

JSC TOXICOLOGY AND ENVIRONMENTAL CHEMISTRY GROUP

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TOX-AR-2018-02**

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DATE: April 5, 2018
SUBJECT: Toxicological Assessment of ISS Air and Water Quality: September 3, 2017 – December 14, 2017 (Increment 53), Including OA-8 Ingress and Node 1 Contingency 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

Nine archive air samples were collected in mini grab sample containers (mGSCs) on ISS during Increment 53. Five of these samples were collected as part of routine monitoring in the US Lab, Columbus Module (COL), and Russian Service Module (SM). A sixth planned sample was collected as part of OA-8 first ingress operations. The sample from the Japanese Pressurized Module (JPM) collected on 10/25 was collected following a release of Freon 218 from the CSAT payload. The last two samples were collected as part of an investigation into a potential air quality issue in Node 1; however, the second of these samples collected on 12/4/2017 is considered suspect. The first sample (Baseline, 11/14/2017) was collected when crew were experiencing no symptoms, whereas the second sample (Contingency, 12/4/2017) was collected when reporting of symptoms was necessary. A total of four pairs of passive-diffusion formaldehyde badges were also deployed in the Lab and SM during September and November. With the exception of the first ingress and contingency samples, which returned on 51S, all other mGSC samples and formaldehyde badges were returned on SpX-13. A summary of analytical results from the samples is provided in Table 1.

Table 1. Analytical summary of ISS air analyses

Return Flight	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)
SpX-13	Lab	9/19/2017	100	6.4	0.3	7000	38 ^e
SpX-13	COL	9/19/2017	99	6.5	0.3	5900	-
SpX-13	Lab	9/20/2017	92	6.3	0.3	5600	-
SpX-13	SM	9/21/2017	-	-	-	-	23 ^e
SpX-13	JPM	10/25/2017	865	6.5	0.3	6400	-
SpX-13	Lab	11/1/17	456	6.0	0.3	6500	39 ^e
SpX-13	SM	11/1/17	451	5.8	0.3	6800	23 ^e
51S	OA-8 Ingress	11/14/2017	140	3.4	0.9 (0.6)	2800	-
51S	Node 1 Baseline	11/14/2017	630	8.7	0.3	6800	-
51S	Node 1 Contingency	12/4/2017	3.8	3.9	0.5	1200	-
<i>Guideline</i>			---	<5	<1 ^c	<7100 ^d	<120

Suspect sample results are shaded gray

^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 attached to this report. Complete data tables including compounds assessed but not detected are available upon request. The mean relative recoveries of the three surrogate standards from the 51S return mGSC samples were as follows: ^{13}C -acetone, $95\pm 11\%$; fluorobenzene- d_5 , $95\pm 8\%$; and chlorobenzene- d_5 , $89\pm 11\%$. Average surrogate recoveries for the mGSCs returned on SpX-13 were: ^{13}C -acetone, $119\pm 13\%$; fluorobenzene- d_5 , $109\pm 5\%$; and chlorobenzene- d_5 , $123\pm 12\%$. For the passive-diffusion formaldehyde badges, the badges used for monitoring were expired. Additionally, because this lot of badges was used across multiple Increments and returned on several different flights, all of the positive flight and lab controls were inadvertently analyzed with the badges returned on SpX-12. However, ground testing has demonstrated that the formaldehyde complex formed on the badge is very stable, and the data are consistent with historical average. Therefore, the data are believed to be representative of crew exposures.

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

Compound	September Average	October Average	November Average	December Average	Increment Average
2-Propanol	0.09	0.11	0.17	0.35	0.18
Acetone	0.21	0.33	0.41	0.37	0.33
Acrolein	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND
Decamethylcyclotrisiloxane#	0.14	0.10	TRACE	TRACE	0.12
Hexanal	ND	TRACE	TRACE	ND	TRACE
Hexane	ND	ND	ND	ND	ND
m,p-Xylenes#	TRACE	TRACE	TRACE	TRACE	TRACE
Methanol	0.26	0.26	0.25	0.25	0.26
o-Xylene#	0.05	0.09	0.10	0.06	0.08
Octamethylcyclotetrasiloxane#	TRACE	TRACE	TRACE	TRACE	TRACE
Toluene#	0.03	0.03	0.03	ND	0.03
2-Butanone	ND	ND	ND	ND	ND
Acetaldehyde	TRACE	TRACE	TRACE	TRACE	TRACE
Dichloromethane	ND	ND	ND	ND	ND
Ethanol	4.20	3.48	3.63	3.79	3.78
Ethyl Acetate	TRACE	0.04	0.04	ND	TRACE
Hexamethylcyclotrisiloxane#	0.07	0.08	0.08	0.06	0.07
n-Butanol	0.07	0.07	0.08	0.05	0.07
Trimethylsilanol	0.15	0.19	0.18	0.11	0.16

Obtained from prime unit

ND: Not detected; <MDL (Minimum Detection Limit)

TRACE= >MDL, <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-13 confirmed air quality was acceptable during this time frame. **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 53 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. Overall, the reported concentrations for the compounds detected are consistent with levels detected since installation of the Node 1 carbon filters in May 2015. On the first day of the following Increment (Dec 15, 2017), the Node 1 carbon filters were replaced with HEPA filters to assist in removal of fungal spores. Concentrations of some chemical contaminants (e.g. siloxanes) are expected to increase slightly, but levels are not expected to elevate to a point of concern.

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) on the US segment. 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. Concentrations measured by the MCA fluctuate as a result of multiple factors including the number of crew on ISS, current scrubbing capability, and processes and activities that generate CO₂. CO₂ levels (24-hour average) recorded by the MCA were at or slightly above 3 mmHg throughout the majority of the Increment. Average CO₂ levels were approximately 2 mmHg when the crew size was reduced to three (during the first 10 days of the Increment and in mid-December). Brief spikes to ~5 mmHg were observed during MetOx regeneration. Additional measures, including the use of LiOH canisters on the Russian segment and dual CDRA operations on the US segment, were taken to maintain average levels at or below 3 mmHg. Overall, CO₂ concentrations were well controlled throughout the Increment.

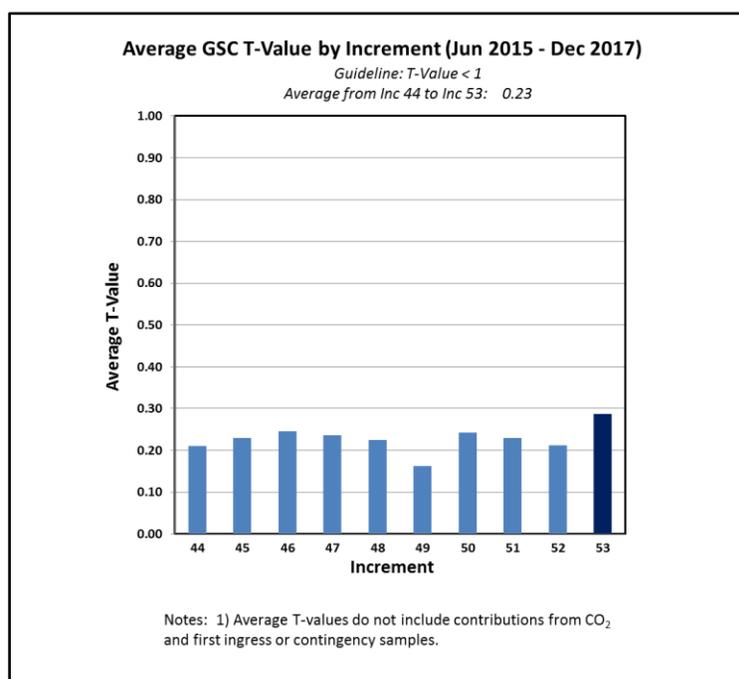


Figure 1. GSC T-values

Alcohol values in all routine archive 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 (Increment average of 3.8 mg/m³) were lower than the levels measured in archive samples collected in October (5.2 mg/m³) and November (4.5 and 4.6 mg/m³). The reason for the apparent off-set in this compound is unknown at this time, but will be continue to be monitored. A corrective action plan will be developed if the values begin to diverge significantly or

off-sets are noted for other compounds. This is similar to the average concentration calculated during Increment 52. Importantly, ethanol levels during the entire Increment did not present a risk for crew health. Octafluoropropane (Freon 218) levels increased significantly after a release from the CSAT payload. The concentration increased from 92 mg/m³ (US Lab on 9/20) to 865 mg/m³ (JPM on 10/25). This concentration is still two orders of magnitude below the 180 d SMAC value (85,000 mg/m³) and does not constitute a toxicological risk. The 11/14/2017 Node 1 contingency sample contained 630 mg/m³ Freon 218. Prior history of leaks resulting in similar concentrations suggests that levels will remain elevated for some time, provided that additional leaks do not occur during this time frame.

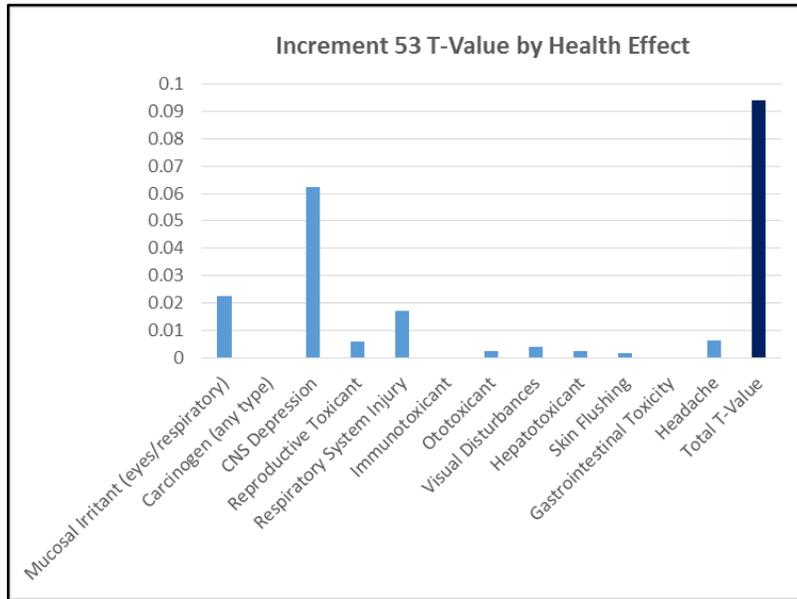


Figure 2. AQM T-values

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/m³.

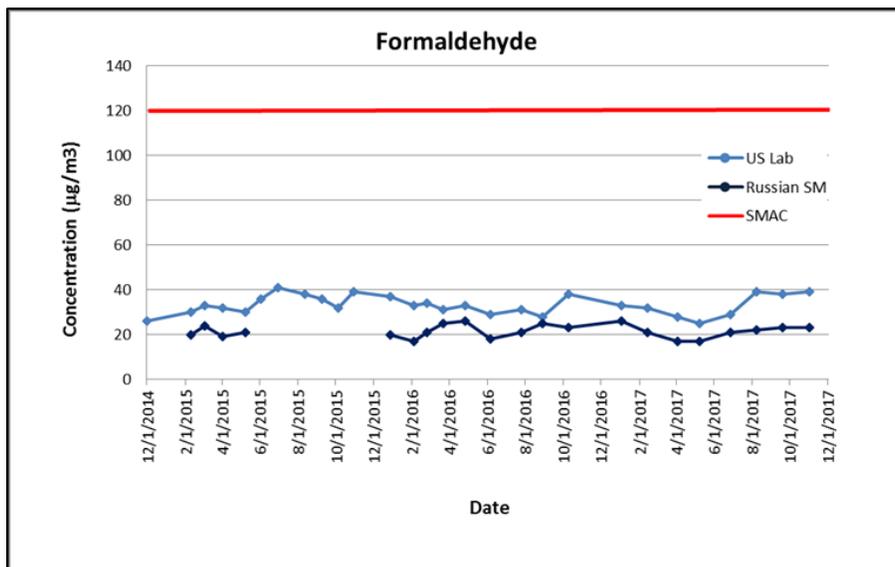


Figure 3. Formaldehyde trending in ISS air.

OA-8 Ingress

A first entry sample was collected upon ingress into OA-8 on 11/14/2017, approximately nine minutes after hatch opening. The concentration of Freon 218 (octafluoropropane), a marker for ISS air dilution of first entry samples, indicated ~ 22% mixing with the ISS atmosphere prior to sample collection. Carbon dioxide was detected in the ingress sample at 2800 mg/m³, 41% of the concentration in the Node 1 sample (6800 mg/m³) and 39% of the MCA value (7104 mg/m³) at the time of sample collection. The total T-value (minus CO₂) was 0.9, which was below the limit of 3.0 units and lower compared to other Orbital ingress results (OA-7: 1.6; OA-6: 1.6; OA-4: 2.2). The primary contributors were trimethylsilanol (0.64 mg/m³), hexamethylcyclotrisiloxane (1.3 mg/m³), carbon monoxide (2.5 mg/m³), carbon disulfide (0.08 mg/m³), and acetaldehyde (0.46 mg/m³). Conservatively accounting for 41% dilution, exposure to OA-8 vehicle air would have posed no risk to crew health.

Node 1 Contingency Samples

Due to reports of recurring crew symptoms localized in Node 1, air samples were collected on 11/14/17 and 12/4/17 to determine if air quality was a causal factor. The first sample served as a baseline and was collected when symptoms were not evident, whereas the second sample was taken when symptoms were reported. No airborne compounds were found at levels of health concern in either the baseline or the follow-up Node 1 contingency sample. Unfortunately, the quality of the second sample was determined to be suspect due to the uncharacteristically low concentrations of octafluoropropane, CO₂, and methane. Thus, it is not possible to draw any firm conclusions regarding crew reported symptoms based on this sample. Microbiological samples were also collected as part of the investigation, which revealed elevated fungal counts. In an effort to reduce fungal contamination in Node 1 air, the charcoal filters in Node 1 were replaced with HEPA filters on the first day of Increment 54 (Dec 15, 2017), which mitigated the elevated fungal counts. For additional information regarding microbial analyses, please see the Increment 53 post-flight report issued by the JSC Environmental Microbiology Laboratory.

WATER QUALITY

Two archive water samples were collected from the US segment during Increment 53 and returned on 51S. These were potable water samples from the ambient and hot legs of the US Potable Water Dispenser (PWD). Complete data tables with results for all measured parameters can be found in report 2018-TEC-WQ-001. A summary of select analytical results is provided in Table 3. 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)	Methyl Sulfone (mg/L)	Conductivity (µS/cm)	Total Iodine (mg/L)
PWD (hot)	11/14/2017	1.26	2.7	0.29	2	<0.05
PWD (ambient)	12/4/2017	1.16	2.5	0.33	2	<0.05

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 detected in the potable water samples met the requirements listed in SSP 41000, *System Specification for the International Space Station and the Medical Operations Requirements Document (MORD)*. Total organic carbon (TOC) concentrations from in-flight (PWD TOC and WPA TOC) and ground analyses (Archive TOC) performed between September 2016 and December 2017 are shown in Figure 4. The TOC concentration in the water produced by WPA remained elevated during Increment 53 (primarily due to DMSD), but measured concentrations were well below both the U.S. Segment Specification (3000 $\mu\text{g/L}$) and the 100-day Spacecraft Water Exposure Guideline (SWEG) (5000 $\mu\text{g/L}$). The TOC concentrations in the U.S. archive samples (Archive TOC) were 1260 $\mu\text{g/L}$ for the hot sample collected on 11/14 and 1160 $\mu\text{g/L}$ for the ambient sample collected on 12/4. It should be noted that both of these concentrations are higher than the concentrations measured on the same days in-flight, which may be indicative of reduced sensitivity of TOCA. As indicated in the Increment 52 Report, PFU2 is nearing its expected lifetime of five years, but is not expected to be replaced prior to failure.

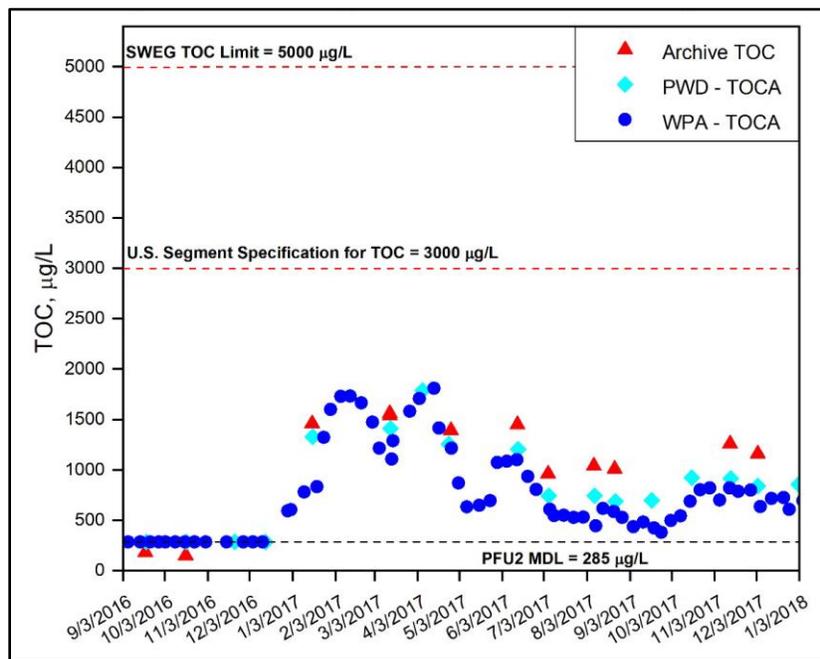


Figure 4. Total Organic Carbon (TOC) trending in US Potable Water

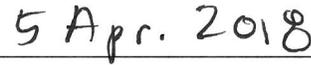
As mentioned, the source of the TOC in the potable samples was primarily DMSD (2.7 mg/L in hot, 2.5 mg/L in ambient). Methyl sulfone, another minor contributor to the TOC, was significantly higher (294 $\mu\text{g/L}$ in hot, 327 $\mu\text{g/L}$ in ambient) than during Increment 52 (101-151 $\mu\text{g/L}$) and the historical average for both ports (59-75 $\mu\text{g/L}$). Although the concentration of this compound has continued to increase over the past several years, levels are still well below the SWEG of 1,500 mg/L. Diethylphthalate, another minor TOC contributor, was detected in the hot sample at a level (24 $\mu\text{g/L}$) consistent with recent results. The presence of 1-methyl-2-pyrrolidinone in both samples (81-83 $\mu\text{g/L}$) was due to confirmed contamination during analysis. Silicon was also detected (0.74-0.89 mg/L) at levels typically seen when DMSD is present in the water. In the potable samples, nickel (6-9 $\mu\text{g/L}$) and zinc (1-2 $\mu\text{g/L}$) were found at concentrations consistent with previous samples.

Iodine is a biocide used on the US segment. It is added to the water produced by the WPA, but removed prior to crew consumption to avoid potential thyroid dysfunction. The total iodine level in the samples collected from the PWD were below the reporting limit (0.05 mg/L), indicating effective removal of iodine

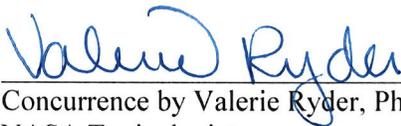
in water intended for consumption. For additional information regarding microbial analyses, please see the Increment 53 post-flight report issued by the JSC Environmental Microbiology Laboratory.



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KBRwyle Toxicologist



Date



Concurrence by Valerie Ryder, Ph.D., DABT
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Date

- Enclosures
- Table 1A: Analytical concentrations of compounds quantified in the mGSC returned on SpaceX-13
 - Table 1B: Analytical concentrations of compounds quantified in mGSCs returned on 51S
 - Table 2A: T-values corresponding to concentrations in Table 1A, based on 180-day SMACs
 - Table 2B: T-values corresponding to concentrations for Node 1 Contingency samples in Table 1B, based on 180-day SMACs
 - Table 2C: T-values corresponding to concentrations for the OA-8 Ingress sample in Table 1B, based on 7-day and 180-day SMACs
 - Table 3: Analytical concentrations of compounds quantified in US potable water samples returned on Soyuz 51

TABLE 1A
ANALYTICAL RESULTS OF SPACEX-13 RETURN

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M ³)					
	AQ180010 SN2069	AQ180011 SN2068	AQ180012 SN2070	AQ180013 SN2073	AQ180014 SN2074	AQ180015 SN2075
	LAB	Columbus	LAB	JPM	LAB	SM
	09/19/17 @ 08:15 GMT	09/19/17 @ 08:15 GMT	09/20/17 @ 07:19 GMT	10/25/17 @ 11:26 GMT	11/01/17 @ 18:56 GMT	11/01/17 @ 18:58 GMT
TARGET COMPOUNDS (TO-15) **						
1,1,1,2-Tetrafluoroethane (Norflurane)	0.069	0.075	0.066	0.074	<0.050	0.058
Isobutane	TRACE	TRACE	TRACE	<0.025	<0.025	<0.025
Methanol *	0.48	0.44	0.41	0.43	0.43	0.42
Acetaldehyde	0.33	0.33	0.33	0.34	0.30	0.32
2-Methyl-1-propene	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
Ethanol *	5.0	5.2	5.0	5.2	4.6	4.5
Acetone	0.53	0.50	0.48	0.45	0.52	0.56
Propanal (Propionaldehyde)	<0.025	TRACE	<0.025	<0.025	<0.025	TRACE
Pentane	<0.025	<0.025	<0.025	<0.025	<0.025	TRACE
2-Propanol (Isopropanol)	0.24	0.25	0.28	0.29	0.29	0.30
Isoprene (2-Methyl-1,3-butadiene)	0.030	0.040	0.037	0.026	0.043	0.042
Methylene chloride (Dichloromethane)	0.033	0.035	0.035	0.028	0.029	0.029
1-Propanol	0.050	0.042	0.050	0.053	0.044	0.035
Trimethylsilanol	0.15	0.17	0.15	0.20	0.18	0.14
2-Butanone (Methyl ethyl ketone)	<0.025	TRACE	<0.025	0.028	<0.025	<0.025
Ethyl acetate	0.027	0.029	0.026	0.031	0.028	0.030
1-Butanol	0.067	0.075	0.066	0.077	0.079	0.077
3-Methylhexane	0.030	0.032	0.028	0.030	0.031	0.031
Pentanal	TRACE	<0.025	<0.025	<0.025	<0.025	0.026
Toluene	0.034	0.036	0.031	0.032	0.032	0.031
Hexanal	0.082	0.072	0.058	0.049	0.047	0.049
o-Xylene	TRACE	TRACE	TRACE	0.053	0.056	0.060
Octafluoropropane (Perfluoropropane) *	100	99	92	865	456	451
SPECIAL INTEREST COMPOUNDS ***						
Hexamethylcyclotrisiloxane #	0.22	0.24	0.22	0.24	<0.20	<0.20
NON-TARGET COMPOUNDS ***						
Dodecafluoropentane	<0.050	0.15	<0.050	0.18	<0.050	0.15
TOTAL ALCOHOLS PLUS ACETONE	6.4	6.5	6.3	6.5	6.0	5.8
TARGET COMPOUNDS (GC) **						
Methane	20	20	21	35	36	36
Carbon dioxide	7000	5900	5600	6400	6500	6800
Hydrogen	3.3	3.3	3.3	3.7	3.6	3.6
Carbon monoxide	1.4	1.3	1.3	1.3	1.3	1.3
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	107	107	100	873	463	458
TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	7.4	7.8	7.4	7.8	6.7	6.9

* 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 1B
ANALYTICAL RESULTS OF SOYUZ 51 RETURN**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M ³)		
	AQ170261 SN2077 Node 1 Contingency Near Table 11/14/17 @14:40 GMT	AQ170162 SN2076 OA-8 Ingress 11/14/17 @17:30 GMT	AQ170263 SN 2078 Node 1 Contingency Dining Area 12/4/17 @19:33 GMT
TARGET COMPOUNDS (TO-15) **			
1,1,1,2-Tetrafluoroethane (Norflurane)	0.065	0.12	3.2
Propane	<0.025	TRACE	0.030
Carbonyl sulfide (Carbon oxide sulfide)	<0.025	0.075	<0.025
Isobutane	<0.025	0.65	0.24
Methanol *	0.36	0.24	0.20
Acetaldehyde	0.37	0.46	0.19
2-Methyl-1-propene	TRACE	0.15	0.060
Butane	<0.025	0.028	TRACE
Ethanol *	7.4	1.6	1.4
Acetone	0.56	0.45	0.33
Propanal (Propionaldehyde)	<0.025	0.029	TRACE
2-Propanol (Isopropanol) *	0.27	0.91	1.8
Isoprene (2-Methyl-1,3-butadiene)	0.043	<0.025	<0.025
2-Methyl-2-propanol	<0.025	0.033	TRACE
Methylene chloride (Dichloromethane)	0.031	<0.025	0.025
Carbon disulfide	<0.025	0.084	<0.025
1-Propanol	0.047	0.029	0.030
Trimethylsilanol	0.30	0.64	1.5
Butanal (Butyraldehyde)	<0.025	0.027	<0.025
2-Butanone (Methyl ethyl ketone)	TRACE	0.10	TRACE
Ethyl acetate	0.029	0.062	<0.025
1-Butanol	0.093	0.11	0.081
3-Methylhexane	0.033	0.029	<0.025
Toluene	0.031	0.035	0.028
o-Xylene	0.068	<0.050	<0.050
Decamethylcyclopentasiloxane	<0.175	TRACE	<0.175
Octafluoropropane (Perfluoropropane) *	630	140	3.8
SPECIAL INTEREST COMPOUNDS ***			
Hexamethylcyclotrisiloxane #	<0.20	1.3	<0.20
NON-TARGET COMPOUNDS ***			
1,1-Difluoroethane	<0.050	<0.050	0.12
Fluorotrimethylsilane	<0.050	0.085	<0.050
1,3-Dichloro-1,1,2,2,3-pentafluoropropane	<0.050	0.15	<0.050
C11-Alkane	<0.050	0.32	<0.050
C11-Alkane	<0.050	0.11	<0.050
C11-Alkane	<0.050	0.088	<0.050
C12-Alkane	<0.050	0.50	<0.050
C12-Alkane	<0.050	0.21	<0.050
C12-Alkane	<0.050	0.61	0.13
C12-Alkane	<0.050	0.093	<0.050
C12-Alkane	<0.050	0.50	0.091
C12-Alkane	<0.050	0.45	<0.050
C12-Alkane	<0.050	0.18	<0.050
TOTAL ALCOHOLS PLUS ACETONE	8.7	3.4	3.9
TARGET COMPOUNDS (GC) **			
Methane	38	9.9	< 2.6
Carbon dioxide	6800	2800	1200
Hydrogen	4.2	1.4	0.75
Carbon monoxide	1.1	2.5	1.1
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	640	151	13
TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	9.7	11	9.5

* 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

Note: Shaded results are suspect.

**TABLE 2A
T-VALUES FOR SPACEX-13 RETURN**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)					
	AQ180010 SN2069	AQ180011 SN2068	AQ180012 SN2070	AQ180013 SN2073	AQ180014 SN2074	AQ180015 SN2075
	LAB	Columbus	LAB	JPM	LAB	SM
	09/19/17 @ 08:15 GMT	09/19/17 @ 08:15 GMT	09/20/17 @ 07:19 GMT	10/25/17 @ 11:26 GMT	11/01/17 @ 18:56 GMT	11/01/17 @ 18:58 GMT
TARGET COMPOUNDS (TO-15)						
1,1,1,2-Tetrafluoroethane (Norflurane)	0.00035	0.00037	0.00033	0.00037	ND	0.00029
Isobutane	0.00005	0.00005	0.00005	ND	ND	ND
Methanol	0.00533	0.00485	0.00459	0.00473	0.00480	0.00466
Acetaldehyde	0.08158	0.08358	0.08139	0.08527	0.07390	0.08043
2-Methyl-1-propene	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054
Ethanol	0.00251	0.00260	0.00252	0.00260	0.00231	0.00223
Acetone	0.01020	0.00958	0.00925	0.00862	0.00998	0.01078
Propanal (Propionaldehyde)	ND	0.00104	ND	ND	ND	0.00104
Pentane	ND	ND	ND	ND	ND	0.00139
2-Propanol (Isopropanol)	0.00158	0.00168	0.00188	0.00196	0.00194	0.00203
Isoprene (2-Methyl-1,3-butadiene)	0.01011	0.01324	0.01232	0.00882	0.01439	0.01406
Methylene chloride (Dichloromethane)	0.00328	0.00355	0.00347	0.00284	0.00291	0.00291
1-Propanol	0.00051	0.00043	0.00051	0.00054	0.00045	0.00036
Trimethylsilanol	0.03761	0.04291	0.03637	0.04996	0.04554	0.03526
2-Butanone (Methyl ethyl ketone)	ND	0.00042	ND	0.00092	ND	ND
Ethyl acetate	0.00015	0.00016	0.00014	0.00017	0.00016	0.00017
1-Butanol	0.00168	0.00189	0.00166	0.00193	0.00197	0.00192
3-Methylhexane	0.00248	0.00264	0.00230	0.00252	0.00256	0.00259
Pentanal	0.00069	ND	ND	ND	ND	0.00144
Toluene	0.00226	0.00243	0.00206	0.00211	0.00213	0.00210
Hexanal	0.00408	0.00361	0.00289	0.00246	0.00234	0.00246
o-Xylene	0.00068	0.00068	0.00068	0.00145	0.00152	0.00163
Octafluoropropane (Perfluoropropane)	0.00118	0.00117	0.00109	0.01017	0.00536	0.00531
SPECIAL INTEREST COMPOUNDS						
Hexamethylcyclotrisiloxane	0.02480	0.02643	0.02472	0.02666	ND	ND
NON-TARGET COMPOUNDS						
Dodecafluoropentane	ND	0.00052	ND	0.00060	ND	0.00050
TARGET COMPOUNDS (GC)						
Methane	0.00568	0.00575	0.00586	0.00988	0.01024	0.01031
Carbon dioxide	0.53520	0.45549	0.43442	0.49286	0.49632	0.52300
Hydrogen	0.00957	0.00962	0.00960	0.01081	0.01054	0.01070
Carbon monoxide	0.08179	0.07829	0.07666	0.07492	0.07532	0.07559
TOTAL T-VALUE	0.82387	0.75352	0.71530	0.80371	0.76524	0.79369
TOTAL T-VALUE - CO2	0.28867	0.29803	0.28088	0.31085	0.26892	0.27069

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 51 RETURN**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)	
	AQ170261 SN2077 Node 1 Contingency Near Table 11/14/17 @14:40 GMT	AQ170263 SN 2078 Node 1 Contingency Dining Area 12/4/17 @19:33 GMT
TARGET COMPOUNDS (TO-15)		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.00032	0.01587
Propane	ND	0.00536
Isobutane	ND	0.00099
Methanol	0.00398	0.00224
Acetaldehyde	0.09180	0.04875
2-Methyl-1-propene	0.00011	0.00052
Butane	ND	0.00179
Ethanol	0.00370	0.00071
Acetone	0.01083	0.00633
Propanal (Propionaldehyde)	ND	0.00104
2-Propanol (Isopropanol)	0.00179	0.01207
Isoprene (2-Methyl-1,3-butadiene)	0.01420	ND
2-Methyl-2-propanol	ND	0.00010
Methylene chloride (Dichloromethane)	0.00308	0.00251
1-Propanol	0.00048	0.00030
Trimethylsilanol	0.07428	0.36561
2-Butanone (Methyl ethyl ketone)	0.00042	0.00042
Ethyl acetate	0.00016	ND
1-Butanol	0.00232	0.00202
3-Methylhexane	0.00271	ND
Toluene	0.00205	0.00185
o-Xylene	0.00184	ND
Octafluoropropane (Perfluoropropane)	0.00736	0.00004
SPECIAL INTEREST COMPOUNDS		
All Special Interest Compounds were below their reporting limit		
NON-TARGET COMPOUNDS		
1,1-Difluoroethane	ND	0.00177
C12-Alkane	ND	0.00287
C12-Alkane	ND	0.00206
TARGET COMPOUNDS (GC)		
Methane	0.01076	0.00036
Carbon dioxide	0.52649	0.09127
Hydrogen	0.01222	0.00219
Carbon monoxide	0.06629	0.06435
TOTAL T-VALUE	0.83720	0.63340
TOTAL T-VALUE - CO2	0.31071	0.54213

ND : Value is less than the laboratory reporting limit.

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

Note: Shaded results are suspect.

**TABLE 2C
T-VALUES FOR OA-8 INGRESS**

CHEMICAL CONTAMINANT	T-VALUE	
	(7-d SMAC)	(180-d SMAC)
	AQ170162 SN2076 OA-8 Ingress 11/14/17 @ 17:30 GMT	AQ170162 SN2076 OA-8 Ingress 11/14/17 @ 17:30 GMT
TARGET COMPOUNDS (TO-15)		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.00061	0.00061
Propane	0.00012	0.00227
Carbonyl sulfide (Carbon oxide sulfide)	0.02984	0.02984
Isobutane	0.00272	0.00272
Methanol	0.00264	0.00264
Acetaldehyde	0.11492	0.11492
2-Methyl-1-propene	0.00128	0.00128
Butane	0.00019	0.00394
Ethanol	0.00080	0.00080
Acetone	0.00865	0.00865
Propanal (Propionaldehyde)	0.00239	0.00239
2-Propanol (Isopropanol)	0.00609	0.00609
2-Methyl-2-propanol	0.00022	0.00028
Carbon disulfide	0.13979	0.13979
1-Propanol	0.00029	0.00029
Trimethylsilanol	0.16025	0.16025
Butanal (Butyraldehyde)	0.00179	0.00179
2-Butanone (Methyl ethyl ketone)	0.00336	0.00336
Ethyl acetate	0.00035	0.00035
1-Butanol	0.00139	0.00278
3-Methylhexane	0.00012	0.00239
Toluene	0.00232	0.00232
Decamethylcyclopentasiloxane	0.00088	0.00583
Octafluoropropane (Perfluoropropane)	0.00160	0.00160
SPECIAL INTEREST COMPOUNDS		
Hexamethylcyclotrisiloxane	0.01397	0.13968
NON-TARGET COMPOUNDS		
Fluorotrimethylsilane	0.02247	0.02247
1,3-Dichloro-1,1,2,2,3-pentafluoropropane	0.00179	0.03711
C11-Alkane	0.00737	0.00737
C11-Alkane	0.00250	0.00250
C11-Alkane	0.00199	0.00199
C12-Alkane	0.01142	0.01142
C12-Alkane	0.00467	0.00467
C12-Alkane	0.01386	0.01386
C12-Alkane	0.00212	0.00212
C12-Alkane	0.01143	0.01143
C12-Alkane	0.01034	0.01034
C12-Alkane	0.00419	0.00419
TARGET COMPOUNDS (GC)		
Methane	0.00283	0.00283
Carbon dioxide	0.21352	0.21352
Hydrogen	0.00415	0.00415
Carbon monoxide	0.03894	0.14431
TOTAL T-VALUE		
	0.85017	1.13115
TOTAL T-VALUE - CO2		
	0.63665	0.91763

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: Analytical concentrations of compounds quantified in US potable water samples returned on Soyuz 51

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	53	
					Soyuz 51	
					WPA PWD Hot Potable Water 11/14/2017 20171215001	WPA PWD Ambient Potable Water 12/4/2017 20171215002
Physical Characteristics						
Conductivity	µS/cm	U.S.			2	2
pH	pH units	U.S.	4.5-8.5	41000	5.70	5.65
Minerals ICPMS						
Calcium	mg/L	U.S.	30	41000	0.01	0.01
Trace Metals ICPMS						
Nickel	µg/L	U.S.	300	SWEG&41000	6	9
Zinc	µg/L	U.S.	2,000	SWEG&41000	2	1
Silicon ICPMS						
Silicon	µg/L	U.S.			891	735
Total Organic Carbon-Sievers						
Total Inorganic Carbon (TIC)	mg/L	U.S.			1.06	1.03
Total Organic Carbon (TOC)	mg/L	U.S.	5 / 3	SWEG / 41000	1.26	1.16
Semi-volatile Organics-Targets GCMS						
Methyl sulfone	µg/L	U.S.	1,500,000	interim SWEG (06-2017)	294	327
Base and Neutral Extractables-EPA 625 List GCMS						
Diethylphthalate	µg/L	U.S.			24	<20
Semi-volatiles (GC/MS) - Special Interest Compounds (Semi-quantitative)						
1-Methyl-2-pyrrolidinone	µg/L	U.S.			83	81
Silanols LCRI (R & D Method -NIST traceable standard not available)						
Dimethylsilanediol (DMSD)	µg/L	U.S.	35,000	SWEG	2,700	2,500
Organic Carbon Recovery						
	percent	U.S.			66.96	67.54
Unaccounted Organic Carbon						
	mg/L	U.S.			0.42	0.38

Comments: None

Data Qualifiers: 20171215001 & 002 - 1-Methyl-2-pyrrolidone- Results near RL after blank correction due to confirmed contamination.

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