LightWAVE | Developing Mass Spectrometry for Water Quantitation and Volatiles Analysis from In-Situ Lunar Regolith

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Mission

Light Water Analysis and Volatile Extraction (LightWAVE) calibrates a modified commercial-off-the-shelf (COTS) residual gas analyzer (RGA) to-quantitate water from *in-situ* regolith samples on the lunar surface and to identify any volatile gases that evolve upon heating regolith.

Introduction

NASA is aiming to a continuous and sustainable lunar presence on the moon to gain more knowledge and prepare for Mars exploration [1]. In-Situ Resource Utilization (ISRU) will be critical for future mission success as it would enable independent operation of missions while reducing the dependence on the complex supply chain created between the Earth, the moon and Mars.

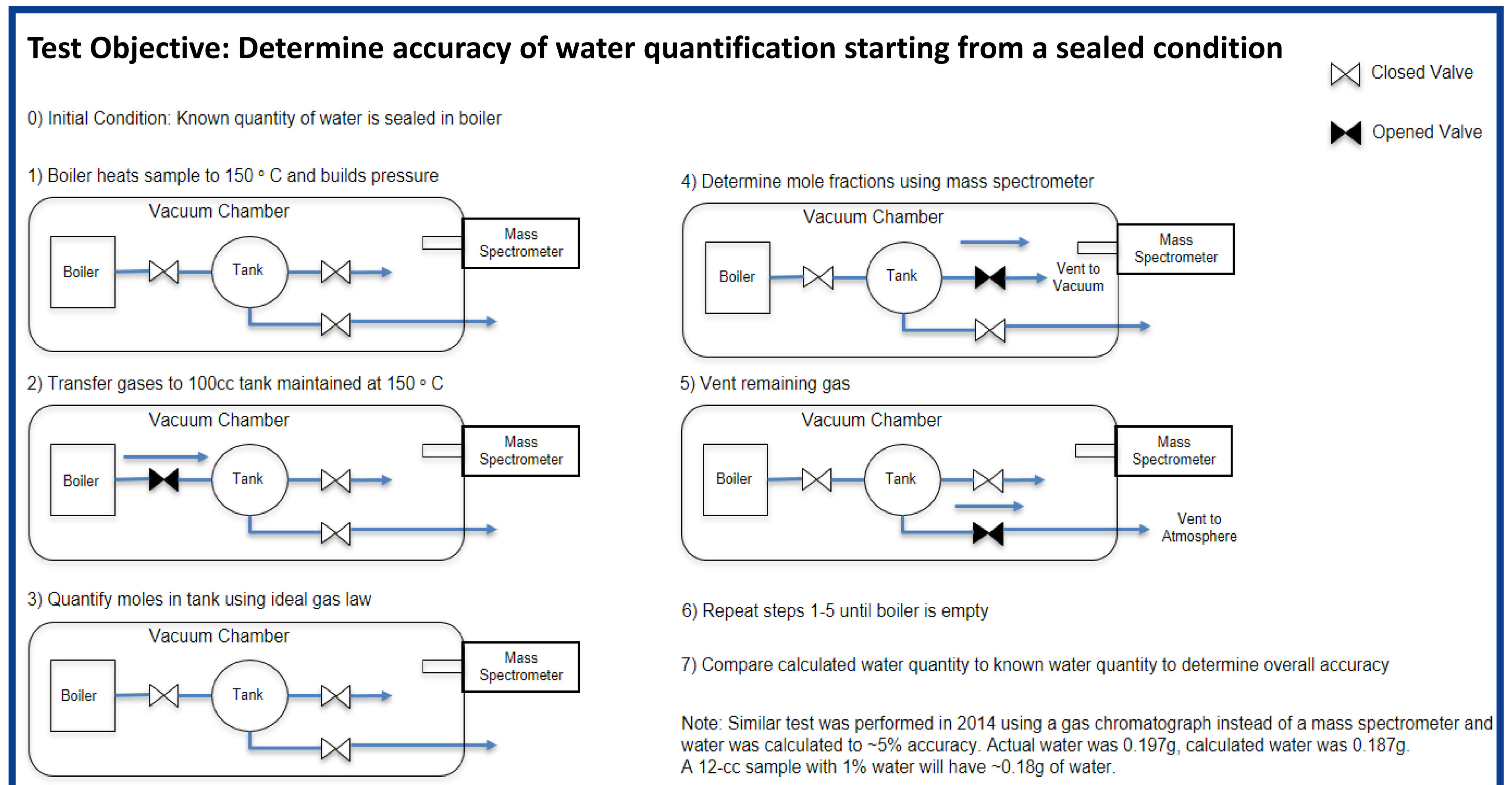
One of the most critical resources that has been identified for ISRU on the lunar surface is water [2]. Water is a versatile resource that can be used in various space operations, such as radiation shielding and conversion to oxygen (O_2) for propellant [3,4]. One of the most water rich resources is thought to be within the regolith located in the permanently shadowed regions (PSR) of the Moon; several upcoming missions, such as PRIME-1 and VIPER, are already scheduled to confirm this hypothesis [5,6]. However, there are currently no missions planned to quantify the abundance of water at these regions. The quantity of water contained in the ice will inform and help the development of future ISRU plants and operation.

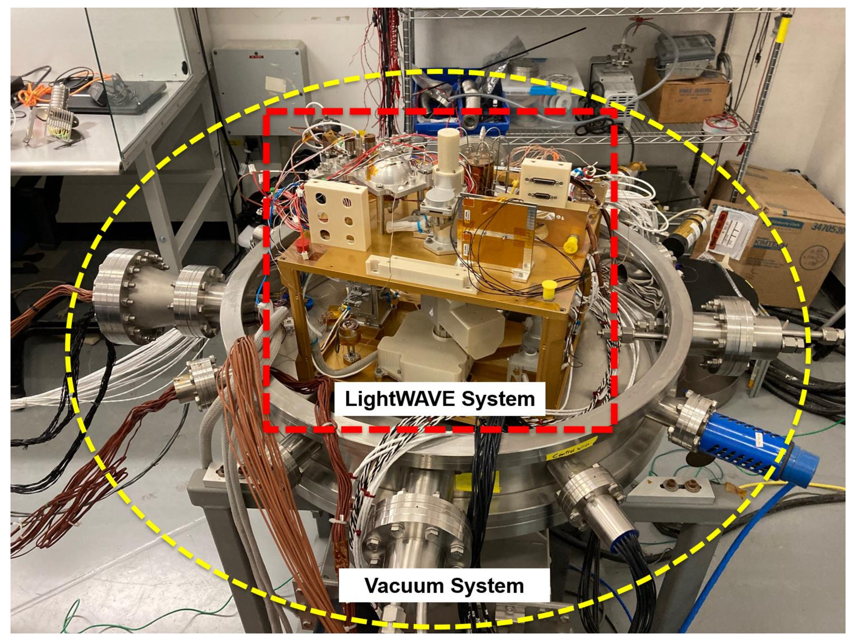
Water and other volatile gases can be detected upon controlled heating of icy lunar regolith for an accurate quantification of water. This method is similar to thermogravimetric analysis, which was used to analyze Apollo lunar regolith samples. However, losses via sublimation/evaporation or contamination may have occurred with the samples due to the transit and exposure to the terrestrial environment. Furthermore, water would not be expected for these samples since they were not collected from a PSR. Thus, for more accurate results, icy lunar regolith should be analyzed *in-situ* to provide the most representative composition of both water and other volatile gases.

System Overview

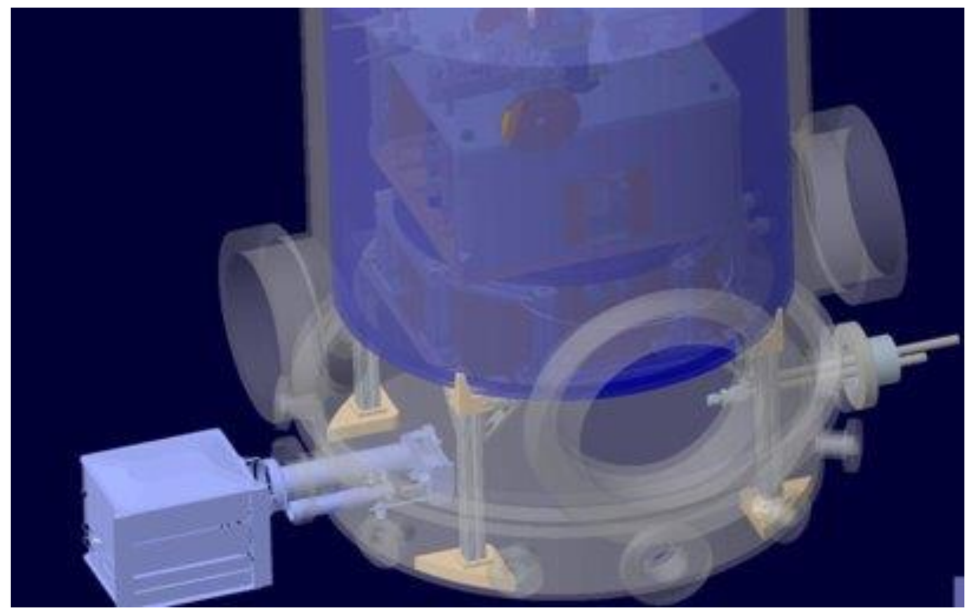
The **Light Water Analysis and Volatile Extraction** (LightWAVE) project aims to address this knowledge gap. A system has been developed to collect, heat and analyze evolved gases from lunar regolith on the lunar surface. The gases will be analyzed by a modified commercial-off-the-shelf (COTS) residual gas analyzer (RGA) quadrupole mass spectrometer. Evolved gases from heated regolith samples can be identified by the observed mass-to-charge (*m/z*) ratios, and the peak intensities correlate to the abundances of the observed gases for quantitation. Therefore, our group is developing a calibration methodology utilizing a COTS RGA to quantitate water from in-situ regolith samples on the lunar surface. The partial pressure of water and ideal gas law will be used to quantify the total water evolved from a regolith sample. Here we present our methodology for the design and calibration for water quantitation using a COTS RGA.

ConOps





➢ Pictured below Boiler system assembly

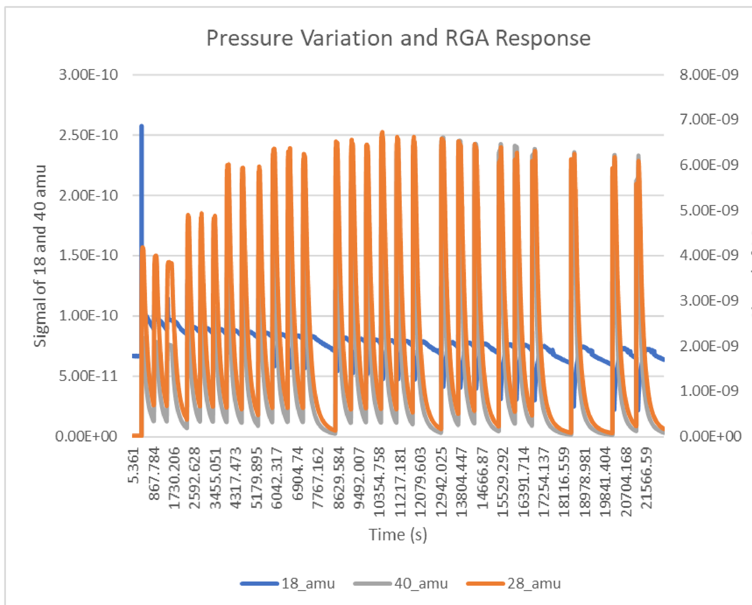


➢ Pictured above System integrated on CAD to determine space needed on the test chamber

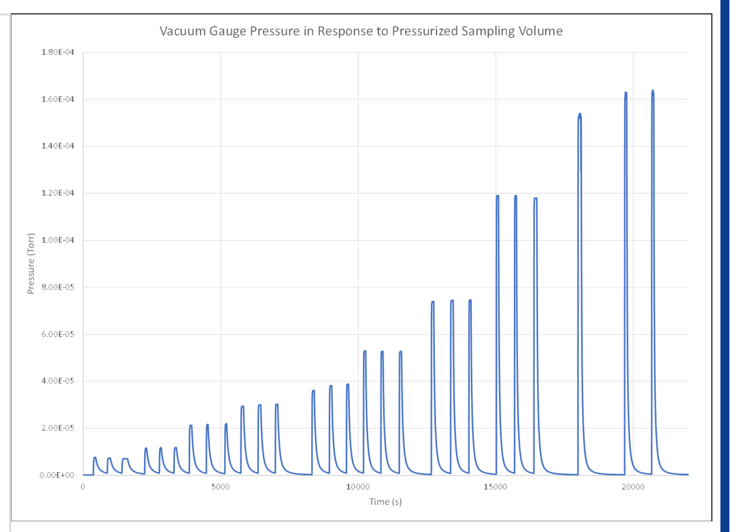
Preliminary Results

On-going testing is being performed, at KSC in preparation of the integrated test in a thermal vacuum chamber at JSC.

- ➢ To date pressure reduction optimization has been established, using a GC capillary column.
- ➢ RGA settings for data acquisition method have been setup and are established.
- ➢ Optimizing of steam generation and subsequent RGA analysis.



➢**Pictured Above:** Initial data testing mass filter dwell times for method development



➢**Pictured Above:** Sample pressure vs. vacuum chamber pressure testing for KSC testing assembly

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