

# Soyuz 23 Return Samples: Assessment of Air Quality aboard the International Space Station



**International Space Station:** Six mini-grab sample containers (m-GSCs) were returned aboard Soyuz 23 because of concerns that new air pollutants had been present in the air and these were getting into the water recovery system. The Total Organic Carbon Analyzer had been giving increasing readings of total organic carbon (TOC) in the potable water, and it was postulated that an increased load into the system was responsible. The TOC began to decline in late October, 2010. The toxicological assessment of 6 m-GSCs from the ISS is shown in Table 1. The recoveries of <sup>13</sup>C-acetone, fluorobenzene, and chlorobenzene from the GSCs averaged 73, 82, and 59%, respectively. We are working to understand the sub-optimal recovery of chlorobenzene.

**Table 1. Analytical Summary of ISS Results**

Module/ Sample	Date of Sample	NMVOCS <sup>a</sup> (mg/m <sup>3</sup> )	Freon 218 (mg/m <sup>3</sup> )	T Value <sup>b</sup> (units)	Alcohols (mg/m <sup>3</sup> )
Lab	10/14/10	7	50	0.38	5
JEM	10/14/10	7	43	0.25	6
SM	10/14/10	8	44	0.23	7
SM	11/24/10	6	58	0.56	4
Columbus	11/24/10	6	54	0.27	4
Lab	11/24/10	4	47	0.22	3
<i>Guideline</i>		<25	<i>none</i>	<1.0	<5

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

<sup>b</sup> Based on 180-d SMACs and calculated excluding CO<sub>2</sub>, formaldehyde, and siloxanes.

The T-values suggest relatively clean air. There was nothing in the air samples to suggest that the load of organic compounds detected by our methods had changed in conjunction with the rise and decline in water TOC. Freon 218 (perfluoropropane) levels continue to be high and fairly uniformly distributed throughout the ISS stack. This compound's concentration is far below harmful levels. Other compounds that were fairly evenly distributed include the following: ethanol, acetone, n-butanol, methyl acetate, ethyl acetate, sulfur hexafluoride, hydrogen, and carbon monoxide. Trimethylsilanol, a product of materials offgassing, was high in the 11/24/10 SM sample, but was still only a third the 180-day spacecraft maximum allowable concentration (SMAC). There was no evidence of the reappearance of propenal, a highly irritating compound, which has been found occasionally in ISS air samples. On average, alcohols are just within guidelines for protection of the water recovery system.

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## Enclosures

Table 1: Analytical concentrations of compounds found in the Soyuz m-GSCs

Table 2: T-values of the compounds in table 1

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)					
	AA05004	AA05005	AA05006	AA05007(2)	AA05008	AA05009(1)
	S/N 2024 LAB 10/14/10 @ 14:17 GMT	S/N 2026 JEM 10/14/10 @ 14:25 GMT	S/N 2025 SM 10/14/10 @ 14:30 GMT	S/N 2037 SM 11/24/10 @ 08:40 GMT	S/N 2029 COLUMB US 11/24/10 @ 08:45 GMT	S/N 2057 LAB 11/24/10 @ 08:53 GMT
<b>TARGET COMPOUNDS (TO-14/POLAR)+++</b>						
FREON12	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CHLOROMETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
FREON114	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
METHANOL	0.37	0.32	0.36	0.51	0.21	0.20
ACETALDEHYDE	0.12	0.12	0.11	0.21	0.072	0.055
VINYLCHLORIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
BROMOMETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
<b>ETHANOL *</b>	<b>4.3</b>	<b>4.2</b>	<b>5.7</b>	<b>3.2</b>	<b>3.6</b>	<b>2.9</b>
CHLOROETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ACETONITRILE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PROPENAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ACETONE	0.27	0.32	0.30	0.15	0.26	0.17
PROPANAL	TRACE	TRACE	TRACE	<0.050	<0.050	<0.050
ISOPROPANOL	0.18	0.48	0.36	0.15	0.26	0.12
FREON11	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
FURAN	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ACRYLONITRILE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PENTANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-METHYL-2-PROPANOL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
METHYLACETATE	0.11	0.089	0.13	<0.050	<0.050	<0.050
1,1-DICHLOROETHENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
DICHLOROMETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
3-CHLOROPROPENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
FREON113	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
N-PROPANOL	TRACE	0.063	0.059	<0.050	TRACE	TRACE
1,1-DICHLOROETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
BUTANAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-BUTANONE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CIS-1,2-DICHLOROETHENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-METHYLFURAN	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ETHYLACETATE	0.15	0.13	0.18	<0.050	TRACE	<0.050
HEXANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CHLOROFORM	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-BUTENAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,2-DICHLOROETHANE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
1,1,1-TRICHLOROETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
N-BUTANOL	0.099	0.094	0.099	0.091	0.068	TRACE
BENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CARBONTETRACHLORIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

2-PENTANONE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-METHYLHEXANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2,3-DIMETHYLPENTANE	<0.050	<0.050	<0.050	TRACE	<0.050	<0.050
PENTANAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
3-METHYLHEXANE	TRACE	<0.050	<0.050	TRACE	TRACE	<0.050
1,2-DICHLOROPROPANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,4-DIOXANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
TRICHLOROETHENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2,5-DIMETHYLFURAN	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
N-HEPTANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
4-METHYL2-PENTANONE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CIS-1,3-DICHLOROPROPENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-PENTENAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
TRANS-1,3-DICHLOROPROPENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,1,2-TRICHLOROETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
TOLUENE	<0.050	<0.050	<0.050	0.069	0.068	<0.050
HEXANAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
MESITYLOXIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,2-DIBROMOETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
BUTYLACETATE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
OCTANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
TETRACHLOROETHENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CHLOROBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ETHYLBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
M/P-XYLENES	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-HEPTANONE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CYCLOHEXANONE	TRACE	TRACE	TRACE	<0.050	<0.050	<0.050
HEPTANAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
STYRENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,1,2,2-TETRACHLOROETHANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
O-XYLENE	TRACE	0.055	0.062	0.074	TRACE	<0.050
NONANE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,3,5-TRIMETHYLBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,2,4-TRIMETHYLBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,3-DICHLOROBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,4-DICHLOROBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,2-DICHLOROBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1,2,4-TRICHLOROBENZENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
HEXACHLORO-1,3-BUTADIENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

**ANALYTICAL RESULTS OF  
23S RETURN MINI-GRAB SAMPLE CONTAINER AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)					
	AA05004 S/N 2024 LAB 10/14/10 @ 14:17 GMT	AA05005 S/N 2026 JEM 10/14/10 @ 14:25 GMT	AA05006 S/N 2025 SM 10/14/10 @ 14:30 GMT	AA05007(2) S/N 2037 SM 11/24/10 @ 08:40 GMT	AA05008 S/N 2029 COLUMBUS 11/24/10 @ 08:45 GMT	AA05009(1) S/N 2057 LAB 11/24/10 @ 08:53 GMT
<b>TARGET COMPOUNDS (TO-14/POLAR)</b>						
FREON12	ND	ND	ND	ND	ND	ND
CHLOROMETHANE	ND	ND	ND	ND	ND	ND
FREON114	ND	ND	ND	ND	ND	ND
METHANOL	0.00413	0.00352	0.00399	0.00567	0.00236	0.00218
ACETALDEHYDE	0.02903	0.02935	0.02663	0.05128	0.01801	0.01380
VINYLCHLORIDE	ND	ND	ND	ND	ND	ND
BROMOMETHANE	ND	ND	ND	ND	ND	ND
<b>ETHANOL *</b>	<b>0.00214</b>	<b>0.00212</b>	<b>0.00284</b>	<b>0.00161</b>	<b>0.00180</b>	<b>0.00146</b>
CHLOROETHANE	ND	ND	ND	ND	ND	ND
ACETONITRILE	ND	ND	ND	ND	ND	ND
PROPENAL	ND	ND	ND	ND	ND	ND
ACETONE	0.00527	0.00619	0.00583	0.00287	0.00496	0.00323
PROPANAL	0.00227	0.00227	0.00227	ND	ND	ND
ISOPROPANOL	0.00120	0.00323	0.00242	0.00098	0.00173	0.00077
FREON11	ND	ND	ND	ND	ND	ND
FURAN	ND	ND	ND	ND	ND	ND
ACRYLONITRILE	ND	ND	ND	ND	ND	ND
PENTANE	ND	ND	ND	ND	ND	ND
2-METHYL-2-PROPANOL	ND	ND	ND	ND	ND	ND
METHYLACETATE	0.00096	0.00074	0.00110	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
DICHLOROMETHANE	ND	ND	ND	ND	ND	ND
3-CHLOROPROPENE	ND	ND	ND	ND	ND	ND
FREON113	ND	ND	ND	ND	ND	ND
N-PROPANOL	0.00026	0.00064	0.00060	ND	0.00026	0.00026
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND
BUTANAL	ND	ND	ND	ND	ND	ND
2-BUTANONE	ND	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
2-METHYLFURAN	ND	ND	ND	ND	ND	ND
ETHYLACETATE	0.00085	0.00073	0.00099	ND	0.00014	ND
HEXANE	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND
2-BUTENAL	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	0.01563	0.01563	0.01563	0.01563	0.01563	0.01563
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND
N-BUTANOL	0.00249	0.00236	0.00249	0.00229	0.00169	0.00063
BENZENE	ND	ND	ND	ND	ND	ND
CARBONTETRACHLORIDE	ND	ND	ND	ND	ND	ND
2-PENTANONE	ND	ND	ND	ND	ND	ND
2-METHYLHEXANE	ND	ND	ND	ND	ND	ND
2,3-DIMETHYLPENTANE	ND	ND	ND	0.00208	ND	ND
PENTANAL	ND	ND	ND	ND	ND	ND
3-METHYLHEXANE	0.00208	ND	ND	0.00208	0.00208	ND
1,2-DICHLOROPROPANE	ND	ND	ND	ND	ND	ND
1,4-DIOXANE	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND
2,5-DIMETHYLFURAN	ND	ND	ND	ND	ND	ND
N-HEPTANE	ND	ND	ND	ND	ND	ND
4-METHYL2-PENTANONE	ND	ND	ND	ND	ND	ND
CIS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
2-PENTENAL	ND	ND	ND	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	0.00463	0.00453	ND

HEXANAL	ND	ND	ND	ND	ND	ND
MESITYLOXIDE	ND	ND	ND	ND	ND	ND
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND	ND
BUTYLACETATE	ND	ND	ND	ND	ND	ND
OCTANE	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND
M/P-XYLENES	ND	ND	ND	ND	ND	ND
2-HEPTANONE	ND	ND	ND	ND	ND	ND
CYCLOHEXANONE	0.00042	0.00042	0.00042	ND	ND	ND
HEPTANAL	ND	ND	ND	ND	ND	ND
STYRENE	ND	ND	ND	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND	ND	ND	ND
O-XYLENE	0.00068	0.00149	0.00166	0.00201	0.00068	ND
NONANE	ND	ND	ND	ND	ND	ND
1,3,5-TRIMETHYLBENZENE	ND	ND	ND	ND	ND	ND
1,2,4-TRIMETHYLBENZENE	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND
HEXACHLORO-1,3-BUTADIENE	ND	ND	ND	ND	ND	ND

TARGET COMPOUNDS (TOXIC)						
1,3-BUTADIENE	ND	ND	ND	ND	ND	ND
ETHYLENE OXIDE	ND	ND	ND	ND	ND	ND
CARBON DISULFIDE	0.00156	ND	0.00156	0.00156	0.00156	0.00156
2-METHYL-2-PROPENAL	0.01471	ND	ND	0.01471	ND	ND
3-BUTEN-2-ONE	ND	ND	ND	ND	ND	ND
2-ETHOXYETHANOL	ND	ND	ND	ND	ND	ND
DIMETHYLDISULFIDE	ND	ND	ND	ND	ND	ND
OCTAMETHYLCYCLOTETRA-SILOXANE	##	##	##	##	##	##

NON-TARGET COMPOUNDS						
OCTAFLUOROPROPANE++	0.00062	0.00050	0.00052	0.00068	0.00064	0.00056
SULFURHEXAFLUORIDE	0.00033	0.00030	0.00031	0.00018	0.00024	0.00016
1-BUTENE	ND	ND	ND	ND	ND	ND
TRIMETHYLSILANOL	0.17931	0.10602	0.05573	0.32228	0.08431	0.03384
2,5-DIHYDROFURAN	ND	ND	ND	ND	ND	ND
HEXAMETHYLCYCLOTRI-SILOXANE	##	##	##	##	##	##
C12-ALKANE	ND	ND	ND	ND	ND	ND
LIMONENE	0.00245	0.00156	0.00390	0.00083	0.00170	0.00106
DECAMETHYLCYCLOPENTASILOXANE	##	##	##	##	##	##

TARGET COMPOUNDS (GC)						
CARBON MONOXIDE	0.10431	0.07753	0.08755	0.11796	0.11757	0.09601
METHANE	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023
HYDROGEN	0.00648	0.00595	0.00689	0.00859	0.00895	0.00840
CARBON DIOXIDE	0.52607	0.49547	0.54492	0.51169	0.62821	0.47899

<b>TOTAL T-VALUE</b>	<b>0.90346</b>	<b>0.75624</b>	<b>0.76846</b>	<b>1.06983</b>	<b>0.89728</b>	<b>0.65876</b>
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<b>TOTAL T-VALUE - OFP</b>	<b>0.90285</b>	<b>0.75574</b>	<b>0.76794</b>	<b>1.06915</b>	<b>0.89664</b>	<b>0.65820</b>
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(1) Pressure dilution factor corrected

(2) Sample was heated to 50C for 30 minutes

## Present, subject to large, random variability, therefore not quantifiable

< : Value is less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only.