Application note

PPS-M sample flowrate in different pressure conditions

! For correct use of Pegasor M -sensor (PPS-M) or Mi3, please read carefully product manuals and Application note for general engine emission measurements.

PPS-M flow configuration

PPS-M sample intake is powered by a choke-stabilized ejector pump, which provides stable sample mass flow in wide range of sampling pressures, if the inlet and outlet probes are in the same pressure (Common mode pressure).

The sensor flow status is determined by three pressures: pump air pressure, inlet pressure and differential pressure between inlet and outlet. Figure 1 clarifies these pressures.

Common mode pressure is the static pressure in exhaust channel and is determined by the exhaust flow and channel resistance. The differential pressure is the pressure difference between the sample inlet and outlet. It is caused by a restriction in the sample flow in inlet or outlet line and the pressure difference between the inlet and outlet. Note that common mode and differential pressures are independent of each other when inlet and outlet are installed in the same channel according to installation instructions.

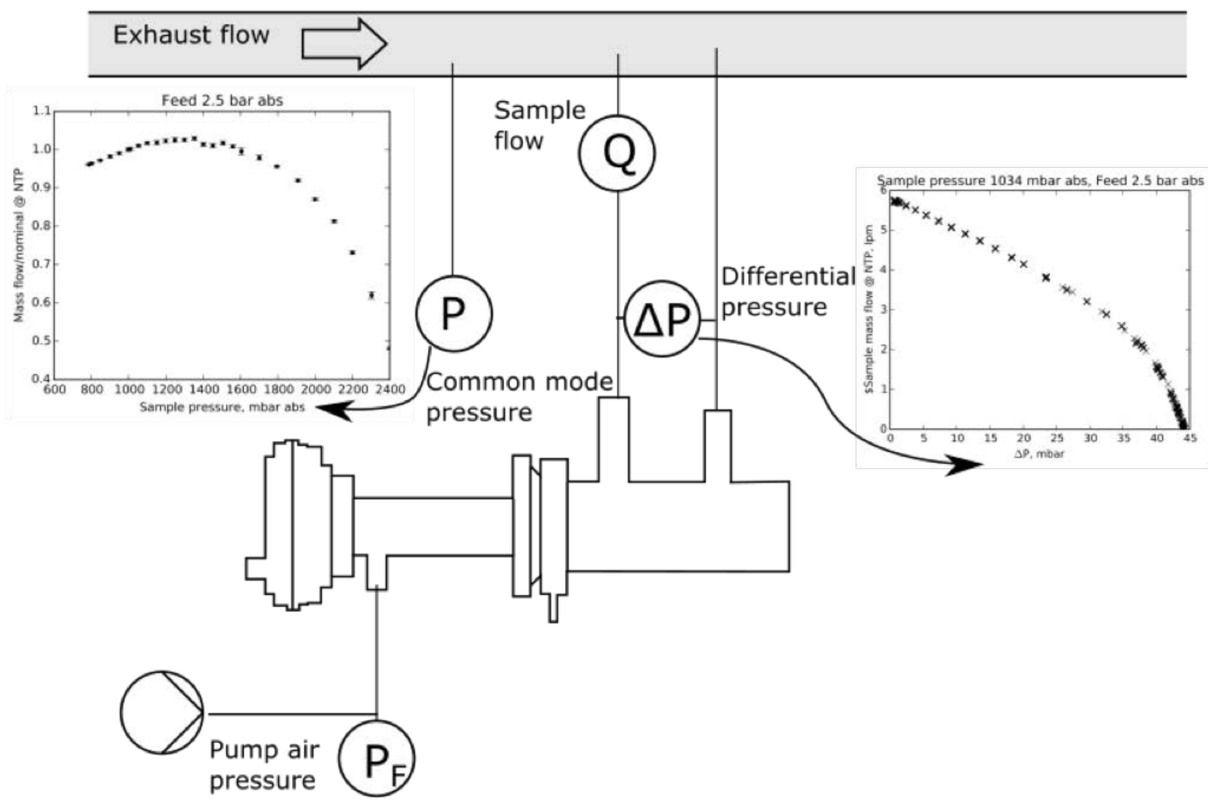

Figure 1 PPS-M flow configuration and effect of different sampling pressure conditions on sample mass flow.

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The ejector pump has stabilizing properties over changing sample pressure. At increasing sample pressure, the increasing sample density compensates for the decreasing nozzle flow.

At pressure above 1700 mbar the compensation effect decreases as the nozzle is no longer supersonic and the pump flow starts to drop steeply.

At lower pressure the mass flow tends to decrease due to decreasing sample density, but the increasing pressure difference over the nozzle increases the ejector pumping power. The sensitivity to sample pressure is given in Figure 2.

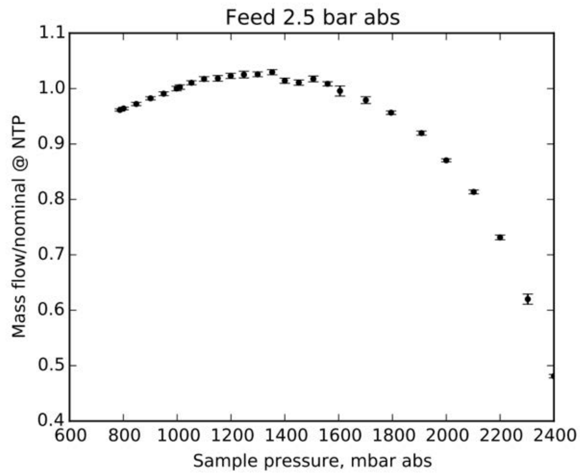

Figure 2 PPS-M inlet mass flow at different sampling pressures. Right side figure is magnification of -15% +5% range.

The pump performance in differential pressure situation is much more sensitive to variation, as the ejector pump is not a displacement pump.

Even though sample pressure can vary over 1000 mbar while keeping sample mass flow within ±5%, differential pressure between probes of 10 mbar already affects sample flow around 20% (See Figure 3).

Therefore, it is crucial to install the probes at the same static and stagnation pressure conditions i.e. close enough to each other, no restriction between the probe points, no bends before probes.

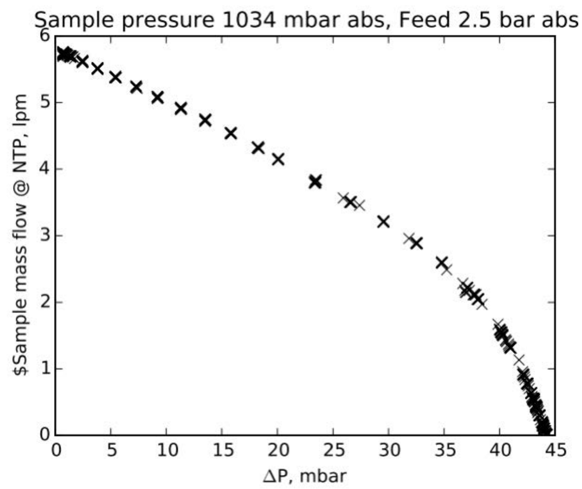

Figure 3 Effect of pressure difference between inlet and outlet to sample flow in PPS-M

Sensor flow testing

Sensor sample flow performance can change due to faulty pressure regulator in the feed air, heavy contamination of the ejector or the corona nozzle, misassembly causing leaks or misalignment and aforementioned pressure changes and restrictions.

Primary method for sensor deviation control are the quality control at the manufacture and maintenance, where inlet stagnation pressure test and inlet flow measurement give the most useful results in terms of fault finding sensitivity and useful information. Doing these two tests can validate a correctly operating sensor and give the inlet flow for calibration.

Suggested procedure for sensor tightness and critical flow validation:

1. inlet stagnation pressure test (pass for value e.g. >40 mbar)
   a. Reason for failure: leak in sampling path, clogged ejector or inlet, misassembled sensor
2. Inlet flow measurement (pass: e.g. >90% of nominal), set value for sensor calibration

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PPS-M inlet stagnation pressure

The pressure difference sensitivity of the PPS-M can be used for sensor integrity testing. A simple performance test is to block the inlet and measure the stagnation pressure of the ejector pump. At zero flow the ejector can develop a pressure difference of more than 40 mbar and deteriorates rapidly when there is any leakage in the sampling line or internal leakage due to e.g. misassembled internal component.

This testing does not address any leakages at high pressure, but these have no effect on the sensor sample flow, only flow measurement when done at the inlet.

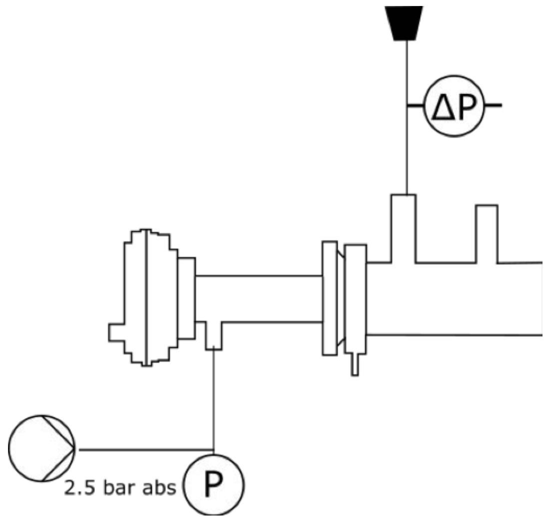

Figure 4 Ejector stagnation pressure test

Inlet flow measurement

Another performance validation point is the maximum flow measurement that characterizes the sensor sample flow.

Deviation from calibration value signals a problem in sampling line, sensor assembly or serious soot contamination.

Consult Figure 3 and calibration sheet of your sensor to adjust the reading for a high flow resistance flow meter.

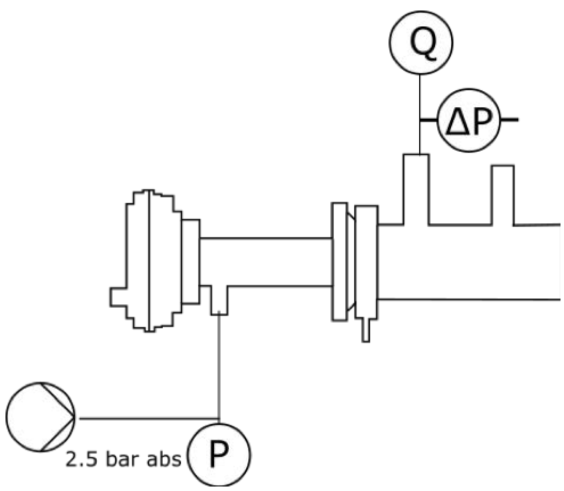

Figure 5 Sensor inlet flow test.
Flow meter pressure drop is measured with a manometer to make sure the flow meter does not induce too high pressure drop. In case of high pressure drop, the zero pressure difference can be realized by using e.g. mass flow controller adjusted until zero pressure difference is achieved.

For further details, please contact your local supplier or Pegasor for further details and support.