Application Note

Application of the VB-1 Vacuum Bakeout Package in the ECLIPS Space Environments Simulation Facility

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ECLIPS Space Environments Simulation Facility

The Electrostatic Charging Laboratory for Interactions between Plasma and Spacecraft (ECLIPS) research vacuum chamber facility in the Autonomous Vehicle Systems (AVS) laboratory at the University of Colorado Boulder has been developed to conduct experiments related to spacecraft charging, charged astrodynamics, and remote sensing of electrostatic potentials [1]. The vacuum chamber has a diameter of 75 cm and is 1 meter high, and the pressure in the chamber is decreased using a scroll pump and a turbo pump. A VB-1 Vacuum Bakeout Package* was recently installed with one IRB-600 infrared emitter to decrease the amount of time it takes to pump down to the desired pressure, and to reduce the contamination with residual gases inside the vacuum chamber.

Reference [1] discusses the development and characterization of the ECLIPS facility and provides an overview of the experiments conducted.

Utilization of the Bakeout System

Several instruments are included in the ECLIPS facility both inside and outside the chamber. Due to limitations of some equipment inside the chamber regarding the maximum tolerable temperature, a temperature of 70°C is chosen for the bakeout process. This temperature is maintained with the BC-3 bakeout controller and a Type-J thermocouple that come with the VB-1 package. Immediately after beginning to pumping down the pressure with the scroll pump, the bakeout is started using a temperature of 70°C and with the timer set to the maximum value of 999 minutes, or about 17 hours.

The electron gun of the ECLIPS facility requires a pressure below 1×10^{-5} torr during operation. Thus, a maximum pressure of about 1×10^{-6} torr is desired for all experiments, because the occasional movement of stepper motors inside the chamber temporarily increases the temperature and outgassing, and consequently the pressure. Figure 1 shows a comparison of the pump-down process with and without baking out. Without the bakeout system, it takes over three days to reach the desired pressure. Using the VB-1 bakeout package, this time is reduced to less than one day. As visible in Figure 1, the pressure drops significantly once the bakeout is finished after about 17 hours as the temperature in the chamber decreases. The 3x speed-up of the pump-down process brings a noteworthy advantage to our facility, since we often have to make small adjustments to the hardware inside the chamber that requires the chamber to be vented and pumped down again.

A Residual Gas Analyzer (RGA) is used to measure the contamination with residual gases inside the chamber. Figure 2 shows the difference in the mass spectrum before and after baking out the chamber for a few days. The partial pressure of H (1 amu), H_2O (18 amu) and CO_2 (44 amu) decreases considerably, even though the temperature during the bakeout is only 70°C (usual operating temperatures for this system are between 115°C and 150°C) and even less at the areas of the chamber that are on the opposite side of the infrared emitter.

We plan to use the bakeout system in the future every time while pumping down, and occasionally for extended periods of time to reduce the contamination inside the chamber.

References

[1] Wilson, K., Bengtson, M. T., Romero-Calvo, Á., Maxwell, J., and Schaub, H., "Characterization of the ECLIPS Space Environments Simulation Facility," *AIAA Scitech 2021 Forum*, American Institute of Aeronautics and Astronautics, Reston, Virginia, 2021. https://doi.org/10.2514/6.2021-1538.

*https://rbdinstruments.com/products/vb.html

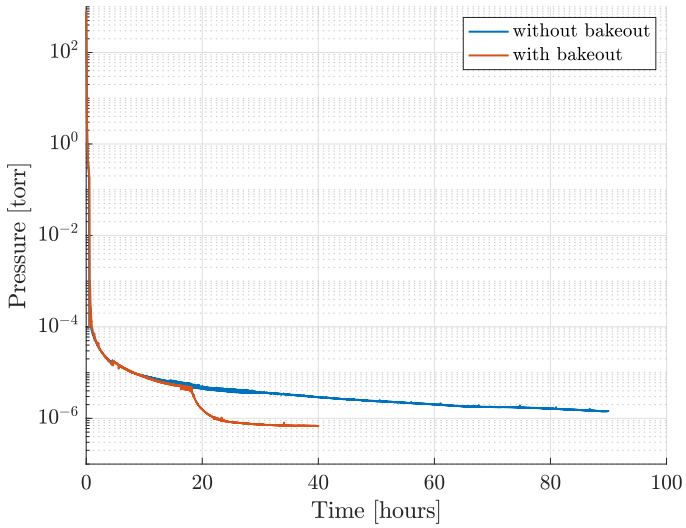

Fig. 1 Pressure over time with and without baking out

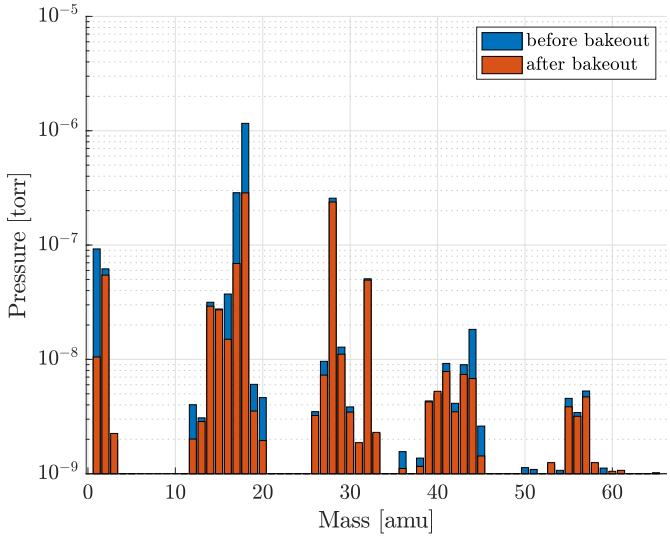

Fig. 2 Difference in RGA spectrum before and after bakeout