

Hiden 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)







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



C 0 to 1bar Bourdon tube gauge

Mass flow meter with Modbus communication and 65°C heating





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, bidirectional 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 H₂0⁺ 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



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

Multistream Setup.vi			-
	Multistream Setup Configuration		
	Stream 1 Stream 21 Stream 31		
	Stream 2 Stream 12 Stream 22 Stream 32		
	Stream 3 Stream 13 Stream 23 Stream 33		
	Stream 4 Stream 14 Stream 24 Stream 34		
	Stream 5 Stream 15 Stream 25 Stream 35		
	Stream 6 Stream 16 Stream 26 Stream 36		
	Stream 7 Stream 17 Stream 27 Stream 37		
	Stream 8 Stream 18 Stream 28 Stream 38		
	Stream 9 Stream 19 Stream 29 Stream 39		Click to add
	Stream 10 Stream 20 Stream 30 Stream 40		click to add
	Select Select Select Column Column		from the analysis
Flush Stream			sequence
None Selected			-
Flush Time Purge Time	Set Stream None	Exit	

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.

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





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



Elapsed Time (s)	Water (%)	Nitrogen (%)	Oxygen (%)	Argon (%)	MFC1-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	
55.46	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	
C						

<u>Data Export</u>

- Data export to MS Excel.
- New workbook for each data file.

	1 10000															- Aller State	-
ole Edit	yes must	Pyrnat Io	ole <u>D</u> eta <u>W</u>	ndow thelp										7ype	a question for h	6 · _ 8	×
i 🖬 🔒	3 🗋 🗳	11 X X	1 II II.	9 . (9 .)	👷 Σ 🔹	21 31 🛍	🦂 107% 🔹	i Ans		* 10 *	BII	1 2 3 3	💽 🦉 %	· % 3	「龍田・	ð• <u>A</u> •	E IA
힘힘길	0000	0 2 1	1 1 Ye Repl	with Change	s End Re	101											
At	• <u>6</u> h	fode = Nix	ture			_											
A	B	C.	0	E	F	G	н	E	J	K	L	M	N	0	Ρ	0	-
lode – M	xture																
ican = De	fault Speed																
xperimen	t Start time: 1	0:15:54 Da	ite: 12 Feb 20	999								-					
xperimen IGA - %	Gas	CO	mpo	sitic	n	Raw Dota	RAW	dat	a			Corrected	orre	cteo	d dat	a	
xperimen IGA - % Time (ms)	Gas Nitrogen 28	CO Argen 40	0xygen 32	sitic Water 18	n	Raw Dota Time (ms)	Alfres Nitrogen 28	dat Argon 40	a Oxygen 32	Water 18		Corrected Time (ms)	orre	cteo Argon 40	d dat Oxygen 32	a Water 18	
xperimen IGA - % Time (ms) 5638	Gas Nitrogen 28 80.148	CO Argen 40 1.014	Oxygen 32 18.124	Water 18 0.714	n	Raw Dota Time (rss) 5.64E-03	Nitrogen 28 1 27E-07	dat Argon 40 1.45E-09	a 0xygen 32 2.67E-08	Water 18 1.06E-09		Corrected Time (ms) 5.64E+03	orre Nitrogen 28 1.25E-07	Argon 40	d dat 0xygen 32 2.82E-08	Water 18 1.11E-09	_
sperimen IGA - % Time (ms) 9638 36480	Gas Nitrogen 28 80.148 80.198	Argen 40 1.014 1.004	0xygen 32 18.124 18.094	Water 18 0.704	on	Raw Data Time (rss) 5.64E-03 3.65E-04	Nitrogen 28 1 27E-07 1 26E-07	dat Argen 40 1.45E-09 1.43E-09	0 xygen 32 2.67E-08 2.66E-08	Water 18 1.06E-09 1.04E-09		Corrected Time (ms) 5.64E+03 3.65E+04	Nitrogen 28 1.25E-07 1.25E-07	Argon 40 1.59E-09	d dat 0xygen 32 2.82E-08 2.81E-08	Water 18 1.11E-09 1.09E-09	
sperimen IGA - % Time (ms) 9638 36480 64966	B0.149 80.137	Argen 40 1.014 1.004 1.002	0xygen 32 19.124 18.094 18.142	Water 18 0.704 0.719	on	Raw Dota Time (res) 5.64E-03 3.65E-04 8.48E-04	Nitrogen 28 1 276-07 1 266-07 1 266-07	dat Argon 40 1.45E-09 1.43E-09 1.42E-09	0xygen 32 2.67E-08 2.66E-08 2.66E-08	Water 18 1.06E-09 1.04E-09 1.06E-09		Corrected Time (ms) 5.64E+03 3.65E+04 6.48E+04	Nitrogen 28 1.25E-07 1.25E-07 1.24E-07	Argon 40 1.59E-09 1.55E-09 1.55E-09	0xygen 32 2.82E-08 2.81E-08 2.81E-08	Water 18 1.11E-09 1.09E-09 1.11E-09	
xp orimon IGA - % Time (ms) 9638 36480 64966 93416	B0.149 80.149 80.137 80.173	Argen 40 1.014 1.004 1.002 1.001	0xygen 32 0xygen 32 18.124 18.084 18.142 18.121	Water 18 0.714 0.704 0.719 0.705	on	Raw Dota Time (res) 5.64E-03 3.65E-04 6.48E-04 9.34E-04	Mitrogen 28 1 27E-07 1 26E-07 1 26E-07 1 26E-07 1 26E-07	dat Argon 40 1.45E-09 1.43E-09 1.42E-09 1.42E-09	0xygen 32 2.67E-08 2.86E-08 2.86E-08 2.86E-08 2.66E-08	Water 18 1.06E-09 1.04E-09 1.06E-09 1.04E-09		Corrected Time (ms) 5.64E+03 3.65E+04 6.46E+04 9.34E+04	Nitrogen 28 1.25E-07 1.25E-07 1.24E-07 1.24E-07	Argon 40 1.59E-09 1.55E-09 1.55E-09 1.55E-09	0xygen 32 2.82E-08 2.81E-08 2.81E-08 2.81E-08 2.80E-08	Water 18 1.11E-09 1.09E-09 1.11E-09 1.09E-09	
xp or iman IGA - % 5638 35430 64965 93415 122582	B0.148 80.198 80.173 80.225	Argen 49 1.014 1.004 1.001 1.001 1.005	0xygen 32 0xygen 32 18.124 18.084 18.142 18.142 18.145	Water 18 0.714 0.704 0.719 0.705 0.725	on	Raw Dota Time (res) 5.64E-03 3.65E-04 8.48E-04 9.34E-04 1.23E-05	Nitrogen 28 1 27E-07 1 26E-07 1 26E-07 1 26E-07 1 26E-07 1 26E-07 1 26E-07	dat Argon 40 1.45E-09 1.43E-09 1.42E-09 1.42E-09 1.42E-09 1.43E-09	0xygen 32 2.67E-08 2.66E-08 2.66E-08 2.66E-08 2.66E-08 2.64E-08	Water 18 1.06E-09 1.04E-09 1.06E-09 1.04E-09 1.04E-05 1.07E-09		Corrected Time (ms) 5.64E+03 3.55E+04 6.48E+04 9.34E+04 1.23E+05	Nitrogen 28 1.25E-07 1.25E-07 1.24E-07 1.24E-07 1.24E-07 1.24E-07	Argon 40 1.59E-09 1.55E-09 1.55E-09 1.55E-09 1.55E-09 1.55E-09	0xygen 32 2.82E-08 2.81E-08 2.81E-08 2.81E-08 2.80E-08 2.79E-08	Water 18 1.11E-09 1.09E-09 1.11E-09 1.09E-09 1.09E-09 1.12E-09	

- Quantitative data, raw data values and corrected data values are exported.
- Calibration factors and background correction values are recorded.

IN .	0	F	Q	π	1 3		0
					09.Feb-09 Ca	libration	factor
gen 28	Argon 40	Oxygen 32	Water 18		Background	Calibration Fa	ctor
26E-07	1.58E-09	2.82E-08	1.11E-09		8.19E-11	1.01349	
25E-07	1.56E-09	2.81 E-08	1.09E-09		1.58E-10	0.91654	
24E-07	1.55E-09	2.81E-08	1.11E-D9		1.54E-10	0.9474	
24E-07	1.55E-09	2.80E-08	1.09E-09		1.14E-09	0.95104	
24E-07	1.55E-09	2.79E-08	1.12E-09		0	1	
24E-07	1.54E-09	2.82E-08	1.11E-09		0	1	
14E OT	1 55 5 00	D 01 E 00	1.11E.DD		0	1	

- 10 - B / U = = = = 3 😳 % , 🐭 🕮 🛱 🖽 - 加 - 🛓 -

_ 5 ×

Type a question for help 🚽 🚽 🗷 🗙

			00.100	1.0021	10.001	0.1001	
The weather als	38	903940	80.193	1.009	18.102	0.695	
Ine workbook	39	932948	80.203	1.016	18.076	0.705	
contains a	40	961778	80.065	1.018	18.221	0.696	
worksheet for	41	990701	80.181	1.015	18.091	0.714	
each gas	42	1019570	80.185	1.031	18.077	0.707	
stream	43	1048680	80.149	1.023	18.125	0.704	
Stream.	44	1077430	80.12	1.023	18.155	0.702	
	45	1106301	80.076	1.013	18.218	0.693	
Data for up to 80 gas	46	1135051	80.207	0.996	18.099	0.698	
sample streams	47	1163923	80.185	1.018	18.089	0.708	
	48	1192796	80.148	0.997	18.172	0.684	
	49	1221002	_80 195	1 011	18.1	0.694	
	H 4	► ► ► \\ <u>Strea</u>	am 1 / Stream 3	CStream 4	/ Stream 5 /	Stream 7 /	
	Read	dy					

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. N₂, which can markedly affect the efficiency of the PPS

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



PAUL SCHERRER INSTITUT



References

1. O.Auban, J Malet, P.Brun, J.Brinster, J.J Quillico, E.Sruder. IMPLEMENTATION OF GAS CONCENTRATION MEASUREMENT SYSTEMS USING MASS SPECTROMETREY IN CONTAINMENT THERMAL-HYDRAULICS TEST FACILITIES: DIFFERENT APPROACHES FOR CALIBRATION AND MESUREMENT WITH STEAM/AIR/HELIUM MIXTURES. The 10th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-10) Seoul, Korea, October 5-9, 2003.

Nuclear Energy Agency
Committee on the safety of nuclear installations.
OECD/SETH-2 PROJECT PANDA AND MISTRA EXPERIMENTS FINAL
SUMMARY REPORT
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.