

**JSC TOXICOLOGY AND ENVIRONMENTAL CHEMISTRY GROUP**

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SUBJECT: Toxicological Assessment of ISS Air and Water Quality: September 6, 2016 –October, 30, 2016 (Increment 49), Including OA-5 Ingress Report and Oil Paint Odor Investigation (Second Sample)

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 49. The first sample was a contingency sample collected in Node 3 on 9/30/2016 after the crew reported an “oil paint” odor in the vicinity of panel 430 in the Russian Service Module (SM). The second sample was a routine archive sample collected in the US Lab on 10/10/16. Due to collection of the contingency sample, the second Increment 49 nominal sample was not obtained to conserve supplies. The final sample was the first ingress sample collected during crew entry into the OA-5 vehicle. Due to collection of the contingency sample, only one nominal sample was collected to conserve supplies. Two pairs of passive-diffusion formaldehyde badges were also deployed in the Lab and SM on 10/10/2016. All three archive samples and the formaldehyde badges were returned on Soyuz 47 (47S). A summary of the analytical results from the samples and badges is provided in Table 1.

Table 1. Analytical summary of ISS air analyses

Return Flight	Sample Location	Sample Date	NMVOCs <sup>a</sup> (mg/m <sup>3</sup> )	Freon 218 (mg/m <sup>3</sup> )	Alcohols <sup>b</sup> (mg/m <sup>3</sup> )	T-Value <sup>c</sup> (units)	CO <sub>2</sub> (mg/m <sup>3</sup> )	Formaldehyde (µg/m <sup>3</sup> )
47S	Node 3 Contingency	9/30/2016	7.7	115	3.9	0.3	4900	--
47S	LAB	10/10/2016	5.5	101	4.1	0.2	3500	38 <sup>f</sup>
47S	SM	10/10/2016	-	-	-	-	-	23 <sup>f</sup>
47S	OA-5 Ingress	10/23/2016	27	6.7	11	1.3 (1.0)	1500	--
<i>Guideline</i>			<25	---	<5	<1 <sup>d</sup>	<7100 <sup>e</sup>	<120

<sup>a</sup>Non-methane volatile organic hydrocarbons, excluding Freon 218

<sup>b</sup>Includes acetone

<sup>c</sup>Sum of the ratios of the measured concentration and the corresponding 180-day SMAC for each compound, excluding CO<sub>2</sub>; parentheses indicate value based on 7-day SMACs and applicable to first ingress

<sup>d</sup>T-value <1 used to evaluate routine monthly sampling; <3 used to evaluate first ingress

<sup>e</sup>CO<sub>2</sub> to be controlled as low as reasonably achievable (ALARA) – currently 3 mmHg (7100 mg/m<sup>3</sup>) or lower

<sup>f</sup>Average from pair of formaldehyde badges

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 mean relative recoveries of the 3 surrogate standards from the 47S mGSC samples were as follows: <sup>13</sup>C-acetone, 87±18%; fluorobenzene-d<sub>5</sub>, 91±15%; and chlorobenzene-d<sub>5</sub>,



75±14%. For the passive-diffusion formaldehyde badges, positive control recoveries (1 in-flight and 2 lab controls) were 103, 113, and 108%, 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<sup>3</sup>) of AQM target compounds

	September	October	Average
2-Propanol	0.30	0.18	0.24
Acetone	0.39	0.22	0.31
Acrolein	ND	ND	ND
Benzene	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
Decamethylcyclotetrasiloxane#	TRACE	TRACE	TRACE
Hexanal	ND	ND	ND
Hexane	ND	ND	ND
m,p-Xylenes#	ND	ND	ND
Methanol	0.46	0.48	0.47
o-Xylene#	TRACE	TRACE	TRACE
Octamethylcyclotetrasiloxane#	ND	ND	ND
Toluene#	ND	ND	ND
2-Butanone	ND	ND	ND
Acetaldehyde	0.12	TRACE	0.11
Dichloromethane	ND	ND	ND
Ethanol	5.81	3.25	4.53
Ethyl Acetate	TRACE	TRACE	TRACE
Hexamethylcyclotrisiloxane#	ND	ND	ND
n-Butanol	0.09	0.11	0.10
Trimethylsilanol	0.12	0.13	0.13

# Derived 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) are collected during each increment and returned for analysis in the Toxicology and Environmental Chemistry air quality laboratories. 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 sample for this Increment that returned on 47S 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 rounded T-value for Increment 49 from the single mGSC sample was 0.2 (Figure 1). The average T-value calculated from the AQM data (Figure 2) was also 0.2, indicating excellent agreement between the detection methods for the Increment. AQM S/N 1005 was relocated back to the US Lab from Node 3 on 9/26/ 2016 and the sieve cartridges were replaced in this unit on 10/27/2016. 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 sample contained a CO<sub>2</sub> concentration below the Increment limit documented in Chit 14468, which requests that the 24 hour average concentration not exceed 3.0 mmHg (7100 mg/m<sup>3</sup>). While mGSC CO<sub>2</sub> sampling provides a snap-shot of the CO<sub>2</sub> concentration, the major constituent analyzer (MCA)

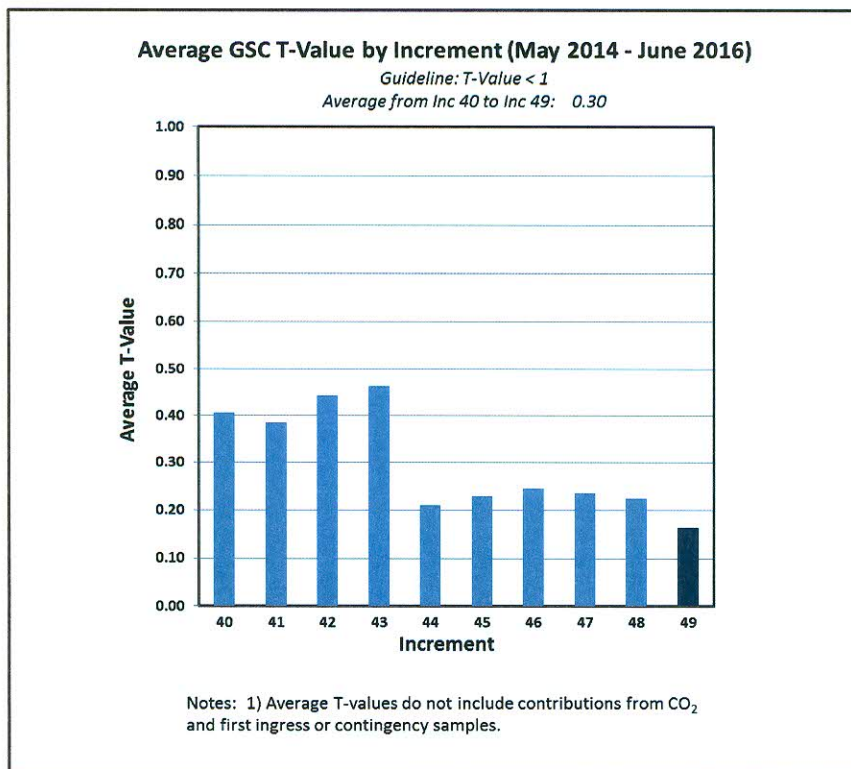


Figure 1. GSC T-values

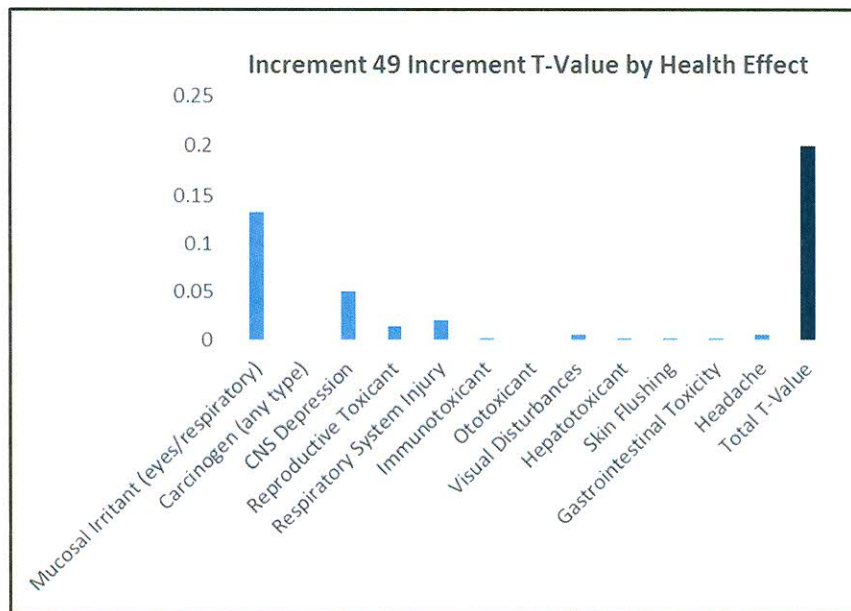


Figure 2. AQM T-values

routinely monitors CO<sub>2</sub> levels in the US segment. For this reason, data from the MCA is better suited for evaluation of short and long-term trends in CO<sub>2</sub>. 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 CO<sub>2</sub>. There was a marked decrease in CO<sub>2</sub> at the beginning of the Increment, which coincided with 46S undock and the transition to 3 crew operations. Although several brief CO<sub>2</sub> increases were detected due to Metox regeneration on 9/9/2016 and 9/17/2016 and airway monitoring activities



(10/25/2016), CO<sub>2</sub> concentrations were, overall, well controlled. Levels averaged 2.0 mmHg until 48S docking (10/21/2016), then increased to 2.5 mmHg for the remainder of October, which was below the Increment Chit level of 3.0 mmHg.

The total alcohol value in the routine mGSC sample collected on 10/10/2016 was below the US alcohol guideline of <5 mg/m<sup>3</sup>, which is intended to protect the water recovery system from risk of overloading. AQM results indicate that ethanol levels were approximately a third of the level reported at the beginning of the Increment. Methanol levels decreased sharply following installation of new sieve cartridges on 10/27/2016. The previous cartridges were believed to be saturated with a contaminant (possibly methanol), causing exaggerated levels. Importantly, alcohol 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 180-day SMAC of 120 µg/m<sup>3</sup>.

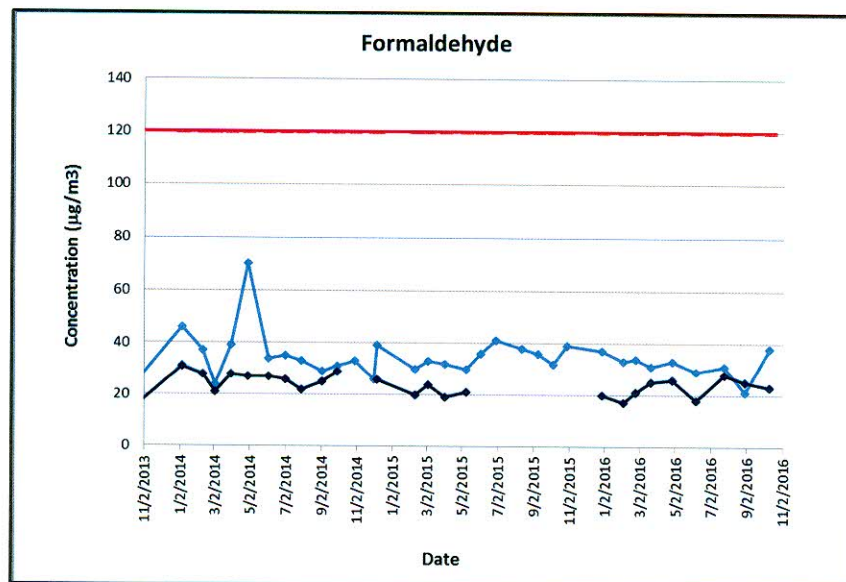


Figure 3. Formaldehyde trending in ISS air.

#### *Oil Paint Odor Contingency Sample*

A contingency air sample was collected during Increment 48 (8/15/2016) after the crew reported an “oil paint-like” odor in the vicinity of SM Panel 430 where batteries 7 & 8 are housed. Two compounds in the sample were slightly elevated relative to the nominal ISS background (see memo TOX-AR-2017-02): cyclohexanone (0.052 mg/m<sup>3</sup>) and o-xylene (0.11 mg/m<sup>3</sup>). A second contingency sample was collected on 9/30/2016 after a recurrence of the odor during SM battery cycling. This sample was collected in Node 3 due to detection of the pungent odor throughout the US segment; however, the second sample did not contain detectable levels of either compound. The Russian crew did collect an archive sample in the SM at approximately the same time that the US Node 3 sample was collected. Results from analysis of the Russian samples are typically communicated through the Air Quality Subgroup. US representatives will coordinate with their Russian counterparts to compare data from the investigation. Any notable conclusions will be discussed in a future report.

#### *OA-5 Ingress*

The total T-value for OA-5 (1.3) was lower than OA-4 (2.2) and OA-6 (1.6). Carbon monoxide, trimethylsilanol, and acetaldehyde comprised the majority of this result. The T-value was well below the limit (3.0 units) for ingress samples, indicating no impact to crew health. It was determined, however, that the test results may not be accurate due to a possible mGSC leak. While the data for the OA-5 ingress sample are fairly typical for Orbital vehicles, an unexplained loss in canister pressure (from 28.7 to 20.7

psia) and lower surrogate recoveries suggest that the resulting data may not be fully representative of OA-5 ingress air quality. OA-5 data is shaded gray in the first enclosed table (Table 1) denoting the suspected decrease in sample quality.

### WATER QUALITY

Two archive samples were collected from the potable water dispenser (PWD) in the US segment during Increment 49. No non-potable samples were collected in the US segment during the Increment. Both water samples were returned on 47S. Complete data tables with results from chemical analyses performed on the samples can be found in report 2016-TEC-WQ-009. A summary of select analytical results is provided in Table 3. An expanded summary table containing organic carbon recoveries and results for analytes detected in the samples at concentrations above reporting limits are included as attachments to this report.

Table 3. Analytical Summary of ISS Water Analyses

Return Flight	Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Conductivity (µS/cm)	Total Iodine (mg/L)	Total Silver (µg/L)
47S	PWD (hot)	9/19/2016	0.18	<1	2	<0.05	<1
47S	PWD (ambient)	10/18/2016	0.15	<1	2	<0.05	<1

**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 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

Total organic carbon (TOC) concentrations from in-flight and ground analyses performed on samples from the U.S. potable water system between November 2015 and October 2016 are shown in Figure 4. The TOC concentrations measured by the TOCA in the U.S. potable water sample (PWD TOC) and product water

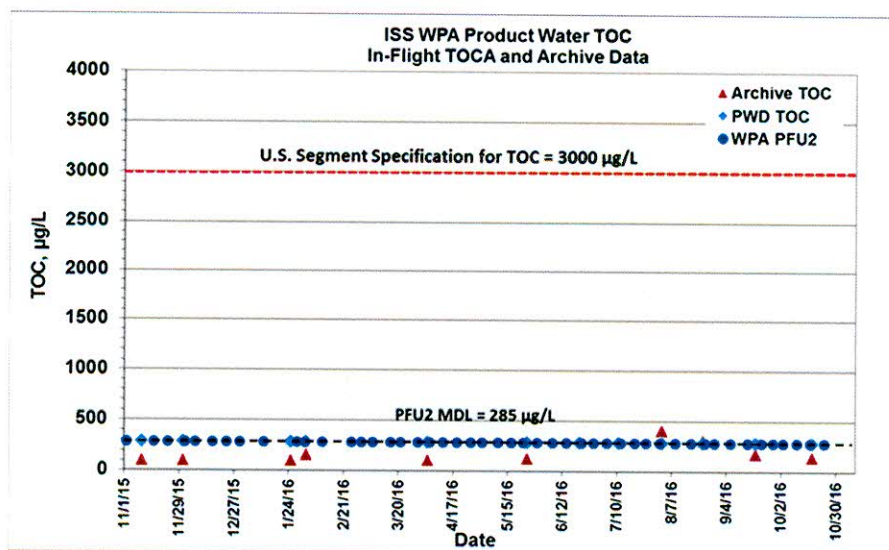


Figure 4. Total Organic Carbon (TOC) trending in US Potable Water



sample (WPA PFU2) were below the method reporting limit (285 µg/L) throughout the Increment. TOC concentrations in the U.S. archive samples (Archive TOC) were 180 µg/L for the PWD hot sample and 150 µg/L for the PWD ambient sample. Compared to Increment 48 archive samples (PWD hot: 410 µg/L, PWD ambient: 310 µg/L), TOC concentrations were lower, and still well below the Spacecraft Water Exposure Guideline (SWEG) of 3.0 mg/L (3000 µg/L).


Although dimethylsilanediol (DMSD) was present in humidity condensate and wastewater samples collected during Increment 48, it was not detected in either of the potable water samples. Only trace levels of other organics were detected.

Silicon was detected in both U.S. samples (PWD ambient = 119 µg/L and PWD hot = 63 µg/L) at levels typically found when no DMSD is present, but at higher levels than what was detected during Increment 48. Traces of aluminum, copper (hot sample only), nickel, and zinc were detected in the samples, but all were well under the SWEGs and 41000 requirements. **Importantly, all chemical parameters measured in U.S. potable water samples collected during Increment 49 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. Total iodine levels in the samples collected from the PWD were below detection limits (0.05 mg/L), indicating effective removal of iodine. For additional information regarding microbial analyses, please see the Increment 49 post-flight report issued by the JSC Environmental Microbiology Laboratory.




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Enclosures      Table 1: Analytical concentrations of compounds quantified in mGSCs returned on 47S  
 Table 2A: T-values corresponding to concentrations in Table 1, based on 180-day SMACs  
 Table 2B: T-values corresponding to OA-5 Ingress concentrations in Table 1, based on 7-day and 180-day SMACs  
 Table 3: Analytical concentrations of compounds quantified in US potable water samples returned on 47S

**TABLE 1**  
**ANALYTICAL RESULTS OF SOYUZ 47 RETURN GSC AIR SAMPLES**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M <sup>3</sup> )		
	AQ160288 SN2053 Node 3 Contingency (oily paint smell in SM) 09/30/16 @ 12:40 GMT	AQ160289 SN2054 LAB 10/10/16 @ 09:39 GMT	AQ160290 SN2055 OA-5 Ingress 10/23/16 @ 20:06 GMT
	<b>TARGET COMPOUNDS (TO-15) **</b>		
Octafluoropropane (Perfluoropropane) *	<b>115</b>	<b>101</b>	<b>6.7</b>
Propene	<0.025	<0.025	TRACE
Propane	<0.025	<0.025	0.077
Carbonyl sulfide (Carbon oxide sulfide)	<0.025	<0.025	TRACE
Isobutane	<0.025	<0.025	9.9
Methanol *	<b>0.28</b>	<b>0.25</b>	0.76
Acetaldehyde	0.33	0.25	0.79
2-Methyl-1-propene	TRACE	TRACE	0.16
Butane	<0.025	<0.025	0.056
Ethanol *	<b>2.9</b>	<b>3.3</b>	<b>2.0</b>
Acetone	0.42	0.31	0.96
Propanal (Propionaldehyde)	<0.025	<0.025	0.069
Furan	<0.025	<0.025	TRACE
2-Propanol (Isopropanol) *	0.17	0.12	<b>6.7</b>
Isoprene (2-Methyl-1,3-butadiene)	0.03	TRACE	<0.025
2-Methyl-2-propanol	<0.025	<0.025	0.085
1-Propanol	0.026	TRACE	TRACE
Trimethylsilanol	0.10	0.10	1.6
Butanal (Butyraldehyde)	<0.025	<0.025	TRACE
2-Butanone (Methyl ethyl ketone)	<0.025	<0.025	0.033
Hexane	<0.025	<0.025	0.042
Ethyl acetate	TRACE	<0.025	0.086
1-Butanol	0.076	0.064	0.044
2-Methylhexane	<0.025	<0.025	0.027
3-Methylhexane	<0.025	<0.025	0.066
Toluene	<0.025	<0.025	TRACE
Octane	<0.050	<0.050	TRACE
Decamethylcyclopentasiloxane	0.60	<0.175	<0.175
<b>SPECIAL INTEREST COMPOUNDS</b>			
All Special Interest Compounds were below their reporting limit			
<b>NON-TARGET COMPOUNDS ***</b>			
1,1,1,2-Tetrafluoroethane	2.7	1.1	0.95
1,1-Difluoroethane	<0.050	<0.050	0.10
2-Methylbutane	<0.050	<0.050	0.27
C11-Alkane	<0.050	<0.050	0.25
C11-Alkane	<0.050	<0.050	0.10
C12-Alkane	<0.050	<0.050	0.10
C12-Alkane	<0.050	<0.050	0.34
C12-Alkane	<0.050	<0.050	0.15
C11-Alkane	<0.050	<0.050	0.37
C12-Alkane	<0.050	<0.050	0.34
C12-Alkane	<0.050	<0.050	0.27
C12-Alkane	<0.050	<0.050	0.12
<b>TOTAL ALCOHOLS PLUS ACETONE</b>	<b>3.9</b>	<b>4.1</b>	<b>11</b>
<b>TARGET COMPOUNDS (GC) **</b>			
Carbon monoxide	0.67	0.56	5.8
Methane	17	13	3.9
Hydrogen	3.2	2.8	1.8
Carbon dioxide	4900	3500	1500
<b>TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)</b>	<b>122</b>	<b>106</b>	<b>34</b>
<b>TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)</b>	<b>7.7</b>	<b>5.5</b>	<b>27</b>

\* 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.

< : 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 SOYUZ 47 RETURN GSC AIR SAMPLES

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)	
	AQ160288 SN2053 Node 3 Contingency (oily paint smell in SM) 09/30/16 @ 12:40 GMT	AQ160289 SN2054 LAB 10/10/16 @ 09:39 GMT
<b>TARGET COMPOUNDS (TO-15)</b>		
Octafluoropropane (Perfluoropropane)	0.00135	0.00118
Methanol	0.00307	0.00272
Acetaldehyde	0.08238	0.06353
2-Methyl-1-propene	0.00001	0.00001
Ethanol	0.00146	0.00165
Acetone	0.00809	0.00602
2-Propanol (Isopropanol)	0.00111	0.00081
Isoprene (2-Methyl-1,3-butadiene)	0.00986	0.00417
1-Propanol	0.00027	0.00013
Trimethylsilanol	0.02622	0.02613
Ethyl acetate	0.00007	ND
1-Butanol	0.00190	0.00159
Decamethylcyclopentasiloxane	0.04032	ND
<b>SPECIAL INTEREST COMPOUNDS</b>		
All Special Interest Compounds were below their reporting limit		
<b>NON-TARGET COMPOUNDS</b>		
1,1,1,2-Tetrafluoroethane	0.02605	0.01028
<b>TARGET COMPOUNDS (GC)</b>		
Carbon monoxide	0.03935	0.03313
Methane	0.00478	0.00363
Hydrogen	0.00948	0.00813
Carbon dioxide	0.37597	0.27148
<b>TOTAL T-VALUE</b>	<b>0.63173</b>	<b>0.43459</b>
<b>TOTAL T-VALUE - CO2</b>	<b>0.25576</b>	<b>0.16311</b>

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 SOYUZ 47 RETURN GSC AIR SAMPLES

CHEMICAL CONTAMINANT	T-VALUE (7-d SMAC)	T-VALUE (180-d SMAC)
	AQ160290 SN2055 OA-5 Ingress 10/23/16 @20:06 GMT	AQ160290 SN2055 OA-5 Ingress 10/23/16 @ 20:06 GMT
<b>TARGET COMPOUNDS (TO-15)</b>		
Octafluoropropane (Perfluoropropane)	0.00008	0.00008
Propene	0.00029	0.00029
Propane	0.00072	0.01404
Carbonyl sulfide (Carbon oxide sulfide)	0.00104	0.00104
Isobutane	0.04128	0.04128
Methanol	0.00840	0.00840
Acetaldehyde	0.19716	0.19716
2-Methyl-1-propene	0.00015	0.00015
Butane	0.00039	0.00806
Ethanol	0.00100	0.00100
Acetone	0.01846	0.01846
Propanal (Propionaldehyde)	0.00625	0.00625
Furan	0.17857	0.17857
2-Propanol (Isopropanol)	0.04499	0.04499
2-Methyl-2-propanol	0.00057	0.00071
1-Propanol	0.00013	0.00013
Trimethylsilanol	0.38756	0.38756
Butanal (Butyraldehyde)	0.00096	0.00096
2-Butanone (Methyl ethyl ketone)	0.00110	0.00110
Hexane	0.00020	0.00383
Ethyl acetate	0.00048	0.00048
1-Butanol	0.00055	0.00110
2-Methylhexane	0.00011	0.00225
3-Methylhexane	0.00026	0.00552
Toluene	0.00083	0.00083
Octane	0.00009	0.00179
<b>SPECIAL INTEREST COMPOUNDS</b>		
All Special Interest Compounds were below their reporting limit		
<b>NON-TARGET COMPOUNDS</b>		
1,1,1,2-Tetrafluoroethane	0.00918	0.00918
1,1-Difluoroethane	0.00150	0.00150
2-Methylbutane	0.00088	0.00088
C11-Alkane	0.00572	0.00572
C11-Alkane	0.00237	0.00237
C12-Alkane	0.00192	0.00192
C12-Alkane	0.00657	0.00657
C12-Alkane	0.00292	0.00292
C11-Alkane	0.00847	0.00847
C12-Alkane	0.00647	0.00647
C12-Alkane	0.00525	0.00525
C12-Alkane	0.00222	0.00222
<b>TARGET COMPOUNDS (GC)</b>		
Carbon monoxide	0.09138	0.33863
Methane	0.00112	0.00112
Hydrogen	0.00521	0.00521
Carbon dioxide	0.11340	0.11340
<b>TOTAL T-VALUE</b>	<b>1.11999</b>	<b>1.40164</b>
<b>TOTAL T-VALUE - CO2</b>	<b>1.00659</b>	<b>1.28824</b>

Note: Number of decimal places in T-Values do not represent significant figures of measurements.

**Table 3. Increment 49 Water Sample Summary Report  
US Potable 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 47/Expedition 49		
									WPA PWD Hot Potable Water 9/19/2016 20161031001	WPA PWD Ambient Potable Water 10/18/2016 20161031002	
Physical Characteristics											
	pH				pH units	U.S.	4.5-8.5	41000		5.57	5.32
	Conductivity				µS/cm	U.S.				2	2
Trace Metals (ICP/MS)											
	Calcium				mg/L	U.S.	30	41000		0.01	0.02
	Aluminum				µg/L	U.S.				2	2
	Copper				µg/L	U.S.	1,000	41000		2	<1
	Nickel				µg/L	U.S.	300	SWEG&41000		4	3
	Zinc				µg/L	U.S.	2,000	SWEG&41000		3	4
Silicon (ICP/MS)											
	Silicon				µg/L	U.S.				63	119
Total Organic Carbon (Sievers)											
	Inorganic Carbon				mg/L	U.S.				0.97	0.97
	Organic Carbon				mg/L	U.S.	3	41000		0.18	0.15
Semi-volatiles (GC/MS) - Target List											
	Methyl sulfone				µg/L	U.S.				105	111
Base/Neutral Extractables - EPA 625 List											
	Diethylphthalate				µg/L	U.S.				21	<20
	Organic Carbon Recovery				percent	U.S.				23.21	18.76
	Unaccounted Organic Carbon				mg/L	U.S.				0.13	0.12

Data Qualifiers: None.

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