Validation of the Volatile Organic Analyzer Aboard the International Space Station

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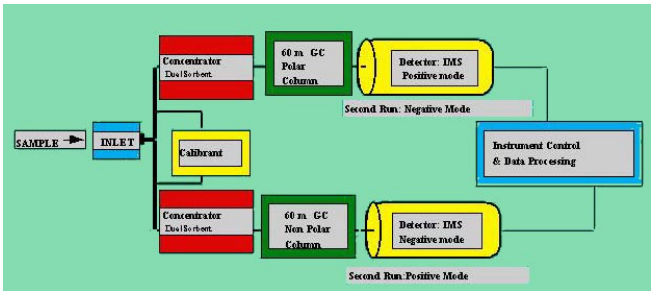
The Space Station crew may stay for six months or more in an environment that is scrubbed and recirculated rather than frequently replaced. Crew health and safety concerns led to the development of the volatile organic analyzer (VOA) to fulfill the real-time air quality monitoring requirements for the Space Station.

The VOA is made of four major components that provide its analytical capability. These components are the sampling system, gas chromatography (GC) columns, ion mobility spectrometer (IMS) detectors, and the computer control and data analysis system. An air sample, acquired via sample pumps, is pulled through sorbent materials that retain the volatile organic compounds (VOCs) in the sample. When the sorbent is heated, the VOCs are moved to the GC column where they are separated in time to enable better detection. As a compound elutes from the GC column, although it enters the ionization (Ni63) region of the detector, it is ionized by charge transfer and not by direct ionization from the source. Ions formed are "gated" into a drift region characterized by a weak electric field and a counter flow of "drift gas." The detector is at ambient pressure. Ions are separated by their size and shape as they move through the drift region. The detector acquires the ion's drift region transit time and its signal strength to produce the necessary analytical data.



The two parameters necessary for the VOA to correctly identify the contaminants are the GC retention times and the ion drift times in the IMS. The VOA determines the contaminant concentration when the integrated area of a compound's product ion peak is compared to a calibration table of integrated areas for known concentrations of the product ion peak.

The VOA target compounds assessed during the validation are listed in the table below. Validation data were obtained by comparing VOA results to gas chromatography/mass spectrometry analysis of archival samples returned from the Space Station. The VOA was installed in the U.S. Laboratory module, and archival samples were acquired in this module at the approximate times (±2 hours) of the VOA sample runs. The VOA accuracy requirement is ±50 percent, which is relaxed from the usual ±25 percent because of the user needs and the constraints, such as calibration frequency on field-deployable instruments.

Compound Name	Compound Name
Methanol	Ethanol
1-butanol	2-methyl 2-propanol
Ethanal	Benzene
m,p xylenes	(F22) chlorodifluoromethane
o xylene	1,1,1, trichloroethane
Toluene	(F113) 1,1,2-trichloro-1,2,2-trifluoroethane
Dichloromethane	Hexane
Propanone	Isoprene
2-butanone	(halon 1301) trifluorobromomethane
2-propanol	ethyl acetate

Proper identification of compounds in the sample must occur prior to any quantitative determinations. The data, which were reduced from 18 target compounds detected by the VOA in the Space Station atmosphere from January to December 2002, generated relative standard deviations of < 2.0 percent for GC retention times and < 1.3 percent for ion drift times. The precision of these parameters translated into very accurate compound identification throughout the validation study.

Results from eight VOA runs performed with the simultaneously acquisition of GC samples are shown in the table at right. These samples were collected from January through December of 2002. The compounds detected can be divided into two categories: those in which the concentrations were high enough in the majority of runs to be detected at measurable levels, and those compounds that were never detected above a trace level. Trace level is defined as a response below the compound's calibration curve, yet it is a sufficient response for positive identification. Consequently, a compound's validation was classified as either trace or full. Six compounds (gray) were fully validated with the caveat that the instrument's detector remains clean via operation mode and routine maintenance. Although ethanol is included as fully validated, most samples were detected at concentrations that exceeded the VOA's calibration curve for ethanol. Eight compounds (crosshatch) were validated at trace levels, since these compounds where never detected in either VOA or archival samples at measurable concentrations. Two compounds (no highlight) could not be validated because they were not detected in VOA or archival samples. Finally, the inconsistency of the methanol quantitative data relegated this compound to only qualitative analysis by VOA. The VOA was validated for 18 of the 21 target compounds.

Compound Name	Compound Name
Methanol	Ethanol
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Toluene	(F113) 1,1,2-trichloro-1,2,2-trifluoroethane
Dichloromethane	Hexane
Propanone	
2-butanone	Isoprene
ethyl acetate	(halon 1301) trifluorobromomethane
2-propanol	