JSC TOXICOLOGY GROUP

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Memorandum Number

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SUBJECT: Toxicological Assessment of ISS Air and Water Quality: September – November 2013 and Orb-D1 First Ingress (Increment 37)

SUMMARY: Based on these limited data, air quality was nominal on ISS for this period, and potable water remains acceptable for crew consumption.

AIR QUALITY

Seven mini grab sample containers (mGSCs) were collected on ISS during Increment 37 and were returned on 35S. Of these, 6 were collected as routine monthly samples in the Russian Service Module (SM), US Laboratory (Lab), and either the Japanese Pressurized Module (JPM) or the Columbus module (Col), and 1 was collected during Orbital-Demonstration 1 (Orb-D1) first ingress. Two pairs of passive-diffusion formaldehyde badges were also deployed in the US Lab or Russian Service Module (SM) and returned aboard 35S. A summary of the analytical results is provided in Table 1.

Table 1. Analytical Summary of ISS air analyses

Sample Location	Sample Date	NMVOCs[a] (mg/m^3)	Freon 218 (mg/m^3)	Alcohols[b] (mg/m^3)	T-Value[c] (units)	CO_2 (mg/m^3)	Formaldehyde ($\mu g/m^3$)
Orb-D1	9/30/2013	33	0.4	5.9	0.6[d] 2.9	1600	--
Lab	10/4/2013	8.8	3.9	4.4	0.5	7600	30
SM	10/4/2013	10	4.8	4.8	0.5	8000	15
JPM	10/4/2013	9.7	4.9	4.5	0.6	7600	--
Lab	10/30/2013	8.1	5.8	3.9	0.5	5200	28
Col	10/30/2013	10	4.1	4.2	0.6	8000	--
SM	10/30/2013	8.9	4.8	4.1	0.5	5800	18
Guideline		*<25*	---	*<5*	*<1*[e]	*<9300*	*<120*

[a]Non-methane volatile organic hydrocarbons, excluding Freon 218
[b]Includes acetone
[c]Sum of the ratios of the measured concentration and the corresponding 180-day SMAC for each compound, excluding CO_2
[d]Value based on 7-day SMACs used for evaluating first ingress.
[e]T-value <1 used to evaluate routine monthly sampling; T-value <3 used to evaluate first ingress samples

Complete data tables of all measured concentrations and corresponding T-values based on 180-day SMACs are enclosed. A data table containing T-values based on both the 7-day and 180-day SMACs is enclosed for the (Orb-D1) first ingress sample. The detection limit for all target compounds, except m/p-xylenes and hexachloro-1,3-butadiene, was 0.025 mg/m^3. The detection limit for m/p-xylenes, hexachloro-1,3-butadiene, and all non-target compounds was 0.05 mg/m^3. The average recoveries of the 3

surrogate standards from the mGSCs were as follows: ^{13}C-acetone, 112 ± 8%; fluorobenzene-d_5, 115 ± 6%; and chlorobenzene-d_5, 117 ± 7%. For the passive-diffusion formaldehyde badges, positive control recoveries (1 trip and 2 lab controls) were 109%, 100%, and 80%, respectively.

Toxicological Evaluation of ISS Air Quality: Routine monthly sampling provides a very limited set of samples on which to perform an air quality assessment, but is complimentary to in-flight air monitoring data collected by the air quality monitor (AQM). Based on these samples, there is no concern for crew health. Formaldehyde levels in the US Lab are consistent with historical levels which are generally between 30-40 μg/m^3 (Figure 1). Concentrations in the Russian SM are generally lower than the US, but all levels are below the SMAC of 120 μg/m^3. The T-value for all routine samples collected was below 1 in all locations. Primary contributors to the total T-value across all routine sampling locations throughout this time period were hexamethylcyclotrisiloxane and decamethylcyclopentasiloxane. These compounds were measured well below levels of health concern but may contribute to periodic accumulation of siloxanes in the water recovery system (see Water Quality section below). Alcohol values in all routine monthly samples were below the alcohol guideline of <5 mg/m^3, which is intended to protect the water recovery system from risk of overloading. The mGSCs provide only a snapshot of conditions and are not ideal for evaluating potential CO_2 exposures; however, reported levels were below 4 mmHg (9300 mg/m^3), as requested for this Increment in Chit 011659.

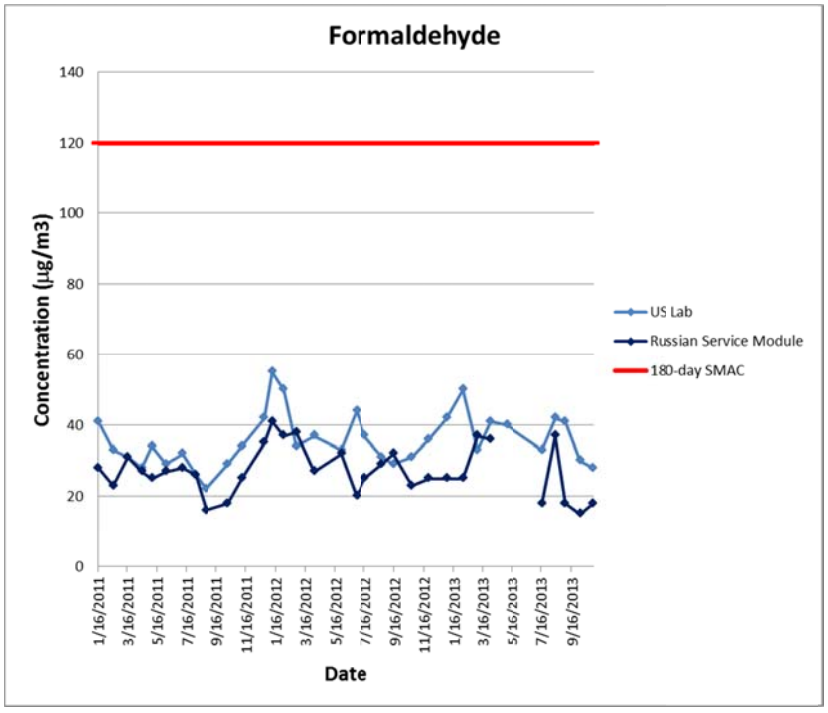

Figure 1. Formaldehyde trending in ISS air.

The CO_2 and Freon 218 levels measured in the Orb-D1 first ingress sample indicate that minimal mixing occurred with the ISS atmosphere prior to sample collection. The measured T-value of 0.6 based on 7-day SMACs at Orb-D1 first ingress was well below levels of concern for crew health. This value was lower than the predicted value of 1.1 based on the off-gas test (0.085 units/day x 13 days). This result is expected due to the conservative linear extrapolation used to predict the first ingress T-value from the off-gas test. Consistent with the off-gas test, the primary contributors to the total T-value were hexamethylcyclotrisiloxane, trimethylsilanol, and acetaldehyde. The total NMVOCs in the first entry sample did exceed the 25 mg/m^3 guideline, so odors may have been noted, but all compounds were well below their individual health-based values.

WATER QUALITY

Archive samples were collected from the potable water dispenser (PWD) in the US Lab and the SVO-ZV and the SRV-K systems in the Russian segment during Increment 37 and were returned on 35S. A summary of the analytical results from those samples is provided in Table 2. Complete data tables for the water analyses are found in analytical chemistry report #2014-WFL-ISSWQ-001.1.

Table 2. Analytical Summary of ISS water analyses

Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Conductivity (µS/cm)	Total Iodine (mg/L)	Total Silver (µg/L)
PWD	10/8/2013	2.8	12	5	<0.05	--
PWD	11/6/2013	<0.1	<0.5	4	<0.05	--
SVO-ZV	11/6/2013	0.5	<0.5	490[a]	--	134
SRV-K	11/6/2013	0.3	<0.5	220[a]	--	21
Guideline		*<3*	*<35*	--	*<0.2*	*>100*

[a]Russian water system is intentionally mineralized.

Toxicological Evaluation of ISS Water Quality: Routine monthly sampling provides a very limited set of samples on which to perform a water quality assessment; however, data from archive samples are complimentary to in-flight monitoring data collected by the total organic carbon analyzer protoflight unit 2 (TOCA PFU2) and the colorimetric water quality monitor kit (CWQMK). Total organic carbon (TOC) trending data from in-flight and archival sampling of the US potable water system are shown in Figure 2. The multifiltration beds in the water processor assembly (WPA) were replaced on August 21, 2013. The TOC concentration in the WPA product water peaked in early October as the residual TOC was flushed out of the ion exchange bed and product water tank, but TOC concentrations remained below the health-based guideline of 3 mg/L throughout this event. The concentrations returned to normal levels (below the TOCA detection limit) by early November. The primary contributor to the TOC rise was dimethylsilanediol (DMSD). This is consistent with previous TOC increases. Throughout this time period, DMSD levels remained well below the spacecraft water exposure guideline (SWEG) of 35 mg/L and did not present a risk to crew health.

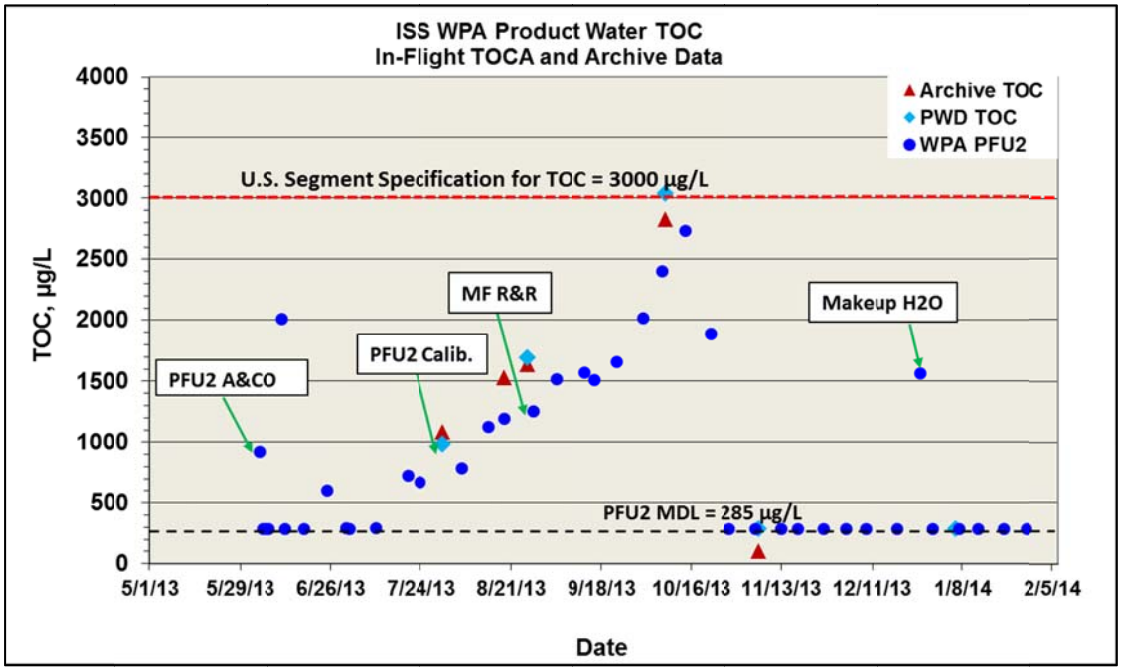

Figure 2. Total Organic Carbon (TOC) trending in US Potable Water

Conductivity provides an indirect measure of the amount of total inorganic contaminants. Inorganic levels in US water were very low, as expected. In the Russian segment, calcium, magnesium, and inorganic carbon levels in the SVO-ZV were well above historic averages, but below levels of concern for crew health. Manganese levels (58 μg/L) in the SVO-ZV exceeded the MORD limit of 50 μg/L but remained well below the US SWEG of 300 μg/L. No measured compounds exceeded MORD limits in the SRV-K sample. Iodine and silver are biocides used on the US and Russian segments, respectively. Iodine is added to the water produced by the WPA but is removed prior to crew consumption to avoid potential thyroid damage. Total iodine levels measured in the US water samples were below levels of concern for human consumption. Conversely, silver levels in Russian water samples are expected to remain above the minimal effective biocidal level of 100 μg/L. Levels in the SRV-K sample were well below this acceptable level, which increases the risk of microbial growth. See the Soyuz 35 post-flight report issued by the Environmental Microbiology for additional information on the results from microbial analyses run on the samples.

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Enclosures Table 1: Analytical concentrations of compounds found in the mGSCs returned on 35S
Table 2: T-values corresponding to analytical concentrations in Table 1, based on 180-day SMACs
Table 2A: T-values corresponding to the analytical concentrations in Table 1, based on 180-day and 7-day SMACs for Orb-D1 first ingress