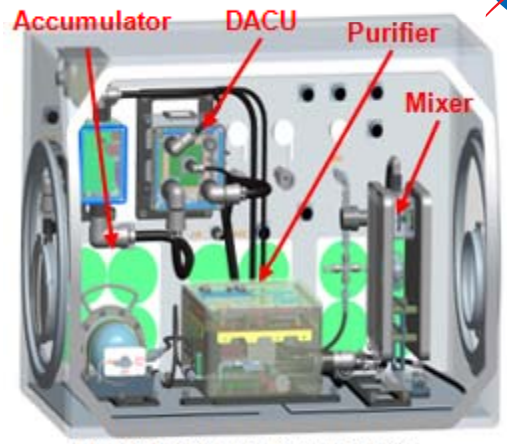
IVGEN

The Exploration Medical Capabilities Element of NASA's Human Research Program chartered the IV fluid GENeration (IVGEN) project at the NASA Glenn Research Center to develop a system that could produce IV fluid in a microgravity environment meeting USP standards.



IVGEN Hardware Components


Flight Engineer TJ Creamer with MSG and IVGEN onboard the ISS

Background:

NASA's flight surgeons have identified medical conditions likely to arise during exploration missions of various length and distance from the earth. Adequately treating some of those conditions will require the ability to utilize Intravenous (IV) therapy to either serve as a method for delivering pharmaceuticals that can only be administered via that route, or to hydrate patients that are unable to hydrate themselves. Given that need, NASA currently maintains a reserve of IV fluid on ISS sufficient to treat an astronaut until they can be returned to earth, which is generally within 24 hours. Because such a rapid return will not be an option for missions extending beyond low earth orbit, NASA must either fly as many as 100 liters of IV fluid, with a total mass of 100 Kg, or provide systems that can use vehicle resources to produce such fluid if it is needed. The IVGEN hardware, a compact water purification and mixing system, was designed to produce United States Pharmacopeia (USP) grade IV fluid in a reduced gravity environment using available resources.

IVGEN Development and ISS Experiment:

Trade studies were conducted at the Glenn Research Center (GRC) to identify the appropriate purifying and mixing technologies that could produce USP grade IV fluid. In conjunction with purifying and mixing, the team identified portions of the process that could be negatively impacted by microgravity, and designed hardware that was functionally independent of gravity. This hardware utilized a cartridge containing deionizing resin and air removal and sterilizing filters to purify water supplied by the ISS Water Processing Assembly (WPA). The main components of the IVGEN hardware were: a Data Acquisition and Control Unit (DACU), an accumulator, a purifier, and a mixer.

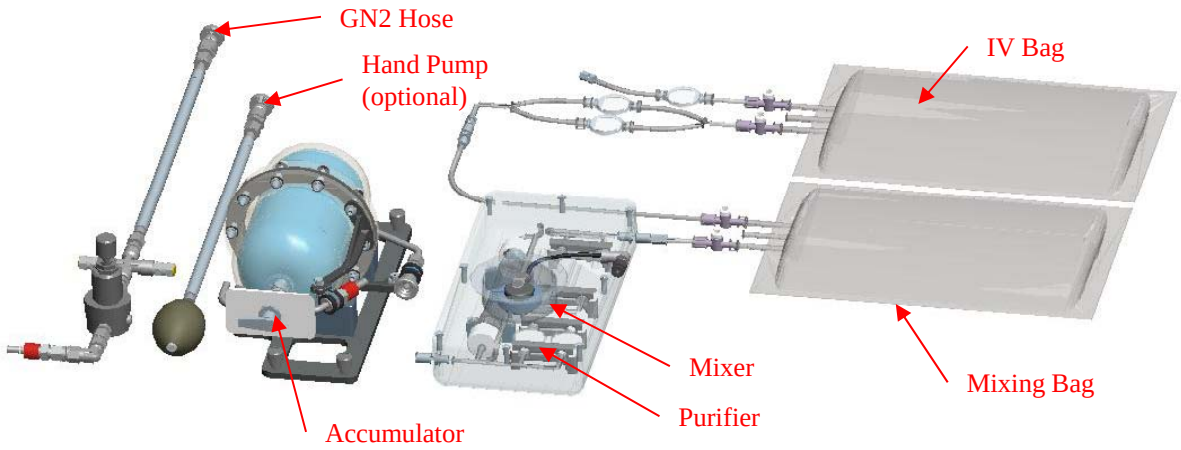
IVGEN experimental operations involved first filling the IVGEN accumulator from the pressurized potable water source onboard the ISS. Once filled, the accumulator was connected to the purifier and pressurized. The pressure forced water through the IVGEN purifier, which housed multiple filters and diagnostic instruments, and then into the saline bag. The saline bag contained a premeasured amount of salt to make a 0.9% sodium chloride solution, as well as a magnetic stir bar. After the bag was filled, the stir bar mixed the solution. Purified water was fed into bags containing a magnetic stir bar and a predetermined

amount of salt and was mixed for several minutes before being transferred through a sterilizing filter into sterile bags. Several diagnostic measurements were incorporated into the hardware including a flow meter, pressure transducers and conductivity sensors to quantify on-orbit performance.

Several batches of IV fluid were generated and submitted to USP certified laboratories for analysis to verify that the design did produce IV quality solutions. The IVGEN experimental hardware was flown and tested onboard the International Space Station (ISS) in May 2010. For the experiment, multiple diagnostic sensors quantified the feedstock water quality, output water purity, mixing uniformity, temperature and flowrate. The hardware operated inside the Microgravity Science Glovebox (MSG) facility and consumed nearly all of the MSG's nine cubic feet internal volume with cameras, power and data cables, a data acquisition system, power converter, and the fluid generation and mixing systems.

Recommendations for Operational IVGEN System:

For a deployed system, the design concept would be greatly simplified, as the experimental diagnostic sensors, data cables, and data acquisition system are not needed. Like the experimental system, the exploration system would consist of an accumulator, a pressure hose, a water purification assembly, a mixer, and IV bags. The major difference between the two systems is in the design of the water purification assembly. The purification assembly could be reduced to approximately 17% of the original volume and 10% of the original mass, while maintaining the purifying capacity seen in the flight experiment. The deployed hardware design concept is shown below. Additional recommendations, based on the flight experiment, for an operational system were also determined as part of the IVGEN effort. These plans call for the incorporation of air-water separator to prevent air bubbles from infiltrating into a dry system during initial wetting and a different method to verify the amount of salt crystals preloaded into the mixing bags. An activated carbon filter may also be necessary for an operational system depending on the system's feed water source. The ISS currently utilizes an activated carbon filter in the water processing assembly, but deployed systems may not have the benefit of pretreatment of the water with this feature. Consequently, integrating an activated carbon filter to provide additional filtration against complex organic molecules is recommended. Plans are also underway for post-flight analysis of the returned experimental hardware and lifetime testing.



For more information, visit the NASA Glenn Exploration Systems Web site at
http://spaceflightsystems.grc.nasa.gov/Advanced/HumanResearch/Medical/

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