National Aeronautics and Space Administration

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SPACE LAUNCH SYSTEM

1/7/2016

Hydraulic Flow Simulators

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HAS and 3rd Actuator Flow Simulators

Outline

This test supports the SLS Core Stage Thrust Vector Control (TVC) Qualification Test –scheduled for CY16 in the Bldg. 4205 TVC lab**.**

- **Flow Simulators**
- **Design**
- **Description of test**
- **Results**
- **Lessons learned**

Flow Simulators

- The flow simulators were designed to simulate the hydraulic fluid that would be diverted from the core stage TVC system.
- The Hydraulic Actuation System (HAS) is the accumulation of all RS-25D engine propellant control valves that will require hydraulic power during flight operation.
- The 3rd actuator simulator is a simulated failure of a core stage TVC system. Each TVC system must be able to hydraulically power two actuators plus one additional actuator from another engine.
- Should one TVC power system fail the other TVC systems must be able to compensate for the loss of hydraulic power.

Design

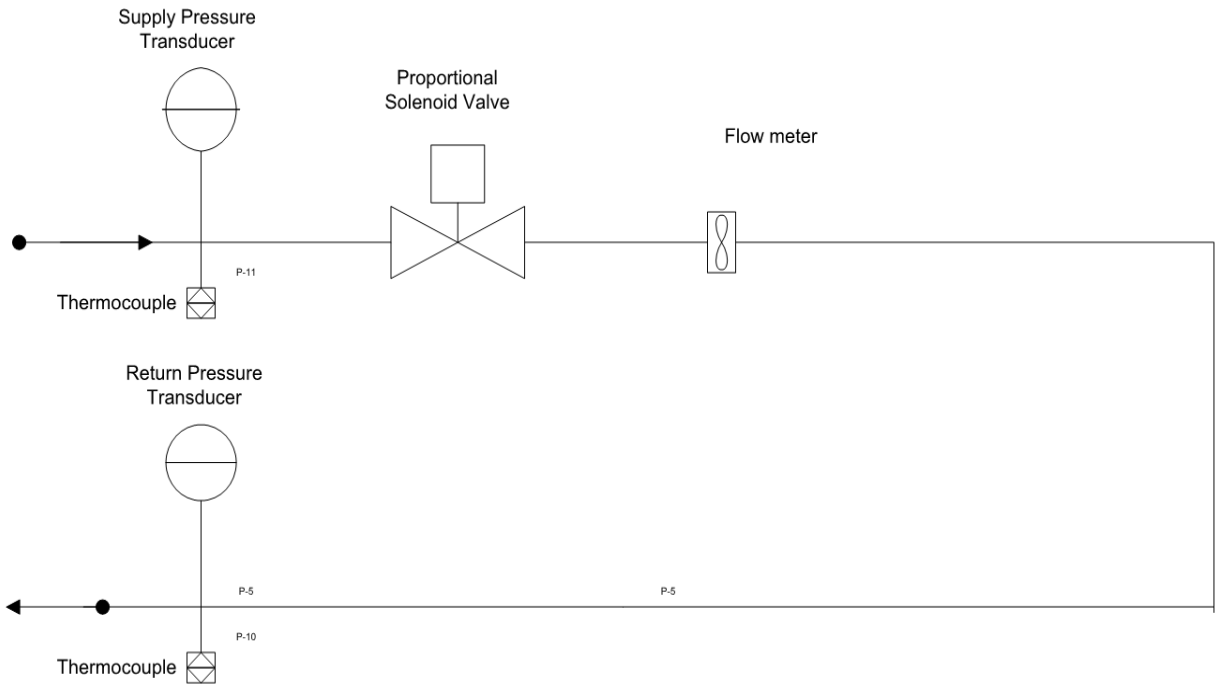
- The design of each system was a collaboration between engineers and technicians in the TVC test laboratory.

- Each system was designed to simulate the flow expected from the HAS and the 3rd actuator. The proper solenoid valves were chosen. All components were hydrostatically tested and precision cleaned. A Visio diagram of the each system was created.

- A LabVIEW code was created to command the solenoid valves and receive data from the pressure and temperature transducers as well as the flow meter.

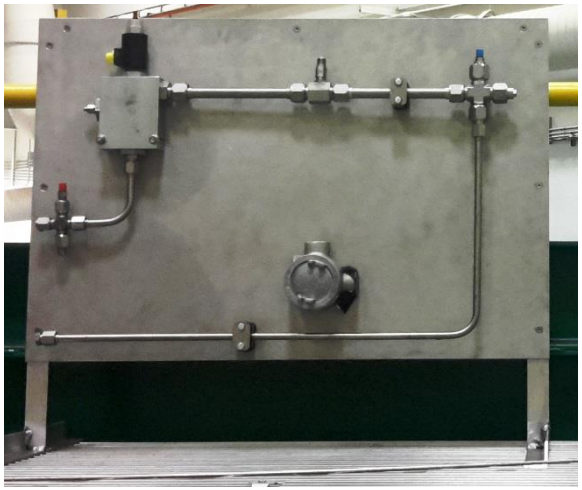
- A procedure was written with all the necessary steps to perform the test. The procedure also included steps on how to operate the test safely. Each step of the procedure was entered into a work order. The testing results were displayed using WinPlot.

Design



Visio Diagram

3rd Actuator



HAS

Description of Test

- Each System was connected to the ILS test stand. The system was brought up to pressure. The solenoid valves were commanded to the required flow rate.

- The system response was recorded. Pressure measurements were taken up and downstream of the flow simulator and flow was measured downstream. This data was used to validate the system response of each flow simulator.

ILS Hydraulic System Connection

Results

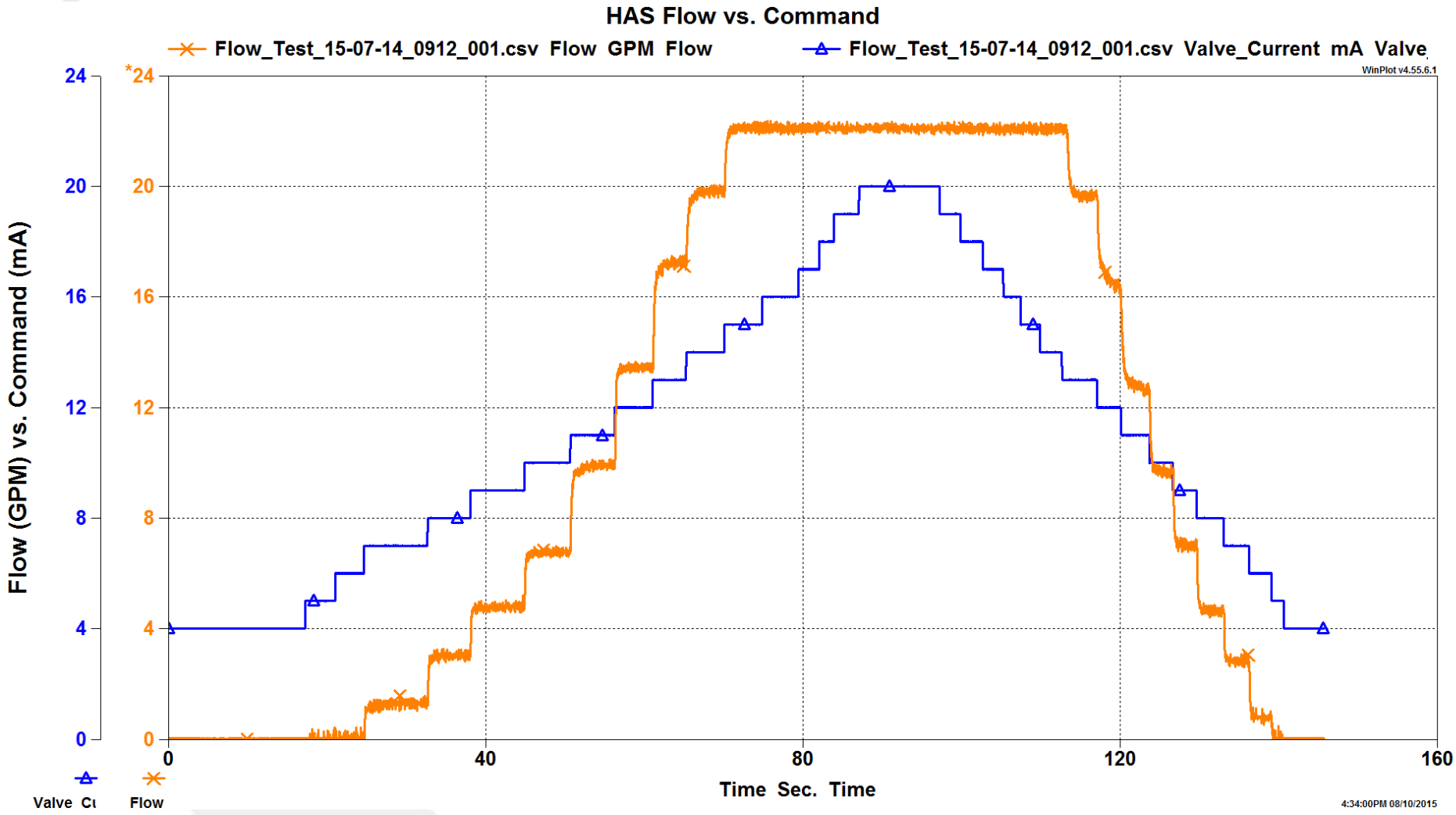
- The Results of this test showed the flow simulators will be able to divert the necessary amount of hydraulic fluid from the system during a system test

- A lesson learned from this test was the evaluation of line size and how it can effect pressure and flow rate. The initial procedure used the ½ inch supply and 1 inch return lines on the West ILS stand.

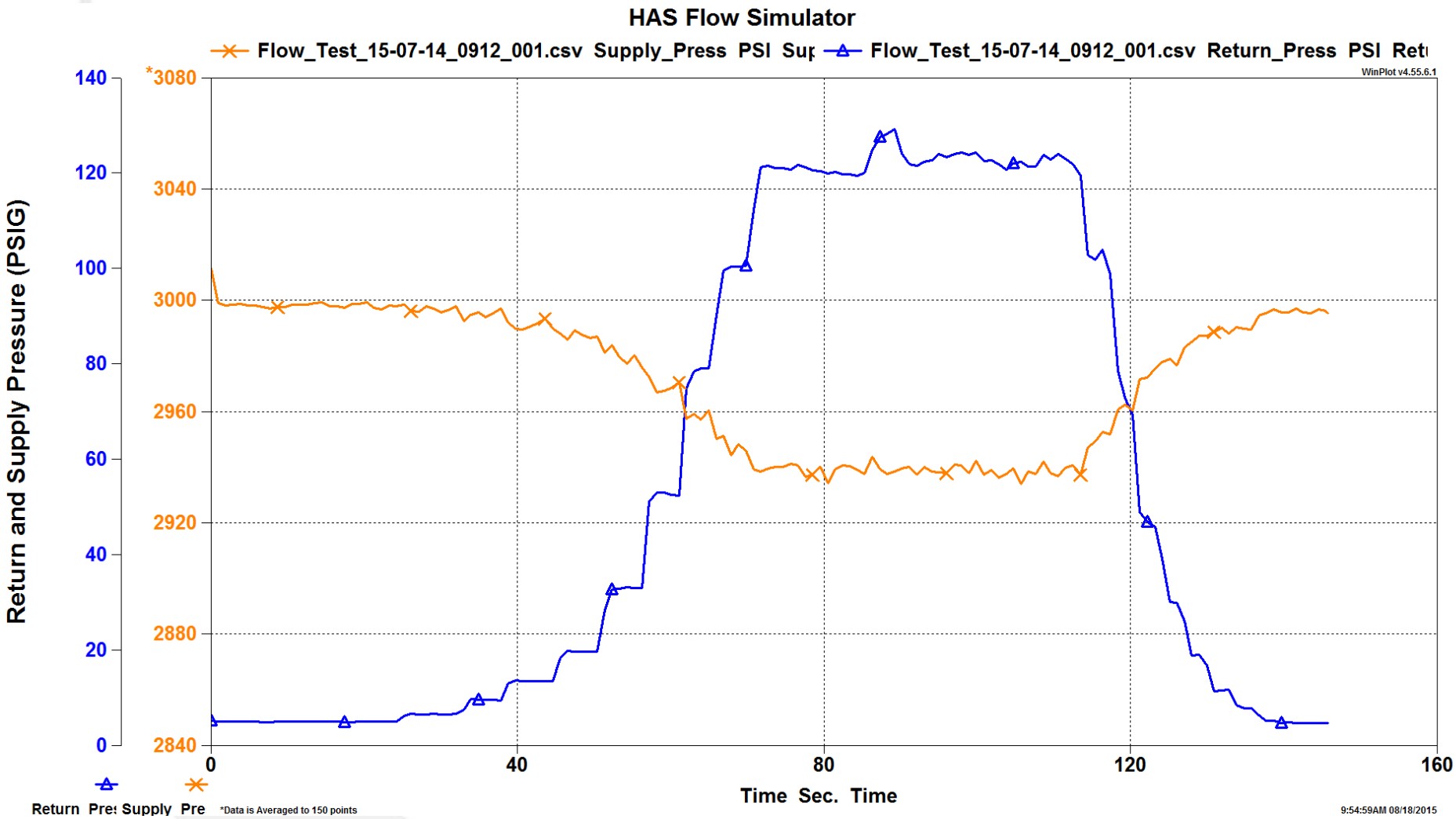
- During the initial test the pressure transducer on the return line spiked. A possible cause for the spike could be from choked flow. The flow could not leave the system fast enough and as a result pressure built up in the line. The system was moved to the East ILS stand where the return line was 1 ¼ inch. This resolved the choked flow problem.

- The flowing charts show the data collected during each test of the HAS and 3rd Actuator Flow Simulators.

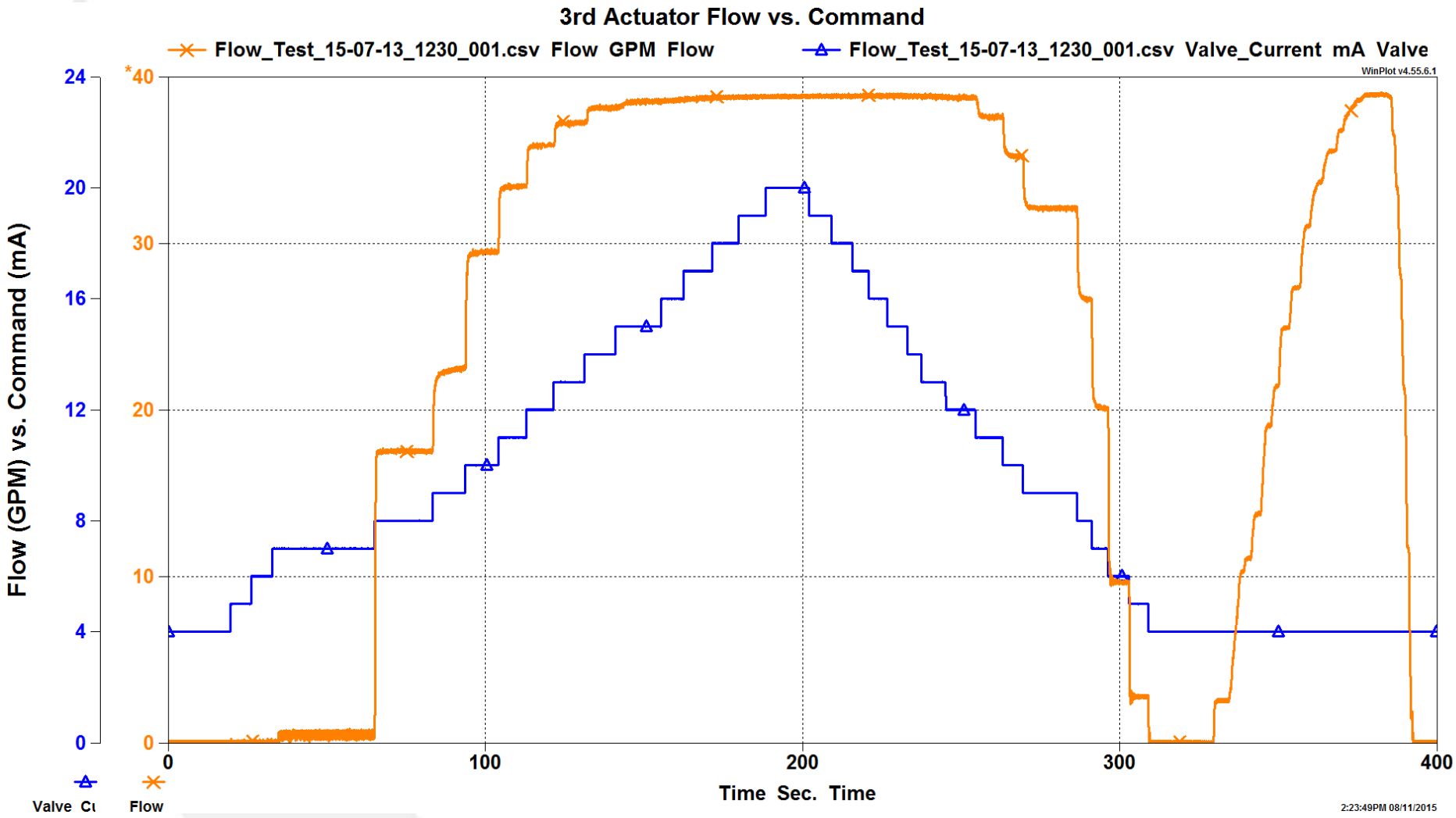
HAS Flow Simulator
Flow vs. Command



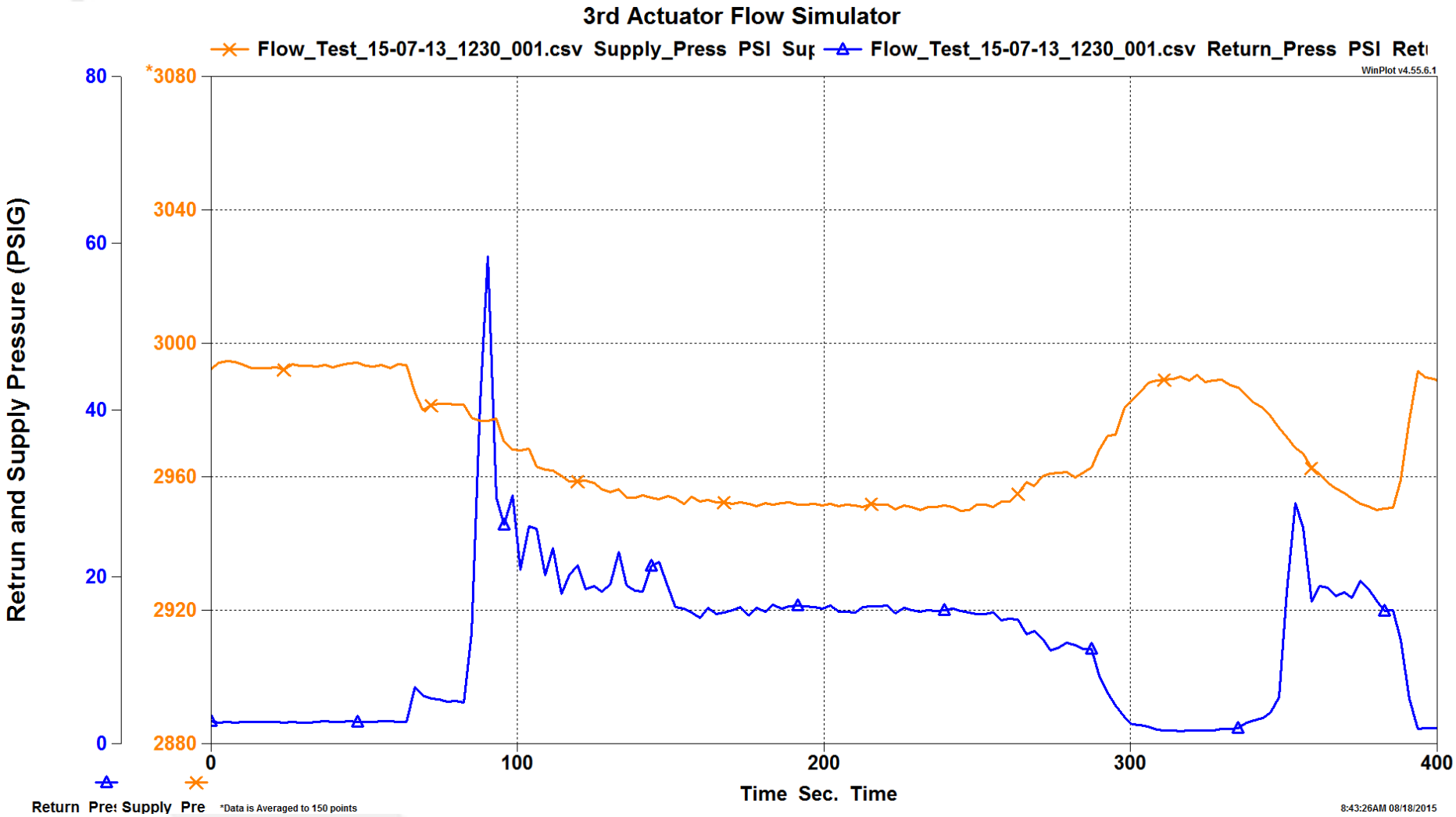
HAS Flow Simulator
Return and Supply Pressure



3rd Actuator Flow Simulator
Flow vs. Command



3rd Actuator Flow Simulator
Return and Supply Pressure



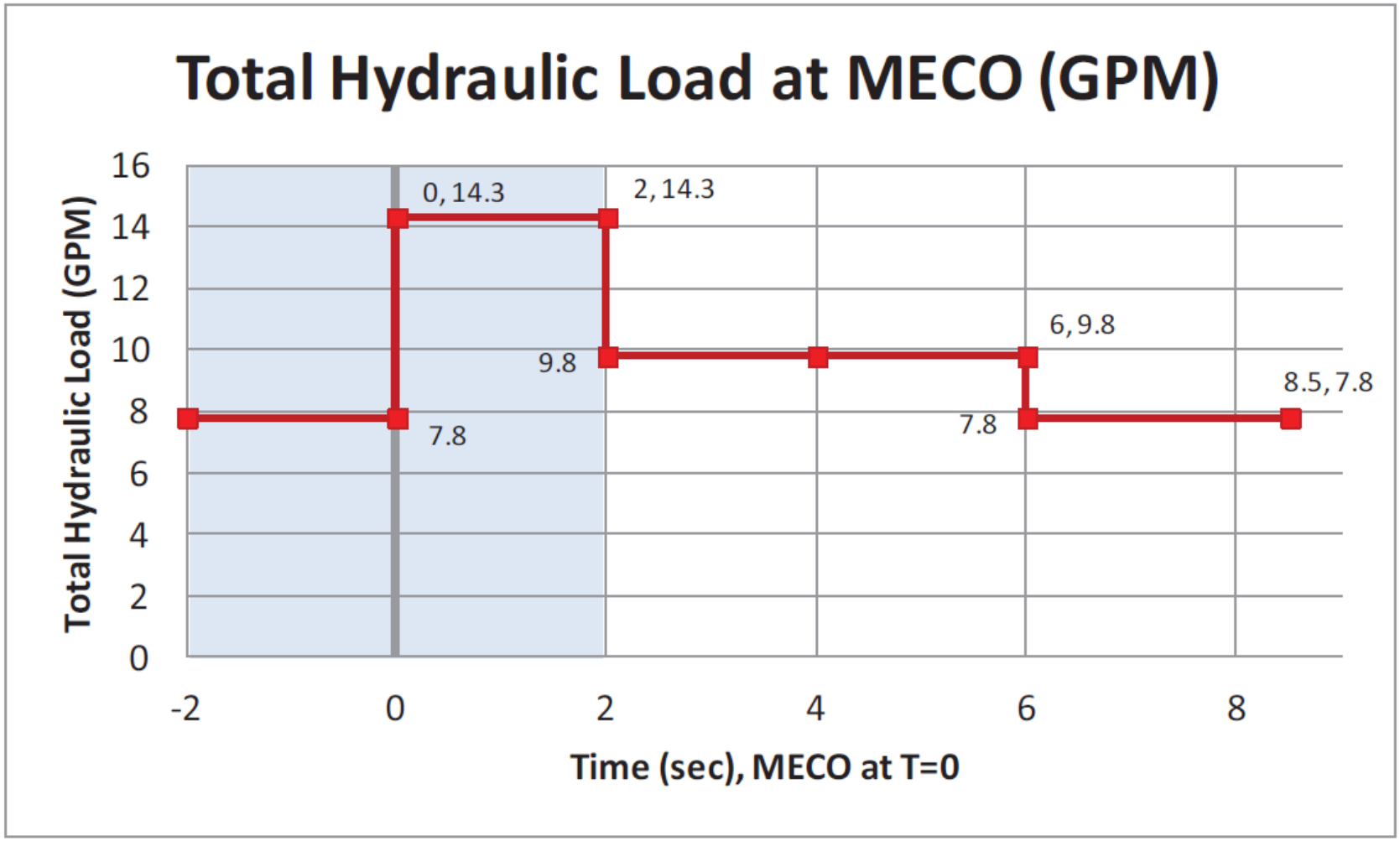
Results

- It was found that the maximum GPM for the 3rd actuator flow simulator was 38 GPM. 35 GPM is required for the actual test so the flow simulator will meet the requirements to be tested on the two-axis ILS stand in support of Core Stage testing.

- The solenoid valve was rated to 50 GPM. With the valve fully open it only reached 38 GPM (Manual flow is depicted on far right of Slide 10). After contacting the manufacture it was found if the pressure was increased to 3500 psig 50 GPM could be achieved with the valve. However since the system operating pressure is 3000 PSIG and 38 GPM is high enough to create the necessary flow the valve was passed for testing.

- The HAS actuator flow simulator was also tested on the East ILS stand and the flow went up to 23 GPM. Since 15 GPM is all that is required for the actual test the flow simulator is well over the range needed.

Results


Total Hydraulic Load at MECO (GPM)
Total Hydraulic Load (GPM)
16
14
12
10
8
6
4
2
0
-2
0
2
4
6
8
Time (sec), MECO at T=0
0, 14.3
2, 14.3
6, 9.8
8.5, 7.8
9.8
7.8
7.8

Lessons Learned

- Numerous lessons were learned from this project. This project exposed me to all of the aspects associated with testing in the TVC Test Laboratory. From the procedure, LabVIEW code, work order, to making graphs on WinPlot, I now have a better understanding of all that is involved in testing.

- Both flow simulators will be able to support core stage testing for the SLS.

- The most important lessoned learned is that a test cannot be done without exceptional people to make it happen. I feel privileged to work with such people.