Water Security in Space and on Earth

Quality Assurance by Conductivity Measurements

As with any drinking water, quality is a major concern, particularly when the water in question has been recycled. This is an issue of particular interest in space, where ISS crew members would have to deal with any contaminated water-induced illness far from the nearest medical personnel and facilities. The WPA employs sensors that monitor water quality by measuring its conductivity.

Introduction

Resourcefulness is a key quality for living in space and on the International Space Station (ISS) that means making the most of water supplies. In 2008, the installation of the Water Processing Assembly (WPA) onboard the ISS allowed the space station's crew to optimize their resources. The WPA purifies moisture from nearly every possible source, including sweat, water vapor, wastewater and even urine, for drinking water and oxygen generation. Capable of producing 35 gallons of potable, recycled water a day, the system has reduced the need for water delivered to the ISS by over 1,000 gallons a year, saving significant payload costs in the process.

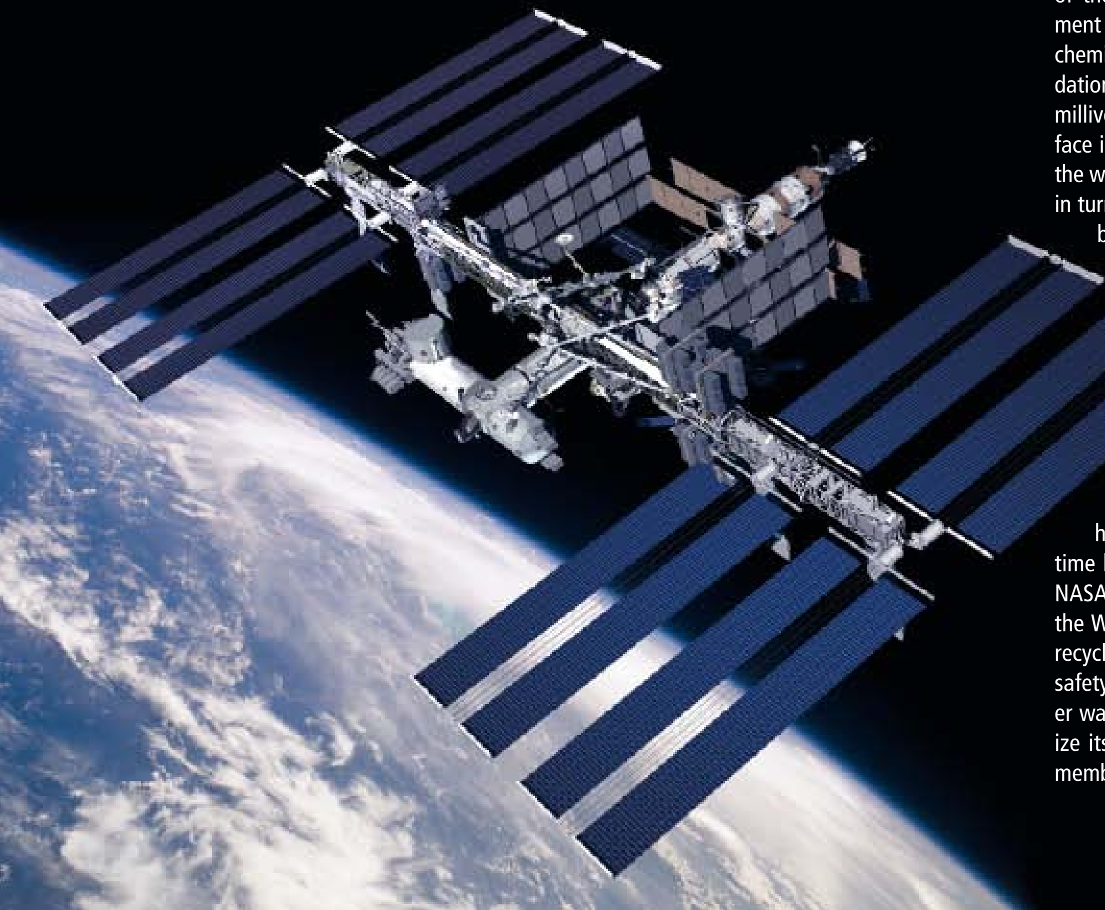
Rounding out the system's quality assurance methods is a device developed for NASA by a private industry partner. That company has now made the technology available for ensuring the purity of water for consumption and industrial uses on Earth.

Breakthrough Technology

Known as a total organic carbon analyzer (TOCA), the new device measures organic carbon levels in water. Carbon is a key indicator of water quality as it is present in the most dangerous contaminants. Prior to the installation of the WPA, the ISS had a commercial TOCA onboard, but that technology did not fully satisfy NASA's requirements. To develop a better solution to ensure the potability of the WPA's recycled water, NASA contracted the Xylem brand O.I. Analytical of College Station, Texas, in 2006. The company had proposed an advanced TOCA device that would provide fast and effective monitoring of TOC levels while eliminating aspects of the technology that made it impractical for space applications.

The resulting Proto-flight Unit, or PFU1, proved to be the breakthrough system NASA needed to fully enable the WPA. Detection of TOC in water requires an oxidation process that standard TOCA instrumentation perform using either expensive and hazardous chemicals or through high temperature combustion. Neither of these methods are feasible for an environment like that of the ISS. In response, an electrochemical solution was developed to create oxidation using the water itself. By applying millivolts of electricity to a specially coated surface inside the analyzer, the TOCA breaks down the water sample, forming hydroxyl radicals that in turn break down any organic carbon into carbon dioxide and water. The analyzer's infrared detector then measures the concentration of carbon dioxide to provide an accurate assessment of the water's carbon content.

The company already had research underway on the electrochemical oxidation technique for use in a TOC analyzer. This head start allowed to compress the project time line for delivery of the prototype TOCA to NASA. This in turn allowed NASA to implement the WPA ahead of schedule. With the system's recycling capabilities and now fully redundant safety measures, the ISS not only required fewer water deliveries, but it was also able to realize its full crew capacity increasing from three members to six.



Benefits for Commercial Applications

Where large amounts of water are used, from the cleanest to the most contaminated, the need to measure organic carbon exists. Unfortunately, the cost-prohibitive nature of traditional TOC measurement technology has prevented it from being implemented in a number of commercial applications. In line with this challenge, the new technology was quickly recognized for its potential as a commercial solution for terrestrial use.

The most significant cost incurred when using standard TOCA technology originates from the chemicals needed to support it. The electrochemical process of the new technology is reagent-free, thus eliminating the need for expensive chemicals, saving as much as $500 per month. This is a significant advantage for industrial users who often have tens to hundreds of units installed in their plants.

For combustion oxidation-based analyzers, expensive infrastructure is often unavoidable, particularly in chemical plants and petrochemical refineries where cooled, explosion-proof housing is required, incurring costs as high as $300,000 to $500,000. The latest TOCA device has a footprint roughly the size of an 11-by-7-inch piece of paper, which is much smaller than the size of conventional units that typically are as big as a small refrigerator. As a result of its small footprint, the instrument can be installed at a cost as much as 90 % lower than traditional TOCA systems. The day-to-day operating costs are much lower as well.

The technology's ease-of-use and low maintenance requirements also generate cost savings. One customer has reported that it used to be necessary to employ one technician for every two TOC analyzers prior to switching to the new device. Following installation of the advanced system, a single technician can operate and service 8 to 10 analyzers.

Collaboration with the US EPA

The development of the new technology has led to collaboration with the US Environmental Protection Agency (EPA) to ensure the security of the Nation's drinking water. TOC measurement is one of the parameters the EPA would like to use in a more widespread fashion in order to provide early warning, whether it is of intentional contamination or from natural events.

Conclusion

The collaboration with NASA enabled the development of an innovative technology that would otherwise have been brought to market at a much later point in time. The NASA-derived system provides a host of benefits for water quality applications, ranging from municipal waste treatment to pharmaceutical manufacturing to monitoring feed water in turbines and boiler systems. Since its initial installation, the technology continues to benefit the ISS. The follow-on to the first NASA TOCA system arrived at the ISS in 2011 on STS-133, the Space Shuttle Discovery's final flight, and an even more advanced version of the device currently awaits a future delivery.

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