Document title : # Sampling system test procedure

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Introduction

This document details the test procedure to assess the presence or absence of biases and leaks in the station sampling system.

Please read it to the end before beginning the tests.

As specified in [AD1], the full intake system check should be done on a yearly basis and the shelter test twice a year.

Begin by the shelter test as this is the place with the most connections, the easiest to test and the less gas consuming. Check the biases for all species. Look [AD2] for the expected performances of your instrument, in particular the factory water correction bias and the intrinsic bias observed in the comparison.

Once this test is done and all leaks have been fixed and no significant biases are observed, perform the full intake system test every other time.

Applicable Documents

ID	Reference	Title	Date
AD 1	ATC-GN-GN-SP-1.2	ICOS atmospheric station specifications	2016-08
AD2	ATC-ML-IT-RP-XX	ICOS ATC Metrology Laboratory Evaluation report for your instrument	

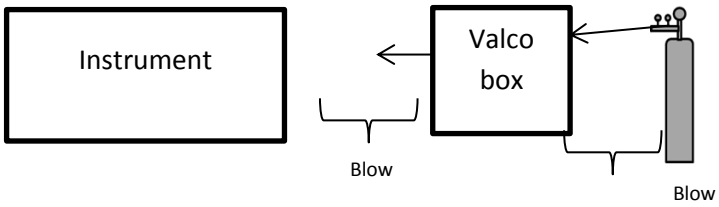
1. Shelter test

From [AS1] “Measurement systems, which have devices such as a sampling pump, drier, buffer volumes, in the inlet line upstream of the analyzer, have to be tested by a test gas measurement, which has an insertion point upstream of these devices. The test conditions (e.g. sample flow rate and pressure) have to be comparable to the conditions for the ambient sampling. The same test gas has to be measured at the selection valve insertion point as well. This test has to be done during maintenance visits at least twice per year. The concentrations of this test should be close to background conditions for the respective station.”

Before beginning the tests, note the flow rate and/or pressure (Outletvalve for Picarro) for your ambient air at each level.

First, connect your test gas to a free port of the valco valve. Open the cylinder, then open the pressure regulator **in order to match the flow and/or pressure observed for ambient air**. When there are different levels, match the average flow and/or pressure, they should be close to each other.

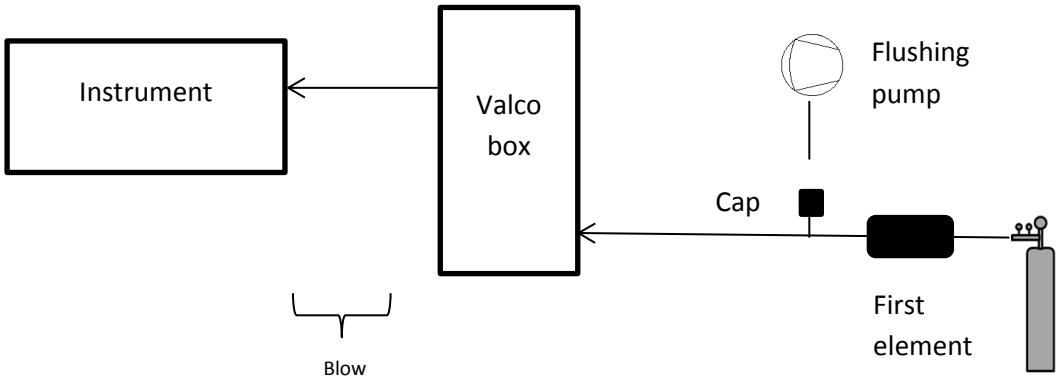
Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Blow around the fittings and follow the CO_2 values on the instrument screen. If a peak appears, there is a leak. Moreover (or in the case of an instrument not measuring CO_2), target gas is dry, so if H_2O increases above 0,005%v, it means that there is a leak on the line. If after several tightenings, the leak is still here, you may need to change the line.



Note the time at which the test begins and measure your test gas for at least 30 minutes. On a Picarro, zoom in on the last 5 minutes and note the displayed average value for each species for the test gas (H_2O as well). This will allow you a quick assessment on site. You can report these values and the next values in the table provided at the end of this document.

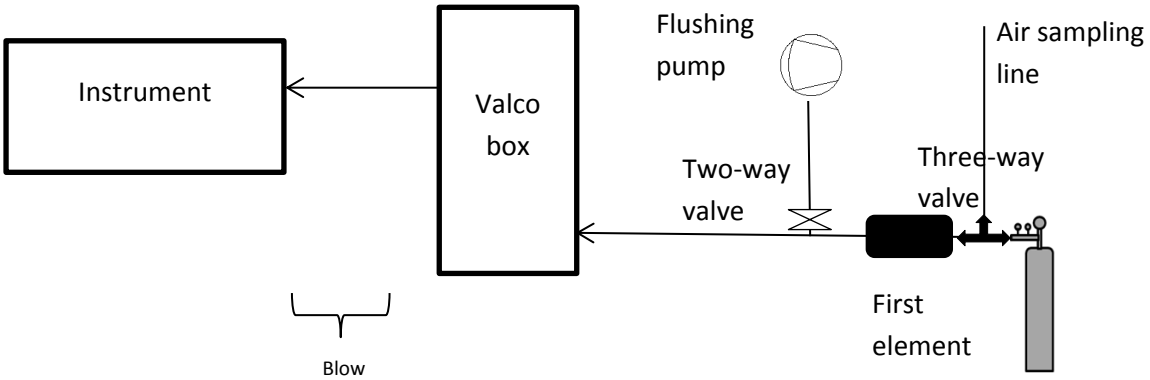
During that time, connect to ATCconfig to connect the cylinder on the valco port. Select the cylinder "DUMMY_TANK" in the list. The disconnection time will be the time at which all tests are done and not just while the cylinder is really connected to the valco valve.

Then connect your test cylinder upstream of the first element in your shelter. It may be the flushing pump, a filter or a valve. To do so, turn off the flushing pump, disconnect the line on the T and put a cap. Disconnect the sampling line before the first element and connect the test cylinder there.



To minimize connections and disconnections, we recommend to add permanently before the first element a three-way valve and on the pump line a two-way valve. The two-way valve should be as close as possible to the inlet line going to the valco to minimize dead volume. You can as well use quickconnect on the valco valve and the the three-way valve.

In this case, turn the pump off and close the two-way valve. Connect the cylinder on the free way of the three-way valve and switch so the gas in the cylinder is measured.



Open the cylinder, then open the pressure regulator **in order to match the flow and/or pressure observed for ambient air.**

Measure your test gas for at least 30 minutes. On a Picarro, zoom in on the last 5 minutes and note the average value for each species (H_2O as well) for the test gas.

Repeat the operation for each level. Testing each line will take about one hour between the connections and the measurements.

When testing the lines inside the shelter, the water vapor content of the gas after 30minutes should be comparable to the content of the dry target gas measured by the instrument. If it is not the case, it may be another sign of leak (if the H_2O level is stable) or the gas needs to be measured for a longer period until dry.

If there is a significant bias between the first measurement (test gas on the instrument) and the others (after taking the H_2O induced bias into account if necessary (section factory water correction of [AD2])), there may be a leak in the shelter (see below). A bias will be significant if it is larger than the intrinsic bias noted in the comparison part of [AD2].

2. Checking for leaks in the shelter

If there is a significant bias then follow the next steps to identify the potential leaks. Keep using the test gas.

For CO_2/CH_4/CO instrument: with concentrated CO_2

You can purchase pure CO_2 for fish tank that are small and easy to use. Using the bottle, press the nozzle briefly and follow the CO_2 values on the instrument screen. If a peak appears, there is a leak at this stage. If after several tightenings, the leak is still here, you may need to change the connections.

Warning: If you find a leak at the inlet of the Picarro, do not open it to fix it.

Blow (with your mouth) around the inlet with your hands around it to minimize fast dilution. If you observe a signal higher than 0.3ppm, notify ATC to better investigate the problem.

For N_2O/CO instrument: with air duster

You can use air duster in the same way as the CO_2 bottle, except that if there is a leak, you will observe a negative peak.

Note that there may also be a surface contamination, due to certain materials, or aging, or water vapor. Therefore, when a significant bias is observed but no leak is detected, further investigation should follow up, for example, connecting the test cylinder at each connection can help locate the problem.

3. Full intake system test

Injecting a gas in a similar way as for the shelter test when having several levels will be gas and time consuming. This full test should be performed to test the lines after several years of use.

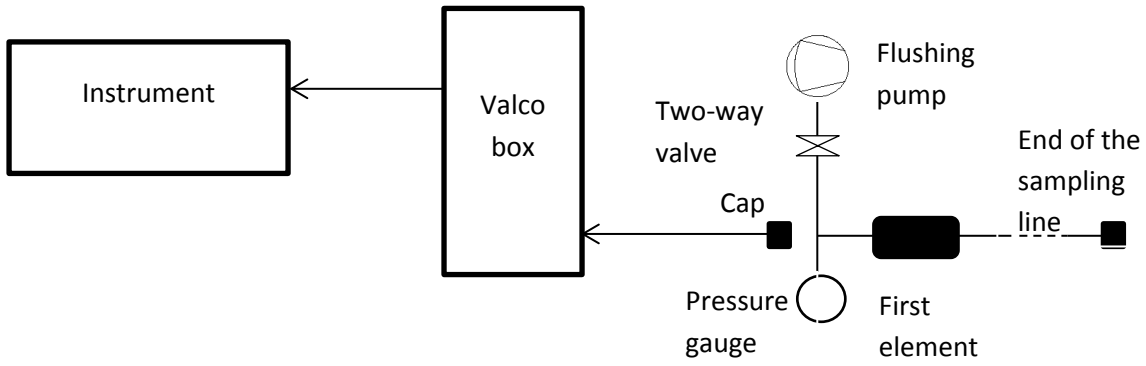
Two persons are recommended to perform this test and the simpler version below.

A simpler test is proposed hereafter to be done on a yearly basis.

Testing lines every year

Turn the flushing pump off. Disconnect it from the line going to the instrument and add a two-way valve to be able to isolate the pump (we have tested without problem the Swagelok Stainless Steel 1-Piece 40 Series Ball Valve). Plug the line going to the instrument. **As said before, we recommend to install permanently that two-way valve.** Connect a pressure

gauge that can read absolute pressures down to zero (for example Leo2 from Keller) on the T. Open the valve and turn on the pump. Plug the end of your sampling line. Depending on your setup, you could also add permanently a three-way valve with one way plugged. On your way up and down your tower/mast, try to observe the lines for any signs of wear. If you have several levels, you can do it for all at the same time.



Once the line is plugged, wait until you reach steady state. Then close the valve and turn the pump off and check if the vacuum is stable. If after 20 minutes, there is no change, your line does not present leaks.

Testing aged lines after several years of use

From [AD1]: "Intake system tests may be done by inserting a gas of a known concentration to the top inlet of each heights, or comparing ambient air concentrations swapping between the sample inlet and the spare line (ideally simultaneously with 2 instruments or in very stable ambient conditions if only one instrument available)."

If you did the previous shelter test, you can skip the first step and go to the next subsection.

Before beginning the tests, note the flow rate and/or pressure (Outletvalve for Picarro) for your ambient air at each level.

First, connect your test gas to a free port of the valco valve. Open the cylinder, then open the pressure regulator in order to match the flow and pressure observed for ambient air. When there are different levels, match the average flow and pressure, they should be close to each other.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Blow around the fittings and follow the CO_2 values on the instrument screen. If a peak appears, there is a leak. Moreover, target gas is dry,

so if H_2O increases above 0,005%v, it means that there is a leak on the line. If after several tightenings, the leak is still here, you may need to change the line.

Measure your test gas for at least 30 minutes. On a Picarro, zoom in on the last 5 minutes and note the average value for each species for the target. This will allow you a quick assessment on site.

Measuring a target gas through the sampling lines

Every station must have a spare line for each sampling level.

Either your spare and main lines are already connected at the top, either you will need to do it for the test. Of course, be mindful of the leaks when connecting the two lines. On your way up and down, try to observe the lines for any signs of wear.

Once they are connected, connect the end of the spare line in the shelter to your test gas cylinder. Open the cylinder, then open the pressure regulator in order to match the flow and/or pressure observed for ambient air at this level.

Measure your gas for at least 30 minutes. Depending on the height of your sampling level after 30 minutes, H_2O may be still above 0.1%. If you can sample for longer, wait until the sample is as dry as for the shelter test. If you cannot, use the instrument test report to assess the H_2O induced bias. On a Picarro, zoom in on the last 5 minutes and note the average value for each species for the target.

Do the test for each line.

If there is a significant bias between the first measurement (test gas on the instrument) and the others (after taking the H_2O induced bias into account if necessary), there is a probably a leak.

4. Checking for leaks outside the shelter

If there is a significant bias then follow the next steps to identify the potential leaks.

For CO_2/CH_4/CO instrument: with concentrated CO2

You can purchase pure CO_2 for fish tank that are small and easy to use.

Climb back and pay close attention to the lines to see if there is cut or wear that could cause a leak. Using the bottle, press the nozzle briefly around any fittings outside of the shelter and have someone follow the CO_2 values on the instrument screen. If a peak appears, there is a leak at the stage. If after several tightenings, the leak is still here, you may need to change the connections.

For N_2O/CO instrument: with air duster

For N_2O and CO, you can use air duster in the same way as the CO_2 bottle, except that if there is a leak, you will observe a negative peak.

Example of tables to fill up

Last five minutes of sampling for level ___	CO_2 (ppm)	CH_4 (ppb)	H_2O (%)
Reference			
Factory water correction bias			NA
Intrinsic bias			NA
Shelter			
Shelter bias			NA
Full system (aged lines)			
Full system bias			NA

Level ___	Steady state pressure	Pressure after 20 min, pump off
Pressure (mBar)		