

# 2019 WERC Design Contest

## TASK 1

### Silver-based Microbial Check Valve for spacecraft potable water systems

#### Background

Bacterial infections are a major concern for manned space missions. The surfaces, air and water systems are common areas where bacteria are able to grow on a spacecraft. Silver ions have long been used for water purification in space. The Russians have been using silver to disinfect their water supply on the International Space Station since its inception while, until recently, the Americans have used iodine to disinfect their drinking water. Russian technology is believed to use an electrochemical approach, but they have not shared their technology. NASA has adopted the use of colloidal silver to treat drinking water because, unlike iodine, which must be filtered from the water supply before it is consumed, silver can remain in the water supply so long as its concentration is kept below 500 parts per billion. An effective delivery system to regulate the amount of silver released into the water supply while at the same time preventing back contamination by bacteria is sought. Specifically, NASA is seeking a design for what might be described as a “microbial check valve” that is able to reliably and efficiently deliver a measured supply of ionized silver to the spacecraft water supply while keeping microbes from escaping through the check valve.

A side problem that accompanies the use of silver ion is the plating of silver on metal surfaces within the water supply system. The silver species must be kept in solution, and thus any silver injection system must address the plating problem, such as by appropriate choice of silver species to be injected, choice of counter ions that might also be injected, or another approach.

#### Problem statement

Your team must design a microbial check valve (MCV) for spacecraft potable water treatment. Your design must be easy to install and provide continuous, stable, autonomous operation. The MCV must be able to inject an appropriate silver species to control microbe levels in the spacecraft’s drinking water supply in accordance with NASA’s typical treatment specifications listed in the design requirements. The system proposed must also prevent the plating of silver metal on water supply components.

#### Design requirements

Your team will be provided with 500 L of water for dosing in the bench scale demonstration. Your team’s MCV design must conform to the following criteria:

- Add an appropriate quantity of your chosen silver species to a stream of water flowing at 0.1 to 0.15 L/min. The concentration of silver cannot exceed 500 ppb.
- No plating of silver metal on water supply components (piping, storage tanks, etc.).
- Must be able to operate at ambient temperature and pressures up to 30 psig
- Must operate at pH ranges between 4.5-9.0

- Must weigh less than or equal to 5kg
- The apparatus should be small, robust, easily maintainable, and be capable of working in microgravity.

## **Evaluation Criteria**

Each team is advised to read the Participation Guide for a comprehensive understanding of the contest evaluation criteria. Please visit the WERC website:

<https://iee.nmsu.edu/outreach/events/international-environmental-design-contest/guidelines/> for a copy of the Public Involvement Plan and Participation Guide and other important resources. Additionally, our design will be evaluated based on how well it addresses the problem statement and design conditions including:

- Safety considerations taken by your team during the demonstration and safety of the proposed commercial product
- The ability of your design to deliver add silver ions on demand to a stream of water flowing at a rate of 0.1 to 0.15 L/min
- The total concentration of silver ions in the processed water
- Ability to eliminate silver plating on the interior of the water handling system
- Innovativeness and functionality of the design
- Total weight of your design
- Ability of your system to operate in microgravity
- Maintainability and ease of use
- Overall cost of the mechanism and thoroughness of the economic analysis
- Technical fundamentals

Other specific evaluation criteria may be provided at a later date.

## **Past works**

In the mid 1960's NASA developed a copper/silver ion generator for water purification. This technology was used on the Apollo space missions [1].

A water purification company called Sensible Technologies Inc. (STI) developed a silver ion water purifier for large-scale non-potable water uses such as swimming pool cleaning and purifying water for industrial cooling applications [1].

Another company called Carefree uses copper/silver ions to replace chlorine in swimming pools and water features, such as public fountains [1].

In 2011, NASA tested silver ions as a means of disinfecting potable water they found that 0.4mg/L of silver was an effective biocide. They also found that ionic silver reduced bacterial growth on metal surfaces [2].

Silver nanoparticles have also been studied for their anti-bacterial properties. There are three possible explanations for the antimicrobial properties of silver nanoparticles [3].

1. Silver alters cell membrane structure
2. Particles penetrate the cell and cause DNA damage
3. Dissolution of silver particles releases silver ions

## References

- [1] NASA, "WATER TREATMENT SYSTEMS MAKE A BIG SPLASH," [Online]. Available: [https://spinoff.nasa.gov/Spinoff2004/er\\_1.html](https://spinoff.nasa.gov/Spinoff2004/er_1.html). [Accessed 14 May 2018].
- [2] M. Birmele, M. Roberts and L. McCoy, "Disinfection of spacecraft potable water systems by passivation with ionic silver," *41st International Conference on Environmental Systems*, p. 5278, 2011.
- [3] Q. Li, S. Mahendra, D. Y. Lyon, L. Brunet, M. V. Liga, D. Li and P. J. Alvarez, "Antimicrobial nanomaterials for water disinfection and microbial control: potential applications and implications," *Water research*, vol. 42, no. 18, pp. 4591-4602, 2008.