Testing Volume calibration of leak testers

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Overview

- Importance of calibration
- A crude estimation
- Tygon leak tubes
- Variations on Injection methods
- Conclusions

Importance of calibrations

The CO_2 detectors measure in PPM.

$$PPM = \frac{V_{CO_2}}{V_{chamber}} \times 10^6$$

As we want our values in terms of cm^3/sec

$$Leak_{co_2} = Fit(\Delta PPM) * V_{chamber} \times 10^{-6}$$

It would be useful to get the systematic error of the volume to the 1-2% level, below the error from fitting.

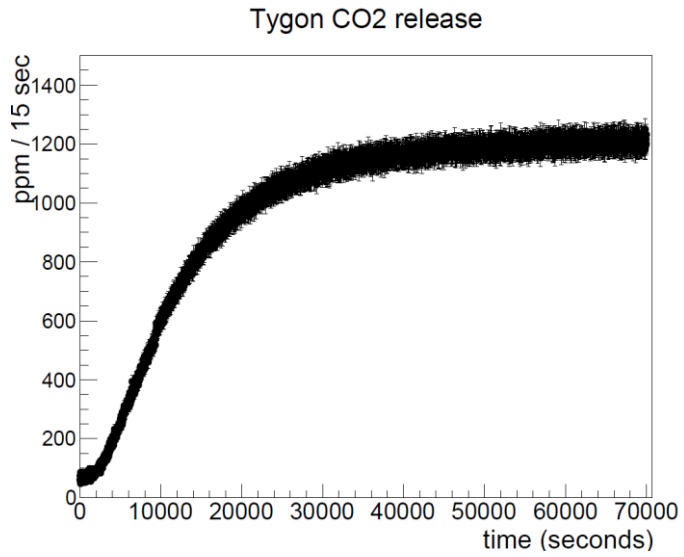
A crude estimate of the Chamber Volume

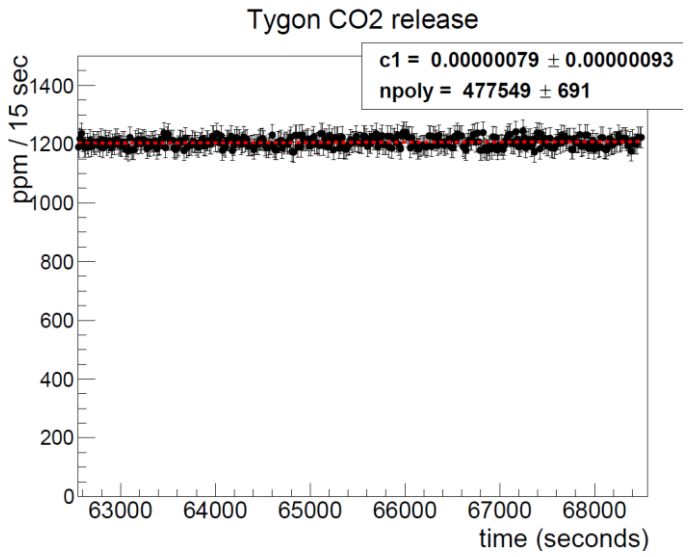
- Pipes : $V_{pipes} = \ell \pi r^2$ = (365cm)$\pi 0.635^2 = 460 \pm 10 cm^3$
- Pipes lengths are different sizes for chambers here.
- Box : ~70 cm^3 with nothing in it → $35 \pm 15 cm^3$
- Plastic tube : when plastic tube is holding straw we subtract $26 \pm 2 cm^3$

Chamber	est. Volume	Volume w/ tube
0	497±18	471±18
1	497±18	471±18
2	472±18	446±18
3	476±18	450±18
4	480±18	454±18

Tygon leak tubes

- Tygon leaks CO_2 but not too quickly giving us time to pressurize tube with known amount of CO_2 , install tube, and flush chamber system.
- After ~14 hours CO_2 levels have stabilized and we can take a measurement.
- Fit the last hour with a linear fit, make sure slope is consistent with 0.





Preparing Tygon Tubes

- All tubes cut to 32 cm to be near .5 cc of CO_2 with room to crimp ends
- Flush and pressure tube to 14.5 psi
- Use vacuum grease for ease of sliding plugs into tygon.
- Put into plastic tube and plastic tube into chamber.
- Flushing chamber for 15 sec.
- Run for 16+ hours

Results

Each measurement 5 tubes are rotated. No noticeable systematic from tube used.
Volume measurements in cubic cm(cc).

Chamber	Volume1	Volume2	Volume3	Volume4	Volume5	Volume6	AVE	Std Dev	est. Volume w/ tube
0	588	507	549	523	537	552	543	28	471±18
1	584	553	550	550	539	559	556	15	471±18
2	555	511	524	511	523	551	529	19	446±18
3	474	460	467	466	466	472	468	5	450±18
4	479	468	429	435	450	469	455	20	454±18

Systematic Uncertainties

	Measurements	Volume effect
Tube Size	1.16±.1 cc	1%
Tube Saturation	0?	
Initial PPM	±50 PPM	10%
Leaks before Chamber	1%	1%
Pressure measurement	14.5±.1 psi	1%
CO2/argon ratio	0.50±.02	2%
Other	??	2%
TOTAL		10%

Injection Method

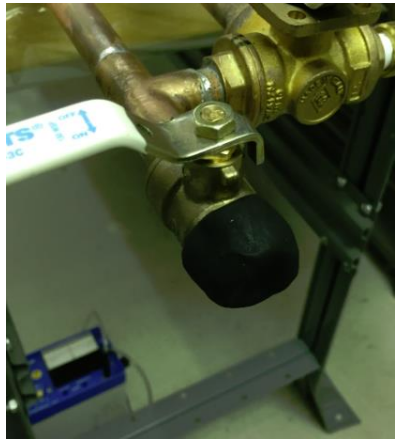
- It would be nice to be able to quickly add a known quantity of CO_2 to chambers for calibration of volume.
- Test how effective this method is and multiple approaches to seal the end.

Different tests with injection

- Needles: 22 gauge 3 ½ inch needle with sharp end
- Syringe: tested both 3 cc and 1 cc syringes
- Tried 5 methods of sealing ends

Teflon tape

Duck-seal



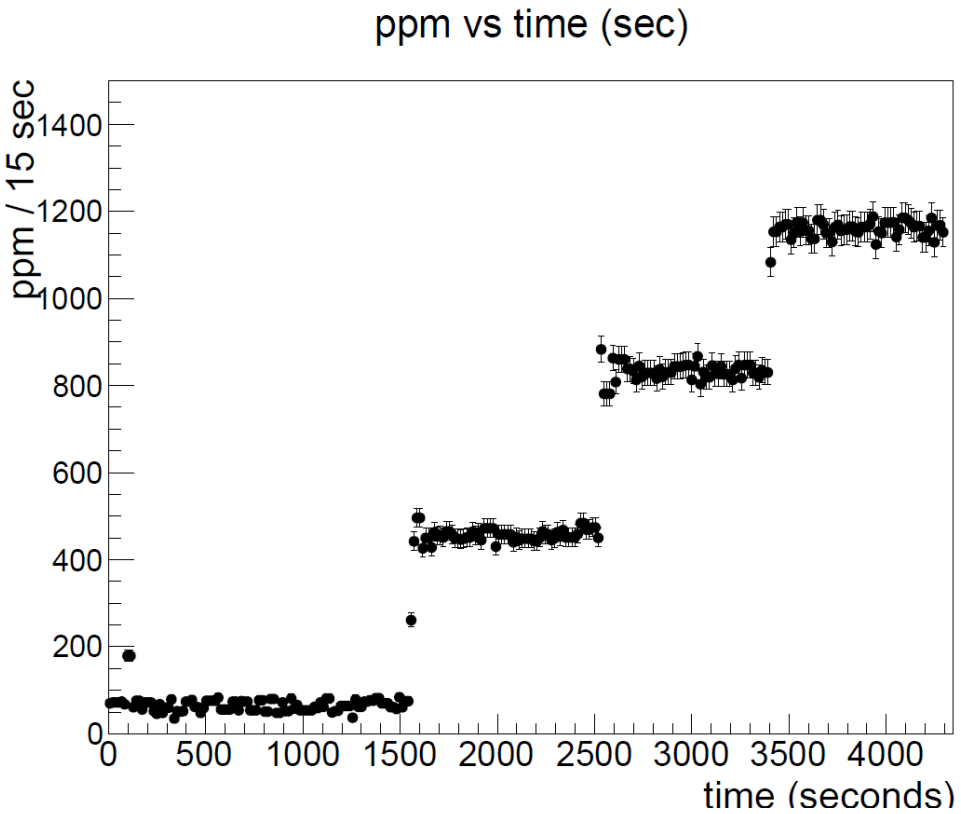
Duck-seal +Teflon tape

Rubber Stopper

Nothing

Measurements

- Flushed system, wait 10 min
- Inject 0.5 cc of 50% argon CO_2
- Wait 15 minute and repeat
- Each plateau is fit for measurement
- Difference of measurements are used to determine volume.



Results *Not done but currently bad

Teflon tape			
Chambers			
0	749	720	
1	710	731	767
2	765	656	676
3	549	648	622
4	590	676	670

Duck-seal			
Chambers			
0	791	1351	947
1	779	698	916
2	635	714	661
3	561	595	656
4	600	718	809

Nothing			
Chambers			
0	644	628	610
1	725	698	929
2	923	661	
3			
4	693	600	

Consistently larger number suggests :

- injecting less co2 than thought
- Co2 escaping into valve or in front of valve

Leading culprit is syringe

Conclusions

- Injection method needs work, would still be something nice to get working.
- Tygon method while slow seems at least consistent, while all are larger than the estimate they all match with given error.

AVE,dev,sys	Estimate	Diff
543±28±54	471±18	72
556±15±56	471±18	85
529±19±53	446±18	83
468±5±47	450±18	18
455±20±46	454±18	1