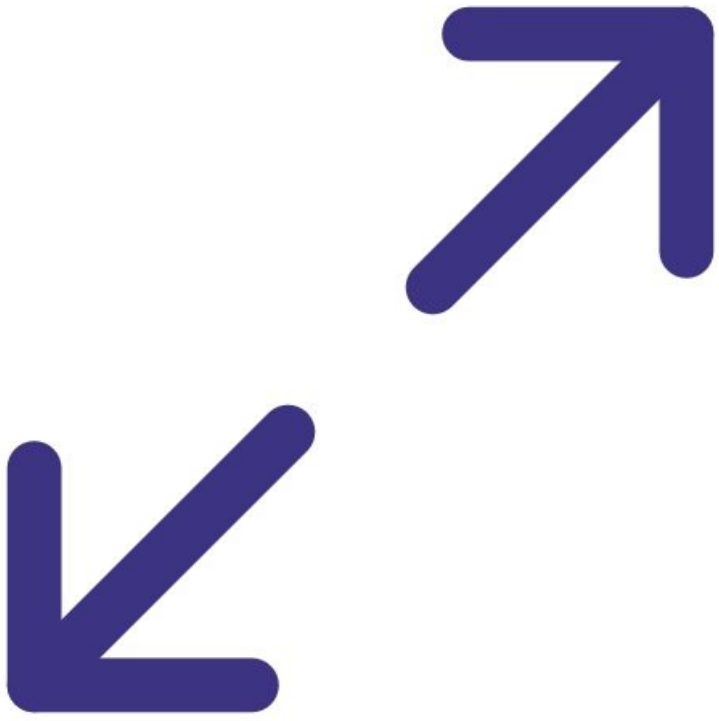
4. Perform span calibration (all modules except CO2 and O3)

Written By: Tanya Taylor



INTRODUCTION

Span calibration should only be performed on modules that've been successfully zero calibrated.

It is performed module by module, one at a time. Each gas module takes between 20 and 40 minutes to calibrate with span gas. Gains are applied using either the **Manual Entry** or the **Calibration** areas of the **Calibration and Service** app.

If you have an AQS 1, use this procedure to span calibrate your NO_2, CO and VOC gas modules. If you have an AQM 65, use it to span calibrate your NO_2, NOx, SO_2, CO, H_2S and VOC gas modules.

If your monitor uses the O_x/O_3 system to measure NO_2, you can also use this guide to span calibrate your Ox module. Note: For monitors using the O_x/O_3 system, you must calibrate the Ox and O3 before any other modules.

The sensors in Aeroqual's gas modules require oxygen to operate correctly. Gas modules can be span calibrated from gas cylinders in a balance of air to achieve this. Gas cylinders in a balance of N_2 can only be used when diluted with air. A dilution ratio of 50x is sufficient for most applications. The Aeroqual AirCal1000's inbuilt zero-air generator can achieve this as it uses scrubbed ambient air as it's zero-air source.

We recommend you leave any failed modules running in the monitor throughout the zero and span calibration process. After you've calibrated the remaining modules, you can open the door to the monitor and remove the failed modules for inspection.

This procedure assumes you are familiar with how to operate the AirCal 1000.

To understand how often you should perform this service activity, click here.

There is no specific recommended span concentration for each gas module.
The calibration engineer should choose a span gas concentration which best suits their calibration needs: Two possible approaches to choosing a span gas concentration are:

1. A span gas concentration can be chosen which best represents the concentrations expected at the measuring site.
2. A span gas concentration can be chosen which is at 80 % of the full measurement range of the module. This is an approach specified by some manufactures and is written in to the standard operating procedures of some municipal monitoring networks based on reference monitoring equipment.

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For example: At your measurement location the range of CO concentrations measured are between 1 and 8 ppm with an average of 4 ppm. You might choose to calibrate the CO module at 5 ppm which in the middle of the expected measurement range and just above the average expected concentration. Or you might just calibrate the CO module at 20 ppm which is 80 % of the full range (0 to 25 ppm).

TOOLS:

- Adjustable spanner (1)

PARTS:

- AirCal 1000 portable calibrator (1)
- Calgaz gas cylinders (1)
- Gas regulator (1)

Step 1 — Assumptions



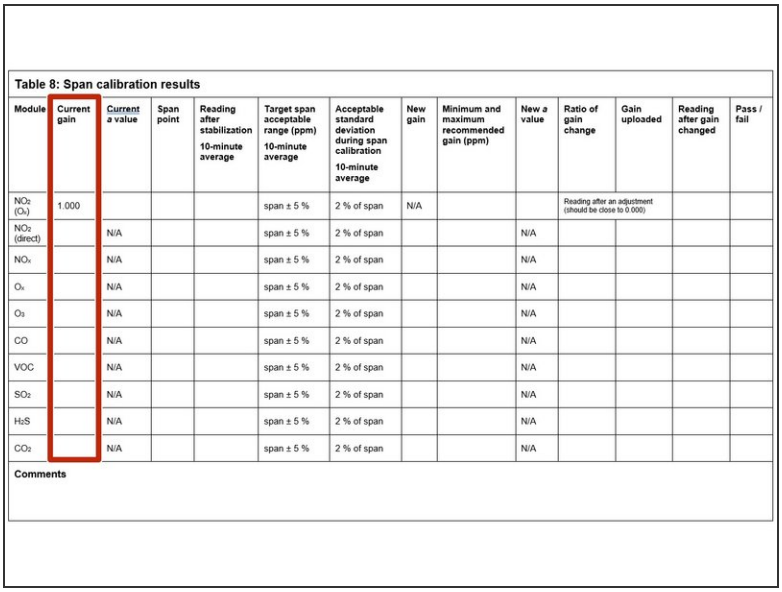


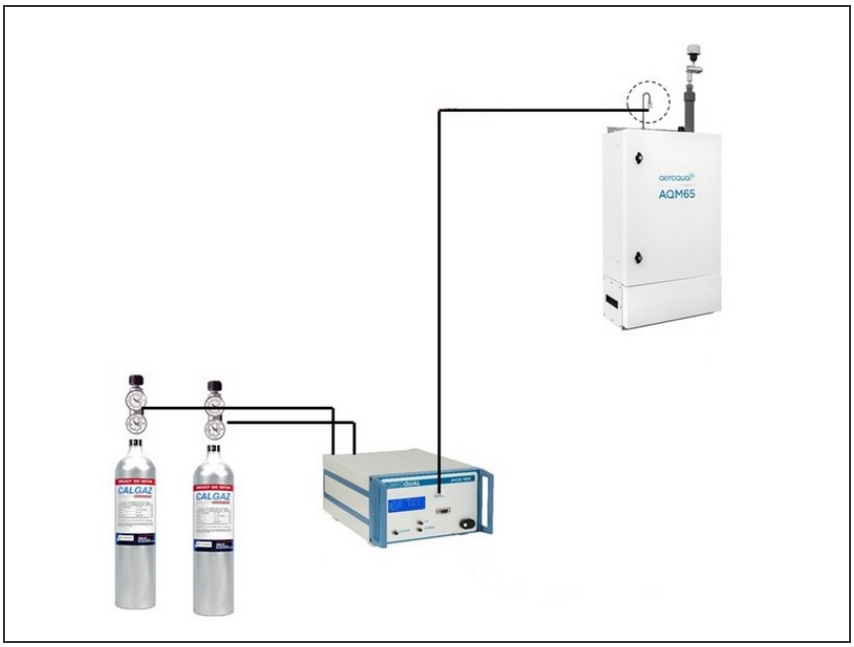
Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_x)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				

Comments

- This guide assumes:
  - You've already done a zero calibration and the AirCal 1000 is warmed up and stable.
  - The AirCal 1000 is already connected to the gas inlet via a 3-way tee that is open (uncapped) on one side.
  - You've got the correct gas cylinders with gas concentrations that suit your calibration needs. For gas cylinder guidelines, see here.
- Start by recording the current gains for each gas module in the **Current gain** column in table 8 of the calibration form.
  - ⓘ If an Ox module is fitted, NO2 doesn't have a gain adjustment.

Step 2 — Connect cylinders



- Attach (screw on) a gas regulator on to each of your 2 gas cylinders.
- Connect the gas regulators to the gas inlet ports on the back of the AirCal 1000. Use 1/8 inch OD Teflon tubing to make this connection.
- Make sure the connections are leak tight.

Step 3 — Record span point

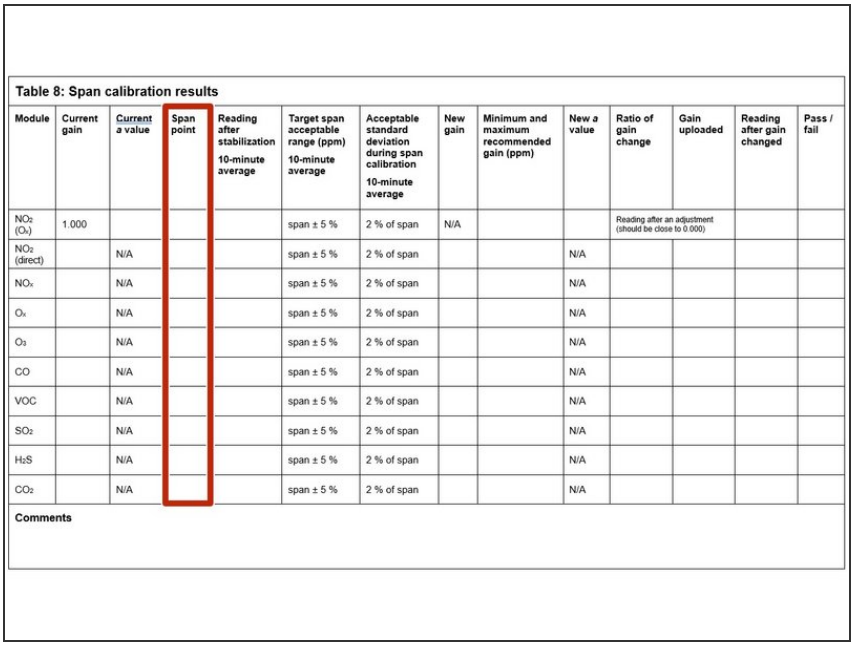


Table 8: Span calibration results

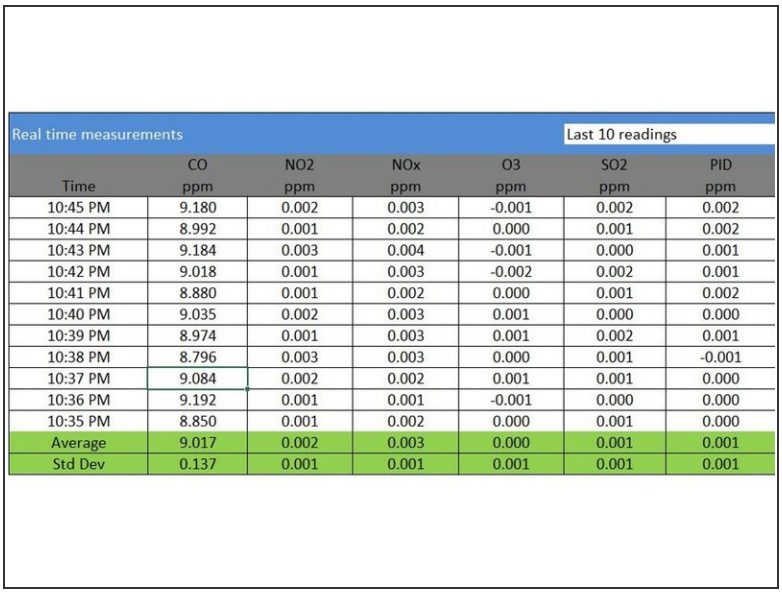
Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_3)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				

Comments

- Start the calibration gas flowing at your chosen span point.
- Make sure there is excess flow out from the tee at the monitor inlet.
- Record your span gas concentrations in the Span point column.

ⓘ You should have also defined this in your calibration run.

Step 4 — Determine stability



Real time measurements — Last 10 readings

Time	CO ppm	NO2 ppm	NOx ppm	O3 ppm	SO2 ppm	PID ppm
10:45 PM	9.180	0.002	0.003	-0.001	0.002	0.002
10:44 PM	8.992	0.001	0.002	0.000	0.001	0.002
10:43 PM	9.184	0.003	0.004	-0.001	0.000	0.001
10:42 PM	9.018	0.001	0.003	-0.002	0.002	0.001
10:41 PM	8.880	0.001	0.002	0.000	0.001	0.002
10:40 PM	9.035	0.002	0.003	0.001	0.000	0.000
10:39 PM	8.974	0.001	0.003	0.001	0.002	0.001
10:38 PM	8.796	0.003	0.003	0.000	0.001	-0.001
10:37 PM	9.084	0.002	0.002	0.001	0.001	0.000
10:36 PM	9.192	0.001	0.001	-0.001	0.000	0.000
10:35 PM	8.850	0.001	0.002	0.000	0.001	0.000
Average	9.017	0.002	0.003	0.000	0.001	0.001
Std Dev	0.137	0.001	0.001	0.001	0.001	0.001

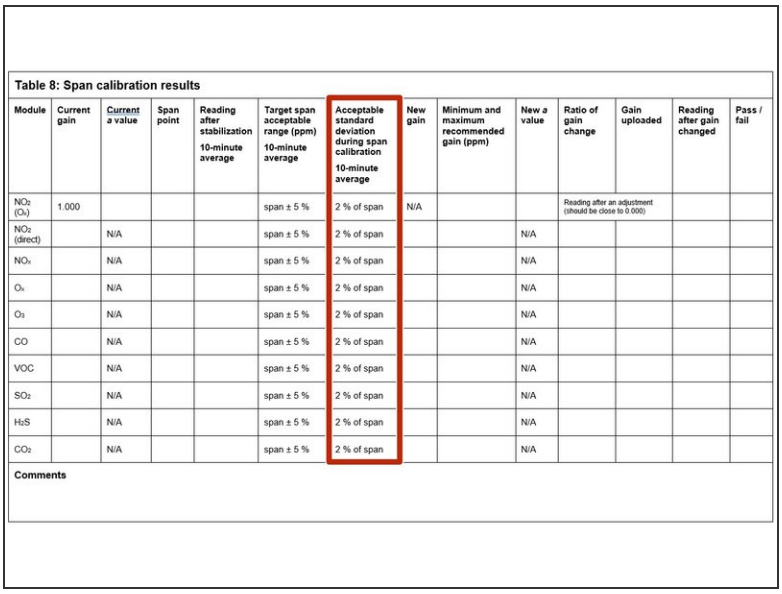


Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_3)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				

Comments

- Wait 30 to 40 minutes for the module readings to stabilize towards span air.
- To determine if stabilization is successful:
  - Look at the standard deviation over a ten-minute period in the **Manual Entry** (shown) or **Calibration** areas of the **Calibration and Service** app.
  - See if they fall within the acceptable range listed in the **Acceptable standard deviation during span calibration** column of your calibration form.

Step 5 — Determine need for adjustment

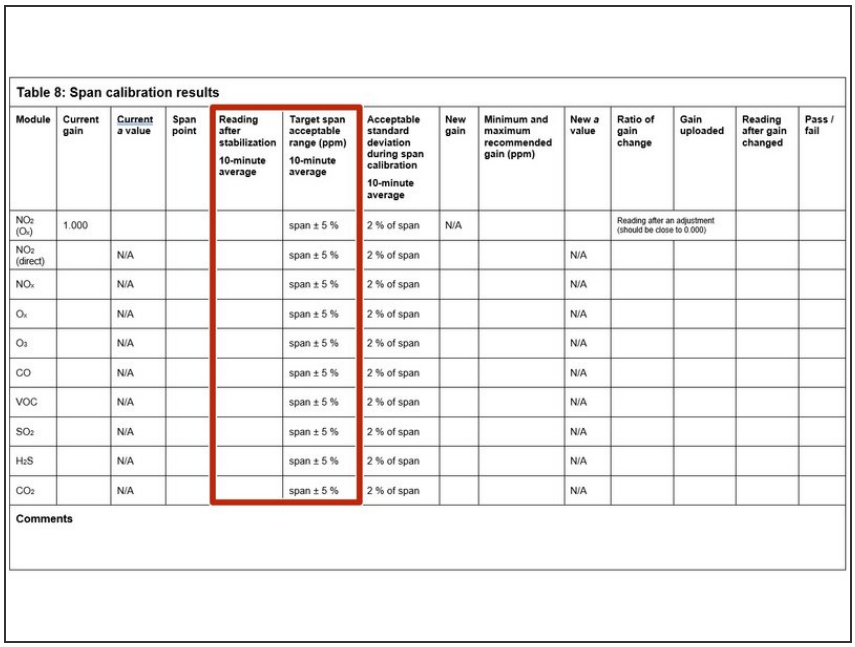


Table 8: Span calibration results

Module	Current gain	Current *a* value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New *a* value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_x)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				

Comments

- Record the stabilized reading from the 10-minute average in the **Reading after stabilization** column.
- If the stabilized value is within the accepted range (see **Target span acceptable range** column), no gain adjustment is needed. Write *pass* in the **Pass** / **fail** column and move on to next module.
- If the stabilized value is outside the accepted range, you need to make a gain adjustment.

Step 6 — Manually calculate gain

New gain = current gain x (span concentration / gas reading)

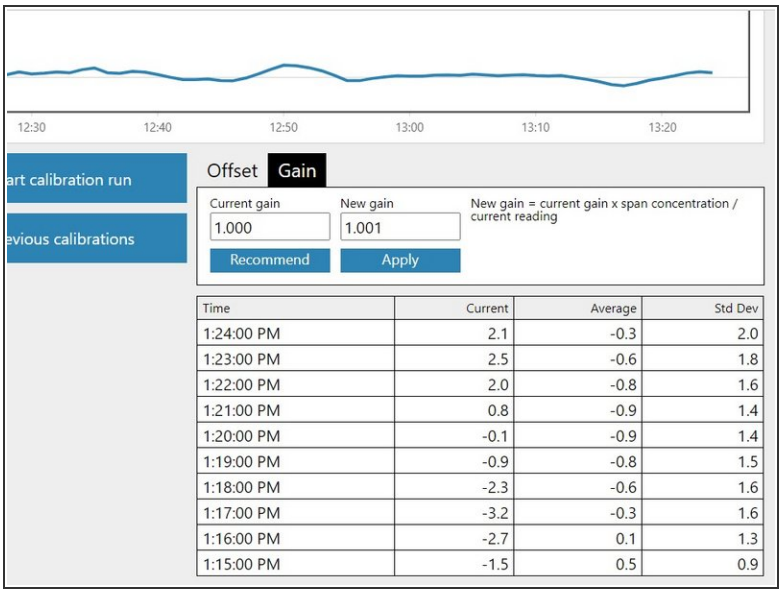
Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_3)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				

Comments

- If you're using the **Manual Entry** area to upload gain adjustments, you need to calculate your new gain using the equation shown.
- To make the calculation, you need to know the:
  - Current gain
  - Span gas concentration
  - Gas module reading
- Record the calculated gain in the **New gain** column.

Step 7 — Automatically calculate gain



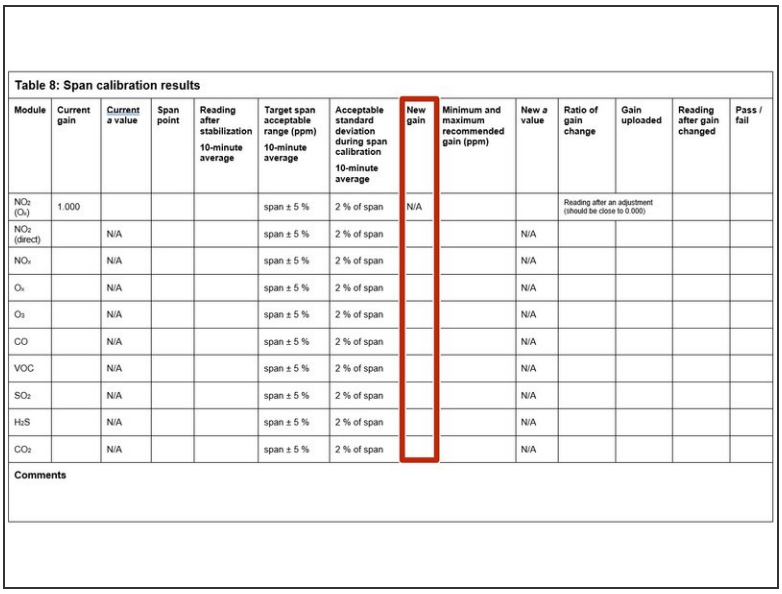


Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_3)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				

Comments

- If you're using the **Calibration** area to upload gain adjustments, select the correct gas channel and click the **Recommend** button to calculate the gain for your selected gas.
- Record the calculated gain in the **New gain** column.
- To learn more about the functionality in the **Calibration** area, go here.

Step 8 — Apply gain adjustment

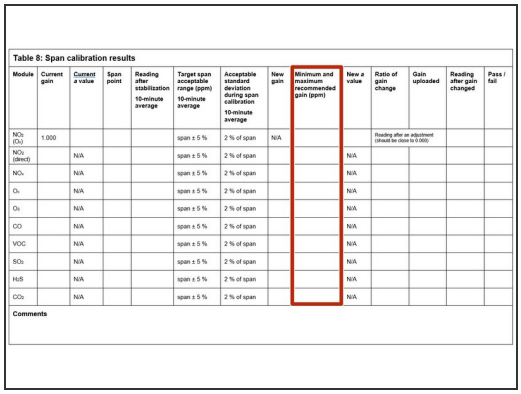
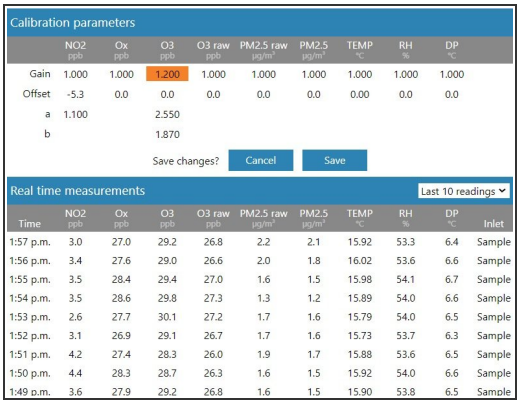


Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NOx (Ox)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment should be close to 0.000			
NO2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NOx		N/A			span ± 5 %	2 % of span			N/A				
O3		N/A			span ± 5 %	2 % of span			N/A				
O3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO2		N/A			span ± 5 %	2 % of span			N/A				
H2S		N/A			span ± 5 %	2 % of span			N/A				
CO2		N/A			span ± 5 %	2 % of span			N/A				

Comments



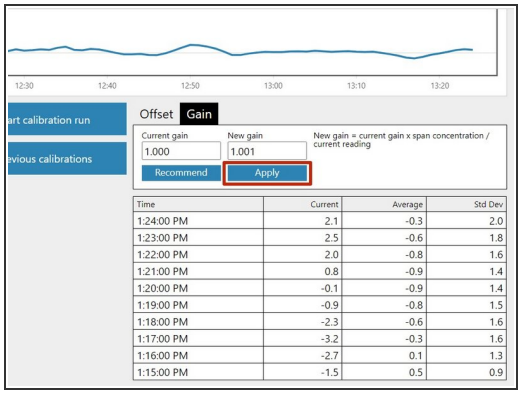
Calibration parameters

	NO2 ppb	Ox ppb	O3 ppb	O3 raw ppb	PM2.5 raw µg/m³	PM2.5 µg/m³	TEMP °C	RH %	DP °C
Gain	1.000	1.000	1.200	1.000	1.000	1.000	1.000	1.000	1.000
Offset	-5.3	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0
a	1.100		2.550						
b			1.870						

Save changes? Cancel Save

Real time measurements — Last 10 readings

Time	NO2 ppb	Ox ppb	O3 ppb	O3 raw ppb	PM2.5 raw µg/m³	PM2.5 µg/m³	TEMP °C	RH %	DP °C	Inlet
1:57 p.m.	3.0	27.0	29.2	26.8	2.2	2.1	15.92	53.3	6.4	Sample
1:56 p.m.	3.4	27.6	29.0	26.6	2.0	1.8	16.02	53.6	6.6	Sample
1:55 p.m.	3.5	28.4	29.4	27.0	1.6	1.5	15.98	54.1	6.7	Sample
1:54 p.m.	3.5	28.6	29.8	27.3	1.3	1.2	15.89	54.0	6.6	Sample
1:53 p.m.	2.6	27.7	30.1	27.2	1.7	1.6	15.79	54.0	6.5	Sample
1:52 p.m.	3.1	26.9	29.1	26.7	1.7	1.6	15.73	53.7	6.3	Sample
1:51 p.m.	4.2	27.4	28.3	26.0	1.9	1.7	15.88	53.6	6.5	Sample
1:50 p.m.	4.4	28.3	28.7	26.3	1.6	1.5	15.92	54.0	6.6	Sample
1:49 p.m.	3.6	27.9	29.2	26.8	1.6	1.5	15.90	53.8	6.5	Sample



12:30 12:40 12:50 13:00 13:10 13:20

art calibration run

evious calibrations

Offset Gain

Current gain 1.000 New gain 1.001 New gain = current gain x span concentration / current reading

Recommend Apply

Time	Current	Average	Std Dev
1:24:00 PM	2.1	-0.3	2.0
1:23:00 PM	2.5	-0.6	1.8
1:22:00 PM	2.0	-0.8	1.6
1:21:00 PM	0.8	-0.9	1.4
1:20:00 PM	-0.1	-0.9	1.4
1:19:00 PM	-0.9	-0.8	1.5
1:18:00 PM	-2.3	-0.6	1.6
1:17:00 PM	-3.2	-0.3	1.6
1:16:00 PM	-2.7	0.1	1.3
1:15:00 PM	-1.5	0.5	0.9

- If the new gain is within the accepted range (see the **Minimum and maximum recommended gain** column), you can upload your new gain.
  - If you're using the **Manual Entry** area, click the appropriate cell, type in the new value and click **Save**.
  - If you're using the **Calibration** area, simply click the **Apply** button.
  - ⓘ It might take several minutes for the gain to be applied and to see the changed readings.
- If the new gain is outside the accepted range, don't upload the gain. Write *fail* in the **Pass / fail** column and move on to next module.

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Step 9 — Calculate ratio of gain change

Gain change ratio = new gain / current gain

Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_x)	1.000				span ± 5 %	2 % of span	N/A			Reading after a (should be clos	adjustment ± 0.000)		
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				
Comments													

- Calculate and record the ratio of the gain change using the equation shown.
- Record the ratio in the **Ratio of gain change** column.

Step 10 — Record applied gain

Table 8: Span calibration results

Module	Current gain	Current a value	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm) 10-minute average	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New a value	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO_2 (O_x)	1.000				span ± 5 %	2 % of span	N/A			Reading after a (should be clos	adjustment ± 0.000)		
NO_2 (direct)		N/A			span ± 5 %	2 % of span			N/A				
NO_x		N/A			span ± 5 %	2 % of span			N/A				
O_x		N/A			span ± 5 %	2 % of span			N/A				
O_3		N/A			span ± 5 %	2 % of span			N/A				
CO		N/A			span ± 5 %	2 % of span			N/A				
VOC		N/A			span ± 5 %	2 % of span			N/A				
SO_2		N/A			span ± 5 %	2 % of span			N/A				
H_2S		N/A			span ± 5 %	2 % of span			N/A				
CO_2		N/A			span ± 5 %	2 % of span			N/A				
Comments													

- Record the offset you uploaded in the **Gain uploaded** column.
- Wait 2 or 3 minutes then record the current reading in the **Reading after gain changed** column.
- Confirm the reading is within acceptable limits. If yes, write *pass* in the **Pass** / **fail** column. If not, write *fail*.
- Move on to next module.

Step 11 — Purge gas lines



- Deliver zero air for 10 minutes to purge (clean) the gas lines.
- Move on to next module.

For further support, contact Technical Support.