THE DOG THAT TROTS ABOUT FINDS A BONE: HOW TO CERTIFY THE MASS FLOW CONTROLLER OF THE THERMO 146I GAS DILUTION SYSTEM

Rebecca Peltzer
Polk County - Air Quality
Des Moines Iowa
Introduction

- EPA Requirement
- Guide to how a local gal found her trail
- Verification
  - Zero
  - Span
- Calibration
  - Zero
  - Span
CO, NO\textsubscript{X} and SO\textsubscript{2} must have their Gas Dilution Systems evaluated once every 3 months with an accuracy of +/- 2% 

Complications

- Poor instruction manual
- Lack of guidance from EPA
- Up hill battle
The Hesitation

- Pioneer
- As an operator, our motto is if it isn’t broken don’t try to fix it!
Why Persist

- Operating at low levels.
- Proactive to insure accurate data.
- Requirement by EPA
When to Verify

- Measurement Quality Objectives (MQO’s) require once every 3 months
- New – Out of the box
- Following a repair
- Following a calibration
Components Needed

- NIST traceable flow meter
  - Zero Air MFC: DC-Lite 40K BIOS
  - Gas Air MFC: DC-Lite L BIOS
- Zero air generator: Teledyne API 701H
- Temperature gauge
- Pressure gauge
- 9/16” and 7/16” wrenches
Zero Verification Procedure
ZERO MFC (20L)
Zero Verification Set-up
ZERO MFC (20L)

- Power off instrument.
- Disconnect MFC2 from the interface board.
Connect a source of clean, dry air to the zero air inlet on the back of the 146i.
Zero Verification Set-up
ZERO MFC (20L)

- Directly connect the NIST traceable flow meter (40K BIOS) to the Zero Air MFC (20 slpm) with a 9/16” wrench.
Zero Verification Set-up
ZERO MFC (20L)

- With the power back on, press the OPER key.
- Select GAS A.
- Select ZERO gas dilution mode.
Manually adjust **GAS** flow to verification levels of: 90%, 60%, 30%, and 15%.

For a 20 L Calibrator: 18,000 12,000 6,000 and 3,000 sccm respectively.
Turn the NIST traceable flow meter on. Wait until it stabilizes.

Record readings from the flow meter and 146i on the Mass Flow Controller Verification Form.

Note: the calibrator is reading the flow in sccm. Divide by 1000 to convert all units to L.
Once all 4 points are completed, enter the results into the Mass Flow Controller Verification Linear Regression.
Zero Verification Shut Down
ZERO MFC (20L)

- Return GAS A zero air flow back to its previous setting by selecting the OPERATION button and turning Gas and Zero mode to off.
- Turn off instrument and plug the MFC2 back into the interface board.
- Disconnect Flow device and reconnect the fitting to the Zero MFC.
- Turn instrument back on.
If readings are $\leq 2\%$, the verification is complete.

If readings are off by $\geq 2\%$, a calibration must be done on the Zero Air MFC.
Part 1 - target values versus the measured flow

- Zero Mass Flow Controller (20 lpm) is verified at 3000, 6000, 12000, & 18000. The allowable difference is ± 200 sccm.
Part 2

- Set flow 90% full-scale
- Push the Menu button and select DIAGNOSTICS and then FLOWS to view the Zero Actual Readings
- **Actual flow** must be no more than +/- 2% Target Flow
Gas Verification Procedure

GAS MFC (100CCM)
Gas Verification Set-up
GAS MFC (100CCM)

- Turn Off Instrument.
- Disconnect MFC1 from the interface board.
Gas Verification Set-up
GAS MFC (100CCM)

- Connect a source of clean, dry air to the GAS A inlet on the back of the 146i.
Directly connect the NIST traceable flow meter to the Gas MFC (100 sccm) inside the instrument with a 7/16” wrench.
Push the **OPER** button. Select **GAS A**. Scroll to **MANUAL** and press **ENTER**.

Select **ENTER** again and set **GAS A Z FLOW** to 90% (18,000 sccm) and press **ENTER**.
Gas Verification

GAS MFC (100CCM)

- Turn on the NIST traceable flow meter and allow it to stabilize.
- Push the menu button and select DIAGNOSTICS and then FLOWS to view the Gas Actual reading.
- Record readings on the Gas Mass Flow Controller Verification Form.
Select the OPER button again. Toggling back and forth from the OPER button to the MENU button will allow the user to view both actual readings and set readings.

Continue for gas flow settings of 60%, 30%, and 15% of full-scale (12000, 6000 and 3000 respectively).

Once all 4 points are complete, enter the results into the Mass Flow Controller Linear Regression.
Gas Verification Shut Down

GAS MFC (100CCM)

- Turn the GAS off in the OPERATION menu. Put back in STANDBY mode.
- Turn instrument off and plug the MFC1 back into the interface board.
- Disconnect the dry air source.
- Disconnect flow device and reattach fitting to the gas MFC.
EPA Acceptance Criteria

- If readings are $\leq 2\%$, the verification is complete.
- If readings are off by $\geq 2\%$, a calibration must be done on the Gas MFC.
Thermo Acceptance Criteria

Target values versus the measured flow

- Gas Side (100 sccm) Verify at 15%, 30% 60%, 90% full scale ± 1.0 sccm
- If readings are off by ± 1.0 sccm a calibration must be done on the Gas MFC.
Zero Calibration Procedure

ZERO MFC (20L)
Zero Calibration Set-up
ZERO MFC (20L)

Same as Verification:

1) Power off the instrument and disconnect MFC2 from the interface board.

2) Connect a source of clean, dry air to the zero air inlet on the back of the 146i.

3) Directly connect the NIST traceable flow meter to the zero MFC (20 slpm) inside the instrument.
Put 146i in Service Mode.

Once in Service Mode, the Service Menu becomes available.
Calibrate Pressure/Temperature
ZERO MFC (20L)

- Scroll to CALIBRATION PRESS/TEMP and press ENTER.
- Enter the transfer standard barometric pressure and temperature readings.
Zero Calibration Set-up
ZERO MFC (20L)

- Press the **OPER** key.
- Select **GAS A**.
- Select **ZERO** gas dilution mode.
Zero Calibration Set-up
ZERO MFC (20L)

- From the Service Menu, scroll to ZERO FLOW CALIBRATION and press ENTER.
- Select 95% and press ENTER.
Enter the NIST traceable flow reading into the VOL FLOW on the 146i.

Continue for Zero Air settings of 80%, 65%, 50%, 35%, 20% and 5% of full-scale.
Record readings from flow meter and new standard flow readings from 146i on the Mass Flow Controller Calibration Field Sheet

<table>
<thead>
<tr>
<th>Reference</th>
<th>Manufacturer/Model</th>
<th>Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Standard</td>
<td>Oakton Temp 10 T</td>
<td>44124</td>
</tr>
<tr>
<td>Pressure Standard</td>
<td>Cole-Parmer Hand Held Barometer</td>
<td>212</td>
</tr>
<tr>
<td>Zero Air Standard</td>
<td>API 701 H</td>
<td>2925</td>
</tr>
<tr>
<td>Gas Flow Standard</td>
<td>BOC H</td>
<td>1899</td>
</tr>
<tr>
<td>Gas Flow Standard</td>
<td>BOC L</td>
<td>106633</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent</th>
<th>sccm</th>
<th>Blas Limit</th>
<th>Calibrator sccm</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>1000</td>
<td>5%</td>
<td>5.00</td>
</tr>
<tr>
<td>25%</td>
<td>4000</td>
<td>20%</td>
<td>20.00</td>
</tr>
<tr>
<td>35%</td>
<td>7000</td>
<td>35%</td>
<td>35.00</td>
</tr>
<tr>
<td>50%</td>
<td>10000</td>
<td>50%</td>
<td>50.00</td>
</tr>
<tr>
<td>65%</td>
<td>13000</td>
<td>65%</td>
<td>65.00</td>
</tr>
<tr>
<td>80%</td>
<td>14000</td>
<td>80%</td>
<td>80.00</td>
</tr>
<tr>
<td>95%</td>
<td>16000</td>
<td>95%</td>
<td>95.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent</th>
<th>SCCM</th>
<th>Blas Limit</th>
<th>Calibrator SCCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>20.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35%</td>
<td>35.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>50.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65%</td>
<td>65.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td>80.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>95%</td>
<td>95.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Once all points are completed, enter the results into the Mass Flow Controller Calibration Linear Regression.
Zero Flow Calibration Shut Down

ZERO MFC (20L)

Same as Verification:

- Return GAS A zero air flow back to its previous setting by selecting the OPERATION button and turning Gas and Zero mode to off.

- Turn off instrument and plug the MFC2 back into the interface board.

- Disconnect Flow device and reconnect the fitting to the Zero MFC.

- Turn instrument back on.
EPA Acceptance Criteria
ZERO MFC (20L)

- If readings are ≤ 2%, the calibration is complete.
- If readings are ≥ 2%, repeat procedure. If unable to meet technical support.
(Thermo: 866-282-0430)
Gas Calibration Procedure

GAS MFC (100CCM)
Gas Calibration Set-Up
GAS MFC (100CCM)

Same as Verification:
1) Power instrument off and disconnect the MFC1 from the interface board.
2) Connect a source of clean, dry air to the Gas A inlet on the back of the 146i.
3) Directly connect the NIST traceable flow meter to the gas MFC (100 sccm) inside the instrument.
Gas Flow Calibration Set-up
GAS MFC (100CCM)

- Press the OPER key, select Gas A and MANUAL Mode.
- From the Service Menu, Scroll to GAS FLOW CALIBRATION and press ENTER.
- Select Solenoid A.
Select 95% and press ENTER.

Enter the NIST traceable flow reading into the VOL FLOW on the 146i.

Continue for gas flow settings of 80%, 65%, 50%, 35%, 20% and 5% of full-scale.

Once all points are complete, enter results in the MFC Calibration Linear Regression.
If readings are ≤ 2%, the calibration is complete.

If readings are ≥ 2%, repeat procedure. If unable to meet, call technical support.
(Thermo: 866-282-0430)
Gas Calibration Shut Down
GAS MFC (100CCM)

Same as Verification:
- Turn the GAS off in the OPERATION menu. Put in STANDBY mode.
- Turn instrument off and plug the MFC1 back into the interface board.
- Disconnect the dry air source.
- Disconnect flow device and reattach fitting to the gas MFC.

Unique to Calibration:
- Take out of SERVICE mode.
Conclusion

- Hasn’t been an easy task – Black Diamond Run!
- Think we are there to the best of my knowledge.
- Remember to verify after a calibration.
- After instrument passes initial Thermo Criteria from factory stick to EPA Criteria.
Contact Information

Rebecca Peltzer
Polk County Air Quality
Des Moines, IA 50313
515-286-2235
rebecca.peltzer@polkcountyiowa.gov
AND THAT IS HOW IT IS DONE