JSC TOXICOLOGY AND ENVIRONMENTAL CHEMISTRY GROUP

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SUBJECT: Toxicological Assessment of ISS Air and Water Quality: December 11, 2015 – March 1, 2016 (Increment 46)

SUMMARY: Based on these data, air quality was acceptable 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 46 and were returned on Soyuz 45 (45S), SpX-8, and SpX-9. Six mGSCs were collected as routine monthly samples for January, February, and March in the US Laboratory (Lab) and the Russian Service Module (SM), the Japanese Pressurized Module (JPM), or Columbus (Col). One contingency mGSC sample was collected on 2/11/2016 in Node 3 as part of an investigation after crew reported a solvent smell. Six pairs of passive-diffusion formaldehyde badges were deployed in the Lab and SM in December and in early and late February (3 separate deployments), comprising nominal monthly samples for January, February, and March. All formaldehyde badges and the January nominal mGSC sample collected in the Lab were returned on 45S. The nominal January mGSC sample collected in the SM was returned later on SpX-9. All remaining mGSC samples collected during Increment 46 were returned on SpX-8. 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/m³)	Freon 218 (mg/m³)	Alcohols[b] (mg/m³)	T-Value[c] (units)	CO_2 (mg/m³)	Formaldehyde (µg/m³)[d]
Lab	12/28/2015	6.4	64	5.9	0.2	6100	37
SM	12/28/2015	9.7	74	8.7	0.3	7500	20
LAB	2/3/2016	8.0	78	7.2	0.2	5400	33
JPM	2/3/2016	7.3	72	6.4	0.3	6100	--
SM	2/3/2016	--	--	--	--	--	17
Node 3 Contingency	2/11/2016	10	79	9.4	0.2	6600	--
Lab	2/24/2016	12	85	12	0.2	6400	34
SM	2/24/2016	--	--	--	--	--	21
Col	2/24/2016	12	85	11	0.3	7500	--
Guideline		*<25*	---	*<5*	*<1*	*<7100[e]*	*<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]Average from pair of formaldehyde badges
[e]CO_2 to be controlled as low as reasonably achievable (ALARA) – currently 3 mmHg (7100 mg/m³) or lower

Data tables containing concentrations and corresponding T-values based on appropriate Spacecraft Maximum Allowable Concentrations (SMACs) for compounds present at levels above the laboratory reporting limit are enclosed. Complete data tables including compounds assessed but not detected are available upon request. The relative recoveries of the 3 surrogate standards from the 45S mGSC were as follows: 13C-acetone, 149%; fluorobenzene-d5, 126%; and chlorobenzene-d5, 142%. The average relative recoveries of the 3 surrogate standards from the SpX-8 mGSCs were as follows: 13C-acetone, 108±9%; fluorobenzene-d5, 111±7%; and chlorobenzene-d5, 130±13%. For the SpX-9 sample, relative recovery was as follows: 13C-acetone, 114%; fluorobenzene-d5, 116%; and chlorobenzene-d5, 150%. For the passive-diffusion formaldehyde badges, positive control recoveries (1 in-flight and 2 lab controls) were 105, 104, and 100%, respectively.

Simultaneous automated sampling sessions are scheduled on the Air Quality Monitors (AQMs) every 73 hours, which results in 2-3 sampling sessions per unit per week. Monthly average concentrations as well as the Increment average concentrations for compounds measured on the AQMs are presented in Table 2.

Table 2. Average monthly concentrations (mg/m^3) of AQM target compounds.

	Dec	Jan	Feb	Average
2-Propanol†	--	--	--	--
Acetone†	--	--	--	--
Acrolein†	--	--	--	--
Benzene†	--	--	--	--
1,2-Dichloroethane†	--	--	--	--
Decamethylcyclopentasiloxane&	1.1#	0.9#	TRACE#	0.9#
Hexanal†	--	--	--	--
Hexane†	--	--	--	--
m,p-Xylenes	ND#	ND#	ND#	ND#
Methanol†	--	--	--	--
o-Xylene	TRACE#	TRACE#	TRACE#	TRACE#
Octamethylcylcotetrasiloxane	ND#	ND#	ND#	ND#
Toluene	ND#	ND#	ND#	ND#
2-Butanone	ND	ND	ND	ND
Acetaldehyde	0.1	0.2	0.3	0.2
Dichloromethane	0.1	TRACE	ND	TRACE
Ethanol	3.3	3.4	10.1	5.6
Ethyl Acetate	0.1	0.1	0.1	0.1
Hexamethycyclotrisiloxane	0.8	0.8	TRACE	0.8
n-Butanol	0.1	0.1	0.1	0.1
Trimethylsilanol	0.2	0.3	0.1	0.2

&Trending only
#Data reported are from the non-prime Unit 2 as available
†No values reported due to failed AQM unit 1 (S/N 1003)
ND: Not detected

Due to failure of AQM S/N 1003 (Unit 1), data were only available from AQM S/N 1004 (Unit 2) from December 2015 through February 2016. During this period, archive samples were relied upon to provide insight into compounds typically measured on Unit 1. AQM S/N 1018, deployed on 2/3/2016, replaced S/N 1004. An additional instrument (AQM S/N 1005) was also deployed in February to replace S/N 1003. That instrument was declared operational in March 2016, restoring full in-flight analytical capabilities (dual, complimentary instruments). However, the first AQM sample run in March occurred on 3/3/2016, which is

beyond the timeframe of this report. Data from the initial runs on AQM S/N 1005 will be included in the Increment 47 report. Generation of data from both AQM units allows for greater insight into ISS air quality, and thus more representative T-values, which are calculated to estimate toxicological risk to crew.

With restoration of full in-flight analytical capabilities, the frequency of archive sample collection will be reduced to a 45-day interval in future Increments. Underreporting of ethanol on AQM S/N 1004 is thought to have occurred during the first part of Increment 46 due to decreased sensitivity as the unit approached the end of its certified life. Fortunately, ethanol levels remained well below the health based limits so this is not expected to have impacted crew health. The ethanol concentrations measured on the new AQM (S/N 1018) were more consistent with the Increment 46 mGSC sample results. Levels of siloxanes (DMCPS, HMCTS, OMCTS, and TMS) decreased following the deployment of S/N 1018, primarily due to improvements in the calibration process for these analytes. Revision of the method, which now accounts for losses during analysis, has led to closer agreement of GSC and AQM data.

Toxicological Evaluation of ISS Air Quality

Routine air quality monitoring is performed in-flight using the AQMs. Archive air samples (mGSCs) are collected during each increment and returned for analysis in ground laboratories. Data from the ground analyses complement the in-flight data and provide a more complete understanding of air quality on the ISS. Archive samples for this Increment were returned on SpX-8, SpX-9, and 45S, which confirmed air quality was acceptable during this timeframe. **Importantly, all measured values (mGSC and AQM) met T-value guideline criteria (T < 1), indicating no concern for crew health.** The average T-value for Increment 46 calculated from the mGSC samples was 0.2 (Figure 1). Despite the loss of AQM S/N 1003, the average T-value calculated from the AQM data (Figure 2) was identical (0.2), because the primary contributors to the T-value, hexamethylcyclotrisiloxane (HMCTS), acetaldehyde, and trimethylsilanol (TMS), are all measured on S/N 1004. The reported values continue to be approximately half of historical averages, likely due to installation of carbon filters in Node 1 in May 2015.

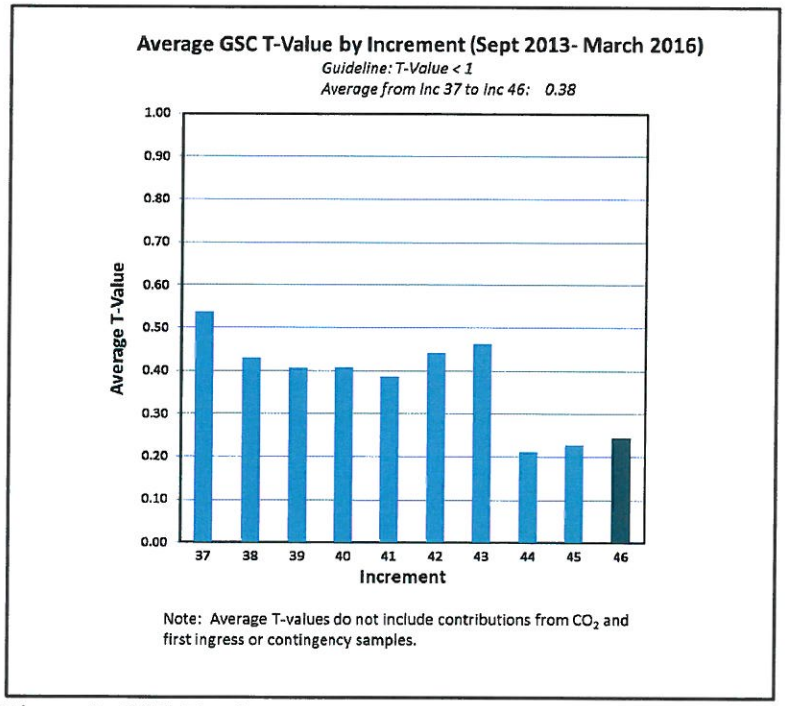

Figure 1. GSC T-values

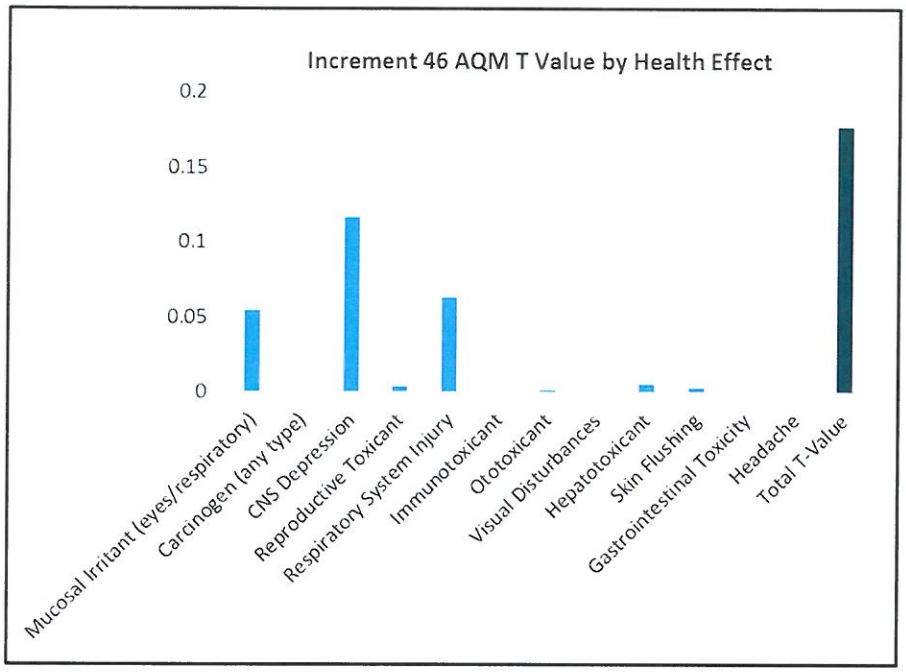

Figure 2. AQM T-values

Two mGSC samples contained a carbon dioxide concentration above the Increment limit documented in Chit 013929, which requests that the 24 hour average concentration not exceed 3 mmHg (7100 mg/m^3). However, the mGSCs provide only a snapshot of conditions and are not ideal for evaluating CO_2 exposures, which may fluctuate rapidly depending on crew activity. The major constituent analyzer (MCA) provides routine monitoring of CO_2 levels and is better suited for monitoring short and long-term trends in CO_2 data. Reported 24-hour average levels measured on the MCA decreased briefly in December due to 3-crew operations. During the remainder of December, January, and February the average CO_2 concentration was approximately 3 mmHg (7100 mg/m^3). There were several instances when levels exceeded the current Increment limit of 3.0 mmHg (24-hr avg) due to issues with the Carbon Dioxide Removal Assemblies (CDRAs). Node 3 CDRA was inoperable from 1/19/2016 to 2/4/2016. After maintenance was successfully completed, the CO_2 levels remained lower for the remainder of the Increment. The Lab CDRA functioned nominally and maintained acceptable CO_2 levels while the Node 3 CDRA was inoperable.

Alcohol values in all routine monthly samples continue to exceed the alcohol guideline of <5 mg/m^3, which is intended to protect the water recovery system from risk of overloading. These levels are primarily due to a sustained increase in ethanol levels on ISS. Elevated ethanol levels were also detected in US water samples during this Increment (see Water Quality discussion below). Formaldehyde levels in the US Lab (shown in Table 1 and Figure 3) are generally consistent with historic levels and remain below the SMAC of 120 μg/m^3.

Node 3 Contingency Sample

Concentrations of target compounds in the Node 3 contingency sample did not differ substantially from background ISS levels, although ethanol was elevated compared to samples collected eight days prior in the Lab and JEM. This increase in ethanol concentration did not affect the overall T-value or health of the crew, however, and is not likely to be the source of the odor since the GSC concentration differed only slightly from prior GSC samples. In addition, seven AQM measurements taken between February 3rd and February 21st revealed consistent ethanol levels, which further suggests that ethanol was not the source of the odor. All target compounds detected were well below SMAC levels and would not be expected to affect the health of the crew. The non-target compound, 1,1,1,2-tetrafluoroethane was also detected, but not at a

level substantially different than samples collected earlier or later during the Increment. Therefore, the source of the odor was not identified. It is commonly difficult to attribute odors to a particular source due to the ability of humans to detect odors at levels that are often lower than analytical capability.

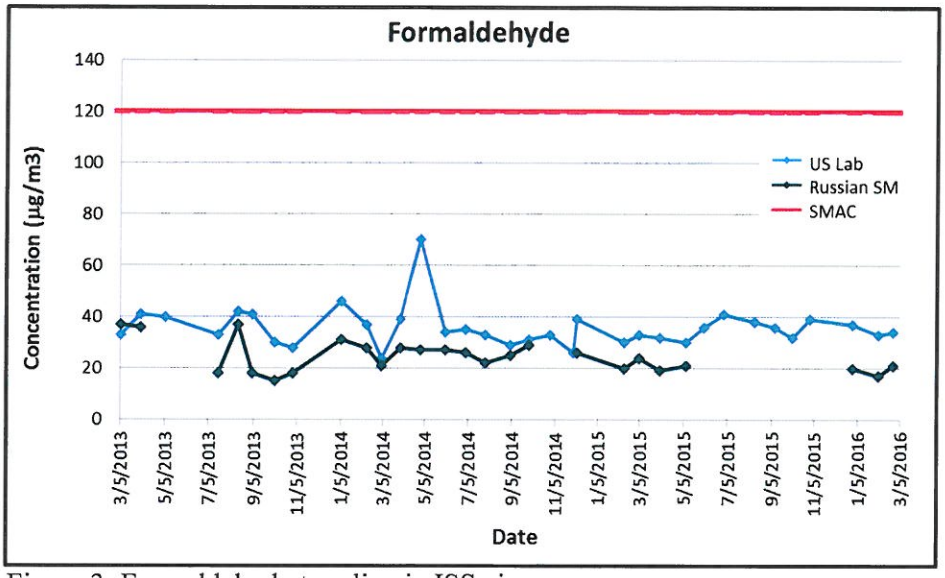

Figure 3. Formaldehyde trending in ISS air.

WATER QUALITY

Archive samples were collected from the potable water dispenser (PWD) in the US segment and the SVO-ZV and SRV-K systems in the Russian segment during Increment 46. In addition, samples of wastewater and condensate were also collected from the US segment during the Increment. All of these samples were returned on Soyuz 44. Due to limited sample volume, total solids were not measured on any of the Increment 46 samples and turbidity was not measured on condensate, wastewater or SVO-ZV samples. Complete data tables with results from these analyses can be found in report #2016-TEC-WQ-003. A summary of select analytical results is provided in Table 3 below.

Table 3. 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)	Manganese (µg/L)
PWD (ambient)	1/25/2016	<0.1	<1	2	<0.05	<1	<1
PWD (hot)	2/2/2016	0.16	<1	2	<0.05	<1	<1
SVO-ZV	2/2/2016	1.14	<1	310[b]	<0.05	90	43
SRV-K (hot)	2/2/2016	0.25	<1	41[b]	<0.05	36	19
US Wastewater[a]	2/12/2016	25	12	88	NA	3	13
US Condensate[a]	2/16/2016	114	35	300	NA	8	9

[a]US Wastewater and Condensate are not considered potable. The ISS Water Recovery System successfully removes contaminants and excess minerals from wastewater and condensate prior to consumption.
[b]Russian water system is intentionally mineralized.

Expanded summary tables containing organic carbon recoveries and results for analytes detected in the samples at concentrations above reporting limits are included as attachments to this report.

Toxicological Evaluation of ISS Water Quality: Routine water quality monitoring is performed in-flight using the total organic carbon analyzer (TOCA). The colorimetric water quality monitor kit (CWQMK) is also available to monitor biocide levels on an as-needed basis. Results from these analyses provide a general indication of overall water quality. Archive water samples are collected during each increment and returned for analysis in ground laboratories. Data from the ground analyses complement the in-flight data and provide a more complete understanding of water quality on the ISS.

Potable Water

All chemical parameters measured in U.S. potable water samples collected during Increment 46 met the requirements listed in SSP 41000. Total organic carbon (TOC) concentrations from in-flight and ground analyses performed on samples from the U.S. potable water system between March 2015 and March 2016 are shown in Figure 4. The TOC concentrations measured on the TOCA in the U.S. potable water samples (designated as "PWD TOC") and product water samples ("WPA PFU2") were below the method reporting limit (TOCA: 285 µg/L) throughout the Increment. TOC concentrations in the U.S. archive samples ("Archive TOC") were 160 µg/L for the PWD hot sample and below the method reporting limit (100 µg/L) for the PWD ambient sample. Results for all U.S. potable samples were well below the Spacecraft Water Exposure Guideline (SWEG) of 3.0 mg/L. Both Russian samples also contained acceptable TOC levels (SRV-K: 0.25 mg/L, SVO-ZV: 1.14 mg/L).

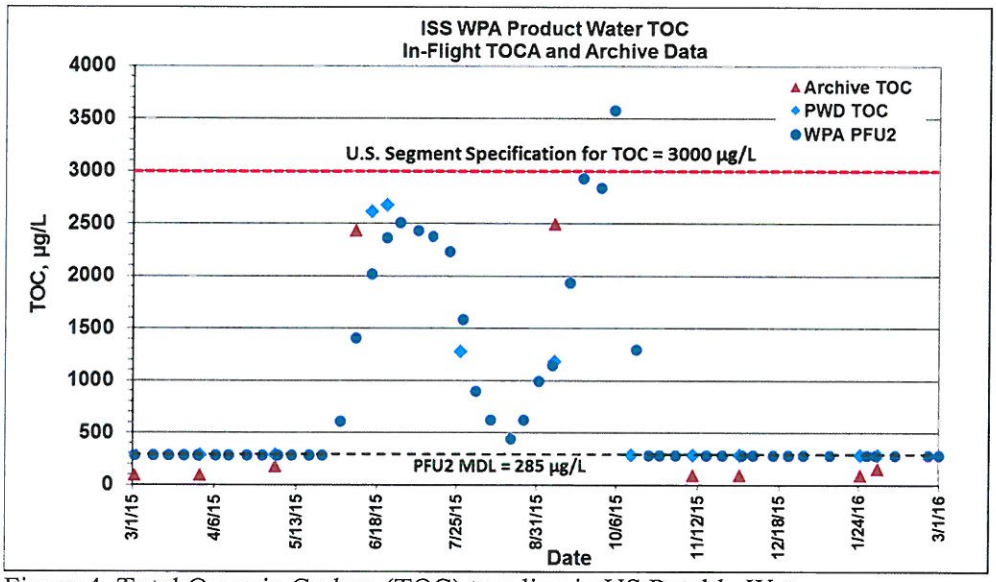

Figure 4. Total Organic Carbon (TOC) trending in US Potable Water

Although dimethylsilanediol (DMSD) was present in the wastewater and humidity condensate, it was not detected in any of the archive potable water samples. Only trace levels of other organics were detected. Silicon was detected in both U.S. samples (PWD ambient = 104 µg/L and PWD hot = 125 µg/L) at levels typically found when no DMSD is present. Zinc was detected in the PWD ambient sample at a concentration (42 µg/L) higher than in recent Increment samples, but well under the 1000 day SWEG (2,000 µg/L). Low levels of nickel (3-5 µg/L) were also detected in the U.S. potable water samples. Detectable levels of aluminum, arsenic, barium, copper, iron, magnesium, nickel, and zinc were present in both Russian potable water samples. Manganese was also detected in both samples, but the levels (43 and 19 µg/L) were below the 50 µg/L Medical Operations Requirements Document (MORD) limit. Inorganic levels tend to be higher in Russian water, which is mineralized to improve palatability. **Importantly, all compounds measured in these archive samples were below MORD limits.**

Iodine and silver are biocides used on the US and Russian segments, respectively. Iodine is added to the water produced by the Water Processor Assembly (WPA), but it is removed prior to crew consumption to avoid potential thyroid dysfunction. Total iodine levels in the samples collected from the PWD were below detection limits (0.05 mg/L), indicating effective removal of iodine. Conversely, silver levels in Russian water samples are expected to remain above the minimal effective biocidal level of 0.1 mg/L or 100 µg/L. The total silver concentration in the SVO-ZV (90 µg/L) was slightly under this minimum. The level in the SRV-K (36 µg/L) was substantially lower than the minimal effective biocide level, which increases the risk of microbial growth. For additional information regarding microbial analyses, please see the Increment 46 post-flight report issued by the JSC Environmental Microbiology Laboratory.

Wastewater

US wastewater is a composite of humidity condensate and urine distillate that is stored in the waste tank of the WPA prior to being processed into potable water. The TOC concentration in the sample was 25.0 mg/L, which is lower than Increment 44 (27.1 mg/L) and substantially less than typical U.S. wastewater concentrations (> 37 mg/L). Multiple compounds were detected at concentrations above 1 mg/L, including DMSD (12.0 mg/L), acetone (8.11 mg/L), methanol (5.38 mg/L), and propylene glycol (3.33 mg/L). Both silicon (4.23 mg/L) and ammonia (11.7 mg/L, as N) were below the historical averages for wastewater samples. The observed levels of alcohols do not pose a concern for crew health, but may negatively impact the performance of the water recovery system. No metals were detected above 0.1 mg/L, although traces of aluminum, chromium, manganese, silver, nickel, and zinc were present.

Condensate

The TOC concentration in the Lab condensate tank (collected on February 16, 2016) was 114 mg/L, which is below the historical average of 170 mg/L. Multiple compounds were detected at concentrations above 1.0 mg/L, but were comparable to those previously reported. The ethanol concentration (97.8 mg/L), which was within normal range, was higher than the Increment 45 sample (41.7 mg/L), but significantly lower than in the Increment 43 condensate sample (180 mg/L). This finding is consistent with February data from the ISS AQM, which showed a higher ethanol concentration than during Increment 45. DMSD (35 mg/L) and silicon (12.6 mg/L) were lower than levels in Increment 45 condensate (49.0 mg/L for DMSD; 16.0 mg/L for silicon).

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Enclosures

Tables 1A, 1B, and 1C: Analytical concentrations of compounds quantified in mGSCs returned on 45S, SpX-9, and SpX-8

Table 2A, 2B, and 2C: T-values corresponding to concentrations in Tables 1A, 1B, and 1C, based on 180-day SMACs

Table 3: Analytical concentrations of compounds quantified in US potable water samples returned on 44S

Table 4: Analytical concentrations of compounds quantified in Russian potable water samples returned on 44S

Table 5: Analytical concentrations of compounds quantified in US wastewater and condensate samples returned on 44S

TABLE 1A
ANALYTICAL RESULTS OF 45S RETURN GRAB AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M^3) AQ160195 SN 2013 LAB 12/28/15 @ 11:50 GMT
TARGET COMPOUNDS (TO-15) **	
Octafluoropropane (Perfluoropropane) *	**64**
Isobutane	TRACE
Methanol *	**0.43**
Acetaldehyde	0.24
2-Methyl-1-propene	TRACE
Ethanol *	**4.9**
Acetone	0.33
2-Propanol (Isopropanol)	0.18
Isoprene (2-Methyl-1,3-butadiene)	0.039
Methyl acetate	0.036
1-Propanol	TRACE
Trimethylsilanol	0.080
Ethyl acetate	0.057
1-Butanol	0.035
TOTAL ALCOHOLS PLUS ACETONE	**5.9**
TARGET COMPOUNDS (GC) **	
Carbon monoxide	1.2
Methane	5.5
Hydrogen	5.4
Carbon dioxide	6100
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	**71**
TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	**6.4**

* GC/FID data results are in bold

** Quantified using a multi-point calibration

TRACE: Amount detected is sufficient for compound identification only.

OFP - Octafluoropropane

TABLE 1B
ANALYTICAL RESULTS OF
SPACEX-9 RETURN GSC AIR SAMPLE

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M^3) AQ160241 SN 2014 SM 12/28/15 @ 12:00GMT
TARGET COMPOUNDS (TO-15) **	
Octafluoropropane (Perfluoropropane) *	**74**
Isobutane	TRACE
Methanol *	**0.51**
Acetaldehyde	0.29
2-Methyl-1-propene	TRACE
Ethanol *	**7.5**
Acetone	0.44
2-Propanol (Isopropanol)	0.21
Isoprene (2-Methyl-1,3-butadiene)	0.045
Methyl acetate	0.052
1-Propanol	TRACE
Trimethylsilanol	0.072
Ethyl acetate	0.071
1-Butanol	0.035
o-Xylene	TRACE
SPECIAL INTEREST COMPOUNDS ***	
Hexamethylcyclotrisiloxane #	0.28
NON-TARGET COMPOUNDS ***	
1,1,1,2-Tetrafluoroethane	0.081
TOTAL ALCOHOLS PLUS ACETONE	**8.7**
TARGET COMPOUNDS (GC) **	
Carbon monoxide	1.2
Methane	5.8
Hydrogen	5.5
Carbon dioxide	7500
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	**84**
TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	**9.7**

* GC/FID data results are in bold

** Quantified using a multi-point calibration

*** Quantified using "B" response factor except where noted; concentrations are estimates only.

Response factor generated from an internal study

< : Value is less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only.

OFP - Octafluoropropane

TABLE 1C
ANALYTICAL RESULTS OF SPACEX-8 RETURN GRAB AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION mg/M^3				
	AQ160101 SN 2016 LAB 02/03/16 @ 19:18 GMT	AQ160102 SN 2017 JPM 02/03/16 @ 19:18 GMT	AQ160112 SN 2018 NODE 3 02/11/16 @ 20:25 GMT	AQ160103 SN 2021 LAB 02/24/16 @ 15:40 GMT	AQ160104 SN 2025 COLUMBUS 02/24/16 @ 15:40 GMT
TARGET COMPOUNDS (TO-15) **					
Octafluoropropane (Perfluoropropane) *	**78**	**72**	**79**	**85**	**85**
Isobutane	<0.025	TRACE	<0.025	<0.025	<0.025
Methanol	**0.62**	**0.59**	**0.64**	**0.58**	**0.56**
Acetaldehyde	0.40	0.36	0.25	0.23	0.25
Ethanol	**6.0**	**5.2**	**8.2**	**10**	**9.9**
Acetone	0.36	0.33	0.33	0.34	0.40
2-Propanol (Isopropanol)	0.18	0.17	0.11	0.13	0.22
Isoprene (2-Methyl-1,3-butadiene)	0.044	0.036	0.039	0.052	0.057
1-Propanol	0.030	TRACE	TRACE	0.042	0.050
Trimethylsilanol	0.12	0.17	0.16	0.11	0.16
Ethyl acetate	0.059	0.048	0.053	0.059	0.061
1-Butanol	0.038	0.041	0.037	0.043	0.047
SPECIAL INTEREST COMPOUNDS ***					
Hexamethylcyclotrisiloxane #	<0.10	0.21	<0.10	<0.10	0.22
NON-TARGET COMPOUNDS ***					
1,1,1,2-Tetrafluoroethane	0.12	0.10	0.084	0.087	0.086
TOTAL ALCOHOLS PLUS ACETONE	**7.2**	**6.4**	**9.4**	**12**	**11**
TARGET COMPOUNDS (GC) **					
Carbon monoxide	0.94	0.99	1.1	1.1	1.2
Methane	5.3	5.3	4.8	5.6	5.5
Hydrogen	5.3	5.5	5.9	6.1	6.3
Carbon dioxide	5400	6100	6600	6400	7500
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	**86**	**80**	**89**	**97**	**97**
TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	**8.0**	**7.3**	**10**	**12**	**12**

* GC/FID data results are in bold

** Quantified using a multi-point calibration

*** Quantified using "B" response factor except where noted; concentrations are estimates only.

Response factor generated from an internal study

< : Value is less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only.

OFP - Octafluoropropane

TABLE 2A
T-VALUES FOR 45S RETURN GRAB AIR SAMPLE

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC) AQ160195 SN 2013 LAB 12/28/15 @ 11:50 GMT
TARGET COMPOUNDS (TO-15)	
Octafluoropropane (Perfluoropropane)	0.00076
Isobutane	0.00005
Methanol	0.00480
Acetaldehyde	0.06107
2-Methyl-1-propene	0.00001
Ethanol	0.00245
Acetone	0.00631
2-Propanol (Isopropanol)	0.00118
Isoprene (2-Methyl-1,3-butadiene)	0.01314
Methyl acetate	0.00030
1-Propanol	0.00013
Trimethylsilanol	0.01998
Ethyl acetate	0.00031
1-Butanol	0.00087
TARGET COMPOUNDS (GC)	
Carbon monoxide	0.06957
Methane	0.00156
Hydrogen	0.01591
Carbon dioxide	0.46851
TOTAL T-VALUE	**0.66690**
TOTAL T-VALUE - CO2	**0.19839**

ND : Value is less than the laboratory reporting limit.
Note: Number of decimal places in T-Values do not represent significant figures of measurements.

TABLE 2B
T-VALUES FOR SPACEX-9 RETURN GSC AIR SAMPLE

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC) AQ160241 SN 2014 SM 12/28/15 @ 12:00GMT
TARGET COMPOUNDS (TO-15)	
Octafluoropropane (Perfluoropropane)	0.00087
Isobutane	0.00005
Methanol	0.00568
Acetaldehyde	0.07237
2-Methyl-1-propene	0.00001
Ethanol	0.00377
Acetone	0.00849
2-Propanol (Isopropanol)	0.00137
Isoprene (2-Methyl-1,3-butadiene)	0.01509
Methyl acetate	0.00044
1-Propanol	0.00013
Trimethylsilanol	0.01808
Ethyl acetate	0.00039
1-Butanol	0.00088
o-Xylene	0.00068
SPECIAL INTEREST COMPOUNDS	
Hexamethylcyclotrisiloxane	0.03126
NON-TARGET COMPOUNDS	
1,1,1,2-Tetrafluoroethane	0.00077
TARGET COMPOUNDS (GC)	
Carbon monoxide	0.07276
Methane	0.00165
Hydrogen	0.01622
Carbon dioxide	0.57829
TOTAL T-VALUE	**0.82925**
TOTAL T-VALUE - CO2	**0.25096**

Note: Number of decimal places in T-Values do not represent

TABLE 2C
T-VALUES FOR SPACEX-8 RETURN GRAB AIR SAMPLES

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)				
	AQ160101 SN 2016 LAB 02/03/16 @ 19:18 GMT	AQ160102 SN 2017 JPM 02/03/16 @ 19:18 GMT	AQ160112 SN 2018 NODE 3 Contingency 02/11/16 @ 20:25 GMT	AQ160103 SN 2021 LAB 02/24/16 @ 15:40 GMT	AQ160104 SN 2025 COLUMBUS 02/24/16 @ 15:40 GMT
TARGET COMPOUNDS (TO-15)					
Octafluoropropane (Perfluoropropane)	0.00091	0.00085	0.00093	0.00100	0.00100
Isobutane	ND	0.00005	ND	ND	ND
Methanol	0.00684	0.00659	0.00709	0.00640	0.00621
Acetaldehyde	0.09899	0.08976	0.06346	0.05736	0.06171
Ethanol	0.00300	0.00261	0.00412	0.00521	0.00497
Acetone	0.00686	0.00634	0.00634	0.00653	0.00760
2-Propanol (Isopropanol)	0.00120	0.00110	0.00072	0.00085	0.00145
Isoprene (2-Methyl-1,3-butadiene)	0.01465	0.01213	0.01305	0.01726	0.01884
1-Propanol	0.00030	0.00013	0.00013	0.00042	0.00051
Trimethylsilanol	0.03065	0.04371	0.04067	0.02813	0.04065
Ethyl acetate	0.00033	0.00026	0.00029	0.00033	0.00034
1-Butanol	0.00095	0.00103	0.00092	0.00108	0.00119
SPECIAL INTEREST COMPOUNDS					
Hexamethylcyclotrisiloxane	ND	0.02309	ND	ND	0.02492
NON-TARGET COMPOUNDS					
1,1,1,2-Tetrafluoroethane	0.00112	0.00098	0.00081	0.00083	0.00083
TARGET COMPOUNDS (GC)					
Carbon monoxide	0.05551	0.05849	0.06374	0.06731	0.07084
Methane	0.00150	0.00153	0.00137	0.00160	0.00156
Hydrogen	0.01565	0.01622	0.01748	0.01790	0.01853
Carbon dioxide	0.41401	0.47152	0.50542	0.49559	0.57384
TOTAL T-VALUE	**0.65248**	**0.73641**	**0.72654**	**0.70780**	**0.83498**
TOTAL T-VALUE - CO2	**0.23847**	**0.26489**	**0.22112**	**0.21221**	**0.26114**

ND : Value is less than the laboratory report detection limit.
Note: Number of decimal places in T-Values do not represent significant figures of measurements.

Table 3. Expedition 46 Water Sample Summary Report
US Potable and Product Water Samples

Mission Sample Location Sample Description Sample Date Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	Soyuz 44/Expedition 46 WPA PWD Ambient Potable Water 1/25/2016 20160303001	 WPA PWD Hot Potable Water 2/2/2016 20160303002
Physical Characteristics						
pH	pH units	U.S.	4.5-8.5	41000	5.20	5.10
Conductivity	µS/cm	U.S.			2	2
Iodine (LCV)						
Total I	mg/L	U.S.	6/0.2	41000 (tl I max/tl I at pt of consumption)	NA	NA
Iodine	mg/L	U.S.			NA	NA
Iodide	mg/L	U.S.			NA	NA
Trace Metals (ICP/MS)						
Calcium	mg/L	U.S.	30	41000	0.07	<0.01
Potassium	mg/L	U.S.	340	41000	0.02	0.04
Sodium	mg/L	U.S.			0.02	0.02
Aluminum	µg/L	U.S.			1	<1
Cadmium	µg/L	U.S.	22	SWEG&41000	1	<1
Nickel	µg/L	U.S.	300	SWEG&41000	3	5
Zinc	µg/L	U.S.	2,000	SWEG&41000	42	5
Silicon (ICP/MS)						
Silicon (ICP/MS)	µg/L	U.S.			104	125
Total Organic Carbon (Sievers/OI)						
Inorganic Carbon	mg/L	U.S.			1.04	1.13
Organic Carbon	mg/L	U.S.	3	41000	<0.10	0.16
Semi-volatiles (GC/MS) - Target List						
Methyl sulfone	µg/L	U.S.			89	127
Silanols (LC/RI) (R & D Method -NIST traceable standard not available)						
Dimethylsilanediol (DMSD)	µg/L	U.S.	35,000	SWEG	NA	NA
Monomethylsilanetriol (MMST)	µg/L	U.S.	110,000	SWEG	NA	NA
Amines (IC)						
Trimethylamine	µg/L	U.S.	Trialkylamines 400	SWEG	NA	NA
Organic Carbon Recovery	percent	U.S.			NA	20.78
Unaccounted Organic Carbon	mg/L	U.S.			NA	0.12

Data Qualifiers: None.

Reviewed by/Date: *Debtah Plumlee* *signed on 3/24/2016 & 6/28/2016*

Approved by/Date: *William Wallace* *signed on 3/25/2016 & 6/28/2016*

NA=Not analyzed
MI=Matrix Interference
N/A=Not applicable

Table 4. Water Sample Summary Report
Russian Potable Water Samples

Mission					Soyuz 44/Expedition 46	
Sample Location			Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	SVO-ZV	SRV-K Hot
Sample Description					Potable Water	Potable Water
Sample Date					2/2/2016	2/2/2016
Analysis/Sample ID	Units	Test Conducted by			20160303003	20160303004
Physical Characteristics						
pH	pH units	U.S.	5.5-9.0	MORD	7.72	6.96
Conductivity	µS/cm	U.S.			310	41
Anions (IC)						
Chloride	mg/L	U.S.	250	MORD	10.8	0.8
Fluoride	mg/L	U.S.	1.5/4	MORD/EPA	0.2	<0.1
Sulfate	mg/L	U.S.	250	MORD	29.8	1.5
Metals (ICP/MS)						
Calcium	mg/L	U.S.	100	MORD	34.9	4.16
Magnesium	mg/L	U.S.	50	MORD	10.5	1.63
Potassium	mg/L	U.S.			2.92	0.12
Sodium	mg/L	U.S.			11.0	0.48
Aluminum	µg/L	U.S.			183	12
Arsenic	µg/L	U.S.	10	MORD/EPA	1	<1
Barium	µg/L	U.S.	1,000/10,000	MORD/SWEG	25	5
Copper	µg/L	U.S.	1,000/1,300	MORD/EPA	1	7
Iron	µg/L	U.S.	300	MORD	18	<5
Manganese	µg/L	U.S.	50/300	MORD/SWEG	43	19
Molybdenum	µg/L	U.S.			2	<1
Nickel	µg/L	U.S.	100/300	MORD/SWEG	9	4
Silver	µg/L	U.S.	500/400	MORD/SWEG	90	36
Silver, Dissolved	µg/L	U.S.			2	25
Zinc	µg/L	U.S.	5,000/2,000	MORD/SWEG	62	43
Silicon (ICP/MS)						
Silicon (ICP/MS)	µg/L	U.S.			1,850	106
Total Organic Carbon (OI)						
Inorganic Carbon	mg/L	U.S.			27.8	4.41
Organic Carbon	mg/L	U.S.	20	MORD	1.14	0.25
Organic Carbon Recovery	percent	U.S.			0.00	0.00
Unaccounted Organic Carbon	mg/L	U.S.			1.14	0.25

Data Qualifiers: None

Reviewed by/Date:	*Debtah Plumlee*	*signed on 3/24/2016*
Approved by/Date:	*William Wallace*	*signed on 3/25/2016*

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
#allowable limit after mineralization

Table 5. Expedition 46 Water Sample Summary Report
US Wastewater and Condensate Samples

Mission Sample Location Sample Description Sample Date Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	WPA Wastewater ORU WPA Wastewater 2/12/2016 **20160303005**	WPA Condensate Sample Port US Condensate sample 2/16/2016 **20160303006**
Physical Characteristics						
pH	pH units	U.S.	4.5-8.5	41000	7.72	7.89
Conductivity	µS/cm	U.S.			88	300
Anions (IC)						
Fluoride	mg/L	U.S.			0.2	0.2
Cations (IC)						
Ammonia as Nitrogen (NH3-N)	mg/L	U.S.	1	SWEG&41000	11.7	38.3
Trace Metals (ICP/MS)						
Calcium	mg/L	U.S.	30	41000	0.07	0.10
Potassium	mg/L	U.S.	340	41000	0.12	<0.01
Sodium	mg/L	U.S.			0.11	<0.01
Aluminum	µg/L	U.S.			4	7
Chromium	µg/L	U.S.	230	41000	65	3
Copper	µg/L	U.S.	1,000	41000	<1	1
Manganese	µg/L	U.S.	300	SWEG&41000	13	9
Nickel	µg/L	U.S.	300	SWEG&41000	233	462
Silver	µg/L	U.S.	400	SWEG&41000	3	8
Zinc	µg/L	U.S.	2,000	SWEG&41000	721	1,790
Silicon (ICP/MS)						
Silicon (ICP/MS)	µg/L	U.S.			4,230	12,600
Total Organic Carbon (OI)						
Inorganic Carbon	mg/L	U.S.			10.9	23.4
Organic Carbon	mg/L	U.S.	3	41000	25.0	114
Volatile Organics						
Acetone	µg/L	U.S.	15,000	SWEG	8,110	2,570
Volatile Organics -Special Interest Compounds (Semi-quantitative)						
Acetaldehyde	µg/L	U.S.			not found	980
Trimethylsilanol	µg/L	U.S.			100	280
Semi-volatiles (GC/MS) - Target List						
Benzothiazole	µg/L	U.S.			81	109
N-n-Butylbenzenesulfonamide	µg/L	U.S.			<40	86
Decamethylcyclopentasiloxane	µg/L	U.S.			<40	76
Dodecamethylcyclohexasiloxane	µg/L	U.S.			<40	61
Methyl sulfone	µg/L	U.S.			206	224
Benzoic acid	µg/L	U.S.			<200	**>640**
Phenol	µg/L	U.S.	4,000	SWEG	150	431
bis-(2-Ethylhexyl)phthalate	µg/L	U.S.	20,000/6	SWEG/EPA	<40	44
Benzyl alcohol	µg/L	U.S.			<40	6,510
Dibutylphthalate	µg/L	U.S.	40,000	SWEG	<40	74
Diethylphthalate	µg/L	U.S.			106	1,090
Semi-volatiles (GC/MS) - Special Interest Compounds (Semi-quantitative - 2 pt curve)						
Acetophenone	µg/L	U.S.			not found	29
Benzaldehyde	µg/L	U.S.			not found	89
2-Butoxyethanol	µg/L	U.S.			not found	170
2-(2-Butoxyethoxy)ethanol	µg/L	U.S.			250	2,100
Butylated hydroxyanisole (BHA)	µg/L	U.S.			<80	200
N,N-Diethylformamide	µg/L	U.S.			not found	660
N,N-Dimethyl acetamide	µg/L	U.S.			380	930
Dipropylene glycol methyl ether	µg/L	U.S.			150	not found
2-Ethoxyethanol	µg/L	U.S.			not found	500
2-Ethyl-1-hexanol	µg/L	U.S.			not found	170
2-Ethylhexanoic acid	µg/L	U.S.			not found	130
Ibuprofen	µg/L	U.S.			840	not found
p-Menth-1-en-8-ol (alpha-Terpineol)	µg/L	U.S.			not found	65
1-Methyl-2-pyrrolidinone	µg/L	U.S.			310	690
Monomethyl phthalate	µg/L	U.S.			not found	**>120**
(+)-Neomenthol	µg/L	U.S.			100	61
2-Phenoxyethanol	µg/L	U.S.			not found	250
Phenethyl alcohol	µg/L	U.S.			not found	51
Tributyl phosphate	µg/L	U.S.			not found	26
Alcohols (DAI/GC/MS)						
Ethanol	µg/L	U.S.			<400	97,800
Methanol	µg/L	U.S.	40,000	SWEG	5,380	6,970
Glycols (DAI/GC/MS)						
1,2-Ethanediol (Ethylene glycol)	µg/L	U.S.	4000	SWEG	<1000	1,360
1,2-Propanediol (Propylene glycol)	µg/L	U.S.	1,700,000	SWEG	3,330	15,100
Silanols (LC/RI) (R & D Method -NIST traceable standard not available)						
Dimethylsilanediol (DMSD)	µg/L	U.S.	35,000	SWEG	12,000	35,000
Carboxylates (IC)						
Acetate	µg/L	U.S.			<500	42,900
Non-volatiles (LC/UV-VIS)						
Caprolactam	µg/L	U.S.	100,000	SWEG	<500	1,190

NA=Not analyzed
MI=Matrix Interference
N/A=Not applicable

Table 5. Expedition 46 Water Sample Summary Report
US Wastewater and Condensate Samples

Mission Sample Location Sample Description Sample Date Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	WPA Wastewater ORU WPA Wastewater 2/12/2016 **20160303005**	WPA Condensate Sample Port US Condensate sample 2/16/2016 **20160303006**
Organic Carbon Recovery	percent	U.S.			53.68	89.01
Unaccounted Organic Carbon	mg/L	U.S.			11.58	12.53

Data Qualifiers: **20160303005** - Possible low bias: acetone & 1-pentanol
20160303006 - Possible high bias-acetone; possible low bias-ethanol

Reviewed by/Date: *Debtah Plumlee* *signed on 3/24/2016*

Approved by/Date: *William Wallace* *signed on 3/25/2016*

NA=Not analyzed
MI=Matrix Interference
N/A=Not applicable