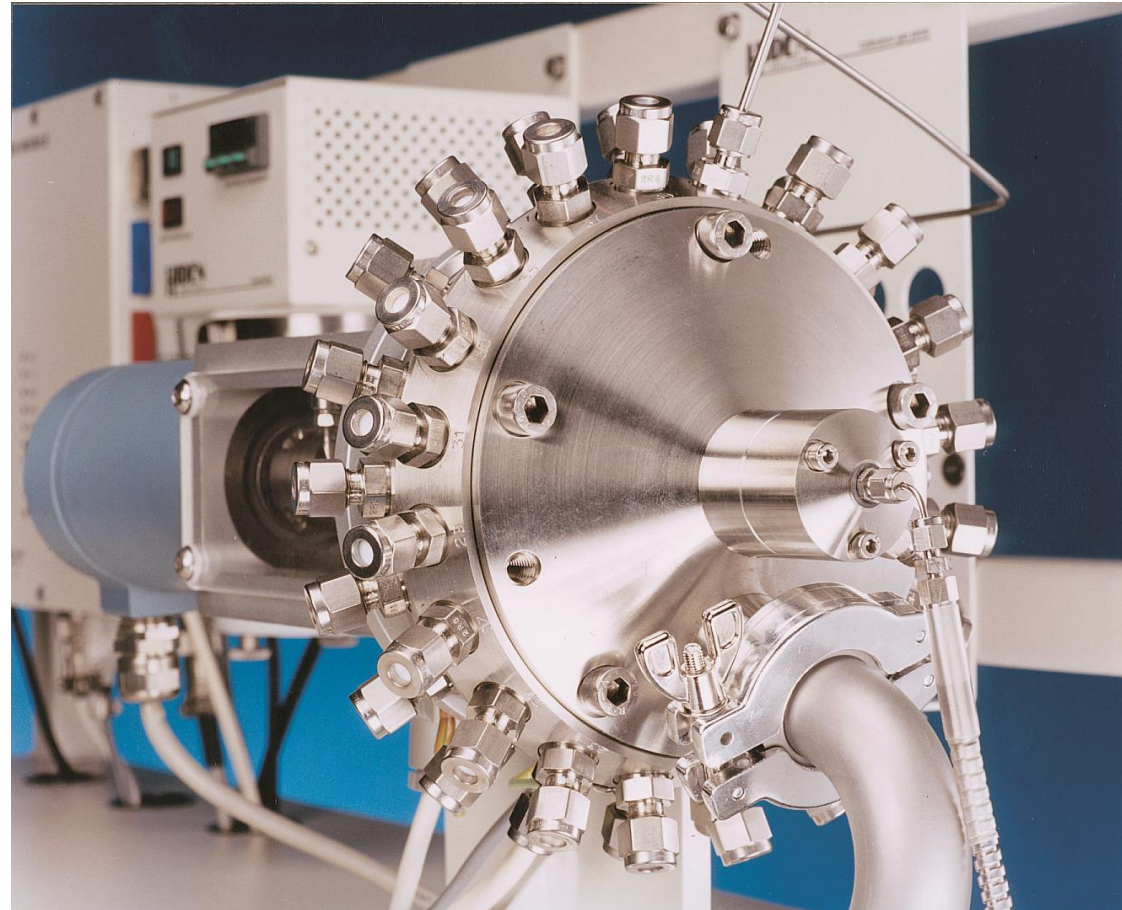


Hidden HPR-20 Gas Analysis System with Proteus Multi-way valve

**Mass Spectrometry In Containment
Thermal-hydraulic Test Facilities**

HPR-20 Gas Analysis System with Proteus 40-way valve



Introduction

The analysis of thermal-hydraulic processes that might occur in a nuclear water reactor containment building under severe accident conditions is very important. Hydrogen behaviour in the reactor containment is studied during a postulated severe accident. Hydrogen is of concern because, at some concentrations, deflagration can occur, resulting in damage to the containment and the release of radioactive material into the environment.

(Helium is used to simulate Hydrogen)

Quadrupole Mass Spectrometers for Advanced Science

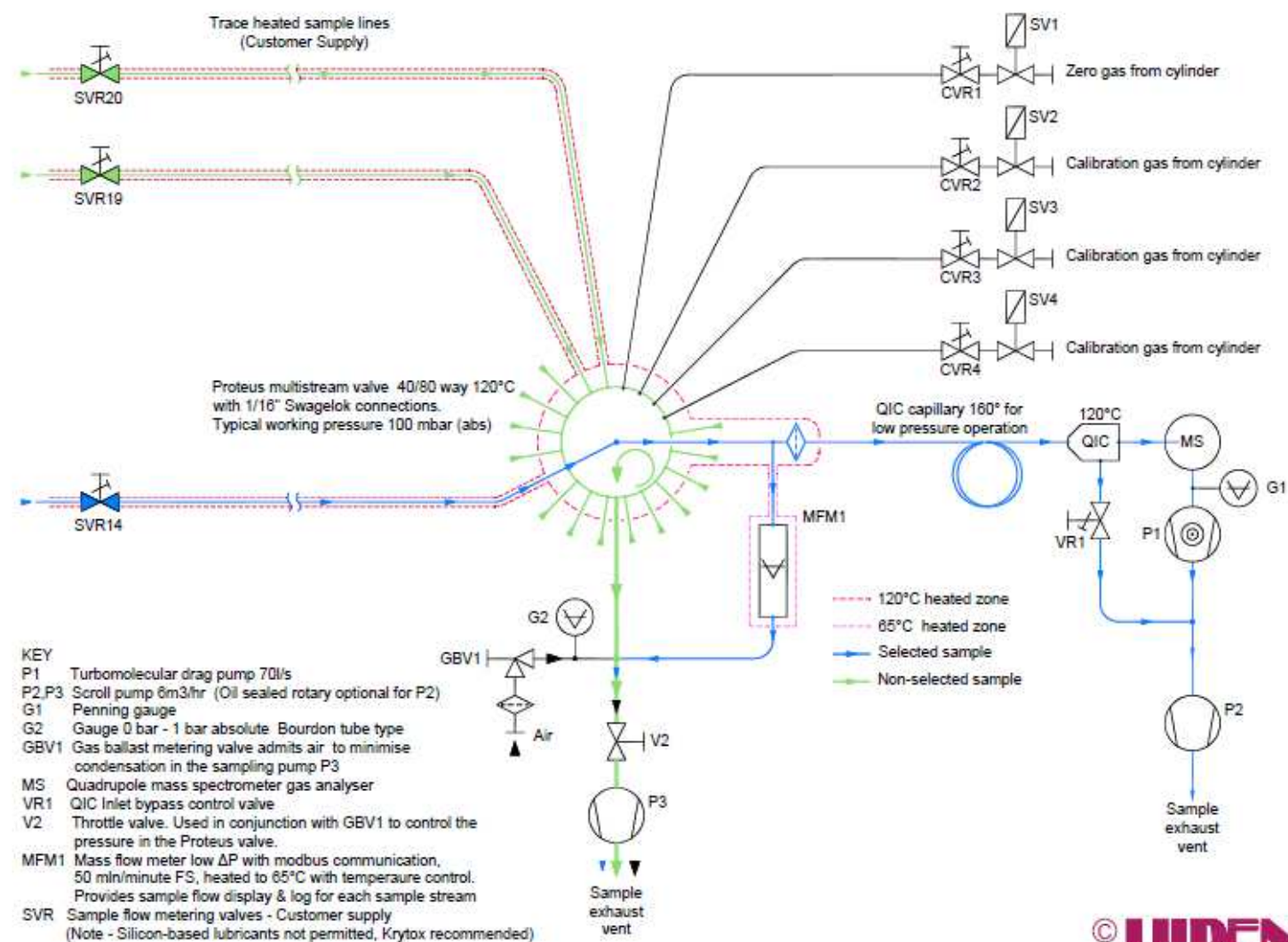
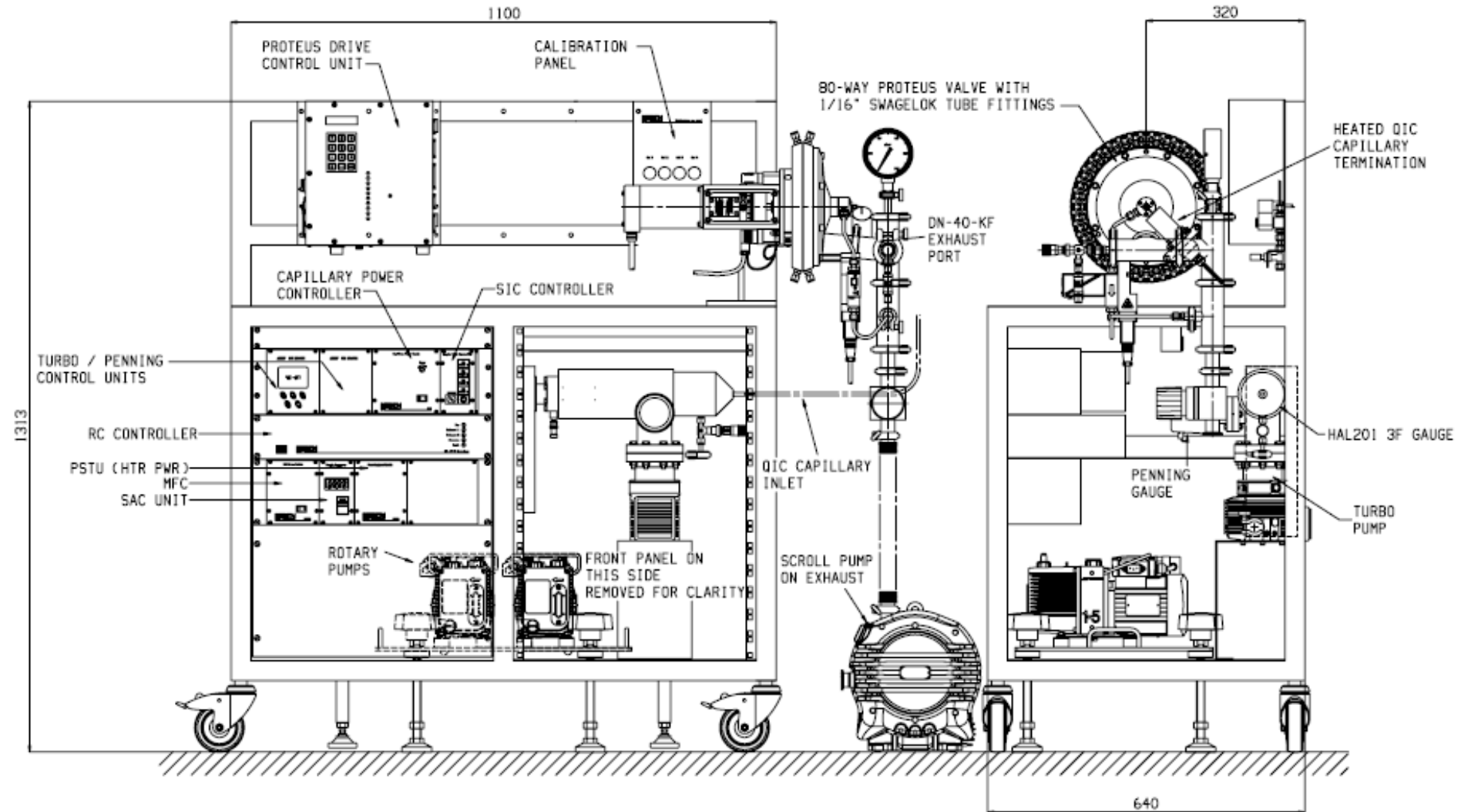


Fig.1 Multipoint system for central analysis of gases from thermal-hydraulic test facilities

Quadrupole Mass Spectrometers for Advanced Science

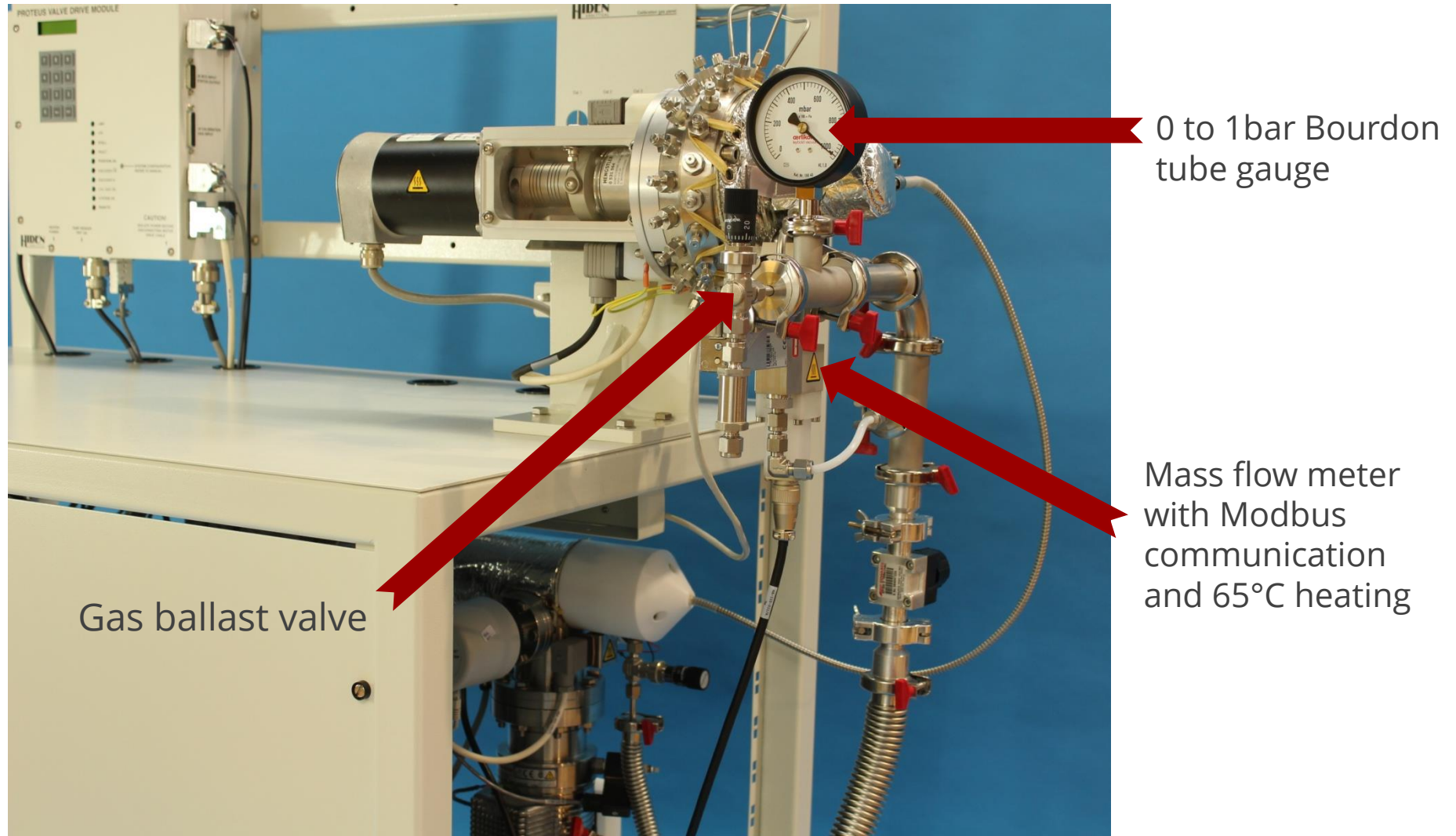


Quadrupole Mass Spectrometers for Advanced Science

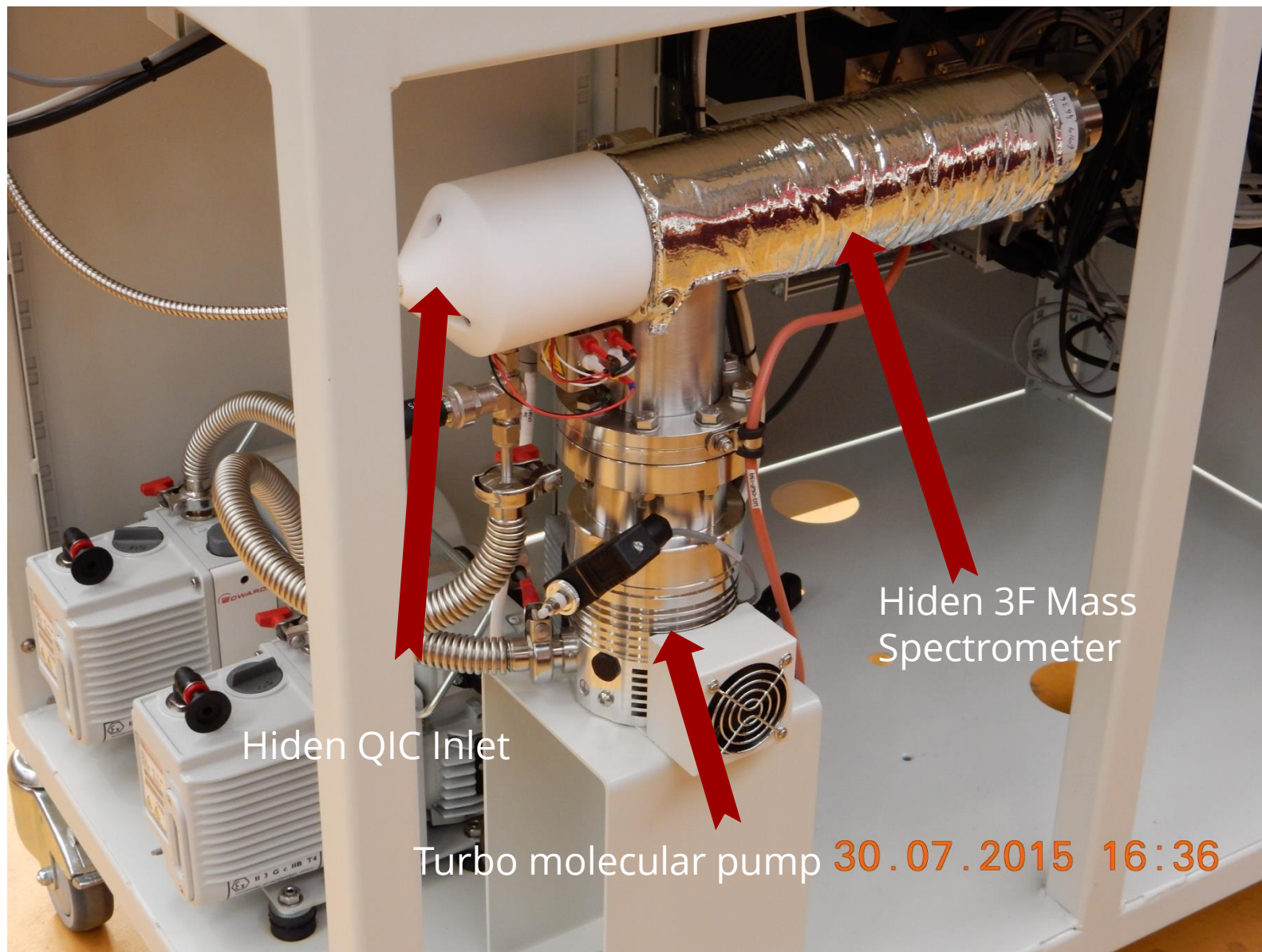


- Multi-stream measurement system
- Specialised for helium/air/steam mixtures.

Quadrupole Mass Spectrometers for Advanced Science



Quadrupole Mass Spectrometers for Advanced Science



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Quadrupole Mass Spectrometers for Advanced Science

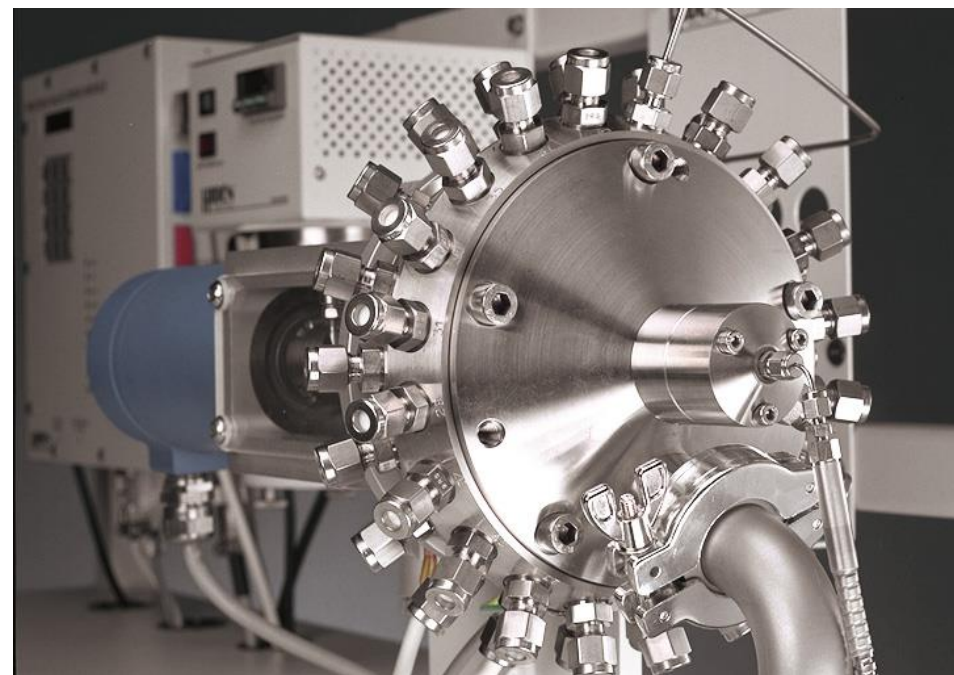


QIC Connection to
Hiden Mass
Spectrometer

Dual rotary backing pumps

Proteus Valve Features and Benefits

- Gas Selector Valve – novel face sealing technology – to give effective sealing and long life
- Maximum operating temperature 120°C
- No minimum sample flow
- Zero crosstalk from other samples
- > 6 x10⁶ operations before maintenance
- 20, 40 or 80 ports
- Direct drive, high torque micro-stepping motor with IP65 protected incremental rotary encoder providing z-home position and closed loop motor control.
- Full motion management including intelligent acceleration/ deceleration, position maintenance, bi-directional drive and position error annunciation
- Positional Accuracy +/- 0.09°
- Full brown-out sensing and operation
- Communication (valve port position select) via Binary, BCB and RS232C
- Also available as a separate product



Worked Example – Multi-stream Analysis

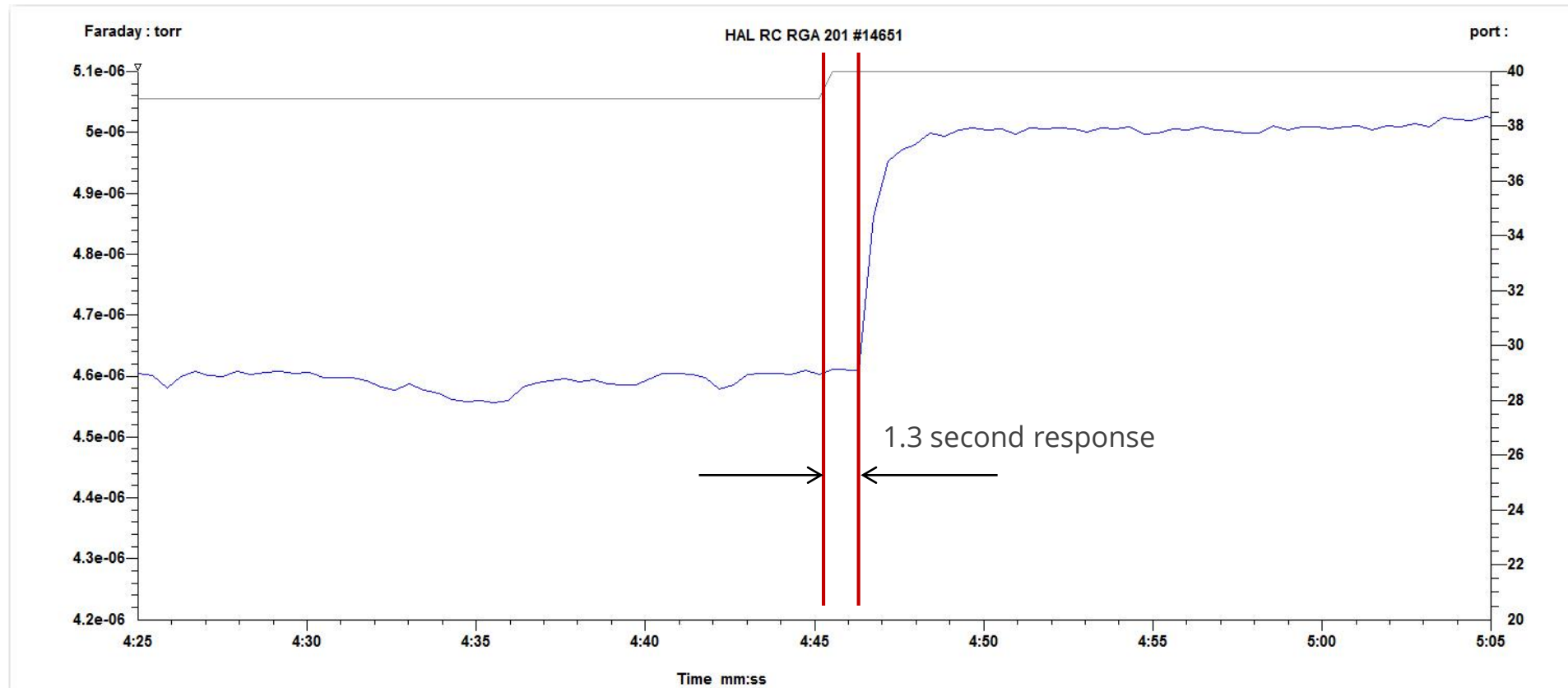
Test Setup:

- 2 x 5 m lines (1/16"OD x 0.05"ID) heated to 170°C.
- Line 1: Port 40 – 100% steam
- Line 2: Port 39 – 96% steam, 4% He

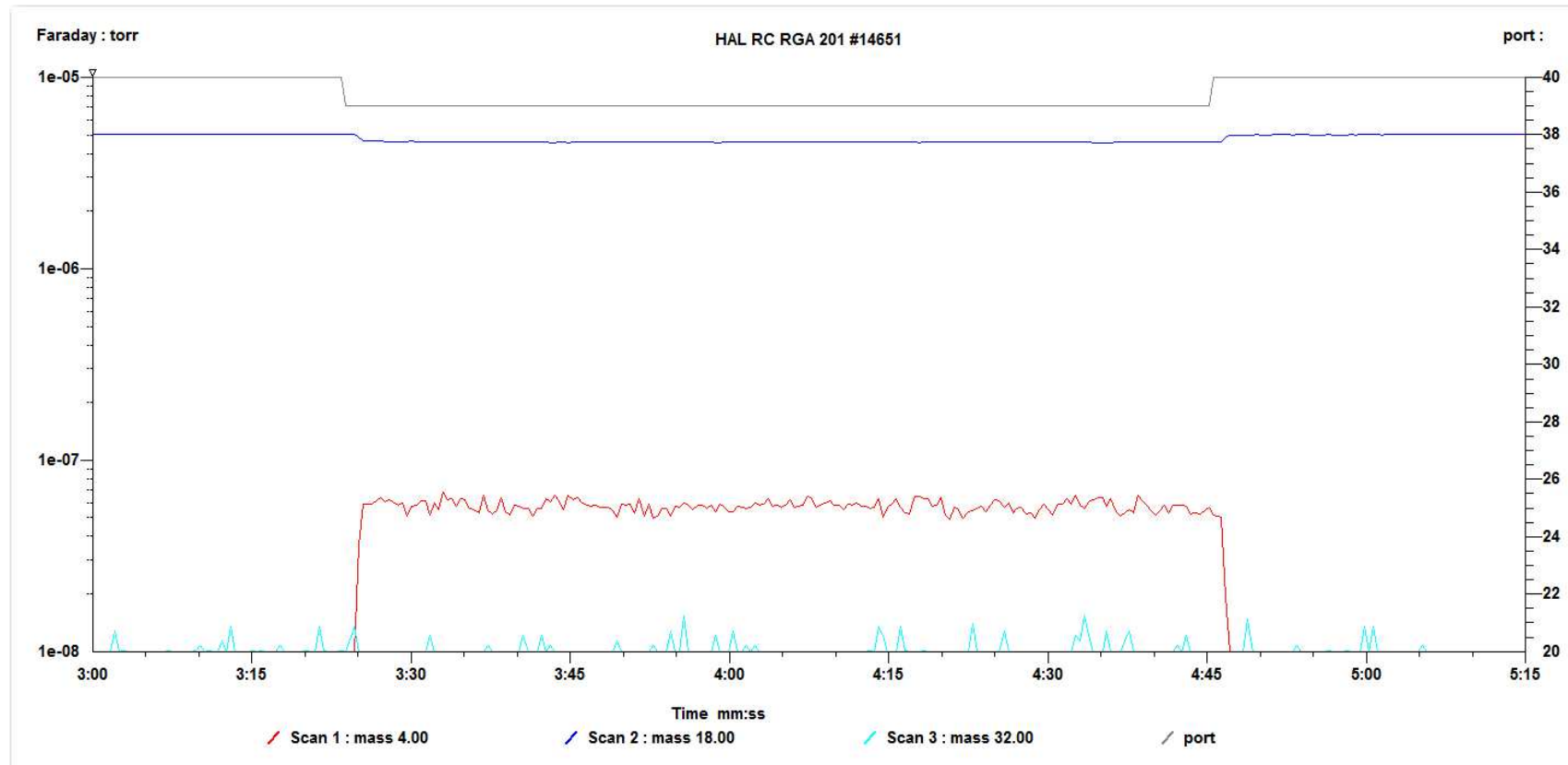
Test design:

- Measure response (s) switching between steam and steam/helium at 10 mln/min, (this is about 8.5 mln/min as read on the MFM and 1.5 mln/min through the capillary taken from the pressure vs flow table).
- Pressure 100 mbar, flow rate ~10 mln/min, sample time 400 ms (this is the time for a data cycle).

Response of water H_2O^+ signal switching port 40 to port 39



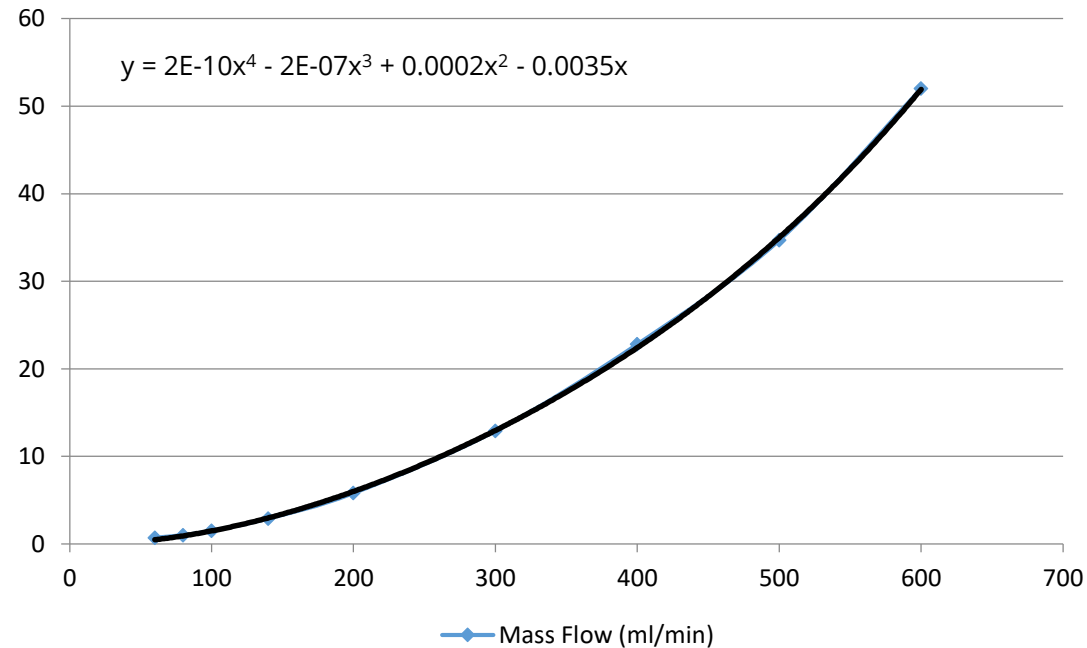
Helium response



Typical data cycle including stream switching and measurement of helium , oxygen, nitrogen, water is 5 seconds

Bourdon gauge Pressure with respect to Mass Flow

Bourdon gauge
pressure mbar



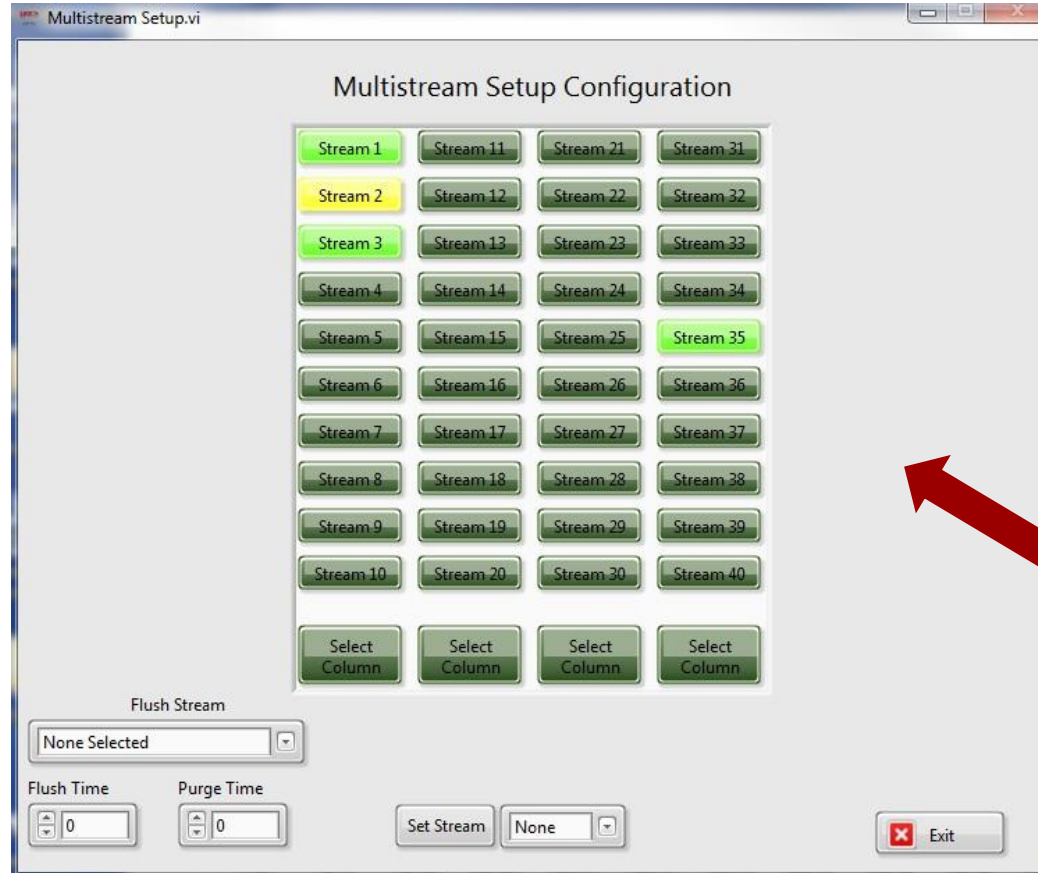
QGA Professional Software for Quantitative Gas Analysis



An application specific software package for quantitative gas and vapour analysis providing real time continuous analysis of up to 32 species with concentrations measured in the range 0.1PPM to 100%.

- Automatic subtraction of spectral overlaps
- Automated calibration routines
- Mass spectral library with intelligent scan feature
- Multi-stream support
- Data export OPC and/or direct to Excel

Multiple stream sequence set-up – 40 stream example

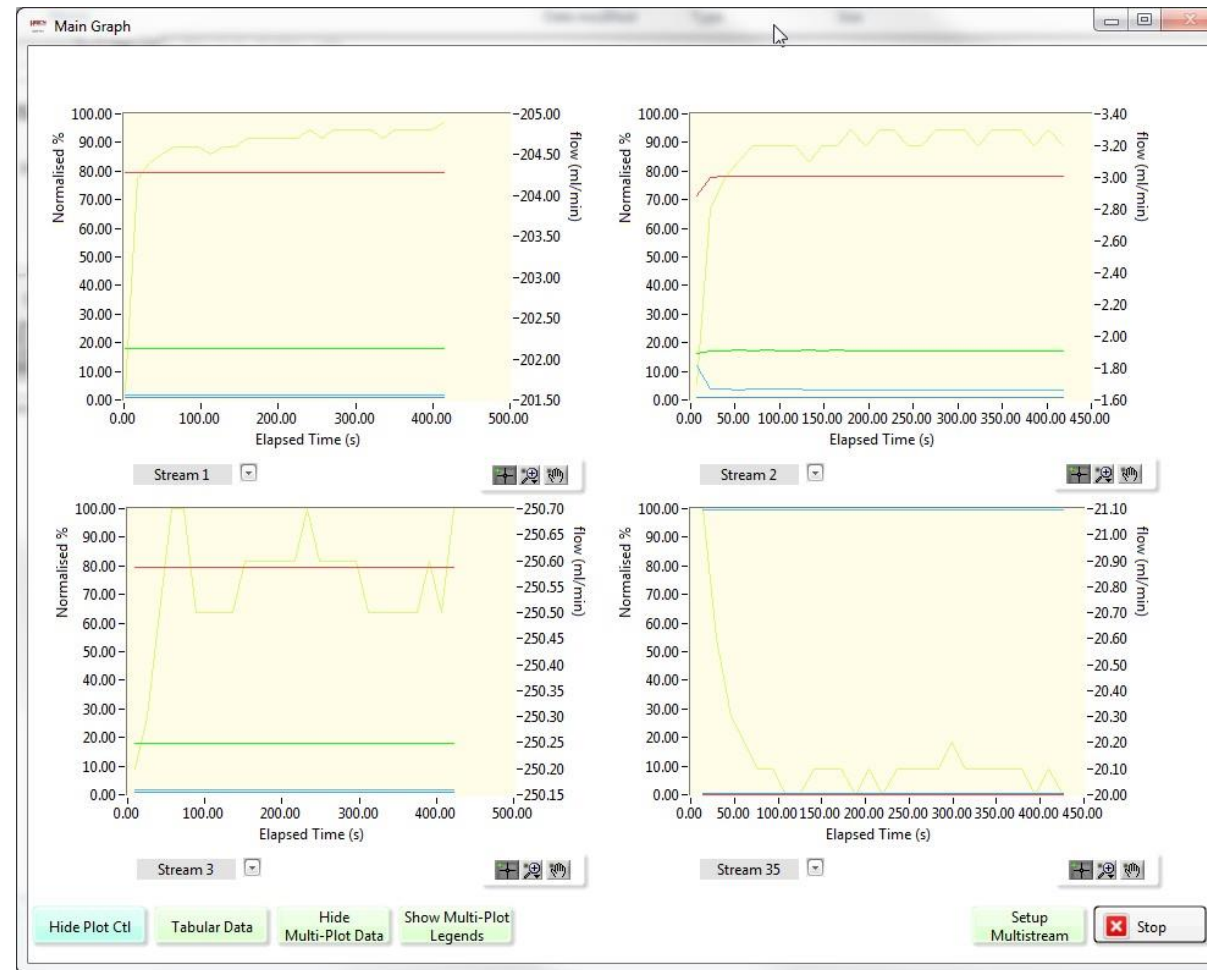


Click to add
or subtract a stream
from the analysis
sequence

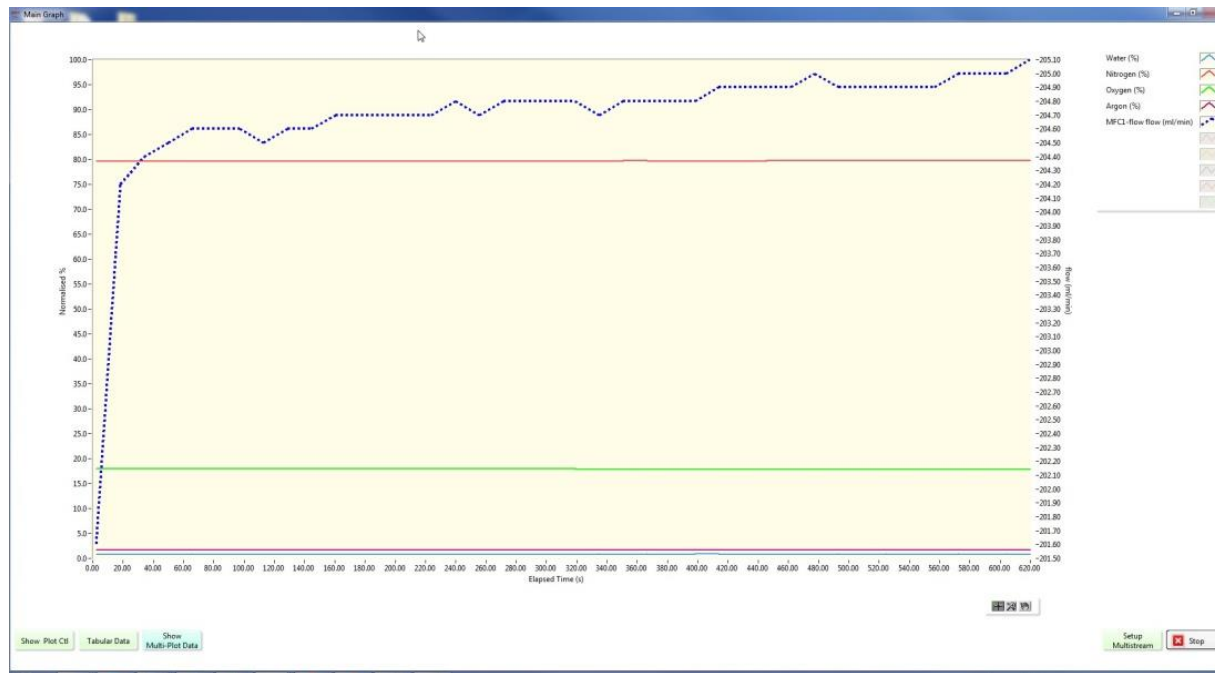
Additional streams can be added or subtracted from the stream sequence at any time during the analysis with a simple click on the stream LED.

Quadrupole Mass Spectrometers for Advanced Science

Multi stream gas analysis - The real time trend analysis of up to 4 selected streams can be viewed in real time and in review.



Quadrupole Mass Spectrometers for Advanced Science



- Graphical view with % on left axis and flow on the right axis

The figure shows a tabular data view titled 'Main Graph'. It contains a table with 6 columns: Elapsed Time (s), Water (%), Nitrogen (%), Oxygen (%), Argon (%), and MFCL-flow flow (ml/min). The table lists data points from 508.96 to 2.26 seconds. The 'Water (%)' column is constant at 0.8. The 'Nitrogen (%)' column fluctuates between 79.6 and 79.7. The 'Oxygen (%)' column fluctuates between 17.8 and 17.9. The 'Argon (%)' column fluctuates between 1.5 and 1.6. The 'MFCL-flow flow (ml/min)' column fluctuates between 201.60 and 204.90. At the bottom, there are buttons for 'Hide Plot Ctrl', 'Graph', 'Show Multi-Plot Data', 'Setup Multistream', and 'Stop'.

Elapsed Time (s)	Water (%)	Nitrogen (%)	Oxygen (%)	Argon (%)	MFCL-flow flow (ml/min)
508.96	0.8	79.7	17.8	1.6	204.90
493.15	0.8	79.7	17.8	1.6	204.90
477.35	0.8	79.7	17.8	1.6	205.00
461.60	0.8	79.7	17.8	1.6	204.90
445.73	0.8	79.7	17.8	1.6	204.90
429.81	0.8	79.7	17.9	1.6	204.90
413.97	0.8	79.7	17.9	1.6	204.90
398.07	0.8	79.7	17.9	1.6	204.80
382.20	0.8	79.7	17.9	1.6	204.80
366.39	0.8	79.7	17.9	1.6	204.80
350.60	0.8	79.7	17.9	1.6	204.80
334.77	0.8	79.7	17.9	1.6	204.70
318.88	0.8	79.6	17.9	1.6	204.80
303.04	0.8	79.7	17.9	1.6	204.80
287.21	0.8	79.6	17.9	1.6	204.80
271.40	0.8	79.7	17.9	1.6	204.80
255.63	0.8	79.7	17.9	1.6	204.70
239.77	0.8	79.6	17.9	1.6	204.80
223.93	0.8	79.7	17.9	1.6	204.70
208.07	0.8	79.6	17.9	1.6	204.70
192.22	0.8	79.6	17.9	1.6	204.70
176.32	0.8	79.6	17.9	1.6	204.70
160.50	0.8	79.6	17.9	1.6	204.70
144.61	0.8	79.6	17.9	1.6	204.60
128.81	0.8	79.6	17.9	1.6	204.60
112.91	0.8	79.6	17.9	1.6	204.50
97.07	0.8	79.6	17.9	1.6	204.60
81.25	0.8	79.6	17.9	1.6	204.60
65.46	0.8	79.6	17.9	1.6	204.60
49.71	0.8	79.6	17.9	1.6	204.50
33.87	0.8	79.6	17.9	1.6	204.40
18.07	0.8	79.6	17.9	1.6	204.20
2.26	0.8	79.6	17.9	1.6	201.60

- Tabular data view

Quadrupole Mass Spectrometers for Advanced Science

Data Export

- Data export to MS Excel.
- New workbook for each data file.
- Quantitative data, raw data values and corrected data values are exported.
- Calibration factors and background correction values are recorded.
- The workbook contains a worksheet for each gas stream.

Gas composition					RAW data					Corrected data				
Time (min)	Nitrogen 28	Argon 40	Oxygen 32	Water 18	Time (min)	Nitrogen 28	Argon 40	Oxygen 32	Water 18	Time (min)	Nitrogen 28	Argon 40	Oxygen 32	Water 18
36.40	80.198	1.004	18.124	0.714	5.6E-09	1.27E-07	1.40E-09	2.81E-08	1.11E-09	5.6E-09	1.27E-07	1.40E-09	2.81E-08	1.11E-09
64.66	80.137	1.002	18.142	0.719	6.4E-04	1.26E-07	1.40E-09	2.80E-08	1.09E-09	6.4E-04	1.24E-07	1.55E-09	2.81E-08	1.11E-09
93.16	80.173	1.001	18.121	0.705	9.34E-04	1.26E-07	1.40E-09	2.80E-08	1.04E-09	9.34E-04	1.24E-07	1.55E-09	2.80E-08	1.09E-09
122.95	80.225	1.006	18.045	0.725	1.22E-05	1.26E-07	1.40E-09	2.84E-08	1.07E-09	1.22E-05	1.24E-07	1.55E-09	2.79E-08	1.12E-09

09 Feb.09 Calibration factor				
Time (min)	Nitrogen 28	Argon 40	Oxygen 32	Water 18
26E-07	1.58E-09	2.82E-08	1.11E-09	
25E-07	1.56E-09	2.81E-08	1.09E-09	
24E-07	1.56E-09	2.81E-08	1.11E-09	
24E-07	1.55E-09	2.80E-08	1.09E-09	
24E-07	1.55E-09	2.79E-08	1.12E-09	
24E-07	1.54E-09	2.82E-08	1.11E-09	
24E-07	1.55E-09	2.81E-08	1.11E-09	

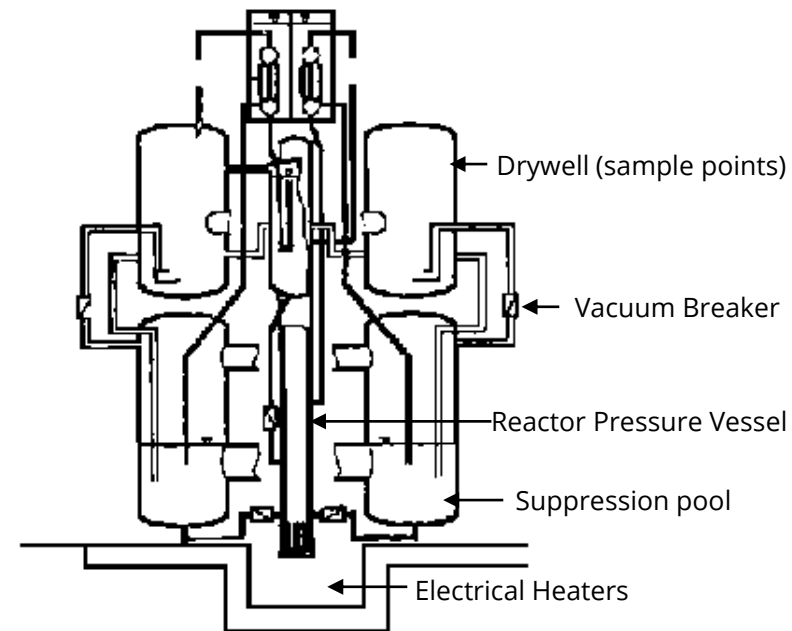
Time (min)	Nitrogen 28	Argon 40	Oxygen 32	Water 18
38	903940	80.193	1.009	18.102
39	932948	80.203	1.016	18.076
40	961778	80.065	1.018	18.221
41	990701	80.181	1.015	18.091
42	1019570	80.185	1.031	18.077
43	1048680	80.149	1.023	18.125
44	1077430	80.12	1.023	18.155
45	1106301	80.076	1.013	18.218
46	1135051	80.207	0.996	18.099
47	1163923	80.185	1.018	18.089
48	1192796	80.148	0.997	18.172
49	1221607	80.195	1.011	18.1

Data for up to 80 gas sample streams

Paul Scherrer Institute – PANDA Test Facility Studies



PANDA during construction
Passive condensers are at the top of the large cylindrical vessels



Paul Scherrer Institute – PANDA Test Facility Studies

- Analysis of the composition and characteristics of vent streams from a Passive Decay Heat Removal safety system for Advanced Light Water Reactor Systems
- The development of Passive Protection Systems eliminates sources of failure present for active systems e.g. Human error or power failure
- The Hiden system was commissioned to investigate the function and reliability of passive condensers under severe accident conditions, in presence of "non-condensable" gases e.g. N_2 , which can markedly affect the efficiency of the PPS

Hideen HPR-20 Gas Analysis System with Proteus Multi-way valve – Selected Customers



PAUL SCHERRER INSTITUT



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Investigation of Key Issues for the Simulation of Thermal-Hydraulic
Conditions in Water Reactor Containment.
NEA/CSNI/R (2012)5, 06 April 2012.

Alternative Configuration



Bench-top version of the instrument is also available

- 
- www.HidenAnalytical.com
 - The Hiden website is an excellent resource with product pages, brochures, catalogues, product pages with some application notes, presentation and other information.
 - Contact +44 1925 445225 for direct support.