SoLID Magnet Load Sensors Controls

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The control and monitoring of the load sensors are critical to ensure that the magnet coils correct position while magnet is energized and electromagnetic forces are present. The developed control system is based on Programmable Logic Controller (PLC), which monitors and controls 16 strain gauges load sensors and four axial load cell load sensors.

All load sensors are full bridged 350 Ohms, 1mV/V at 11,000 lbf. and are energized by Dataforth signal conditioning modules with +/- 10 mV excitation voltage. The same Dataforth module is used to clean and amplify the read back signal and output it to the PLC analog digital converter (ADC) input module.

I written PLC code with multiple routines to monitor, check sensor faults, compare read back values against limits and interlock the system.

A Subroutine in ladder logic allows to read back the voltage and convert them to force units, in Kgf, and allows their calibration by adjusting the coefficients in the voltage vs force curves. Another subroutine allows to check the sensor connection errors by looking at the individual ADC input channels of the PLC.

I wrote there subroutines to compare the read back value against the warning limits and alarm to the operators. A subroutine checks only radial support load sensors located in the upstream side, the other checks the radial support sensors in the downstream side, and the third one checks the axial load sensors. For these three routines, I implemented a pre-created add-on instruction, which was very useful and allowed to simplify the code since all radial and axial support load sensors are evaluated in the same way. In the same manner as the subroutines written for the warnings I wrote another three subroutines to compare the read back load sensors against the slow ramp down limits. I added code to generate a controlled ramp down of the power supply of any of the radial or axial load cells are not within the minimum and maximum set limits

- **Written PLC code to monitor and control 20 load sensors**
- **Developed HMI screens to monitor and control**
- **Implemented load sensors read back values to data archiver system**

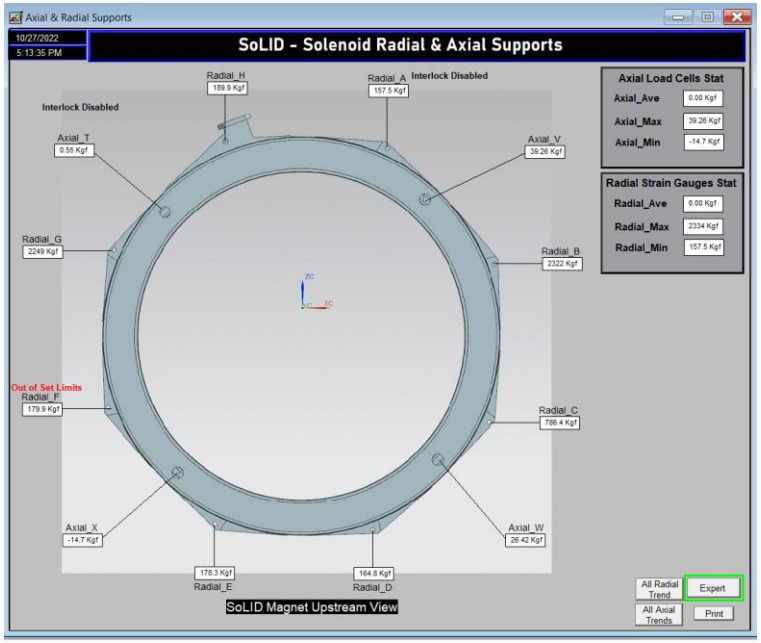

Fig.1. *Solenoid Radial & Axial Supports* HMI screen

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I found complications to removed not used add-on instruction from the code online, solved by creating the add-on on a separate PLC program, once add-on was completed I imported the SoLID PLC program online. To clean up the unused add-on instructions and logic I will take the PLC off line and deploy a new version of the program to the controller.

I developed three Human Machine Interface (HMI) screens to control and monitor the load sensors in the whole magnet. Two HMI screen developed provide approximated physical location, sensor readout, and sensor status of the axial and radial supports sensors on the upstream side and the downstream side (See Fig.1).

A screen was developed to provide expert control and monitoring to the operator, the screen allows to enter the low and high limits for the warnings and controlled ramp down for each load sensor, the screen allows to the user to disable or enable the interlock for each sensor, shows the fault and interlock status for each sensor and also the overall status for all sensors in the downstream side and the upstream side, as shown in fig.2.

I added each load sensor readout o the data logger system to be archived, therefore, this will allow to the expert users refer to the data in case is needed.

I tested successfully the PLC program and HMI screens to ensure proper operations to monitor and control the load sensors.

PLC code and HMI screens are ready to be used during the 100A testing planned for the SoLID magnet at the Test Lab.

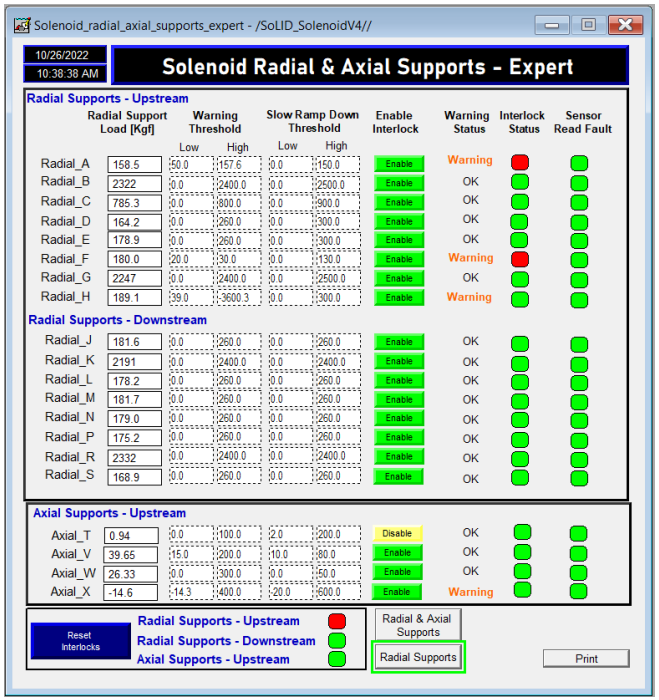

Fig.2. *Solenoid Radial & Axial Supports – Expert* HMI screen