ABSTRACT

Naunovic, Zorana, Ph.D., Purdue University. Modeling and Design of an Ultraviolet Water Disinfection System for Long-term Space Missions. Major Professor: Ernest R. Blatchley III.

The nature of long-term space missions that involve extended stays by astronauts in locations beyond near-Earth orbit is such that complete water reuse is required. When combined with the high profile of these missions and other constraints imposed by NASA (*e.g.*, restricted use of mercury, extreme space, mass and energy limitations), this project represents a challenging design for water treatment. The proposed water recycling loop consists of a series of biological and physicochemical treatment processes, including disinfection as a component in the water cycle.

In conjunction with NASA's interests in conducting long-duration human space travel, a UV system was designed based on XeBr excimer lamp technology. XeBr excimer lamps emit nearly monochromatic radiation at a characteristic wavelength of 282 nm. Baseline experiments conducted with a XeBr excimer lamp demonstrated its germicidal UV output to be highly effective for inactivation of *Bacillus subtilis* spores.

A numerical prototype of this new reactor system was developed using a Lagrangian modeling scheme. The modeling approach involved simulation of fluid mechanics and particle trajectories using commercially available computational fluid dynamics software (FLUENT). Accurate simulations of the radiation intensity field within the reactor required the development of a new intensity field model. This new model, termed the Surface Power Apportionment for Cylindrical Excimer lamps (SPACE) radiation intensity model, was developed specifically for this purpose. The SPACE model accounts

for the geometry and emission characteristics of the XeBr excimer lamp; it also provides a detailed accounting of the effects of absorption, dissipation, reflection, and refraction within the reactor system. The final design of the reactor was produced by an iterative procedure using these modeling tools, thereby allowing for optimization of reactor characteristics. Simulations of the behavior of the numerical prototype indicated high efficiency, in terms of microbial inactivation.

The reactor system designed in this effort is being considered for inclusion in the next generation of NASA space vehicles. Reactors of this type could also be used in terrestrial applications, and may be of particular interest in applications where mercury use is restricted or undesirable.