National Aeronautics and Space Administration

Development of Planetary Protection Technologies for Potential Missions to Special Region

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Program: Strategic Initiatives

Project Objective:

The 3-year goal of our work is to develop aseptic assembly techniques and investigate biobarrier/bioshield implementation to obviate the need for subsystem and system-level dry heat microbial reduction. Our work is focused on aseptic assembly techniques and processes considering a variety of sterilization modalities; (e.g., Vapor Hydrogen Peroxide, radiation). We aim to:

1. Evaluate the effectiveness of techniques in view of hardware with complex geometries, size scale up issues, and material compatibility issues.
2. Determine targets for research augmentation of approved modalities.
3. Develop biobarrier/bioshield implementation options for recontamination prevention.
4. Evaluate biobarrier/bioshield options for use both at the subsystem and the system level.

FY16 Results:

Task 1: Performed a literature review on the cutting edge sterilization techniques of the last five years and evaluated the advancements in sterilization technologies and their applicability to spacecraft hardware (H/W). Identified γ-radiation as PP sterilization technology for further investigation.

Task 2: Designed and built a complex geometry model to simulate flight H/W for sterilization purposes; materials were chosen to be compatible with the selected sterilization modality: Vapor Hydrogen Peroxide (VHP). The complex geometry model was coupled with a modular enclosure we designed to achieve in situ (hi-bay and launch pad) sterilization capability of flight H/W. In our testing campaign we modified various operational parameters of our VHP generator to develop a sterilization cycle capable of processing complex spacecraft (S/C) H/W. We also initiated evaluation of γ-radiation as a sterilization modality for S/C H/W.

Task 3: Interviewed hardware Subject Matter Experts (SME) representing the major S/C subsystems and potential instruments (that could be used on notional missions to Mars Special Region) to identify those components with potential issues with dry heat microbial reduction (DHMR) and other sterilization modalities. Under the same study, we surveyed PP records for Mars Exploration Rover and Mars Science Laboratory H/W for documented sterilization compatibility. We also developed the structure for a web-based database to compile material and component sterilization compatibilities, beginning the compilation of that data into a spreadsheet for future import into the database.

Benefits to NASA and JPL:

A 2006 case study done by the Mars program at JPL has shown that if a “MER-like” mission needed to meet “Viking-like” sterilization requirements using system-level DHMR, the project costs would increase by 14%, and ~$25M would be required to update existing JPL and KSC facilities. DHMR is also time-consuming, having a significant impact on ATLO critical path schedules. The work we are conducting should provide a low-temperature local sterilization technology for aseptic assembly and integration of S/C parts. Application of this alternative approach is estimated to reduce the cost of “Viking-like” sterilization of the “MER-like” S/C to ~7.5%, since system-level DHMR related rework and redesign could be eliminated. Furthermore, the estimated $25M facility cost would also be eliminated, and impacts on ATLO critical path schedule would be reduced. Our work will also develop an aseptic assembly technique for system and subsystem sterilization of S/C for the potential robotic exploration of Martian special regions and other solar system targets such as Europa. We will investigate biobarrier/bioshield implementation approaches to allow the S/C H/W to remain sterile during final ATLO activities, launch decompression, cruise, and EDL (entry, descent, and landing) activities.

The results of this work are expected to enhance JPL’s ability to meet Planetary Protection requirements and to obtain significant cost/risk/schedule reduction for flight hardware activities. It also will help JPL to prepare for future life detection and potential sample return missions where stringent biological cleanliness are needed for scientific reasons.

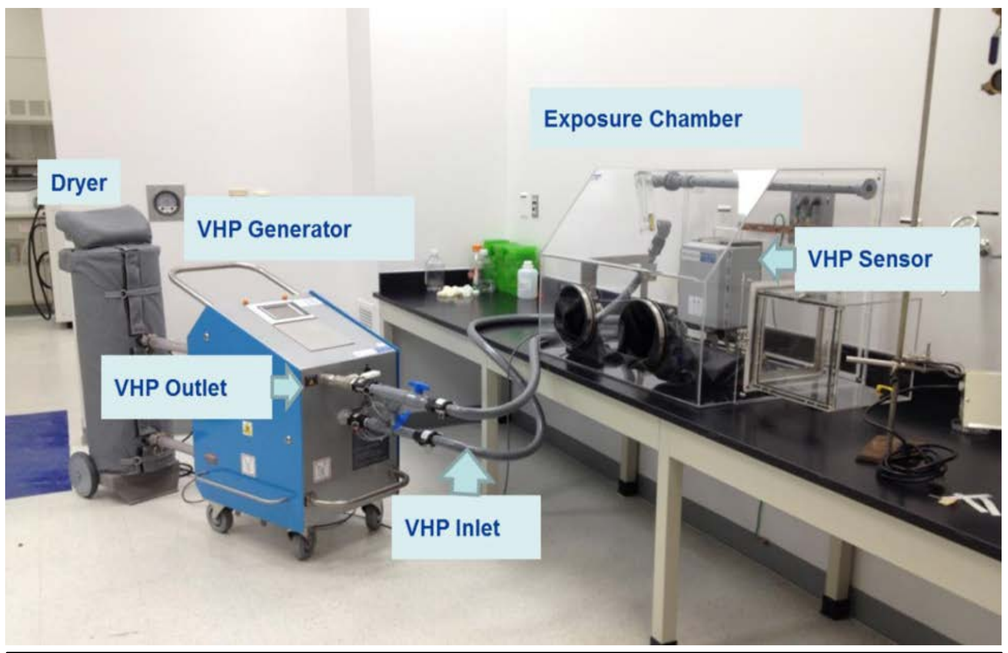

Fig 1. Biotechnology and Planetary Protection Group VHP generator equipment inside building 125

Fig 2. The enclosure attached to the VHP 1000ARD Biodecontamination unit

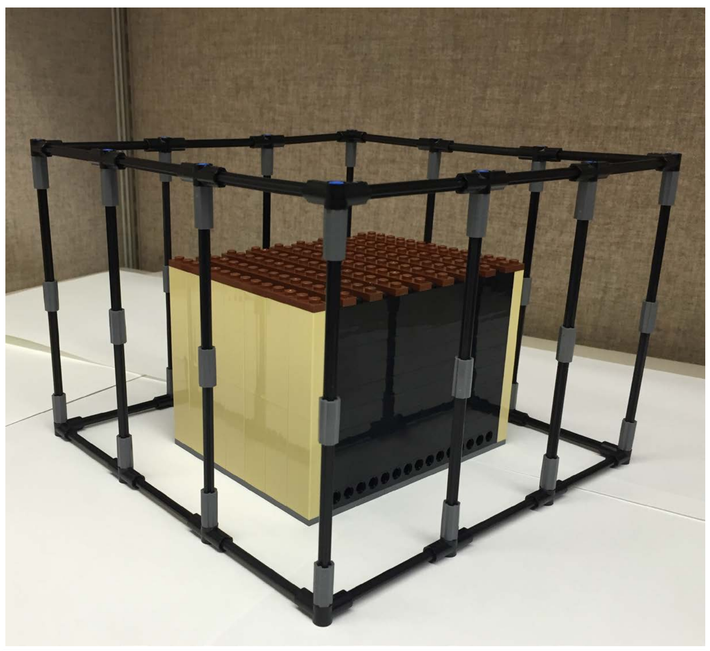

Fig 3. The complex geometry model (beige and black) surrounded by the enclosure structure

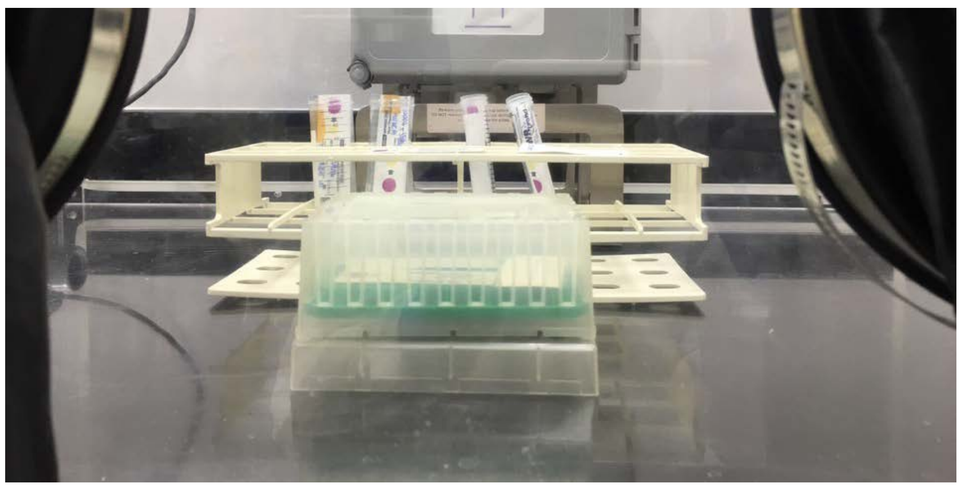

Fig 4. Test tubes (in the back) and testing box (in the front) inside the exposure chamber. The box was later updated with the one in Fig 3.

Publications:

R. Gradini, F. Chen, L. Newlin, *“A Summary on Cutting Edge Advancements in Sterilization and Cleaning Technologies in Medical, Food, and Drug Industries, and Its Applicability to Spacecraft Hardware”* , to be submitted to Advances in Space Research, 2016.

R. Gradini, K. Stott, W. Schubert, L. Newlin, “*Results of the First Testing Campaign for the Validation of Gamma Irradiation for Planetary Protection Purpose*”, to be submitted to Advances in Space Research, 2016.

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