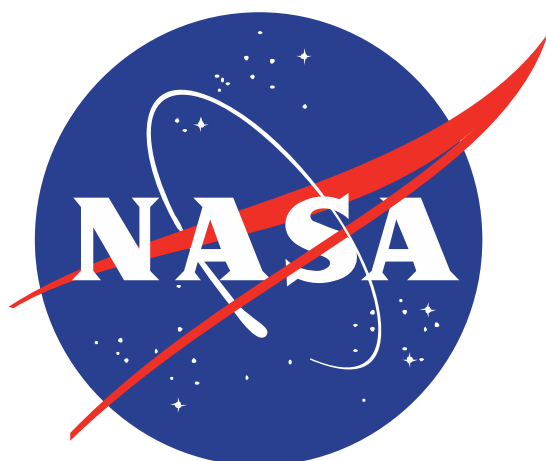


AMEBoP: Additive Manufacturing Enabled Biofilm Prevention

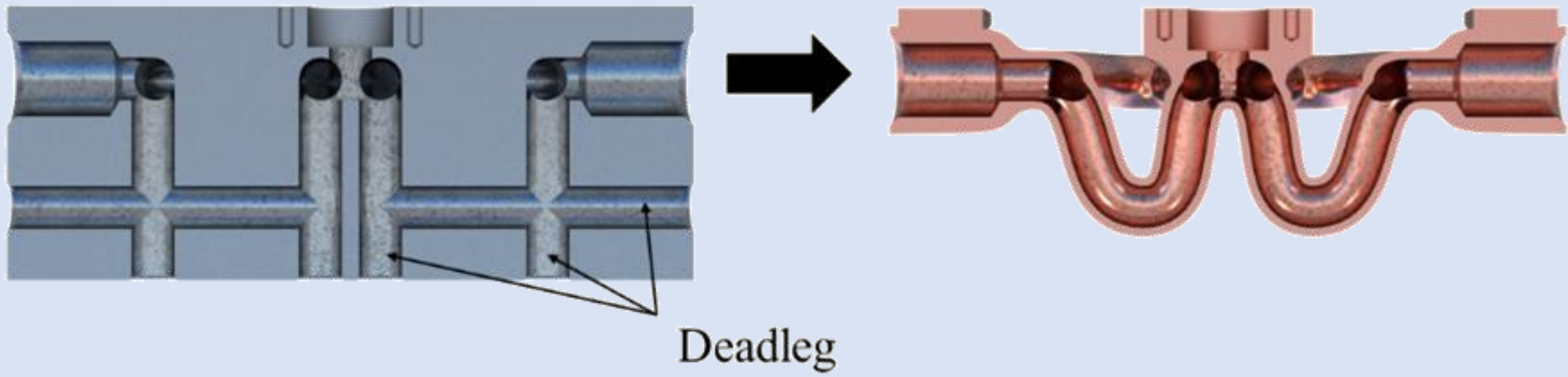


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Objective: Leverage additive manufacturing to fortify ECLSS (Environmental Control and Life Support Systems) manifolds and other vulnerable components against biofilm growth during dormancy. This project aims to improve dormancy tolerance by eliminating dead legs to reduce stagnate fluid volume and to limit available nutrients, and by printing from inherently biocidal materials. It is also helping to characterize the dormancy tolerance of traditional ECLSS manifolds today.

Alignment
Business Unit: Habitation Systems
Pursuit: ECLSS
TX06.1.2 Water Recovery and Management
TX06.1.3 Waste Management
TX06.6.6 Maintainability and Supportability
TX12.1.7 Special Materials
Shortfall Gaps 1005, 1147,366, 977



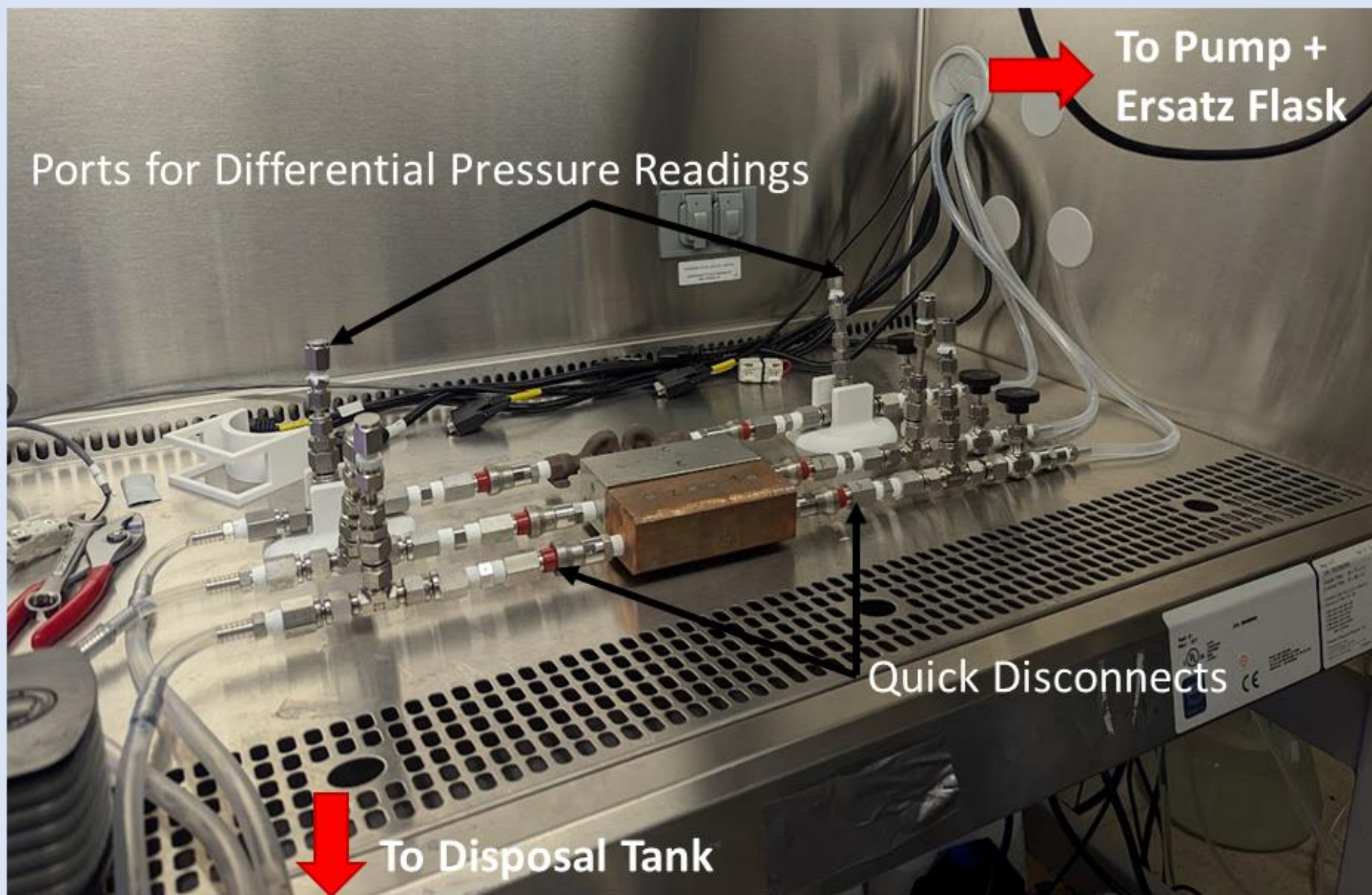
Test Articles:

- Performance will be baselined for both traditional and novel manifold designs.
- Manufacturing technique (additive vs subtractive), material (stainless steel vs copper), and geometry are controlled.
- Each combination of characteristics will be tested over dormancy periods of 2, 4, and 6 months.
- 12 test articles are used to assess the impact of different design choices.
- 24 material coupons are used to understand the impact of a printed surface finish.

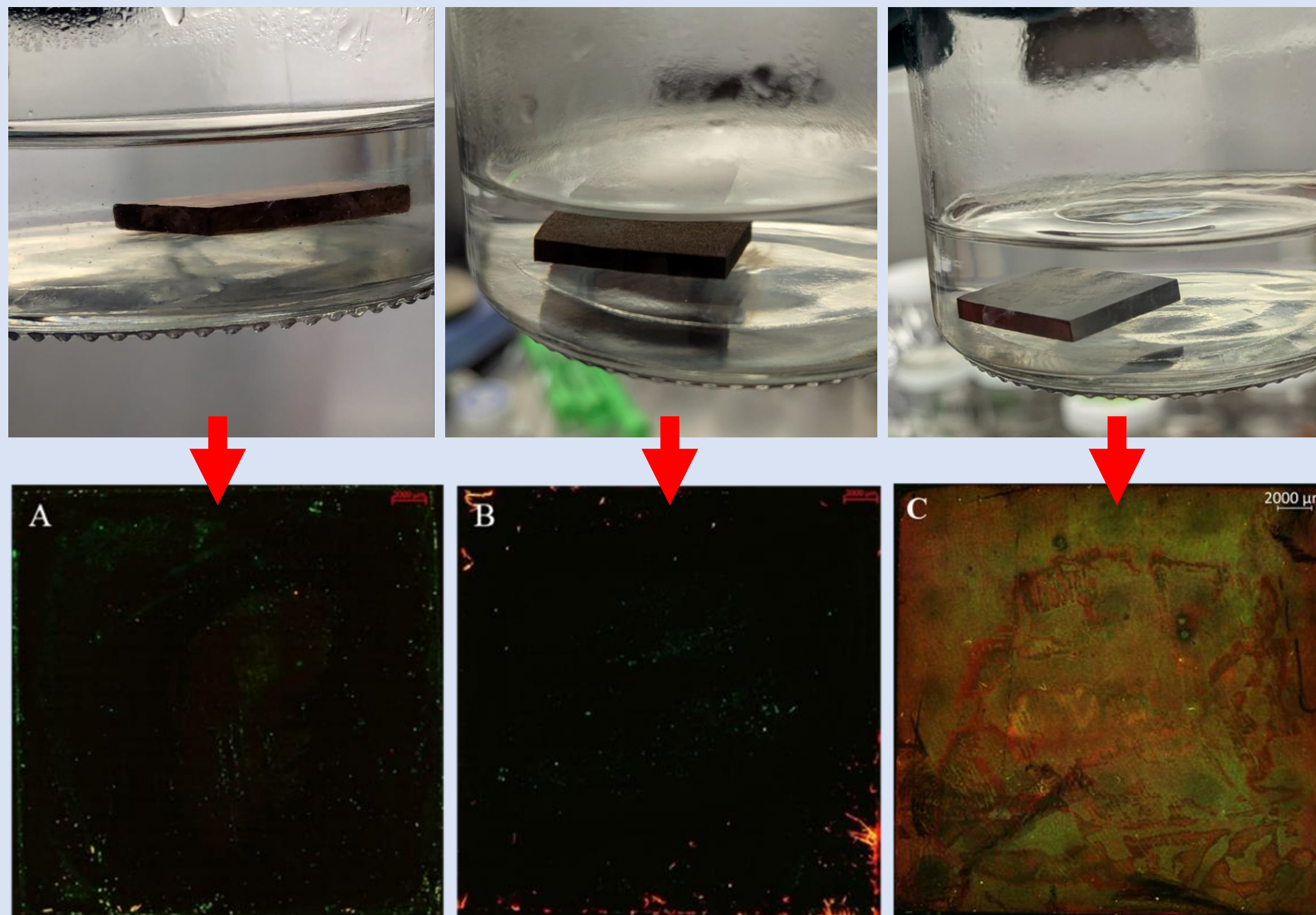


Test Setup and Metrics:

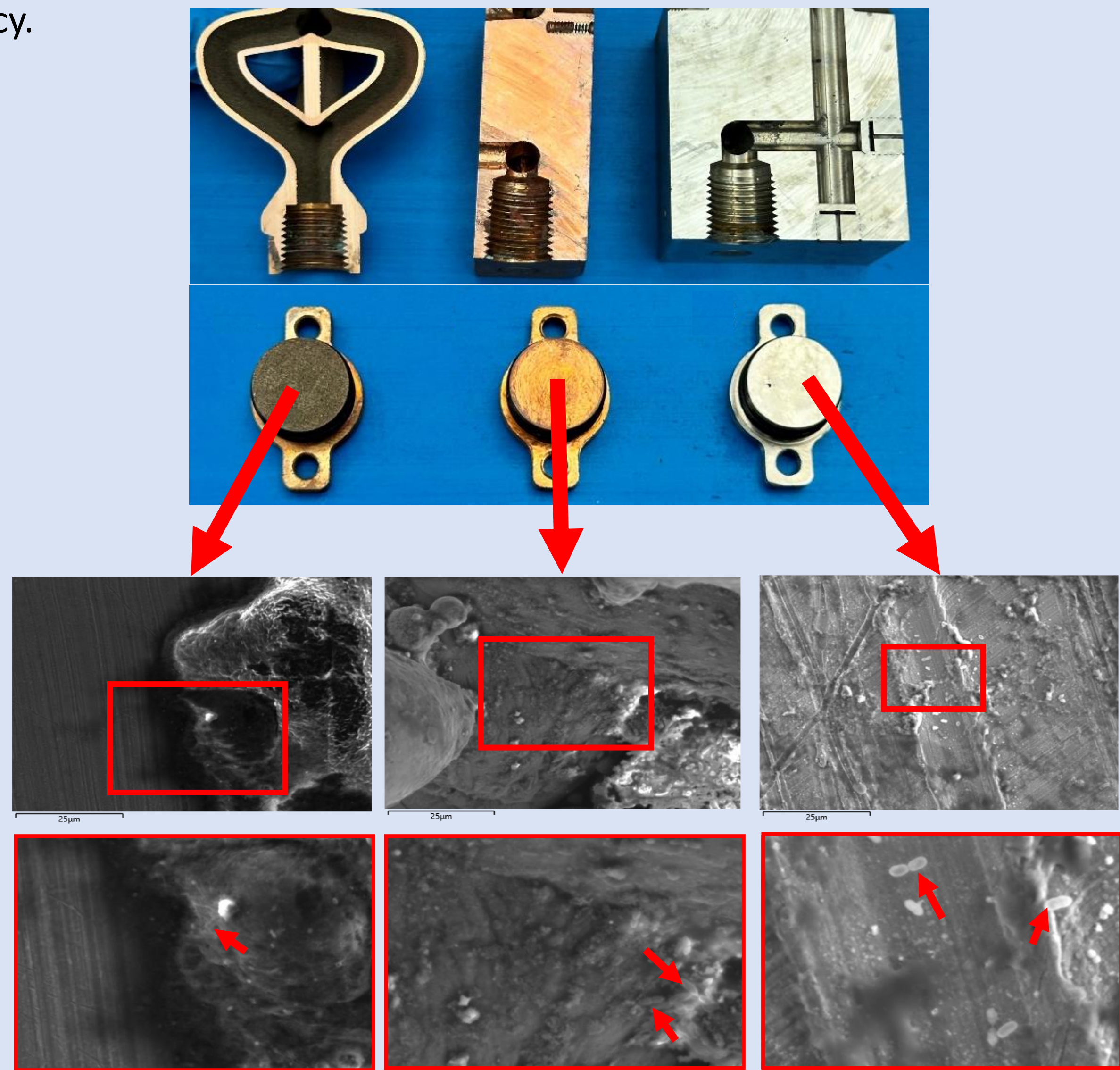
- Inoculated ersatz (10⁶ cells/mL) is flowed through each test article before being allowed to stagnate within for varying periods of dormancy.
- Differential pressure from inlet to outlet for each test article is measured before and after each dormancy period.
 - Colony Forming Units (CFU) in the discharged fluid are measured at the beginning and end of each dormancy period.
 - Each test article is sectioned, and the flow path inspected to assess biofilm formation. Biofilms are imaged using a scanning electron microscopy (SEM).
 - Material Coupons are stained with SYBR Green Live-Dead and imaged with fluorescence microscopy.



2 Month Dormancy Test Articles Undergoing Pre-dormancy Flow



Fluorescence Microscopy—3 Month Dormancy Coupons



Scanning Electron Microscopy—2 Month Dormancy Test Articles

Preliminary Results: Testing is ongoing. Only data from 2-month test articles and 1-,2-, and 3-month coupons is available. Copper test articles show no detectable microbial load in their effluent, while the stainless-steel test article did show a microbial load. The surface finish of the additively manufactured coupons does appear to encourage the establishment of biofilm, but this effect may prove to be less pronounced for longer time scales. Initial results are encouraging but more data is needed before making strong conclusions.

Impact and Infusion:

Project Outcomes

- Characterize the dormancy tolerance of a traditional ECLSS manifold.
- Assess the merit of 3D printable biocidal materials for improving dormancy tolerance in life support systems.
- Identify promising materials and geometries for biofilm reduction in manifolds.
- Enhance biofilm management for long-duration missions beyond LEO.

MSFC Alignment, Growth, and Infusion

- Development of reduced volume and antimicrobial ECLSS components aligns with MSFC efforts to develop novel approaches to biofilm mitigation for long-duration missions beyond LEO.
- This component level dormancy testing will complement system level testing and coupon testing also occurring at MSFC.
- Lessons learned from this test campaign will provide a development baseline that can be utilized by NASA ECLSS design groups, industry partners, and academia partners.

