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TOX-SW-2019-06

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SUBJECT: Toxicological Assessment of ISS Air and Water Quality: December 20, 2018 – March 14, 2019 (Increment 58)

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

AIR QUALITY

Four archive air samples were collected in mini grab sample containers (mGSCs) on ISS during Increment 58; two each on December 31, 2018 and February 11, 2019. These were returned on SpX-16 and -17. Two sets of formaldehyde badges were returned on 57S, providing formaldehyde data for the US Lab and Russian Service Module (SM) for the same dates. Due to the Soyuz anomaly in October 2018, only three crew were present on ISS for the entirety of Increment 58.

The first demonstration flight of SpaceX's Dragon 2 vehicle (Demo-1) was conducted in the first week of March. All data and interpretation for air samples collected during that flight are summarized in TOX-SW-2019-03, Toxicological Assessment of Air Samples Collected During the SpaceX Dragon 2 Demo-1 Mission (March 3-7, 2019). No other vehicles docked to ISS during Increment 58.

Table 1. Analytical summary of ISS air analyses (Increment 58)

Return Flight	Sample Location	Sample Date	Freon 218 (mg/m ³)	Alcohols ^a (mg/m ³)	T-Value (units)	Formaldehyde (µg/m ³)
SpaceX-16	Lab	12/31/2018	54	7.4	0.3	36
SpaceX-16	SM	12/31/2018	53	6.8	0.3	17
SpaceX-17	Lab	2/11/2019	38	4.3	0.2	43
SpaceX-17	JPM	2/11/2019	37	4.4	0.2	28
Guideline			---	<5	<1	<120

^aIncludes acetone

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, which include compounds assessed but not detected, are available upon request. The mean relative recoveries of the three surrogate standards from the mGSC samples returned on SpX-16 and -17 were all within acceptable limits.

On-orbit, the Air Quality Monitors (AQMs) automatically collect and analyze samples 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. One of

the AQMs (S/N 1005) failed in November 2018, so no December data was available for compounds measured on that unit. New AQM units (S/Ns 1011 and 1016) were delivered on SpX-16 and began acquiring data on January 21, 2019.

Table 2. Average monthly concentrations (mg/m³) of AQM target compounds

Compound	December Average	January Average	February Average	March Average	Increment Average
2-Propanol	--	0.2	0.2	2.9	1.1
Acetone	--	0.2	0.1	0.2	0.2
Acrolein	--	ND	ND	ND	ND
Benzene	--	ND	ND	ND	ND
1,2-Dichloroethane	--	ND	ND	ND	ND
Decamethylcyclopentasiloxane#	0.2	0.5	0.4	0.5	0.4
Hexanal	--	ND	ND	TRACE	ND
Hexane	--	ND	ND	ND	ND
m,p-Xylenes#	ND	TRACE	TRACE	ND	ND
Methanol	--	0.2	0.2	0.2	0.2
o-Xylene#	TRACE	TRACE	TRACE	0.04	TRACE
Octamethylcyclotetrasiloxane#	TRACE	TRACE	TRACE	TRACE	TRACE
Toluene#	ND	TRACE	0.03	0.03	0.03
2-Butanone	ND	ND	ND	ND	ND
Acetaldehyde	0.2	0.2	0.4	0.4	0.3
Dichloromethane	ND	ND	ND	ND	ND
Ethanol	4.2	2.8	2.8	3.0	3.2
Ethyl Acetate	TRACE	TRACE	ND	ND	ND
Hexamethylcyclotrisiloxane#	0.1	0.2	0.2	0.2	0.2
n-Butanol	0.1	0.04	0.1	0.1	0.1
Trimethylsilanol	0.1	0.1	0.1	0.1	0.1

Obtained from prime unit

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

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

--: Not assessed due to AQM failure.

Notes: An AQM unit failed in early November 2018, and so data for several compounds are lacking for December 2018. The units were replaced in January. Data for those compounds in January represents January 21-31, 2019.

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 mGSC and formaldehyde samples for this Increment that returned on SpX-16, SpX-17, and 57S confirmed air quality was acceptable. **All measured values for routine samples (mGSC and AQM) met 180-d T-value guideline criteria ($T < 1$), indicating no concern for crew health.** The average, rounded T-value calculated from the nominal Increment 58 mGSC samples was 0.2, excluding CO₂ (Figure 1). T-values calculated from GSC results (Figure 1) and AQM (Figure 2) were in reasonable agreement given the differences between the analytical techniques and the number of target compounds used in the calculation.

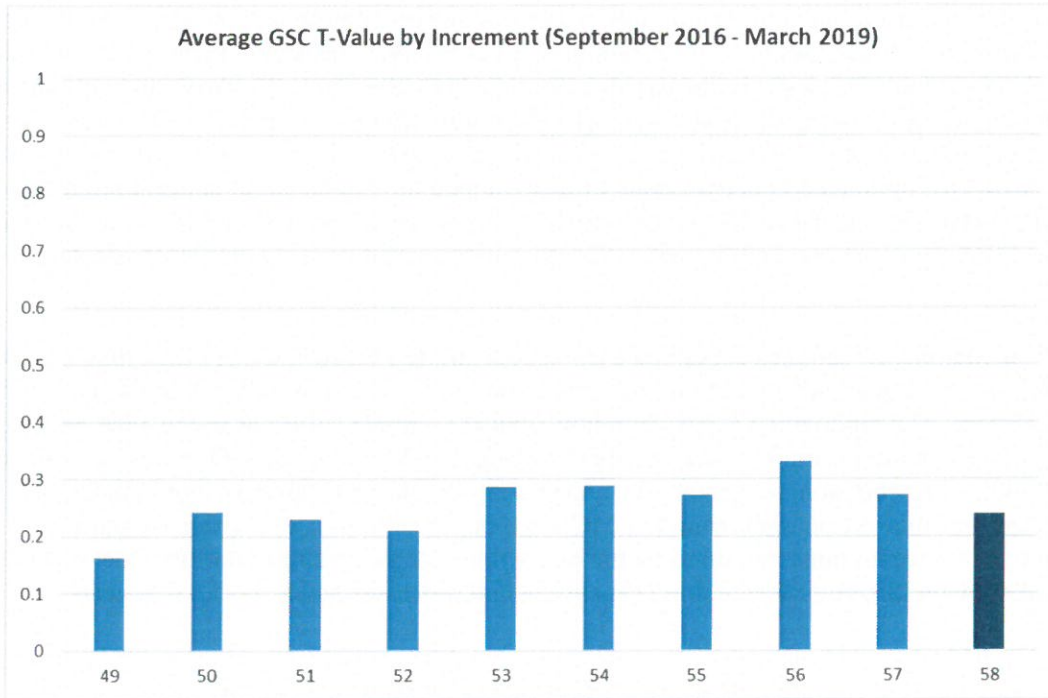


Figure 1. GSC-Derived T-values for Increments 49- 58

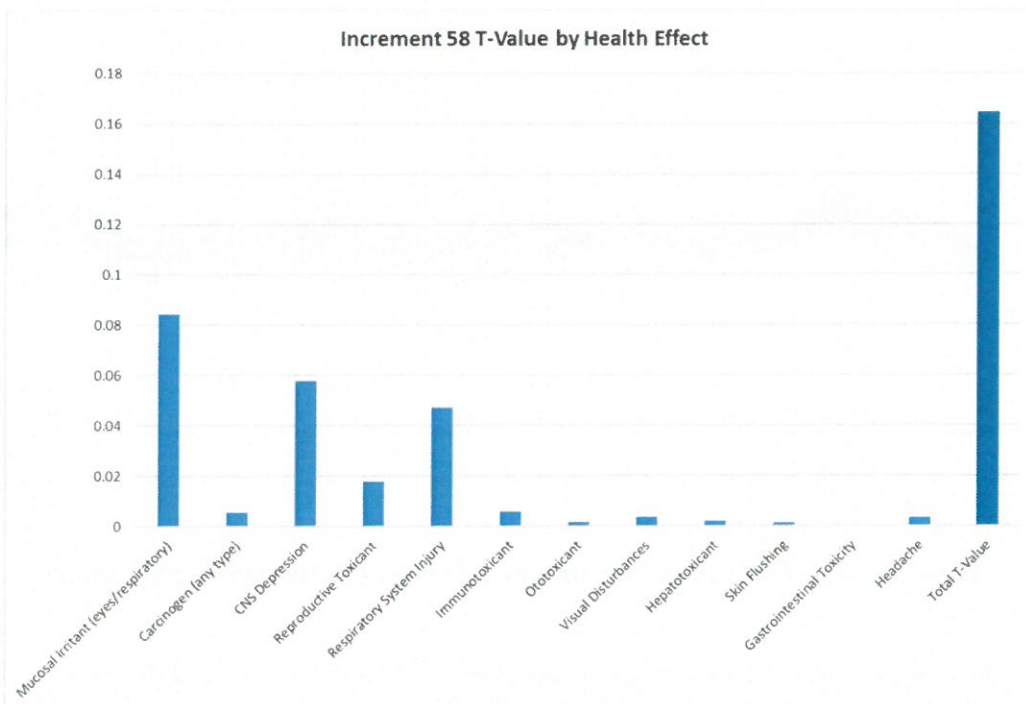


Figure 2. AQM-Derived T-Values by Health Effect for Increment 58

Generally, the reported concentrations for the compounds detected during Increment 58 are similar to levels detected during recent Increments. The concentration of 2-propanol measured on the AQMs in March 2019 is a notable exception. This issue is discussed in detail in TOX-SW-2019-03, Toxicological Assessment of Air Samples Collected During the SpaceX Dragon 2 Demo-1 Mission (March 3-7, 2019). While it is clear that the Dragon 2 Demo-1 vehicle contained a source of 2-propanol, analysis of archive samples indicated that the AQM over-predicted concentrations of this compound. Atmospheric concentrations of siloxanes (i.e., TMS, OMCTS, and HMCTS) were similar to those observed during Increment 57, though the December 2018 samples were slightly higher than those observed during the prior Increment or in February 2019.

Three of the four 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. The reported CO₂ concentration from the sample collected in the JPM on February 11, 2019 slightly exceeded this limit at ~3.2 mmHg (7500 mg/m³). While mGSC CO₂ sampling provides a snapshot of the CO₂ concentration, the major constituent analyzer (MCA) routinely monitors CO₂ levels in the US segment. For this reason, data from the MCA are 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.

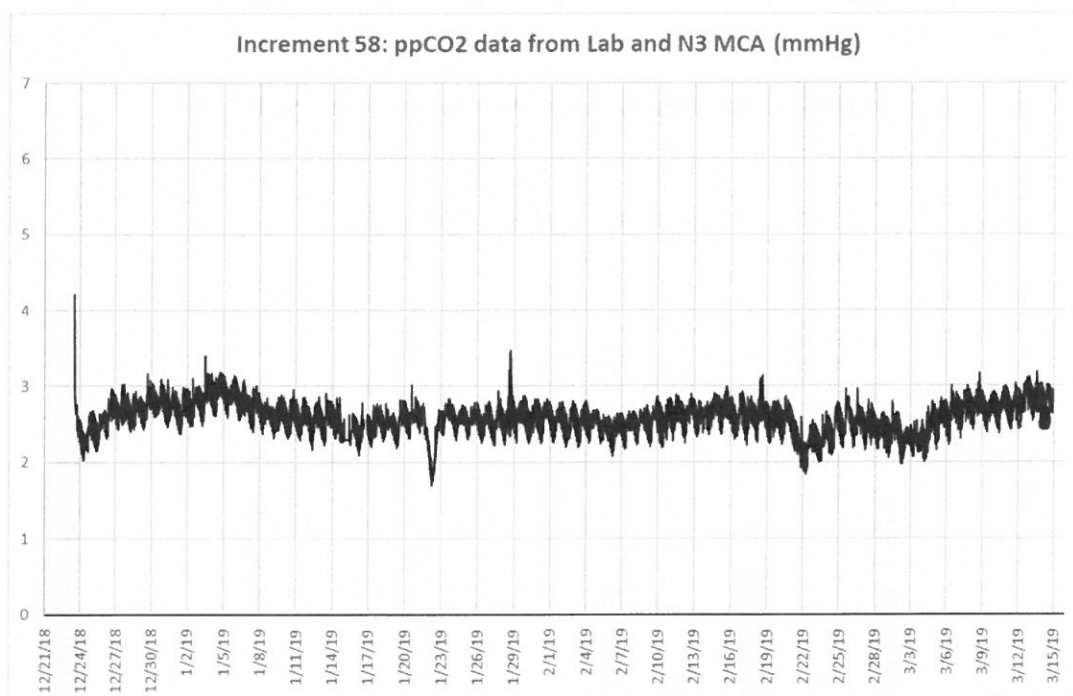


Figure 3. Environmental CO₂ Concentrations on ISS Increment 58 in mmHg

Most CO₂ data for Increment 58 were obtained from the MCA in the Node 3 and the remainder from Lab MCA. Overall, CO₂ concentrations were well-controlled throughout the Increment (Figure 3). CO₂ levels have historically been maintained between 1.5 and 2 mmHg with 3-person crew and closer to the 3 mmHg limit with 6 crew. During this Increment, which operated with 3 crew for the entire duration, the goal was to maintain a steady concentration of CO₂ on ISS regardless of the crew complement, and thus the Carbon Dioxide Removal Assembly (CDRA) was operated so as to maintain CO₂ levels at around 2.5-3 mmHg. The objective in controlling CO₂ in this manner is to reduce the possibility of effects related to fluctuating

levels. The Node 3 MCA reported elevated CO₂ levels after it was activated on December 23, 2018; however, this was attributed to residual moisture in the system, not actual CO₂ elevation. The MCA went offline briefly on January 15 and 21, 2019 due to false fire events. The sharp decrease on January 22 was due to brief operation of the LSR. The spike on January 28 was due to a SPHERES experiment, which generated concentrated CO₂ in a localized area during operations. On February 22, the notable decrease in concentration was associated with a Nitrogen Oxygen Recharge System O₂ (NORSO2) repressurization and increased CO₂ scrubbing to counter MetOx regeneration during 3-crew ops.

Alcohol values in the December 2018 routine archive samples returned on SpaceX-16 exceeded the guideline of <5 mg/m³, which is intended to protect the water recovery system from risk of overloading. However, samples taken in February 2019 and returned on SpaceX-17 demonstrated a decrease in alcohol below 5 mg/m³. Total alcohol levels are primarily attributable to ethanol in the ISS atmosphere. GSC samples confirmed that alcohol levels in December (6.8-7.4 mg/m³) were similar to those measured in November (6.6-6.9 mg/m³), but that levels decreased in February 2019 (4.3-4.4 mg/m³).

Two sets of passive formaldehyde badges were deployed on ISS during Increment 58 (on December 31, 2018 and February 11, 2019). Analytical and sampling issues created a data gap in formaldehyde monitoring that spanned from May until December 2018. Results from the Increment 58 badges indicated that formaldehyde remains in the historical range observed on ISS and concentrations were well below the SMAC of 120 µg/m³ (Figure 4). The concentration in the SM ranged from 15-28 µg/m³ and the range in the US Lab was 34-44 µg/m³.

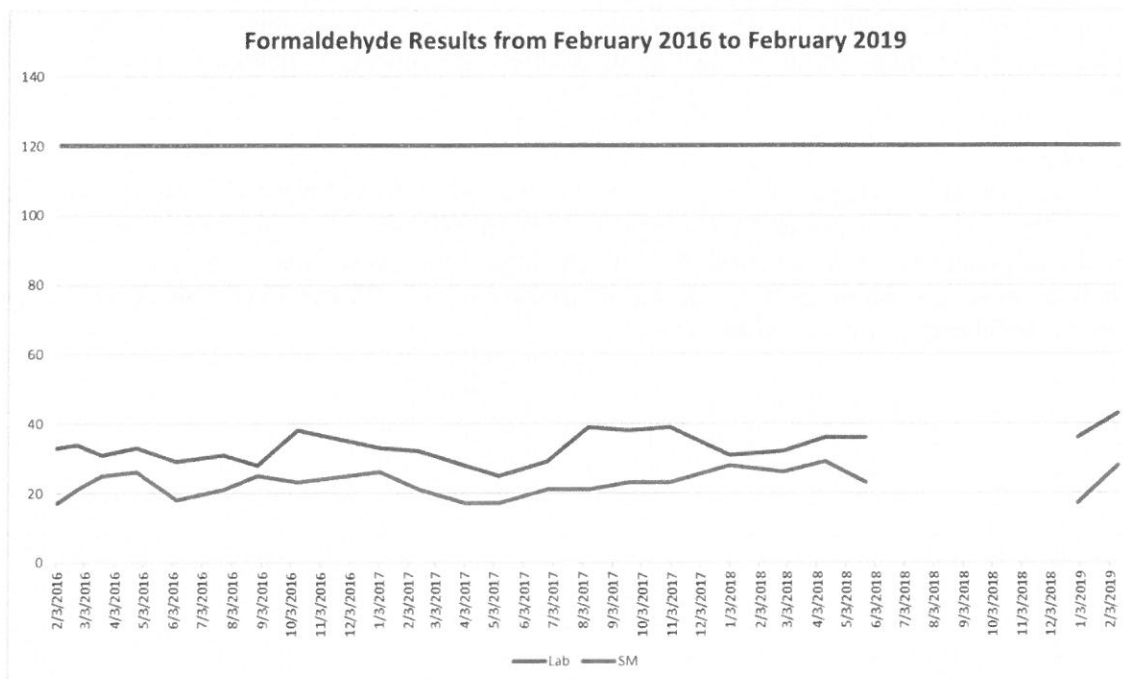


Figure 4. Trends in Formaldehyde (µg/m³) in ISS Air from Passive Sampling of US Lab and Russian Service Module from February 2016 through February 2019

WATER QUALITY

No potable water samples were collected during Increment 58. Two samples of Multifiltration (MF) bed effluent, one sample of Water Processor Assembly (WPA) wastewater, and one US condensate sample were collected during the Increment. Complete data tables with results for all measured parameters are available upon request. A summary of select analytical results from the Increment 58 samples 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 (Increment 58)

Return Mission	Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Methyl Sulfone (mg/L)	Conductivity (µS/cm)	Total Iodine (mg/L)
SpaceX-16	MF Bed Effluent	12/21/2018	44.2	20	0.1	90	<0.004
SpaceX-16	MF Bed Effluent	12/21/2018	28.9	21	0.1	5	<0.004
SpaceX-16	WPA Wastewater	12/28/2018	41.6	17	0.2	88	0.17
SpaceX-16	Russian Condensate	12/31/2018	153	39	0.5	270	<0.004

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. Typically, archive water samples are also 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. However, since no archive samples of potable water were collected during Increment 58, the evaluation of potable water quality is limited to data collected with TOCA.

Potable Water

Total organic carbon (TOC) concentrations from in-flight (PWD TOC and WPA TOC) and ground analyses (Archive TOC) performed between March 2016 and March 2019 are shown in Figure 5. As noted above, no samples of potable water are available from this Increment for comparison to in-flight TOC. **Based on results from analyses run on TOCA, the water produced by the Water Processor Assembly (WPA) met the US potability requirement for TOC.**

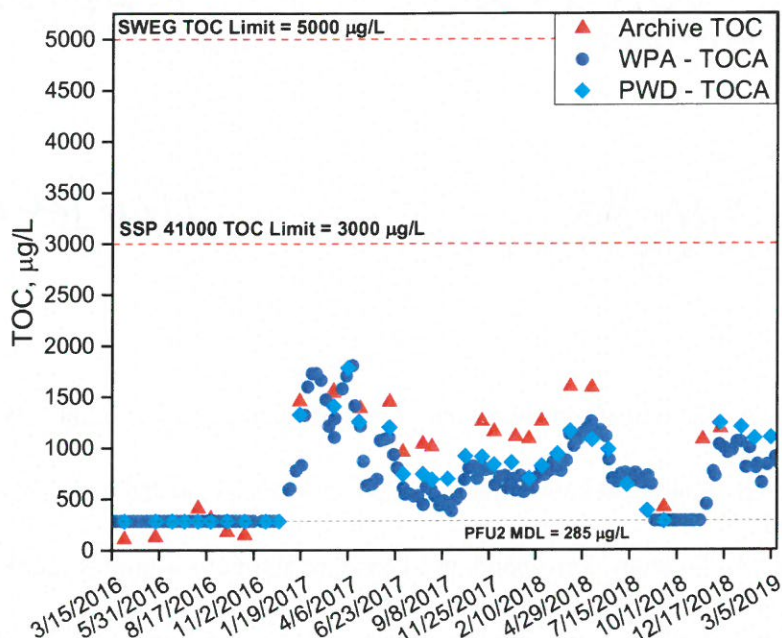


Figure 5. Total Organic Carbon (TOC) trending in US Potable Water

MF Bed Effluent

Two samples of MF bed effluent were collected on December 21, 2018 as part of an effort to identify the species responsible for the increasing conductivity in the effluent. The TOC concentrations in these samples were 44.2 mg/L (MF bed #1) and 28.9 mg/L (MF bed #2). As a result of new sampling procedures, the accountability for TOC in the MF bed effluent increased to >97.8%. Organic compounds present at concentrations greater than 0.5 mg/L in both samples include ethanol (37-45 mg/L), DMSD (20-21 mg/L), acetate (1.4-19 mg/L), acetone (4-5.5 mg/L), methanol (4-5 mg/L), isopropanol (3.5-4.3 mg/L), and propylene glycol (1.1-1.6 mg/L). Silicon was present at 5.0 and 6.2 mg/L, which is attributable to DMSD. Trace metals detected in these samples included boron (20-27 µg/L), nickel (19-22 µg/L), and zinc (21-48 µg/L).

WPA Wastewater

A sample was collected from the WPA Wastewater ORU on December 28, 2018. The TOC concentration was 41.6 mg/L, which is consistent with the historical average of 44.0 mg/L. Organic compounds detected at or above 1 mg/L include DMSD (17 mg/L), acetone (10.7 mg/L), benzyl alcohol (9.1 mg/L), ethanol (6.6 mg/L), methanol (6.3 mg/L), propylene glycol (4.0 mg/L), ethylene glycol (1.0 mg/L), and ibuprofen (1.0 mg/L). The silicon concentration was 4.9 mg/L, all of which can be accounted for by the presence of DMSD. Zinc (2.4 mg/L) was the only metal present at or above 1.0 mg/L.

US Condensate

A sample of condensate from the US segment was collected on December 31, 2018. The TOC concentration in the sample was 153 mg/L. Organic compounds detected at or above 1 mg/L include ethanol (99.2 mg/L), acetate (39.1 mg/L), DMSD (39 mg/L), benzyl alcohol (25.7 mg/L), propylene glycol (17.3 mg/L), methanol (8.4 mg/L), ethylene glycol (4.3 mg/L), acetone (4.2 mg/L), caprolactam (2.6 mg/L), isobutyrate (1.2 mg/L), and diethylphthalate (1.2 mg/L). Silicon was present at a concentration of 11.9 mg/L, which is accounted for by DMSD. Metals detected at levels above 0.1 mg/L include zinc (4.94 mg/L) and nickel (0.11 mg/L).

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- Enclosures
- Table 1A: Analytical concentrations of compounds quantified in the mGSC returned on SpaceX-16
 - Table 1B: Analytical concentrations of compounds quantified in the mGSC returned on SpaceX-17
 - Table 2A: T-values corresponding to concentrations for samples returned on SpaceX-16, based on 180-day SMACs
 - Table 2B: T-values corresponding to concentrations for samples returned on SpaceX-17, based on 180-day SMACs
 - Table 3: Analytical concentrations of compounds quantified in MF bed effluent, WPA wastewater, and US condensate returned on SpaceX-16

**TABLE 1A
ANALYTICAL RESULTS FOR SPACEX-16 RETURN AIR SAMPLES**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M3)	
	AQ190023 SN2004 LAB 12/31/18 @ 12:15 GMT	AQ190025 SN2019 SM 12/31/18 @ 12:30 GMT
	TARGET COMPOUNDS (TO-15) *	
1,1,1,2-Tetrafluoroethane (Norflurane)	0.11	0.11
Methanol	0.54	0.41
Acetaldehyde	0.36	0.37
Ethanol	6.1	5.9
Acetone	0.31	0.23
2-Propanol (Isopropanol)	0.39	0.24
Isoprene (2-Methyl-1,3-butadiene)	TRACE	TRACE
Carbon disulfide	TRACE	TRACE
1-Propanol	0.027	TRACE
Trimethylsilanol	0.088	0.071
1-Butanol	0.043	0.045
o-Xylene	<0.050	TRACE
Decamethylcyclopentasiloxane	0.84	0.54
Octafluoropropane (Perfluoropropane)	54	53
SPECIAL INTEREST COMPOUNDS #		
Hexamethylcyclotrisiloxane	0.27	0.21
NON-TARGET COMPOUNDS **		
All non-target compounds were below their reporting limit		
TOTAL ALCOHOLS PLUS ACETONE		
	7.4	6.8
TARGET COMPOUNDS (GC) *		
Methane	36	35
Carbon dioxide	6700	6000
Hydrogen	3.1	3.1
Carbon monoxide	0.79	0.53

* 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; 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

**TABLE 1B
ANALYTICAL RESULTS FOR SPACEX-17 RETURN AIR SAMPLES**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M ³)	
	AQ190283 SN 2014 LAB 2/11/2019 @ 12:45 GMT	AQ190284 SN 2016 JPM 2/11/2019 @ 12:50 GMT
TARGET COMPOUNDS (TO-15) *		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.073	0.079
Methanol	0.29	0.31
Acetaldehyde	0.19	0.20
Ethanol	3.5	3.5
Acetone	0.22	0.24
2-Propanol (Isopropanol)	0.16	0.18
Isoprene (2-Methyl-1,3-butadiene)	0.028	0.033
1-Propanol	0.034	0.044
Trimethylsilanol	0.079	0.11
Ethyl acetate	<0.025	TRACE
1-Butanol	0.053	0.054
Decamethylcyclopentasiloxane (DMCPS)	0.24	0.27
Octafluoropropane (Perfluoropropane)	38	37
SPECIAL INTEREST COMPOUNDS #		
Hexamethylcyclotrisiloxane	0.25	0.28
NON-TARGET COMPOUNDS **		
All non-target compounds were below their reporting limit		
TOTAL ALCOHOLS PLUS ACETONE	4.3	4.4
TARGET COMPOUNDS (GC) *		
Methane	34	34
Carbon dioxide	7000	7500
Hydrogen	2.5	2.5
Carbon monoxide	0.46	0.43

* 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; 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.

**TABLE 2A
T-VALUES FOR SPACEX-16 RETURN AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)	
	AQ190023 SN2004 LAB 12/31/18 @ 12:15 GMT	AQ190025 SN2019 SM 12/31/18 @ 12:30 GMT
TARGET COMPOUNDS (TO-15)		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.00001	0.00001
Methanol	0.00603	0.00453
Acetaldehyde	0.09083	0.09207
Ethanol	0.00304	0.00294
Acetone	0.00593	0.00448
2-Propanol (Isopropanol)	0.00261	0.00163
Isoprene (2-Methyl-1,3-butadiene)	0.00417	0.00417
Carbon disulfide	0.01136	0.01136
1-Propanol	0.00036	0.00017
Trimethylsilanol	0.02190	0.01772
1-Butanol	0.00106	0.00113
o-Xylene	ND	0.00068
Decamethylcyclopentasiloxane	0.05583	0.03571
Octafluoropropane (Perfluoropropane)	0.00063	0.00062
SPECIAL INTEREST COMPOUNDS		
Hexamethylcyclotrisiloxane	0.03028	0.02388
NON-TARGET COMPOUNDS		
All non-target compounds were below their reporting limit		
TARGET COMPOUNDS (GC)		
Methane	0.01032	0.01003
Hydrogen	0.00926	0.00921
Carbon monoxide	0.04666	0.03135
TOTAL T-VALUE	0.30028	0.25169

ND : Value is less than the laboratory reporting limit.

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

**TABLE 2B
T-VALUES FOR SPACEX-17 RETURN AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)	
	AQ190283 SN 2014 LAB 2/11/2019 @ 12:45 GMT	AQ190284 SN 2016 JPM 2/11/2019 @ 12:50 GMT
TARGET COMPOUNDS (TO-15)		
1,1,1,2-Tetrafluoroethane (Norflurane)	0.000	0.000
Methanol	0.003	0.003
Acetaldehyde	0.048	0.050
Ethanol	0.002	0.002
Acetone	0.004	0.005
2-Propanol (Isopropanol)	0.001	0.001
Isoprene (2-Methyl-1,3-butadiene)	0.009	0.011
1-Propanol	0.000	0.001
Trimethylsilanol	0.020	0.028
Ethyl acetate	ND	0.000
1-Butanol	0.001	0.001
Decamethylcyclopentasiloxane	0.016	0.018
Octafluoropropane (Perfluoropropane)	0.000	0.000
SPECIAL INTEREST COMPOUNDS		
Hexamethylcyclotrisiloxane	0.028	0.031
NON-TARGET COMPOUNDS		
All non-target compounds were below their reporting limit		
TARGET COMPOUNDS (GC)		
Methane	0.010	0.010
Hydrogen	0.007	0.007
Carbon monoxide	0.027	0.026
TOTAL T-VALUE	0.2	0.2

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 Archive Water Samples Returned on SpaceX-16

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	58 SpaceX-16			
					WPA MF Bed #1 ORU S/N 00016	WPA MF Bed #2 ORU S/N 00017	WPA Wastewater ORU	WPA Condensate Sample Port
					MF Bed Effluent	MF Bed Effluent	WPA Wastewater	US Condensate
					12/21/2018 WQ190024	12/21/2018 WQ190025	12/28/2018 WQ190026	12/31/2018 WQ190027
Physical Characteristics								
Conductivity	µMho/cm	U.S.			90	5	88	270
pH	pH units	U.S.	4.5-8.5	41000	6.99	5.26	7.39	7.66
Iodine ICPMS								
Total I	µg/L	U.S.	6/0.2	41000 (tl I mx/tl I at pt of consumption)	< 4	< 4	174	< 4
Anions IC								
Bromide	mg/L	U.S.			< 0.1	< 0.1	< 0.1	0.1
Fluoride	mg/L	U.S.			0.2	< 0.1	0.3	0.2
Cations IC								
Ammonium (as N)	mg/L	U.S.	1	SWEG&41000	11.1	< 0.25	11	31.4
Minerals ICPMS								
Calcium	mg/L	U.S.	30	41000	0.09	0.07	0.08	0.18
Phosphate (as P)	mg/L	U.S.			0.01	< 0.01	0.09	0.05
Potassium	mg/L	U.S.	340	41000	< 0.01	< 0.01	0.06	0.02
Sodium	mg/L	U.S.			0.41	< 0.01	0.07	0.01
Trace Metals ICPMS								
Boron	µg/L	U.S.			20	27	13	30
Chromium	µg/L	U.S.	230	41000	2	2	14	< 10
Nickel	µg/L	U.S.	300	SWEG&41000	19	22	65	108
Zinc	µg/L	U.S.	2,000	SWEG&41000	48	21	2,370	4,940
Silicon ICPMS								
Silicon	µg/L	U.S.			6,180	4,980	4,900	11,900
TOC OI								
Total Inorganic Carbon (TIC)	mg/L	U.S.			6.0	0.6	10.6	18.2
Total Organic Carbon (TOC)	mg/L	U.S.		SWEG&41000	44.2	28.9	41.6	153
Volatile Organics-Targets								
2-Butanone (Methyl ethyl ketone)	µg/L	U.S.	54,000	SWEG	438	400	488	< 50
Volatile Organics-Special Interest Compounds (Semi-quantitative)								
Trimethylsilanol	µg/L	U.S.			330	not found	130	280

Table 3: Analytical Concentrations of Compounds Quantified in Archive Water Samples Returned on SpaceX-16

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	58			
					SpaceX-16			
					WPA MF Bed #1 ORU S/N 00016 MF Bed Effluent 12/21/2018 WQ190024	WPA MF Bed #2 ORU S/N 00017 MF Bed Effluent 12/21/2018 WQ190025	WPA Wastewater ORU WPA Wastewater 12/28/2018 WQ190026	WPA Condensate Sample Port US Condensate 12/31/2018 WQ190027
Volatile Organics-Non-Targets (estimated conc.)								
4-Heptanone	µg/L	U.S.			not found	not found	79	not found
Semi-volatile Organics-Targets								
Benzothiazole	µg/L	U.S.			< 20	< 20	81	115
Decamethylcyclopentasiloxane (DMCPS)	µg/L	U.S.			< 20	< 20	< 40	86
Methyl sulfone	µg/L	U.S.	15,000,000	interim SWEG (06-2017)	103	113	244	508
N-n-Butylbenzenesulfonamide	µg/L	U.S.			< 20	< 20	< 40	69
Acid Extractables-EPA 625 list GCMS								
4-Methylphenol (p-Cresol)	µg/L	U.S.			< 20	< 20	392	65
Benzoic acid	µg/L	U.S.			< 100	< 100	290	1,840
Phenol	µg/L	U.S.	4,000	SWEG	< 20	< 20	186	557
Base and Neutral Extractables-EPA 625 List GCMS								
Benzyl alcohol	µg/L	U.S.			< 20	< 20	9,100	25,700
Diethylphthalate	µg/L	U.S.			< 20	< 20	654	1,160
Di-n-butylphthalate	µg/L	U.S.	40,000	SWEG	< 20	< 20	90	320
Semi-volatiles S/Cs GCMS								
1,3,5-Triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione	µg/L	U.S.			not found	not found	< 40	48
1-Methyl-2-pyrrolidinone	µg/L	U.S.			420	not found	< 160	370
2-(2-Butoxyethoxy)ethanol	µg/L	U.S.			not found	not found	330	930
2-Butoxyethanol	µg/L	U.S.			not found	not found	140	290
2-Ethoxyethanol	µg/L	U.S.			not found	not found	220	480
2-Ethyl-1-hexanol	µg/L	U.S.			not found	not found	150	420
2-Ethylhexanoic acid	µg/L	U.S.			not found	not found	not found	260
2-Methyl-2,4-pentanediol	µg/L	U.S.			not found	not found	93	200
2-Phenoxyethanol	µg/L	U.S.			not found	not found	95	770
2-Phenyl-2-propanol	µg/L	U.S.			not found	not found	not found	170
Acetophenone	µg/L	U.S.			not found	not found	22	22
Benzaldehyde	µg/L	U.S.			not found	not found	100	160
Butylated hydroxyanisole (BHA)	µg/L	U.S.			not found	not found	200	430
Diethylene glycol monoethyl ether	µg/L	U.S.			not found	not found	not found	210

Table 3: Analytical Concentrations of Compounds Quantified in Archive Water Samples Returned on SpaceX-16

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	58			
					SpaceX-16			
					WPA MF Bed #1 ORU S/N 00016 MF Bed Effluent 12/21/2018 WQ190024	WPA MF Bed #2 ORU S/N 00017 MF Bed Effluent 12/21/2018 WQ190025	WPA Wastewater ORU WPA Wastewater 12/28/2018 WQ190026	WPA Condensate Sample Port US Condensate 12/31/2018 WQ190027
Dipropylene glycol methyl ether	µg/L	U.S.			not found	not found	360	840
Heptanoic acid	µg/L	U.S.			not found	not found	not found	200
Hexanoic acid (Caprolate)	µg/L	U.S.			not found	not found	not found	690
Ibuprofen	µg/L	U.S.			not found	not found	1000	not found
Monomethyl phthalate	µg/L	U.S.			not found	not found	140	340
N,N-Diethylformamide	µg/L	U.S.			not found	not found	44	73
N,N-Dimethyl acetamide	µg/L	U.S.			310	310	360	540
N,N-Dimethylformamide	µg/L	U.S.			not found	200	420	700
Neomenthol	µg/L	U.S.			not found	not found	110	110
Phenethyl alcohol	µg/L	U.S.			not found	not found	not found	63
p-Menth-1-en-8-ol (alpha-Terpineol)	µg/L	U.S.			not found	not found	< 40	78
Tetramethyl thiourea	µg/L	U.S.			not found	not found	not found	28
Tributyl phosphate	µg/L	U.S.			not found	not found	48	57
Triethyl phosphate	µg/L	U.S.			not found	not found	not found	< 20
Alcohols and Acetone GCMS								
1-Butanol	µg/L	U.S.			< 400	544	< 400	649
1-Propanol	µg/L	U.S.			583	402	< 400	414
2-Butanol	µg/L	U.S.			407	< 400	< 400	< 400
2-Propanol (Isopropanol)	µg/L	U.S.			3,480	4,280	850	937
Acetone	µg/L	U.S.	15,000	SWEG	5,560	4,060	10,700	4,200
Ethanol	µg/L	U.S.			36,900	44,700	6,560	99,200
Methanol	µg/L	U.S.	40,000	SWEG	3,970	5,210	6,330	8,390
Glycols GCMS								
1,2-Ethandiol (Ethylene glycol)	µg/L	U.S.	4,000	SWEG	< 1000	< 1000	1,020	4,310
1,2-Propanediol (Propylene glycol)	µg/L	U.S.	17,000,000	SWEG	1,630	1,120	3,980	17,300
Silanols LCRI (Semi-Quantitative-NIST traceable standard not available)								
Dimethylsilanediol (DMSD)	µg/L	U.S.	35,000	SWEG	20,000	21,000	17,000	39,000
Carboxylates IC								
Acetate	µg/L	U.S.			19,000	1,360	< 500	39,100
Butyrate	µg/L	U.S.			1,250	< 500	< 500	< 500

Table 3: Analytical Concentrations of Compounds Quantified in Archive Water Samples Returned on SpaceX-16

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	58			
									SpaceX-16			
									WPA MF Bed #1 ORU S/N 00016	WPA MF Bed #2 ORU S/N 00017	WPA Wastewater ORU	WPA Condensate Sample Port
									MF Bed Effluent	MF Bed Effluent	WPA Wastewater	US Condensate
									12/21/2018	12/21/2018	12/28/2018	12/31/2018
									WQ190024	WQ190025	WQ190026	WQ190027
Isobutyrate (2-Methylpropanoic acid)					µg/L	U.S.			< 500	< 500	< 500	1,170
Propionate					µg/L	U.S.			2,180	< 500	< 500	< 500
Aldehydes GCMS												
Formaldehyde (Methanal)					µg/L	U.S.	12,000	SWEG	< 20	11	< 10	< 20
Non-volatile Organics LC												
Caprolactam					µg/L	U.S.	100,000	SWEG	< 500	< 500	847	2,630
Urea					µg/L	U.S.			< 800	1,360	< 800	< 800
Organic Carbon Recovery					percent	U.S.			97.8	132.6	75.5	81.9
Unaccounted Organic Carbon					mg/L	U.S.			1.0	0.0	10.2	27.7

Data Qualifiers: WQ190024 to 27 - Possible low bias: 2-Ethoxyethanol, Acenaphthene, Anthracene, Benzo(a)pyrene, Benzo(g,h,i)perylene & Tris(2-Chloroethyl)phosphate