BISMUTH PROPELLANT FEED SYSTEM DEVELOPMENT AT NASA-MSFC

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NASA-MSFC has been developing liquid metal propellant feed systems capable of delivering molten bismuth at a prescribed mass flow rate to the vaporizer of an electric thruster. The first such system (see Fig. 1) was delivered to NASA-JPL as part of the Very High I_{sp} Thruster with Anode Layer (VHITAL) program. In this system, the components pictured were placed in a vacuum chamber and heated while the control electronics were located outside the chamber. The system was successfully operated at JPL in conjunction with a propellant vaporizer, and data was obtained demonstrating a new liquid bismuth flow sensing technique developed at MSFC[1].

The present effort is aimed at producing a feed-system for use in conjunction with a bismuth-fed Hall thruster developed by Busek Co. Developing this system is more ambitious, however, in that it is designed to self-contain all the control electronics inside the same vacuum chamber as an operating bismuth-fed thruster. Consequently, the entire system, including an on-board computer, DC-output power supplies, and a gas-pressurization electro-pneumatic regulator, must be designed to survive a vacuum environment and shielded to keep bismuth plasma from intruding on the electronics and causing a short-circuit. In addition, the hot portions of the feed system must be thermally isolated from the electronics to avoid failure due to high heat loads. This is accomplished using a thermal protection system (TPS) consisting of multiple layers of aluminum foil. The only penetrations into the vacuum chamber are an electrically isolated (floating) 48 VDC line and a fiberoptic line. The 48 VDC provides power for operation of the power supplies and electronics co-located with the system in the vacuum chamber. The fiberoptic Ethernet connection is used to communicate user-input control commands to the on-board computer and transmit real-time data back to the external computer. The partially assembled second-generation system is shown in Fig. 2. Before testing at Busek, a more detailed flow sensor calibration will be performed to accurately quantify the flow monitoring capabilities. This effort is funded under a Technology Innovation Program (TIP) award from NASA-MSFC's Technology Transfer office and performed under SAA8-061060.

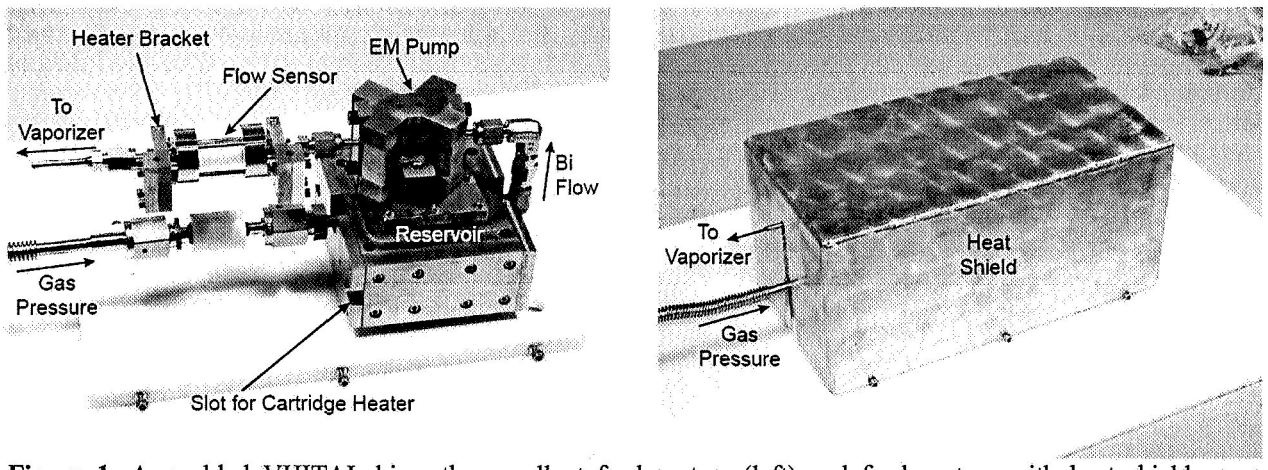

Figure 1: Assembled VHITAL bismuth propellant feed system (left) and feed system with heat shield cover installed (right).

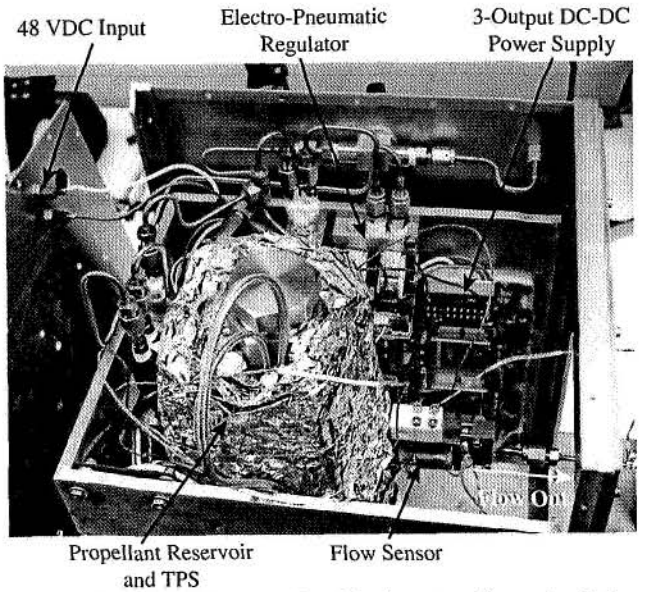

Figure 2: Assembled second-generation bimsuth propellant feed system (box size is less than 12"x12").

[1] K.A. Polzin, T.E. Markusic, B.J. Stanojev, and C. Marrese-Reading, "Integrated Liquid Bismuth Propellant Feed System," AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, 9-12 July 2006. AIAA Paper 2006-4636.