Asia Pacific Mercury Monitoring Network

Center for Environmental Monitoring and Technology
National Central University

CONTINUOUS SPECIATED MERCURY MONITORING IN AMBIENT AIR

TEKRAN SYSTEM 2537/1130/1135

GARDIS-5 SYSTEM

Outline

1. *Mercury Monitoring in Ambient Air*
2. *Tekran 2537/1130/1135 continuous speciated mercury monitoring*
3. *Sampling & Analysis*
4. *Data output*
5. *Routine Maintenance and instrument problems*
6. *Gardis-5 system*

1. MERCURY MONITORING IN AMBIENT AIR

Why the Interest in Atmospheric Mercury?

- Mercury is one of the most potent neurotoxins known
- Bio-accumulates up the food chain

  Inorganic and ionic mercury can convert to **methyl mercury**

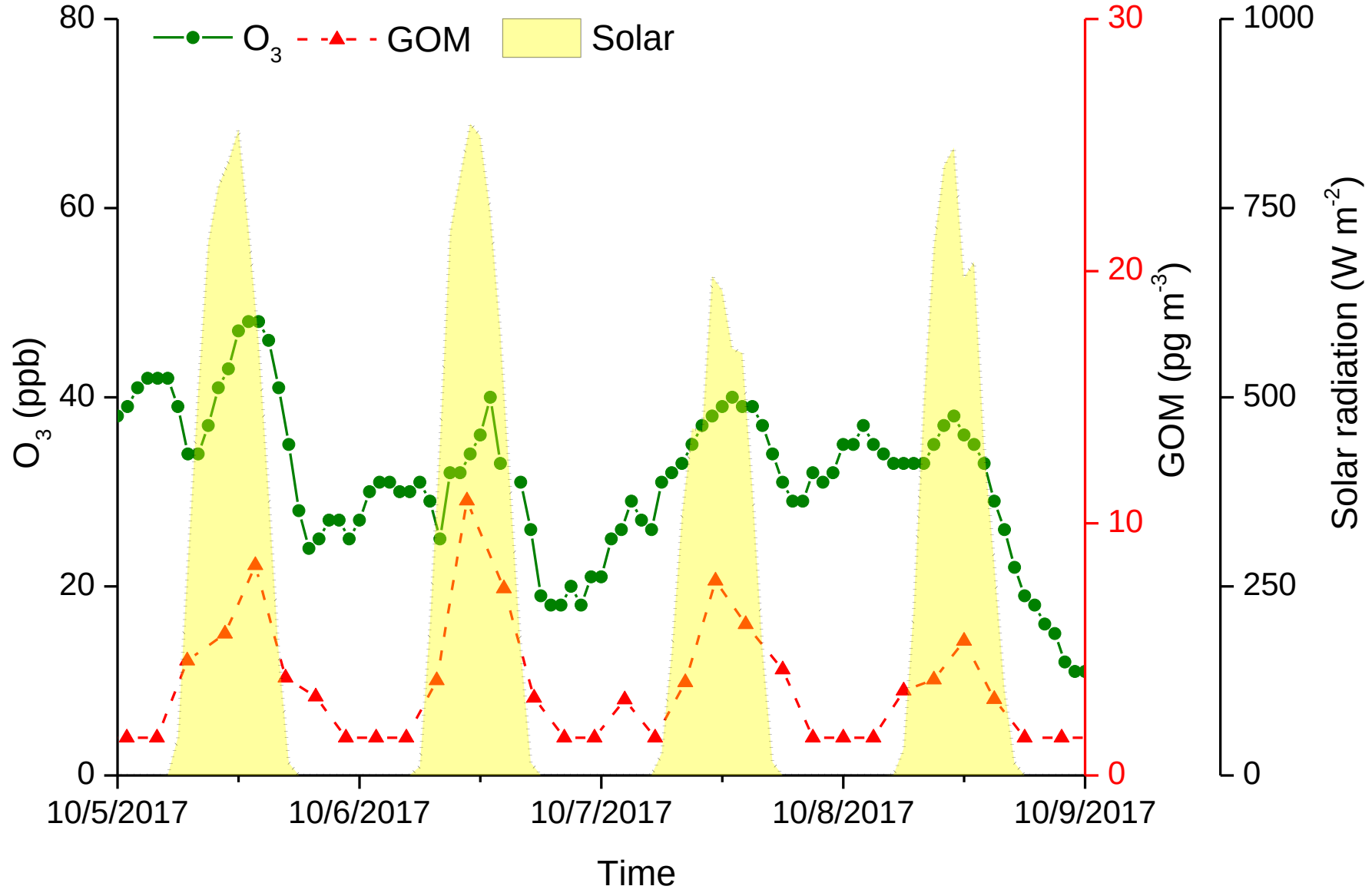
  Sub-ppt levels in air can accumulate to toxic ppm levels in fish

- Long life in the atmosphere means that mercury emissions are of *global* concern

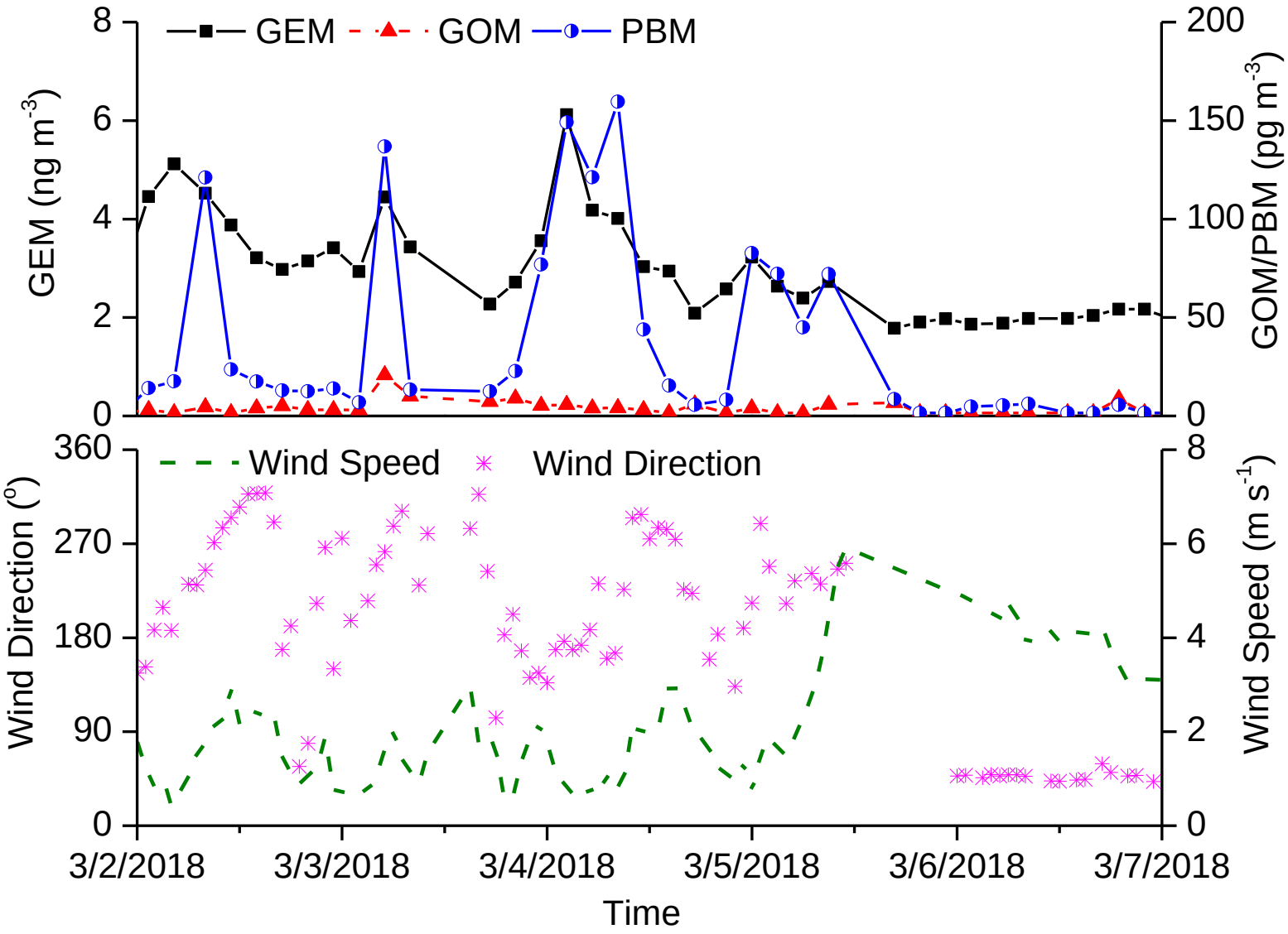
Ambient Air Mercury Speciation – Why?

- Types of mercury in ambient air:
  - Elemental mercury: Hg^0, (GEM)
  - Reactive (ionic) mercury: Hg(II), RGM, Hg^{2+}, (GOM)
  - Particulate bound mercury: PHg, TPM, (PBM)
- Different forms of gaseous Hg have very different behaviors
- Forms can interconvert in the atmosphere and in various reservoirs

NCU- Photo-oxidation



Local emission events: typical pattern



Local emission events are often associated with low wind speed and S-SW-W direction

Mercury Detection - The Challenges

❖ Sensitivity

Mercury is present in the low ppt range

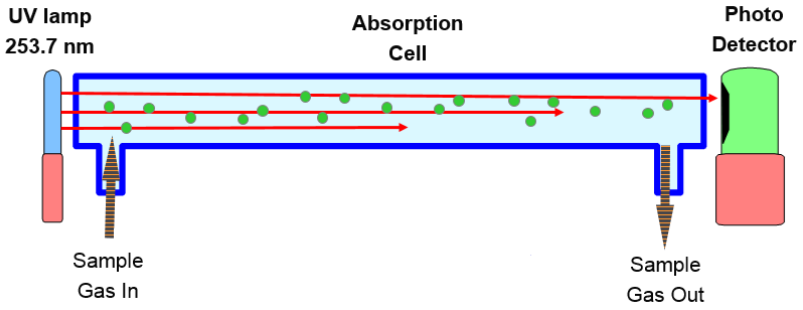
❖ Selectivity

Potential interferents are present at *1000's of times* higher concentration than mercury: O_3, SO_2, NO_X, HCl.

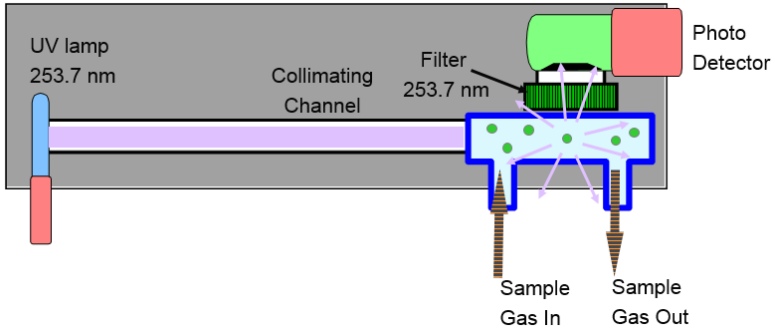
Mercury Detection Techniques

Two spectroscopic techniques used for analysis

Atomic Absorption (*AA*)

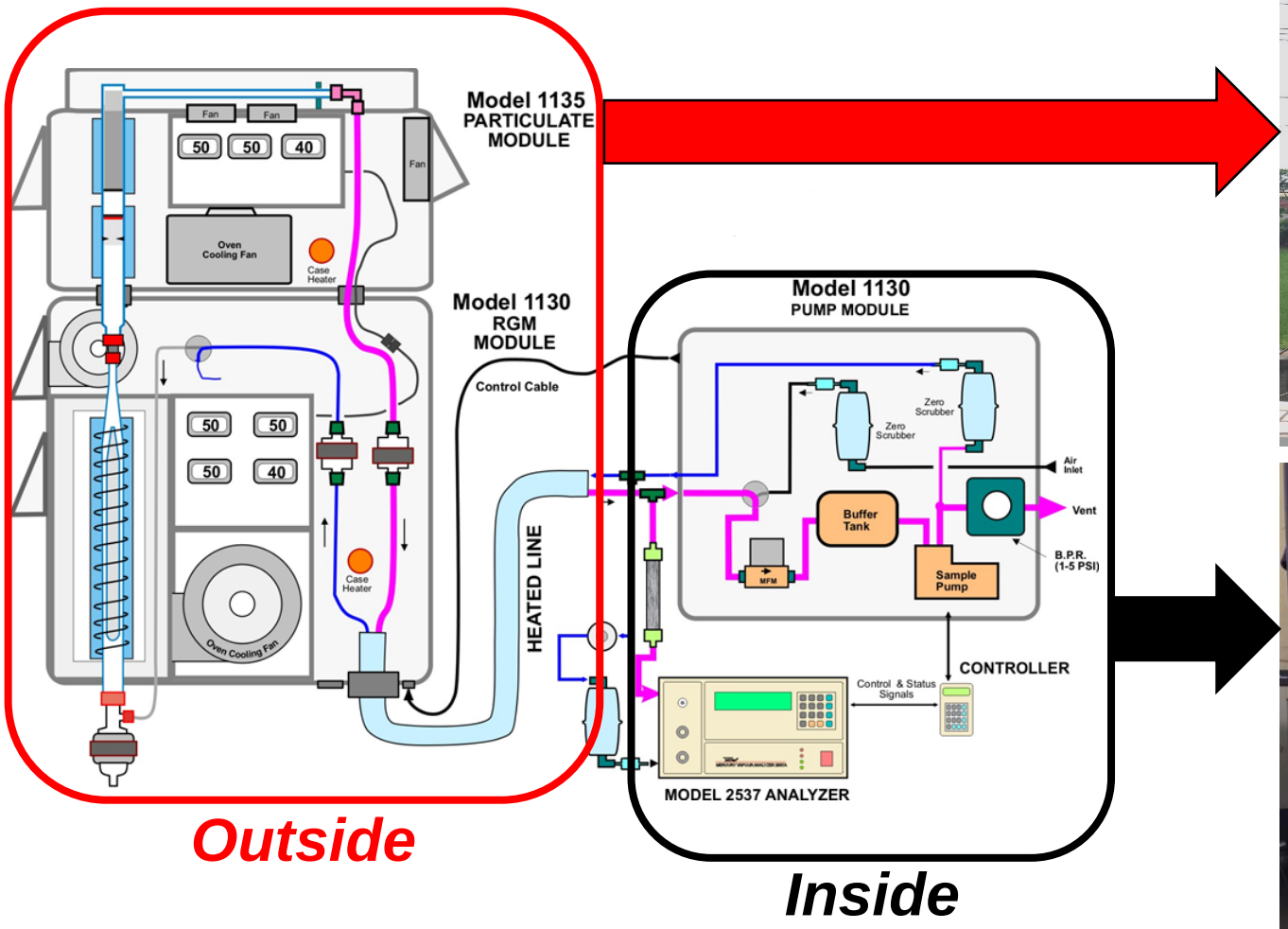


Atomic Fluorescence (*AF*)



- Much more sensitive than atomic adsorption (MDL < 0.1 pg absolute)
- Not subject to interferences
- Inherently linear

2. TEKRAN SYSTEM 2537/1130/1135

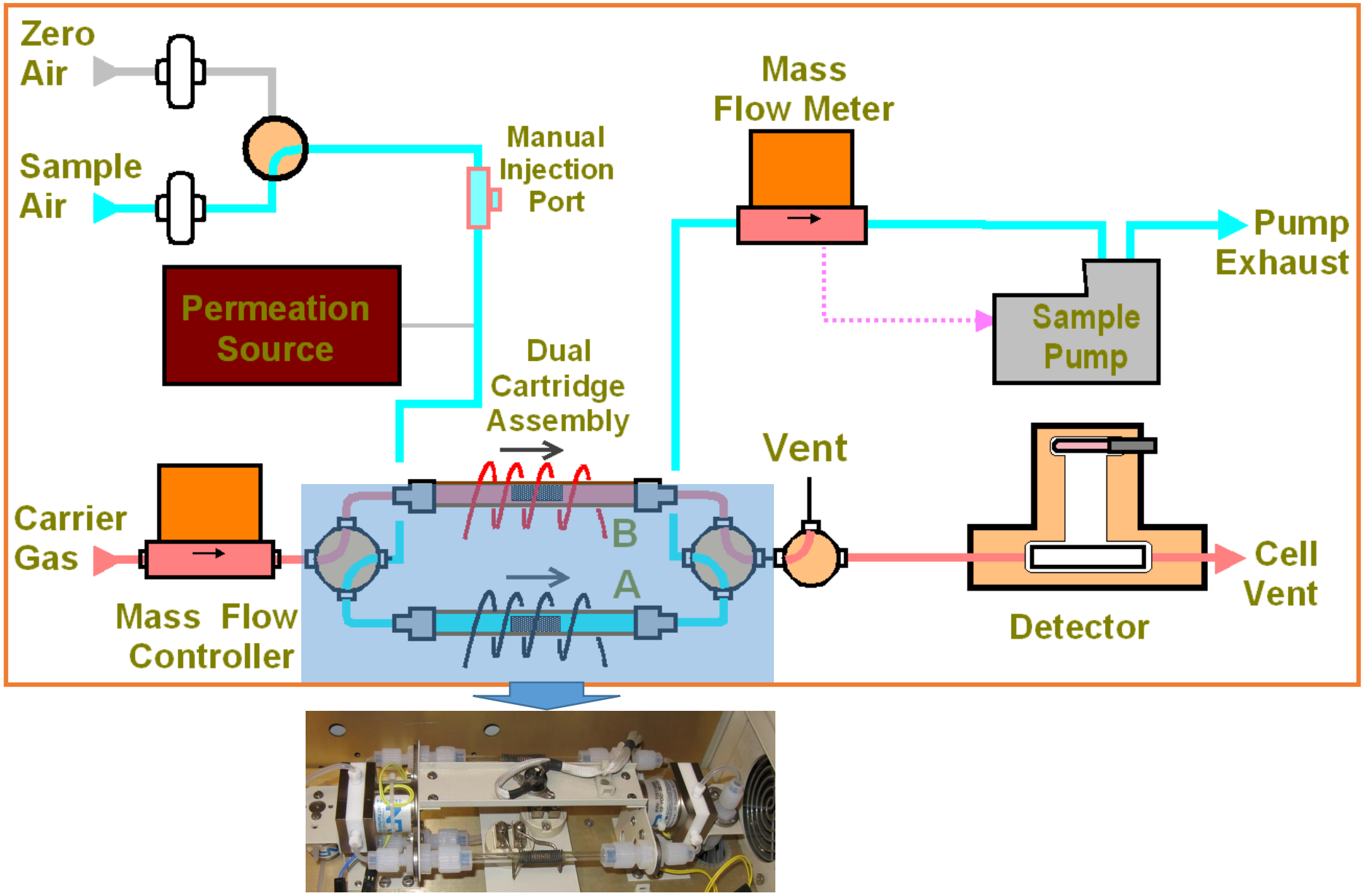


Model 2537 Analyzer

- Automated implementation of gold/AF manual method
- Has largely supplanted manual cartridge methods
- Detection limit ***< 0.1 ng/m³*** *(5 min. samples)*
- Automatic recalibration with internal Hg^0 permeation source
- Capable of unattended operation for extended periods
- Two cartridges are used to alternately sample and desorb

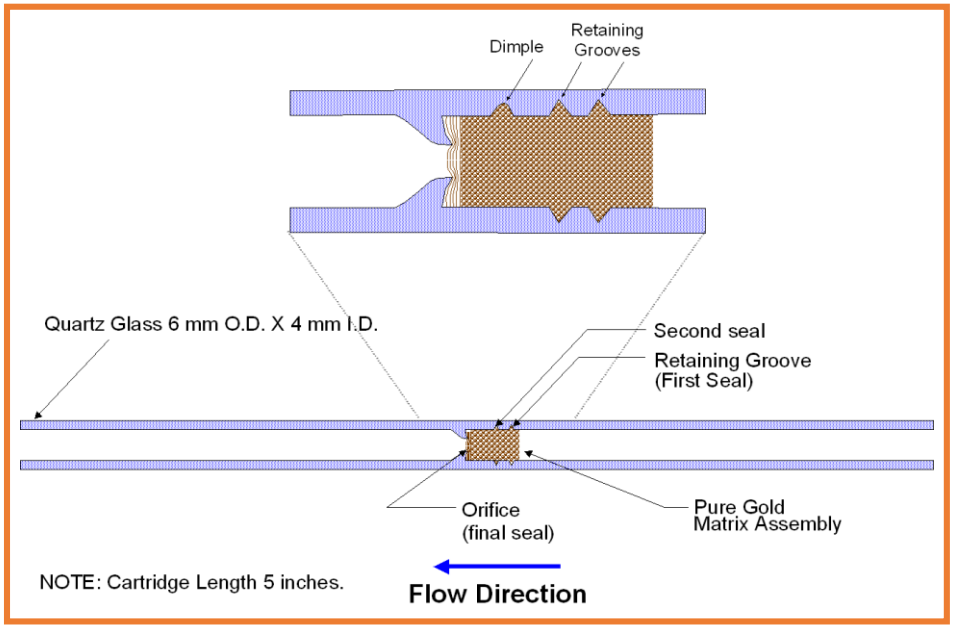
  No gaps in data stream

Diagram of Tekran Model 2537



Tekran Pure Gold Cartridge

- Pure gold is used as the mercury adsorbent
  - No quartz wool or silica
  - No memory effect



- Extremely durable design
  - Lasts for years of continuous use

Internal Permeation Source

- Allows automated, unattended calibrations

  Ensures that analyzer results are always accurate

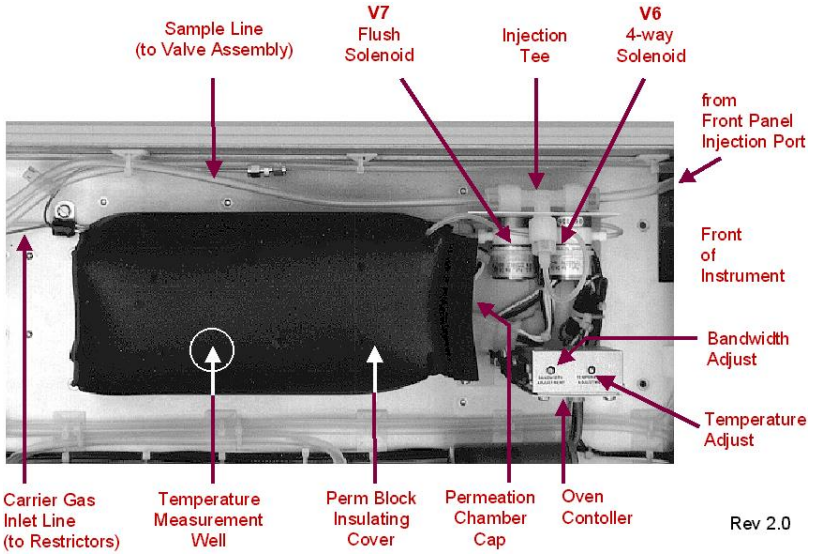
- Allows standard additions to sample gas

  Ensures that analyzer is working properly

- Long life permeation tube

  Low emission rate: Approx 30 µg/yr

  Theoretical life: thousands of years!



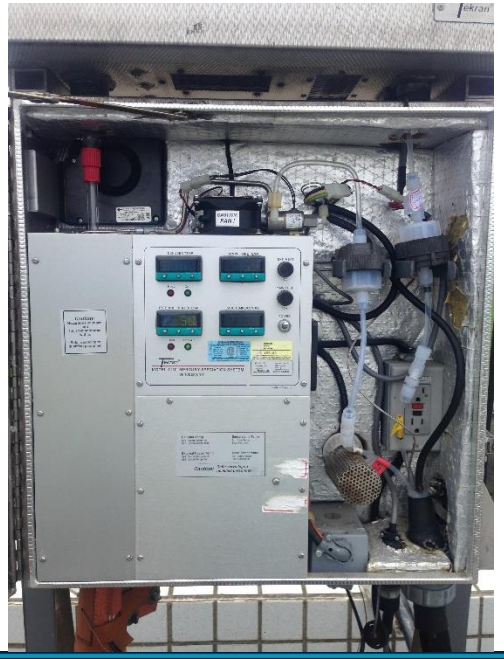
Model 1130 Speciation System

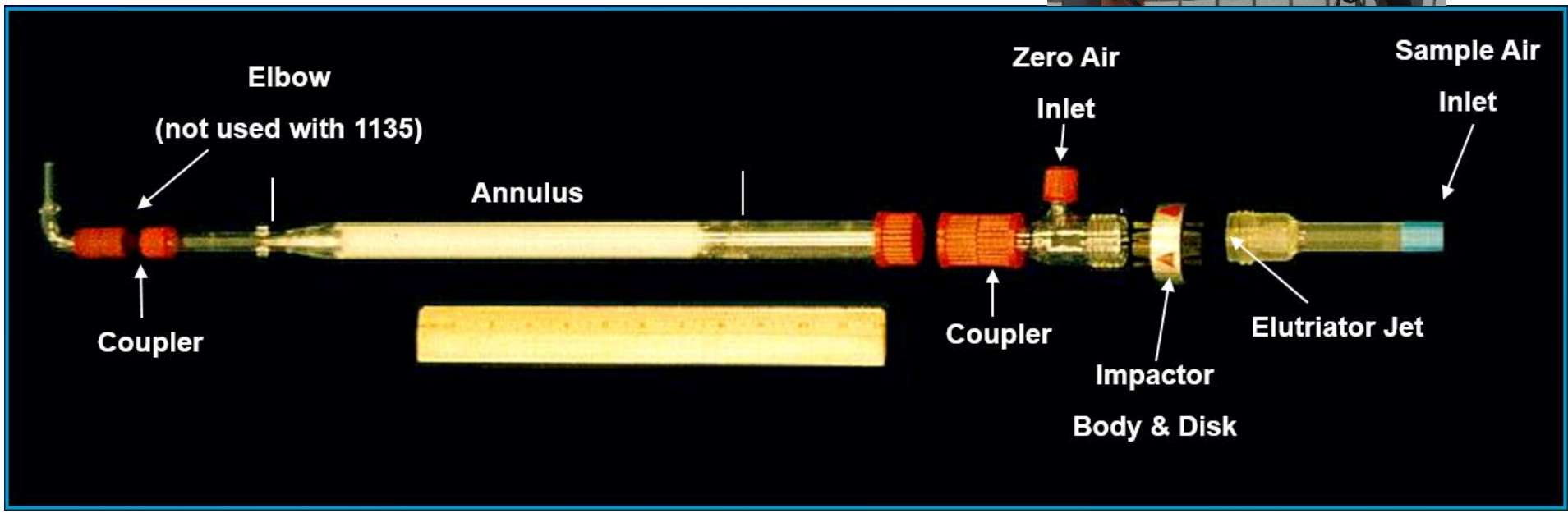
Denuder Module (highlighted)

- Located out of doors
- Contains denuder element within high performance oven
- Impactor inlet removes coarse particles (> 2.5 um)
- Climate controlled enclosure

Quartz Denuder Assembly

Quartz, KCL coated annular denuder is thermal desorbed and regenerated.





Model 1130 Speciation System

1130 Pump Unit

- Located beside 2537
- Provides extra flow required during sampling
- Generates the zero air required during desorption
- Also provides all zero air required by Model 2537

Heated line (not shown)

- 25 ft. length connects the two modules

Model 1130 - Principles of Operation

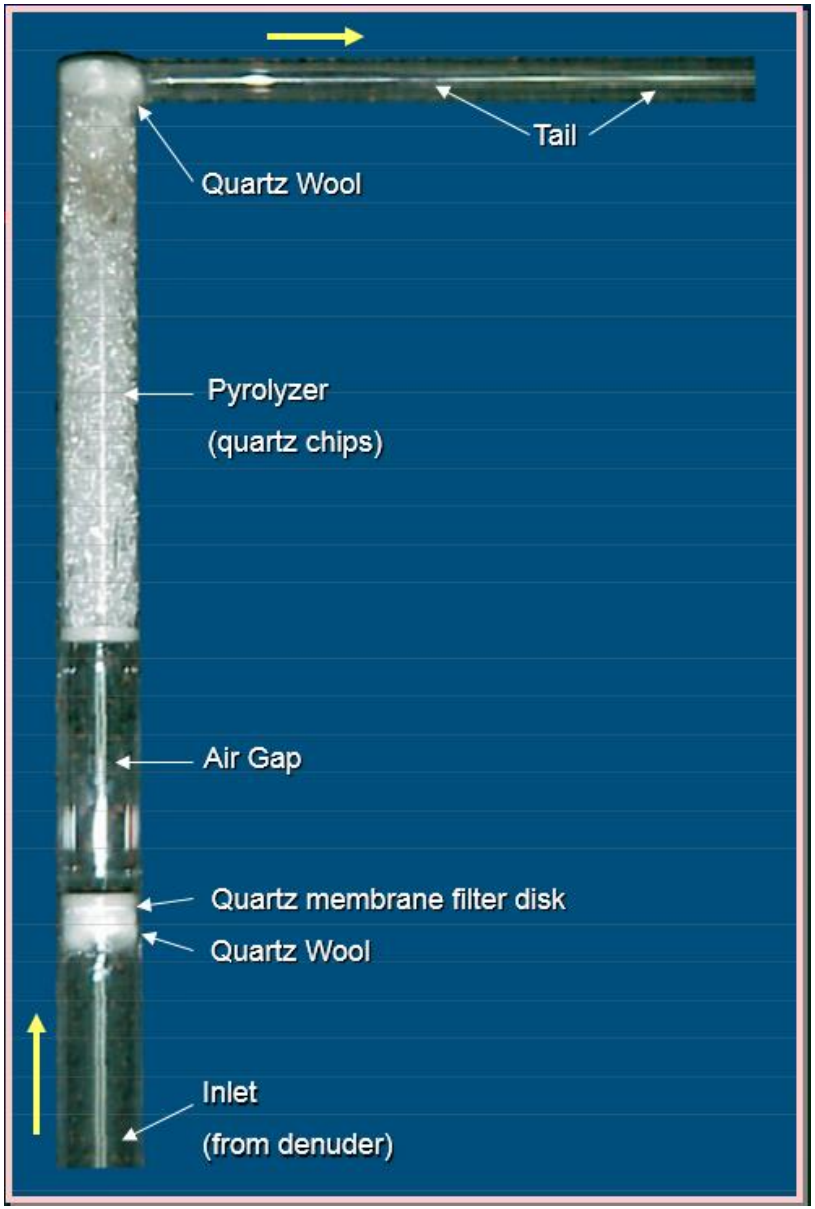
- Quartz, KCl coated annular denuder is thermally desorbed and regenerated
- Sampling Phase
  - Absorbs GOM while passing all GEM
  - Model 2537 reads **GEM** during this phase
- Desorption/Analysis Phase
  - Zero air used as carrier
  - GOM released as elemental mercury

Model 1135 – Particulate Mercury Monitor

- Unit stacks on top of Model 1130
- Allows ***simultaneous*** determination of GEM, GOM and PBM
- Detection limit < 2 pg/m^3

RPF

- Quartz wool captures bulk of particulate matter
- Quartz filter membrane provides sharp cut-off (<0.1 µm)
- Built in pyrolyzer section converts desorbed species to elemental Hg
- Tail provides cooling



Model 1135 - Principles of Operation

❖ Sampling Phase

Sample passes through impactor to eliminate coarse particles (***> 2.5 µm***)

Quartz, ***Regenerable Particulate Filter*** (***RPF***) captures fine fraction (***< 2.5 µm***) particulates

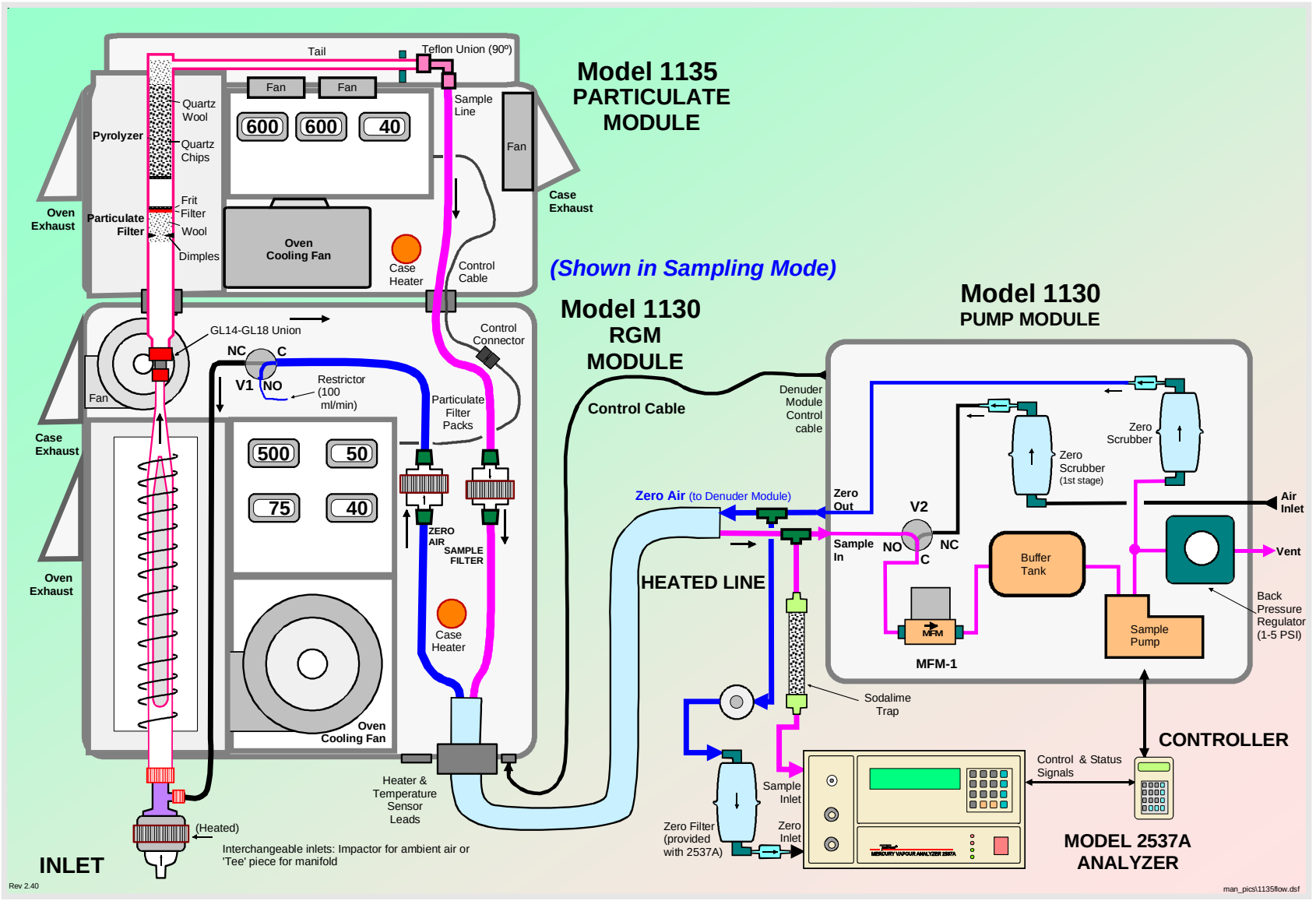
❖ Desorption/Analysis Phase

Zero air used as carrier

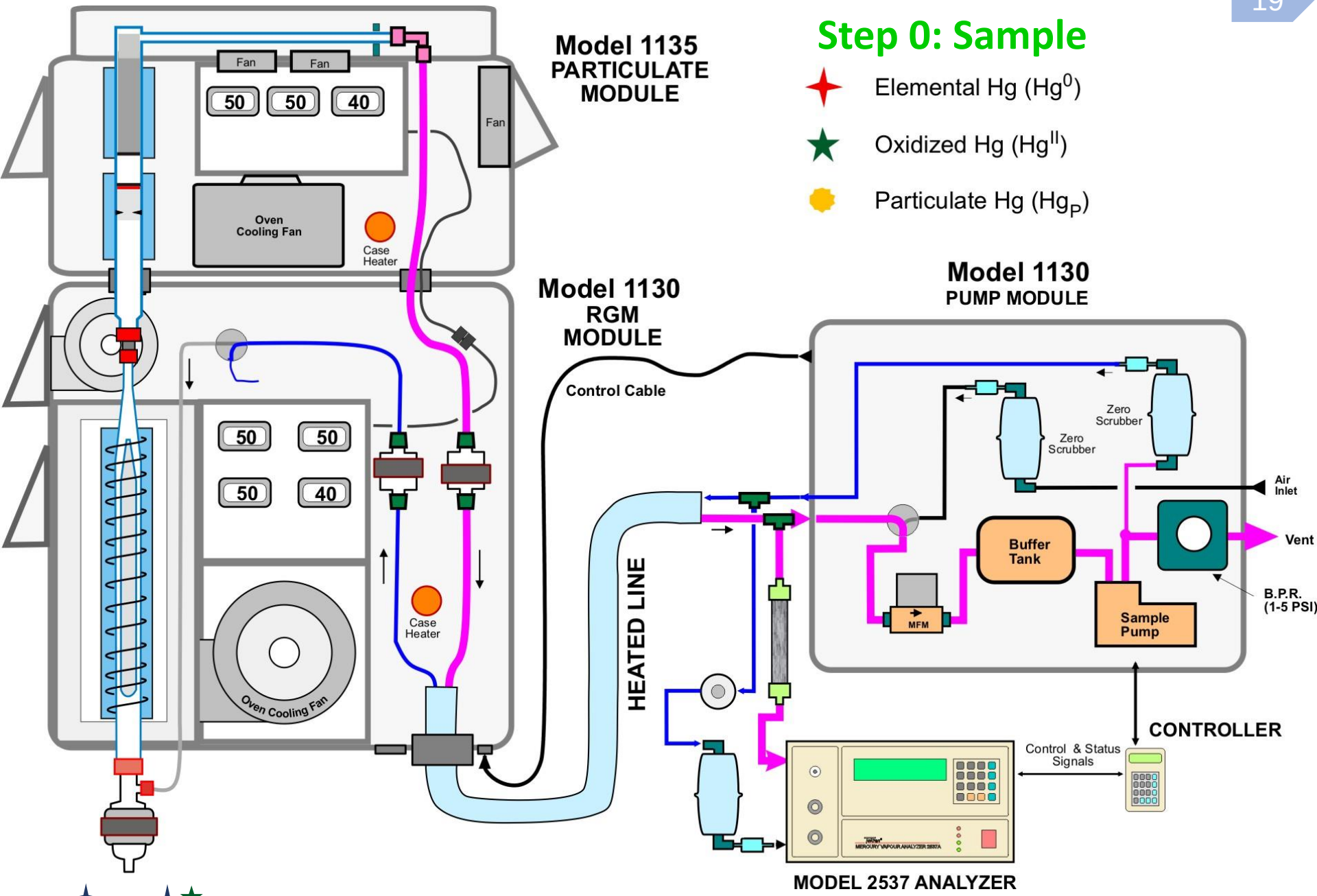
Downstream ***pyrolyser*** is activated first

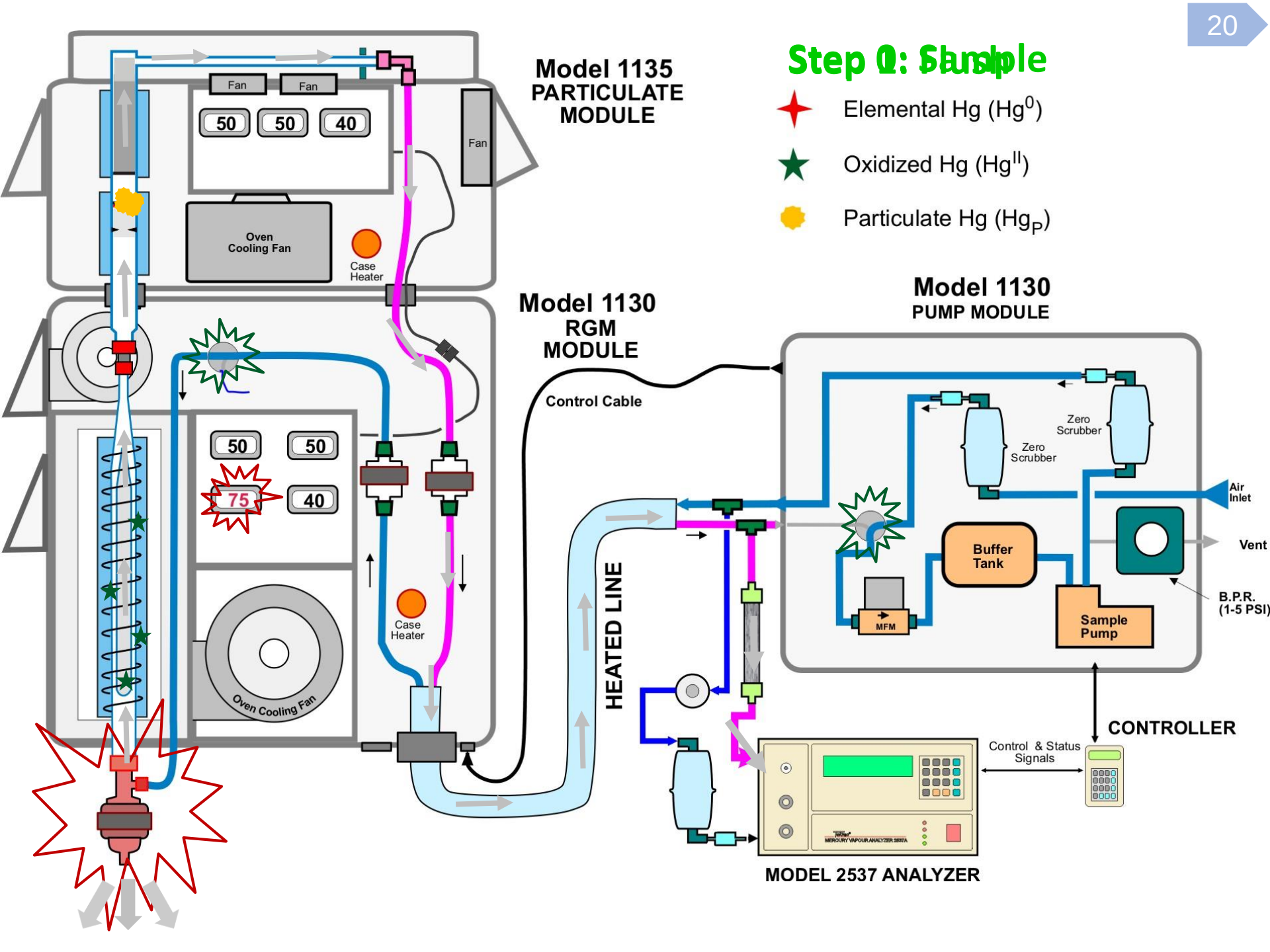
RPF is then heated to desorb captured particulates

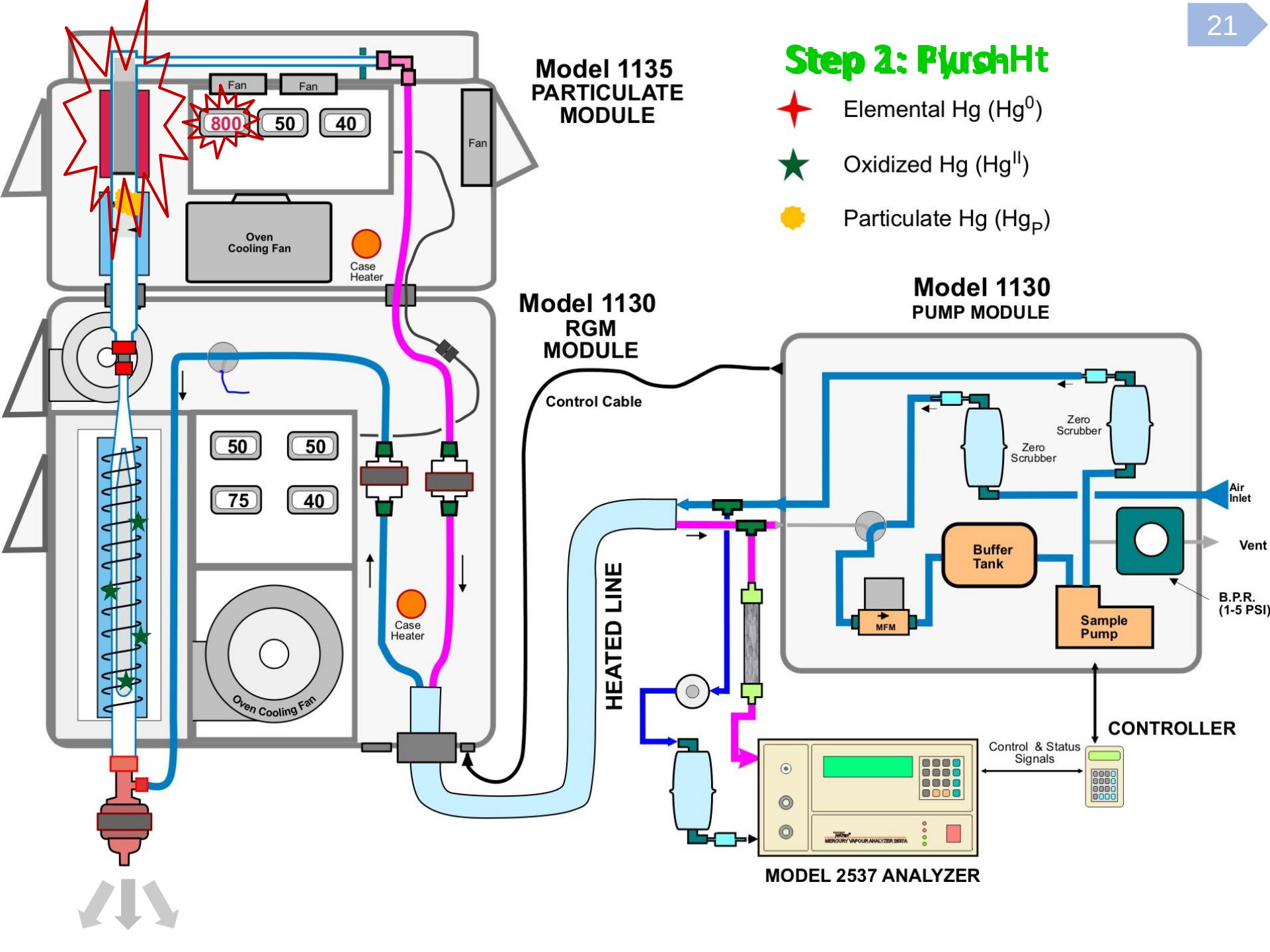
3. SAMPLING & ANALYSIS



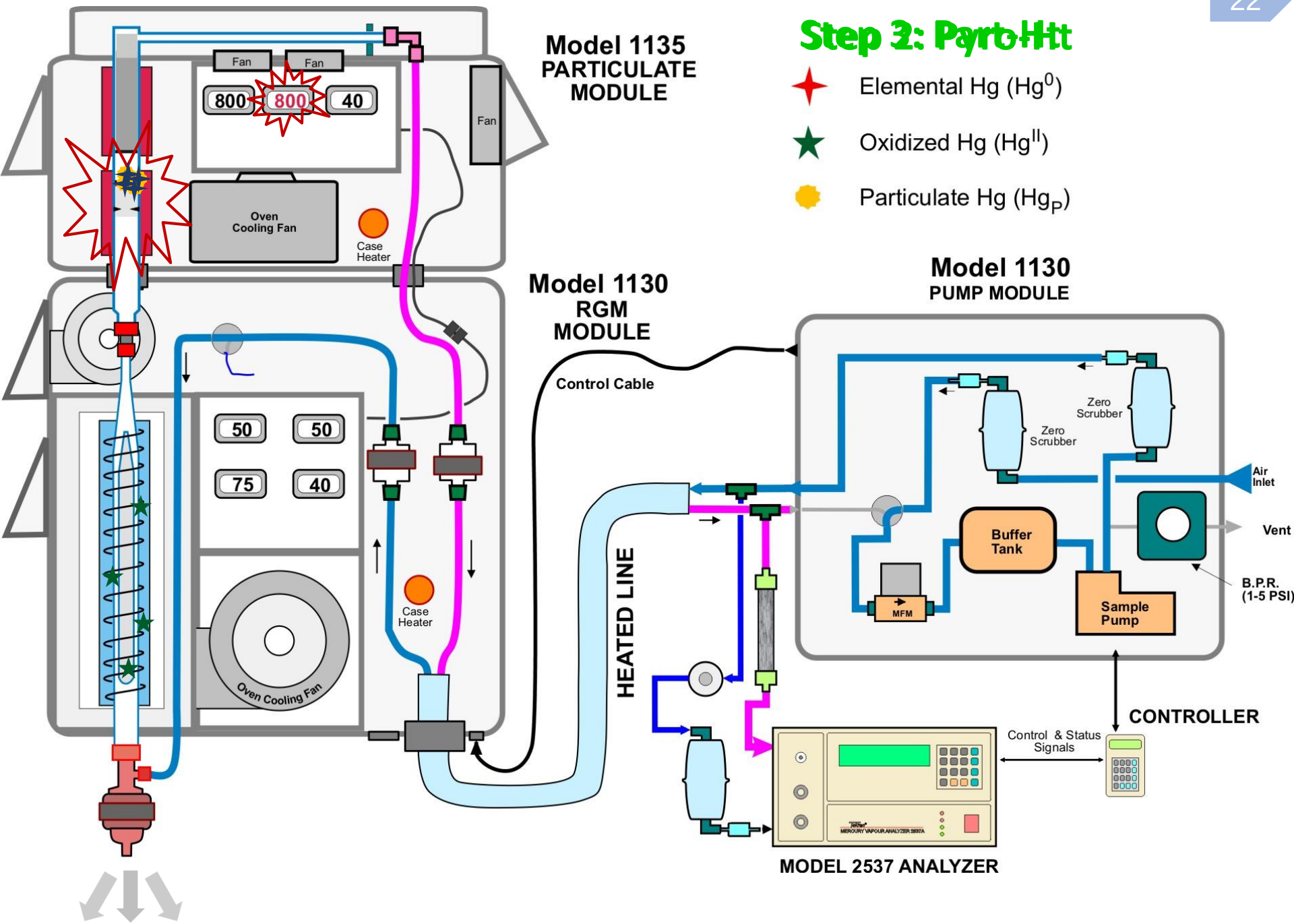
Step 0: Sample

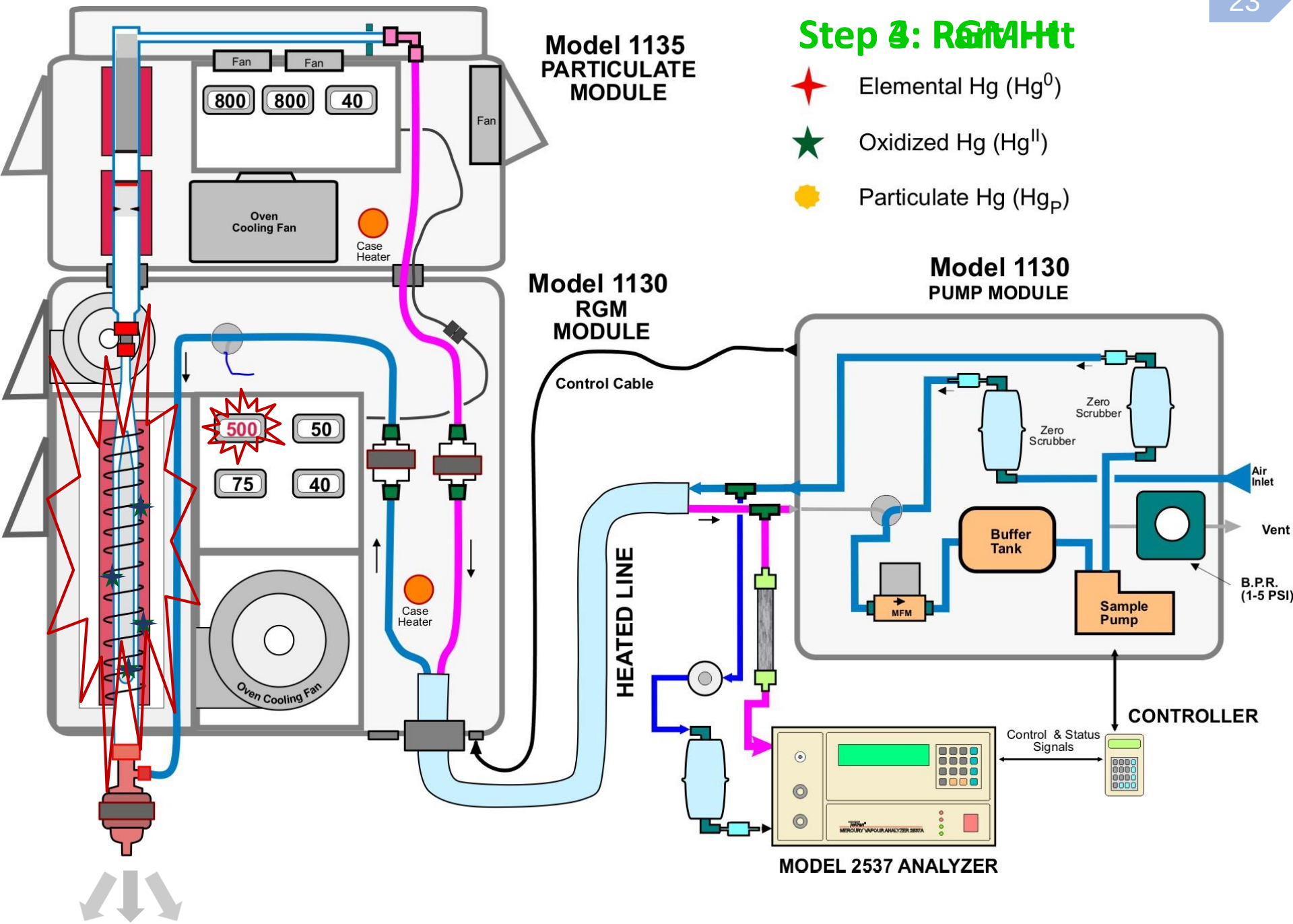



Step 1: Sample
Elemental Hg (Hg^0)
Oxidized Hg (Hg^{II})
Particulate Hg (Hg_P)
Model 1135
PARTICULATE
MODULE
Fan
Fan
Fan
50
50
40
Oven
Cooling Fan
Case
Heater
Model 1130
RGM
MODULE
Control Cable
Model 1130
PUMP MODULE
50
50
75
40
Case
Heater
Oven Cooling Fan
HEATED LINE
Zero
Scrubber
Zero
Scrubber
Air
Inlet
Buffer
Tank
Vent
MFM
Sample
Pump
B.P.R.
(1-5 PSI)
CONTROLLER
Control & Status
Signals
MODEL 2537 ANALYZER

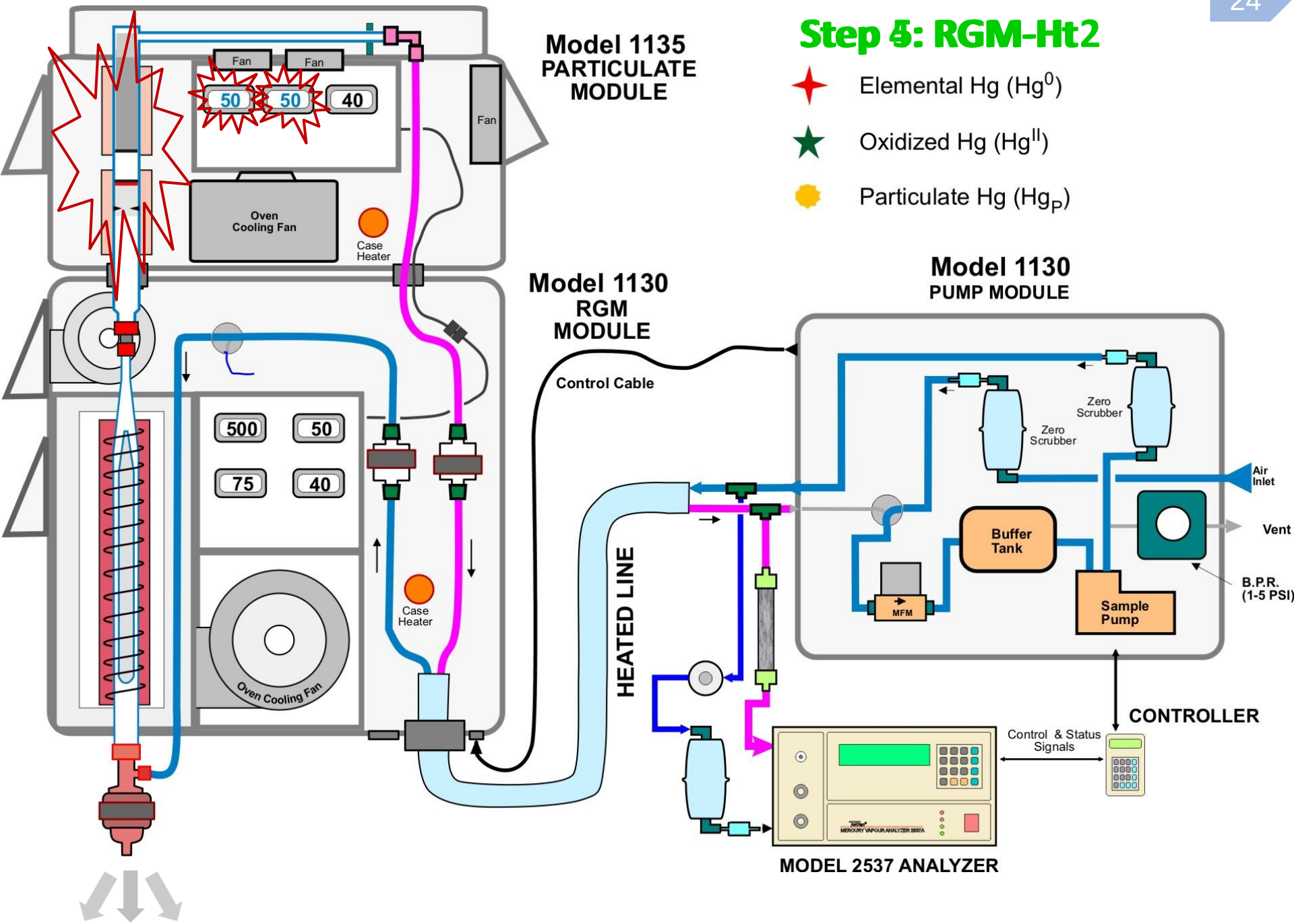

Step 2: Purge
Elemental Hg (Hg^0)
Oxidized Hg (Hg^{II})
Particulate Hg (Hg_P)
Model 1135
PARTICULATE
MODULE
Fan
Fan
800
50
40
Fan
Oven
Cooling Fan
Case
Heater
Model 1130
RGM
MODULE
Control Cable
Model 1130
PUMP MODULE
50
50
75
40
Case
Heater
Oven Cooling Fan
HEATED LINE
Zero
Scrubber
Zero
Scrubber
Air
Inlet
Buffer
Tank
Vent
MFM
Sample
Pump
B.P.R.
(1-5 PSI)
CONTROLLER
Control & Status
Signals
MODEL 2537 ANALYZER

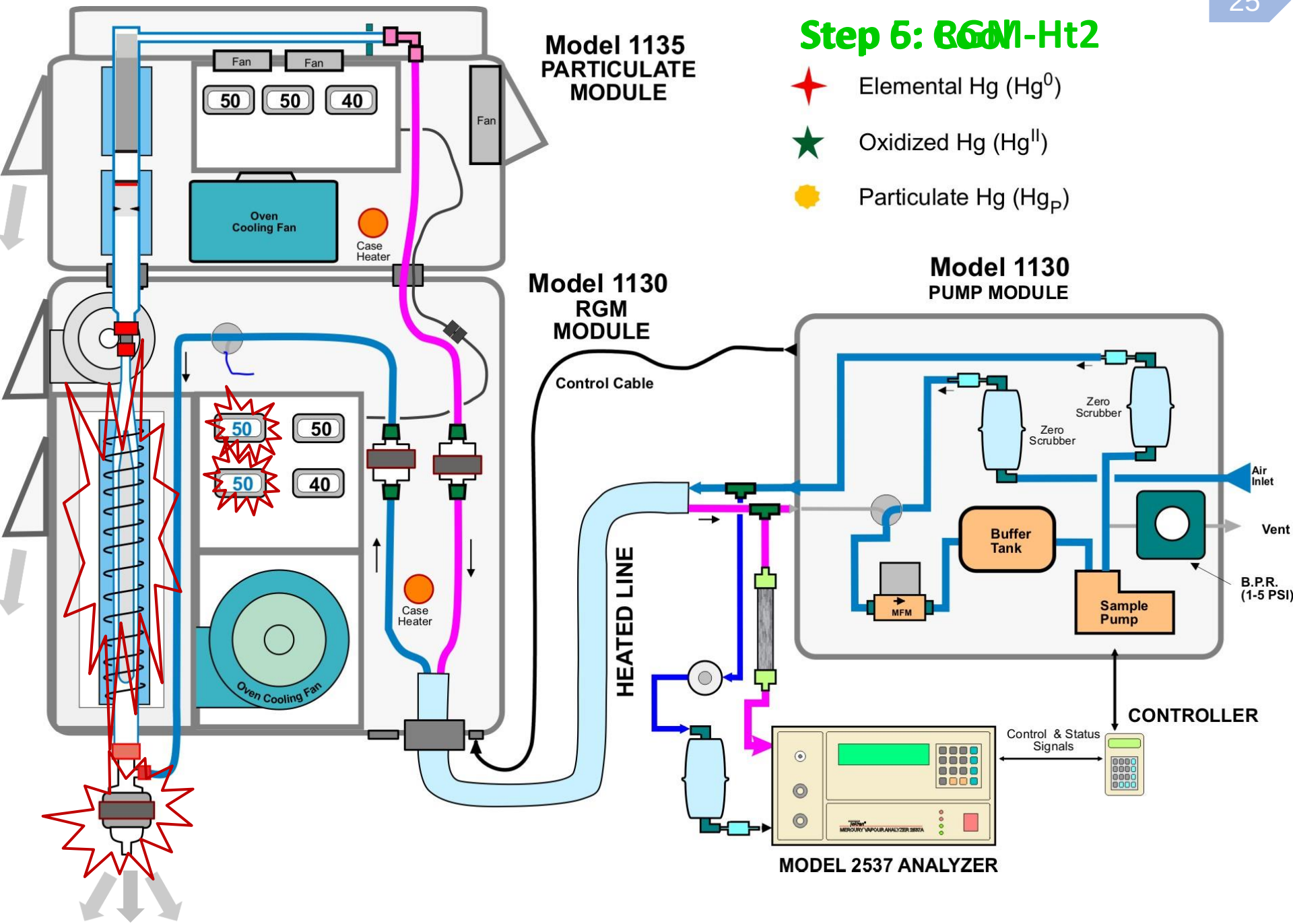
Step 3: Pyro-Htt

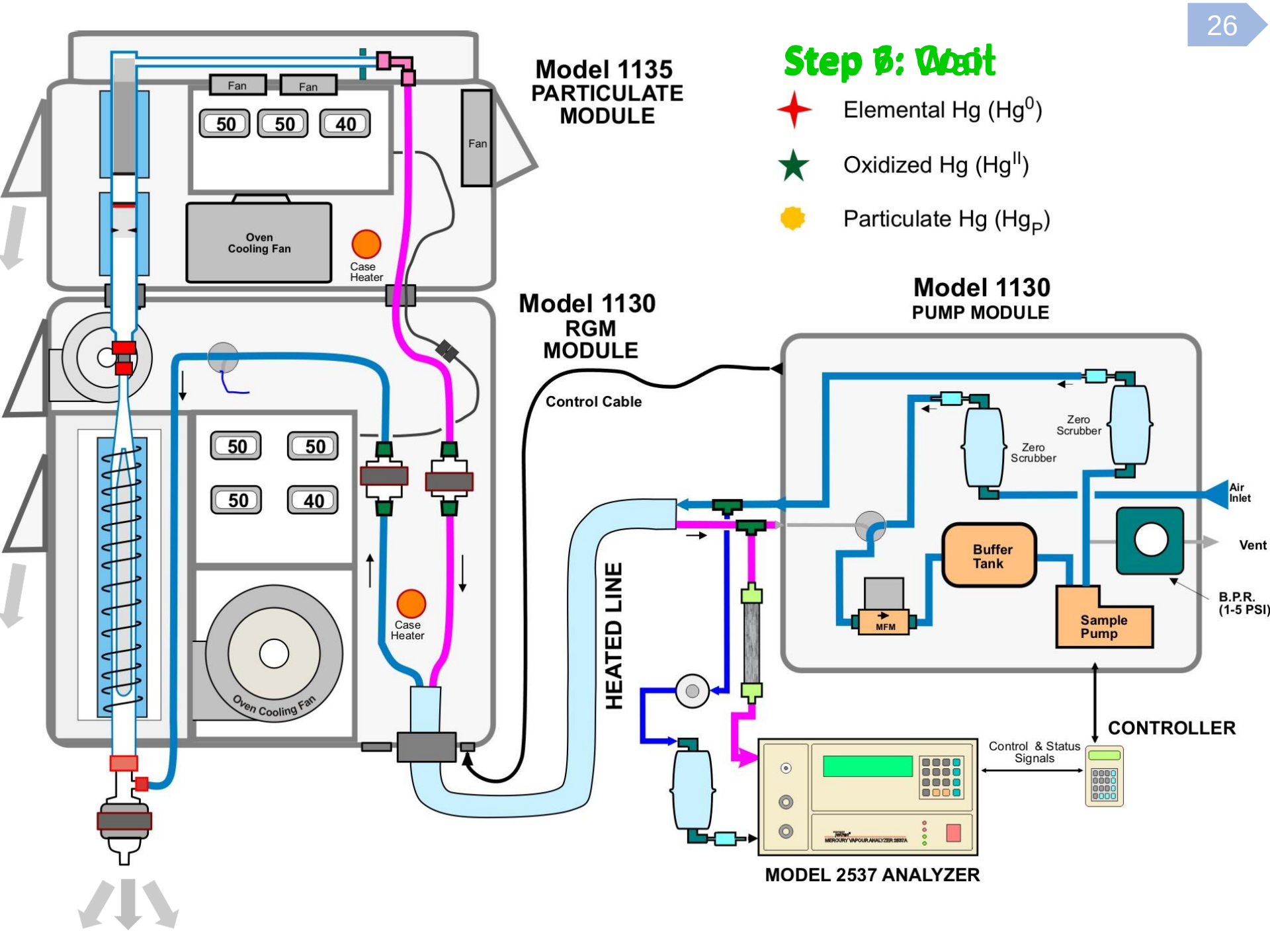


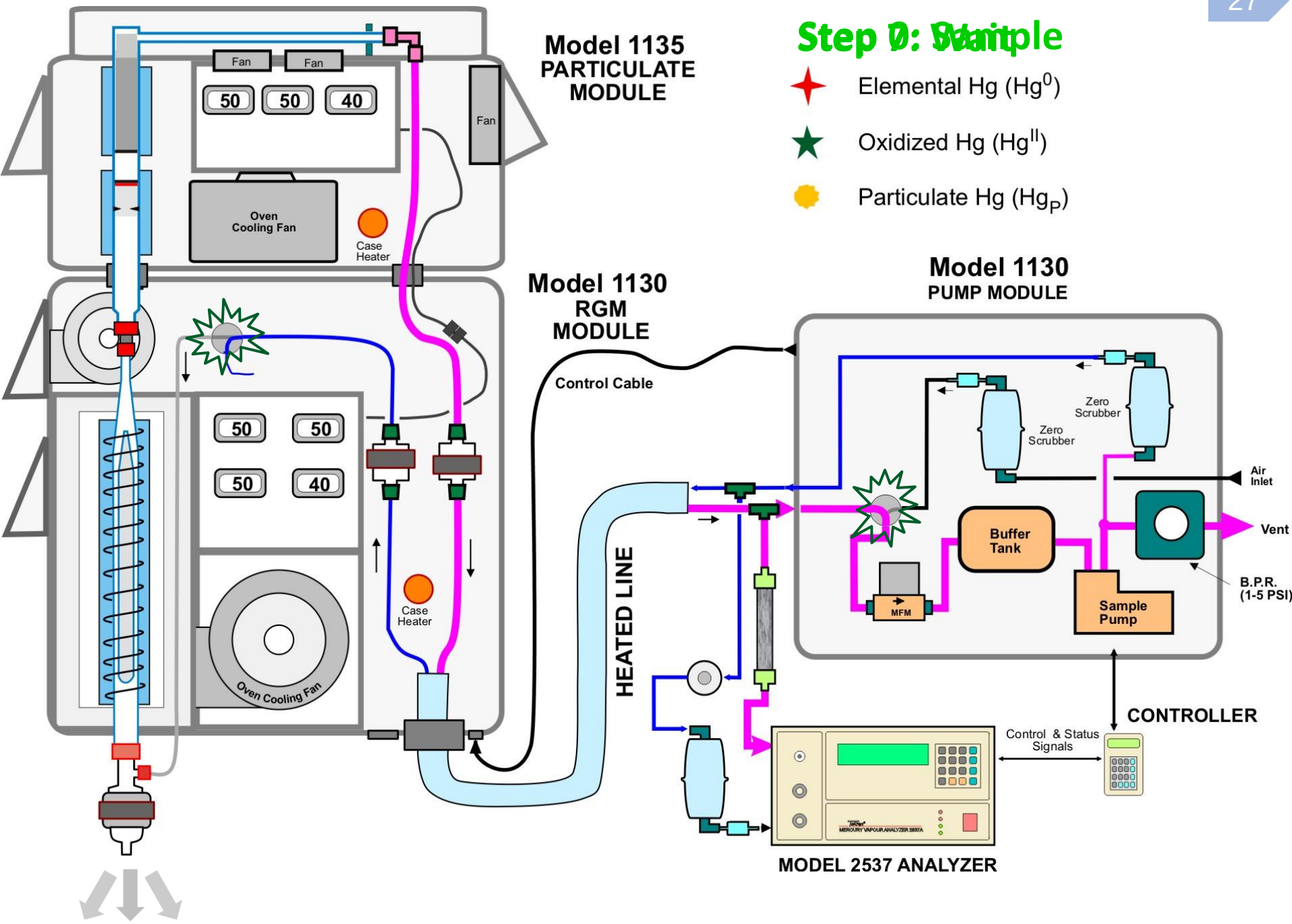

Step 3: RGM Hot
Model 1135
PARTICULATE
MODULE
Fan
Fan
800
800
40
Fan
Oven
Cooling Fan
Case
Heater
Elemental Hg (Hg0)
Oxidized Hg (HgII)
Particulate Hg (HgP)
Model 1130
RGM
MODULE
Model 1130
PUMP MODULE
Control Cable
500
50
75
40
Case
Heater
Oven Cooling Fan
HEATED LINE
Zero
Scrubber
Zero
Scrubber
Air
Inlet
Buffer
Tank
Vent
MFM
B.P.R.
(1-5 PSI)
Sample
Pump
CONTROLLER
Control & Status
Signals
MODEL 2537 ANALYZER

Step 4: RGM-Ht2

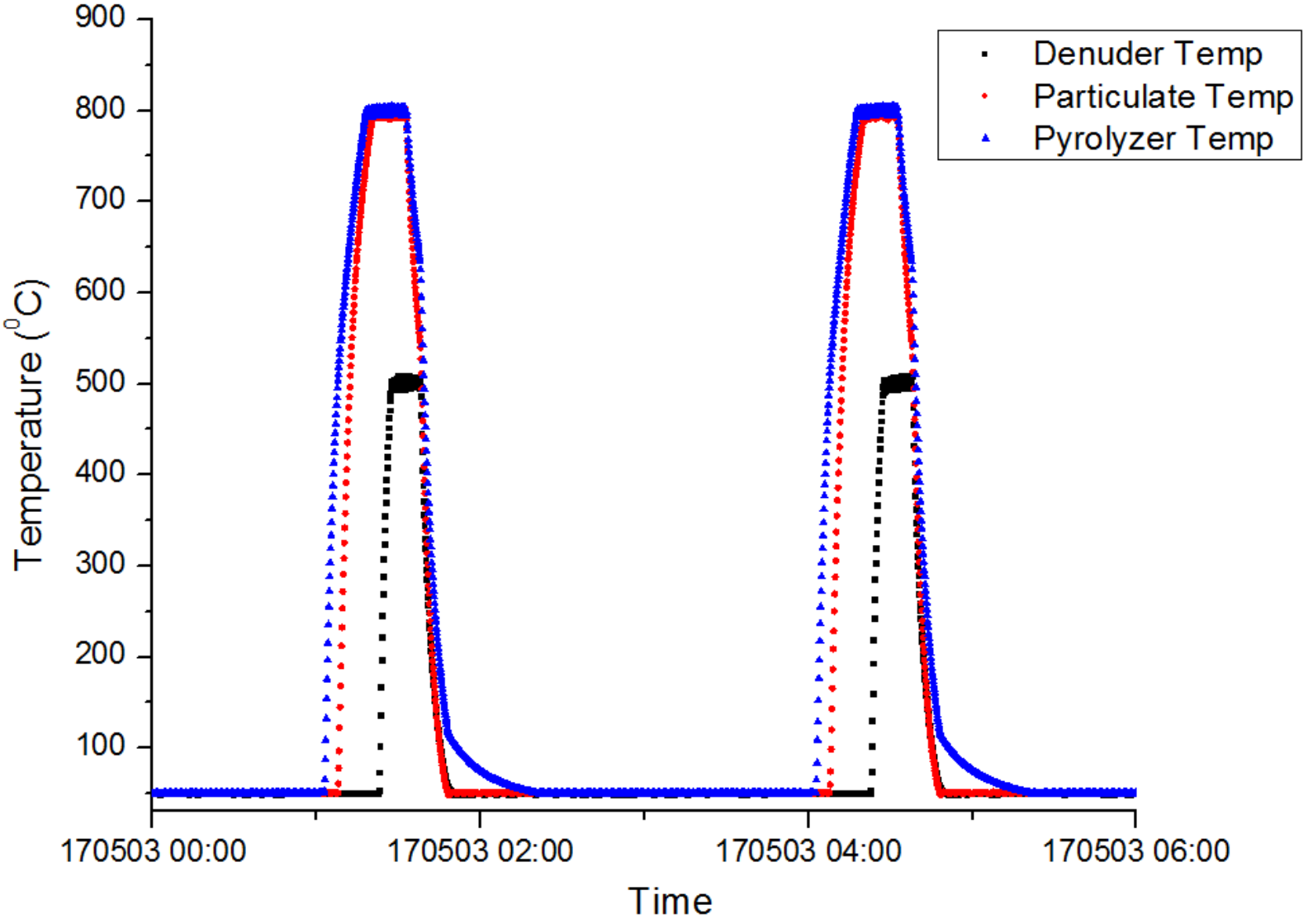



Step 6: RGM-Ht2
Elemental Hg (Hg^0)
Oxidized Hg (Hg^{II})
Particulate Hg (Hg_P)
Model 1135
PARTICULATE
MODULE
Fan
Fan
50
50
40
Fan
Oven
Cooling Fan
Case
Heater
Model 1130
RGM
MODULE
Control Cable
50
50
50
40
Case
Heater
Oven Cooling Fan
HEATED LINE
Model 1130
PUMP MODULE
Zero
Scrubber
Zero
Scrubber
Air
Inlet
Buffer
Tank
Vent
MFM
Sample
Pump
B.P.R.
(1-5 PSI)
CONTROLLER
Control & Status
Signals
MODEL 2537 ANALYZER


Step 3: Wait
Elemental Hg (Hg^0)
Oxidized Hg (Hg^{II})
Particulate Hg (Hg_P)
Model 1135
PARTICULATE
MODULE
Fan
Fan
Fan
50
50
40
Oven
Cooling Fan
Case
Heater
Model 1130
RGM
MODULE
Control Cable
Model 1130
PUMP MODULE
Zero
Scrubber
Zero
Scrubber
Air
Inlet
Vent
Buffer
Tank
MFM
Sample
Pump
B.P.R.
(1-5 PSI)
50
50
50
40
Case
Heater
Oven Cooling Fan
HEATED LINE
CONTROLLER
Control & Status
Signals
MODEL 2537 ANALYZER


Step 0: Sample
Elemental Hg (Hg^0)
Oxidized Hg (Hg^{II})
Particulate Hg (Hg_P)
Model 1135
PARTICULATE
MODULE
Fan
Fan
Fan
50
50
40
Oven
Cooling Fan
Case
Heater
Model 1130
RGM
MODULE
Control Cable
50
50
50
40
Case
Heater
Oven Cooling Fan
HEATED LINE
Model 1130
PUMP MODULE
Zero
Scrubber
Zero
Scrubber
Air
Inlet
Buffer
Tank
Vent
B.P.R.
(1-5 PSI)
MFM
Sample
Pump
CONTROLLER
Control & Status
Signals
MODEL 2537 ANALYZER

Temperature program



Typical Temperature Settings

- Temperatures are set directly on the PID controllers
- System simply selects between the two set-points on analytical PID controllers
- Case temperature controllers independently actuate either:
  - case heater, or
  - cooling fan

Model 1130 Denuder Module Temperature Settings (deg C)		
SP1	Case Heater:	**38**
SP2	Case Fan:	**40**
SP1	Heated Line:	**50**
SP1	Denuder Keep Warm:	**50**
SP2	Denuder Heat:	**500**
SP1	Ext. Heat:	**60**
SP2	Ext Keep Warm:	**50**

Model 1135 Particulate Module Temperature Settings (deg C)		
SP1	Pyrolyzer Keep Warm	**50**
SP2	Pyrolyzer Heat:	**800**
SP1	Part-Trap Keep Warm	**50**
SP2	Part-Trap Heat:	**800**
SP1	Case Heater:	**38**
SP2	Case Fan:	**40**

Method Calculated Values

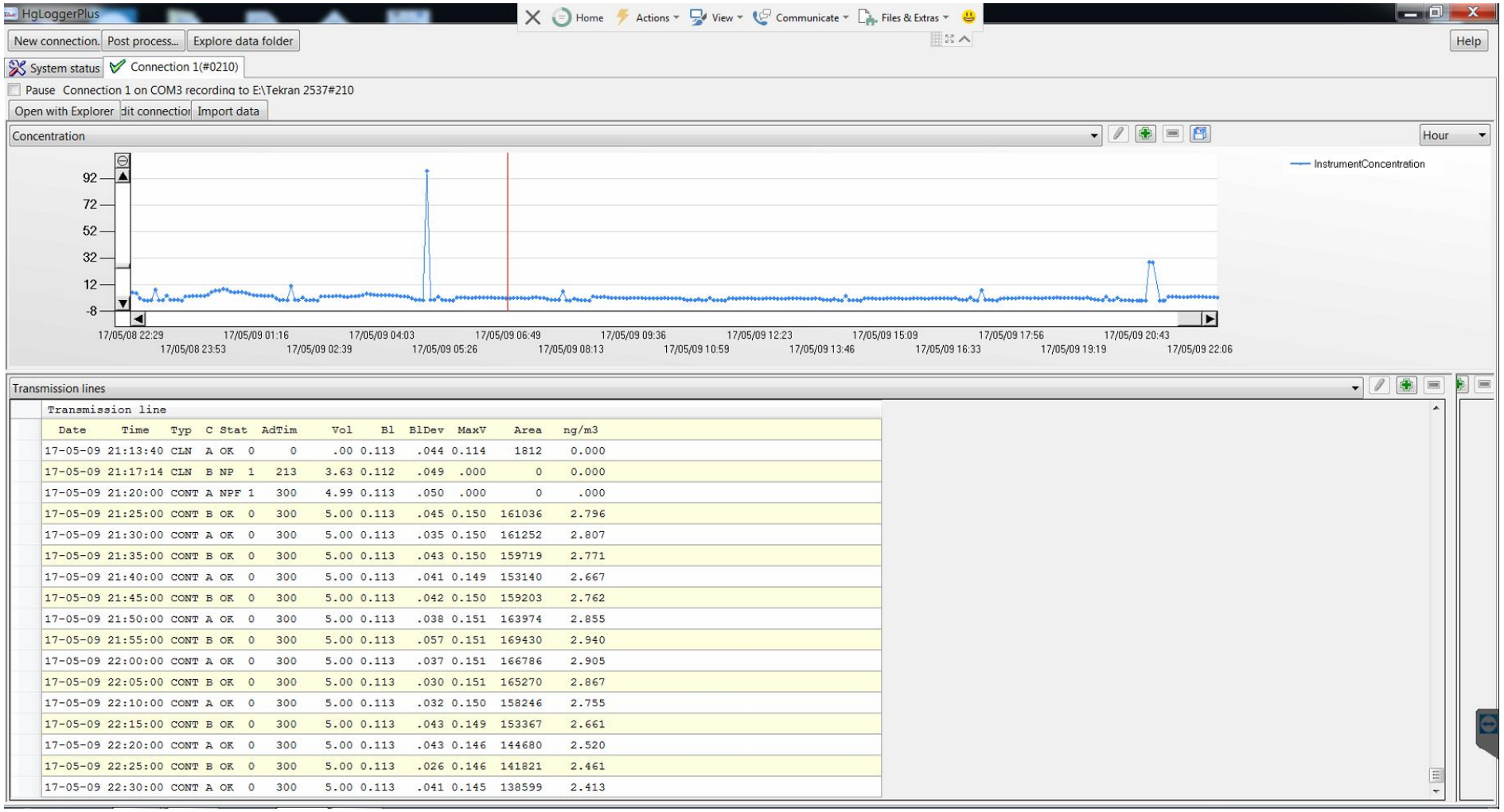
- Values are calculated both by the controller and by XLS spread sheet
- Most are for info only
- ***Factors*** must be entered into 2537 to ensure direct reading in pg/m^3

Calculated Values	
5	Model 2537 Sample Volume (L)
10	Denuder Flow Rate (L/min)
600	Denuder Total Volume (L)
0.00833	Model 2537 Factor (for ng/m^3)
8.333	Model 2537 Factor (for pg/m^3)
60	Denuder Sample Time (min)
60	Desorb Analysis Time (min)
120	Total Cycle time (min)
24	Auto-Recal interval (hours)

Denuder figures above also apply to the particulate trap.

4. DATA OUTPUT

Software interface



Transmission line

Date	Time	Typ	C	Stat	AdTim	Vol	Bl	BlDev	MaxV	Area	ng/m3
17-05-09	21:13:40	CLN	A	OK	0	0	.00	0.113	.044	0.114	1812	0.000
17-05-09	21:17:14	CLN	B	NP	1	213	3.63	0.112	.049	.000	0	0.000
17-05-09	21:20:00	CONT	A	NPF	1	300	4.99	0.113	.050	.000	0	.000
17-05-09	21:25:00	CONT	B	OK	0	300	5.00	0.113	.045	0.150	161036	2.796
17-05-09	21:30:00	CONT	A	OK	0	300	5.00	0.113	.035	0.150	161252	2.807
17-05-09	21:35:00	CONT	B	OK	0	300	5.00	0.113	.043	0.150	159719	2.771
17-05-09	21:40:00	CONT	A	OK	0	300	5.00	0.113	.041	0.149	153140	2.667
17-05-09	21:45:00	CONT	B	OK	0	300	5.00	0.113	.042	0.150	159203	2.762
17-05-09	21:50:00	CONT	A	OK	0	300	5.00	0.113	.038	0.151	163974	2.855
17-05-09	21:55:00	CONT	B	OK	0	300	5.00	0.113	.057	0.151	169430	2.940
17-05-09	22:00:00	CONT	A	OK	0	300	5.00	0.113	.037	0.151	166786	2.905
17-05-09	22:05:00	CONT	B	OK	0	300	5.00	0.113	.030	0.151	165270	2.867
17-05-09	22:10:00	CONT	A	OK	0	300	5.00	0.113	.032	0.150	158246	2.755
17-05-09	22:15:00	CONT	B	OK	0	300	5.00	0.113	.043	0.149	153367	2.661
17-05-09	22:20:00	CONT	A	OK	0	300	5.00	0.113	.043	0.146	144680	2.520
17-05-09	22:25:00	CONT	B	OK	0	300	5.00	0.113	.026	0.146	141821	2.461
17-05-09	22:30:00	CONT	A	OK	0	300	5.00	0.113	.041	0.145	138599	2.413

Event Flag Assignments

Flag	Function
0	Sample (GEM analysis)
1	Initial Zero
2	Pyro Pre-Heat
3	RPF Desorb (PHg analysis)
4	GOM heat (GOM analysis)

Data obtained

Date	Time	Typ	C	Stat	AdTim	Vol	Bl	BlDev	MaxV	Area	ng/m3
17-04-23	06:38:41	CLN	A	NP 0	0	.00	.095	.045	.000	0	0.000
17-04-23	06:42:14	CLN	B	NP 1	213	3.63	.095	.035	.000	0	0.000
17-04-23	06:45:00	CONT	A	OKF 1	300	4.99	.095	.026	.096	1574	0.133
17-04-23	06:50:00	CONT	B	OK 0	300	5.00	.095	.029	0.117	92107	1.875
17-04-23	06:55:00	CONT	A	OK 0	300	5.00	.095	.030	0.119	96178	1.944
17-04-23	07:00:00	CONT	B	OK 0	300	5.00	.095	.028	0.118	93946	1.912
17-04-23	07:05:00	CONT	A	OK 0	300	5.00	.095	.025	0.119	94898	1.918
17-04-23	07:10:00	CONT	B	OK 0	300	5.00	.095	.032	0.118	95039	1.934
17-04-23	07:15:00	CONT	A	OK 0	300	5.00	.095	.028	0.119	96348	1.946
17-04-23	07:20:00	CONT	B	OK 0	300	5.00	.095	.030	0.118	95070	1.934
17-04-23	07:25:00	CONT	A	OK 0	300	5.00	.096	.032	0.119	94958	1.919
17-04-23	07:30:00	CONT	B	OK 0	300	5.00	.096	.035	0.117	93819	1.909
17-04-23	07:35:00	CONT	A	OK 0	300	5.00	.096	.032	0.119	95199	1.924
17-04-23	07:40:00	CONT	B	OK 0	300	5.00	.096	.035	0.118	94134	1.915
17-04-23	07:45:00	CONT	A	OK 0	300	5.00	.096	.023	0.119	95946	1.939
17-04-23	07:50:00	CONT	B	OK 0	300	5.00	.096	.034	0.118	95688	1.947
17-04-23	07:55:00	CONT	A	OK 0	300	5.00	.096	.029	0.119	96002	1.939
17-04-23	08:00:00	CONT	B	OK 0	300	5.00	.096	.028	0.117	93328	1.899
17-04-23	08:05:00	CONT	A	OK 0	300	5.00	.096	.025	0.119	94580	1.911
17-04-23	08:10:00	CONT	B	OK 0	300	5.00	.096	.030	0.117	91966	1.871
17-04-23	08:15:00	CONT	A	OK 0	300	5.00	.096	.030	0.119	92416	1.867
17-04-23	08:20:00	CONT	B	OK 0	300	5.00	.096	.029	0.117	92997	1.892
17-04-23	08:25:00	CONT	A	OK 0	300	5.00	.095	.031	0.119	92715	1.874
17-04-23	08:30:00	CONT	B	OK 0	300	5.00	.095	.029	0.117	91866	1.869
17-04-23	08:35:00	CONT	A	OK 0	300	5.00	.095	.040	0.118	92736	1.874
17-04-23	08:40:00	CONT	B	OK 0	300	5.00	.095	.030	0.116	90733	1.846
17-04-23	08:45:00	CONT	A	OK 0	300	5.00	.095	.027	0.118	91584	1.851
17-04-23	08:50:00	CONT	B	OKF 1	300	5.01	.095	.025	.099	11931	1.011
17-04-23	08:55:00	CONT	A	OKF 1	300	5.00	.095	.028	.097	2163	0.182
17-04-23	09:00:00	CONT	B	NPF 1	300	5.00	.095	.031	.000	0	.000
17-04-23	09:05:00	CONT	A	NPF 2	300	5.00	.095	.027	.000	0	.000
17-04-23	09:10:00	CONT	B	OKF 3	300	5.00	.095	.026	0.103	28657	2.429
17-04-23	09:15:00	CONT	A	NPF 3	300	5.00	.095	.036	.000	0	.000
17-04-23	09:20:00	CONT	B	NPF 3	300	5.00	.095	.024	.000	0	.000
17-04-23	09:25:00	CONT	A	OKF 4	300	5.00	.095	.026	0.117	86936	7.320
17-04-23	09:30:00	CONT	B	OKF 4	300	5.00	.095	.030	.097	3227	0.274
17-04-23	09:35:00	CONT	A	OKF 4	300	5.00	.095	.032	.096	1703	0.143
17-04-23	09:40:00	CONT	B	NPF 1	300	5.00	.095	.033	.000	0	.000
17-04-23	09:45:00	CONT	A	NPF 1	300	5.00	.095	.035	.000	0	.000
17-04-23	09:50:00	CONT	B	OK 0	300	5.00	.095	.027	0.115	88291	1.797
17-04-23	09:55:00	CONT	A	OK 0	300	5.00	.095	.034	0.117	92140	1.862
17-04-23	10:00:00	CONT	B	OK 0	300	5.00	.095	.029	0.116	89602	1.823
17-04-23	10:05:00	CONT	A	OK 0	300	5.00	.095	.035	0.117	91134	1.841
17-04-23	10:10:00	CONT	B	OK 0	300	5.00	.095	.030	0.117	91183	1.855

GEM (ng/m^3)

PHg (pg/m^3)

RGM (pg/m^3)

Data obtained

Date	Time	Typ	C	Stat	AdTim	Vol	Bl	BlDev	MaxV	Area	ng/m3
17-04-23	06:38:41	CLN	A	NP	0	.00	.095	.045	.000	0	0.000
17-04-23	06:42:14	CLN	B	NP	1	213	3.63	.095	.035	.000	0	0.000
17-04-23	06:45:00	CONT	A	OKF	1	300	4.99	.095	.026	.096	1574	0.133
17-04-23	06:50:00	CONT	B	OK	0	300	5.00	.095	.029	0.117	92107	1.875
17-04-23	06:55:00	CONT	A	OK	0	300	5.00	.095	.030	0.119	96178	1.944
17-04-23	07:00:00	CONT	B	OK	0	300	5.00	.095	.028	0.118	93946	1.912
17-04-23	07:05:00	CONT	A	OK	0	300	5.00	.095	.025	0.119	94898	1.918
17-04-23	07:10:00	CONT	B	OK	0	300	5.00	.095	.032	0.118	95039	1.934
17-04-23	07:15:00	CONT	A	OK	0	300	5.00	.095	.028	0.119	96348	1.946
17-04-23	07:20:00	CONT	B	OK	0	300	5.00	.095	.030	0.118	95070	1.934
17-04-23	07:25:00	CONT	A	OK	0	300	5.00	.096	.032	0.119	94958	1.919
17-04-23	07:30:00	CONT	B	OK	0	300	5.00	.096	.035	0.117	93819	1.909
17-04-23	07:35:00	CONT	A	OK	0	300	5.00	.096	.032	0.119	95199	1.924
17-04-23	07:40:00	CONT	B	OK	0	300	5.00	.096	.035	0.118	94134	1.915
17-04-23	07:45:00	CONT	A	OK	0	300	5.00	.096	.023	0.119	95946	1.939
17-04-23	07:50:00	CONT	B	OK	0	300	5.00	.096	.034	0.118	95688	1.947
17-04-23	07:55:00	CONT	A	OK	0	300	5.00	.096	.029	0.119	96002	1.939
17-04-23	08:00:00	CONT	B	OK	0	300	5.00	.096	.028	0.117	93328	1.899
17-04-23	08:05:00	CONT	A	OK	0	300	5.00	.096	.025	0.119	94580	1.911
17-04-23	08:10:00	CONT	B	OK	0	300	5.00	.096	.030	0.117	91966	1.871
17-04-23	08:15:00	CONT	A	OK	0	300	5.00	.096	.030	0.119	92416	1.867
17-04-23	08:20:00	CONT	B	OK	0	300	5.00	.096	.029	0.117	92997	1.892
17-04-23	08:25:00	CONT	A	OK	0	300	5.00	.095	.031	0.119	92715	1.874
17-04-23	08:30:00	CONT	B	OK	0	300	5.00	.095	.029	0.117	91866	1.869
17-04-23	08:35:00	CONT	A	OK	0	300	5.00	.095	.040	0.118	92736	1.874
17-04-23	08:40:00	CONT	B	OK	0	300	5.00	.095	.030	0.116	90733	1.846
17-04-23	08:45:00	CONT	A	OK	0	300	5.00	.095	.027	0.118	91584	1.851
17-04-23	08:50:00	CONT	B	OKF	1	300	5.01	.095	.025	.099	11931	1.011
17-04-23	08:55:00	CONT	A	OKF	1	300	5.00	.095	.028	.097	2163	0.182
17-04-23	09:00:00	CONT	B	NPF	1	300	5.00	.095	.031	.000	0	.000
17-04-23	09:05:00	CONT	A	NPF	2	300	5.00	.095	.027	.000	0	.000
17-04-23	09:10:00	CONT	B	OKF	3	300	5.00	.095	.026	0.103	28657	2.429
17-04-23	09:15:00	CONT	A	NPF	3	300	5.00	.095	.036	.000	0	.000
17-04-23	09:20:00	CONT	B	NPF	3	300	5.00	.095	.024	.000	0	.000
17-04-23	09:25:00	CONT	A	OKF	4	300	5.00	.095	.026	0.117	86936	7.320
17-04-23	09:30:00	CONT	B	OKF	4	300	5.00	.095	.030	.097	3227	0.274
17-04-23	09:35:00	CONT	A	OKF	4	300	5.00	.095	.032	.096	1703	0.143
17-04-23	09:40:00	CONT	B	NPF	1	300	5.00	.095	.033	.000	0	.000
17-04-23	09:45:00	CONT	A	NPF	1	300	5.00	.095	.035	.000	0	.000
17-04-23	09:50:00	CONT	B	OK	0	300	5.00	.095	.027	0.115	88291	1.797
17-04-23	09:55:00	CONT	A	OK	0	300	5.00	.095	.034	0.117	92140	1.862
17-04-23	10:00:00	CONT	B	OK	0	300	5.00	.095	.029	0.116	89602	1.823
17-04-23	10:05:00	CONT	A	OK	0	300	5.00	.095	.035	0.117	91134	1.841
17-04-23	10:10:00	CONT	B	OK	0	300	5.00	.095	.030	0.117	91183	1.855

Data obtained

17-04-23	08:50:00	CONT	B	OKF	1	300	5.01	.095	.025	.099	11931	1.011
17-04-23	08:55:00	CONT	A	OKF	1	300	5.00	.095	.028	.097	2163	0.182
17-04-23	09:00:00	CONT	B	NPF	1	300	5.00	.095	.031	.000	0	.000
17-04-23	09:05:00	CONT	A	NPF	2	300	5.00	.095	.027	.000	0	.000
17-04-23	09:10:00	CONT	B	OKF	3	300	5.00	.095	.026	0.103	28657	2.429
17-04-23	09:15:00	CONT	A	NPF	3	300	5.00	.095	.036	.000	0	.000
17-04-23	09:20:00	CONT	B	NPF	3	300	5.00	.095	.024	.000	0	.000
17-04-23	09:25:00	CONT	A	OKF	4	300	5.00	.095	.026	0.117	86936	7.320
17-04-23	09:30:00	CONT	B	OKF	4	300	5.00	.095	.030	.097	3227	0.274
17-04-23	09:35:00	CONT	A	OKF	4	300	5.00	.095	.032	.096	1703	0.143
17-04-23	09:40:00	CONT	B	NPF	1	300	5.00	.095	.033	.000	0	.000
17-04-23	09:45:00	CONT	A	NPF	1	300	5.00	.095	.035	.000	0	.000

Blank used on calculation

Majority of PBM *(Most the PBM should come off in the 1st cycle)*

Majority of GOM *(Most the PBM should come off in the 1st cycle)*

Sample calibration report

```
-
  Date     Time    Typ  C Stat  AdTim     Vol     Bl  BlDev  MaxV    Area   ng/m3
17-04-16 07:00:47 CLN  A NP  0     0     .00 0.105   .028  .000       0   0.000
17-04-16 07:04:21 CLN  B NP  1   213    3.63 0.105   .030  .000       0   0.000
17-04-16 07:07:07 ZERO A NP  1   300    4.99 0.105   .041  .000       0   0.000
17-04-16 07:12:07 ZERO B NP  1   300    5.00 0.105   .031  .000       0   0.000
17-04-16 07:17:07 SPAN A OK  1   300    5.00 0.105   .034 0.428 1395464  28.848
17-04-16 07:22:07 SPAN B OK  1   300    5.00 0.105   .029 0.433 1395255  28.848
-
CALIBRATION:  S/N:0210    H/W: 2.21   S/W: 1.04      17-04-16   07:25:41
-
ZERO:  A
Sample  :   300 sec   |  BlArea  :      0
Volume  :  4.99 l     |  BlCorr  :     0/l
Baseline: 0.105 v     |  PkMax   :  .000 v
Bl StDev:   .04 mv    |  PkWid   :    .0 sec
Start   : 17-04-16       07:07:07
-
ZERO:  B
Sample  :   300 sec   |  BlArea  :      0
Volume  :  5.00 l     |  BlCorr  :     0/l
Baseline: 0.105 v     |  PkMax   :  .000 v
Bl StDev:   .03 mv    |  PkWid   :    .0 sec
Start   : 17-04-16       07:12:07
-
SPAN:  A     SOURCE
Sample  :   300 sec   |  Area    :1395464
Volume  :  5.00 l     |  AdjArea :1395464 *
HgAmt   :  144.2pg    |  RespFctr:9674597
Baseline: 0.105 v     |  PkMax   : 0.428 v
Bl StDev:   .03 mv    |  PkWid   :  20.9 sec
Start   : 17-04-16       07:17:07
-
SPAN:  B     SOURCE
Sample  :   300 sec   |  Area    :1395255
Volume  :  5.00 l     |  AdjArea :1395255 *
HgAmt   :  144.2pg    |  RespFctr:9673148
Baseline: 0.105 v     |  PkMax   : 0.433 v
Bl StDev:   .03 mv    |  PkWid   :  21.0 sec
Start   : 17-04-16       07:22:07
-
-
  Date     Time    Typ  C Stat  AdTim     Vol     Bl  BlDev  MaxV    Area   ng/m3
17-04-16 07:28:41 CLN  A NP  0     0     .00 0.105   .030  .000       0   0.000
17-04-16 07:32:14 CLN  B NP  1   214    3.63 0.105   .025  .000       0   0.000
17-04-16 07:35:01 CONT A OKF 1   300    5.00 0.105   .031 0.109   11265   0.970
17-04-16 07:40:01 CONT B OK  0   300    5.00 0.105   .031 0.148  180842   3.738
17-04-16 07:45:01 CONT A OK  0   300    5.00 0.105   .032 0.147  179833   3.716
17-04-16 07:50:01 CONT B OK  0   300    5.00 0.105   .030 0.144  172022   3.555
```

Zero

Calibration points

SPAN Response Factor > 6 x 10^6 *RespFctr*

SPAN Difference A vs. B < 5%

(RF A – RF B) / RF A

(9674597 – 9673148) / 9674597 = 0.015%

Data evaluation

Flag criteria

- The 24 hour average for cartridge A vs. B
  - A1 – Warning > 10% difference
  - A2 - Invalid > 15% difference
- Baseline
  - B0 – Invalid if baseline < 0.010
  - B1 – Warning if baseline < 0.050 or > 0.250
  - B2 – Warning if baseline change > 0.010
  - B3 – Warning 5 consecutive BLDev > 0.100
  - B5 – Invalid if BLDev > 0.200
- Peak
  - M2 – Warning double peak detected
  - M3 – Invalid > double peak detected
  - NP – Invalid for GEM only, No peak detected
  - OL – Warning overloaded detector (> 5.125V)

Data evaluation

Flag criteria

- GEM

  E1 – Warning GEM < 1.0 ng/m3

  E5 – Warning GEM change > 50%

- Volume

  V5 – Warning volume > 5% from expected

  V7 – Invalid volume > 7% from expected

- Calibration Frequency

  F1 – Warning last calibration > 3 days ago

  F2 – Control last calibration > 6 days ago

After a power failure – need to calibrate once perm source is stable

Data evaluation

Flag criteria

- Response Factor

  R1 – Warning RF < 6 m or > 12 million

  R2 – Invalid RF < 4 million

- Calibration Cartridge Bias

  C1 – Warning calibration trap bias > 10%

  C2 – Invalid calibration trap bias > 20%

- Calibration Zero

  Z1 – Warning zero > 1500 PA

  Z2 – Invalid zero > 1% of SPAN

Find the NADP AMNet Data Management Manual 2015-10 for more detail

Data evaluation

datetime	channel	status	flag	sample_v	baseline_	baseline_	maximum	integrate	hg_conc	notes	validation	QaStatus	Liaison_N	RevDate
7/11/2007 2:51	B	OK	0	3.47	0.098	0.049	0.101	12633	0.839	E1R1	V	2	NULL	NULL
7/11/2007 2:56	A	OK	0	3.33	0.098	0.056	0.101	11217	0.798	E1R1	V	2	NULL	NULL
7/11/2007 3:01	B	OK	0	3.48	0.098	0.045	0.102	15418	1.022	R1	V	2	NULL	NULL
7/11/2007 3:06	A	OK	0	3.34	0.099	0.061	0.102	12610	0.893	E1R1	V	2	NULL	NULL
7/11/2007 3:11	B	OK	0	3.48	0.099	0.045	0.102	10645	0.705	E1R1	V	2	NULL	NULL
7/11/2007 3:16	A	OK	0	3.35	0.099	0.059	0.102	15235	1.077	R1	V	2	NULL	NULL
7/11/2007 3:21	B	OK	0	3.48	0.099	0.042	0.103	12484	0.827	E1E5R1	V	2	NULL	NULL
7/11/2007 3:26	A	OK	0	3.36	0.099	0.039	0.103	11415	0.805	E1R1	V	2	NULL	NULL
7/11/2007 4:31	B	OK	0	3.24	0.1	0.044	0.102	5214	0.372	E0V7E1E5R1	E	2	NULL	NULL
7/11/2007 4:36	A	OK	0	3.11	0.1	0.057	0.103	9511	0.724	E0V7E1R1	E	2	NULL	NULL
7/11/2007 4:41	B	OK	0	3.3	0.1	0.048	0.103	12711	0.889	V5E1E5R1	V	2	NULL	NULL
7/11/2007 4:46	A	OK	0	3.17	0.1	0.045	0.103	14050	1.049	V7R1	I	2	NULL	NULL
7/11/2007 4:51	B	OK	0	3.35	0.099	0.066	0.103	12544	0.864	E1R1	V	2	NULL	NULL
7/11/2007 4:56	A	OK	0	3.21	0.099	0.047	0.102	10393	0.766	V7E1R1	I	2	NULL	NULL
7/11/2007 5:01	B	OK	0	3.39	0.099	0.044	0.103	15226	1.037	R1	V	2	NULL	NULL
7/11/2007 5:06	A	OK	0	3.25	0.099	0.053	0.102	12910	0.941	V7E1R1	I	2	NULL	NULL
7/11/2007 5:11	B	OK	0	3.42	0.099	0.046	0.103	14665	0.989	E1R1	V	2	NULL	NULL
7/11/2007 5:16	A	OK	0	3.27	0.099	0.048	0.102	11765	0.851	V5E1R1	V	2	NULL	NULL
7/11/2007 5:21	B	OK	0	3.45	0.099	0.044	0.102	19046	1.274	E5R1	V	2	NULL	NULL
7/11/2007 5:26	A	OK	0	3.3	0.099	0.037	0.102	13087	0.94	V5E1R1	V	2	NULL	NULL
7/11/2007 6:31	B	OK	0	3.4	0.098	0.047	0.1	7549	0.513	E0E1E5R1	E	2	NULL	NULL
7/11/2007 6:36	A	OK	0	3.25	0.098	0.045	0.101	10630	0.774	E0V7E1R1	E	2	NULL	NULL
7/11/2007 6:41	B	OK	0	3.43	0.098	0.045	0.101	11492	0.773	E1E5R1	V	2	NULL	NULL
7/11/2007 6:46	A	OK	0	3.28	0.098	0.048	0.101	9564	0.69	V5E1R1	V	2	NULL	NULL
7/11/2007 6:51	B	OK	0	3.45	0.098	0.04	0.101	13975	0.934	E1R1	V	2	NULL	NULL

5. Routine Maintenance and instrument problems

2537

2537 Routine checks

- Date time correct – *Date Time*
- Peak Status (OK, OKF or NP) – *Stat*
- Sample Volume 5.0 L (adjustable) - *Vol*

  Within 2% of set point
- Baseline - *Bl*

  Within 0.100 – 0.250 Volts
- Baseline Deviation – *BLDev*

  BLDev < 0.100 Volts
- Calibration check (criteria show on above)
- Argon tank > 200 psi

  Sufficient volume until next visit

2537 Instrument Problem Indicators

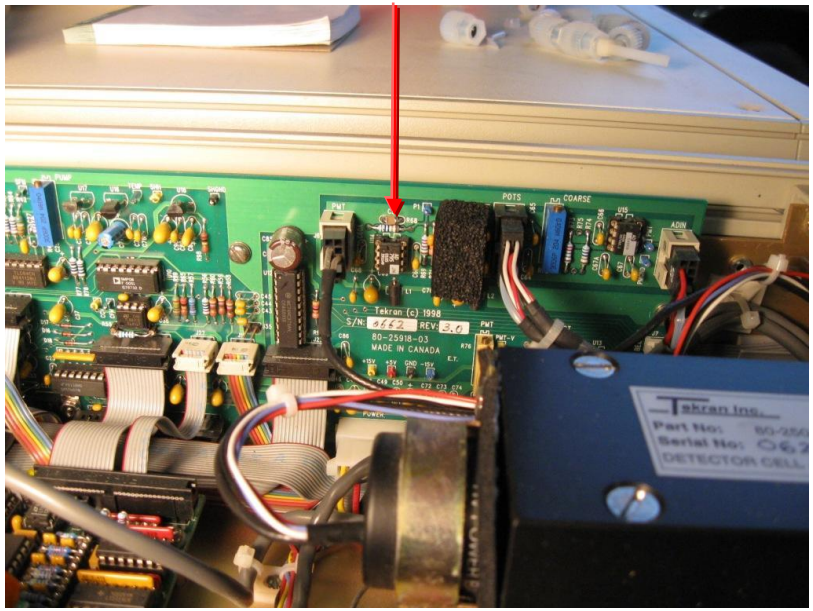
2537 Flow

- Does 2537 pump work hard?
  - Only on one cartridge?
  - Both cartridges?
- 2537 flow bias on one channel
  - Valves check
  - Trap restrictive
- 2537 flow bias on both channels
  - Pump diaphragm
  - Pump check valves
  - Common restriction (Soda lime, filter)

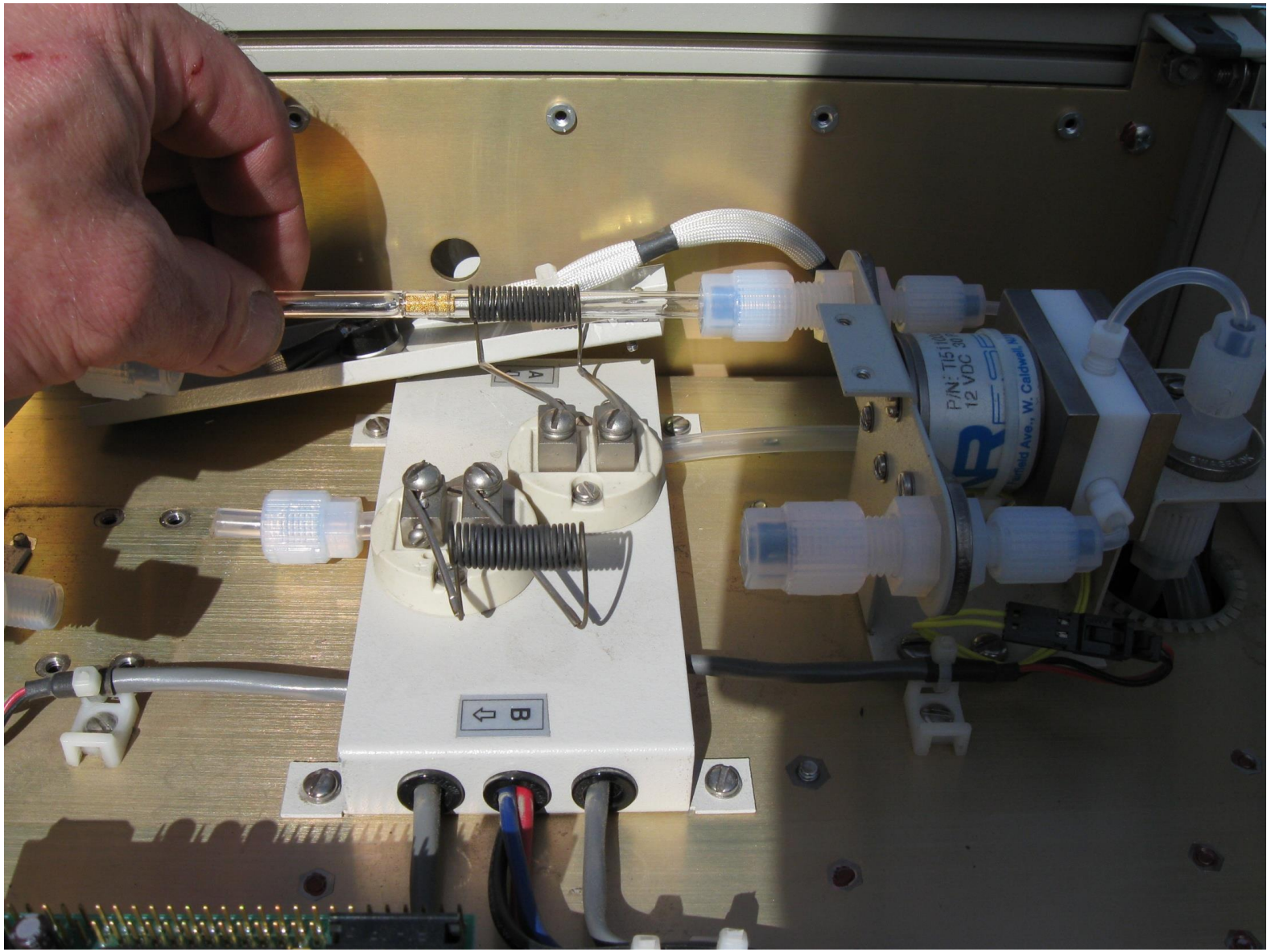
Baseline Deviation Problems and Solutions

- High BLDev
  - Lamp
  - Lamp Stabilizer Board
    - Photo Diode
    - Baseline fluctuation
  - Cuvette
  - Argon purge line
  - C-59 Chip on Main Board
    - Baseline deviation is very high (>1)

C-59 Chip Needs to be soldered



Replace the Cartridges



Lamp Adjustment

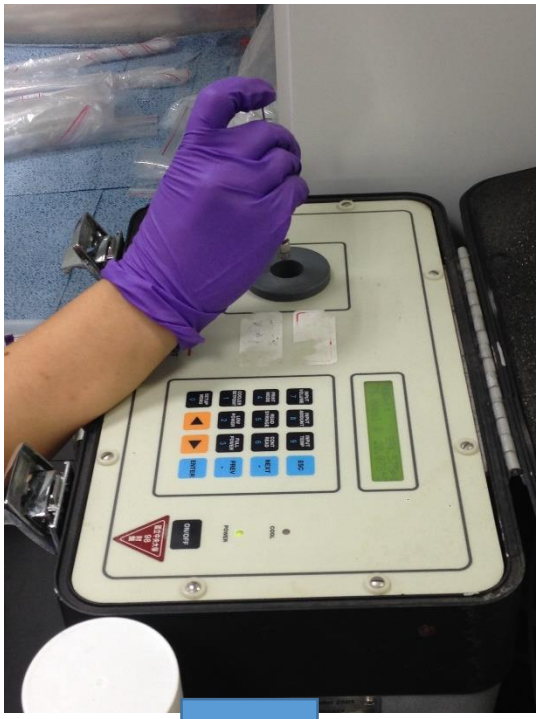
Lamp change

Unable to reduce lamp voltage

High Baseline Deviation (*BLDev*)

External calibration

Tekran 2505 Calibrator



5. Routine Maintenance and instrument problems

1130/1135

Operational Requirements

- Denuder requires changing every week or two
- RPF requires exchanging every 2 months
- Weekly or bi-weekly site visits recommended
- Filter changes, leak checks, etc. as required during site visits

1130/1135 Routine checks

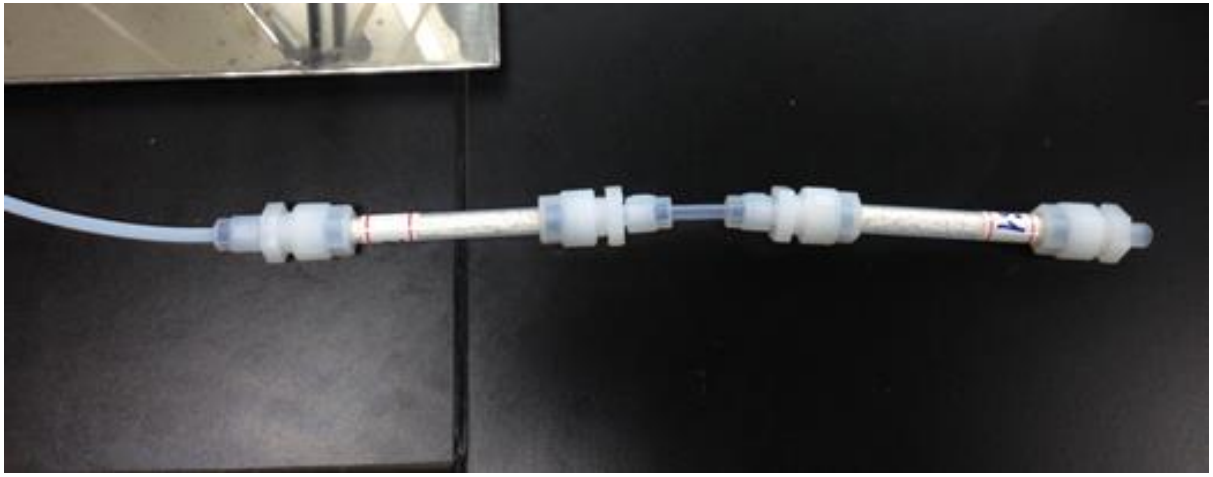
- ✓ Final desorption blank C ~ 0.000 pg/m^3
- ✓ PHg and GOM clear peak

  Most the PHg and GOM should come off in the 1st cycle

- ✓ Check pump, temp.
- ✓ Denuder changed
- ✓ RPF changed
- ✓ 1130/1135 filter changed
- ✓ Leak check < 0.3 ng/m^3
- ✓ Flow check (1130 pump check with in 3% set point)
- ✓ RPF elbow and tubing replaced
- ✓ 1130 pump diaphragm replaced
- ✓ 1130 pump brushes > 1 cm
- ✓ Denuder to RPF (14/18) union replaced

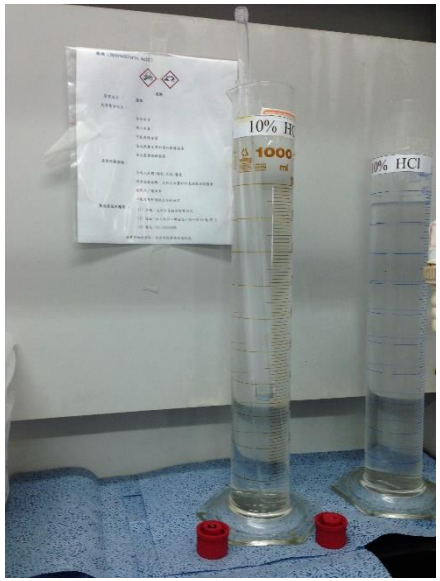

1135 Temperatures
1130 Temperatures
MODEL 1135 MERCURY SPECIATION SYSTEM
PARTICULATE UNIT
MODEL 1130 MERCURY SPECIATION SYSTEM
DENUDER UNIT
CAUTION: FAN !

Filter and soda lime reparation



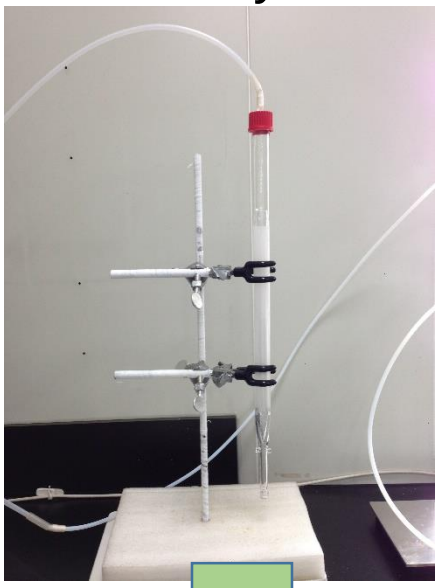
Ar purge in 8 hours

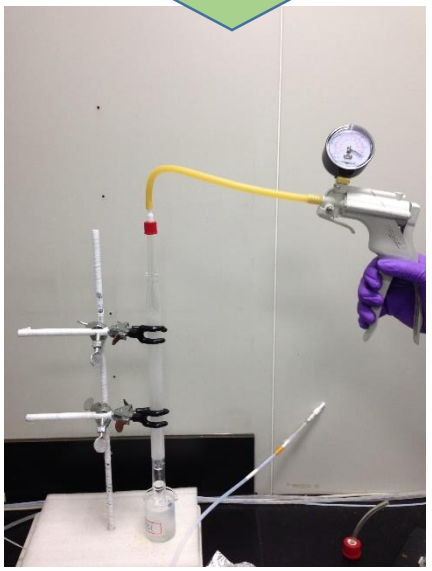
Denuder reparation



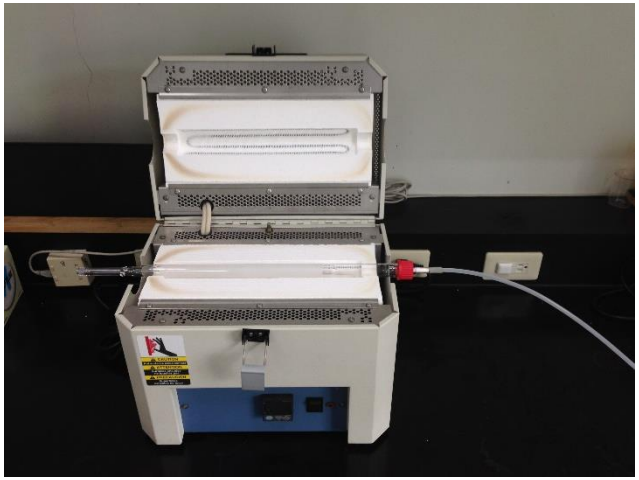
Clean

Dry





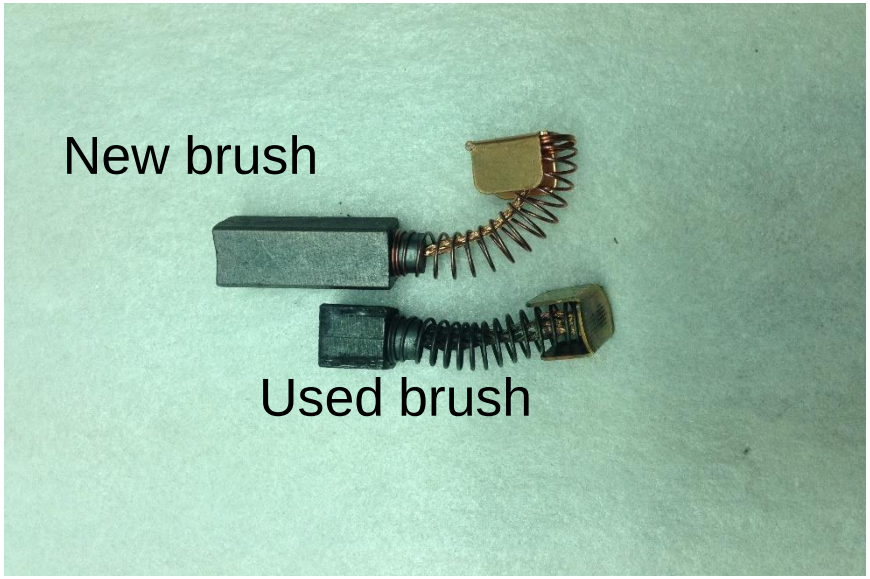
Coating



Beak 30 min, max temp 500^{0}C. Ar purge

1130 pump diaphragm and brushes replaced

Broken diaphragm



RPF

Frosting on RPF Tail

Dirty RPF

Zero Canisters

- Two zero canisters inside 1130 PM
  - Likely to require changing rarely (if ever)
  - Usually best to get your air supply from outdoors
    - Lower Hg levels
    - Drier (especially in Arctic)
    - Exception for hot, humid areas
- Most high blanks are due to -
  - Leaks
  - Contamination
  - BPR problem

Lab Support

- Extra denuders & RPF's are usually kept on hand
  - Several units recoated / restuffed at one time
  - Blanked, capped and shipped to site
  - Tube furnace required for blanking
  - Source of DIW is required
- Elements may be exchanged in the field using relatively unskilled personnel

Summary 1130/1135

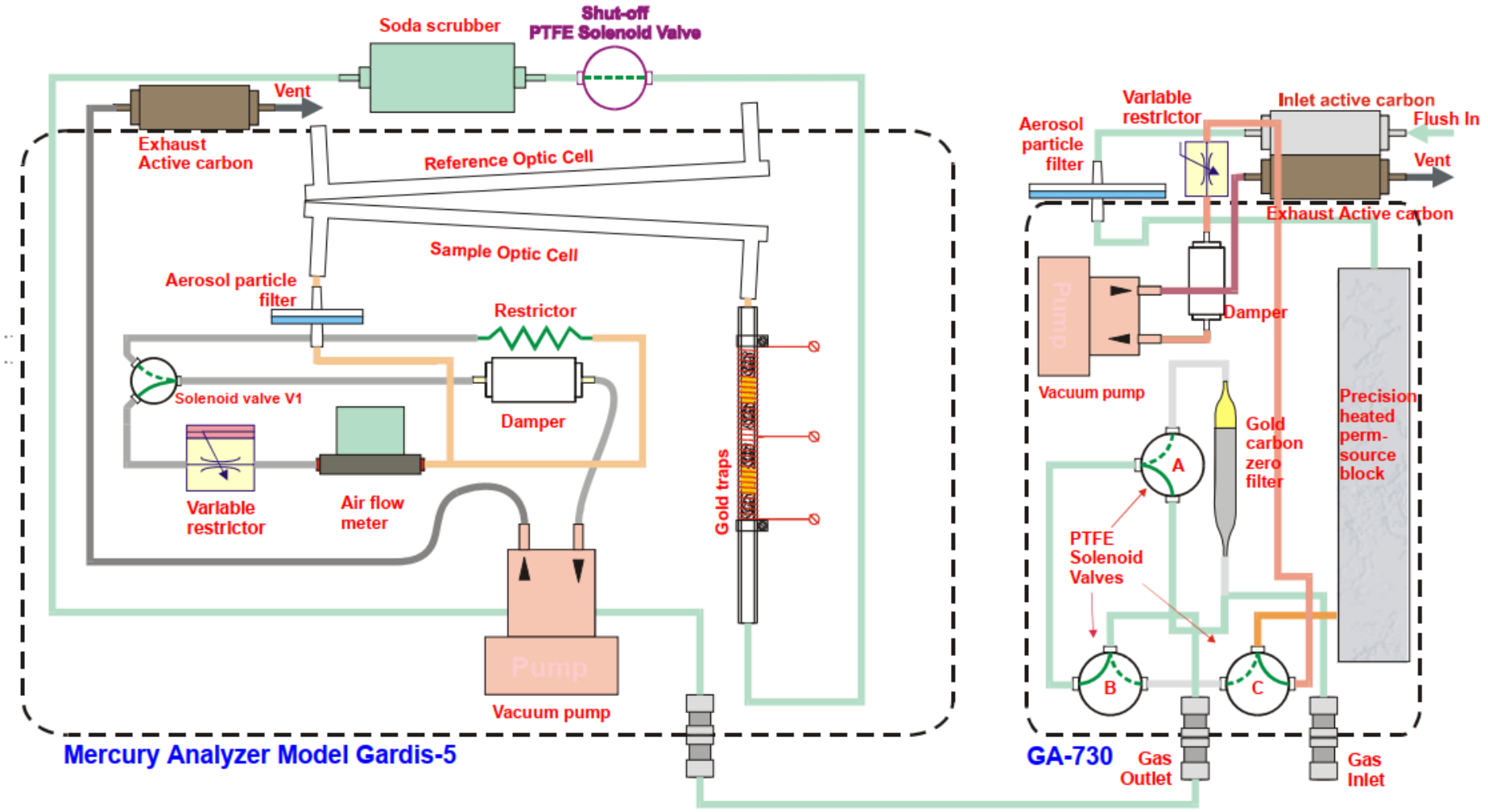
- Model 1130 & 1135 require somewhat more time to run and maintain than the Model 2537 alone
- Plan on at least bi-weekly site visits to change denuder, RPF and filters
- Data handling and validation also require more time
- Determining why the species behave the way they do may be the biggest challenge

GARDIS-5 SYSTEM

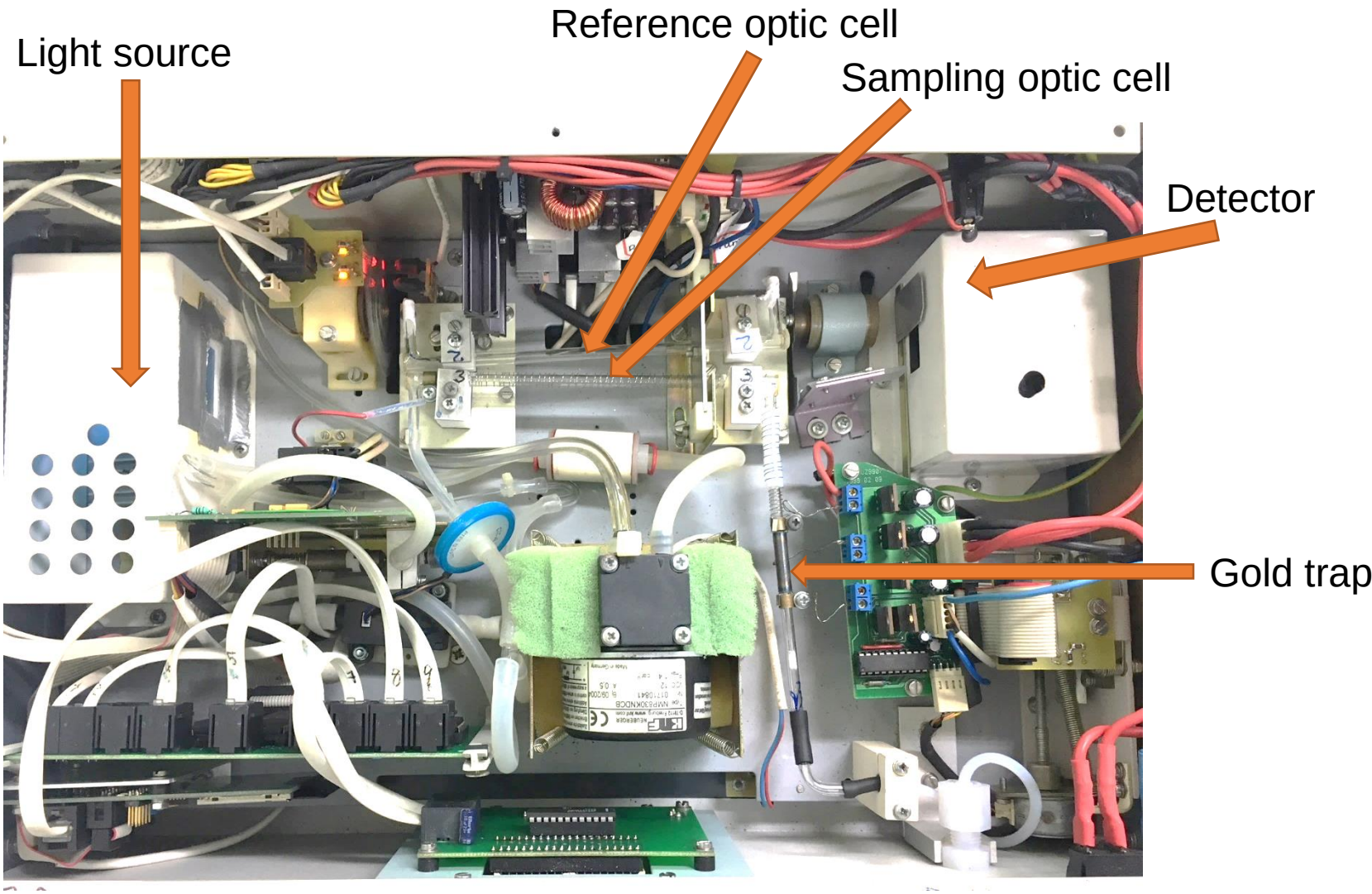
- Measure THg in the atmosphere. THg = GEM + GOM.
- GARDIS-5 based on cold vapor atomic absorption spectrometry (CVAAS) method.
- The detection limit is ***0.5 pg*** Hg.
- Automatic daily calibration with the mercury vapor dosing (calibration) device Ga-730.
- Resolution: 20 min for sampling and 4 min for analysis and cooling.

GARDIS-5 SYSTEM

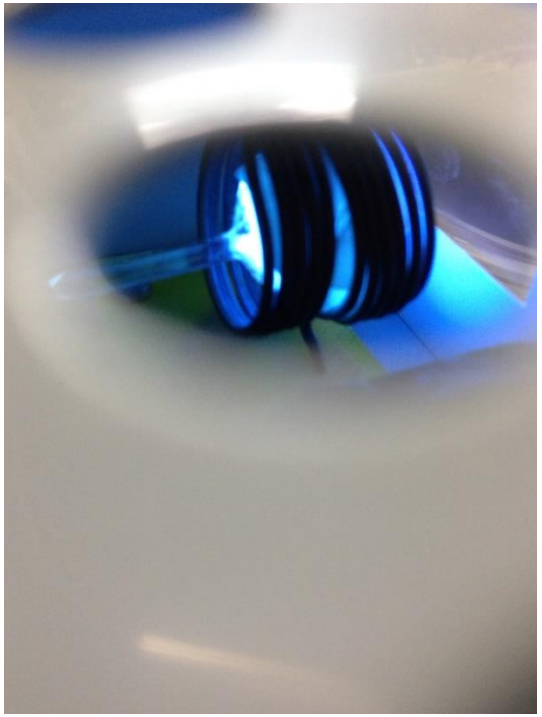
Flow diagram mercury analyzer coupled with the dosing unit

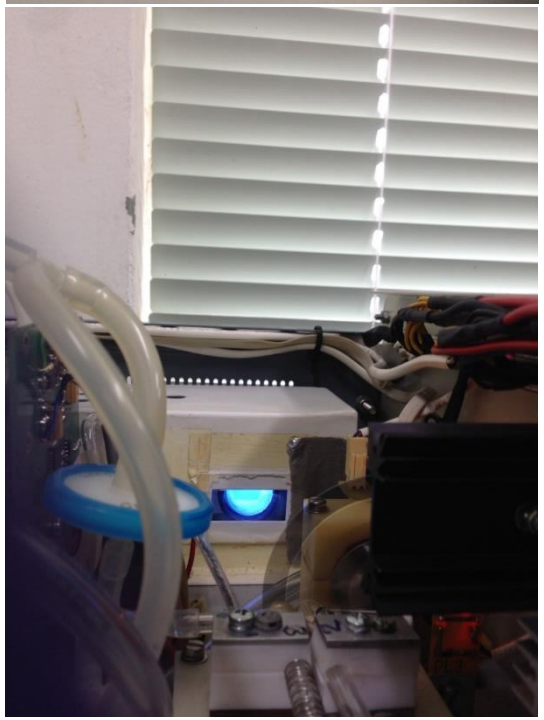


GARDIS-5

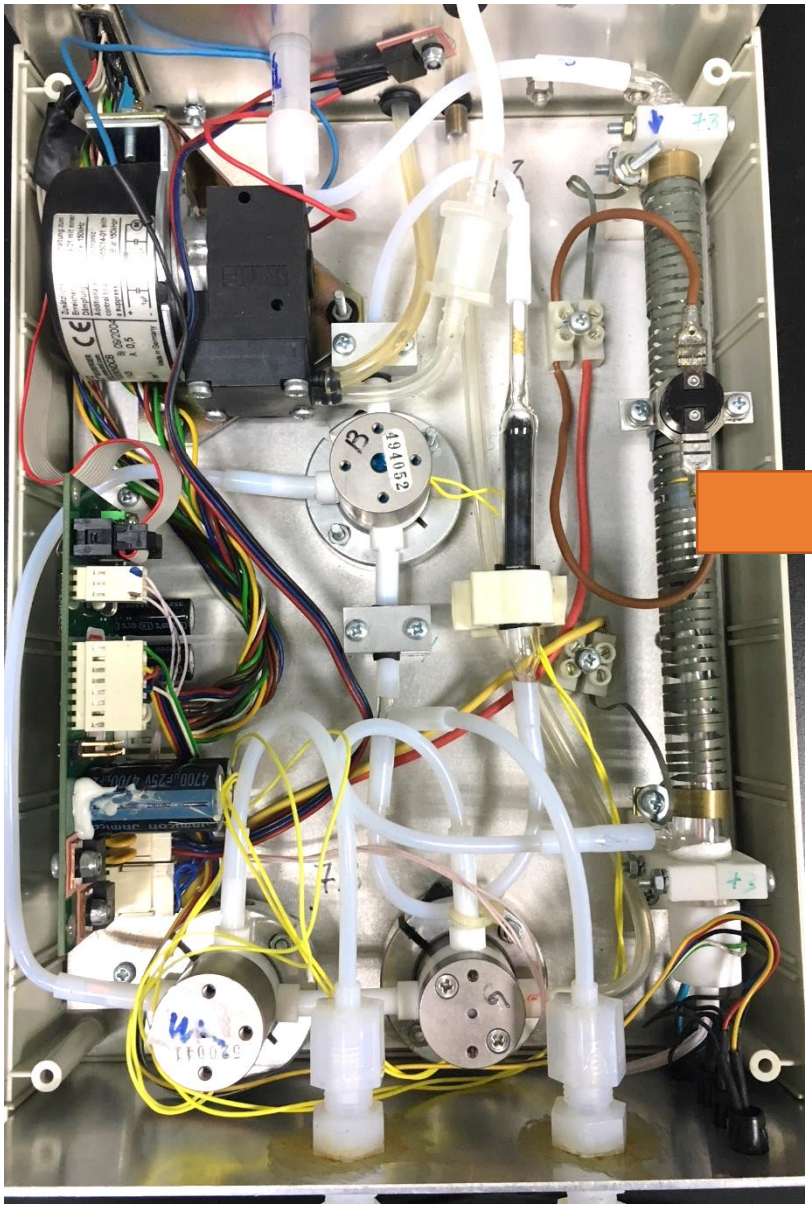

Light source
Reference optic cell
Sampling optic cell
Detector
Gold trap

Light source

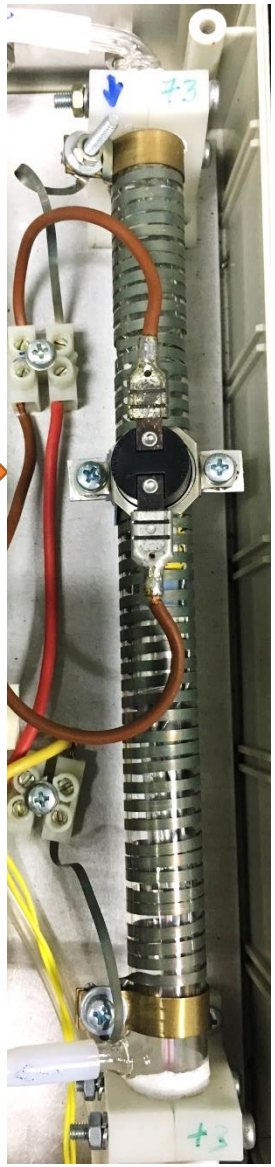




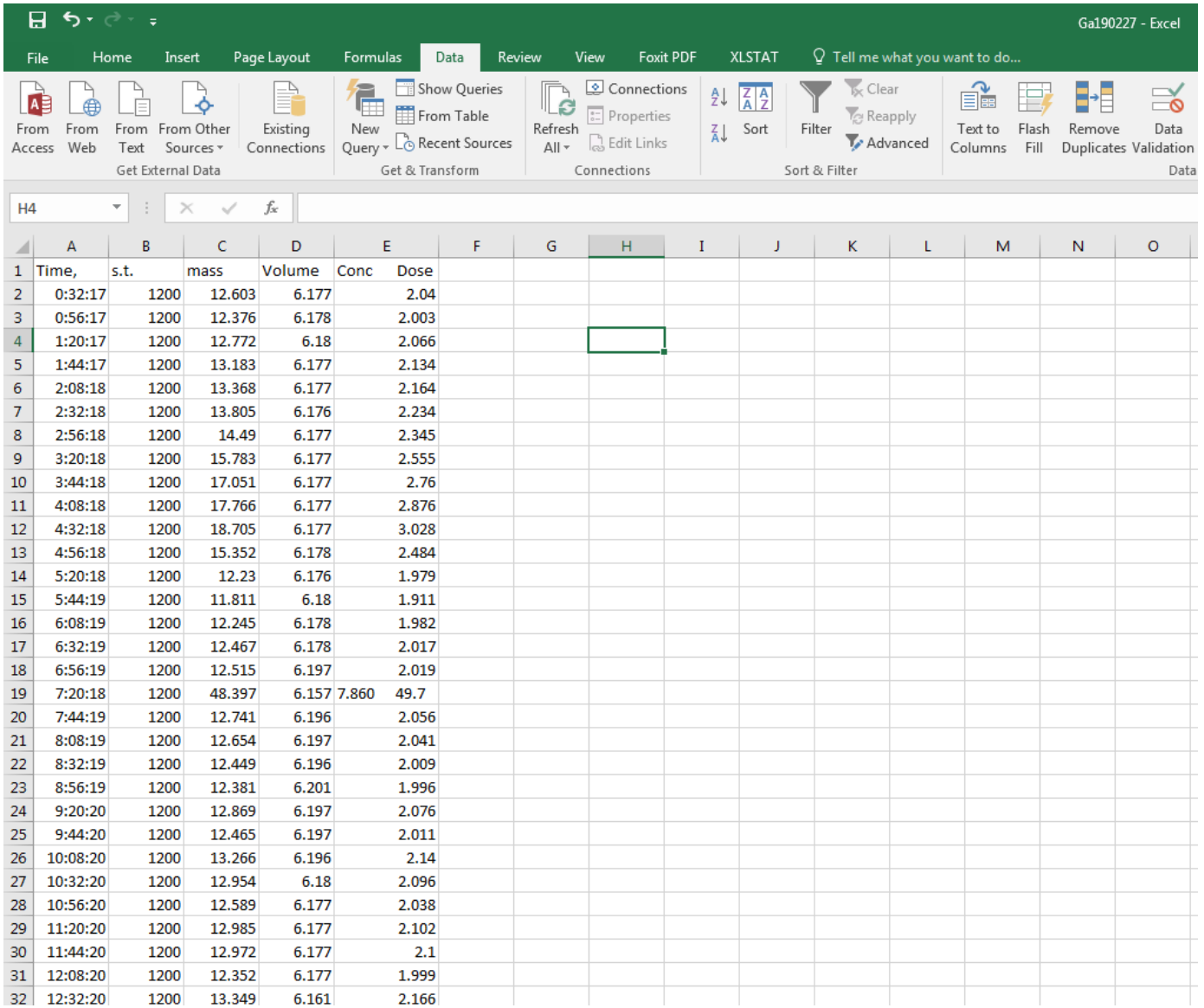
MERCURY VAPOR DOSING DEVICE GA-730



Perm-source block

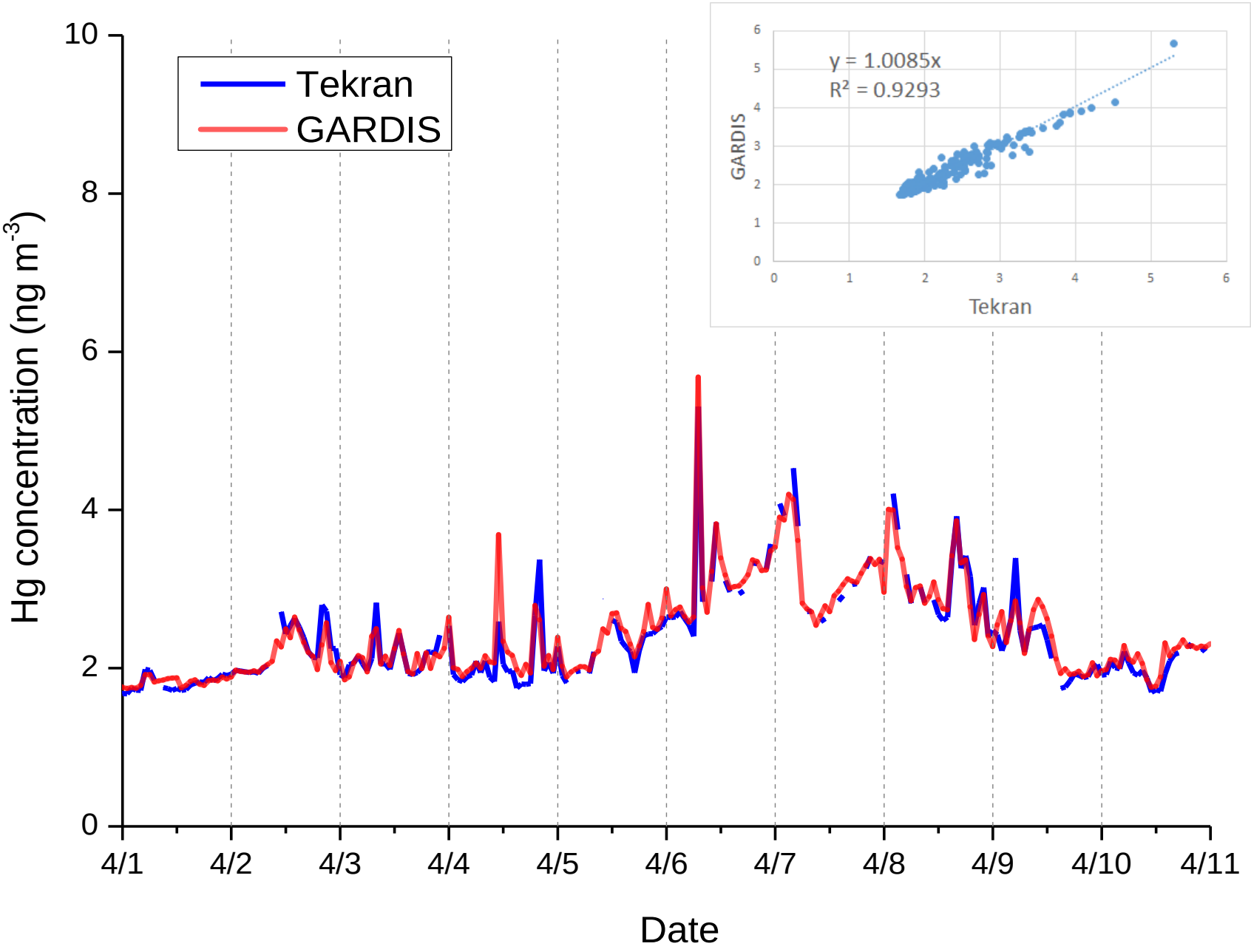


Data output



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Time,	s.t.	mass	Volume	Conc	Dose									
2	0:32:17	1200	12.603	6.177		2.04									
3	0:56:17	1200	12.376	6.178		2.003									
4	1:20:17	1200	12.772	6.18		2.066									
5	1:44:17	1200	13.183	6.177		2.134									
6	2:08:18	1200	13.368	6.177		2.164									
7	2:32:18	1200	13.805	6.176		2.234									
8	2:56:18	1200	14.49	6.177		2.345									
9	3:20:18	1200	15.783	6.177		2.555									
10	3:44:18	1200	17.051	6.177		2.76									
11	4:08:18	1200	17.766	6.177		2.876									
12	4:32:18	1200	18.705	6.177		3.028									
13	4:56:18	1200	15.352	6.178		2.484									
14	5:20:18	1200	12.23	6.176		1.979									
15	5:44:19	1200	11.811	6.18		1.911									
16	6:08:19	1200	12.245	6.178		1.982									
17	6:32:19	1200	12.467	6.178		2.017									
18	6:56:19	1200	12.515	6.197		2.019									
19	7:20:18	1200	48.397	6.157	7.860	49.7									
20	7:44:19	1200	12.741	6.196		2.056									
21	8:08:19	1200	12.654	6.197		2.041									
22	8:32:19	1200	12.449	6.196		2.009									
23	8:56:19	1200	12.381	6.201		1.996									
24	9:20:20	1200	12.869	6.197		2.076									
25	9:44:20	1200	12.465	6.197		2.011									
26	10:08:20	1200	13.266	6.196		2.14									
27	10:32:20	1200	12.954	6.18		2.096									
28	10:56:20	1200	12.589	6.177		2.038									
29	11:20:20	1200	12.985	6.177		2.102									
30	11:44:20	1200	12.972	6.177		2.1									
31	12:08:20	1200	12.352	6.177		1.999									
32	12:32:20	1200	13.349	6.161		2.166									

GARDIS vs Tekran



THANH FOR YOUR ATTENTION

QUESTION ?