



Perform Direct Span Calibration

Perform a direct span calibration from the gas bottle.

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INTRODUCTION

Span calibration should only be performed on modules that've been successfully zero calibrated. Span calibration can be performed either via dilution calibration using higher concentration gases or direct calibration using bottled gas at your desired calibration concentration. This set of instructions covers **direct calibration**.

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** page.

This procedure can be used for either AQS1 or AQM65 instruments.

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.

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.

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.

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)
- [9/16 Spanner](#) (1)



PARTS:

- [ACC R43 Calibration Kit](#) (1)
- [17 oz \(500ml\) of Water](#) (1)

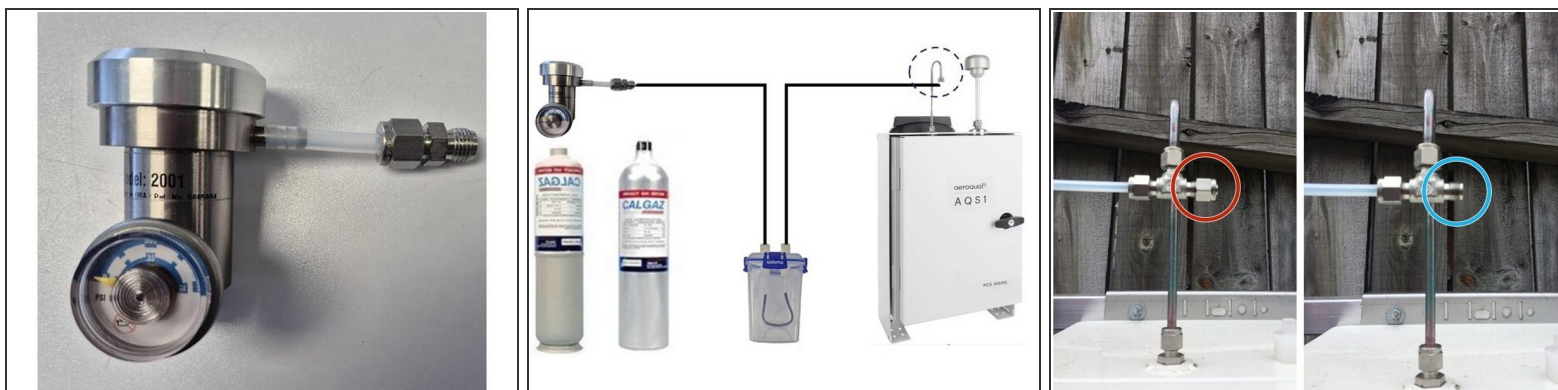
Step 1 — Assumptions



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 ₂)	1.000				span ± 5 %	2 % of span	N/A			Reading after an adjustment (should be close to 0.000)			
NO ₂ (direct)					span ± 5 %	2 % of span			N/A				
NO _x		N/A			span ± 5 %	2 % of span			N/A				
O ₂		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 ₂ S		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.
 - You've got the correct gas cylinders with gas concentrations that suit your calibration needs.
- Start by recording the current gains for each gas module in the **Current gain** column in table 8 of the calibration table.

Step 2 — Connect flow regulator



- If not already fitted, connect 5cm of tubing with Swaglok union to your flow regulator.
- Connect your flow regulator to your gas cylinder.
- Remove the Kynar fitting (inlet mesh filter) from the monitor's gas inlet.
- Connect the 3-way tee to the inlet.
- Add 17oz(500ml) of water to the humidifier.
- Connect the two lengths of ¼" Teflon tubing to the humidifier. One tube goes to the flow regulator, the other to the tee.
- If you're using a demand flow regulator, close (cap) the other side of the tee.
- If you're using a fixed or adjustable flow regulator, add a length of tubing to the other side of the tee to exhaust the excess gas away from you.

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 ₂)	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 ₂ S		N/A			span ± 5 %	2 % of span			N/A				
CO ₂		N/A			span ± 5 %	2 % of span			N/A				
Comments													

- Open the regulator and start supplying gas at your chosen span point. For fixed and variable regulators make sure excess flow is coming out of the exhaust tubing.
- Record your span gas concentrations in the **Span point** column.

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 ₂)	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 ₃		N/A			span ± 5 %	2 % of span			N/A				
O ₂		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 ₂ S		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 table.

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 ₂)	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 ₂ S		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 ₂)	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 ₂ S		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

12:30

12:40

12:50

13:00

13:10

13:20

Start calibration run

Previous calibrations

Offset

Gain

Current gain

New gain

New gain = current gain x span concentration / current reading

1.000

1.001

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

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 ₂)	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 ₂		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 ₂ S		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.

Step 8 — Apply gain adjustment

Table 8: Span calibration results

Module	Current gain	Current span	Span point	Reading after stabilization 10-minute average	Target span acceptable range (ppm)	Acceptable standard deviation during span calibration 10-minute average	New gain	Minimum and maximum recommended gain (ppm)	New span	Ratio of gain change	Gain uploaded	Reading after gain changed	Pass / fail
NO ₂ (DU)	1.000				span ± 5 %	2 % of span	N/A						
NO ₂ (ppb)		N/A			span ± 5 %	2 % of span							
NO _x		N/A			span ± 5 %	2 % of span							
O ₃		N/A			span ± 5 %	2 % of span							
O ₂		N/A			span ± 5 %	2 % of span							
CO		N/A			span ± 5 %	2 % of span							
VOC		N/A			span ± 5 %	2 % of span							
SO ₂		N/A			span ± 5 %	2 % of span							
H ₂ S		N/A			span ± 5 %	2 % of span							
CO ₂		N/A			span ± 5 %	2 % of span							
Comments													

Calibration parameters

	NO ₂ ppb	O _x ppb	O ₃ ppb	O ₃ raw ppb	PM _{2.5} raw µg/m ³	PM _{2.5} µg/m ³	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	0.0	0.0	0.0
a	1.100		2.550						
b			1.870						

Save changes? Cancel Save

Real time measurements Last 10 readings ▼

Time	NO ₂ ppb	O _x ppb	O ₃ ppb	O ₃ raw ppb	PM _{2.5} raw µg/m ³	PM _{2.5} µg/m ³	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

Start calibration run

Previous 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 offset 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

$$\text{Gain change ratio} = \text{new gain} / \text{current gain}$$

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 ₂)	1,000				span ± 5 %	2 % of span	N/A			Reading after 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 ₃		N/A			span ± 5 %	2 % of span			N/A				
O ₂		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 ₂ S		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 ₂)	1,000				span ± 5 %	2 % of span	N/A			Reading after 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 ₃		N/A			span ± 5 %	2 % of span			N/A				
O ₂		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 ₂ S		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.

Step 11 — Purge gas lines



- Close your regulator and disconnect the gas cylinder. Connect a cylinder of zero air and flow air for 10 minutes to purge (clean) the gas lines.
- Move on to span calibrating the next module if required.

For further support, contact Aeroqual Support.