



QUADRUPOLE RGA – Past, Present, Future

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What is an RGA?

A Residual Gas Analyser (RGA) is an instrument for measuring the partial pressures of gas species in a vacuum system.

It is really:

A MASS SPECTROMETER

(Small, robust, low cost)

QUADRUPOLE MS

A horizontal green gradient bar at the bottom of the slide, matching the one at the top.

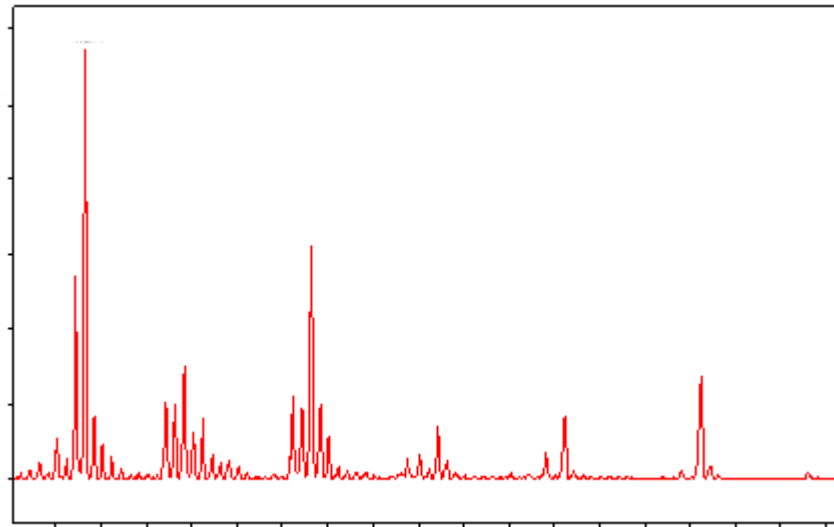
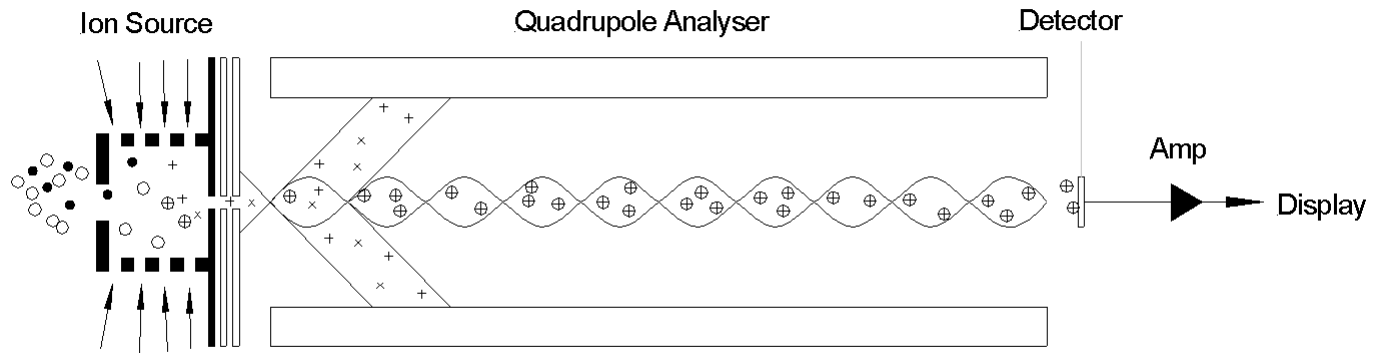


The Past

1942	Early use of a magnetic sector Nier ion source	Manhattan Project Leak Detection			
1945	MS8 Leak Detector	Veeco		(+ GE)	
1952	Cycloidal Leak Detector	CEC			
1958	RF Instrument	Beckman Instruments			
1962	GA3 Gas Analyser	Veeco			
1963	MS10 Magnetic SEM Detector instrument	AEI (UK) GE			Sylvania (Omegatron)
1965	First Commercial quadrupole RGA	EAI (USA)			
1968		Centronics (UK)			
1968	AEI taken over by GE	VG Micromass	+		Kratos
1970	Precision Mass Analyser	UTI (100C)			
1972	Q7 (quadrupole) RGA	VG	→		Thermo
	Development of small quadrupole RGA's + Start of RGA Market	Spectrum Scientific	→	Spectramass	→ Leadermass
			→	Spectra	→ MKS
1980	Digital Electronics + PC	All market participants			Hidden
1988	Smart Head	Leybold Inficon Transpector			
1990	Internet				



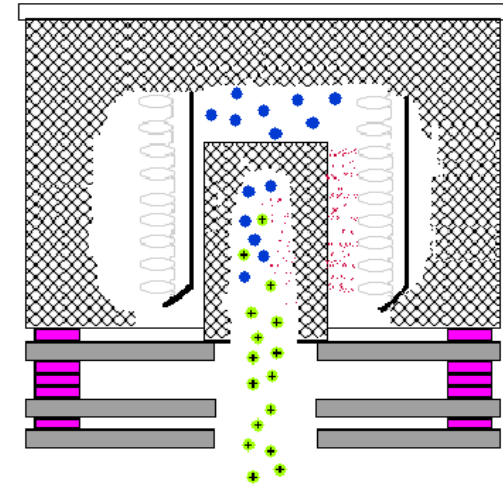
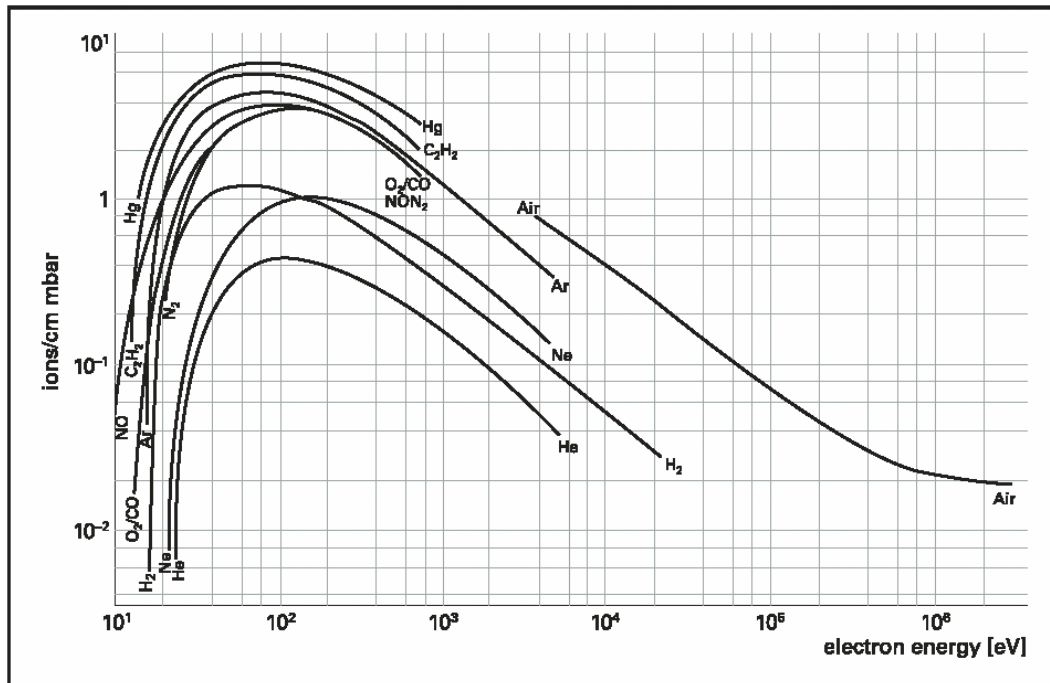
Quadrupole RGA Schematic





Electron Impact Ion Source

- Hot wire filament
~ 2A through filament to emit electrons
- Electrons accelerated to ~ 70eV
emission current of ~ 1mA is feedback controlled





Filament Material

- Tungsten
- Thoria
(thorium oxide coating on iridium wire)
- Yttria
(yttrium oxide coating on iridium wire)

FACTORS

Work function, temperature, outgassing, reactivity, resistance to burn-out, environment.



Cracking Pattern

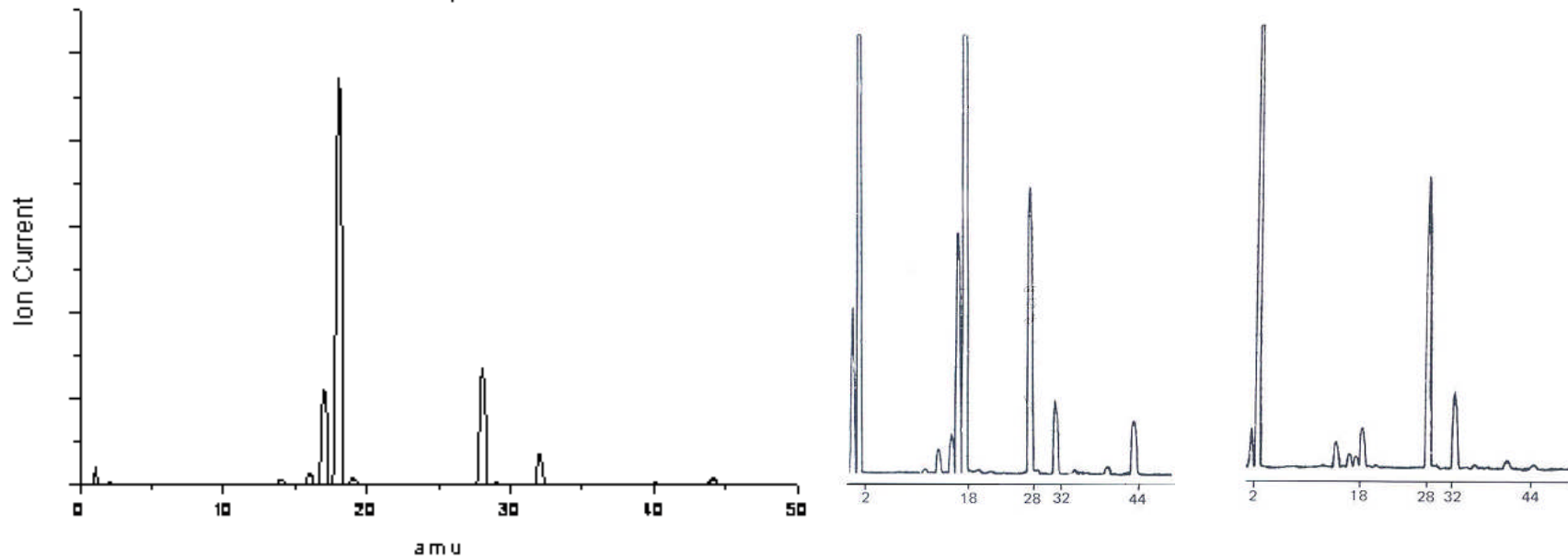
Each Gas produces a characteristic set of fragment peaks referred to as it's
CRACKING PATTERN

Name	Formula	Peak 1		Peak 2		Peak 3		Rel Sens
		m/z	%	m/z	%	m/z	%	
air		28	100	32	27	14	6	1
argon	Ar	40	100	20	16	36	0.3	1.2
carbon dioxide	CO ₂	44	100	16	9	28	8	1.4
carbon monoxide	CO	28	100	12	5	16	2	1.05
ethane	C ₂ H ₆	28	100	27	33	30	26	2.6
Fomblin oil		69	100	20	28	16	16	1
helium	He	4	100					0.14
hydrogen	H ₂	2	100	1	2			0.44
krypton	Kr	84	100	86	31	82	21	1.7
methane	CH ₄	16	100	15	85	14	16	1.6
neon	Ne	20	100	22	10	21	0.3	0.23
nitrogen	N ₂	28	100	14	5	29	1	1
oxygen	O ₂	32	100	16	9			0.86
water	H ₂ O	18	100	17	21	16	2	0.9
xenon	Xe	132	100	129	98	131	79	3

Don't worry - all RGA's have a built-in cracking pattern library



Residual Gas Spectra



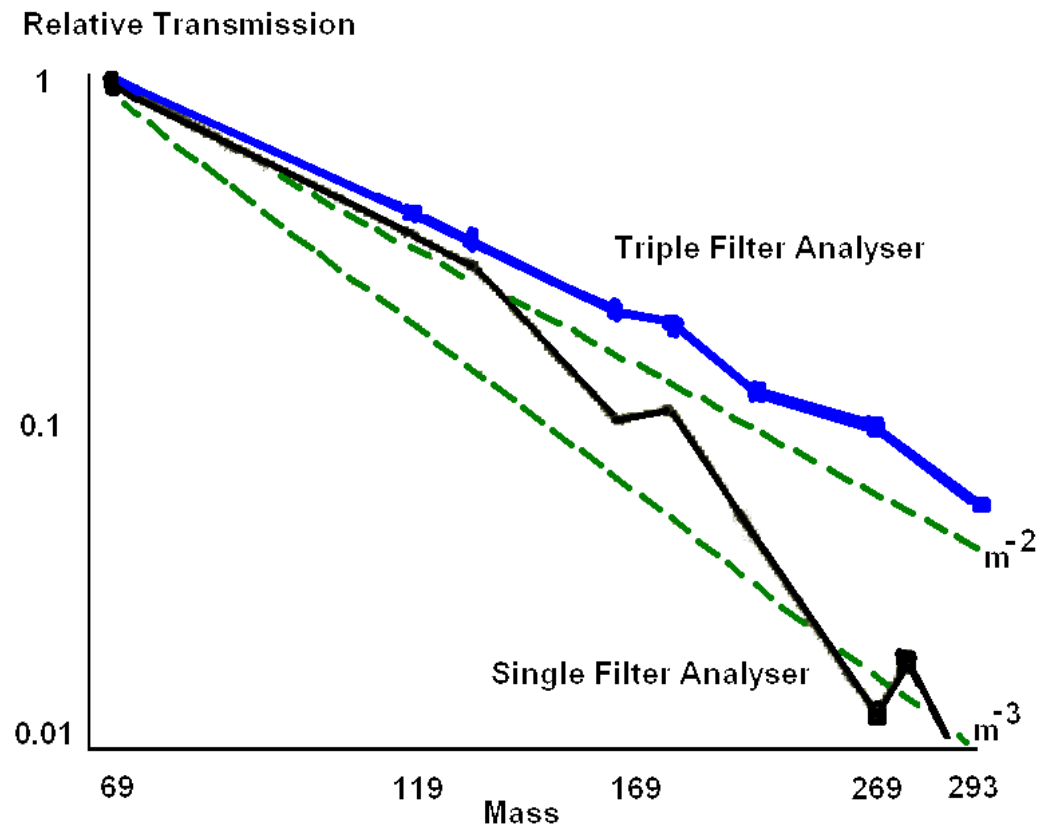


Mass Filter

- Quadrupole
- Magnetic Sector
- Time of Flight (TOF)
- Ion Trap

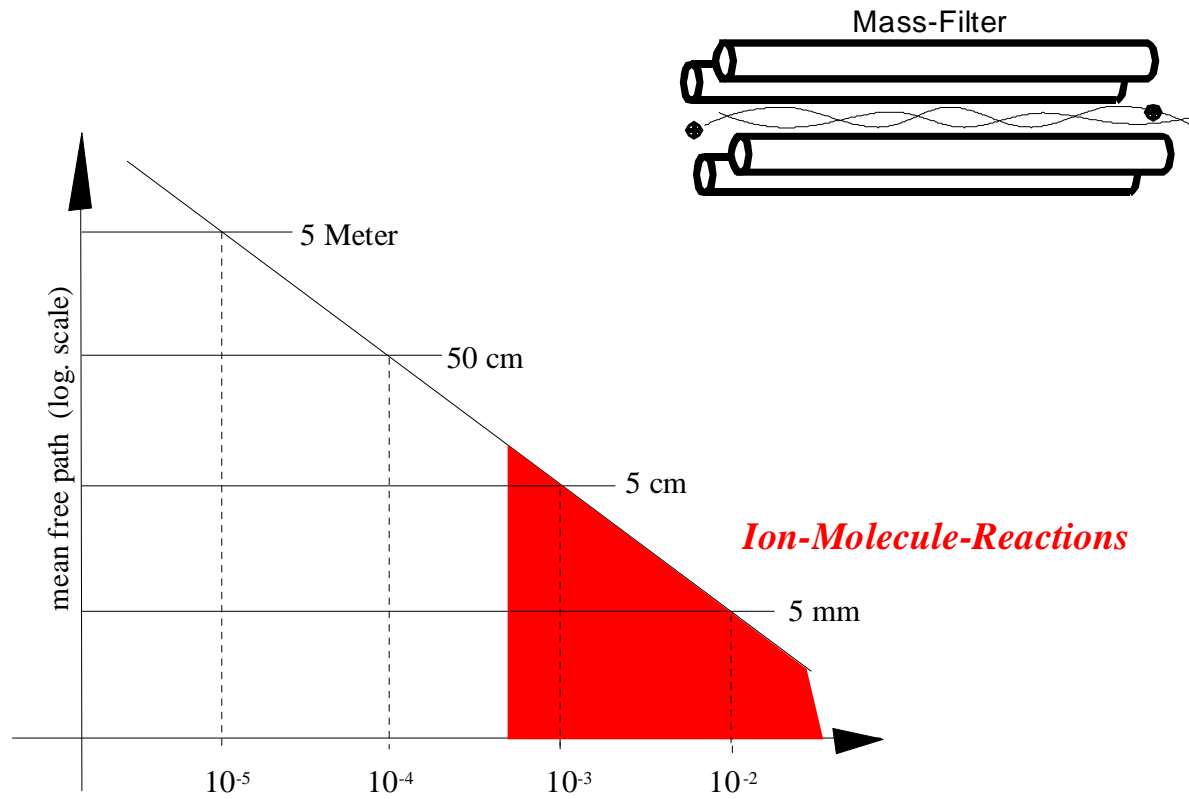


Quadrupole Transmission



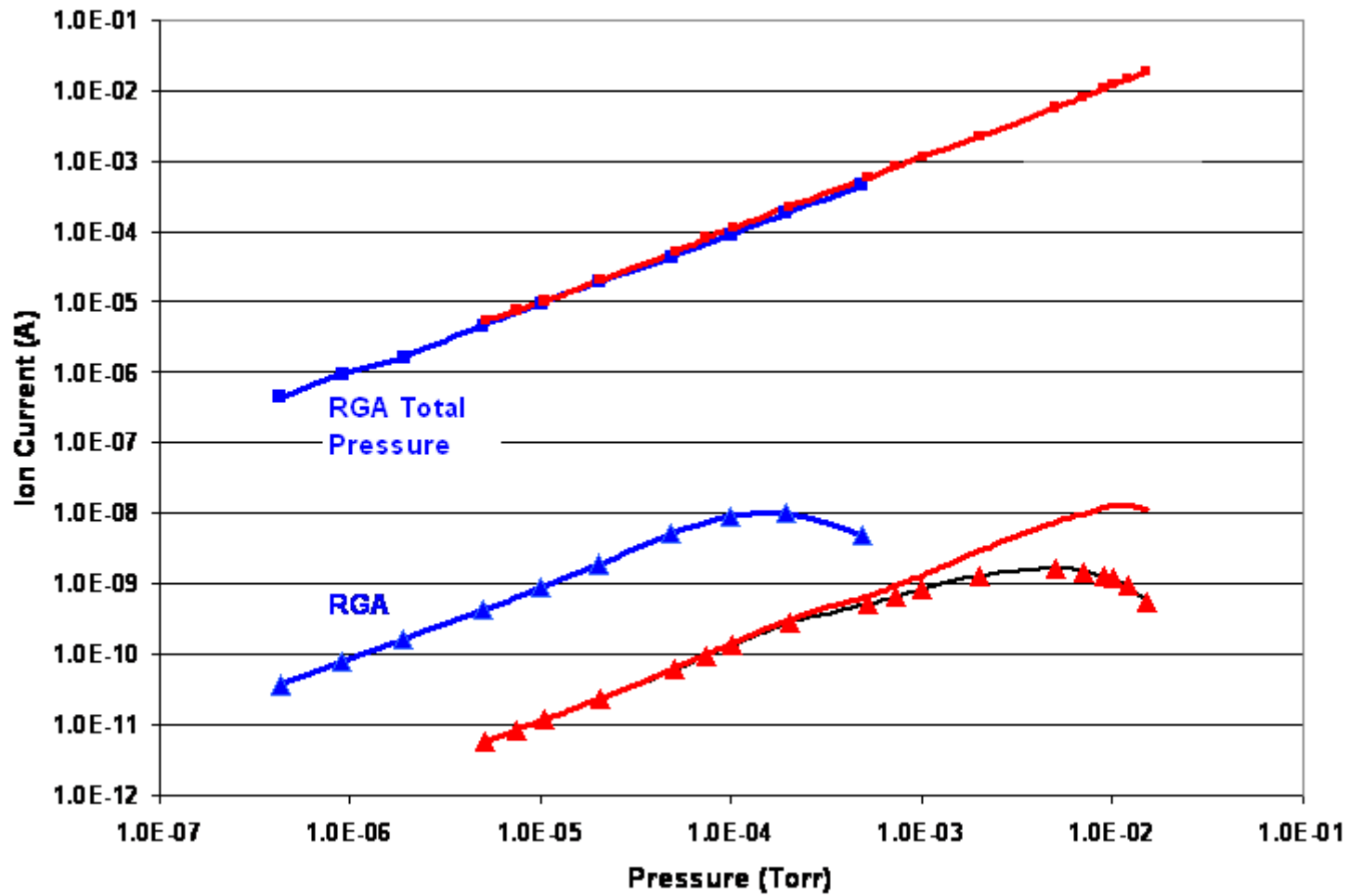


Mean Free Path





Pressure Linearity

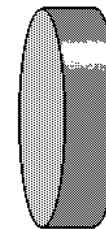
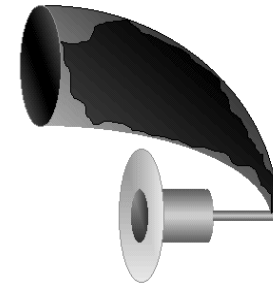




Detection

- Faraday Cup
- Electron Multiplier
- Micro Channel Plate (MCP)

- Measuring a CURRENT of ions
signal is down to pA range, requiring very sensitive amplifier





Measurement / Calibration?

How does RGA convert current measurement to partial pressure or concentration?

- Depends on what you are trying to measure and how accurate you want to be.
- Generally provide a good estimate.
- Excellent for revealing trends and deviations from the norm.

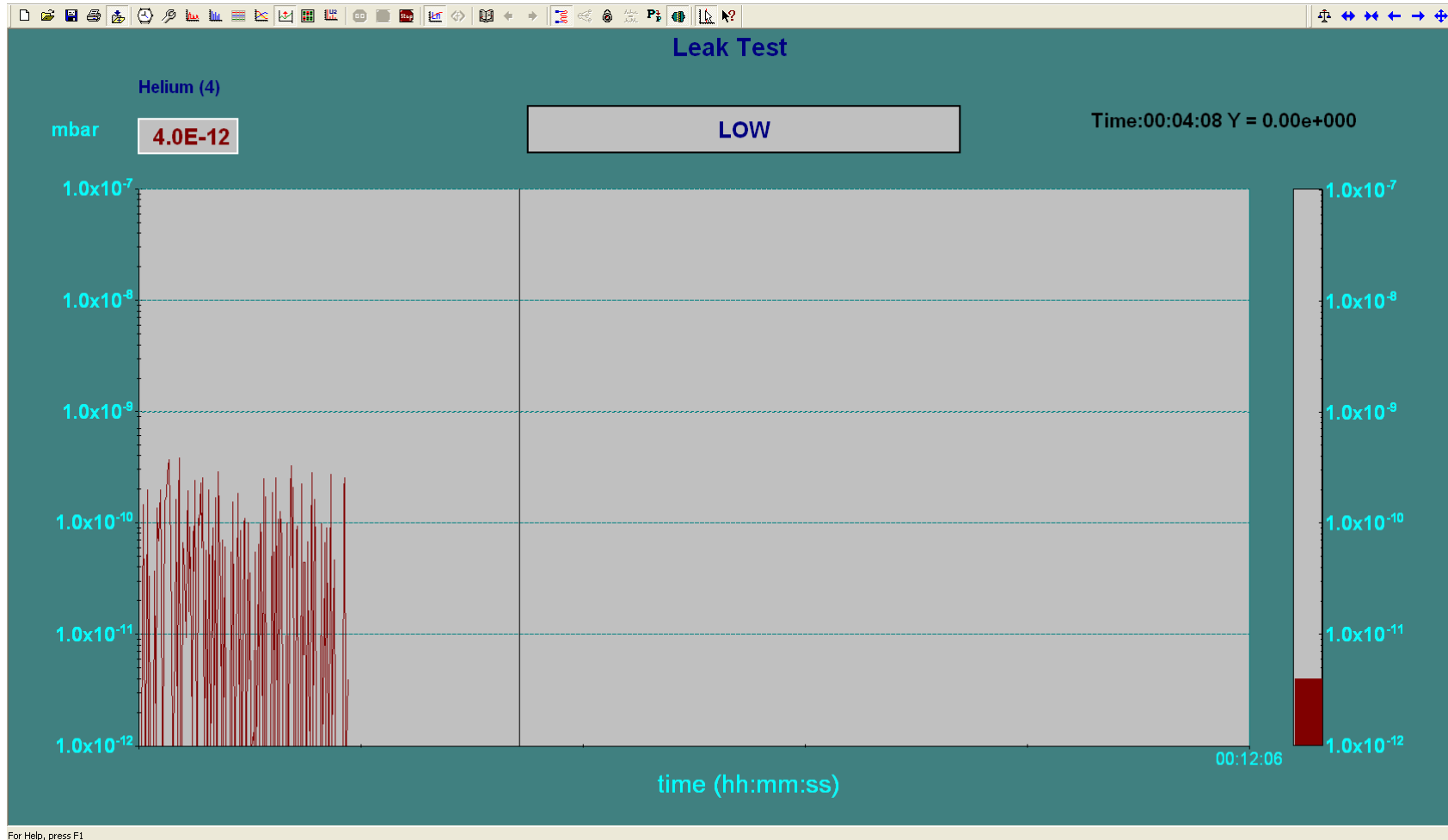


Software Control

- Smart Head technology allows control from PC or networked capability
- Extensive software packages
Easy to use? Depends upon the User point of view!

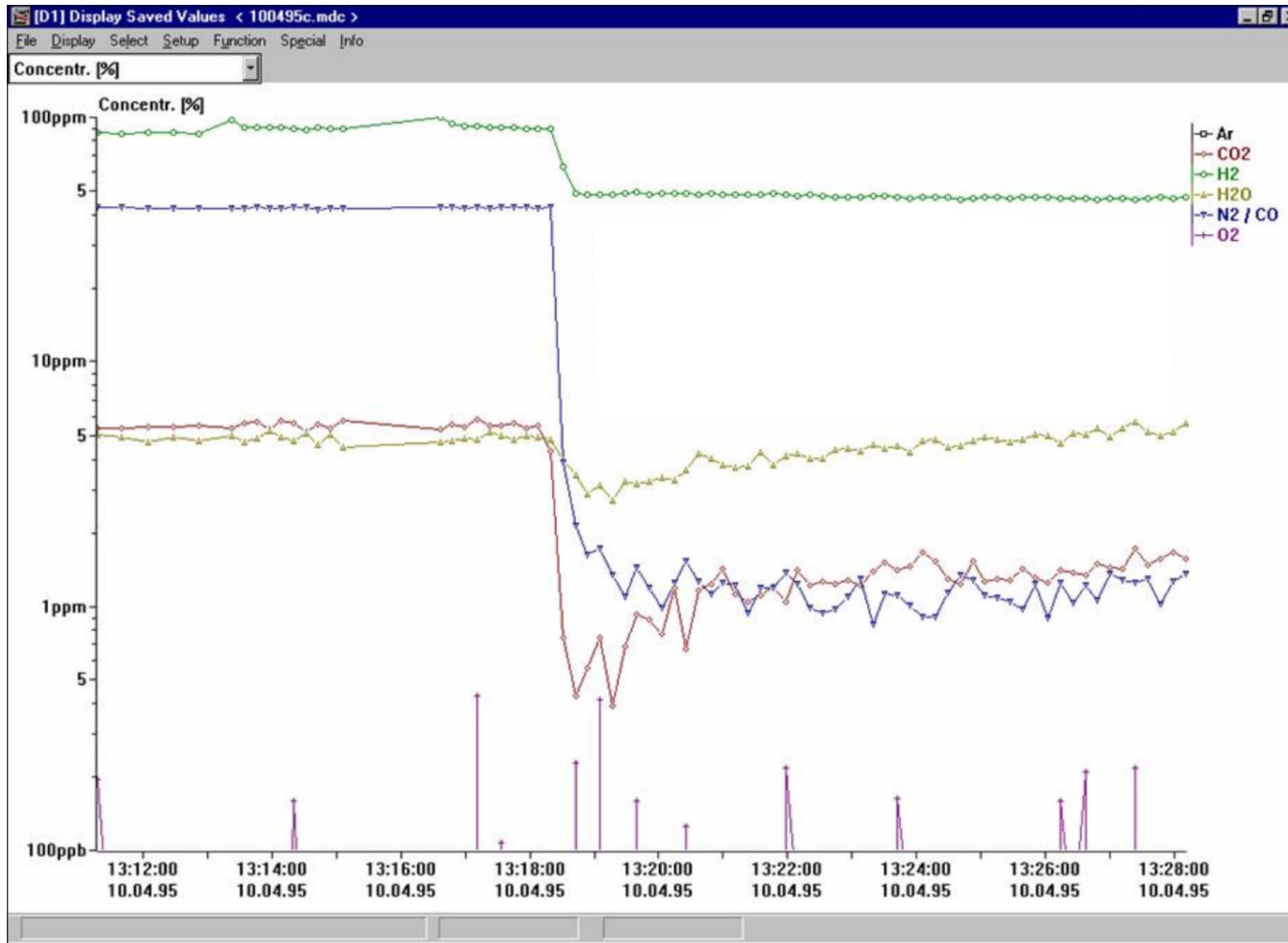


Leak Detection





Trending





Application v. RGA Configuration

Application	Sampling	Ion Source	Quadrupole	Detector	Software
XHV	In vacuum	Ultra low outgassing	Vacuum fired?	SEM	Basic
UHV	In vacuum	Open	Standard	SEM	Basic
General Vacuum	In vacuum	Open	Standard	Faraday (SEM / MCP)	Basic (inc Leak Detection)
Semiconductor	High + low pressure	Open / Closed	Standard or Mini	Faraday + SEM / MCP	Process / Integrated
Process	High + low pressure	Open / Closed	Standard or Mini	Faraday + SEM / MCP	Process
Environmental	Capillary or membrane	Open / Closed	Standard	Faraday + SEM / MCP	Calibration
Research	Various	Many options	High resolution, Triple Filter	SEM	Configurable
Custom	Various	Many options	Many Options	Many Options	Configurable



RGA Today - Summary

- Low cost mass spectrometer
a very powerful diagnostic tool and process monitor
- Leak Detector
- Vacuum Troubleshooter
- Process characterisation
- Understand your vacuum system:
water, outgassing, leaks (real & virtual), foreign objects
- Partial pressure analysis reveals actual contributions to Total Pressure
- Beware: RGA artefacts
Electron source, hot surfaces, ESD spurious peaks



RGAs Wish List

- Minimum of 2 filaments
- Filaments to be easily replaceable
- Choice of filament materials
- Programmable Degas function
- Minimum 50amu; 100amu desirable; 200amu if no cost penalty
- Minimum detectable partial pressure: 1e-12mbar (noise free!)
- No contribution to measurement (e.g. ESD, Outgassing)
- Bakeable to at least 250°C
- Operable at bakeout temperature
- 2¾" connection flange (no requirement for increased bore size!)
- Feedthrough intrinsically safe from damage
- Automatic tuning system (must be reliable!)
- Resolution to allow identification of CO from N2 at 28amu!



Usability

- Improved reliability – current MTBF ~ 3years
- Protection against magnetic fields
- Software: very simple to use at the top level
more complex functionality 'hidden'
- Analogue Scan with full control of mass range and pressure range
- Leak chase mode
- Multi-trend / peak jump
- Fully functional data storage & review (time stamped)
- Easy integration of control software into higher level computer



Residual Gas Analyser

Ametek
Cannon Anelva
Extorr
Extrel
Hiden
Horiba (Ferran)
Inficon
Larimax (Anglo)
MKS Spectra
Pfeiffer Vacuum
Stanford Research Systems
Thermo
Vacuum Technology Inc
VG Scienta

Miniature / Portable Mass Spectrometer

Ardara Technologies
Bruker AXS
Ceromitron
Comstock
Constellation Technology
European Spectrometry Systems
Griffin
John Hopkins University
Kore Technology
Microsaic
Monitorr Instruments
OI Corporation
Purdue University
SpaceHab
Syagen
Torion



Where Next?

THE END