

JSC TOXICOLOGY AND ENVIRONMENTAL CHEMISTRY GROUP

Amelia Romoser, PhD, DABT
Toxicology and Environmental Chemistry
NASA JSC/SK4
Houston, TX 77058



**Memorandum Number
TOX-AR-2017-05**

Voice: (281) 483-3223
Fax: (281) 483-3058
amelia.a.romoser@nasa.gov

DATE: November 2, 2017
SUBJECT: Toxicological Assessment of ISS Air and Water Quality: April 10, 2017 – June 2, 2017 (Increment 51), Including OA-7 Ingress Report
SUMMARY: Based on these data, air quality was acceptable on ISS for this period and potable water remains acceptable for crew consumption.

AIR QUALITY

Three archive air samples were collected in mini grab sample containers (mGSCs) on ISS during Increment 51. Two of these samples were collected as part of routine monitoring in the US Lab and Columbus Module (COL). The third sample was collected as part of nominal ingress operations following initial hatch opening of Orbital/ATK-7 (OA-7). Two pairs of passive-diffusion formaldehyde badges were also deployed in the Lab and SM on 5/8/2017. The mGSC samples were returned on SpX-11 while formaldehyde badges were returned later on SpX-12. A summary of the analytical results from the samples is provided in Table 1.

Table 1. Analytical summary of ISS air analyses

Sample Location	Sample Date	Freon 218 (mg/m ³)	Alcohols ^a (mg/m ³)	T-Value ^b (units)	CO ₂ (mg/m ³)	Formaldehyde (µg/m ³)
OA-7 Ingress	4/22/2017	21	6.5	2.8 (1.6)	4100	-
Lab	5/8/2017	74	7.5	0.2	6600	25 ^e
COL	5/8/2017	75	7.4	0.2	7000	-
SM	5/8/2017	-	-	-	-	17 ^e
<i>Guideline</i>		---	<5	<1 ^c	<7100 ^d	<120

^aIncludes acetone

^bSum of the ratios of the measured concentration and the corresponding 180-day SMAC for each compound, excluding CO₂; parentheses indicate value based on 7-day SMACs and applicable to first ingress

^cT-value <1 used to evaluate routine monthly sampling; <3 used to evaluate first ingress

^dCO₂ to be controlled as low as reasonably achievable (ALARA) – currently 3 mmHg (7100 mg/m³) or lower

^eAverage from pair of formaldehyde badges

Data tables containing measured 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 mean relative recoveries of the 3 surrogate standards from the SpX-11 return mGSC samples were as follows: ¹³C-acetone, 112±10%; fluorobenzene-d₅, 108±9%; and chlorobenzene-d₅, 113±23%. For the passive-diffusion formaldehyde badges, positive control recoveries (1 in-flight and 2 lab controls) were 95, 71, and 106%, respectively.

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/m³) of AQM target compounds

	April	May	Average
2-Propanol	0.19	0.13	0.16
Acetone	0.37	0.35	0.36
Acrolein	ND	ND	ND
Benzene	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
Decamethylcyclopentasiloxane#	0.16	0.20	0.18
Hexanal	ND	ND	ND
Hexane	ND	ND	ND
m,p-Xylenes#	ND	ND	ND
Methanol	0.29	0.27	0.28
o-Xylene#	0.03	0.03	0.03
Octamethylcyclotetrasiloxane#	TRACE	TRACE	TRACE
Toluene#	0.03	0.03	0.03
2-Butanone	ND	ND	ND
Acetaldehyde	0.12	0.12	0.12
Dichloromethane	ND	ND	ND
Ethanol	3.58	3.71	3.65
Ethyl Acetate	0.05	0.05	0.05
Hexamethylcyclotrisiloxane#	0.07	0.07	0.07
n-Butanol	0.08	0.08	0.08
Trimethylsilanol	0.17	0.16	0.17

Obtained from prime unit

ND: Not detected

TRACE= >MDL (Minimum Detection Limit), <MQL (Minimum Quantification Limit)

Toxicological Evaluation of ISS Air Quality

Routine air quality monitoring is performed in-flight using the AQMs. Archive air samples (mGSCs and formaldehyde badges) are collected during each Increment and returned for analysis in the Toxicology and Environmental Chemistry (TEC) Air Quality Laboratory. Data from the ground analyses complement the in-flight data and provide a more complete understanding of air quality on the ISS. The routine archive samples for this Increment that returned on SpX-11 confirmed air quality was acceptable during this timeframe. **All measured values for routine samples (mGSC and AQM) met T-value guideline criteria (T < 1), indicating no concern for crew health.** The average, rounded T-value calculated from the Increment 51 mGSC samples was 0.2 (Figure 1). The average, rounded T-value calculated from the AQM data (Figure 2) was slightly lower (0.1 units), but still showed close agreement with the mGSC value. Due to a modification of the process for calculating T-values from AQM data, the T-value for Increment 51 is approximately half of what was documented in recent reports (Refer to TOX-AR-2017-04 for details). Overall, the reported concentrations for the compounds detected are consistent with levels detected since installation of the Node 1 carbon filters in May 2015.

The nominal mGSC samples contained a CO₂ concentration below the Increment limit documented in Chit 14468, which requests that the 24 hour average concentration not exceed 3.0 mmHg (7100 mg/m³). While mGSC CO₂ sampling provides a snap-shot of the CO₂ concentration, the major constituent analyzer (MCA) routinely monitors CO₂ levels in the US segment. For this reason, data from the MCA is better suited for evaluation of short and long-term trends in CO₂. The MCA data concentrations fluctuate as a result of multiple factors including the number of crew on ISS, current scrubbing capability, and processes and activities that generate CO₂. The average 24 hr CO₂ concentration was approximately 3.0 mmHg or less during all stages (3, 5, and 6-crew operations) of the Increment. Brief excursions above the 3.0 mmHg Increment limit were due to MetOx regeneration activities on April 13 and May 22. CO₂ concentrations were, overall, well controlled.

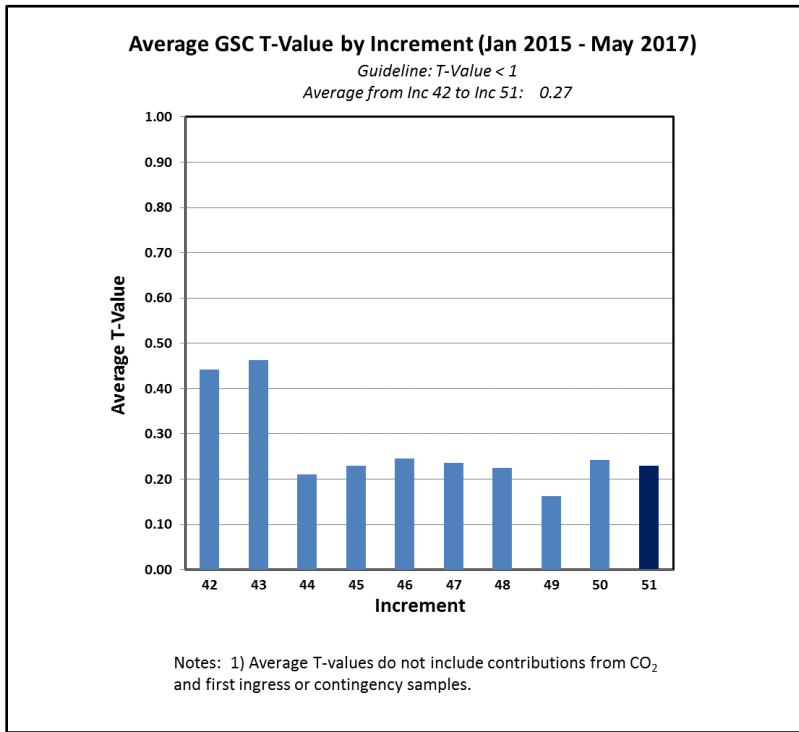


Figure 1. GSC T-values

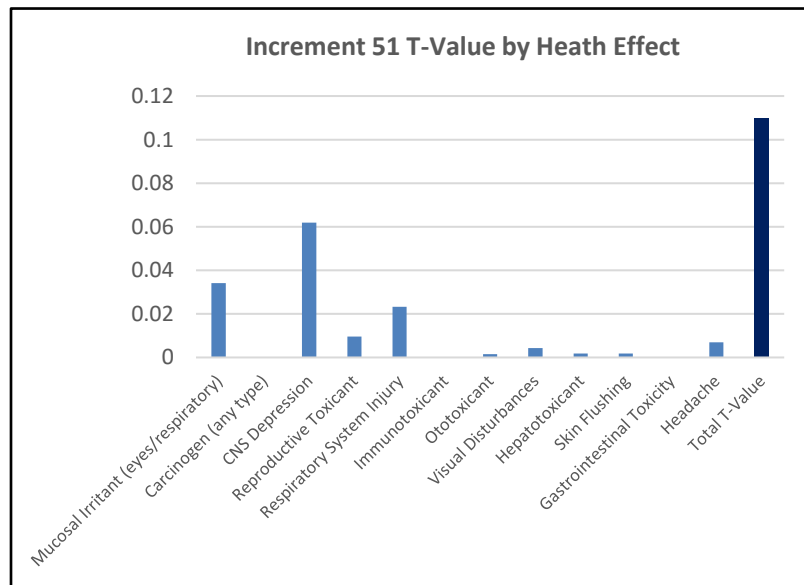


Figure 2. AQM T-values

Alcohol values in May routine samples continued to exceed the guideline of <5 mg/m³, which is intended to protect the water recovery system from risk of overloading. These levels are primarily due to ethanol in the ISS atmosphere. AQM results for ethanol were lower than the levels measured in the mGSCs, with an Increment average of 3.65 mg/m³. This difference may be due to temporal and spatial differences between the AQMs and mGSC sample points. Importantly, ethanol levels during the entire Increment did not present a risk for crew health. 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 $120 \mu\text{g}/\text{m}^3$. Non-methane volatile organic compounds (NMVOCs) were detected at total concentrations of 8.7 and $8.9 \text{ mg}/\text{m}^3$ in nominal archive US Lab and Columbus samples, respectively.

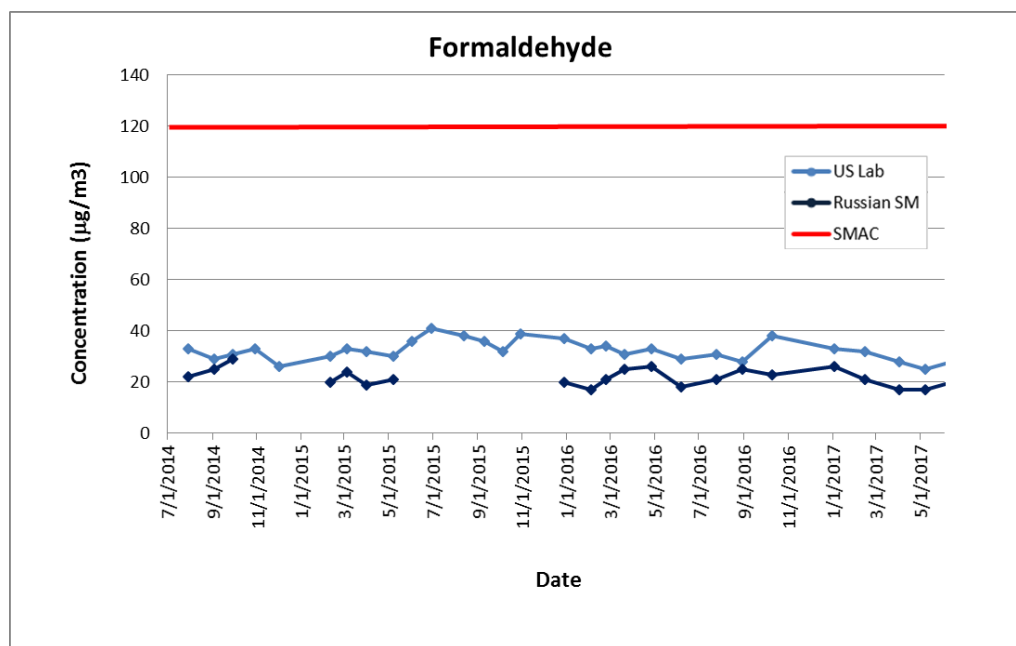


Figure 3. Formaldehyde trending in ISS air.

OA-7 Ingress

A first ingress sample was collected on 4/22/2017, approximately three minutes after hatch opening. The concentration of Freon 218 (octafluoropropane), a marker for ISS air dilution of first entry samples, indicated ~ 27% mixing with the ISS atmosphere prior to sample collection. The total T-value (minus CO_2) was 1.6, which was well below the limit of 3.0 units. After accounting for dilution, exposure to OA-7 vehicle air would have posed no risk to crew health. Comparatively, the level was similar to OA-6, but the Freon 218 concentration suggests that less dilution with ISS air occurred in the OA-6 sample (~11%). This would imply that the OA-6 first ingress environment contained a lower total concentration of volatile contaminants that significantly contributed to the overall T-value than OA-7. No vehicle off-gas test was performed for OA-7, but previous Orbital/ATK vehicles were tested, including OA-6 and OA-4. First ingress of OA-7 and OA-6 yielded similar levels of fluorotrimethylsilane, a compound that significantly impacted the T-value in OA-4. Acetaldehyde ($1.0 \text{ mg}/\text{m}^3$), trimethylsilanol ($2.1 \text{ mg}/\text{m}^3$), dodecafluoropentane ($55 \text{ mg}/\text{m}^3$), fluorotrimethylsilane ($0.49 \text{ mg}/\text{m}^3$), and carbon monoxide ($8.9 \text{ mg}/\text{m}^3$) were the primary contributors to the OA-7 T-value. The concentration of total NMVOCs was $78 \text{ mg}/\text{m}^3$. As might be expected, the total volatile organic compound (VOC) concentration was higher in the OA-7 first entry sample than in the nominal ISS samples. VOC totals generally have limited toxicological applications in situations where individual VOCs can be quantified, although the total load may have usefulness to ECLSS or other stakeholders. Previous memos have cited a guideline value of $25 \text{ mg}/\text{m}^3$ as a general screening indicator for situations where totals are sufficient to potentially cause odors or perception of poor air quality. However, NASA JSC Toxicology is discontinuing this comparison to total VOC concentration, as there is not sufficient scientific evidence to suggest that this is an appropriate guideline or consideration in spaceflight applications. NASA JSC Toxicology will continue to focus on the evaluation of each measured chemical by comparing with applicable SMACs, and by utilizing t-values to assess the overall toxicity of a chemical mixture.

WATER QUALITY

Three archive samples were collected from the US segment during Increment 51. These consisted of one potable water sample from the Hot leg of the US Potable Water Dispenser (PWD), as well as samples of US condensate and wastewater. All three samples were returned on SpX-11. Complete data tables with results for all measured parameters can be found in report 2017-TEC-WQ-003.1. A summary of select analytical results is provided in Tables 3 and 4. Expanded summary tables containing organic carbon recoveries and results for all analytes present at concentrations above reporting limits are included as attachments to this report.

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)
PWD (Hot)	4/25/2017	1.39	4.3	2	<0.05
US Condensate	5/8/2017	48.1	37.0	300	NA
WPA Wastewater	5/19/2017	41.4	12.0	112	NA

Toxicological Evaluation of ISS Water Quality: Routine water quality monitoring is performed in-flight using the total organic carbon analyzer (TOCA). Results from these analyses provide a general indication of overall water quality. Archive water samples are collected during each Increment and returned for comprehensive 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

Concentrations of all chemicals met the requirements listed in SSP 41000, *System Specification for the International Space Station*. Total organic carbon (TOC) concentrations from in-flight (PWD TOC and WPA PFU2) and ground analyses (Archive TOC) performed on samples from the U.S. potable water system between June 2016 and June 2017 are shown in Figure 4. While the TOC concentration was elevated during Increment 51 compared to normal levels (primarily due to DMSD), the TOC concentrations measured in the U.S. potable water samples and product water sample remained below the U.S. Segment Specification (3000 µg/L).

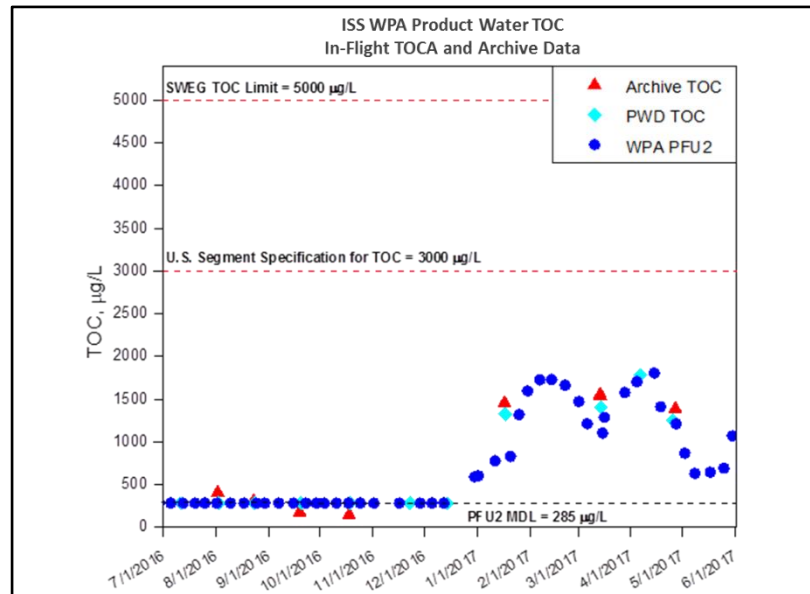


Figure 4. Total Organic Carbon (TOC) trending in US Potable Water

The TOC concentration in the U.S. archive sample (Archive TOC) was 1390 µg/L for the PWD hot sample. Compared to the Increment 50 archive sample (PWD hot: 1330 µg/L), TOC concentrations were similar and well below the Spacecraft Water Exposure Guideline (SWEG) of 5.0 mg/L (5000 µg/L).

As mentioned, the source of the TOC in the potable sample was primarily DMSD (4.3 mg/L). Methyl sulfone, another minor contributor to the TOC, was higher (118 µg/L) than the historical average, but consistent with levels from recent samples. Silicon was also detected (1.29 mg/L) at levels typically seen when DMSD is present in the water. Traces of nickel (3 µg/L), aluminum (2 µg/L), and zinc (3 µg/L) were also detected. **Importantly, all chemical parameters measured in U.S. potable water samples collected during Increment 50 met the requirements listed in SSP 41000 and the Medical Operations Requirement Document (MORD).**

Iodine is a biocide used on the US segment. It is added to the water produced by the Water Processor Assembly (WPA), but removed prior to crew consumption to avoid potential thyroid dysfunction. The total iodine level in the sample collected from the PWD was below the reporting limit (0.05 mg/L), indicating effective removal of iodine in water intended for consumption. For additional information regarding microbial analyses, please see the Increment 51 post-flight report issued by the JSC Environmental Microbiology Laboratory.

Condensate

One condensate sample was collected on 5/8/2017. The TOC level in this sample was 48.1 mg/L, which is below the historical average (166 mg/L). This sample contained some of the lowest levels of contaminants ever detected in a condensate sample. For example, ethanol, 2-propanol, and acetate concentrations were below the method reporting limit. Historical averages for these compounds are 50.1 mg/L, 1.08 mg/L, and 46.0 mg/L, respectively. Metals detected in the sample above 0.1 mg/L included zinc (1.18 mg/L) and nickel (0.501 mg/L). Traces of aluminum (10 µg/L), silver (18 µg/L), and manganese (25 µg/L) were also present. These compounds were effectively removed by the WRS as evidenced by the low or undetectable levels in the potable samples.

Wastewater

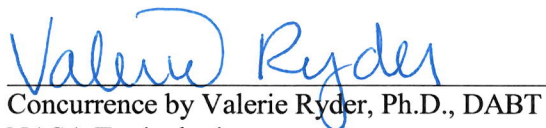
One wastewater sample was collected on 5/19/2017. The TOC level in this sample (41.4 mg/L) was below the historical average of 46.4 mg/L, but higher than recent samples. The DMSD concentration was 12 mg/L, which was slightly lower than Increment 50 (22 mg/L). Other organic compounds detected at levels above 1 mg/L were ethanol (33.6 mg/L), methanol (9.74 mg/L), acetone (7.82 mg/L), propylene glycol (5.82 mg/L), and ethylene glycol (2.02 mg/L). Metals detected above 0.1 mg/L in the samples were zinc (1.15 mg/L) and nickel (0.117 mg/L). Traces of other metals, including aluminum, manganese, and silver were also present. Chromium concentrations have returned to normal levels, which correlates well with the recent decrease in distillate conductivity following installation of the new Distillation Apparatus (DA) in April 2017. As with the condensate samples, all compounds of toxicological interest were effectively cleaned from the samples by the WRS.



Amelia Romoser, Ph.D., DABT
KBRwyle Toxicologist

11/6/2017

Date



Concurrence by Valerie Ryder, Ph.D., DABT
NASA Toxicologist

11/6/2017

Date

- Enclosures
- Table 1: Analytical concentrations of compounds quantified in mGSCs returned on SpX11
 - Table 2A: T-values corresponding to concentrations in Table 1, based on 180-day SMACs
 - Table 2B: T-values corresponding to OA-7 Ingress concentrations in Table 1, based on 7-day and 180-day SMACs
 - Table 3: Analytical concentrations of compounds quantified in US potable water sample returned on SpX-11
 - Table 4: Analytical concentrations of compounds quantified in US wastewater and condensate samples returned on SpX-11

TABLE 1
ANALYTICAL RESULTS OF SPACEX-11 RETURN AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M3)		
	AQ170137 SN2049 OA-7 Ingress 04/22/17 @ 16:51 GMT	AQ170138 SN2061 LAB 05/08/17 @ 14:30 GMT	AQ170139 SN2059 Columbus 05/08/17 @ 14:30 GMT
TARGET COMPOUNDS (TO-15) **			
1,1,1,2-Tetrafluoroethane (Norflurane)	1.3	0.084	0.081
Perfluoro(2-methylpentane)	<0.10	<0.10	<0.10
Propene	0.037	<0.025	<0.025
Propane	0.026	<0.025	<0.025
Carbonyl sulfide (Carbon oxide sulfide)	0.10	<0.025	<0.025
Chloromethane	TRACE	<0.025	<0.025
Isobutane	0.23	<0.025	<0.025
Methanol	0.71	0.35	0.39
Acetaldehyde	1.0	0.28	0.28
2-Methyl-1-propene	0.74	TRACE	<0.025
Butane	0.049	<0.025	<0.025
Ethanol *	2.5	6.6	6.4
Acetone	0.70	0.31	0.33
Propanal (Propionaldehyde)	0.078	<0.025	<0.025
2-Propanol (Isopropanol)	2.3	0.15	0.15
Isoprene (2-Methyl-1,3-butadiene)	<0.025	0.029	0.033
2-Methyl-2-propanol	0.13	<0.025	<0.025
Methylene chloride (Dichloromethane)	<0.025	<0.025	<0.025
Carbon disulfide	0.048	<0.025	<0.025
1-Propanol	0.043	0.032	0.035
Trimethylsilanol	2.1	0.14	0.16
Butanal (Butyraldehyde)	0.040	<0.025	<0.025
2-Butanone (Methyl ethyl ketone)	0.24	TRACE	TRACE
Ethyl acetate	0.047	0.028	0.029
1-Butanol	0.17	0.065	0.11
2-Methylhexane	<0.025	<0.025	<0.025
4-Methyl-2-pentanone (MIBK)	0.026	<0.025	<0.025
Toluene	0.11	TRACE	0.027
Hexanal	0.029	<0.025	<0.025
Butyl acetate	0.11	<0.050	<0.050
Chlorobenzene	<0.050	<0.050	TRACE
Heptanal	TRACE	<0.050	<0.050
o-Xylene	TRACE	<0.050	<0.050
Octamethylcyclotetrasiloxane	0.99	<0.125	<0.125
1,4-Dichlorobenzene	<0.050	<0.050	0.065
Decamethylcyclopentasiloxane	0.73	0.24	0.30
Octafluoropropane (Perfluoropropane) *	21	74	75
SPECIAL INTEREST COMPOUNDS ***			
Hexamethylcyclotrisiloxane #	5.7	<0.20	TRACE
NON-TARGET COMPOUNDS ***			
Dodecafluoropentane	55	0.081	0.097
Tetradecafluorohexane	0.20	0.26	0.27
Fluorotrimethylsilane	0.49	<0.050	<0.050
2-Methyl-1-propanol	0.060	<0.050	<0.050
Pentamethyldisiloxane-1-ol	0.15	<0.050	<0.050
Octamethyltrisiloxane	0.17	<0.050	<0.050
C11-Alkane	0.12	<0.050	<0.050
Unidentified siloxane	0.14	<0.050	<0.050
C11-Alkane	0.060	<0.050	<0.050
C12-Alkane	0.18	<0.050	<0.050
Decamethyltetrasiloxane	0.11	<0.050	<0.050
C12-Alkane	0.071	<0.050	<0.050
C12-Alkane	0.23	<0.050	<0.050
C12-Alkane	0.17	<0.050	<0.050
C12-Alkane	0.17	<0.050	<0.050
C12-Alkane	0.063	<0.050	<0.050
TOTAL ALCOHOLS PLUS ACETONE	6.5	7.5	7.4
TARGET COMPOUNDS (GC) **			
Methane	4.9	16.2	16.5
Carbon dioxide	4100	6600	7000
Hydrogen	2.2	3.8	3.9
Carbon monoxide	8.9	0.85	0.85
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	99	82	84
TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	78	8.7	8.9

* 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 reporting limit.

TRACE: Amount detected is sufficient for compound identification only. One-half of the reporting limit was used in the Total Concentration summation.

OFP - Octafluoropropane

**TABLE 2A
T-VALUES FOR SPACEX-11 RETURN AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)	
	AQ170138 SN2061 LAB 05/08/17 @ 14:30 GMT	AQ170139 SN2059 Columbus 05/08/17 @ 14:30 GMT
TARGET COMPOUNDS (TO-15)		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.00042	0.00040
Methanol	0.00393	0.00436
Acetaldehyde	0.06961	0.07021
2-Methyl-1-propene	0.00011	ND
Ethanol	0.00328	0.00318
Acetone	0.00604	0.00644
2-Propanol (Isopropanol)	0.00102	0.00098
Isoprene (2-Methyl-1,3-butadiene)	0.00973	0.01091
1-Propanol	0.00033	0.00036
Trimethylsilanol	0.03555	0.04022
2-Butanone (Methyl ethyl ketone)	0.00042	0.00042
Ethyl acetate	0.00016	0.00016
1-Butanol	0.00162	0.00287
Toluene	0.00083	0.00181
Chlorobenzene	ND	0.00054
1,4-Dichlorobenzene	ND	0.00217
Decamethylcyclopentasiloxane	0.01571	0.02024
Octafluoropropane (Perfluoropropane)	0.00086	0.00088
SPECIAL INTEREST COMPOUNDS		
Hexamethylcyclotrisiloxane	ND	0.01111
NON-TARGET COMPOUNDS		
Dodecafluoropentane	0.00028	0.00033
Tetradecafluorohexane	0.00000	0.00000
TARGET COMPOUNDS (GC)		
Methane	0.00464	0.00472
Carbon dioxide	0.51029	0.53633
Hydrogen	0.01122	0.01144
Carbon monoxide	0.04972	0.05026
TOTAL T-VALUE	0.72574	0.78035
TOTAL T-VALUE - CO2	0.21545	0.24402

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 OA-7 INGRESS AIR SAMPLE

CHEMICAL CONTAMINANT	T-VALUE (7-d SMAC)	T-VALUE (180-d SMAC)
	AQ170137 SN2049 OA-7 Ingress 04/22/17 @ 16:51 GMT	AQ170137 SN2049 OA-7 Ingress 04/22/17 @ 16:51 GMT
TARGET COMPOUNDS (TO-15)		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.00631	0.00631
Propene	0.00021	0.00021
Propane	0.00024	0.00469
Carbonyl sulfide (Carbon oxide sulfide)	0.04133	0.04133
Chloromethane	0.00030	0.00030
Isobutane	0.00097	0.00097
Methanol	0.00787	0.00787
Acetaldehyde	0.25922	0.25922
2-Methyl-1-propene	0.00647	0.00647
Butane	0.00034	0.00693
Ethanol	0.00123	0.00123
Acetone	0.01347	0.01347
Propanal (Propionaldehyde)	0.00652	0.00652
2-Propanol (Isopropanol)	0.01540	0.01540
2-Methyl-2-propanol	0.00090	0.00112
Carbon disulfide	0.08048	0.08048
1-Propanol	0.00044	0.00044
Trimethylsilanol	0.51269	0.51269
Butanal (Butyraldehyde)	0.00265	0.00265
2-Butanone (Methyl ethyl ketone)	0.00813	0.00813
Ethyl acetate	0.00026	0.00026
1-Butanol	0.00215	0.00431
3-Methylhexane	0.00010	0.00211
4-Methyl-2-pentanone (MIBK)	0.00019	0.00019
Toluene	0.00727	0.00727
Hexanal	0.00144	0.00144
Butyl acetate	0.00058	0.00058
Heptanal	0.00109	0.00109
o-Xylene	0.00034	0.00068
Octamethylcyclotetrasiloxane	0.00355	0.08288
Decamethylcyclopentasiloxane	0.00732	0.04879
Octafluoropropane (Perfluoropropane)	0.00024	0.00024
SPECIAL INTEREST COMPOUNDS		
Hexamethylcyclotrisiloxane	0.06357	0.63572
NON-TARGET COMPOUNDS		
Dodecafluoropentane	0.18774	0.18774
Tetradecafluorohexane	0.00000	0.00000
Fluorotrimethylsilane	0.12832	0.12832
2-Methyl-1-propanol	0.00050	0.00050
Pentamethyldisiloxane-1-ol	0.00302	0.00302
Octamethyltrisiloxane	0.00017	0.00425
C11-Alkane	0.00265	0.00265
Unidentified siloxane	0.01383	0.13827
C11-Alkane	0.00136	0.00136
C12-Alkane	0.00402	0.00402
Decamethyltetrasiloxane	0.00009	0.00018
C12-Alkane	0.00161	0.00161
C12-Alkane	0.00527	0.00527
C12-Alkane	0.00385	0.00385
C12-Alkane	0.00385	0.00385
C12-Alkane	0.00143	0.00143
TARGET COMPOUNDS (GC)		
Methane	0.00139	0.00139
Carbon dioxide	0.31446	0.31446
Hydrogen	0.00650	0.00650
Carbon monoxide	0.14082	0.52187
TOTAL T-VALUE		
	1.87415	3.09252
TOTAL T-VALUE - CO2		
	1.55969	2.77806

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 3. Increment 51 Water Sample Summary Report
US Potable Water Sample**

Increment Mission	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	51
					SpX-11
Sample Location					WPA PWD Hot
Sample Description					Potable Water
Sample Date					4/25/2017
Analysis/Sample ID					20170705001
Physical Characteristics					
pH	pH units	U.S.	4.5-8.5	41000	5.87
Conductivity	µS/cm	U.S.			2
Trace Metals (ICP/MS)					
Calcium	mg/L	U.S.	30	41000	0.02
Sodium	mg/L	U.S.			0.03
Aluminum	µg/L	U.S.			2
Nickel	µg/L	U.S.	300	SWEG&41000	3
Zinc	µg/L	U.S.	2,000	SWEG&41000	3
Silicon (ICP/MS)					
Silicon	µg/L	U.S.			1,290
Total Organic Carbon (Sievers)					
Inorganic Carbon	mg/L	U.S.			0.61
Organic Carbon	mg/L	U.S.	3	41000	1.39
Semi-volatiles (GC/MS) - Target List					
Methyl sulfone	µg/L	U.S.	1,500,000	interim SWEG (06-2017)	118
Silanols (LC/RI) (R & D Method -NIST traceable standard not available)					
Dimethylsilanediol (DMSD)	µg/L	U.S.	35,000	SWEG	4,300
Organic Carbon Recovery					
	percent	U.S.			82.72
Unaccounted Organic Carbon					
	mg/L	U.S.			0.24

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

**Table 4. Increment 51 Water Sample Summary Report WPA
Wastewater and Condensate Samples**

Increment Mission	Sample Location	Sample Description	Sample Date	Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	51		
									SpX-11		
									WPA Wastewater ORU WPA Wastewater 5/19/2017 20170705003	WPA Condensate Sample Port US Condensate 5/8/2017 20170705004	
Physical Characteristics											
pH					pH units	U.S.	4.5-8.5	41000		7.43	7.98
Conductivity					µS/cm	U.S.				112	300
Anions (IC)											
Fluoride					mg/L	U.S.				0.6	0.5
Cations (IC)											
Ammonia as Nitrogen (NH3-N)					mg/L	U.S.	1	SWEG&41000		13.6	35.4
Trace Metals (ICP/MS)											
Calcium					mg/L	U.S.	30	41000		0.10	0.15
Sodium					mg/L	U.S.				0.30	0.34
Aluminum					µg/L	U.S.				17	10
Manganese					µg/L	U.S.	300	SWEG&41000		14	25
Nickel					µg/L	U.S.	300	SWEG&41000		117	501
Silver					µg/L	U.S.	400	SWEG&41000		12	18
Zinc					µg/L	U.S.	2,000	SWEG&41000		1,150	1,180
Silicon (ICP/MS)											
Silicon					µg/L	U.S.				3,720	10,500
Total Organic Carbon (Sievers)											
Inorganic Carbon					mg/L	U.S.				11.6	27.8
Organic Carbon					mg/L	U.S.	3	41000		41.4	48.1
Volatile Organics											
Acetone					µg/L	U.S.	15,000	SWEG		7,820	2,410
Volatile Organics - Special Interest Compounds (Semi-quantitative)											
Trimethylsilanol					µg/L	U.S.				230	370
Semi-volatiles (GC/MS) - Target List											
Benzothiazole					µg/L	U.S.				56	59
N-n-Butylbenzenesulfonamide					µg/L	U.S.				60	83
Tris(2-Chloroethyl)phosphate					µg/L	U.S.				<40	110
Decamethylcyclopentasiloxane					µg/L	U.S.				<40	102
Methyl sulfone					µg/L	U.S.	1,500,000	interim SWEG (06-2017)		58	163
Acid Extractables-EPA 625 List											
Benzoic acid					µg/L	U.S.				<200	389
Phenol					µg/L	U.S.	4,000	SWEG		179	<40
p-Cresol (4-Methylphenol)					µg/L	U.S.				163	<40
Base/Neutral Extractables - EPA 625 List											
Benzyl alcohol					µg/L	U.S.				<40	1,490
Diethylphthalate					µg/L	U.S.				327	642
Semi-volatiles (GC/MS) - Special Interest Compounds (Semi-quantitative - 2 pt curve)											
2-(2-Butoxyethoxy)ethanol					µg/L	U.S.				210	210
N,N-Dimethyl acetamide					µg/L	U.S.				240	550
N,N-Dimethylformamide					µg/L	U.S.				370	570
Dipropylene glycol methyl ether					µg/L	U.S.				140	330
2-Ethoxyethanol					µg/L	U.S.				280	230
2-Ethylhexanoic acid					µg/L	U.S.				110	not found
Ibuprofen					µg/L	U.S.				970	not found
1-Methyl-2-pyrrolidinone					µg/L	U.S.				<160	280
Monomethyl phthalate					µg/L	U.S.				110	110
(+)-Neomenthol					µg/L	U.S.				81	56
2-Phenoxyethanol					µg/L	U.S.				64	55
2-Phenyl-2-propanol					µg/L	U.S.				<80	160
1,3,5-Triallyl-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione					µg/L	U.S.				<40	80
Tributyl phosphate					µg/L	U.S.				36	48
Alcohols (DAI/GC/MS)											
Ethanol					µg/L	U.S.				33,600	<400
Methanol					µg/L	U.S.	40,000	SWEG		9,740	6,860
2-Propanol (Isopropanol)					µg/L	U.S.				518	<400
Glycols (DAI/GC/MS)											
1,2-Ethanediol (Ethylene glycol)					µg/L	U.S.	4000	SWEG		2,020	1,950
1,2-Propanediol (Propylene glycol)					µg/L	U.S.	1,700,000	SWEG		5,820	14,100
Silands (LC/RI) (R & D Method -NIST traceable standard not available)											
Dimethylsilanediol (DMSD)					µg/L	U.S.	35,000	SWEG		12,000	37,000
Carboxylates (IC)											
Acetate					µg/L	U.S.				530	<500
Organic Carbon Recovery											
Organic Carbon Recovery					percent	U.S.				85.82	51.65
Unaccounted Organic Carbon											
Unaccounted Organic Carbon					mg/L	U.S.				5.87	23.26

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