


<p align="center"><b>JSC TOXICOLOGY AND ENVIRONMENTAL CHEMISTRY GROUP</b></p> <p><b>Amelia Romoser, PhD, DABT</b> Toxicology and Environmental Chemistry NASA JSC/SK4 Houston, TX 77058</p>		<p align="center"><b>Memorandum Number TOX-AR-2017-02</b></p> <hr/> <p>Voice: (281) 483-3223 Fax: (281) 483-3058 <a href="mailto:amelia.a.romoser@nasa.gov">amelia.a.romoser@nasa.gov</a></p>
---	---	---

DATE: January 10, 2017

SUBJECT: Toxicological Assessment of ISS Air and Water Quality: June 18, 2016 –September 7, 2016 (Increment 48), Including SpX-9 Ingress Report and Oil Paint Odor Investigation

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

**AIR QUALITY**

Six archive air samples were collected in mini grab sample containers (mGSCs) on ISS during Increment 48 and returned on SpX-9 and Soyuz 46 (46S). Four mGSCs were collected as routine samples in the US Laboratory (Lab) and either the Russian Service Module (SM) or the Columbus Module (COL). One contingency mGSC sample was collected on 8/15/2016 in the SM after the crew reported an “oil paint” odor in the vicinity of panel 430. A first ingress sample was also collected during crew entry into SpX-9. Four pairs of passive-diffusion formaldehyde badges were deployed in the Lab and SM on 7/25/2016 and 8/29/2016. The formaldehyde badges were returned on Soyuz 47 (47S). A summary of the analytical results 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> ) <sup>f</sup>
SpX-9	SpX-9 Ingress	7/21/2016	4.6	23	2.9	0.3 (0.2)	4200	--
SpX-9	LAB	7/25/2016	6.9	85	6.5	0.2	7900	31 (47S) <sup>g</sup>
SpX-9	COL	7/25/2016	6.3	85	5.7	0.2	7300	--
47S	SM	7/25/2016	--	--	--	--	--	21 <sup>g</sup>
SpX-9	SM Contingency	8/15/2016	6.6	86	5.9	0.2	7800	--
46S	Lab	8/29/2016	5.9	101	5.4	0.2	7100	28 (47S)
46S	SM	8/29/2016	6.5	103	6.1	0.2	8500	25 (47S)
<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>Return flight for formaldehyde samples differs from mGSC return flight and is indicated in parentheses

<sup>g</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 46S mGSC samples were as follows: <sup>13</sup>C-acetone, 111±1%; fluorobenzene-d<sub>5</sub>, 108±1%; and chlorobenzene-d<sub>5</sub>, 91±2%.

For the SpX-9 samples, mean relative recoveries was as follows:  $^{13}\text{C}$ -acetone,  $112\pm 4\%$ ; fluorobenzene- $d_5$ ,  $112\pm 5\%$ ; and chlorobenzene- $d_5$ ,  $119\pm 14\%$ . 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 ( $\text{mg}/\text{m}^3$ ) of AQM target compounds

	June	July	August	September	Average
2-Propanol	0.12	0.18	0.25	0.30	0.21
Acetone	0.49	0.38	0.41	0.39	0.42
Acrolein	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND
Decamethylcyclotetrasiloxane#	TRACE	TRACE	TRACE	TRACE	TRACE
Hexanal	ND	ND	ND	ND	ND
Hexane	ND	ND	ND	ND	ND
m,p-Xylenes#	ND	ND	ND	ND	ND
Methanol	0.32	0.38	0.37	0.46	0.38
o-Xylene#	TRACE	TRACE	TRACE	TRACE	TRACE
Octamethylcyclotetrasiloxane#	ND	ND	ND	ND	ND
Toluene#	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND
Acetaldehyde	TRACE	0.13	0.14	0.12	0.13
Dichloromethane	ND	ND	ND	ND	ND
Ethanol	3.02	4.01	6.34	5.81	4.80
Ethyl Acetate	0.06	0.05	0.05	TRACE	0.05
Hexamethylcyclotrisiloxane#	ND	ND	ND	ND	ND
n-Butanol	0.07	0.07	0.07	0.09	0.08
Trimethylsilanol	0.11	0.10	0.12	0.12	0.11

# 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 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-9 and 46S, which confirmed air quality was acceptable during this timeframe. **Importantly, 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 for Increment 48 calculated from the mGSC samples was 0.2 (Figure 1). The average T-value calculated from the AQM data (Figure 2) was similar (0.15). The reported values are consistent with levels seen since installation of carbon filters in Node 1 in May 2015.

All four nominal mGSC samples contained a carbon dioxide concentration at or above the Increment limit documented in Chit 14468, which requests that the 24 hour average concentration not exceed 3 mmHg (7100  $\text{mg}/\text{m}^3$ ). While mGSC  $\text{CO}_2$  sampling provides an estimate of the extent of ISS air dilution in first ingress air samples, the major constituent analyzer (MCA) routinely monitors  $\text{CO}_2$  levels and for this reason

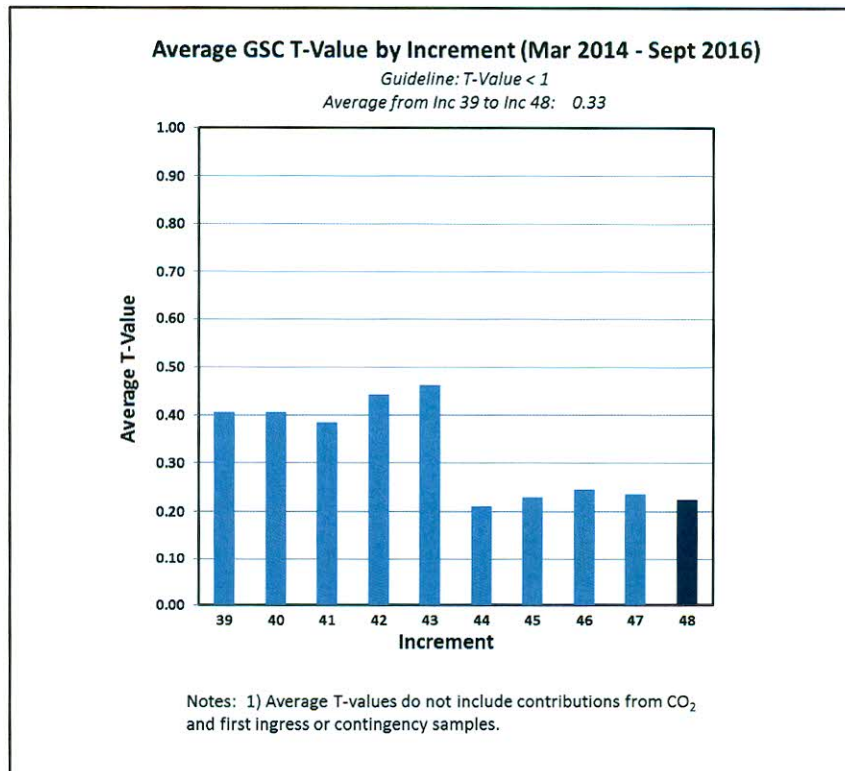


Figure 1. GSC T-values

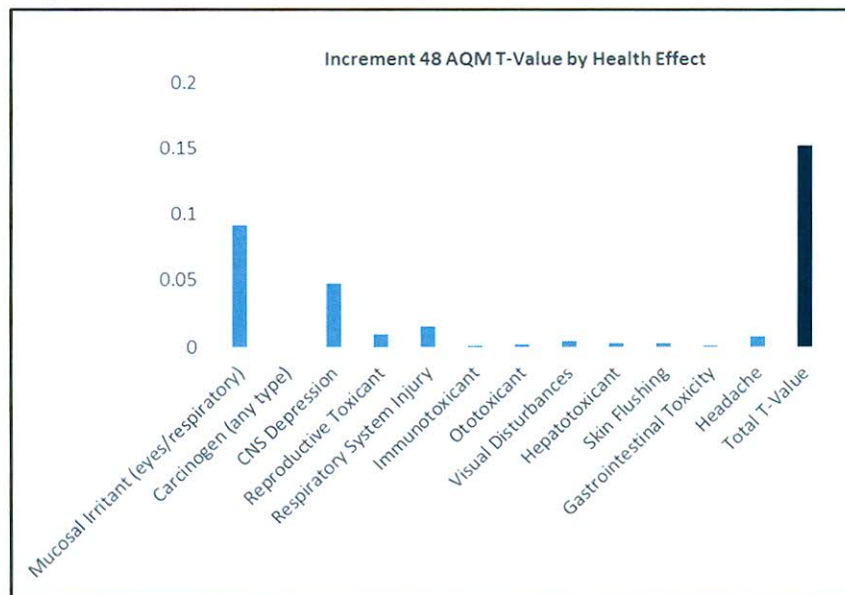


Figure 2. AQM T-values

is better suited for evaluation of short and long-term trends in CO<sub>2</sub> data. 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 45S undock and the transition to 3 crew operations. CO<sub>2</sub> concentrations ranged from 1.5 – 2.5 mmHg until 47S docking (7/9/2016), then increased to 2.5 – 3.5 mmHg with the 24-hr average concentrations at or near the Increment Chit level of 3 mmHg for the majority of July, August, and the first part of September.

Alcohol values in July and August routine samples continued to exceed the alcohol guideline of  $<5 \text{ mg/m}^3$ , which is intended to protect the water recovery system from risk of overloading. These levels are primarily due to a sustained increase in ethanol concentrations on ISS. Elevated ethanol levels were also detected in US non-potable water samples during this Increment (see Water Quality discussion below). 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  $120 \text{ } \mu\text{g/m}^3$ .

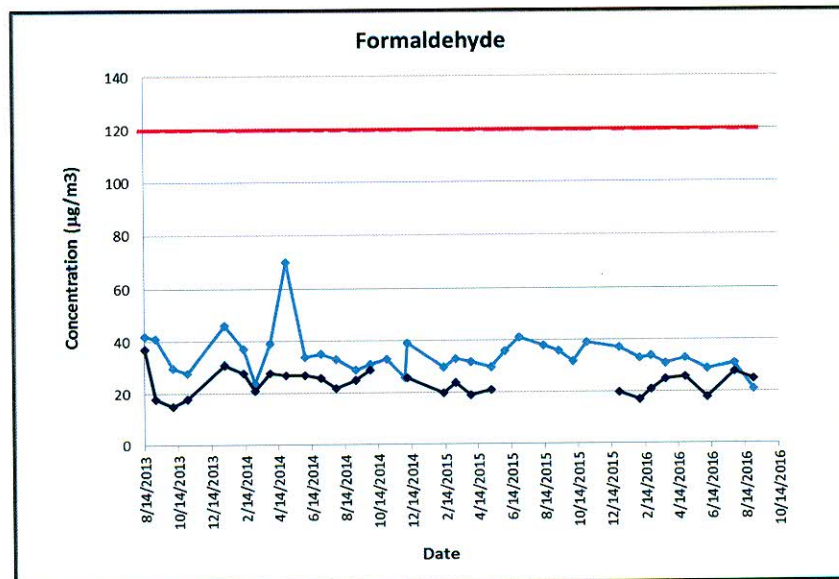


Figure 3. Formaldehyde trending in ISS air.

#### *SM Contingency Sample*

A contingency sample was collected on 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 compared to mGSC samples collected before (7/25/2016) and after (8/29/2016) the report: cyclohexanone ( $0.052 \text{ mg/m}^3$ ) and o-xylene ( $0.11 \text{ mg/m}^3$ ). Both compounds can be found in metal hydride batteries and emit an aromatic odor that could be perceived as resembling oil paint. It is possible that the concentration of o-xylene, while very low, could have been detected due to its extremely low odor detection threshold. When combined with another volatile compound with a similar odor, the likelihood of detection would have been increased. **However, it is important to note that the concentrations of the compounds detected are very low and do not pose a health concern for the crew.** A second contingency sample was collected on 9/30/2016 after a recurrence of the odor. Further discussion of this investigation will be included in a future report once analysis of the second contingency sample is complete.

#### *SpX-9 Ingress*

Although well below the guideline value of 3, the overall T-value for SpX-9 ingress (0.34) was notably higher than SpX-8 (0.07) and SpX-6 (0.11), with CO and acetaldehyde comprising the majority of this result. The acetaldehyde concentration was consistent with nominal samples collected before (6/6/2016) and after (7/25/2016) ingress; however, the CO concentration was at least two times higher than the nominal samples, indicating vehicle or payload offgassing. Importantly, this concentration ( $3.4 \text{ mg/m}^3$ ) was well below the 7-day SMAC for this compound ( $63 \text{ mg/m}^3$ ) indicating no impact to crew health. The sample was collected 8 minutes after hatch opening, allowing some mixing with ISS air. This was apparent because the concentration of Freon 218, a relatively non-toxic refrigerant typically present in ISS air but not in visiting vehicles, was approximately  $\frac{1}{4}$  the current ISS background levels detected in the nominal samples collected before (6/6/2016) and after (7/25/2016) ingress. This suggests that approximately 25-27% dilution

of the vehicle air had occurred by the time the sample was collected. Accounting for dilution, the overall T value and CO concentrations do not present a concern for crew health.

### WATER QUALITY

Archive samples were collected from the potable water dispenser (PWD) in the US segment during Increment 48. In addition, samples of multifiltration (MF) bed effluent, condensate, wastewater, and preserved urine were also collected from the US segment during the Increment. All water samples were returned on 46S and SpX-9. Complete data tables with results from these analyses can be found in reports 2016-TEC-WQ-007 and 2016-TEC-WQ-008. A summary of select analytical results is provided in Table 3. 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.

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)
46S	PWD (hot)	8/2/2016	0.41	<1	2	<0.05	<1
46S	PWD (ambient)	8/23/2016	0.31	<1	2	<0.05	<1
SpX-9	MF Bed Effluent <sup>a</sup>	8/3/2016	5.9	<1	3	NA	<4
SpX-9	US Condensate <sup>a</sup>	8/8/2016	138	37	300	NA	12
SpX-9	WPA Wastewater <sup>a</sup>	8/12/2016	23	18	176	NA	9
SpX-9	Preserved Urine <sup>a</sup>	8/12/2016	6210	NA	>1,410	NA	50
SpX-9	UPA Urine Distillate <sup>a</sup>	Not specified	386	<2	>1,410	0.019	<1

<sup>a</sup>Source not considered potable. The ISS Water Recovery System successfully removes contaminants and excess minerals prior to consumption.

**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 September 2015 and September 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 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 410 µg/L for the PWD hot sample and 310 µg/L for the PWD ambient sample. Compared to Increment 47 archive samples (PWD hot: 130 µg/L, PWD ambient: 110 µg/L), TOC concentrations were higher, but still well below the Spacecraft Water Exposure Guideline (SWEG) of 3.0 mg/L (3000 µg/L).

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

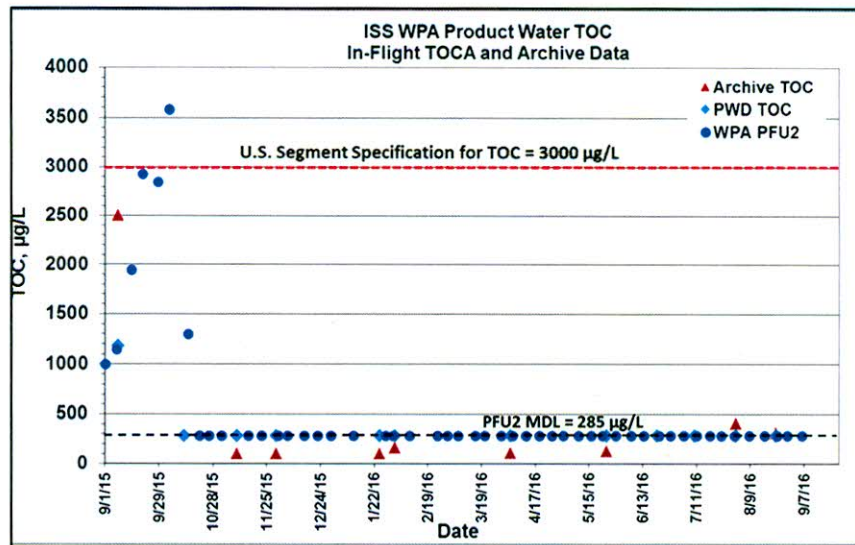


Figure 4. Total Organic Carbon (TOC) trending in US Potable Water

Silicon was detected in both U.S. samples (PWD ambient = 25 µg/L and PWD hot = 28 µg/L) at levels typically found when no DMSD is present, but at lower levels than what was detected during Increment 47. Traces of barium (hot: 6 µg/L), nickel (hot: 5 µg/L), and zinc (hot and ambient: 2 µg/L) were also detected in the U.S. potable water samples, but all were well under the SWEG and 41000 requirements (barium: 10,000 µg/L; nickel: 300 µg/L; 2,000 µg/L). **Importantly, all chemical parameters measured in U.S. potable water samples collected during Increment 48 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 48 post-flight report issued by the JSC Environmental Microbiology Laboratory.

#### *Non-potable Water*

Five non-potable samples were returned on SpX-9 for analysis. Condensate and wastewater samples were collected as routine samples, whereas the MF bed effluent, pretreated urine, and urine distillate samples were collected as part of an investigation of recent anomalies in the U.S. Water Recovery System (WRS). Recently, the WRS reactor effluent conductivity has been elevated, indicating that the reactor capacity has been exceeded. Previous high conductivity readings were observed when the MF beds were approaching their end-of-life and elevated DMSD levels were present in the MF bed effluent. Historically, breakthrough of DMSD has resulted in TOC increases. While the TOC remains below the reporting limit of the TOCA, an increase is expected soon. The MF bed effluent sample was collected to determine if DMSD breakthrough could be responsible for the elevated conductivity in the reactor effluent. Increased conductivity has also been detected in the urine distillate produced by the Urine Processor Assembly (UPA). To determine the cause of this increase, distillate from the UPA purge gas line was collected in CWC-I S/N 2121. A pretreated urine sample was also collected to verify that the dosing of pre-treat solution added was correct.

The U.S. condensate sample contained slightly more contaminants than recent condensates but was still well below the historical average. The TOC level (138 mg/L), specifically, was higher than the last condensate sample collected on 5/3/2016 (126 mg/L), but still lower than the historical average (~170 mg/L). Other organic contaminants of note were ethanol (76.6 mg/L), which was higher than Increment 47

(55.5-63.5 mg/L), and DMSD (37 mg/L), which was on the high end of the range detected during Increment 47 (32-37 mg/L). The condensate formaldehyde concentration (1.33 mg/L) decreased from Increment 47 levels (5.78 – 5.94 mg/L), which were some of the highest condensate concentrations recorded in the last decade. Metals detected in the sample above 0.1 mg/L include zinc (6.27 mg/L) and nickel (0.51 mg/L). Traces of chromium, manganese, and silver were also present. The U.S. wastewater sample was cleaner than recent samples. In particular, the TOC (23 mg/L) and silicon (6.7 mg/L) concentrations were below historical averages (TOC: >37 mg/L; silicon: 8.1 mg/L). Zinc (3.05 mg/L), chromium (0.45 mg/L), and nickel (0.7 mg/L) were detected, in addition to traces of aluminum, iron, manganese, and silver. Based on the very low to non-detectable concentrations of these contaminants in potable samples, the Water Recovery System appears to be operating nominally.

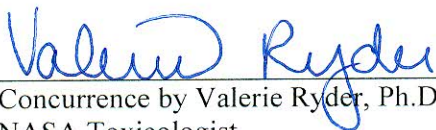
The effluent from the MF bed was expected to show significant concentrations of TOC, silicon, and DMSD. Surprisingly, this sample was extremely clean, suggesting that it was not a representative sample of the current effluent from this particular set of MF beds. The preserved urine sample was essentially nominal, with only a few elevated trace metal concentrations. Nickel (1320 ug/L), which was presumed to be related to tank corrosion, was elevated; however, there was essentially no carryover to the potable water samples (0-5 ug/L). The urine distillate sample contained 100 times more chromium (33.4 mg/L) and urea (762 mg/L) than previously analyzed distillate samples. These concentrations suggest carryover of preserved urine into the distillate. The root cause of the leakage/carryover is still being investigated. Nickel (0.23 mg/L) was the only other metal present in the urine distillate above 0.1 mg/L. Although the DMSD and TOC levels did not correlate well with increases in conductivity, it is likely that the metal concentrations in this sample are responsible for the increased conductivity readings in the UPA distillate. Further efforts are required to identify and understand the cause of the increased conductivity at the reactor health sensor and its impacts on water processor assembly operations.



Amelia Romoser, Ph.D., DABT  
KBRwyle Toxicologist



Date



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



Date

- Enclosures
- Tables 1A and 1B: Analytical concentrations of compounds quantified in mGSCs returned on SpX-9 and 46S
  - Table 2A and 2B: T-values corresponding to concentrations in Tables 1A and 1B, based on 180-day SMACs
  - Table 2C: T-values corresponding to SpX-9 Ingress concentrations in Table 1A, based on 7-day and 180-day SMACs
  - Table 3: Analytical concentrations of compounds quantified in US potable water samples returned on 46S
  - Table 4: Analytical concentrations of compounds quantified in US MF bed effluent, wastewater, condensate, preserved urine, and urine distillate samples returned on SpX-9

TABLE 1A  
ANALYTICAL RESULTS OF SPACEX-9 RETURN GSC AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M <sup>3</sup> )			
	AQ160244 SN 2032 SpaceX-9 Ingress 07/21/16 @ 18:35 GMT	AQ160245 SN 2029 LAB 07/25/16 @ 10:00 GMT	AQ160246 SN 2036 Columbus 07/25/16 @ 10:02 GMT	AQ160247 SN 2027 SM Near Panel 137 Contingency 08/15/16 @ 12:28 GMT
<b>TARGET COMPOUNDS (TO-15) **</b>				
Octafluoropropane (Perfluoropropane) *	<b>23</b>	<b>85</b>	<b>85</b>	<b>86</b>
Perfluoro(2-methylpentane)	0.7	<0.10	<0.10	<0.10
Propane	TRACE	<0.025	<0.025	<0.025
Isobutane	TRACE	<0.025	<0.025	<0.025
Methanol *	<b>0.49</b>	<b>0.34</b>	<b>0.31</b>	<b>0.32</b>
Acetaldehyde	0.29	0.26	0.29	0.30
2-Methyl-1-propene	<0.025	<0.025	TRACE	TRACE
Ethanol *	<b>1.7</b>	<b>4.4</b>	<b>4.4</b>	<b>4.7</b>
Acetone	0.23	0.35	0.34	0.48
2-Propanol (Isopropanol)	0.51	0.27	0.20	0.27
Isoprene (2-Methyl-1,3-butadiene)	<0.025	0.047	0.043	0.037
Methylene chloride (Dichloromethane)	0.028	<0.025	<0.025	<0.025
1-Propanol	<0.025	0.69	0.19	TRACE
Trimethylsilanol	0.11	0.10	0.15	0.077
2-Butanone (Methyl ethyl ketone)	TRACE	<0.025	<0.025	<0.025
Ethyl acetate	<0.025	0.033	0.033	0.032
1-Butanol	0.038	0.443	0.260	0.073
Toluene	0.032	<0.025	<0.025	<0.025
Ethylbenzene	TRACE	<0.050	<0.050	<0.050
m & p-Xylene	0.15	<0.050	<0.050	<0.050
o-Xylene	TRACE	<0.050	<0.050	0.11
Cyclohexanone	<0.025	<0.025	<0.025	0.052
<b>SPECIAL INTEREST COMPOUNDS ***</b>				
All Special Interest Compounds were below the reporting limit				
<b>NON-TARGET COMPOUNDS ***</b>				
1,1,1,2-Tetrafluoroethane	0.15	<0.050	0.053	0.063
Acetic acid, 1-methoxy-2-propylester	0.12	<0.050	<0.050	<0.050
<b>TOTAL ALCOHOLS PLUS ACETONE</b>	<b>2.9</b>	<b>6.5</b>	<b>5.7</b>	<b>5.9</b>
<b>TARGET COMPOUNDS (GC) **</b>				
Carbon monoxide	3.4	1.2	1.2	1.2
Methane	4.6	16	16	25
Hydrogen	1.5	5.6	5.6	6.3
Carbon dioxide	4200	7900	7300	7800
<b>TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)</b>	<b>28</b>	<b>92</b>	<b>91</b>	<b>93</b>
<b>TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)</b>	<b>4.6</b>	<b>6.9</b>	<b>6.3</b>	<b>6.6</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 report detection limit.

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

OFP - Octafluoropropane



**TABLE 1B  
ANALYTICAL RESULTS OF SOYUZ 46 RETURN GSC AIR SAMPLES**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M <sup>3</sup> )	
	AQ160283 SN 2057 LAB	AQ160284 SN 2056 SM
	08/29/16 @ 17:00 GMT	08/29/16 @ 17:00 GMT
<b>TARGET COMPOUNDS (TO-15) **</b>		
Octafluoropropane (Perfluoropropane) *	<b>101</b>	<b>103</b>
Methanol *	<b>0.27</b>	<b>0.37</b>
Acetaldehyde	0.27	0.26
2-Methyl-1-propene	TRACE	TRACE
Ethanol *	<b>4.5</b>	<b>5.0</b>
Acetone	0.37	0.41
2-Propanol (Isopropanol)	0.15	0.15
Isoprene (2-Methyl-1,3-butadiene)	0.038	0.044
Methyl acetate	TRACE	TRACE
1-Propanol	0.027	0.026
Trimethylsilanol	0.118	0.088
2-Butanone (Methyl ethyl ketone)	<0.025	0.029
Ethyl acetate	0.034	0.035
1-Butanol	0.061	0.062
<b>SPECIAL INTEREST COMPOUNDS ***</b>		
All Special Interest Compounds were below the reporting limit		
<b>NON-TARGET COMPOUNDS ***</b>		
All Non-Target Compounds were below the reporting limit		
<b>TOTAL ALCOHOLS PLUS ACETONE</b>	<b>5.4</b>	<b>6.1</b>
<b>TARGET COMPOUNDS (GC) **</b>		
Carbon monoxide	1.0	1.0
Methane	25	25
Hydrogen	6.4	6.5
Carbon dioxide	7100	8500
<b>TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)</b>	<b>107</b>	<b>109</b>
<b>TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)</b>	<b>5.9</b>	<b>6.5</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.

# 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-9 RETURN GSC AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC) mg/M <sup>3</sup>		
	AQ160245 SN 2029	AQ160246 SN 2036	AQ160247 SN 2027
	LAB	Columbus	SM Near Panel 137 Contingency
	07/25/16 @ 10:00 GMT	07/25/16 @ 10:02 GMT	08/15/16 @ 12:28 GMT
<b>TARGET COMPOUNDS (TO-15)</b>			
Octafluoropropane (Perfluoropropane)	0.00101	0.00100	0.00101
Methanol	0.00379	0.00345	0.00351
Acetaldehyde	0.06455	0.07144	0.07542
2-Methyl-1-propene	ND	0.00001	0.00001
Ethanol	0.00221	0.00220	0.00237
Acetone	0.00672	0.00646	0.00921
2-Propanol (Isopropanol)	0.00182	0.00134	0.00180
Isoprene (2-Methyl-1,3-butadiene)	0.01554	0.01443	0.01232
1-Propanol	0.00702	0.00192	0.00013
Trimethylsilanol	0.02517	0.03696	0.01935
Ethyl acetate	0.00018	0.00018	0.00018
1-Butanol	0.01107	0.00650	0.00182
o-Xylene	ND	ND	0.00289
Cyclohexanone	ND	ND	0.00087
<b>SPECIAL INTEREST COMPOUNDS</b>			
All Special Interest Compounds were below the reporting limit			
<b>NON-TARGET COMPOUNDS</b>			
1,1,1,2-Tetrafluoroethane	ND	0.00051	0.00061
<b>TARGET COMPOUNDS (GC)</b>			
Carbon monoxide	0.07192	0.07072	0.07001
Methane	0.00457	0.00458	0.00705
Hydrogen	0.01640	0.01647	0.01862
Carbon dioxide	0.60550	0.56461	0.60259
<b>TOTAL T-VALUE</b>			
	<b>0.83746</b>	<b>0.80278</b>	<b>0.82977</b>
<b>TOTAL T-VALUE - CO2</b>			
	<b>0.23197</b>	<b>0.23817</b>	<b>0.22717</b>

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 2B  
T-VALUES FOR SOYUZ 46 RETURN GSC AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)	
	AQ160283 SN 2057 LAB 08/29/16 @ 17:00 GMT	AQ160284 SN 2056 SM 08/29/16 @ 17:00 GMT
<b>TARGET COMPOUNDS (TO-15)</b>		
Octafluoropropane (Perfluoropropane)	0.00119	0.00121
Methanol	0.00300	0.00411
Acetaldehyde	0.06709	0.06555
2-Methyl-1-propene	0.00001	0.00001
Ethanol	0.00225	0.00252
Acetone	0.00720	0.00797
2-Propanol (Isopropanol)	0.00097	0.00097
Isoprene (2-Methyl-1,3-butadiene)	0.01272	0.01470
Methyl acetate	0.00010	0.00010
1-Propanol	0.00028	0.00026
Trimethylsilanol	0.02954	0.02189
2-Butanone (Methyl ethyl ketone)	ND	0.00097
Ethyl acetate	0.00019	0.00019
1-Butanol	0.00154	0.00156
<b>SPECIAL INTEREST COMPOUNDS</b>		
All Special Interest Compounds are below the reporting limit		
<b>NON-TARGET COMPOUNDS</b>		
All Non-Target Compounds are below the reporting limit		
<b>TARGET COMPOUNDS (GC)</b>		
Carbon monoxide	0.05929	0.05964
Methane	0.00700	0.00726
Hydrogen	0.01881	0.01910
Carbon dioxide	0.54745	0.65293
<b>TOTAL T-VALUE</b>	<b>0.75865</b>	<b>0.86095</b>
<b>TOTAL T-VALUE - CO2</b>	<b>0.21120</b>	<b>0.20802</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 2C  
T-VALUES FOR SPACEX-9 INGRESS AIR SAMPLE**

CHEMICAL CONTAMINANT	T-VALUE (7-d SMAC)	T-VALUE (180-d SMAC)
	AQ160244 SN 2032 SpaceX-9 Ingress 07/21/16 @ 18:35 GMT	AQ160244 SN 2032 SpaceX-9 Ingress 07/21/16 @ 18:35 GMT
<b>TARGET COMPOUNDS (TO-15)</b>		
Octafluoropropane (Perfluoropropane)	0.00027	0.00027
Perfluoro(2-methylpentane)	0.00000	0.00000
Propane	0.00012	0.00227
Isobutane	0.00005	0.00005
Methanol	0.00542	0.00542
Acetaldehyde	0.07231	0.07231
Ethanol	0.00084	0.00084
Acetone	0.00442	0.00442
2-Propanol (Isopropanol)	0.00339	0.00339
Methylene chloride (Dichloromethane)	0.00057	0.00279
Trimethylsilanol	0.02722	0.02722
2-Butanone (Methyl ethyl ketone)	0.00042	0.00042
1-Butanol	0.00048	0.00096
Toluene	0.00213	0.00213
Ethylbenzene	0.00019	0.00050
m & p-Xylene	0.00206	0.00406
o-Xylene	0.00034	0.00068
<b>SPECIAL INTEREST COMPOUNDS</b>		
All Special Interest Compounds were below the reporting limit		
<b>NON-TARGET COMPOUNDS</b>		
1,1,1,2-Tetrafluoroethane	0.00145	0.00145
Acetic acid, 1-methoxy-2-propylester	0.00214	0.00214
<b>TARGET COMPOUNDS (GC)</b>		
Carbon monoxide	0.05398	0.20003
Methane	0.00131	0.00131
Hydrogen	0.00456	0.00456
Carbon dioxide	0.32355	0.32355
<b>TOTAL T-VALUE</b>	<b>0.50721</b>	<b>0.66077</b>
<b>TOTAL T-VALUE - CO2</b>	<b>0.18366</b>	<b>0.33722</b>

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 48 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 46/Expedition 48		
									WPA PWD Hot Potable Water 8/2/2016 20160908001	WPA PWD Ambient Potable Water 8/23/2016 20160908002	
Physical Characteristics											
	pH				pH units	U.S.	4.5-8.5	41000		5.54	5.34
	Conductivity				µS/cm	U.S.				2	2
Trace Metals (ICP/MS)											
	Barium				µg/L	U.S.	10,000	SWEG&41000		6	<1
	Zinc				µg/L	U.S.	2,000	SWEG&41000		2	2
Silicon (ICP/MS)											
	Silicon				µg/L	U.S.				28	25
Total Organic Carbon (Sievers)											
	Inorganic Carbon				mg/L	U.S.				1.01	0.99
	Organic Carbon				mg/L	U.S.	3	41000		0.41	0.31
Semi-volatiles (GC/MS) - Target List											
	Methyl sulfone				µg/L	U.S.				88	108
	Organic Carbon Recovery				percent	U.S.				5.42	8.89
	Unaccounted Organic Carbon				mg/L	U.S.				0.39	0.28

Data Qualifiers: None.

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

**Table 4. Expedition 48 Water Sample Summary Report  
ECLSS Samples**

Mission	Sample Location	Sample Description	Sample Date	Analysis/Sample ID	Units	Test Conducted by	SpX-9/Exp. 48				
							WPA MF Bed #2 Process Line D  MF Bed Effluent 8/3/2016 20160829001	WPA Condensate Sample Port  US Condensate 8/8/2016 20160829002	WPA Wastewater ORU  WPA Wastewater Sample 1 8/12/2016 20160829003	WSTA, EDV S/N 1214  Preserved Urine 8/12/2016 20160829004	CWC-I S/N 2121  UPA Distillate Not Specified 20160913001
<b>Physical Characteristics</b>											
	pH	pH units	U.S.	5.51	7.41	7.44	2.29	2.73			
	Conductivity	µS/cm	U.S.	3	300	176	>1,410	>1,410			
	Turbidity	NTU	U.S.	1.8	NA	NA	NA	NA			
<b>Anions (IC/ICPMS)</b>											
	Bromide	mg/L	U.S.	<0.1	0.2	<0.1	5.0	<0.1			
	Chloride	mg/L	U.S.	<0.5	<0.5	1.2	2,060	109			
	Fluoride	mg/L	U.S.	<0.1	0.3	0.2	MI	0.1			
	Nitrate as Nitrogen (NO3-N)	mg/L	U.S.	<0.2	<0.2	<0.2	34.3	<4.0			
	Phosphate as P (PO4-P)	mg/L	U.S.	<0.1	<0.1	1.0	4,370	167			
	Sulfate	mg/L	U.S.	<0.5	<0.5	1.1	1,550	141			
<b>Cations (IC)</b>											
	Ammonia as Nitrogen (NH3-N)	mg/L	U.S.	<0.25	38.2	19.4	617	NA			
<b>Trace Metals (ICP/MS)</b>											
	Calcium	mg/L	U.S.	<0.04	0.10	0.04	157	6.72			
	Magnesium	mg/L	U.S.	<0.04	<0.04	<0.04	54.1	2.45			
	Potassium	mg/L	U.S.	<0.04	0.04	0.24	1,240	56.7			
	Sodium	mg/L	U.S.	<0.04	<0.04	0.28	1,580	70.1			
	Aluminum	µg/L	U.S.	<4	<4	5	219	27			
	Arsenic	µg/L	U.S.	<4	<4	<4	91	3			
	Barium	µg/L	U.S.	<4	<4	<4	<40	2			
	Chromium	µg/L	U.S.	<4	5	453	750,000	33,400			
	Copper	µg/L	U.S.	<4	<4	<4	<40	2			
	Iron	µg/L	U.S.	<20	<20	76	752	70			
	Lead	µg/L	U.S.	<4	<4	<4	<40	1			
	Manganese	µg/L	U.S.	<4	18	10	<40	4			
	Molybdenum	µg/L	U.S.	<4	<4	<4	102	8			
	Nickel	µg/L	U.S.	<4	509	700	1,320	234			
	Selenium	µg/L	U.S.	<4	<4	<4	47	18			
	Silver	µg/L	U.S.	<4	12	9	50	<1			
	Zinc	µg/L	U.S.	5	6,270	3,050	1,160	67			
<b>Silicon (ICP/MS)</b>											
	Silicon	µg/L	U.S.	15	12,700	6,700	9,870	2,990			
<b>Total Organic Carbon (Sievers)</b>											
	Inorganic Carbon	mg/L	U.S.	1.47	19.8	18.2	<15.0	1.6			
	Organic Carbon	mg/L	U.S.	5.90	138	23.0	6,210	386			
<b>Volatile Organics</b>											
	Acetone	µg/L	U.S.	2,130	1,600	<50	NA	68,800			
	2-Butanone (Methyl ethyl ketone)	µg/L	U.S.	<5	<50	<50	NA	4,570			
<b>Volatile Organics -Special Interest Compounds (Semi-quantitative)</b>											
	Acetaldehyde	µg/L	U.S.	not found	460	not found	NA	72,000			
	Trimethylsilanol	µg/L	U.S.	not found	250	150	NA	530			
<b>Volatiles - Non-Targets (GC/MS) &gt;= 80% match quality (Semi-quantitative)</b>											
	Methyl acetate	µg/L	U.S.	not found	not found	not found	not found	17			
	Butyraldehyde (Butanal)	µg/L	U.S.	not found	not found	not found	not found	110			
	Heptanal	µg/L	U.S.	not found	not found	not found	not found	32			
	4-Heptanone	µg/L	U.S.	not found	not found	not found	not found	1,600			
	Hexanal	µg/L	U.S.	not found	not found	not found	not found	440			
	3-Methylbutanal	µg/L	U.S.	not found	not found	not found	not found	120			
	Methyl disulfide	µg/L	U.S.	not found	not found	not found	not found	420			
	2-Methylpropanal	µg/L	U.S.	not found	not found	not found	not found	60			
	2-Pentanone	µg/L	U.S.	not found	not found	not found	not found	180			
	Propionaldehyde (Propanal)	µg/L	U.S.	not found	not found	not found	not found	110			
	Valeraldehyde (Pentanal)	µg/L	U.S.	not found	not found	not found	not found	290			
	Fluorotrimethylsilane	µg/L	U.S.	not found	not found	not found	not found	58			
	3-Buten-2-one (Methyl vinyl ke	µg/L	U.S.	not found	not found	not found	not found	11			

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

**Table 4. Expedition 48 Water Sample Summary Report  
ECLSS Samples**

Mission	Sample Location	Sample Description	Sample Date	Analysis/Sample ID	Units	Test Conducted by	SpX-9/Exp. 48				
							WPA MF Bed #2 Process Line D  MF Bed Effluent 8/3/2016 20160829001	WPA Condensate Sample Port  US Condensate 8/8/2016 20160829002	WPA Wastewater ORU  WPA Wastewater Sample 1 8/12/2016 20160829003	WSTA, EDV S/N 1214  Preserved Urine 8/12/2016 20160829004	CWC-I S/N 2121  UPA Distillate Not Specified 20160913001
		Dimethyltrisulfide			µg/L	U.S.	not found	not found	not found	not found	37
<b>Semi-volatiles (GC/MS) - Target List</b>											
		Benzothiazole			µg/L	U.S.	<20	92	64	NA	123
		N-n-Butylbenzenesulfonamide			µg/L	U.S.	<20	<50	<60	NA	5,230
		Methyl sulfone			µg/L	U.S.	97	371	270	NA	59
		Benzoic acid			µg/L	U.S.	<100	1,170	<300	NA	217
		Phenol			µg/L	U.S.	<20	374	<60	NA	112
		p-Cresol (4-Methylphenol)			µg/L	U.S.	<20	<50	<60	NA	585
		Benzyl alcohol			µg/L	U.S.	<20	5,540	<60	NA	91
		Dibutylphthalate			µg/L	U.S.	<20	225	<60	NA	<10
		Diethylphthalate			µg/L	U.S.	<20	1,070	220	NA	10
		Dimethylphthalate			µg/L	U.S.	<20	52	<60	NA	<10
<b>Semi-volatiles (GC/MS) - Special Interest Compounds (Semi-quantitative - 2 pt curve)</b>											
		Acetophenone			µg/L	U.S.	not found	not found	not found	NA	50
		Benzaldehyde			µg/L	U.S.	not found	not found	not found	NA	800
		2-Butoxyethanol			µg/L	U.S.	not found	180	not found	NA	63
		2-(2-Butoxyethoxy)ethanol			µg/L	U.S.	not found	1,000	not found	NA	not found
		Caffeine			µg/L	U.S.	not found	not found	not found	NA	35
		Diethylene glycol monoethyl ether			µg/L	U.S.	not found	280	170	NA	not found
		N,N-Dimethyl acetamide			µg/L	U.S.	not found	500	150	NA	not found
		N,N-Dimethylformamide			µg/L	U.S.	not found	970	not found	NA	not found
		Dipropylene glycol methyl ether			µg/L	U.S.	not found	1,100	>420	NA	not found
		2-Ethoxyethanol			µg/L	U.S.	not found	610	not found	NA	not found
		2-Ethylhexanoic acid			µg/L	U.S.	not found	310	not found	NA	not found
		Hexanoic acid			µg/L	U.S.	not found	920	not found	NA	160
		Ibuprofen			µg/L	U.S.	not found	not found	not found	NA	410
		p-Menth-1-en-8-ol (alpha-Terpineol)			µg/L	U.S.	not found	not found	not found	NA	38
		2-Methyl-2,4-pentanediol			µg/L	U.S.	not found	140	75	NA	not found
		1-Methyl-2-pyrrolidinone			µg/L	U.S.	not found	690	not found	NA	not found
		Monomethyl phthalate			µg/L	U.S.	not found	150	65	NA	not found
		(+)-Neomenthol			µg/L	U.S.	not found	not found	not found	NA	1,300
		2-Phenoxyethanol			µg/L	U.S.	not found	3,000	not found	NA	49
		2-Phenyl-2-propanol			µg/L	U.S.	not found	290	not found	NA	not found
		2-Phenylacetic acid			µg/L	U.S.	not found	not found	not found	NA	170
		Thymol			µg/L	U.S.	not found	not found	not found	NA	25
		1,3,5-Triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione			µg/L	U.S.	not found	50	not found	NA	not found
		Tributyl phosphate			µg/L	U.S.	not found	42	not found	NA	not found
		Vanillin			µg/L	U.S.	not found	not found	not found	NA	37
<b>Alcohols (DAI/GC/MS)</b>											
		1-Butanol			µg/L	U.S.	<400	599	<400	NA	<400
		Ethanol			µg/L	U.S.	1,120	76,600	<400	NA	13,100
		Methanol			µg/L	U.S.	2,170	4,120	6,740	NA	18,600
		2-Propanol (Isopropanol)			µg/L	U.S.	495	1,580	<400	NA	570
<b>Glycols (DAI/GC/MS)</b>											
		1,2-Ethanediol (Ethylene glycol)			µg/L	U.S.	1,240	5,490	1,650	NA	<10,000
		1,2-Propanediol (Propylene glycol)			µg/L	U.S.	2,210	23,200	3,840	NA	<10,000
<b>Silanols (LC/RI) (R &amp; D Method -NIST traceable standard not available)</b>											
		Dimethylsilanediol (DMSD)			µg/L	U.S.	<1,000	37,000	18,000	NA	<2000
<b>Carboxylates (IC)</b>											
		Acetate			µg/L	U.S.	<500	60,400	<10,000	33,800	33,300
		Formate			µg/L	U.S.	<500	6,650	<10,000	54,200	46,400
		Glycolate			µg/L	U.S.	<1,000	<1,000	<20000	114,000	3,820
		Propionate			µg/L	U.S.	<500	1,220	<10,000	<10000	<1000
		Oxalate			µg/L	U.S.	<500	<500	<500	136,000	7,110
<b>Amines (IC)</b>											
		Methylamine			µg/L	U.S.	<250	<250	396	<250,000	<2500

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

**Table 4. Expedition 48 Water Sample Summary Report  
ECLSS Samples**

Mission	Sample Location	Sample Description	Sample Date	Analysis/Sample ID	Units	Test Conducted by	SpX-9/Exp. 48				
							WPA MF Bed #2 Process Line D	WPA Condensate Sample Port	WPA Wastewater ORU	WSTA, EDV S/N 1214	CWC-I S/N 2121
							MF Bed Effluent	US Condensate	WPA Wastewater Sample 1	Preserved Urine	UPA Distillate
							8/3/2016	8/8/2016	8/12/2016	8/12/2016	Not Specified
							<b>20160829001</b>	<b>20160829002</b>	<b>20160829003</b>	<b>20160829004</b>	<b>20160913001</b>
<b>Aldehydes</b>											
		Formaldehyde			µg/L	U.S.	<20	1,330	29	NA	96
<b>Non-volatiles (LC/UV-VIS)</b>											
		Urea			µg/L	U.S.	<800	1,030	<800	14,200,000	762,000
		Caprolactam			µg/L	U.S.	<500	2,350	<500	NA	NA
<b>Organic Carbon Recovery</b>											
					percent	U.S.	77.40	78.82	46.27	N/A	not determined
<b>Unaccounted Organic Carbon</b>											
					mg/L	U.S.	1.33	29.23	12.36	N/A	not determined

**Data Qualifiers:** 20160829001 - None.

20160829002 - Possible low bias-ethylamine & formate.

20160829003 - Possible high bias-methanol; Possible low bias-ammonium, ethanol, 1-propanol, 1-pentanol & isovalerate.

20160829004 - Conductivity (estimated result) ~ 15,600 µMho/cm. Result was above highest calibration standard; Possible low bias - ammonium & lactate.

20160913001 - Conductivity (estimated result) ~ 14,800 µMho/cm. Result was above highest calibration standard; Possible low bias - ammonium, fluoride & ethylamine.

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