Solenoid Fast Dump Investigation

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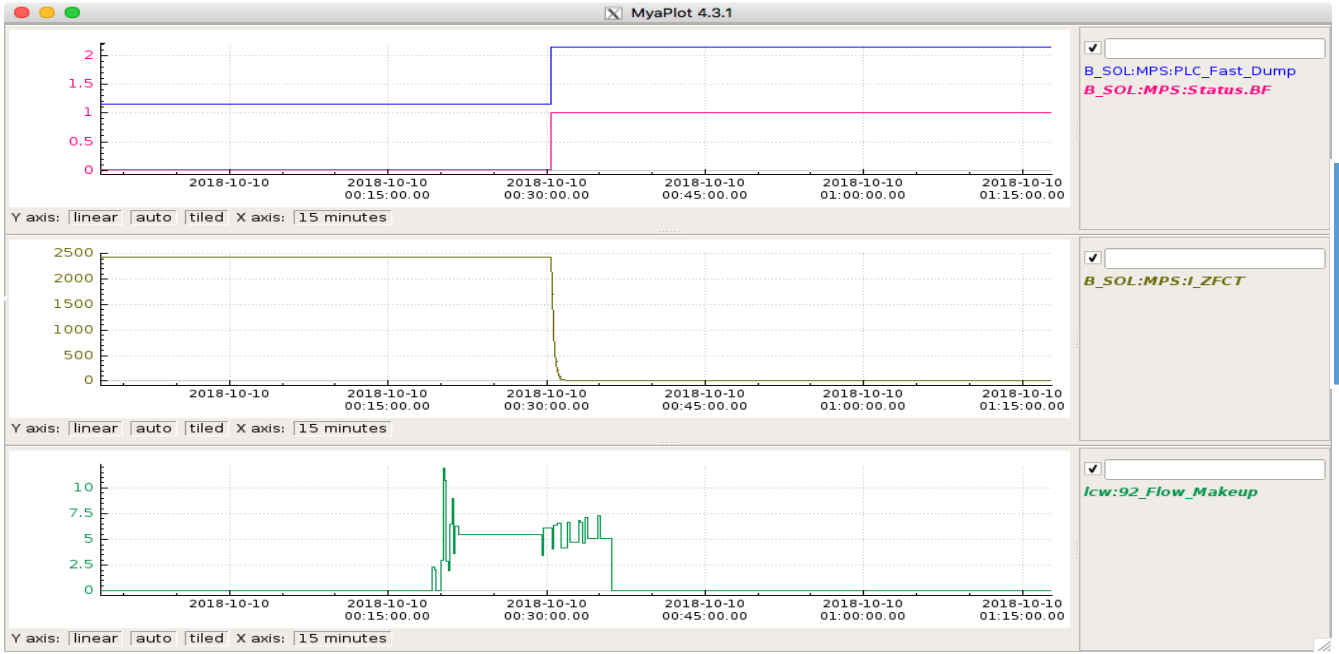
LCW:92_Flow_Makeup Spikes

- Archived data show 10 of 22 fast dumps correlated with LCW:92_Flow_Makeup signal spikes
- LCW:92_Flow_Makeup spikes reduce flow through the Solenoid MPS.
- Plots at : https://userweb.jlab.org/~beng/images/Solenoid%20Fast%20Dumps%20&%20LCW/



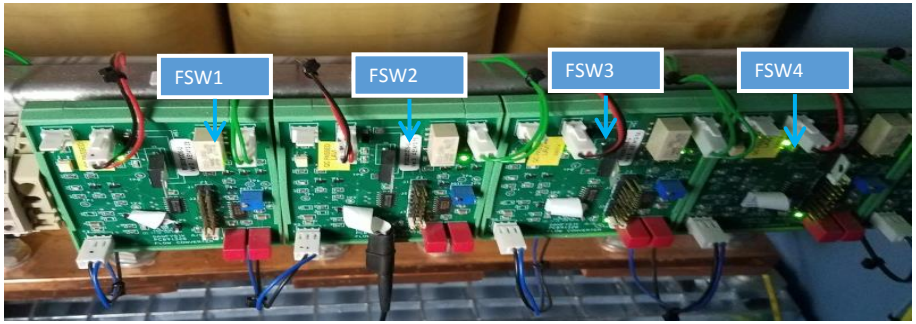
Fast Dump # 20
Plot shows correlation between LCW:92_Flow_Makeup signal and Solenoid MPS water flow bit status

Tasks Performed to Monitor LCW Flow in Solenoid MPS

- After Solenoid Fast Dump # 21 on 11/02/2018
  - —Two new pressure transducers installed in supply and return lines of Solenoid MPS Water flow loop.
- Pressure transducers read by Solenoid PLC
  - —Used available spares channels on local PLC chassis, at 1756-IF16 AI module, slot 4, channel 7 and 8.
- PVs created to monitor and archive these two pressure transducers:
  - —B_LCW_Level1_Sup
  - —B_LCW_Level1_Ret

Tasks Performed to Monitor Internal Water Flow of the MPS

- Solenoid MPS internal flow meters tested on 11/12/2018.
  - —MPS internal flow meters:
    1. Transistor Bank
    2. Rectifier/Thyrister
    3. Transistor Bank 2
    4. Transformer 1
    5. Transformer 2



Flow switches located internally in the MPS.

- Tested Torus MPS internal flow meters to compare and get reference
  - —Both Solenoid and Torus share same water supply and return lines.

Tasks Performed to Monitor Internal Water Flow of MPS

Instrument Used for Measurement	Device/ Point Measured	FSW1	FSW2	FSW3	FSW4	FSW5	Units
	Flow Meter Scale	80	15	80	15	15	l/min
	Full Scale Output	800	150	800	150	150	Hz
DMM	P1 to P2	24.2	24.2	24.2	24.2	24.2	V
DMM	TP8 to TP0	5	5	5	5	5	V
DMM	TP8 to R4 (Power Off)	54.62	230	116	42.68	65	KΩ
Scope	TP2 To TP0	430	73	360	12	10.25	Hz
Scope	TP3 to TP0	1.68	73	1.44	12	10	Hz
Latch Reset	Pull P2	True	True	True	True	True	True/False
Danfysik Recommended Flow Values [l/min]		50	8.22	50	1.45	1.45	Total flow 111.12
Calculated Flow based on measurements [l/min]		43	7.3	36	1.2	1.025	Total Flow 88.52

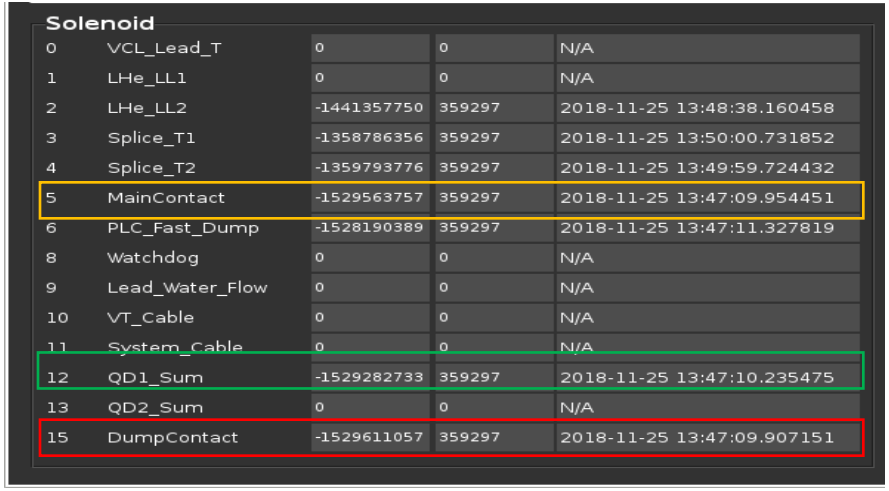
- Noticed that Solenoid MPS internal flows measured in the switches were below recommended flows by Danfysik.

Last Solenoid Fast Dump

- Fast dump #22
  - —Occurred on: 11/25/2018 @ 13:47:09
- Cause: MPS affected by external source.
  - —Possibly by lcw:92_Flow_Makeup signal.

Last Fast Dump - PLC SOE Timestamps

- PLC SOE sequence:
  - 1st Dump Contact :
    - Monitors MPS dump contactor status open/close.
  - 2nd Main Contact :
    - Monitors MPS main contactor status open/close.
    - **Occurred ~ 47 ms after Dump Contact trip.**
  - 3rd QD1_Sum:
    - Quench detector unit #1 relay
      - Monitors voltage taps in Solenoid.
    - **Occurred ~ 281 ms after Main Contact trip.**

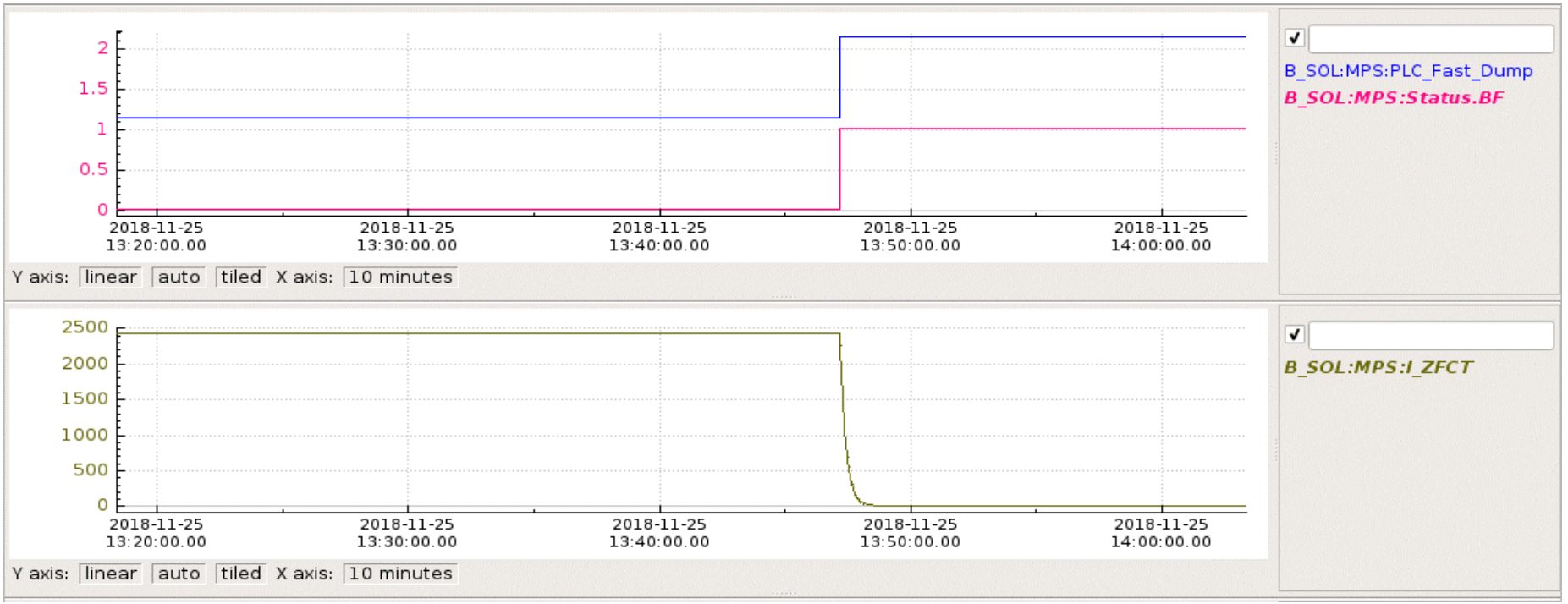


Solenoid

0	VCL_Lead_T	0	0	N/A
1	LHe_LL1	0	0	N/A
2	LHe_LL2	-1441357750	359297	2018-11-25 13:48:38.160458
3	Splice_T1	-1358786356	359297	2018-11-25 13:50:00.731852
4	Splice_T2	-1359793776	359297	2018-11-25 13:49:59.724432
5	MainContact	-1529563757	359297	2018-11-25 13:47:09.954451
6	PLC_Fast_Dump	-1528190389	359297	2018-11-25 13:47:11.327819
8	Watchdog	0	0	N/A
9	Lead_Water_Flow	0	0	N/A
10	VT_Cable	0	0	N/A
11	System_Cable	0	0	N/A
12	QD1_Sum	-1529282733	359297	2018-11-25 13:47:10.235475
13	QD2_Sum	0	0	N/A
15	DumpContact	-1529611057	359297	2018-11-25 13:47:09.907151

- SOE timestamps data prove that trip was in the MPS.
  - MPS behavior for dumps #21 and #22 has been the same
  - Internal trips of MPS are not consequence of the Solenoid instrumentation.
  - Solenoid MPS trips due external sources, most probably LCW flow make up spikes.

Last Fast Dump - MPS Signals at Trip Time



Last Fast Dump- Current, Flow makeup, and Pressure Signals

Last Solenoid Fast Dump
MPS Water Flow Pressure Observations

- During normal operations of the Solenoid at 2416 A
  - —Supply water pressure varies between 115 - 120 psi
  - —Return water pressure varies between 43 - 47 psi
  - —**ΔP (supply-return) ~ 75 psi**

- At solenoid trip (13:47:09 Hrs)
  - —Supply water pressure roughly constant.
  - —Return water pressure increases to 60 psi
  - —**ΔP (supply-return) ~ 60 psi**
    - Flow through MPS drops

Solenoid Tasks Performed to Monitor Internal Water Flow of MPS

- Modification performed:
  - — Manifold fitting changed.
  - —Hose size for water return and supply lines to the MPS increased from ¾'' ID to 1'' ID
  - —Internal flow meters of the Solenoid re-checked

Circuit Flow Switch Name	Previously Measured Flow [l/min]	Recommended Flow by Danfysik [l/min]	Currently Measured Flow [l/min]
FSW1	43	50	67
FSW2	7.3	8.22	8.5
FSW3	45	50	72
FSW4	1.2	1.45	1.65
FSW5	1.03	1.45	1.55

Table shows flow of all 5 circuits. Measured flows greater than Danfysik recommendation.

- Additional 25 psi headroom now available
  - —Additional 25 psi agrees with t calculated pressure drop in the 3/4“ ID vs 1" ID hoses

Conclusions

- LCW:92_Flow_Makeup appears to be a potential source affecting Solenoid MPS water flow and thereby initiating the fast dumps

- Archived data on recent dumps indicate that instrumentation is not the cause of the dumps

- **Hopefully, replacing supply and return hoses with larger inner diameter hoses (3/4'' I.D. → 1'' I.D.), will prevent future fast dumps.**

Thank you