Solenoid Fast Dump Investigation

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Content

- LCW:92_Flow_Makeup signal spikes
- Tasks performed to monitor internal water flow in MPS
- Last Solenoid fast dump
  - Correlations with LCW92 signal based on data archived
  - Observations
  - Tasks performed to improve internal water flow rates in MPS
- Conclusions
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 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

March 20, 2019
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 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

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

Flow switches located internally in the MPS.
Tasks Performed to Monitor Internal Water Flow of MPS

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

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

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

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**Solenoid Fast Dump Investigation**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>VCL_Lead_T</td>
<td>0</td>
<td>N/A</td>
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<tr>
<td>1</td>
<td>LHe_LL1</td>
<td>0</td>
<td>N/A</td>
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<tr>
<td>3</td>
<td>Splice_T1</td>
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<tr>
<td>4</td>
<td>Splice_T2</td>
<td>-1550793776</td>
<td>359297</td>
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<tr>
<td>5</td>
<td>MainContact</td>
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<td>359297</td>
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<tr>
<td>8</td>
<td>Watchdog</td>
<td>0</td>
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<tr>
<td>9</td>
<td>Lead_water_Flow</td>
<td>0</td>
<td>0</td>
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<tr>
<td>10</td>
<td>VT_Cable</td>
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<tr>
<td>11</td>
<td>System_Cable</td>
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<td>0</td>
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<tr>
<td>12</td>
<td>QD1_Sum</td>
<td>-1529282733</td>
<td>359297</td>
</tr>
<tr>
<td>13</td>
<td>QD2_Sum</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Last Fast Dump- Current, Flow Makeup, and Pressure Signals
Last Solenoid Fast Dump
MPS Water Flow Pressure Observations

• During normal operations of Solenoid at 2416 A
  — Supply water pressure varies between 115 and 120 psi
  — Return water pressure varies between 43 and 47 psi
  — $\Delta P$ (supply-return) $\sim 75$ psi

• At Solenoid trip (13:47:09 hrs)
  — Supply water pressure roughly constant
  — Return water pressure increases to 60 psi
  — $\Delta P$ (supply-return) $\sim 60$ 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 MPS increased from ¾” ID to 1” ID
  - Internal flow meters of Solenoid re-checked

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

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

- Additional 25 psi headroom now available
  - Additional 25 psi agrees with calculated pressure drop in the 3/4” ID vs 1” ID hoses
Conclusions

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

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

- Hopefully, replacing supply and return hoses with larger inner diameter hoses (3/4” ID → 1” ID) will prevent future fast dumps.
Thank you