Update: Thermocouple calibrations

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ISU WEEKLY STAVE QC MEETING
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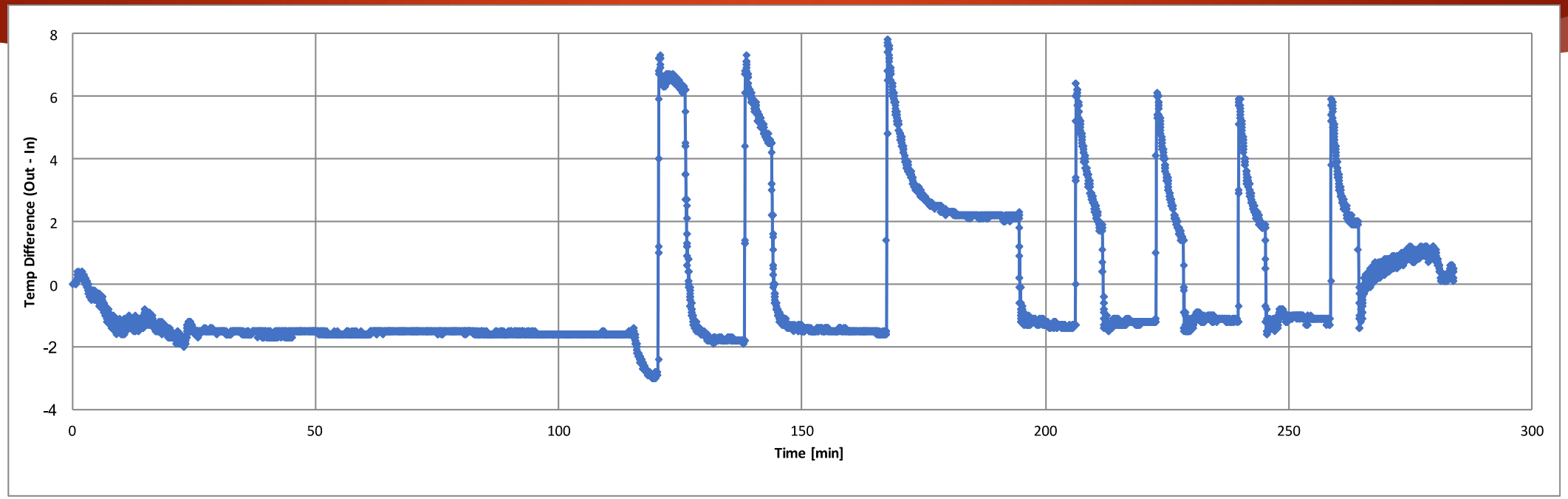
Where we are…

- Worked on fixing thermocouples and leaks
- Studied thermocouple fluctuations and differences…
  - Results shown in later slides
- Took baseline data of stave core # 6 before running a test shock which we will start today

ThermoCalibrations: Motivation



- After replacing one of the thermocouples we noticed that the fluid temperature on the outlet was colder than on the inlet when running cold fluid through the bypass
  - This data was from one of the tests with different flow rates through the stave core while the fluid set temperature is kept at a constant -55C
- The assumption was that when the fluid goes through the bypass the temperature of the fluid should be the same at the inlet and outlet
  - This plot shows that the difference(Out-In) was actually negative when in bypass mode!?!?
  - Now we need to check the thermocouples…

ThermoCalibrations: Motivation cont.

- Extracting some numbers from the plots and data
  - Fluid gains around 2 C as it passes through the stave core
  - Fluid loses heat while it is in the bypass?
- Numbers in parenthesis are approximate because the values were not leveled off

RPS Setting [rps]	T Diff (Bypass) [C]	T Diff (Stave) [C]	Flow Rate (Bypass) [l/min]	Flow Rate (Stave) [l/min]
10	(-2.9)	(6.2)	1.5	0.37
15	-1.8	(4.5)	2.1	0.44
20	-1.6	2.2	2.6	0.58
25	-1.3	(1.9)	3.2	.68
30	-1.2	(1.6)	3.7	0.84
35	-1.1	(1.9)	4.3	0.98
40	-1.1	(1.9)	4.8	1.1

ThermoCalibration: Procedure

- Tied three good thermocouples together and placed them in the chiller reservoir
- Set the chiller to run through 6 different temperatures with a 10 minute hold (-55 C, -40 C, -20 C, 0 C, 20 C, 40 C)
- Extract the temperature log and take the difference between each thermocouple pair (IE: DT12 = Temp 1 – Temp 2)
- Find the average and standard deviation of these DT values over the final five minutes of each set temperature
- Temperature Probes have a 0.1C precision with an accuracy of 2C or 2%

ThermoCalibration: Results

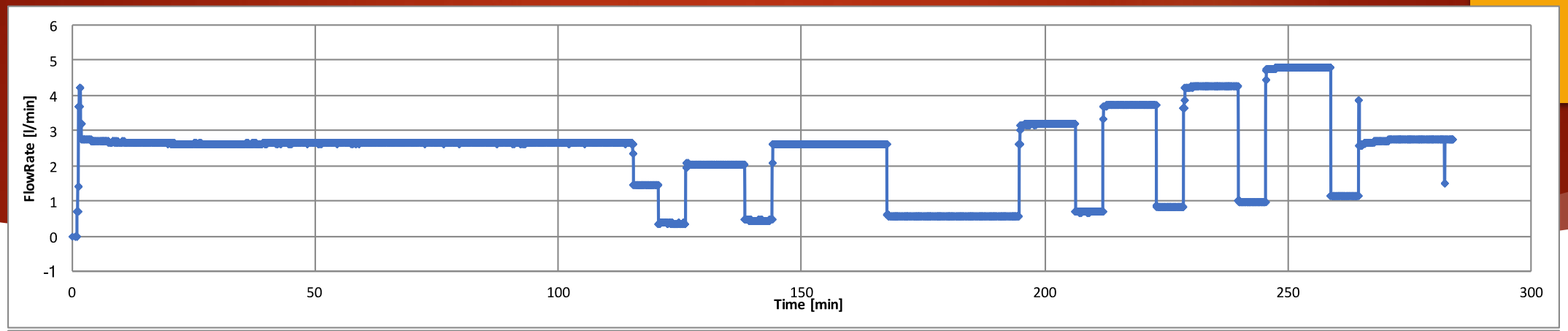
- All three thermocouples are very close well within the given uncertainty
- All three average differences are with in 0.1 C with the biggest differences between thermocouples 1 and 3
- When there are fluctuations in the differences they have a max standard deviation of around 0.2 C
- Possible bias between the thermocouples could be introduced by their location in the reservoir

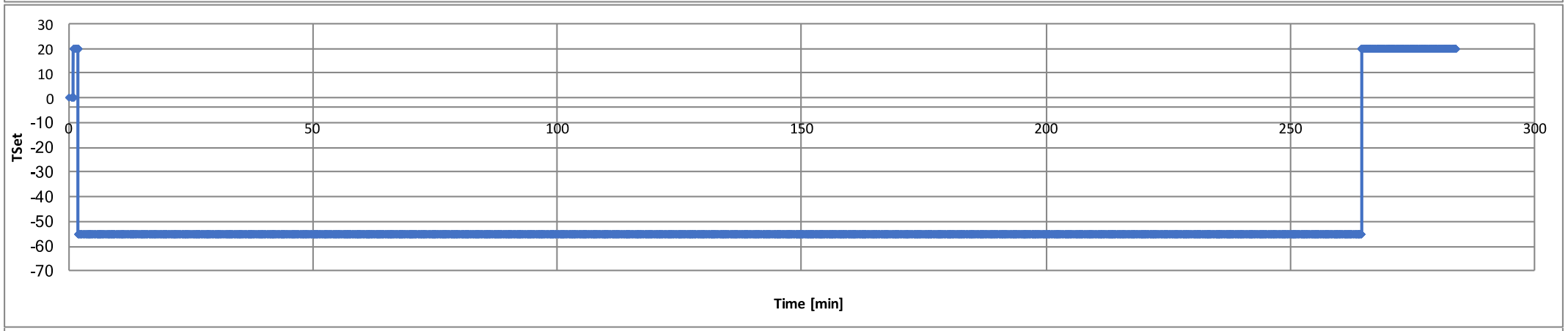
Num Data	T Set	Mean TD12	Mean TD23	Mean TD31	StdDev TD12	StdDev TD23	StdDev TD31
229	-55	0.078	0.027	-0.104	0.042	0.044	0.020
228	-40	0.028	0.072	-0.105	0.045	0.045	0.022
231	-20	0.014	0.003	-0.1	0.035	0.016	-
216	0	0.002	0.023	-0.025	0.099	0.089	0.088
232	20	-0.06	0.03	0.03	0.16	0.16	0.16
226	40	-0.06	0.02	0.04	0.14	0.15	0.15

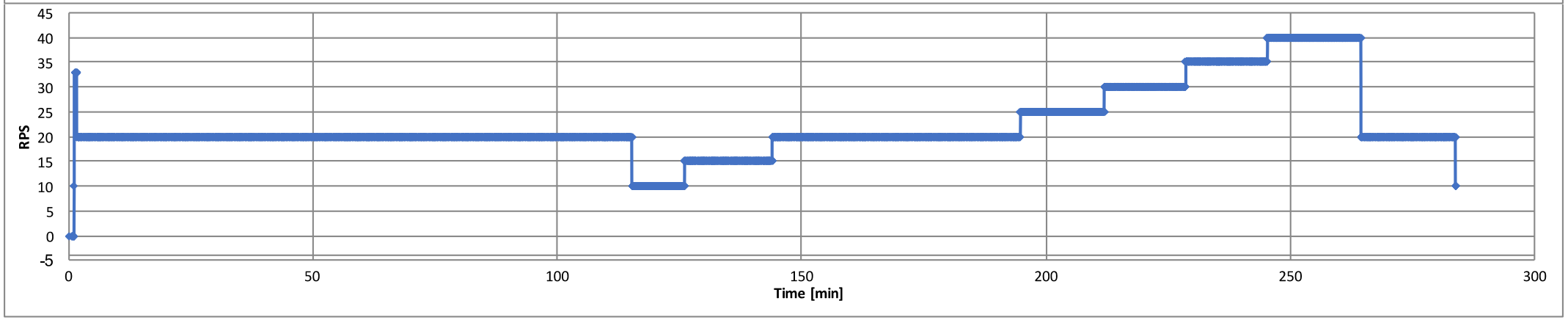
ThermoCalibration: Conclusions

- The thermocouples are all within 0.1 C of each other
- The maximum uncertainty of each thermocouple is around 0.2 C
- The heat loss of cold fluid measured when the system is in bypass mode is a real effect
  - This could be due to the nitrogen blowing right onto the bypass valve? We have put a cardboard block into the system to stop the air from going directly onto the piping
  - This could be due to the bending of the pipes at the bypass. The fluid takes 2 right turns and 2 large bends? Need someone with a good understanding of fluid dynamics…

Backup Slides


FlowRate [l/min]
6
5
4
3
2
1
0
-1
0
50
100
150
200
250
300
Time [min]


TSet
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0
50
100
150
200
250
300
Time [min]


RPS
45
40
35
30
25
20
15
10
5
0
-5
0
50
100
150
200
250
300
Time [min]