HARDWARE SETUP AND APPLICATION NOTES
# FOR CALIBRATING FTS DEVICE WITH molbloc/molbox™

2002 JUN 19

DESCRIPTION

This document describes the hardware setup and other recommendations for testing the orifice flow meters used for verification/calibration of flows into PM2.5 particulate monitoring instruments. The Chinook Engineering Streamline flow transfer standard (FTS) is used by leaving the inlet to the orifice open to atmosphere and drawing the air flow through the device utilizing a downstream vacuum source (sub-atmospheric pressure).

HARDWARE SET UP

The FTS flow measurement can be verified using the **DHI** molbloc/molbox system and the following hardware setup.
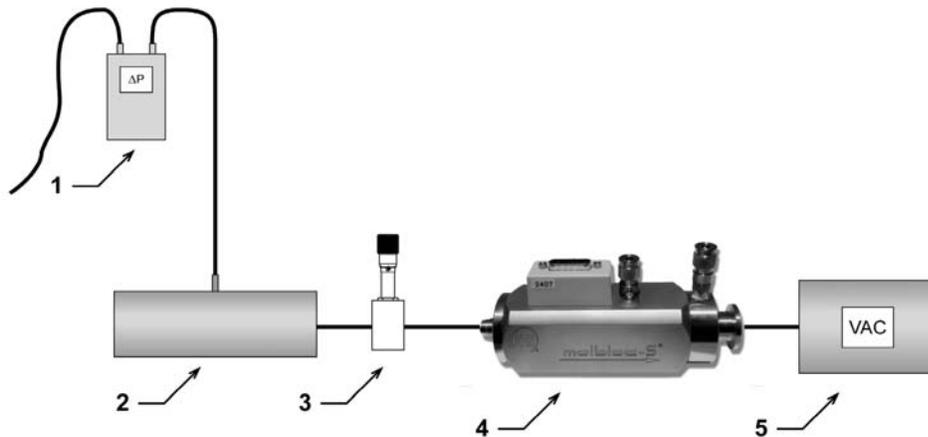
1. H$_2$O manometer
2. Chinook FTS
3. Metering valve or MFC
4. molbloc-S
5. Vacuum pump

APPLICATION NOTES

When operating the 200 sccm/kPaa molbloc-S in sub-atmospheric conditions, its full-scale flowrate is 20 slm (STP: 0°C and 101.325 kPaa) at 101.325kPaa. In order to adjust flow through the FTS to the volumetric flowrate of 16.67 lpm, the inlet absolute pressure to this molbloc-S will have to be approximately 77 kPaa. At its lowest volumetric flowrate of approximately 4 lpm, the inlet absolute pressure will be 20 kPaa.

The 50 sccm/kPaa molbloc-S has full-scale flowrate of 5 slm (STP: 0 °C and 101.325 kPaa), and will flow approximately 3 lpm at 55 kPaa. At its lowest volumetric flowrate of approximately 1 lpm, the inlet absolute pressure will be 20 kPaa.

The regulating valve in the setup described above is used to restrict the flowrate and thereby reduce the molbloc-S inlet pressure. As long as the vacuum source can maintain the molbloc-S outlet pressure to that of no greater than 0.5x that of the inlet pressure, the FTS can be checked at multiple flowrates down to approximately 2 slm for the 200 sccm/kPaa, and 0.5 slm for the 50 sccm/kPaa.

REFERENCE FLOW MEASUREMENT

In order for the molbox or COMPASS for molbox PC software to properly calculate volumetric flowrate, the prevailing conditions of ambient temperature, absolute pressure, and relative humidity of the air flowing into the FTS must be determined and entered.

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If the FTS has the associated instrumentation capable of measuring these values it should be used for this procedure. Typically, the ambient temperature, barometric pressure, and relative humidity of the laboratory in which the calibration takes place can be measured independently and used for this purpose.

> Note: The gas temperature measurement made by the molbloc-S can be selected for use by either the molbox or by COMPASS in order to calculate the FTS flowrate. However, the molbloc-S pressure measurement should NOT be used in this fashion since the upstream absolute pressure at the molbloc-S is not at the same pressure as the inlet pressure to the FTS due to the flow control valve in the hardware setup.

DETERMINATION OF CALIBRATION COEFFICIENTS

Once the calibration is complete, the data obtained can be used to recalculate the FTS values of slope (m) and offset (b). A simple spreadsheet can be produced to make the following calculations:

FTS indication:

$$IND_{FTS} = \sqrt{\frac{\Delta P \bullet T_{amb}}{P_{amb}}}$$

FTS flowrate:

$$Q_{FTS} = m \bullet \sqrt{\frac{\Delta P \bullet T_{amb}}{P_{amb}}} + b$$

where:

ΔP =	Delta-P between ambient pressure and FTS pressure tap,	[in. H_2O]
T_{amb} =	Ambient air temperature in Kelvin	[°C + 273.15]
P_{amb} =	Ambient air pressure in Atm	[mmHg / 760]
m =	slope coefficient	[marked on FTS label]
b =	offset coefficient	[marked on FTS label]

Once sufficient calibration data has been obtained, the "as received" % of reading error can be calculated at each point as follows:

$$\%ERR = \frac{\left(Q_{FTS} - Q_{ref}\right)}{Q_{ref}} \bullet 100$$

The "slope" function in MS Excel can be used to determine the new "m" slope coefficient. The format of this function would take the form similar to:

$$=slope\left(Q_{ref}Datarange, IND_{FTS}Datarange\right)$$

The "intercept" function in MS Excel can be used to determine the new "b" offset coefficient. The format of this function would take the form similar to:

$$=intercept\left(Q_{ref}Datarange, IND_{FTS}Datarange\right)$$

The predicted "as left" % of reading error can be determined in the same manner using the new coefficients of m and b, and re-calculating the FTS indication and volumetric flowrate.

CONNECTION TO FTS

The connection to the outlet of the FTS element must be leak free and allow for the conversion to the inlet connection type of the flow control valve.