Analysis of Hall B Solenoid Load Cells' Readings during Fast Dumps

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As of October 23, 2018, the Hall B Solenoid has had 19 fast dumps, prompting an investigation into whether the loads on structural components of the Solenoid changed as a result of these fast dumps. This note discusses the results of the investigation.

When an interlock causes a fast dump of the Solenoid, the dump contactor of the Solenoid's power supply opens and dumps the current to ground via an internal dump resistor, to quickly (~145 s) reduce the stored energy (< 20 MJ) in the Solenoid.

When a fast dump occurs, it is possible for the Solenoid's structural components to shift, resulting in the loads changing on the structural components, thereby increasing the chances of structural failure.

Load cells on the radial and axial supports of the Solenoid measure the loads on the structural components. Table I lists the locations and Fig. 1 displays the approximate location of the load cells.

Load cell name	Type	Location
RS86101US_BR_B	radial	US, beam right, bottom
RS86102DS_BR_B	radial	DS, beam right, bottom
RS86103DS_BR_T	radial	DS, beam right, top
RS86104US_BR_T	radial	US, beam right, top
RS86105US_BL_T	radial	US, beam left, top
RS86106DS_BL_T	radial	DS, beam left, top
RS86107DS_BL_B	radial	DS, beam left, bottom
RS86108US_BL_B	radial	US, beam left, bottom
ZS86101US_BR_B	axial	US, beam right, bottom
ZS86102DS_BR_B	axial	DS, beam right, bottom
ZS86103DS_BR_T	axial	DS, beam right, top
ZS86104US_BR_T	axial	US, beam right, top
ZS86105US_BL_T	axial	US, beam left, top
ZS86106DS_BL_T	axial	DS, beam left, top
ZS86107DS_BL_B	axial	DS, beam left, bottom
ZS86108US_BL_B	axial	US, beam left, bottom

TABLE I. All Solenoid load cells, their type, and approximate location on Solenoid. (US=upstream, DS=downstream)

To investigate whether the load cell values changed due to the fast dumps, archived data for each load cell was retrieved from September 12, 2017 to October 15, 2018 and analyzed using a program written in Python. The program read in data and plotted the values for each load cell in a color that correlates to the Hall B Magnet System's power state (Table II).

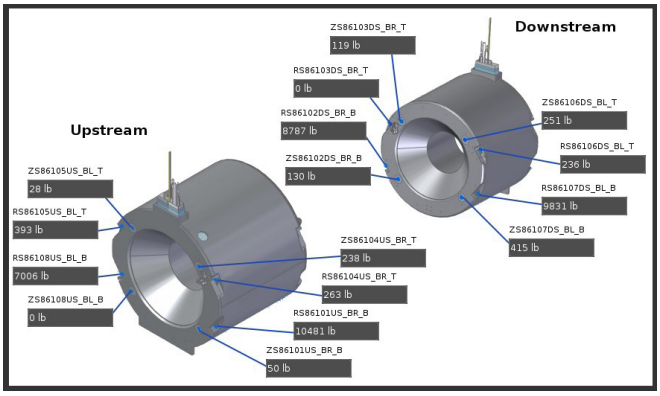

FIG. 1. EPICS monitoring screen showing a diagram with physical locations of Solenoid load cells.

State #	Solenoid status	Torus status	Plot color
1	off	off	green
2	off	on	red
3	on	off	pink
4	on	on	blue

TABLE II. List of Hall B Magnets System power states and their respective colors on generated plots.

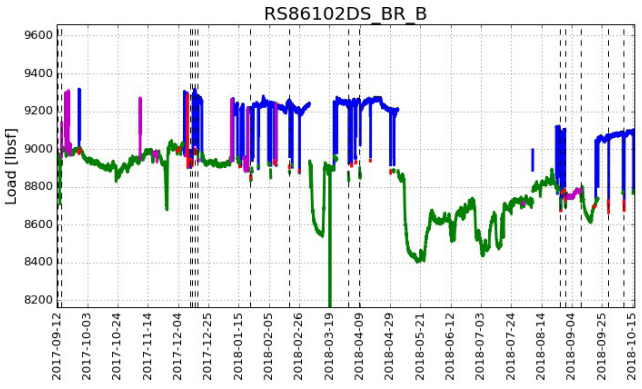

FIG. 2. Plot for radial load cell RS86102DS_BR_B showing coloring for Hall B Magnets System's different states. Vertical dashed lines indicate Solenoid fast dumps. Breaks in plot are a side effect of masking used to color plots.

Fig. 2 shows a plot of the radial load cell values and Fig. 3 a plot of the axial load cell values.

From the plots, it is observed that:

1. There is a direct correlation between increases in load

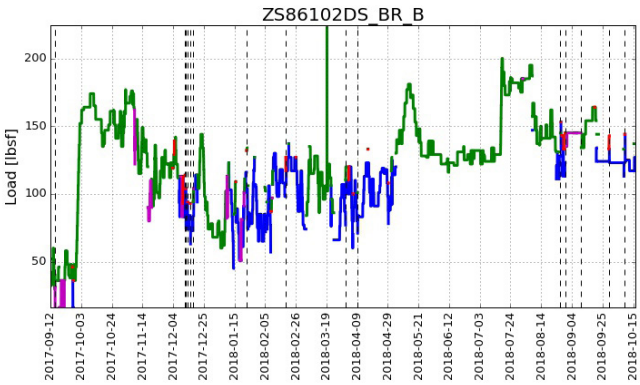

FIG. 3. Plot for axial load cell ZS86102DS_BR_B showing coloring for Hall B Magnets System's different states. Vertical dashed lines indicate Solenoid fast dumps. Breaks in plot are a side effect of masking used to color plots.

cell values and the power state of the Hall B Torus. When Torus is powered and is at full field, all load cells read ~400 lbsf greater than when Torus is not powered. This difference in readings is expected because the Solenoid is within the field of the Torus.

2. There does not appear to be an overall trend in the load cell values due to the fast dumps. However, the load cell values changed over three different periods. From September 2017 to mid-July 2018, there was a decreasing trend in load cell values. During Summer 2018, there was a large change in all load cell readings, most likely due to the Solenoid warming to and remaining at 80 K for an extended period of time. From mid-August 2018 to present, there was a slight increasing trend in radial load cell values and a slight decreasing trend in axial load cell values. It has been determined that the changes in load cell readings and their trends are not significant and should not be concerning.
3. There are three load cells that read 0 lbsf for extended periods of time: RS86103DS_BR_T since the end of October 2017; ZS86105US_BL_T from mid-December 2017 to April 2018 and has since read very low values; and ZS86108US_BL_B since mid-June 2018. Fig. 4 shows these three load cells. It is uncertain what causes this, or if the three load cells should be repaired.

To conclude, the investigation indicates that the 19 fast dumps did not cause any significant change to the load cell readings. However, Hall B Torus power state and long-term cryogenic warm-ups did affect load cell readings. Fortunately, the changes are not significant and do not pose a threat to safe Solenoid operations.

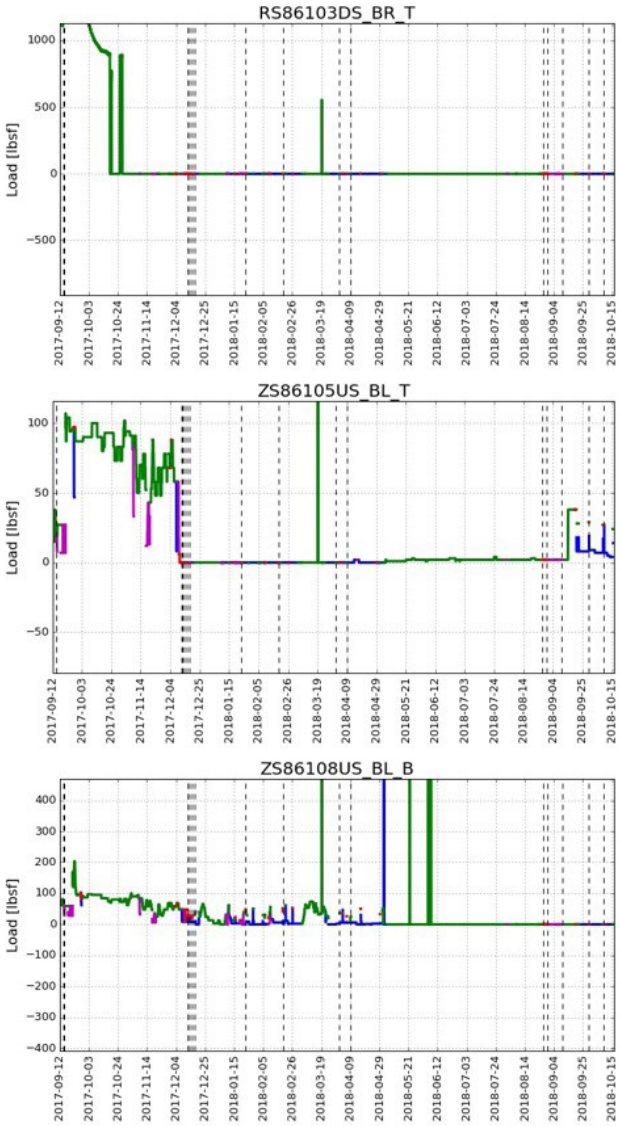

FIG. 4. Plots for load cells RS86103DS_BR_T (top), ZS86105US_BL_T (middle), and ZS86108US_BL_B (bottom) showing that they have read 0 lbsf for extended periods of time.