Controls and Monitoring Screens for the Cryo Control Reservoir Valves of Hall A's SoLID Solenoid

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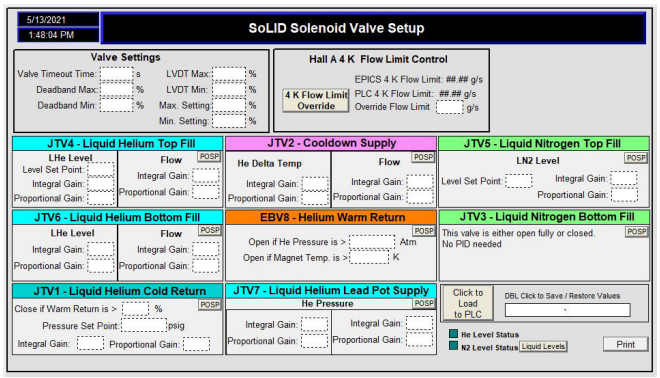
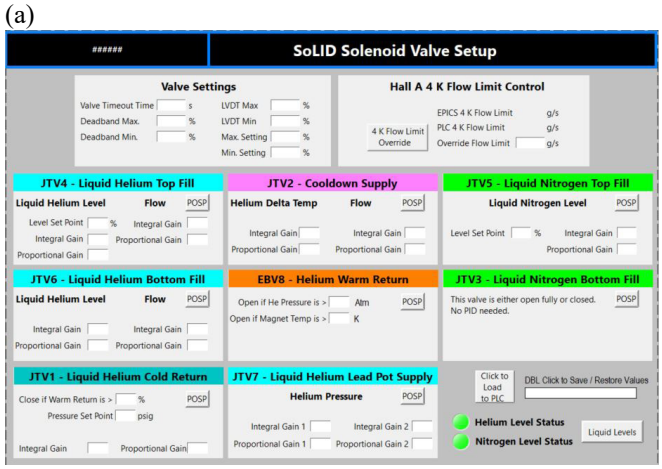
This note describes the Human Machine Interface (HMI) and Control System Studio Best OPI Yet (CSS-BOY) screens that control and monitor the Cryo Control Reservoir (CCR) valves.

HMI and CSS-BOY versions of the *Solenoid Valve Setup* screens, Fig. 1a and b, control and monitor seven Joule-Thomson valves (JTV) and the electric ball valve (EBV) in the CCR [1]. Both versions have similar appearances and features.



(a)



(b)

FIG. 1. *Valve Setup* screens (a) HMI and (b) CSS-BOY. In the figures, white fields accept inputs.

In the *Valve Settings* area, Fig. 2, inputs apply to all valves. The linear variable differential transformers' (LVDTs') readback values should be within the *LVDT Max* and *LVDT Min* limits. Readback values outside the entered limits indicate valve position errors.

Valve Timeout Time is the time that the PLC waits before declaring a valve position error [2]; the declaration occurs only if the difference between the read and the set position of a valve is out of the *Deadband Max* and *Deadband Min* limits; this is another way to determine the valve position errors.

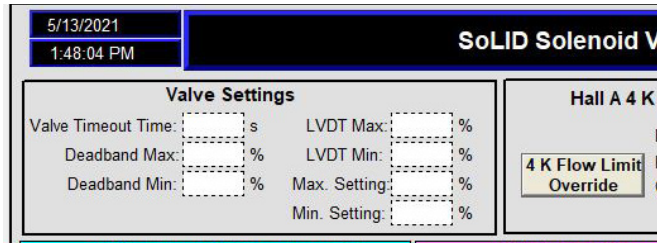


FIG. 2. *Valve Settings* area of screen.

Max Setting value applies only to JTV3. When the system is operating in the automatic mode and the cryogenic conditions of JTV3 trigger an opening of JTV3, the valve will open to the *Max Setting* value.

Min Setting value applies to all seven JTVs. When the system is operating in the automatic mode and the cryogenic conditions of a valve triggers a closing, that valve will close to the *Min Setting* value.

Figure 3 shows the *Hall A 4 K Flow Limit Control* area of the screen. *EPICS 4 K Flow Limit* is the readback of the liquid helium flow rate limit set in EPICS. *PLC 4 K Flow Limit* is the readback value of the flow rate limit set in the PLC program. *Override Flow Limit* input limits the liquid helium flow rate to the specified value. The *4 K Flow Limit Override* button of the control program in use, EPICs or PLC, selects the set override limit as the liquid helium flow rate.

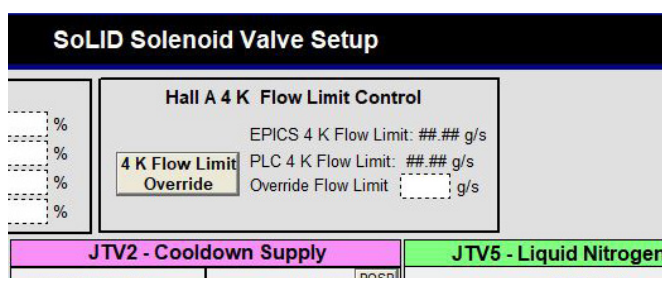


FIG. 3. *Hall A 4 K Flow Limit Control* area of screen.

There is an input area on the main screens, Fig. 1, to control each valve JTV1–JTV7 and EBV8; Fig. 4 shows the JTV6 input area. To the right of each valve name is a description of what that valve controls. The heading color of each valve is the same color as the cryogenic lines on other screens, such as the *Cryo Control Reservoir-Expert* or *Valve Page*. Additionally, the screen accepts inputs for control parameters such as proportional gain and integral gain, and 4 K helium flow limit to control valve positioning set points when the system is operating in the automatic mode.

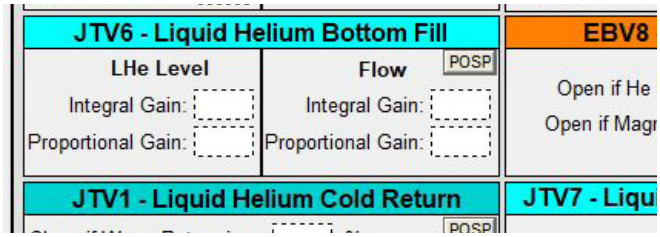


FIG. 4. Inputs for JTV6.

EBV8—helium warm return—screen accepts inputs for the maximum pressure within the liquid helium reservoir and the maximum temperature in the magnet, Fig. 5. EBV8 opens if, and only if, the readback pressure or the readback average temperature in the magnet is greater than the set limits.

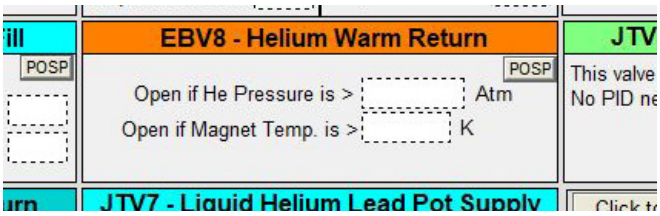
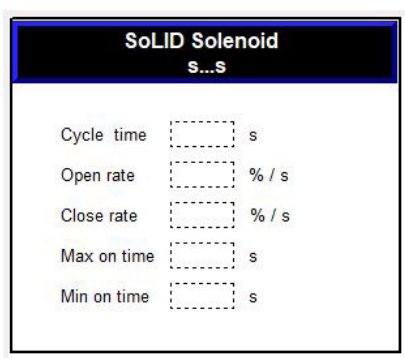
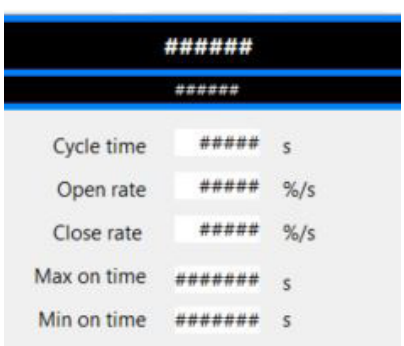


FIG. 5. Inputs for EBV8.

The position proportional (*POSP*) button for each valve opens the *POSP* screen, Fig. 6a and b. These screens control the input parameters required for the POSP instruction—running in the PLC controller—that opens or closes a valve motor controller relay, if, and only if, valves are in the PLC Control mode. A relay contact is pulsed with a width proportional to the difference between the desired and the actual position, to open or close at a defined cycle time.



(a)



(b)

FIG. 6. *POSP* screens (a) HMI and (b) CSS-BOY.

In the bottom right corner, the *Valve Setup* screen allows save and restore of all input values, Fig. 7. If the white area is double-clicked, a screen pops up that permits choosing an existing file or creating a new file. Restoring values can be done only from existing files; backing up values can be done to an existing file or by creating a new file. The *Click to Load to PLC* button downloads all values contained in the selected existing file to the PLC.

FIG. 7. Area of *Valve Setup* screen to save and restore input values.

Below the save/restore box are two indicators that show the status of the liquid helium and liquid nitrogen levels. The indicators blink red if, and only if, the level is out of the set limits or if, and only if, there is a fault in the ADC channel used to read the levels; green indicates no fault. The *Liquid Levels* button to the right of the indicators opens the *Liquid Level Expert* screen, which provides details and controls of the liquid levels. The *Print* button on the HMI screen takes a screenshot; this feature is not available on the CSS-BOY screen.

HMI screens were tested by reading the actual values from the PLC in running mode since the HMI system is linked with the PLC. All variable values and faults were read from the PLC and monitored in real time. To test fault conditions, test PLC tags were used and values were changed without affecting the system. Indicators' values, color changes for the indicators, screen format, and navigation buttons were tested by running FactoryTalk SE Client [3], which is connected to the developed HMI server and allows real time monitoring.

Preliminary testing of the CSS screen is done by using local PVs generated by script that runs in the CSS environment [4, 5].

[1] P. Campero, et al., *Controls and Monitoring Screens for the Cryo Control Reservoir's Instrumentation of the SoLID Solenoid*, DSG Note 2020-33, 2020.
[2] P. Campero, et al., *Controls and Monitoring Screens for the Valves of SoLID Solenoid*, DSG Note 2021-02, 2021
[3] P. Campero, et al., *Steps to Install and Run the HMI System*, DSG Note 2020-21, 2020.
[4] T. Lemon, et al., *Test Operator Interface Creator Program*, DSG Note 2020-23, 2020.
[5] M. A. Antonioli, et al., *Generating CSS-BOY Screens*, DSG Talk 2020-20, 2020.