Soyuz 27 Return Samples: Air Quality aboard the International Space Station-Revised

The toxicological assessment of 6 GSCs from the ISS is shown in Table 1. The average recoveries of the 3 surrogate standards from the grab sample containers were as follows: ^{13}C-acetone, 115%; fluorobenzene, 108%; and chlorobenzene, 93%. Average recovery from formaldehyde control badges was 91%.

Table 1. Analytical Summary of ISS Results

Module/Sample	Approx. Date of Sample	NMVOCs[a] (mg/m^3)	Freon 218 (mg/m^3)	T Value[b] (units)	Alcohols (mg/m^3)	Formaldehyde (µg/m^3)
Lab	8/25/11	--	--	--	--	22
SM	8/25/11	--	--	--	--	16
SM	10/10/11	4.8	37	0.34	3.2	18
Lab	10/10/11	5.4	48	0.37	3.6	29
JPM	10/10/11	4.9	44	0.33	3.4	Not available
SM	11/08/11	5.1	23	0.33	3.2	25
Lab	11/08/11	5.4	40	0.37	3.3	34
Columbus	11/08/11	6.1	41	0.38	3.6	Not available
Guideline		*<25*	*none*	*<1.0*	*<5*	*<120*

[a] Non-methane volatile organic hydrocarbons, excluding Freon 218
[b] Based on 180-d SMACs and calculated excluding CO_2 and formaldehyde.

General Observations about ISS Air Quality:
This is a very limited set of samples on which to perform an air quality assessment. However, based on these samples, we have no reason to believe that nominal ISS air is unsafe to breathe. We must continue to be vigilant when dealing with nominal atmospheres in ISS. Beginning with the next set of grab samples from the ISS, the archival results will be supplemented by results from the Air Quality Monitor DTO unit, which provides a weekly look at selected trace pollutants in the ISS atmosphere.

Carbon Dioxide: This anthropogenic compound has drawn much attention recently because of the possibility that it could contirbute to the ocular effects of intracranial hypertension experienced because of spaceflight-induced fluid shifts. The average carbon dioxide concentrations associated with the samples above were 1.8 ± 0.1 mmHg (October) and 1.6 ± 0.1 mmHg (November). These values are about 0.1 mmHg above the Columbus ppCO2 #2 sensor, which runs 0.1 to 0.2 mmHg above the Columbus ppCO2 #1 sensor. These values are well below the target level, which is below 3.5 mmHg.

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Enclosures
Table 1: Analytical concentrations of compounds found in the Soyuz 27 GSCs
Table 2: T-values of the compounds in table 1

TABLE 1
ANALYTICAL RESULTS OF
SOYUZ 27S RETURN MINI-GRAB SAMPLE CONTAINER AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)					
	AA05245 S/N 2062 SM 10/10/11 @ 9:37 GMT	**AA05246 S/N 2066 LAB 10/10/11 @ 9:39 GMT**	**AA05247 S/N 2067 JPM 10/10/11 @ 9:41 GMT**	**AA05248 S/N 2068 SM 11/08/11 @ 12:48 GMT**	**AA05249 S/N 2069 LAB 11/08/11 @ 12:51 GMT**	**AA05250 S/N 2070 COL 11/08/11 @ 12:54 GMT**
TARGET COMPOUNDS (TO-14/POLAR)						
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	0.47	0.49	0.50	0.47	0.45	0.51
ACETALDEHYDE	0.24	0.26	0.25	0.16	0.18	0.17
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
ETHANOL *	**2.1**	**2.4**	**2.3**	**2.2**	**2.2**	**2.3**
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	0.25	0.27	0.22	0.22	0.25	0.26
PROPANAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ISOPROPANOL	0.29	0.34	0.26	0.24	0.29	0.38
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	TRACE	TRACE	TRACE	0.085	0.082	0.088

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	TRACE	TRACE	TRACE	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	TRACE	<0.050	<0.050	TRACE	TRACE
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	TRACE	TRACE	TRACE	0.24	0.26	0.30
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	0.057	0.065	0.059	0.081	0.081	0.091
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	<0.050	<0.050	<0.050
PENTANAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
3-METHYLHEXANE	<0.050	<0.050	<0.050	<0.050	<0.050	<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	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
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	<0.050	<0.050	<0.050	<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	TRACE	TRACE	0.070	0.072	0.081
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

TARGET COMPOUNDS (TOXIC)* **						
1,3-BUTADIENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
ETHYLENE OXIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CARBON DISULFIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-METHYL-2-PROPENAL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
3-BUTEN-2-ONE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-ETHOXYETHANOL	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

DIMETHYLDISULFIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
OCTAMETHYLCYCLOTETRASILOXANE****	0.053	0.057	TRACE	0.053	0.063	0.074

NON-TARGET COMPOUNDS*						
OCTAFLUOROPROPANE**	37	48	44	23	40	41
SULFURHEXAFLUORIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PROPENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
CARBONYLSULFIDE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
1-BUTENE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
TRIMETHYLSILANOL	0.13	0.16	0.15	0.15	0.17	0.20
HEXAMETHYLCYCLOTRISILOXANE	0.28	0.34	0.28	0.32	0.39	0.50
DECAMETHYLCYCLOPENTASILOXANE****	0.74	0.87	0.65	0.75	0.87	1.0

TOTAL ALCOHOLS PLUS ACETONE	**3.2**	**3.6**	**3.4**	**3.2**	**3.3**	**3.6**

TARGET COMPOUNDS (GC)						
CARBON MONOXIDE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
METHANE	14	14	14	16	15	15
HYDROGEN	3.4	3.3	3.1	3.0	2.9	2.8
CARBON DIOXIDE	4500	4300	4100	4000	3500	3700

TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	**42**	**54**	**49**	**28**	**45**	**47**

TOTAL CONCENTRATION - OFP (NON-METHANE HYDROCARBONS)	**4.8**	**5.4**	**4.9**	**5.1**	**5.4**	**6.1**

*** From GC/FID Results**

** Quantified using one-point calibration

*** Quantified using "B" response factor

**** Historical response factors (RF) were used

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

TRACE: Amount detected is sufficient for compound identification only.

TABLE 2
ANALYTICAL RESULTS OF
SOYUZ 27S RETURN MINI-GRAB SAMPLE CONTAINER AIR SAMPLES

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)					
	AA05245 S/N 2062 SM 10/10/11 @ 9:37 GMT	**AA05246 S/N 2066 LAB 10/10/11 @ 9:39 GMT**	**AA05247 S/N 2067 JPM 10/10/11 @ 9:41 GMT**	**AA05248 S/N 2068 SM 11/08/11 @ 12:48 GMT**	**AA05249 S/N 2069 LAB 11/08/11 @ 12:51 GMT**	**AA05250 S/N 2070 COL 11/08/11 @ 12:54 GMT**
TARGET COMPOUNDS (TO-14/POLAR)						
FREON12	ND	ND	ND	ND	ND	ND
CHLOROMETHANE	ND	ND	ND	ND	ND	ND
FREON114	ND	ND	ND	ND	ND	ND
METHANOL	0.00526	0.00544	0.00558	0.00525	0.00504	0.00565
ACETALDEHYDE	0.05930	0.06414	0.06255	0.03983	0.04398	0.04370
VINYLCHLORIDE	ND	ND	ND	ND	ND	ND
BROMOMETHANE	ND	ND	ND	ND	ND	ND
ETHANOL	**0.00106**	**0.00119**	**0.00117**	**0.00110**	**0.00109**	**0.00117**
CHLOROETHANE	ND	ND	ND	ND	ND	ND
ACETONITRILE	ND	ND	ND	ND	ND	ND
PROPENAL	ND	ND	ND	ND	ND	ND
ACETONE	0.00477	0.00513	0.00416	0.00429	0.00478	0.00504
PROPANAL	ND	ND	ND	ND	ND	ND
ISOPROPANOL	0.00191	0.00228	0.00170	0.00160	0.00192	0.00255
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	0.00021	0.00021	0.00021	0.00071	0.00069	0.00073

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	0.00026	0.00026	0.00026	0.00026	0.00026
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND
BUTANAL	ND	ND	ND	ND	ND	ND
2-BUTANONE	ND	0.00083	ND	ND	0.00083	0.00083
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
2-METHYLFURAN	ND	ND	ND	ND	ND	ND
ETHYLACETATE	0.00014	0.00014	0.00014	0.00134	0.00146	0.00164
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	0.00143	0.00163	0.00147	0.00202	0.00203	0.00226
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	ND	ND	ND
PENTANAL	ND	ND	ND	ND	ND	ND
3-METHYLHEXANE	ND	ND	ND	ND	ND	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	0.00167	0.00167	0.00167	0.00167	0.00167	0.00167
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	ND	ND	ND	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	0.00068	0.00068	0.00190	0.00196	0.00218
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	ND	ND	ND	ND	ND	ND
2-METHYL-2-PROPENAL	ND	ND	ND	ND	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

OCTAMETHYLCYCLOTETRASILOXANE	0.00444	0.00476	0.00208	0.00444	0.00527	0.00619

NON-TARGET COMPOUNDS						
OCTAFLUOROPROPANE	0.00044	0.00057	0.00051	0.00027	0.00046	0.00048
SULFURHEXAFLUORIDE	ND	ND	ND	ND	ND	ND
PROPENE	ND	ND	ND	ND	ND	ND
CARBONYLSULFIDE	ND	ND	ND	ND	ND	ND
1-BUTENE	ND	ND	ND	ND	ND	ND
TRIMETHYLSILANOL	0.03345	0.04108	0.03861	0.03813	0.04372	0.05046
HEXAMETHYLCYCLOTRISILOXANE	0.03161	0.03782	0.03160	0.03597	0.04365	0.05519
DECAMETHYLCYCLOPENTASILOXANE	0.04962	0.05773	0.04362	0.04989	0.05768	0.06740

TARGET COMPOUNDS (GC)						
CARBON MONOXIDE	0.10691	0.10525	0.09919	0.10945	0.11810	0.10169
METHANE	0.00547	0.00537	0.00544	0.00553	0.00540	0.00534
HYDROGEN	0.01456	0.01466	0.01456	0.01220	0.01181	0.01277
CARBON DIOXIDE	0.56207	0.54358	0.51840	0.48121	0.52534	0.48509

TOTAL T-VALUE	**0.90088**	**0.91004**	**0.84921**	**0.81267**	**0.89275**	**0.86792**

TOTAL T-VALUE - OFP	**0.90044**	**0.90947**	**0.84870**	**0.81241**	**0.89228**	**0.86744**

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.