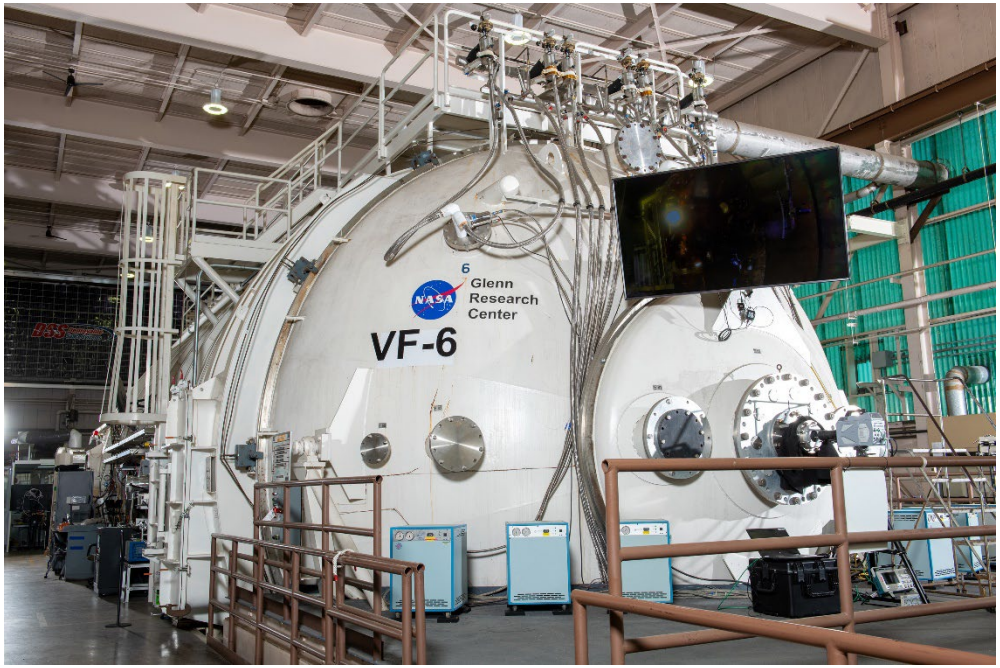
2025 AIAA WGSS PHPK PV-60 Cryogenic Valve Failure

Cody Drum (NASA GRC)

VF6 Background

- Located at NASA GRC building 301, Electric Propulsion Laboratory
- 25 ft (7.6 m) diameter, 70 ft (21.3 m) long
- Primarily used for high power electric propulsion testing



N61 Background

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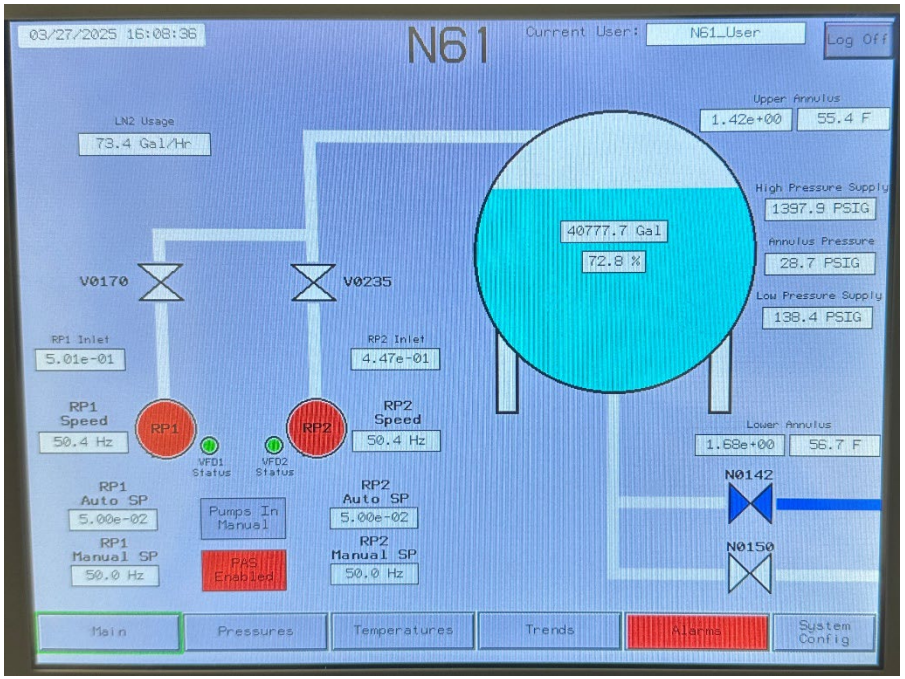


N61 Background

- CryoStar is the building source for high pressure GN2
- Takes LN2 from dewar and converts it to 1600 PSIG GN2
- Excess LN2 is dumped back into the dewar

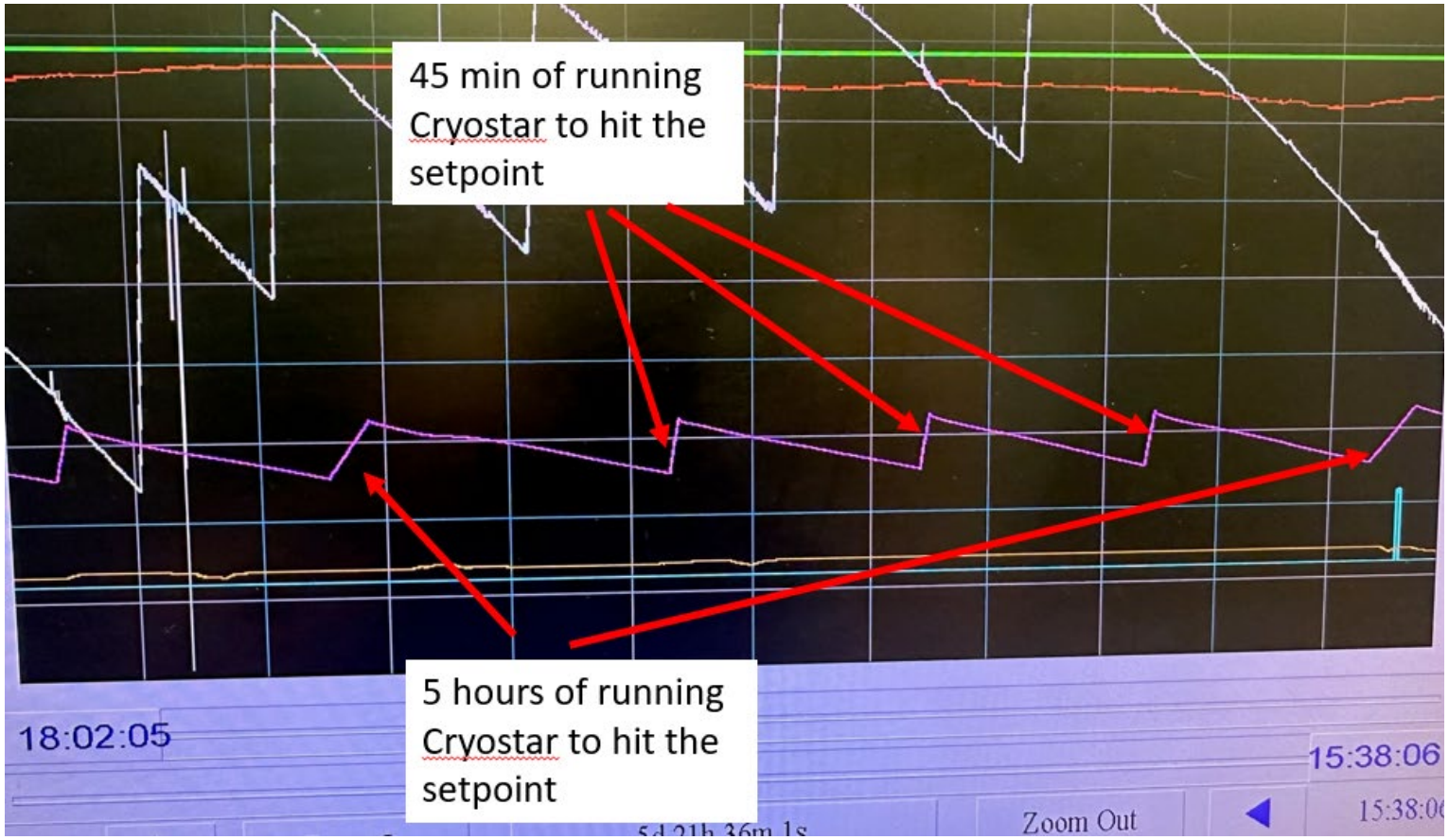
N61 Background

- PHPK PV-60 Cryogenic Globe valves
- Used to isolate the dewar from various systems
- 12 of these valves are installed at our building and were installed in the early 2010s

Early Problems

- Issues were first identified when the annulus pressure in our dewar began to increase without apparent cause
  - The annulus pressure would go from our normal base pressure of 10^-2 Torr up to about 10 Torr intermittently
  - We thought that because the dewar was so old that a leak had formed somewhere, but after extensive leak checking no leak was found
- Later that week, I saw the pressure starting to climb and ran down to the LN2 system to see what was causing it
  - This is when I noticed that the CryoStar was running

Early Problems



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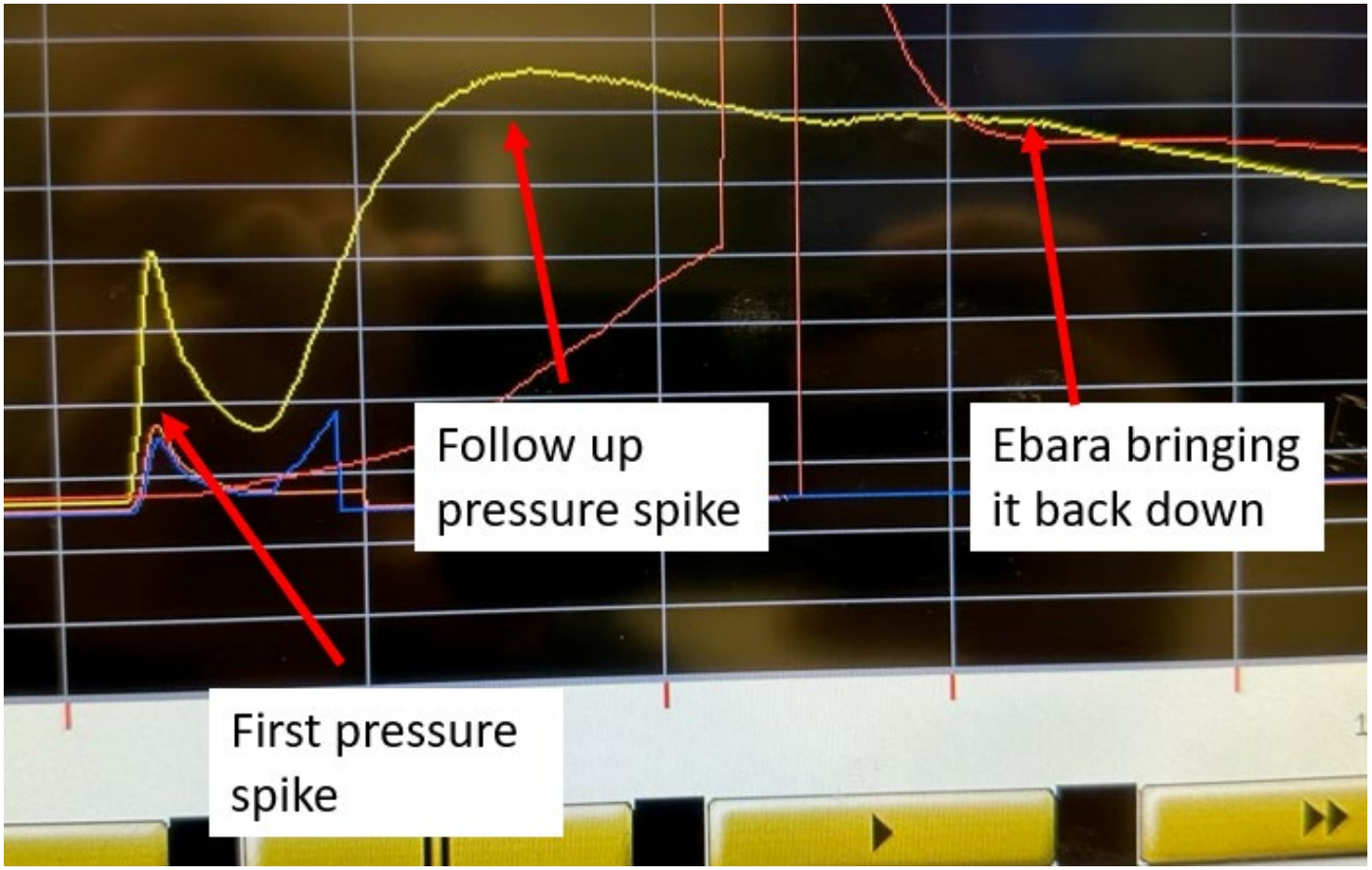

CryoStar Work

- With the longer build up times, we rebuilt the whole CryoStar
  - No Fix
- Checked for high pressure nitrogen leaks
  - No Fix
- Finally during a long run time we noticed that the CryoStar had strange timing sounding like cavitation

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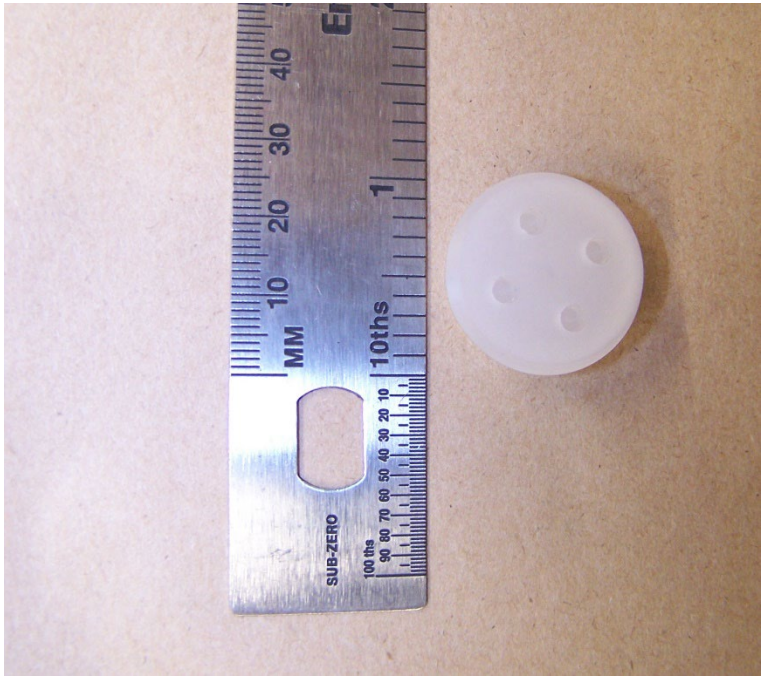
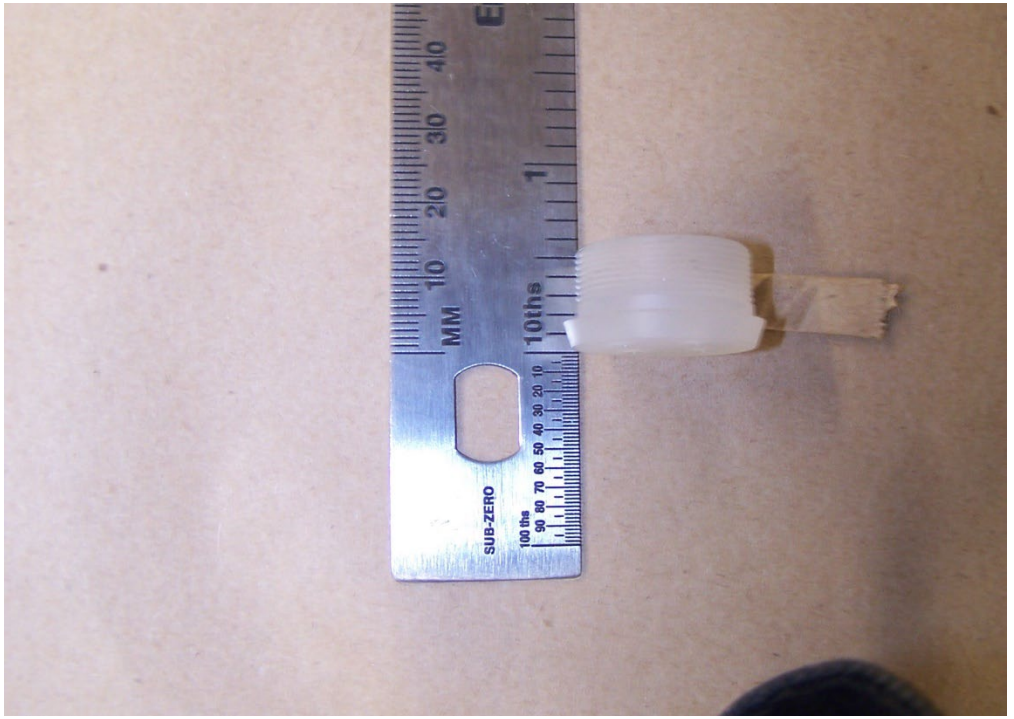
Broken Valve

- Near this same time Building 77, lost LN2 mid test for unexplained reasons
  - We put a borescope down the line and found a strange blockage





Broken Valve

- It was found that this was the Kel-F seats that are in the PHPK PV-60 valves
- At building 77, 5 of these seats were found broken off in the LN2 system and had jammed themselves in the pipe blocking all flow

Broken Valve

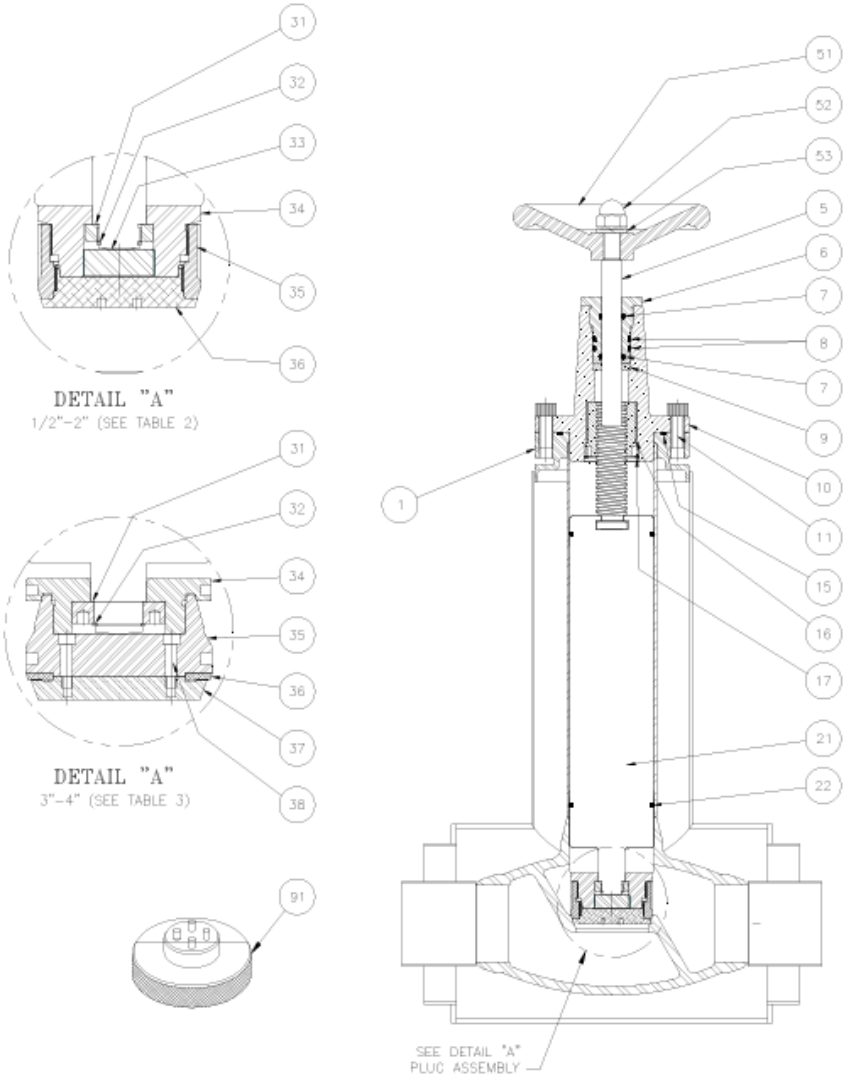
- At building 301, a borescope was used on our system to check the same valves
- It was found that all 12 PHPK PV-60 valves had seats broken off in our system
- With some seats that were found in the line to the CryoStar as well as some that are still missing in our pipes

Broken Valve

- In the CryoStar line, the seat had gotten jammed between the valve and our relief valve causing excessively high pressure in our line
- The seat was ejected from the line at high speed and cracked the Kel-F seat on impact

Broken Seat Photos

Valve Assembly



Risks Of Failure

- Lack of LN2 flow to facilities where this seat has wedged itself
- High pressure in LN2 lines where the seat has blocked the relief valve
- Failure of equipment reliant on LN2 such as the CryoStar
- Damage to LN2 Dewars
  - It was found that the annulus pressure spikes were because the high pressure GN2 from a blocked relief valve caused a crack to form in the CryoStar return line. This will need to be repaired in our next LN2 shutdown

Proposed Solution

- Use a borescope to identify and remove all broken seats
- Replace the innards of your valve with the PHPK PV-70 which has this seat captured and cannot break off in your system

Questions

For more information or follow-up

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