RGA Usage at Jefferson Laboratory

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Abstract

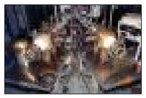
)ver the past 10 years, quadrupole residual as analyzers (RGAs) have become common acuum diagnostic instruments.

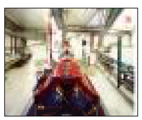
/luch of the proliferation of this technology hroughout the scientific community is due o the high reliability and relatively low cost f modern RGAs.

efferson Lab uses over 70 of these devices or vacuum leak detection, to diagnose acuum limitations of Ultra High Vacuum hotoemission guns, and to detect ydrocarbon contamination during production f superconducting radio frequency (SRF) ccelerator cavities and fundamental power ouplers.

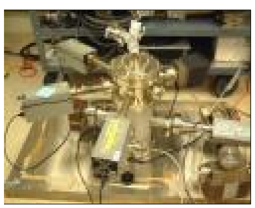
resented here is an overview of uses of :GAs in vacuum systems at Jefferson Lab. 'he goal is to understand the proper perating procedure for these devices in ither turbo pump or NEG/ion pump systems. Ve examine the effects of calibrating the :GA, adjusting filament current, degas rotocol and compare four RGAs on one ystem to study effects of aging of the :GA.

n addition, we compare the RGA to two JHV gauges, the Ulvac Axtran (model X-11) auge and the Leybold Ionovac 514 :xtractor gauge, to investigate gauge umping, gas evolution during outgassing neasurements and the reliability of an RGA s a total pressure gauge.



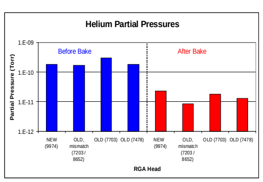


RGA comparison

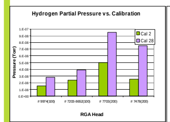


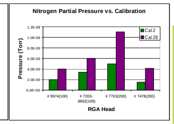
Four Stanford Research Systems (SRS) RGAs installed on test stand with ion pumps. Compare performance of older units with repaired electronics heads to a newer unit

Ielium partial pressure om standard leak in ıked and unbaked ıambers.
ıll four gauges read ɛlium pressure within a ıctor of 3.
iood agreement between ɛpaired and new RGA

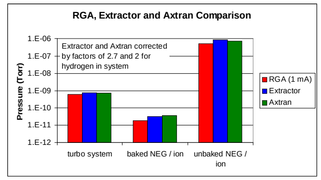


RGA *vs.* Total Pressure Gauges





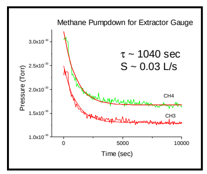
- RGA electron amplifier (CEM) should be calibrated internally *vs.* its Faraday cup before measuring partial pressures in CEM mode
- After bake, mass 28 signal is low, so calibration can be done at mass 2 in the H_2 dominated chamber
- RGA partial pressure reading is not accurate for gas species other than the calibrated mass (see graphs above)
- Scaling factors for different AMUs must be calibrated on a gas specific test stand vs. a total pressure gauge*
- Qualitative helium leak detection is unaffected by CEM calibration



- Total pressure measured by the RGA agrees well with the Extractor and Axtran Gauges
- RGA pressure was obtained by adding up all peak heights in CEM mode with CEM calibrated for mass 2
- Both Extractor and Axtran gauges need correction factors for the difference in ionization cross section between nitrogen and hydrogen. The Axtran factor for hydrogen is 2 (from the manual), and the extractor factor is 2.7 **
- We find that the total pressure from the RGA agrees relatively well with the Extractor and Axtran, without any corrections to the individual peak heights for sensitivities or ionization cross sections.

Conclusion: The RGA works adequately as a total pressure gauge at UHV pressures

**Calibration factor measurement performed by H. Schmidt and H. Eichler, Inficon Laboratory Report 03, *"Gasartabhangigkeit der Empfindlichkeit fur Verschiedene LH Ionisationsvakuummetertypen"*, 1987.



- RGA used to investigate gauge pumping for Extractor gauge
- Extractor gauge pumps methane at ~ 0.03 L/s at $3x10^{-10}$ Torr

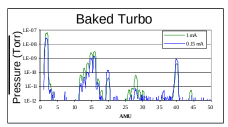
$$P = P_o e^{-St/V}$$

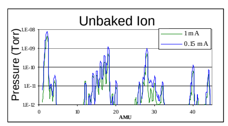
P: Pressure
S: Pumping Speed
V: Volume of chamber
Time constant: 1040 sec

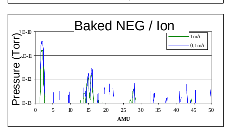
**Evaluation of low cost RGA's for UHV applications M. G. Rao and C. Dong, J. Vac. Sci. Technol. A 15(3) 1997 pp 1312-1318.

Filament Current

Varied RGA filament current between 1 and 0.1 mA to determine if lowering filament current lowered electron stimulated desorption (ESD) Two systems: NEG/ion vs. Turbo







Baked turbo pump system:
- Decreasing filament decreases pressure reading
- Supports theory that electron stimulated desorption (ESD) can be lowered with lower current

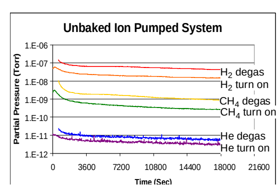
Unbaked Ion pump system:
- Decreasing filament current *increases* pressure reading.
- Confusing: Gauge pumping and ESD are in competition, and pumping wins here?

Baked Ion/NEG system:
- Decreasing filament current increases pressure reading.

Conclusion: Changing filament current affects pressure readings in an RGA, and RGA responds differently in turbo *vs.* ion pump systems

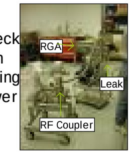
Degas vs. Warm-up

- RGAs do not read accurately when first turned on
- Degas cycle can generate gas load from which the chamber takes many hours to recover
- Degas cycle also may shorten the filament lifetime
- RGA can be used for a rough leak check immediately
- Let your RGA warm up for ~3 hours before trusting total pressure data



RF coupler test stand

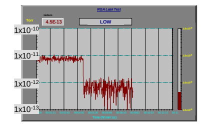
Calibrated pumping system for leak check and of gas evolution during RF conditioning of fundamental power couplers



The leak rate of the system can be determined from the following equation

$$Q_L = \frac{P_L}{P_S} Q_S$$

P_L : HeliumPartialPressurewithactualleak
P_S : HeliumPartialPressurewithstandardle
Q_L : LeakRate
Q_S : StandardLeakRate



Calibrated Helium Leak open/closed

RGA traces during initial RF processing of SRF power couplers for the SNS projec Different species are releas from coupler surface, mostly hydrogen.

When conditioned, RGA traces are flat indicating minimum evolution of gas from clean surface.

Conclusions

- RGAs read within a factor of 3 between four different heads for helium partial pressures even after NF3 exposure and electronics head refurbishment.
- Calibrate RGA before trusting CEM pressure readings: Use mass 28 unbaked or use mass 2 if system is baked.
- A comparison of an RGA with two UHV gauges finds that the total pressure agrees quite well across systems.
- RGAs are useful for measurements such as gauge pumping, outgassing, and NEG pump speeds.
- Lower filament current should limit ESD. Our tests with ion pumped systems show that this is not necessarily the case.
- The degas cycle is not necessary in a clean system. Partial pressure readings should be taken at least 2 hours after turning on the RGA.
- An RGA with a calibrated leak can be used to determine quantitative He leak rates, and can detect hydrocarbon contamination during coupler production