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In-Line Filtration Improves Hygiene and Reduces Expense

Originating Technology/NASA Contribution

Water, essential to sustaining life on Earth, is that much more highly prized in the unforgiving realm of space travel and habitation. Given a launch cost of $10,000 per pound for space shuttle cargo, however, each gallon of water at 8.33 pounds quickly makes Chanel No. 5 a bargain at $25,000 per gallon. Likewise, ample water reserves for drinking, food preparation, and bathing would take up an inordinate amount of storage space and infrastructure, which is always at a premium on a vessel or station.

Water rationing and recycling are thus an essential part of daily life and operations on the space shuttles and International Space Station (ISS). In orbit, where Earth's natural life support system is missing, the ISS itself has to provide abundant power, clean water, and breathable air at the right temperature and humidity for the duration of human habitation and with virtually no waste. The Environmental Control and Life Support System (ECLSS), under continuing developmet at the Marshall Space Flight Center, helps astronauts use and reuse their precious supplies of water. Future work will explore air management, thermal control, and fire suppression—in short, all of the things that will make human habitation in space comfortable and safe.

The ECLSS Water Recycling System (WRS), developed at Marshall, reclaims wastewaters from humans and lab animals in the form of breath condensate, urine, hygiene and washing, and other wastewater streams. On Earth, biological wastewater is physically filtered by granular soil and purified as microbes in the soil break down urea, converting it to a form that plants can absorb and use to build new tissue. Wastewater also evaporates and returns as fresh rain water—a natural form of distillation. WRS water purification machines on the ISS mimic these processes, though without microbes or the scale of these processes.

The DentaPure waterline purification cartridge sees use in 40 percent of dental schools in the United States and is lauded for offering remarkable filtration and significant cost savings.

Partnership

Umpqua Research Company, of Myrtle Creek, Oregon, supplier of the bacterial filters used in the life support backpacks worn by space-walking astronauts, received a number of **Small Business Innovation Research (SBIR)** contracts from the Johnson Space Center to develop air and water purification technologies for human missions in space. A natural choice for water purification research, Umpqua has also provided the only space-certified and approved-for-flight water purification system, which has flown on all shuttle missions since 1990.

To prevent back-contamination of a drinking water supply by microorganisms, Umpqua developed the microbial check valve, consisting of a flow-through cartridge containing iodinated ion exchange resin. In addition to the microbial contact kill, the resin was found to impart a biocidal residual elemental iodine concentration to the water. Umpqua's valve and resin system was adopted by NASA as the preferred means of disinfecting drinking

water aboard U.S. spacecraft, and canisters are now used on space shuttle missions, the ISS, and for ground-based testing of closed life support technology. Iodine was selected by NASA as the disinfectant of choice because of its lower vapor pressure and reduced propensity for formation of disinfection byproducts compared to chlorine or bromine.

Product Outcome

MRLB International Inc., of Fergus Falls, Minnesota, used Umpqua's water purification technology in the design of the DentaPure waterline purification cartridge (*Spinoff* 1998). The cartridge incorporated a resin technology developed by private sector commercialization of Umpqua's system developed under NASA contract. NASA "was an excellent resource," stated Barry Hammarback, president and CEO of MRLB, "and greatly assisted our transition of the iodinated resin technology to the dental industry." DentaPure was designed to clean and decontaminate water as a link between filter and high-speed dental tools and other instruments, and offers easy installation on all modern dental unit waterlines with weekly replacement cycles. The product, like its NASA forebear, furnished disinfected water and maintained water purity even with "suckback," an effect caused by imperfect anti-retraction valves in dental instruments, which draws blood, saliva, and other materials from a patient's mouth into the waterline.

Since its appearance in *Spinoff* 1998, MRLB has continued to use the research conducted by Umpqua to further develop and refine its DentaPure in-line filters. Various models now address a variety of needs, and are used in dental offices and schools across the country. MRLB has paid particular attention to extending the life in lower water usage units—products that before touted a service/replacement interval of 7 days now require changing once every 40 to 365 days. In addition, DentaPure offers remarkable filtration: registered to provide 200 CFU/ml purity (Colony Forming Unit/milliliter, a standard measure of microbial concentration)—the Centers for Disease Control and Prevention (CDC) standard is 500 CFU, and untreated lines can harbor in excess of 1,000,000 CFU/ml.

Long service intervals of up to a year and ease of installation make the DentaPure cartridge particularly user-friendly.

Continued evolution and improvement has led to many unique certifications and commendations for DentaPure. Currently, the only waterline system recognized by the U.S. Food and Drug Administration (FDA) as a medical device which meets all known standards, and by the U.S. Environmental Protection Agency (EPA) as an antimicrobial device, DentaPure has also been tested and utilized by the U.S. Air Force and dental schools in the United States and Europe, and was recognized by Clinical Research Associates as "Outstanding Product 2005."

Better filtration, greater capacity, and longer service intervals have also led to great savings—the University of Maryland Dental School estimates it saves $274,000 per year courtesy of DentaPure. The DentaPure system has proven so effective that 40 percent of dental schools nationwide employ it. Dr. Louis DePaola of the University of Maryland affirms, "The biggest benefit is that we have a system that is efficacious and user-friendly, in that it allows us to consistently deliver water that meets or exceeds CDC standards with a minimum of staff interaction—attach the unit and except for periodic monitoring you don't have to do anything for a year. It's very cost-effective—for a large institution like ours with an excess of 300 units, a daily or weekly treatment is not practical."

DentaPure is currently the number one product for constant chemical treatment applications in dentistry, and was the first treatment to meet CFU standards without interim cleaning protocols—the primary means by which it saves money. Turning to the future, Hammarback sees DentaPure "looking at remote site water purification for continuous use, providing yet longer lasting devices, and increasing product recycling." Ten years after *Spinoff* first profiled the many benefits of this technology it is utilized every day in myriad dental offices, schools, and labs, saving hundreds of thousands of dollars a year for users such as the University of Maryland. The investment in water filtration for space missions continues to pay huge dividends to users and society, year after year, in technologies so woven into our lives that we use them without even thinking about them. ❖

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