ISS ECLS System Overview of Events 2023

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THC: Node 3 Common Cabin Air Assembly (CCAA) Troubleshooting

- The Heat Exchanger (HX) and Water Separator (WS) are critical components of the CCAA. The HX cools and dehumidifies the air, and the WS collects the condensate.
- Node 3 CHX started experiencing Liquid Sensor indications with increasing frequency, which is typically a sign of a degraded HX. After R&R, liquid indications continued.
- Node 3 Water Separator (WS) ORU was then R&R'd, stopping the HX wet indications. The WS had an increase in condensate pressure over a period of time, which was initially mistaken as a sensor drift. This likely led to a reduction of suction in the WS system.
- The team was concerned that the WS may have been contributing to the Node 3 HX carryovers prior to the HX R&R. Therefore, a wettability test was performed on-orbit on the removed Node 3 HX. The wettability test confirmed that the HX had enough hydrophilic properties needed to retain water.
- The unit removed from Node 3 was then installed in the Airlock, which had a degraded HX and had not been replaced since the beginning of A/L operations in 2001. This was accomplished by swapping QDs and hoses (with high torque) on-orbit, an achievement that had not been attempted before.

CCAA CHX ORU

THC: LAB1P6 CCAA WS Liquid Check Valve (LCV) R&R and BIT Test

- The WS ORU's task is to pull the water from the fins of the HX and transport it to the Water Bus by means of the elevated water pressure provided by the WS Impeller. This elevated pressure is controlled by a spring check valve called the LCV, located at the interface between the WS and its internal Bus Line.

- For various reasons, the operation of this poppet valve and spring inside the LCV can be compromised so that the LCV becomes either stuck closed or open, historically causing earlier than-expected R&Rs.

- One such occurrence, when the LCV became stuck open, happened at the end of 2022 on the LAB1P6 WS. Therefore, the LAB1P6 WS LCV was R&R'd in August 2023 and the LAB1P6 CCAA reassumed control over temperature and humidity in Lab. The first analysis of water pressure in the LAB1P6 WS confirmed that the LCV R&R was successful, and the LCV also passed a visual check for the signs of leak or moisture.

- However, the new valve failed the BIT test. There could be an internal leak in the LCV between the valve diaphragm/plunger interface. Further analysis and discussion of the data is needed to understand if this is a nominal internal leak, and data analysis of a dry cycle on the WS is also needed to understand the condition of the LAB1P6 WS LCV. In the end, though, while the newly-installed LCV did fail the pressure check, the internal pressure readings do appear nominal during operation, proving that the LCV can be R&R'd on-orbit.

THC: Charcoal-HEPA Integrated Particle Scrubber (CHIPS) R&R and HEPA Life Extension

- In 2019, 21 CHIPS Filters were installed throughout the USOS, replacing the preexisting Bacteria Filters in each location. CHIPS improved upon the Bacteria Filter design by adding a Charcoal Filter to pull volatiles out of the air that are harmful to Temperature and Humidity Control (THC) and Water systems.
- The initial life expectancy for the CHIPS Charcoal Filters was 3 – 5 years and was 2 – 5 years for the CHIPS HEPA Filters, depending on location. The HEPA Filter life was then extended to 3.5 – 5 years based on data trending and results from on-orbit filter inspections.
- The health of the Charcoal Filters is monitored by dimethylsilanediol (DMSD) levels measured in the potable water and total organic carbon (TOC) breakthroughs in the Multifiltration (MF) Bed. The health of HEPA Filters is monitored through CCAA/Cabin Fan pressure differentials.

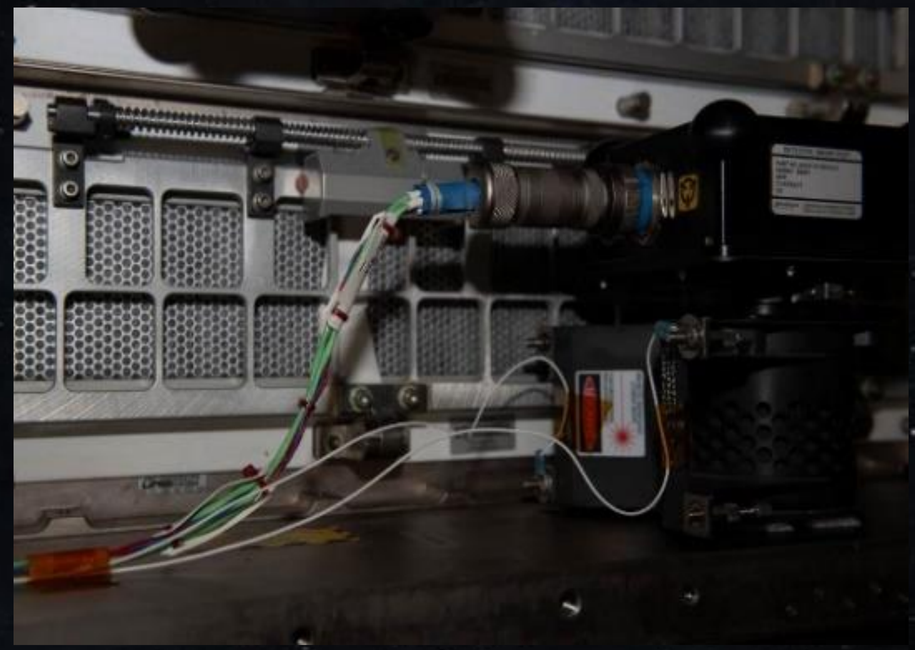
- In August 2023, the Charcoal Filters across Station and the Node 3 HEPA Filters were R&R'd due to trends in on-orbit data. The rest of the HEPA Filters across the USOS were inspected and cleaned.
- Based on this set of inspections and continued ORU Inlet Fan pressure differential trending, the lives of the HEPA Filters will be extended to be 5 years in every module.
- 6 Charcoal Filters and 1 HEPA Filter were returned on SpX-29 to be analyzed for loading patterns and changes in performance following long-term continuous use, DMSD formation, and to complement efforts to determine the per-person particulate emission rates with data from the Airborne Particulate Monitor (APM) payload.

THC: Node 2 Area Smoke Detector (ASD) 2 Grounding Wire R&R and Reconfiguration

- In mid-2021, while relocating the Node 2 ASDs, crew was unable to find the required number of 20/22ga Ring Terminals to fabricate grounding wires for Node 2 ASD 2.

- Until more terminals could be flown, 10/12ga Ring Terminals were used because they could fit over the ASD fasteners. To ensure crew safety against potentially high levels of voltage, routine inspections of the wires were scheduled to ensure the grounding wires still fully grounded the ASD to ISS structure until the proper terminals could be flown.

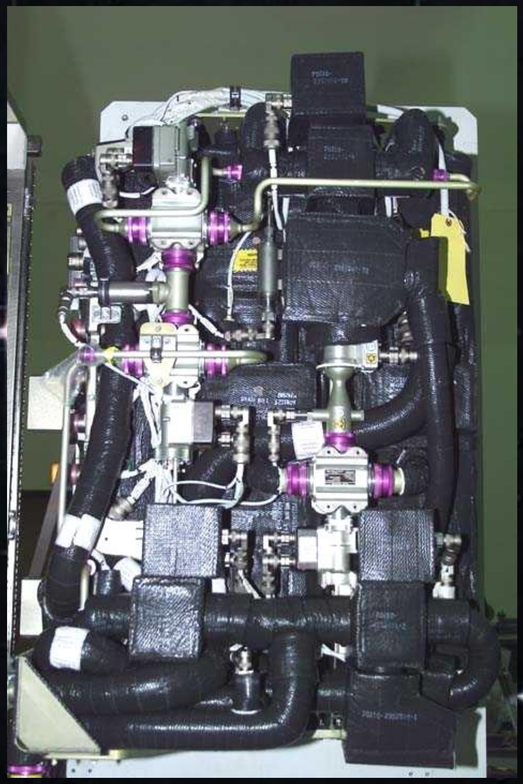
- Once the terminals arrived to ISS, new grounding wires were fabricated, installed, and went through several rounds of reconfigurations from late 2022 to mid-2023 before the configuration was finally deemed safe by the ECLSS and Power Systems teams.



AR: Carbon Dioxide Removal Assembly (CDRA) Status

- Air Selector Valve (ASV) 103 in the Lab CDRA failed which feeds directly into the blower resulting in a failure of the blower.
  - The ASV and blower were subsequently replaced and Lab CDRA functionality was recovered.
  - As part of the blower replacement, a used Four Bed CO2 (FBCO2) blower was used but it failed to start when installed in the Lab CDRA and connected to a Honeywell motor controller.
    - The cause was a difference in functionality (functional in FBCO2 but not in CDRA) likely due to Hall Effect sensor damage incurred during a ground testing event.
  - A second blower replacement was performed using an unused spare blower from an existing on orbit blower/precooler ORU, which did successfully recover the Lab CDRA operation.

- System differential pressure has shown a marked increase in both CDRA units during 2023 which is indicative of a bed cleaning being needed
  - Lab CDRA has significantly more run time recently than the Node 3 CDRA.



CDRA

AR: Major Constituent Analyzer (MCA) Status

Node 3 MCA

- Primary and sole operating MCA during 2023.
- At the end of 2022, received Error Code 63: ‘Plugged Line Pump Failure’
  - Troubleshooting attempts determined that the error was most likely due to a partial blockage in the Sample Distribution Assembly (ORU 06). This activity remains in work but the MCA is still functional.

US Lab MCA

- Failed in late 2022 due to a filament failure in ORU 02 and was R&R’d in June
  - Upon activation, there was various error codes that made the MCA unusable.
  - Troubleshooting determined that there was an intermittent connection of the Interface CCA in the electronics assembly. The Interface CCA is responsible for communications between ORU 01 and ORU 02 and for the communications internal to ORU 02.
- In January, this year, the CCA cards were reseated and two of the CCA cards were found to be loose.
- Lab MCA is currently operational again.

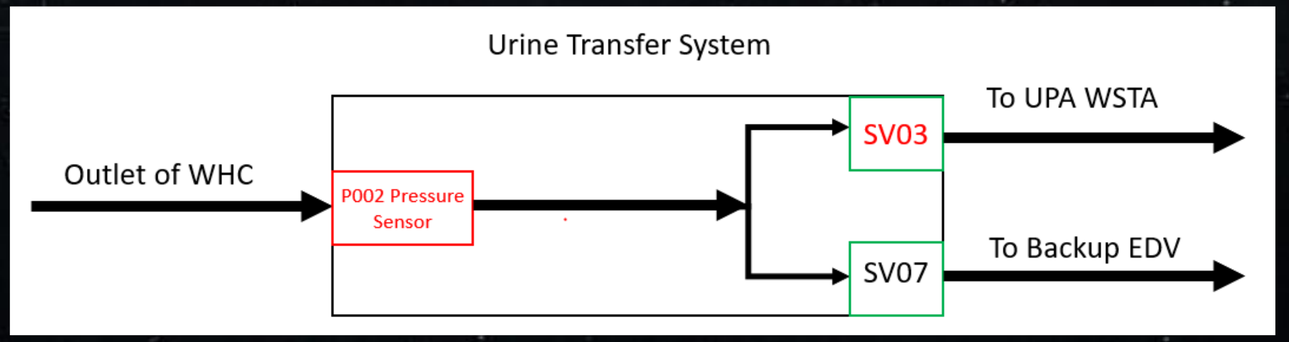
MCA Interface CCA

AR: Trace Contaminant Control System (TCCS) Status

- Lab TCCS failed with a “Lab TCCS Loss of Function on Startup” error during the warmup phase follo activation after a Lab CDRA Blower and valve R&R.
  - Troubleshooting steps have not gained any additional insight to the root cause of the error which is suspected to be either the Electrical Interface Assembly (EIA) or Blower
  - The last startup of Lab TCCS did not have a second recurrence of the error and continues to operate nominally.
- Investigation of the faults is ongoing until more data can be collected.
- Node 3 TCCS is operating nominally

WRM: Urine Transfer System (UTS) Solenoid Valve Cycling Issue

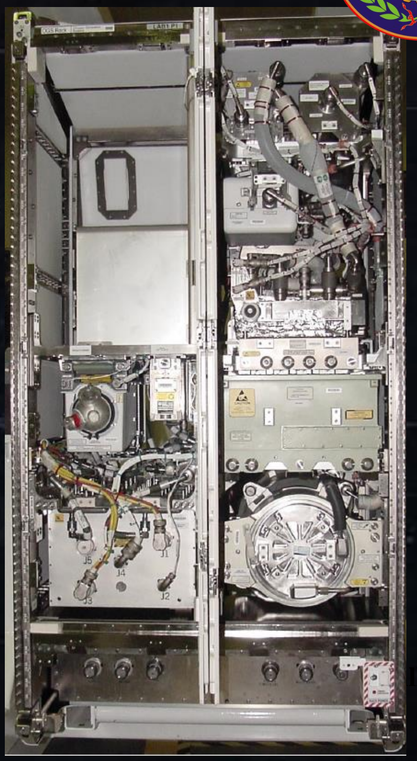
- In January 2023, UTS saw pressure responses through the P002 pressure sensor when WHC is not in use
- The P002 is located in the flow path of WHC and will only detect pressures from WHC
- Nominal response from UTS when the P002 detects a pressure higher than 0.02 psig is to open Solenoid Valve 03 (SV03) which will open the path (from WHC) to the Urine Processor Assembly Wastewater Storage Tank Assembly
- Telemetry showed during offloading of EDVs through UTS, the pressure on the P002 showed responses when it was not nominally expected and the UTS controller responded by opening SV03
- Review of telemetry, showed no WHC uses were performed. This was an indication that SV03 was open when it should be in the close position, but it could be cracked open a minimal amount for the P002 to detect pressure from other sources
- Since the pressure responses from the offloads were small, the solution was to increase the pressure detection limit of 0.03 psig and no reports of any false WHC use has been observed since the change was implemented

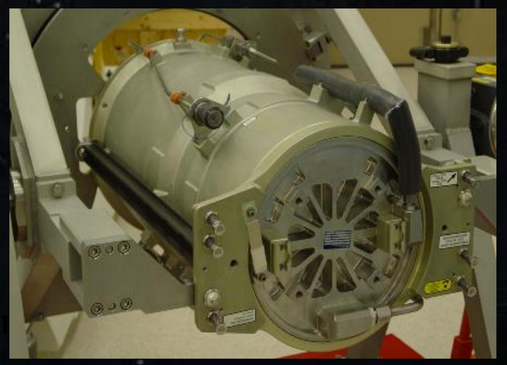


ACS: Oxygen Generator Assembly (OGA) Status

Statistics

- The Oxygen Generation System (OGS) rack was launched July 2006 on STS-121/ULF1.1, activated in U.S. Lab in July 2007, moved to Node 3 in 2010 and relocated back to U.S. Lab in September 2022 to enable co-location of Exploration demo air string systems
- OGA in Process mode at 100% oxygen production rate produces 20.4 lbm O_2 per day (~10.88 U.S. crew average metabolic use) and is commandable from 22 to 100% in 1% increments in Process mode
- As of June 3, 2024, OGA accumulated 13.95 years of run time with an average O_2 production rate of ~5.78 lbm /day (~ 3.08 crew) and has produced approximately 29,422 lbm of O_2 and 3,678 lbm of H_2



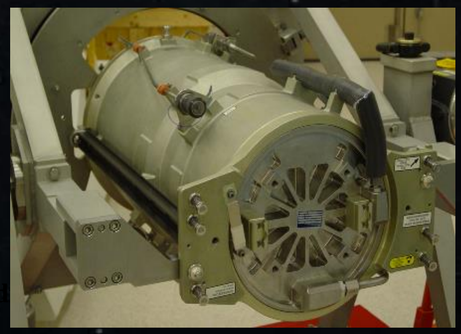


ACS: Oxygen Generator Assembly (OGA) Status

Update (2023)

- TT&E and failure investigation of two failed Pump ORUs (SNs 3 & 5) determined gear lockups were due to precipitation of nickel phosphate caused by wetted QD internal electroless nickel coating degradation
  - Refurbished ORUs have no electroless nickel coatings on QD internal wetted surfaces (SN3 launched SpX-30)
  - In May 2023 crew installed SN2 into OGA to maintain ORU viability since susceptible to gear lockup (old QDs)
- Oct 2021 installed S/N 4 H2 Dome ORU continues to exhibit anomalous hydrogen Back Pressure Regulator (BPR) performance causing low and erratic recirculation loop pressure after transitioning into Standby. Software override is maintained for reducing low pressure shutdown limit to 19 psia (default 20.5 psia) to enable OGA operation
  - TT&E of SN3 H2 ORU's anomalous BPR determined poor passivation and corrosion of the tightly toleranced poppet shaft and guide was the root cause of erratic pressure regulation.
  - Future builds of BPRs will incorporate improved passivation methods into BPR components to mitigate corrosion
- H2 ORU SN 3 was returned to the ground in Jan 2022 due to Cell 1's declining voltage in Standby, indicating possible membrane thinning and a partial short. Program has deferred cell stack failure investigation given this is a known end of life signature and is identical to SN2 H2 ORU cell stack failure
- - Team is closely monitoring SN4 H2 ORU's individual cell voltages while in Standby and during OGA activations / deactivations to identify any early cell failure signatures due to membrane thinning and material loss due to electrolysis given cell stack has been under compression for over 13 years

Oc



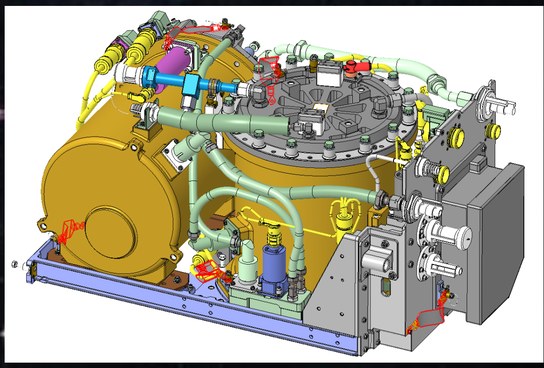
Hyd

ACS: Advanced Oxygen Generator Assembly (AOGA) Status

Overview

- AOGA will be reusing most of the hardware that is in the OGA system but will be replacing the OGA Hydrogen Dome ORU with the AOGA maintainable Oxygen Hydrogen Domes Assembly (OHDA).
- OHDA has two independent domes that crew can remove and replace the cell stack, Rotary Separator Accumulator (RSA) and other components to enable significant reductions in spares mass and volume.
- OHDA H2 Dome Assembly has a new Cell Stack Assembly (28 cells) design that includes better mechanical support for the chemically stabilized PEM cell membranes to mitigate cell thinning and ensuring a 5 year life.
- OHDA includes a crew accessible QD tee for periodic, manual recirculation loop nitrogen purging to minimize H2 and subsequent water flushing into a CWC-I bag to minimize loop concentrating contaminants. This loop purge and water flush maintenance will be employed prior and subsequent to exploration dormancy periods of up to 1 year.
- AOGA ReMediation, Advanced DeIonization and Limited Life Optimization (ARMADILLO) will replace the recirculation loop's ACTEX ion-exchange mixed resin bed. ARMADILLO has five times the resin volume, 3 year operational life versus 1.85 years for ACTEX), a 10 psid pressure drop reduction, 40 micron absolute depth filter (versus 149 micron flat screens in ACTEX), has dual independent seals, meets MDP and has better materials H2 compatibility compared to the OGA loop ACTEX.

OGS rack with AOGA OHDA installed



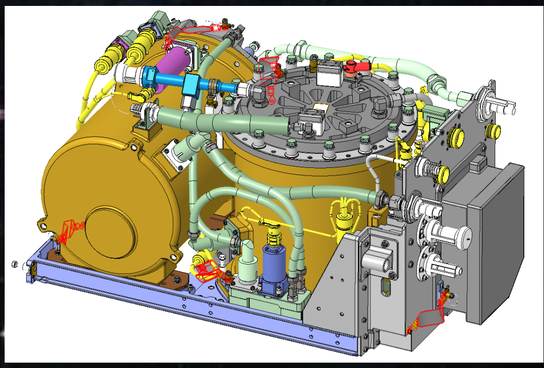
AOGA OHDA

ACS: Advanced Oxygen Generator Assembly (AOGA) Status

Overview (Continued)

- For ISS demonstration (2025 to end of ISS), the AOGA is controlled by the existing OGA Process Controller with its original software and firmware. Commanded software overrides will be utilized for unique AOGA system operation parameters and fault limits.
- AOGA completed CDR in Nov 2022 and in Feb 2023 completed an AOGA Phase 2 safety review of both AOGS Integrated Hazard Reports and Maintenance Hazard Analyses. A delta-CDR was completed in July 2023 for the AOGA dormancy manual recirculation loop N2 purge and water flush hardware.
- The OGS rack will be modified to include a 9 inch bumpout assembly attached to rack by Velcro straps replacing the left side closeout door on the rack to allow more volume for an expanded Sabatier 2.0 design for better maintainability and new CO2 accumulator tanks.
- A new AAA inlet port with an integral screen is located on the aft side of the bumpout with a larger diameter to compensate for additional length and bend of passageway to the legacy muffler filter block.
- New replacement H2/N2 Vent Hose and Waste Water Hose Assemblies with contingency tee QDs for alternate venting and scarring for potential future flushing of the OGA recirculation loop water to the waste bus (instead of to a CWC-I) will be installed within the LAB1P1 standoff volume.

OGS rack with AOGA OHDA installed



AOGA OHDA

Questions?