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ICOS – ATC / MLab

ICOS ATC MLab metrological initial tests

ATC-ML-IT-TD-01
Version 1.0

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Introduction

This document details the metrological initial tests performed by ICOS ATC MLab to assess the performance of each instrument taking part in ICOS Atmosphere or associated projects and technology watch.

Applicable documents

ID	Reference	Titre
AD 1	ATC-ML-IT-PR-06	Gas Cylinder and Pressure regulator use
AD 2	ATC-ML-IT-PR-09	Installation of a nafion

Material and Consumables

- 1 multi-position valve fitted with 2 μ filters hereafter called “Valco-box” (air distribution system based on a Valco rotary valve)
- ¼” Dekabon Synflex 1300 tubing (or 1/8” and 1/16” stainless steel tubing)
- 1 ambient air sampling line (ideally flushed with a dedicated pump downstream the analyser sampling point)
- 1 drying unit: 1 cryocooler + 1 Dewar filled with ethanol + 1 glass water trap
- 1 ambient pressure sensor
- 1 ambient temperature sensor
- Leak detection liquid (e.g. “Snoop”)
- 1 Mass flow controller (type Bronkhorst adapted to the instrument flow rate, for example 400 mL/min for Picarro instruments, 2L/min for Los Gatos instruments)
- 1 forward Electronic Pressure Controller (type Bronkhorst with a pressure range of 2 bar and a capacity of 2 L/min).
- 1 water vapour delivery module (VDM Evaporator from Bronkhorst)
- 1 nitrogen cylinder
- 1 cylinder filled with high pressure natural dry air (more than 100 bar), so called “target”
- 1 set of 4 calibration gases. The cylinders must contain different concentrations of the different species measured by the tested analyser. The concentrations must cover the atmospheric background range. For instance, CO₂ concentration should ideally range between 370 and 450 ppm.
- 2 additional calibration cylinders with extreme concentrations (out of the atmospheric background range) of the different species measured by the tested analyser (for instance, 350 and 500 ppm for CO₂).
- 7 pressure regulators (type SCOTT from AirLiquide, model 514C Brass)
- Gas connectors (type Swagelok)

Ambient conditions

Except for the temperature test, the laboratory temperature must be regulated at 22 ± 2 °C. The tests are performed at ambient atmospheric pressure. Make sure that you have a temperature and pressure logger in the laboratory to monitor the ambient conditions during the experiments.

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1. Outlet valve characterization – Internal leak test

For Picarro G2000 instruments, an automatic valve characterization test is performed in addition to an overall leak test.

1.1. Valve characterization (Picarro G2000 only)

To perform this test, the Picarro instrument must be stabilized and measuring indoor wet air. The purpose is to detect leaks inside the instrument before the execution of the performance tests.

Ideally, this test must be done at the reception of the instrument.

The test consists in four steps. The first step is the outlet leak test with the outlet valve closed and the cavity opened to atmospheric pressure. The pressure stability is monitored during 5 minutes once the cavity reaches the atmospheric pressure, the vacuum system being isolated and the cavity closed. The second step consists in determining the effective opening value of the outlet proportional valve (without unit, from 0 closed to 65000 fully open). In the third step, the cavity is first evacuated and then closed for 5 minutes and the pressure is monitored to evaluate the leakage rate. Finally, the last step consists in determining the effective opening value of the inlet proportional valve.

First, open the “Diagnostics” folder on the desktop and select *Stop Instrument*. Choose *Stop software but keep driver running* and click *Stop* then *Yes*. Still in the same folder, select *Integration* then *Integration Mode Switcher*. Choose *Pressure Calibration* and click *Launch*.

Secondly, return to the “Diagnostics” folder, select *Integration* and *Integration Coordinator Launcher*. Select *Valve characterization* then *Launch*. The valve characterization sequence begins and takes approximately 15 minutes.

Once the sequence is finished, return to the “Diagnostics” folder and select *Stop Instrument*. Then, click the *Picarro Mode Switcher* icon on the desktop and choose the appropriate mode (*CFADS* or *CFKADS mode*) then *Launch*.

A diagnostic file has been created with the results in C:\Picarro\G2000\InstrConfig\Integration\ValveCharaterization.

1.2. Internal leak test (only for instrument with external pump)

The test consists in determining the overall leakage rate of the instrument around its nominal pressure.

For Picarro instruments, the outlet valve is closed with the “Controller” software, *Interface* tab, choose *Full* and enter the password *picarro*. Then *Parameters* tab, choose *Sample Handling Parameters*. At the line *Valve controller Mode*, choose *Manual control* and at the line *Outlet valve value*, replace the value by 0. Put a stainless steel 1/4” cap on the inlet of the instrument and click on *Apply* as quickly as possible, in order to maintain a pressure in the cavity close to the nominal one. Check that the outlet valve is closed and then stop the pump. The test ideally takes place over one night (minimum 6 hours). At the end of the test, restart the pump. In the *Sample Handling Parameters* window, line *Valve Controller mode*, choose *Outlet control* and line *Outlet valve value*, replace 0 by 17000 and then click on *Apply*. Remove the cap at the inlet of the instrument and check that the cavity pressure comes back to its nominal value.

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For other instruments like Los Gatos, use 2 valves 2 ways. One valve is connected to the inlet of the instrument and the second to the outlet, before the external pump. The 2 valves are closed simultaneously, ideally over one night (minimum 6 hours), and the pump stopped. At the end of the test, restart the pump and open the 2 valves at the same time and check that the internal pressure comes back to its nominal value.

2. Continuous Measurement Repeatability (CMR) and Short-term stability and drift assessments

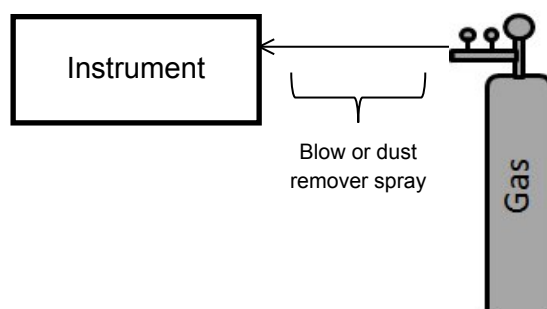
The Continuous Measurement Repeatability and Short-term stability and drift assessments consist in a precision test, measuring a target tank (cylinder filled with dry natural air) during 25 hours. The first hour is not taken into account (stabilization time) and the data distribution is calculated for different integration times. No calibration is applied.

First, connect an 1/4" Synflex tubing to the target cylinder equipped with a pressure regulator. Refer to [AD1] *Gas Cylinder and Pressure Regulator Use*. Open the target cylinder, then open the pressure regulator and set the delivery pressure to about 0.2 bar (g). Flush for a few seconds before connecting the tubing to the instrument inlet.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. For CO₂ instruments, blow around the fittings and follow the CO₂ values on the instrument screen. For other instruments, a dust remover spray can be used. If a peak appears, there is a leak. Moreover, target gas is dry, so if H₂O increases above 0,005%v, it means that there is a leak on the line. If after several tightenings, the leak is still there, you may need to change the connectors or the Synflex line.

Finally, make sure that the principal parameters seem fine. The concentrations displayed must be close to the values of the cylinder. H₂O value must be less than 0,005%v. For Picarro instruments, the outlet valve value must be greater than the nominal value (about 1000 greater). If the outlet valve is too low, increase the delivery pressure on the pressure regulator.

Let the test run during 25 hours.



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3. Short Term Repeatability (STR) assessment

The short-term repeatability consists in the measurement of a target gas for 15 minutes and wet ambient air for 5 minutes alternatively 11 times. The 1st cycle is not taken into account (stabilization) and a mean value is calculated with the last 9 minutes for each period of tank measurement. The result is the dispersion (1σ) of the mean values (10 points). No calibration is applied.

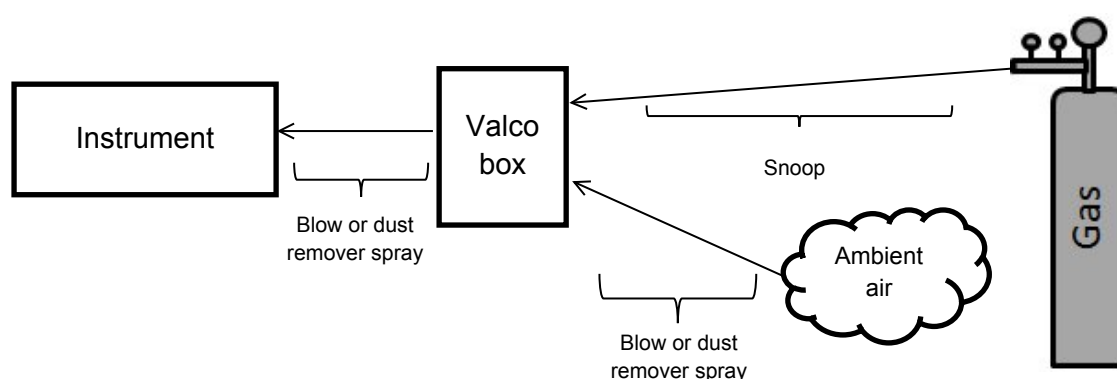
First, connect an ¼" Synflex tubing to the target cylinder equipped with a pressure regulator. Refer to [AD1] *Gas Cylinder and Pressure Regulator Use*. Open the target cylinder, then open the pressure regulator and set the delivery pressure to about 0.2 bar (g). Flush for a few seconds before connecting the tubing to the Valco box. Connect a wet ambient air line to any other unused channel of the Valco box and then switch to this channel.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Use the leak detection liquid *Snoop* to test all pressurized connections: i.e. outlet connection of the pressure regulator and inlet connection of the Valco box. If no bubbles appear after 2 minutes, there is no a leak. Otherwise, most of the time, leaks are due to connections that are not tightened enough. As it is not recommended to tighten a fitting that is under pressure, first close the pressure regulator, drain the pressure in the line and tighten again the suspected fitting. Then reopen the pressure regulator to the recommended pressure (0.2 bar) and check again for leaks.

Connect the Valco box outlet to the instrument inlet with ¼" Synflex tubing. As previously mentioned, it is very important to avoid leaks. Leak detection liquid such as Snoop is only useful to test pressurized fittings. It is not recommended to use the Snoop to test the connections after the Valco valve. Indeed, as the instrument pump sucks the air, there is a risk to introduce Snoop liquid inside the instrument. The best way here is to blow around the fittings and follow the CO₂ values on the instrument screen, for CO₂ instrument or use a dust remover spray. If a peak appears, there is a leak. If after several tightenings, the leak is still there, this might be a sign of potential leak along the sampling line, you may need to change the connectors or the Synflex line itself.

Finally, make sure that the principal parameters seem fine. The concentrations displayed with the target tank must be close to the values of the cylinder. H₂O value must be less than 0,005%v. For Picarro instruments, the outlet valve value must be greater than the nominal value (about 1000 greater). If the outlet valve is too low, increase the delivery pressure on the pressure regulator.

Create a sequence with a sequencer program that consists in 11 cycles where the target gas is measured for 15 minutes and ambient air for 5 minutes alternatively.



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4. Long Term Repeatability (LTR) assessment

The long term repeatability test consists in the measurement of a target gas for 30 minutes and wet ambient air for 270 minutes alternatively over 72 hours. Data processing consists in calculating the mean value of the last 10 minutes for each period of tank measurement.

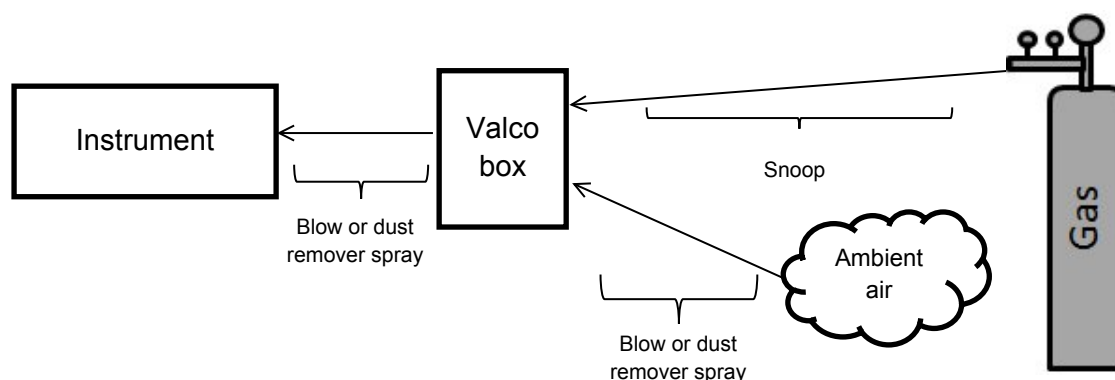
First, connect an ¼" Synflex tubing to the target cylinder equipped with a pressure regulator. Refer to [AD1] *Gas Cylinder and Pressure Regulator Use*. Open the target cylinder, then open the pressure regulator and set the delivery pressure to about 0.2 bar (g). Flush for a few seconds before connecting the tubing to the Valco box. Connect a wet ambient air line to any other unused channel of the Valco box and then switch to this channel.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Use the leak detection liquid *Snoop* to test all pressurized connections: i.e. outlet connection of the pressure regulator and inlet connection of the Valco box. If no bubbles appear after 2 minutes, there is no a leak. Otherwise, most of the time, leaks are due to connections that are not tightened enough. As it is not recommended to tighten a fitting that is under pressure, first close the pressure regulator, drain the pressure in the line and tighten again the suspected fitting. Then reopen the pressure regulator to the recommended pressure (0.2 bar) and check again for leaks.

Connect the Valco box outlet to the instrument inlet with ¼" Synflex tubing. As previously mentioned, it is very important to avoid leaks. Leak detection liquid such as Snoop is only useful to test pressurized fittings. It is not recommended to use the Snoop to test the connections after the Valco valve. Indeed, as the instrument pump sucks the air, there is a risk to introduce Snoop liquid inside the instrument. The best way here is to blow around the fittings and follow the CO₂ values on the instrument screen, for CO₂ instruments or use a dust remover spray. If a peak appears, there is a leak. If after several tightenings, the leak is still there, this might be a sign of potential leak along the sampling line, you may need to change the connectors or the Synflex line itself.

Finally, make sure that the principal parameters seem fine. The concentrations displayed with the target tank must be close to the values of the cylinder. H₂O value must be less than 0,005%v. For Picarro instruments, the outlet valve value must be greater than the nominal value (about 1000 greater). If the outlet valve is too low, increase the delivery pressure on the pressure regulator.

Create a sequence with a sequencer program that consists in the measurement of the target gas for 30 minutes and ambient air for 270 minutes alternatively over 72 hours.



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5. Atmospheric pressure sensitivity

The atmospheric pressure sensitivity is studied using the long term repeatability data (previous test §4.). The mean value of the last 10 minutes is calculated for each period of tank measurement and correlated with atmospheric pressure variation recorded by the pressure logger present in the laboratory.

6. Inlet pressure sensitivity

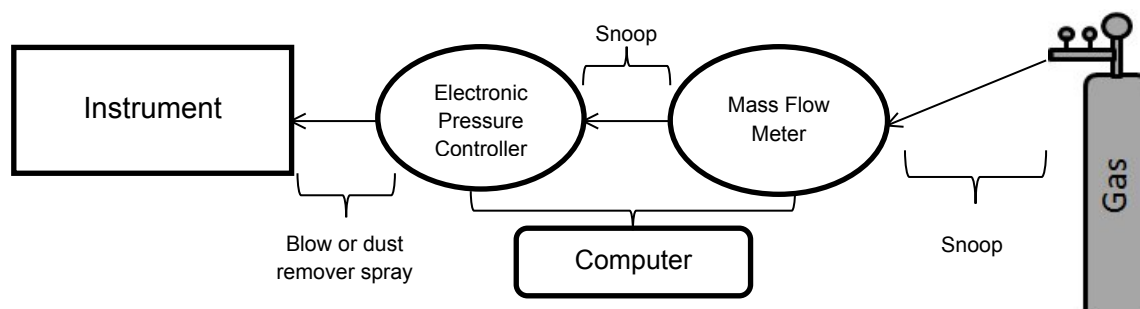
The inlet pressure test is conducted to assess the correlation between the injection pressure of a gas in the instrument and the concentrations measured by this instrument. It consists in the measurement of a target tank through a mass flow meter and an electronic pressure controller at the instrument inlet. The inlet pressure is changed sequentially by step of 30 minutes between 1600 and 300 mbar (a) thanks to the pressure controller. The valid range is evaluated as the range where CO₂ mixing ratios are ± 0.02 ppm or for CO ± 0.2 ppb from the mixing ratio at atmospheric pressure.

First, connect an ¼" Synflex tubing to the target cylinder equipped with a pressure regulator. Refer to [AD1] *Gas Cylinder and Pressure Regulator Use*. Connect the tubing to a Mass Flow Controller (MFC) and an Electronic Pressure Controller (EPC). Connect both controllers to a computer and make sure that they are both open (EPC set at 1 bar and MFC fully open). Open the target, then open the pressure regulator and set the delivery pressure to about 1.6 bar. Flush for few seconds before connecting the outlet of the EPC to the inlet of the instrument, **without filter**, with an ¼" Synflex tubing. Secondly, check for leaks. This step is very important because leaks introduce a bias in the measurement and increase the gas consumption. With the computer, set the target gas pressure with the EPC to 0.3 bar. Use the leak detection liquid *Snoop* to test all pressurized connections: i.e. outlet connection of the pressure regulator, inlet connection of the MFC and between the MFC and the EPC. If no bubbles appear after 2 minutes, there is no a leak. Otherwise, most of the time, leaks are due to connections that are not tightened enough. As it is not recommended to tighten a fitting that is under pressure, first close the pressure regulator, drain the pressure in the line and tighten again the suspected fitting. Then reopen the pressure regulator to the recommended pressure (1.6 bar) and check again for leaks.

For under-pressurized connections (i.e. outlet connection of the EPC and inlet of the instrument) and CO₂ instruments, blow around the fittings and follow the CO₂ values on the instrument screen. For other instruments, a dust remover spray can be used. If a peak appears, there is a leak. Moreover, target gas is dry, so if H₂O increases above 0,005%v, it means that there is a leak on the line. If after several tightenings, the leak is still there, you may need to change the connectors or the Synflex line. Finally, make sure that the principal parameters seem fine. The concentrations displayed with the target tank must be close to the values of the cylinder. H₂O value must be less than 0,005%v. Set the target gas pressure with the EPC to 1.6 bar and wait 30 minutes before starting the inlet pressure test, as stabilization time.

Create a test sequence on the computer which consists in 8 steps of 30 minutes each, with a pressure between 1.6 bar and 0.3 bar by 0.2 bar step, except the last one, 0.1 bar (1.6 / 1.4 / 1.2 / 1.0 / 0.8 / 0.6 / 0.4 / 0.3 bar).

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7. Temperature influence

The temperature influence test is conducted in order to assess the influence of ambient temperature on the instrument measurements. The procedure consists in measuring a target tank for 72 consecutive hours, while setting the room temperature at different levels (low temperature during the night, and high temperature during the day).

First, connect an ¼" Synflex tubing to the target cylinder equipped with a pressure regulator. Refer to [AD1] *Gas Cylinder and Pressure Regulator Use*. Open the target cylinder, then open the pressure regulator and set the delivery pressure to about 0.2 bar (g). Flush for a few seconds before connecting the tubing to the instrument inlet.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. For CO₂ instruments, blow around the fittings and follow the CO₂ values on the instrument screen. For other instruments, a dust remover spray can be used. If a peak appears, there is a leak. Moreover, target gas is dry, so if H₂O increases above 0,005%v, it means that there is a leak on the line. If after several tightenings, the leak is still there, you may need to change the connectors or the Synflex line.

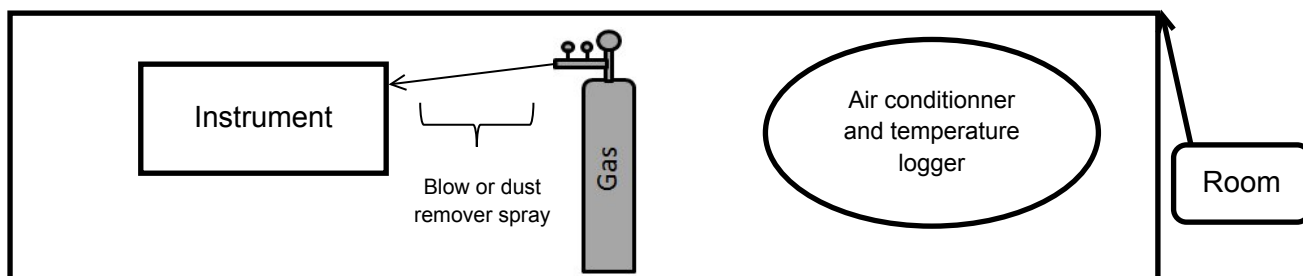
Finally, make sure that the principal parameters seem fine. The concentrations displayed must be close to the values of the cylinder. H₂O value must be less than 0,005%v. For Picarro instruments, the outlet valve value must be greater than the nominal value (about 1000 greater). If the outlet valve is too low, increase the delivery pressure on the pressure regulator.

Keep measuring the target tank during 72 hours and change the room temperature as follow:

- 1st half day and night, 22°C
- 2nd day, 32°C
- 2nd night, 16°C
- 3rd day, 24°C
- 3rd night, 16°C
- 4th half day, 22°C

Make sure that you have a temperature logger next to the instrument to monitor the temperature during the experiment.

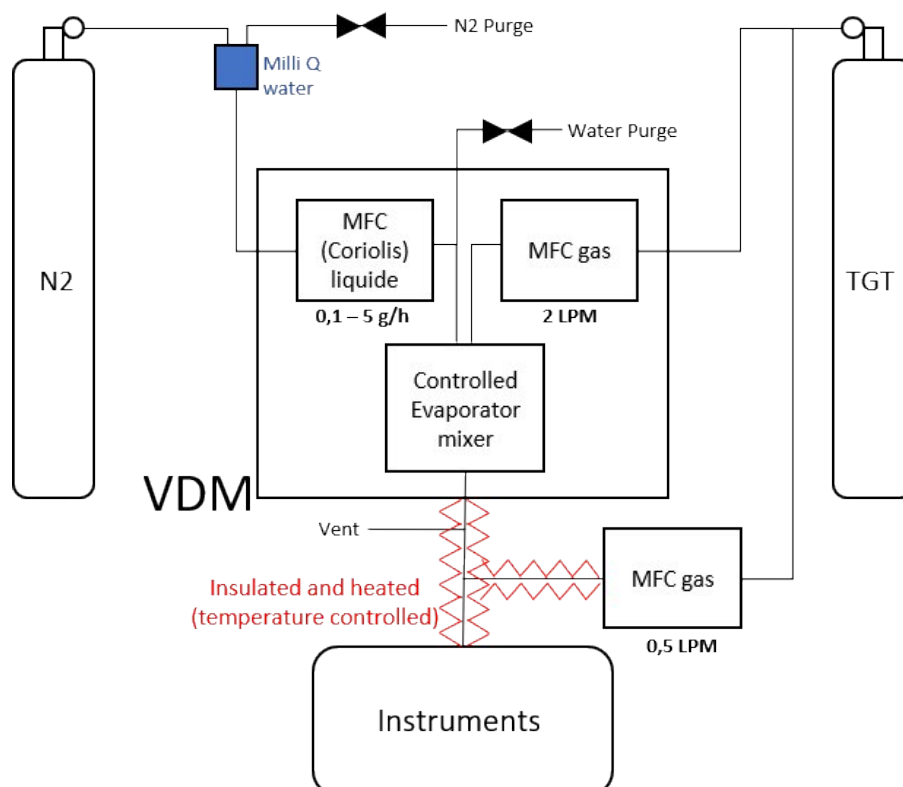
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8. Water vapor correction assessment

The H₂O correction test is conducted in order to check the water vapor correction bias depending on the H₂O level and determine an optimized water vapor correction. The procedure consists in measuring a target gas that will be progressively humidified (0 to 3 g/h). Each step lasts 20 minutes. The test must be performed at least three times. Then 3 more tests must be performed between 0 and 0.5 g/h using the dilution system (MFC gas outside the VDM).

Fill the water container with deionized water. Then, as shown on the figure, connect the nitrogen cylinder to the bench with ¼" Synflex tubing. Refer to [AD 1] *Gas Cylinder and Pressure Regulator Use*. Open the nitrogen cylinder valve and the pressure regulator. Set the delivery pressure to ~1,8 bar(g). To purge the line, slightly open the valve after the water container during 30 seconds (if air bubbles are present in the water container, keep purging until they disappear). Afterwards, close the valve and connect the target cylinder to the VDM with ¼" Synflex tubing. Open the cylinder and the pressure regulator, and set the delivery pressure to about 1.4 bar(g).



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Secondly, connect the VDM to the inlet of the instrument using the principal transfer line. The transfer line is an inox flexible with a central PTFE tube wrapped in a heat transfer line. A potentiometer has to be used in order to avoid overheating the lines and damaging components. The test can be conducted on two instruments at the same time, you just need to add a T-shaped connector. It is very important to let a vent after the VDM as it runs with 1L/min of target (more than the instruments flow rate) and in order to keep the pressure in the cavity of the instrument stable even at the end of the test. Next, connect the VDM to a PC.

Finally, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Use the leak detection liquid *Snoop* to test all pressurized connections: i.e. outlet connection of pressure regulator and inlet connection of the VDM.

If no bubbles appear after 2 minutes, there is no a leak. Otherwise, most of the time, leaks are due to connections that are not tightened enough. As it is not recommended to tighten a fitting that is under pressure, first close the pressure regulator, drain the pressure in the line and tighten again the suspected fitting. Then reopen the pressure regulator to the recommended pressure (1.4 bar) and check again for leaks. For under-pressurized connections (i.e. inlet of the instrument) and CO₂ instruments, blow around the fittings and follow the CO₂ values on the instrument screen. For other instruments, a dust remover spray can be used. If a peak appears, there is a leak. Moreover, target gas is dry, so if H₂O increases above 0,005%v, it means that there is a leak on the line.

Make sure that the principal parameters seem fine. The concentrations displayed with the target tank must be close to the values of the cylinder. H₂O value must be less than 0,005%v.

When all the connections are tightened, pack the transfer line in a foam tube in order to maintain a constant heat during the test. Set the line temperature at 40°C to avoid condensation in the principal transfer line.

Create the test sequence on the computer which consists in 10 steps of 20 minutes each, with a H₂O level between 0,25 and 3 g/h by 0.25 g/h step until 2 g/h and then by 0,5 g/h step, after an initial step and with a final step at 0 g/h H₂O during 1h. The test is repeated 3 times.

Duration (min)	H ₂ O level (g/h)
60	0,00
20	0,25
20	0,50
20	0,75
20	1,00
20	1,25
20	1,50
20	1,75
20	2,00
20	2,50
20	3,00
60	0,00

3 more tests must be performed between 0 and 0,5 g/h. The VDM should be set at 0,5 g/h H₂O and the different steps are done with the MFC outside the VDM used for dilution. The sequence consists in 10 steps of 20 minutes each, with a H₂O level between 0,05 and 0,5 g/h by 0,05 g/h step, after an initial step and with a final step at 0 g/h H₂O during 1h.

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Duration (min)	H2O level (g/h)
60	0,00
20	0,05
20	0,10
20	0,15
20	0,20
20	0,25
20	0,30
20	0,35
20	0,40
20	0,45
20	0,50
60	0,00

9. Calibration

The calibration test consists in measuring a set of calibration cylinders, 4 standards filled with known CO₂, CH₄, CO and N₂O concentrations, for 20 minutes alternatively, 4 times. This test is performed each week. The mean value of the last 5 minutes of each cylinder measurement for the last 2 cycles is calculated and a comparison is done between reported values from the instrument and assigned values. The calibration function is determined and the residuals from the calibration fit ($C_{Assigned} - C_{Reported} = f(C_{Assigned})$) are calculated.

First, connect ¼" Synflex tubing to the calibration cylinders. At that moment, the outlet of the Valco box is not connected to the instrument. Refer to [AD 1] *Gas Cylinder and Pressure Regulator Use*. Open the cylinders and open the pressure regulators to set the delivery pressure to about 0.2 bar (g). Flush for a few seconds before connecting each tubing to the Valco box. Then switch to a channel that is not connected to a cylinder.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Use the leak detection liquid *Snoop* to test all pressurized connections: i.e. outlet connection of pressure regulators and inlet connections of the Valco box.

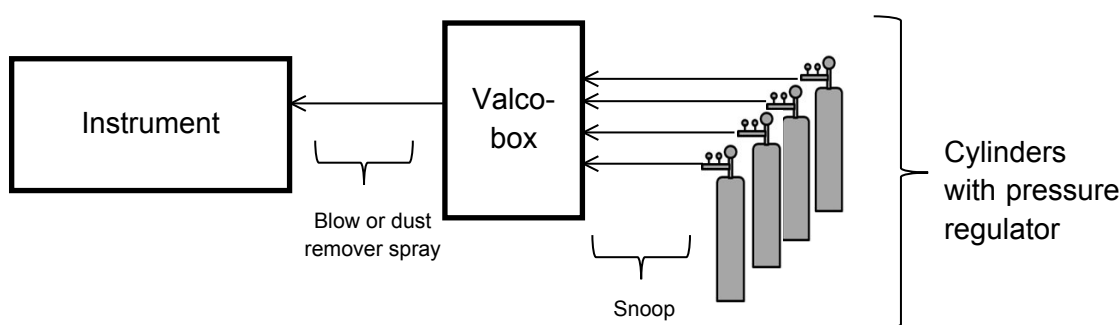
If no bubbles appear after 2 minutes, there is no a leak. Otherwise, most of the time, leaks are due to connections that are not tightened enough. As it is not recommended to tighten a fitting that is under pressure, first close the pressure regulator, drain the pressure in the line and tighten again the suspected fitting. Then reopen the pressure regulator to the recommended pressure (0.2 bar) and check again for leaks.

On the Valco box, select a channel connected to a cylinder and connect the Valco box outlet to the instrument inlet with ¼" Synflex tubing. As previously mentioned, it is very important to avoid leaks. Leak detection liquid such as Snoop is only useful to test pressurized fittings. It is not recommended to use the Snoop to test the connections after the Valco valve. Indeed, as the instrument pump sucks the air, there is a risk to introduce Snoop liquid inside the instrument. The best way here is to blow around the fittings and follow the CO₂ values on the instrument screen, for CO₂ instruments or use a dust remover spray. If a peak appears, there is a leak. Moreover, calibration gas is dry, so if H₂O increases above 0,005%v, there is a leak. If after several tightenings, the leak is still there, this might be a sign of potential leak along the sampling line, you may need to change the connectors or the Synflex line itself.

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Finally, make sure that the principal parameters seem fine. The concentrations displayed with each calibration tank must be close to the values of the cylinder and H₂O value must be less than 0,005%v. For Picarro instruments, the outlet valve value must be greater than the nominal value (about 1000 greater) for each cylinder. If the outlet valve is too low, increase the delivery pressure on the pressure regulator concerned.

Create a sequence with a sequencer program that consists in the measurement of each calibration gas for 20 minutes successively and repeated 4 times.



10. Linearity

The linearity test consists in measuring a complete set of calibration cylinders, 6 standards filled with known CO₂, CH₄, CO and N₂O concentrations within the range guaranteed by the manufacturer, for 20 minutes alternatively, 5 times. The mean value of the last 10 minutes of each cylinder measurement for the last 2 cycles is calculated.

First, connect ¼" Synflex tubing to the calibration cylinders. At that moment, the outlet of the Valco box is not connected to the instrument. Refer to [AD 1] *Gas Cylinder and Pressure Regulator Use*. Open the cylinders and open the pressure regulators to set the delivery pressure to about 0.2 bar (g). Flush for a few seconds before connecting each tubing to the Valco box. Then switch to a channel that is not connected to a cylinder.

Secondly, check for leaks. This is very important because leaks introduce a bias in the measurement and increase the gas consumption. Use the leak detection liquid *Snoop* to test all pressurized connections: i.e. outlet connection of pressure regulators and inlet connections of the Valco box.

If no bubbles appear after 2 minutes, there is no a leak. Otherwise, most of the time, leaks are due to connections that are not tightened enough. As it is not recommended to tighten a fitting that is under pressure, first close the pressure regulator, drain the pressure in the line and tighten again the suspected fitting. Then reopen the pressure regulator to the recommended pressure (0.2 bar) and check again for leaks.

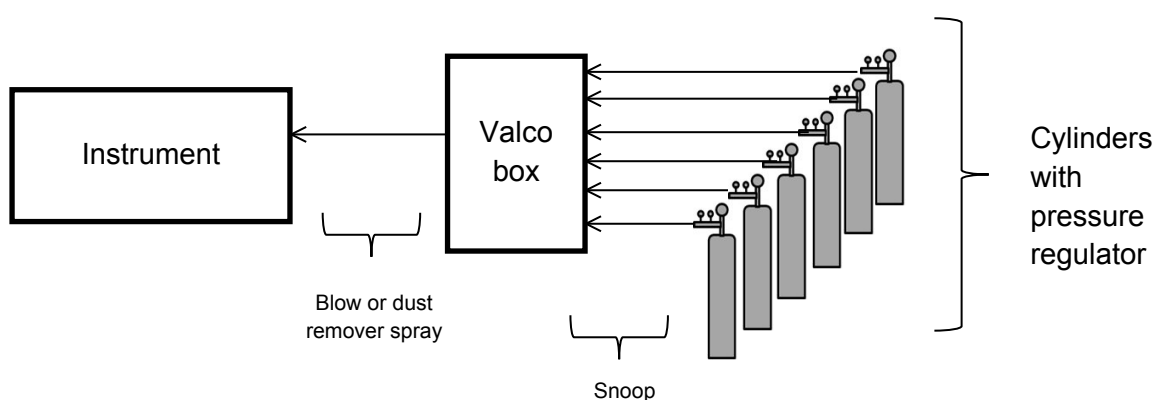
On the Valco box, select a channel connected to a cylinder and connect the Valco box outlet to the instrument inlet with ¼" Synflex tubing. As previously mentioned, it is very important to avoid leaks. Leak detection liquid such as Snoop is only useful to test pressurized fittings. It is not recommended to use the Snoop to test the connections after the Valco valve. Indeed, as the instrument pump sucks the air, there is a risk to introduce Snoop liquid inside the instrument. The best way here is to blow around the fittings and follow the CO₂ values on the instrument screen, for CO₂ instruments or use a dust remover spray. If a peak appears, there is a leak. Moreover, calibration gas is dry, so if H₂O increases above 0,005%v, there is a leak. If after several tightenings, the leak is still there, this might

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be a sign of potential leak along the sampling line, you may need to change the connectors or the Synflex line itself.

Finally, make sure that the principal parameters seem fine. The concentrations displayed with each calibration tank must be close to the values of the cylinder and H₂O value must be less than 0,005%v. For Picarro instruments, the outlet valve value must be greater than the nominal value (about 1000 greater) for each cylinder. If the outlet valve is too low, increase the delivery pressure on the pressure regulator concerned.

Create a sequence with a sequencer program that consists in the measurement of each calibration gas for 20 minutes successively and repeated 5 times.



11. Laboratory inter-comparison

11.1. Without drying system

The laboratory inter-comparison without drying system consists in a long term repeatability (§ 4) performed on the instrument on test without drying system, in parallel with a reference instrument using a cryocooler. The 2 instruments are calibrated against the same set of calibration tanks. They are each equipped with a dedicated sampling line but use the same target gas for quality control.

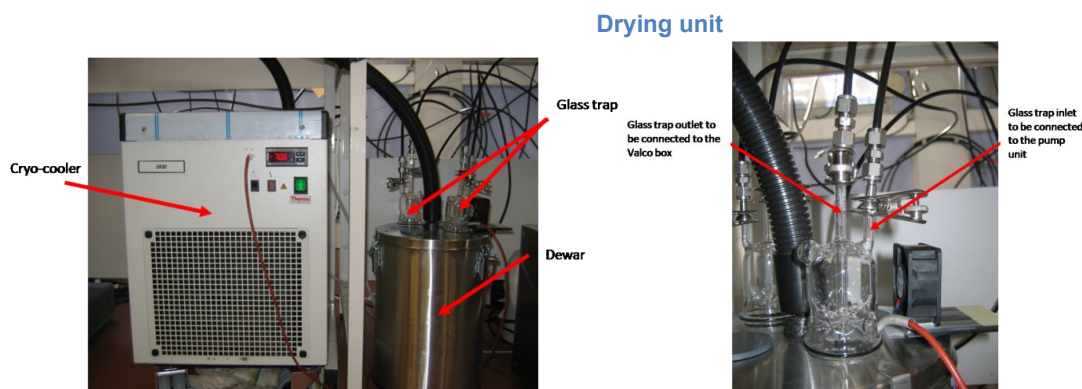
As a reminder, the long term repeatability test consists in the measurement of a target gas for 30 minutes and wet ambient air for 270 minutes alternatively over 72 hours. First, data processing consists in comparing the hourly averaged ambient air data from the two instruments with calibration and factory water vapor correction applied. And, secondly, with the water vapor correction coefficients determined by ATC.

11.2. With drying system (cryocooler)

This time, a long term repeatability (§ 4) is performed on the instrument on test with a cryocooler, in parallel with a reference instrument using a cryocooler too. The 2 instruments are calibrated against the same set of calibration tanks. They are each equipped with a dedicated sampling line but use the same target gas for quality control.

A cryocooler is used to cool an ethanol bath in a Dewar at -60 °C. Circulating the air through a glass trap that is immersed in the ethanol bath has for effect to remove the humidity that is naturally present in ambient air.

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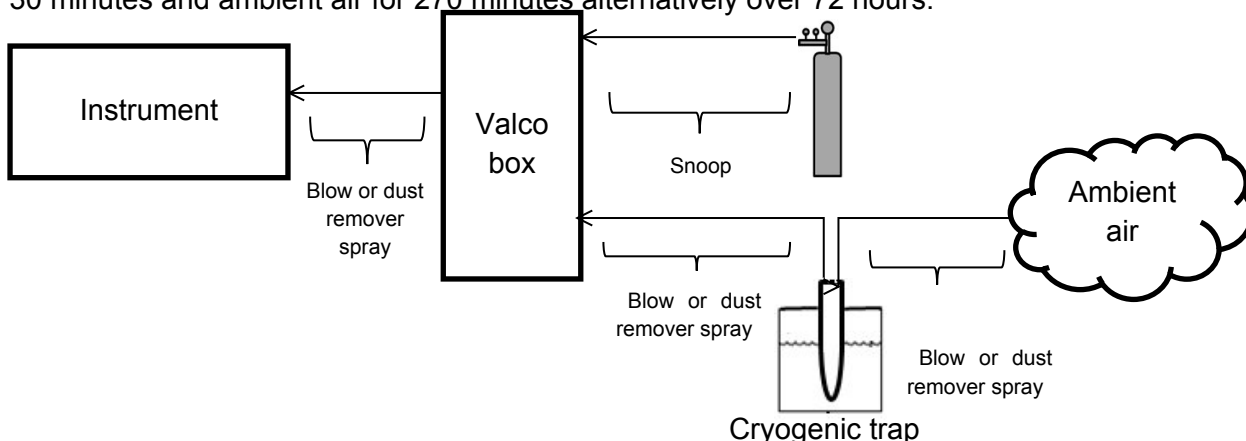


Check the temperature of the ethanol bath. It must be around -60°C . Immerse a new glass trap in the ethanol bath. Be careful: the glass trap must be completely dry (no residual liquid water, it might clog the trap). Connect the ambient air line to the glass trap. There are two inlets on the glass trap. You must connect the ambient air line to the one which corresponds to the larger volume. The other end has to be connected to any unused channel of the Valco box.

Check for leaks. For under-pressurized connections (i.e. ambient air line) and CO_2 instruments, blow around the fittings and follow the CO_2 values on the instrument screen. For others instruments, a dust remover spray can be used. If a peak appears, there is a leak. Moreover, the ambient air after the glass trap must be 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 there, you may need to change the connectors or the Synflex line.

Finally, make sure that the principal parameters seem fine and H_2O value must be less than $0,005\%v$.

Create a sequence with a sequencer program that consists in the measurement of the target gas for 30 minutes and ambient air for 270 minutes alternatively over 72 hours.



11.3. With drying system (Nafion MD-070-144)

This time, a double long term repeatability (§ 4) is performed ($2 \times 72\text{h}$) on the instrument on test with a nafion, in parallel with a reference instrument using a cryocooler. The 2 instruments are calibrated against the same set of calibration tanks. They are each equipped with a dedicated sampling line but use the same target gas for quality control.

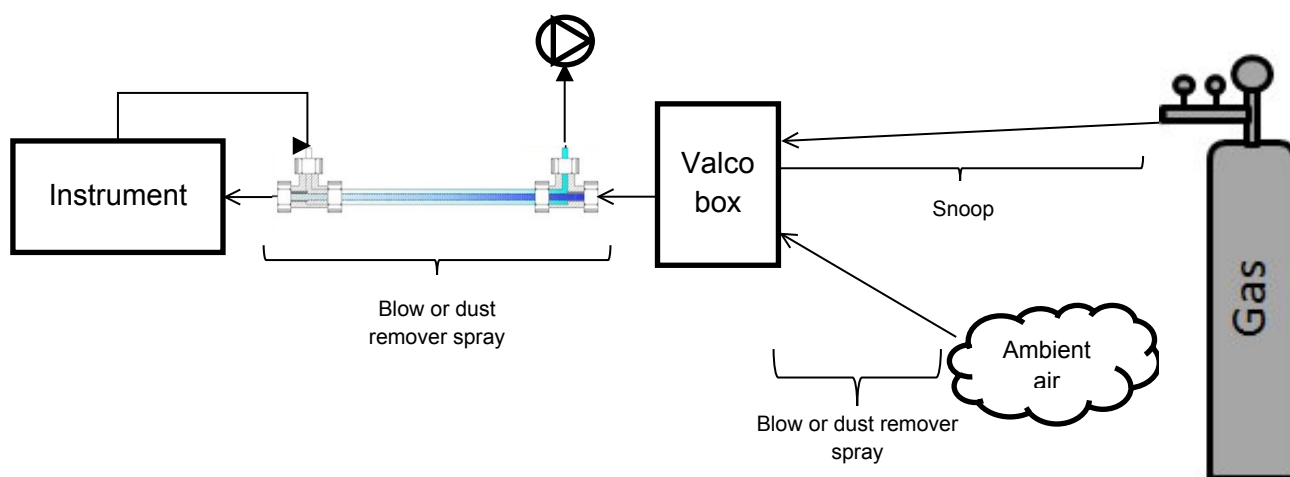
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Refer to [AD 2] *Installation of a nafion*, to install a nafion between the outlet of the Valco box and the inlet of the instrument.

Check for leaks. For under-pressurized connections (i.e. ambient air line and after the Valco box) and CO₂ instruments, blow around the fittings and follow the CO₂ values on the instrument screen. For other instruments, a dust remover spray can be used. If a peak appears, there is a leak. Moreover, the ambient air after the nafion must be pretty dry, so if H₂O increases above 0,2%v, it means that there is a leak on the line. If after several tightenings, the leak is still there, you may need to change the connectors or the Synflex line.

Finally, make sure that the principal parameters seem fine and H₂O value must be less than 0,2%v.

Create a sequence with a sequencer program that consists in the measurement of the target gas for 30 minutes and ambient air for 270 minutes alternatively over 2 x 72 hours.



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