

This is exactly the same as the spectrum of a net water concentration $C_S - C_B$, the difference in concentrations between sample and background. This would also be true for measured spectra if the spectra were measured with infinite resolution. But in reality the spectra I_S and I_B are each apodised and convolved with an instrument lineshape (ILS) of 1 cm^{-1} resolution, significantly wider than the lines themselves, *before* being divided:

$I_{S,\,measured} = I_S \otimes ILS$

$I_{B,\,measured} = I_B \otimes ILS$

The convolution is not linear with respect to τ, and

$T_{measured} = I_{S,measured}/I_{B,measured} \neq I_S/I_B \neq T_{true}$

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