

PRESLHY

Workshop – “Tools for experiments”

PRESLHY general assembly, Buxton, 08-11-2019

Simon Coldrick, HSE

Pre-normative REsearch for Safe use of Liquid HYdrogen

223
1966

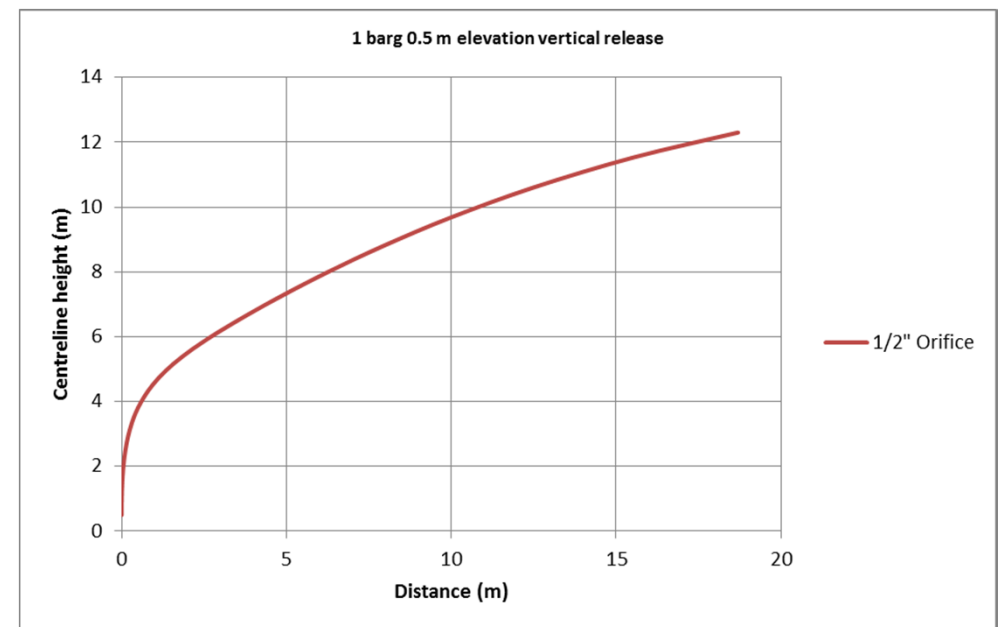
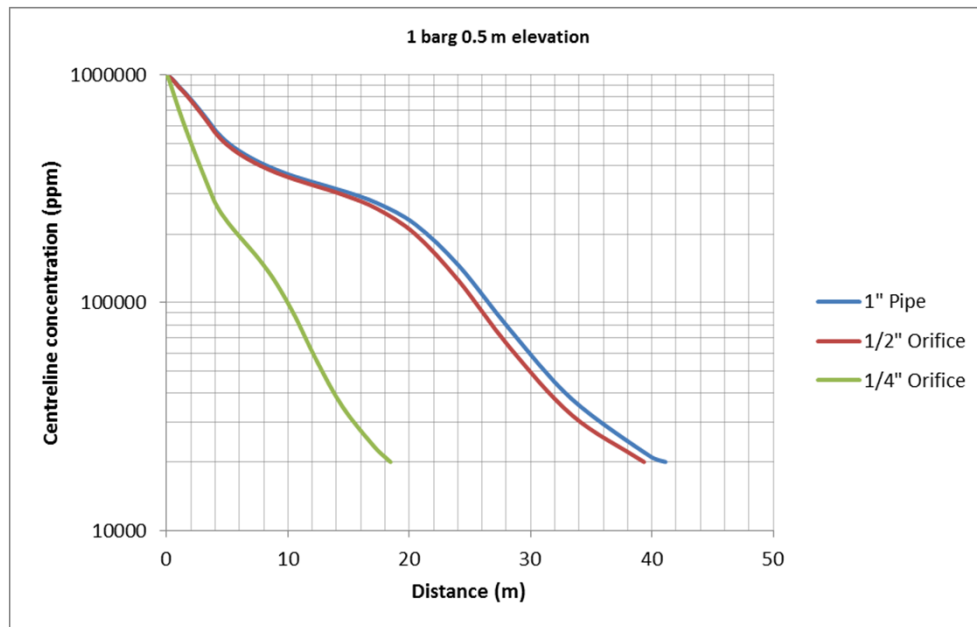


Contents

- Modelling
- Design of experiments
- Data processing

Pre-test modelling

- To support the risk assessment and hazardous area zoning
- To help with sensor placement and component sizing
- Discharge and dispersion modelling with DNVGL Phast
 - Modelled as pipe/orifice flow



Design of experiments

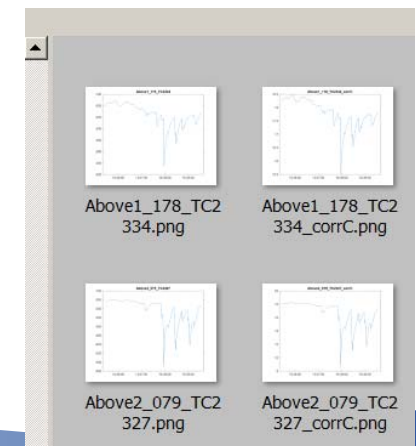
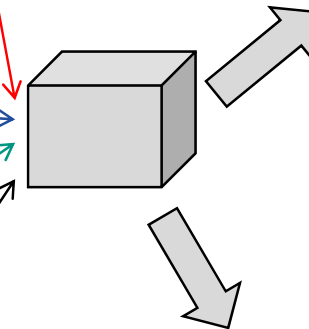
- What do we want from the experiment series?
- For understanding the physical system, a DoE approach is preferable as it can be used to maximise information and minimise cost
- For exploratory experiments, it may be appropriate to use OFAT (One Factor At a Time). Gives data at specific conditions including repeats e.g. for model validation

Data processing



The screenshot shows a file explorer window with several sub-folders. The top folder contains CSV files: '190912 Trial 3&4 5700 Configurable I_O Log Data.csv', '190912 Trial 3&4 5700 Configurable I_O Log Data_mod.csv', '190912 Trial 5 5700 Configurable I_O Log Data.csv', '190912 Trial 5 5700 Configurable I_O Log Data_mod.csv', '190912 Trial 6 5700 Configurable I_O Log Data.csv', '190912 Trial 6 5700 Configurable I_O Log Data_mod.csv', '190912 Trial 7 5700 Configurable I_O Log Data.csv', and '190912 Trial 7 5700 Configurable I_O Log Data_mod.csv'. The bottom folder contains TDMS files: 'PreslHY_Data_2019-09-12-11-45-29.tdms', 'PreslHY_Data_2019-09-12-11-45-29.tdms_index', 'PreslHY_Data_2019-09-12-12-08-45.tdms', 'PreslHY_Data_2019-09-12-12-08-45.tdms_index', 'PreslHY_Data_2019-09-12-14-34-08.tdms', 'PreslHY_Data_2019-09-12-14-34-08.tdms_index', 'PreslHY_Data_2019-09-12-15-35-23.tdms', 'PreslHY_Data_2019-09-12-15-35-23.tdms_index', 'PreslHY_Data_2019-09-12-16-10-11.tdms', and 'PreslHY_Data_2019-09-12-16-10-11.tdms_index'. There are also text documents at the bottom.

	A	B
1	time	Above1_178_TC2334
2	11:45:31	-352.5987478
3	11:45:32	-338.0049222
4	11:45:33	-329.3622481
5	11:45:34	-356.4264838
6	11:45:35	-395.1508787
7	11:45:36	-544.5257154
8	11:45:37	-504.2553249



Data logging

- 57 tests in total
- Up to 150 sensors in each test

```

81;6812370;6812025;;6812950;
08/2019;13/08/2019;13/08/2019;;13/08/201
C;EC;EC;;CAT;
9 09:50:06;Instrument switch on
9 09:50:07;INV;INV;INV;N/A;WUP;N/A;
9 09:50:08;any channel warning changed
9 09:50:08;INV;INV;INV;N/A;WUP;N/A;
9 09:50:09;INV;INV;INV;N/A;WUP;N/A;
9 09:50:10;20.9;810;0.10;N/A;WUP;N/A;
9 09:50:11;20.2;810;0.08;N/A;WUP;N/A;
9 09:50:14;19.9;805;0.08;N/A;WUP;N/A;
9 09:50:15;17.8;795;0.06;N/A;WUP;N/A;
9 09:50:16;any channel warning changed
9 09:50:16;17.8;730;0.04;N/A;WUP;N/A;
9 09:50:17;17.8;700;0.02;N/A;WUP;N/A;
  
```

- Different formats (text, xls, proprietary...)
- Different timestamps (m, s, μ s...)
- Messages in the data

3643	13:58:58.23	-0.023	21.507
3644	13:58:58.53	-0.037	21.513
3645	13:58:58.83	-0.027	21.509
3646	13:58:59.13	-0.024	21.508
3647	13:58:59.43	-0.030	21.510
3648	13:58:59.73	-0.028	21.509
Device ID	Factory	Device ID	
TF_Cal (V/W)	Temp_Cal (°C)	Gain	
02EC25	02EC25	3.2.1	H2
23.071205	1.000000		Standard
Iteration	Time	Output (%)	
(mV)	Ph (mW)	Usyst (V)	Ubat (V)
0	14:07:17.67	-0.030	21.507
1	14:07:17.97	-0.030	21.507
2	14:07:18.27	-0.034	21.508
3	14:07:18.57	-0.030	21.507

	A	B	C	D	E	F
1	NO.	Time	Interval	Indoor Ter	Indoor Hum	Outdoor
2	1	12/09/2019	5	15.6	64	
3	2	12/09/2019	5	15.6	64	
4	3	12/09/2019	5	15.7	64	
5	4	12/09/2019	5	15.7	64	
6	5	12/09/2019	5	15.7	64	

	A	B	C	D
1	Date	Time	Elapse Time(s)	Densi
2	12/09/2019	15:27:02	0.387	
3	12/09/2019	15:27:04	1.5612	
4	12/09/2019	15:27:05	2.5284	
5	12/09/2019	15:27:06	3.4488	
6	12/09/2019	15:27:07	4.5096	
7	12/09/2019	15:27:08	5.4924	
8	12/09/2019	15:27:09	6.5532	
9	12/09/2019	15:27:10	7.536	
0	12/09/2019	15:27:11	8.55	

Tools for data processing

- The goal:
 - Collect all the data for each test into a meaningful format which is easy to understand and work with
- Use data analysis software
 - In-built tools, e.g. import, time synchronisation, signal processing...
- Process the data programmatically
 - The code to process the data only needs to be written once
- Checks
 - Plots
 - Spot checks

Manual vs automatic

■ Manual

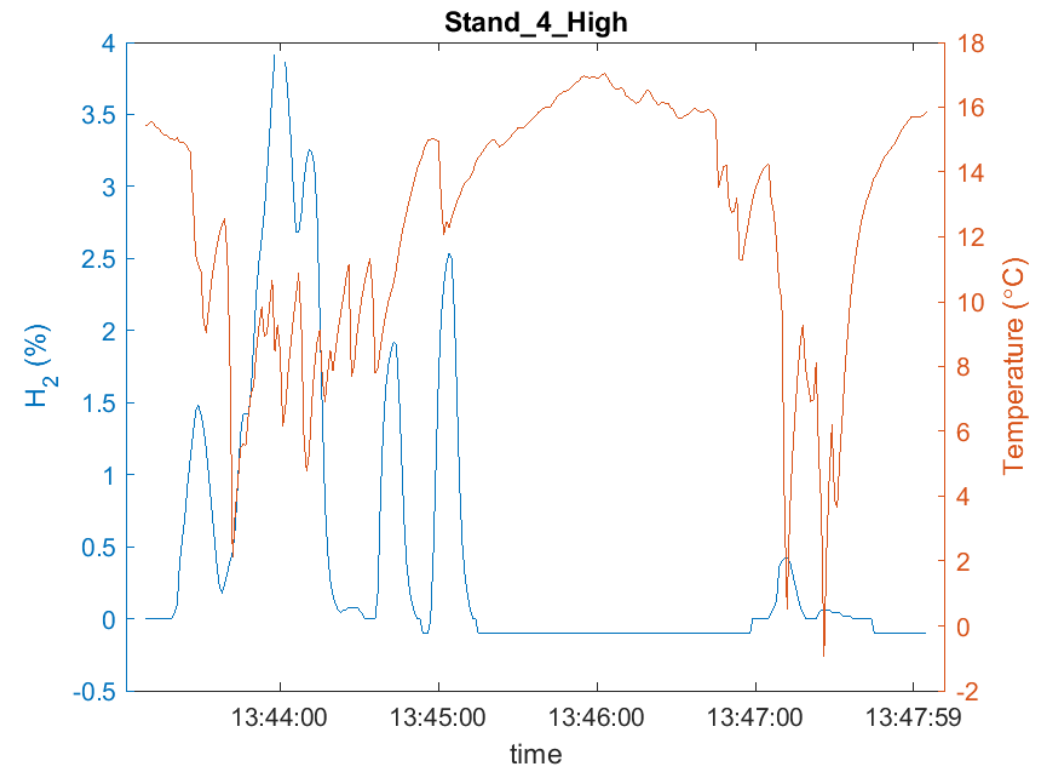
- For small data quantities
- “Quick looks”
- Spreadsheet errors

■ Automatic

- For large data quantities
- Do it once
- Data and processing are kept separate
- Traceability
- Errors

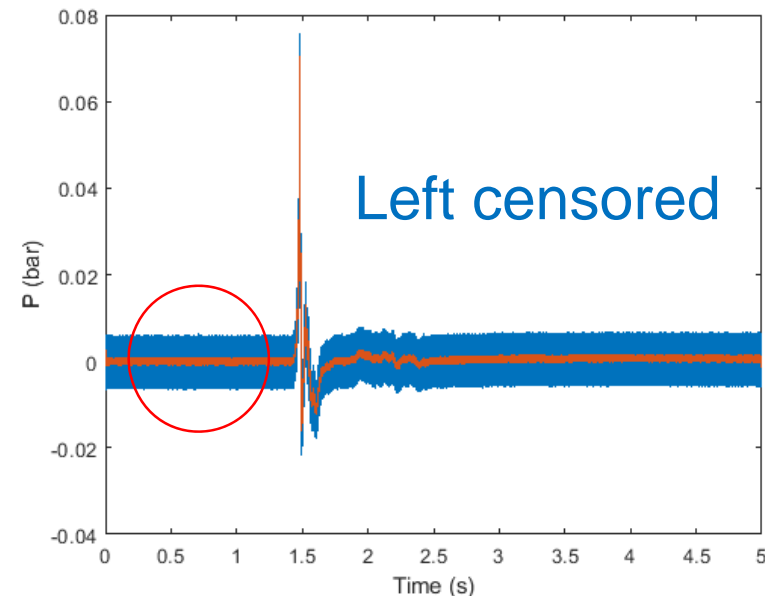
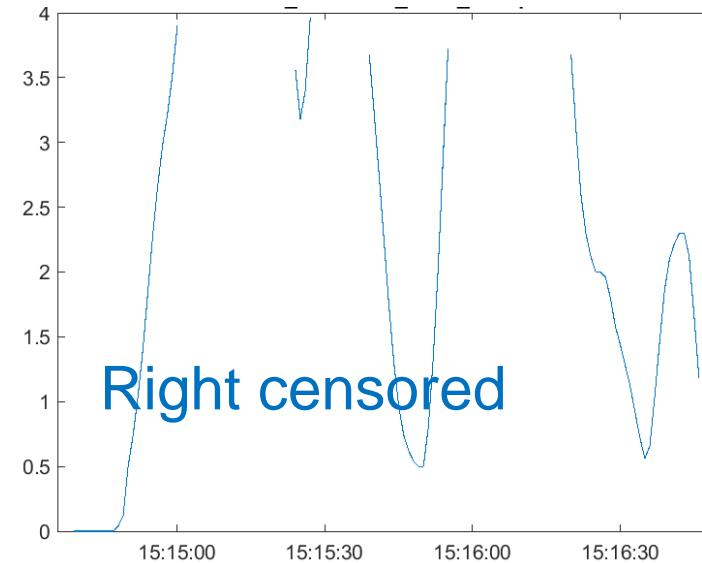
Statistical tools for data

- What is the H_2 concentration at this sensor in this test?
 - Is it the maximum?
 - Is it the average?
 - Over what period?
 - What should be included in the average?
- How will it relate to what the model predicts?



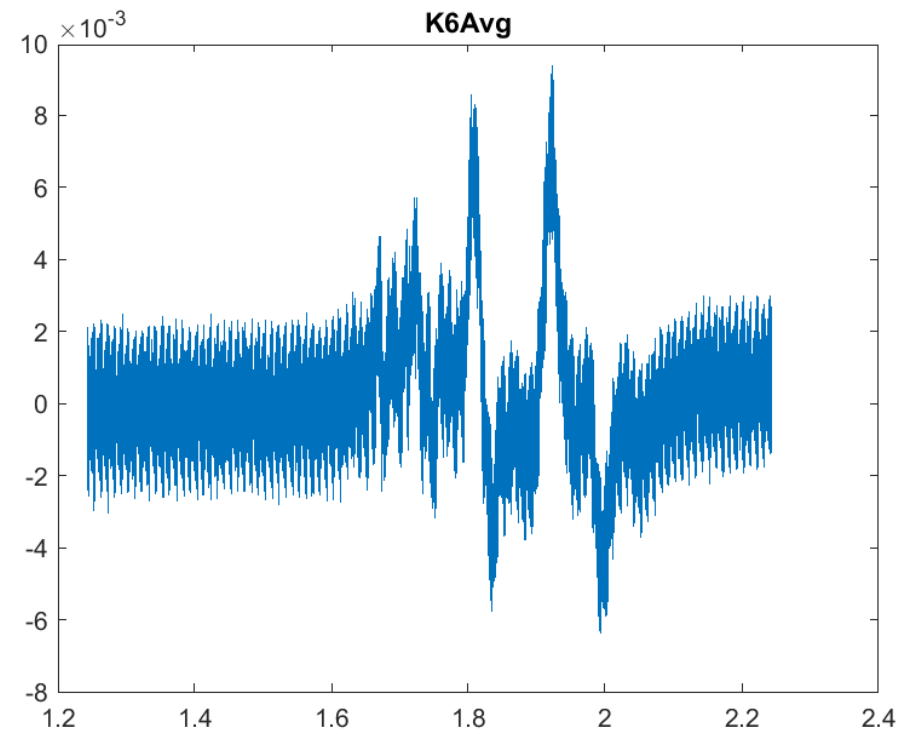
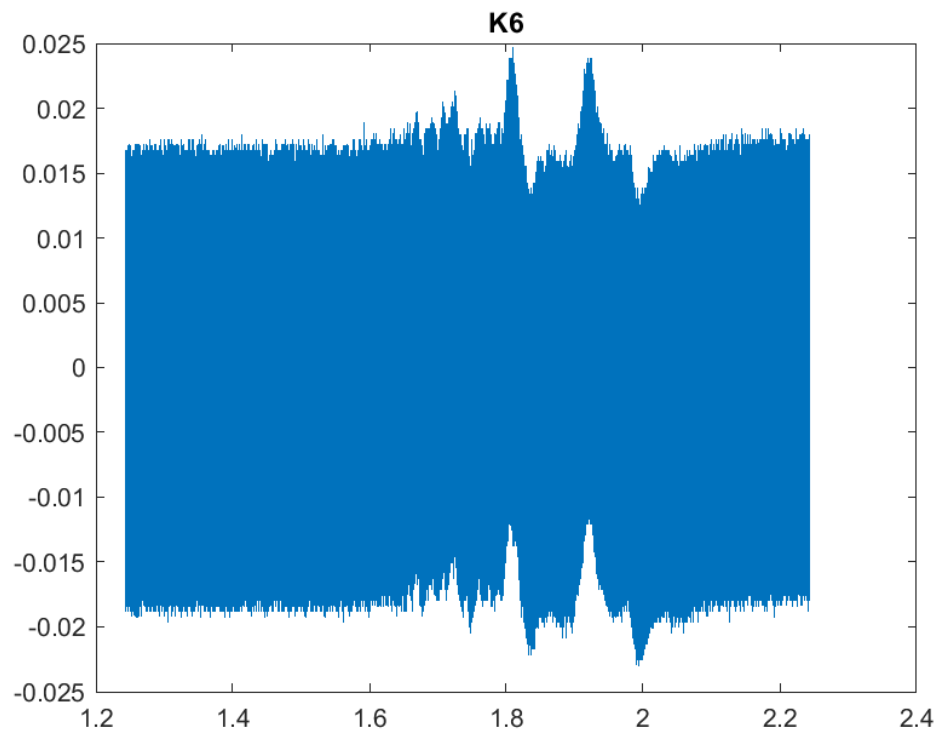
Statistical tools for data

- Censored data
 - When values are above or below a fixed amount e.g LOD
“left” and “right” censored
- Truncated data
 - When the unknown values are removed altogether
- Imputation
- Maximum likelihood estimation
- Useful for dispersion data when comparing with models



Statistical tools for data

- Averaging
- Filtering



To sum up

- Modelling can assist the experimental process in numerous ways:
 - Pre-test modelling to inform experiments
 - Design of experiments
 - Data processing

Acknowledgements



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