Assessment of Air Quality in the International Space Station (ISS)
Based on Samples Returned by Soyuz in November 2001

The toxicological assessment of 2 grab sample canisters (GSCs) returned aboard Soyuz is reported. The samples, which were taken from the FGB and Lab on 13 September 2001, were given early return to better understand the high methanol concentration found in the FGB sample from 6 August 2001. Analytical methods have not changed from earlier reports, and surrogate standard recoveries were 79-106%. Pressure tracking indicated no leaks in either canister.

The two general criteria used to assess air quality are the total-non-methane-volatile organic hydrocarbons (NMVOCs) and the total T-value (minus the CO_2 and formaldehyde contribution). Because of the Freon 218 (octafluoropropane, OFP) leak, its contribution to the NMVOC is indicated in brackets. When comparing the NMVOC values with the 25 mg/m^3 guideline, the OFP contributions should be subtracted. Control of atmospheric alcohols is important to the water recovery system engineers, hence total alcohols were also assessed in each sample. Formaldehyde is quantified separately. These five indices are summarized below:

Sample Location	Date/Type	NMVOCs (mg/m^3)	[OFP] (mg/m^3)	T Value[a] (units)	Alcohols (mg/m^3)	Formaldehyde (mg/m^3)
FGB-GSC	8/06/01	140	[61]	8.47	74.4	ns[b]
FGB-GSC	9/13/01	340	[332]	0.96	4.9	ns
Lab-GSC	9/13/01	341	[334]	0.90	3.6	ns
Acceptable Guideline>>>		<25	[85000]	<1	<10	0.050

[a] Formaldehyde and CO2 not included in T calculation.
[b] ns = not sampled

The FGB sample contained a much lower concentration of methanol (2.1 mg/m3) than the one from August (71 mg/m3); however, the result from September was somewhat higher than usual. The concomitant sample in the Lab showed typical levels of methanol (0.5 mg/m3). All other pollutants were found at comparable concentrations in the two September samples. This clearly suggests a local, short-lived source of methanol in the FGB, but with much less impact on the September sample than on the August sample.

Freon 218 was found at unprecedented concentrations in both samples. Both concentrations were far below the 180-day SMAC; however, these data do suggest an ongoing leak in one of the coolant loops using this heat-exchange fluid. Since concentrations were much lower in the August samples, it appears that efforts to scrub this material from the atmosphere have been overwhelmed by further leaks.

Since both T values were less than 1.0, the atmosphere meet acceptable standards for crew health at the time and location of sampling as specified in the Medical Operations Requirement Document, Revision A. Due to the long interval (38 days) between the August and September samples, one cannot conclude much about total crew exposures to either methanol or Freon 218.

Enclosures
1: Analytical Results of Air Samples Returned on Soyuz in November 2001
2: T Values of Air Samples Returned on Soyuz in November 2001

TABLE 1
ANALYTICAL RESULTS OF
ISS CONTAINER AIR SAMPLES RETURNED ON SOYUZ NOVEMBER 2001

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)	
	AA03223 S/N 1070 FGB 9/13/01@18:08GMT	AA03224 S/N 1018 LAB 9/13/01@18:15 GMT
TARGET COMPOUNDS (TO-14/POLAR)* **		
FREON 12	TRACE	TRACE
CHLOROMETHANE	<0.05	<0.05
FREON 114	<0.05	<0.05
METHANOL (see note)	2.10	0.54
ACETALDEHYDE	0.17	0.15
VINYL CHLORIDE	<0.05	<0.05
BROMOMETHANE	<0.05	<0.05
ETHANOL	2.17	2.28
CHLOROETHANE	<0.05	<0.05
ACETONITRILE	TRACE	TRACE
PROPENAL	TRACE_	TRACE_
ACETONE	0.26	0.30
PROPANAL	TRACE	TRACE
2-PROPANOL	0.22	0.25
FREON 11	<0.05	<0.05
FURAN	<0.05	<0.05
ACRYLONITRILE	TRACE	TRACE
PENTANE	<0.05	<0.05
2-METHYL-2-PROPANOL	TRACE	TRACE
METHYL ACETATE	TRACE	<0.05
1,1-DICHLOROETHENE	<0.05	<0.05
DICHLOROMETHANE	0.11	0.15
3-CHLOROPROPENE	<0.05	<0.05
FREON 113	<0.05	<0.05
N-PROPANOL	0.05	0.07
1,1-DICHLOROETHANE	<0.05	<0.05
BUTANAL	TRACE	TRACE
2-BUTANONE	TRACE	TRACE
1,2-DICHLOROETHENE	<0.05	<0.05
2-METHYLFURAN	<0.05	<0.05
ETHYL ACETATE	TRACE	TRACE
HEXANE	<0.05	<0.05
CHLOROFORM	<0.05	<0.05
2-BUTENAL	TRACE	TRACE
1,2-DICHLOROETHANE	TRACE	TRACE
1,1,1-TRICHLOROETHANE	<0.05	<0.05
N-BUTANOL	0.14	0.15
BENZENE	<0.05	<0.05
CARBON TETRACHLORIDE	<0.05	<0.05
2-PENTANONE	TRACE	TRACE
PENTANAL	TRACE	TRACE
1,2-DICHLOROPROPANE	<0.05	<0.05
1,4-DIOXANE	<0.05	<0.05
TRICHLOROETHENE	<0.05	<0.05
2,5-DIMETHYLFURAN	<0.05	<0.05
4-METHYL-2-PENTANONE	<0.05	<0.05
CIS-1,3-DICHLOROPROPENE	<0.05	<0.05
2-PENTENAL	<0.05	<0.05
TRANS-1,3-DICHLOROPROPENE	<0.05	<0.05
1,1,2-TRICHLOROETHANE	<0.05	<0.05
TOLUENE	TRACE	TRACE
HEXANAL	TRACE	TRACE
MESITYL OXIDE	<0.05	<0.05
1,2-DIBROMOETHANE	<0.05	<0.05
BUTYL ACETATE	TRACE	TRACE
TETRACHLOROETHENE	<0.05	<0.05
CHLOROBENZENE	TRACE	TRACE
ETHYL BENZENE	TRACE	TRACE

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)	
	AA03223 S/N 1070 FGB 9/13/01@18:08GMT	AA03224 S/N 1018 LAB 9/13/01@18:15 GMT
TARGET COMPOUNDS (TO-14/POLAR)* **		
M- + P-XYLENES	TRACE	TRACE
2-HEPTANONE	<0.05	<0.05
CYCLOHEXANONE	TRACE	TRACE
HEPTANAL	TRACE	TRACE
STYRENE	<0.05	<0.05
1,1,2,2-TETRACHLOROETHANE	<0.05	<0.05
O-XYLENE	0.08	0.09
1,3,5-TRIMETHYLBENZENE	<0.05	<0.05
1,2,4-TRIMETHYLBENZENE	<0.05	<0.05
1,3-DICHLOROBENZENE	<0.05	<0.05
1,4-DICHLOROBENZENE	<0.05	<0.05
1,2-DICHLOROBENZENE	<0.05	<0.05
1,2,4-TRICHLOROBENZENE	<0.05	<0.05
HEXACHLORO-1,3-BUTADIENE	<0.05	<0.05
TARGET COMPOUNDS (TOXIC)		
1,3-BUTADIENE	<0.05	<0.05
ETHYLENE OXIDE	<0.05	<0.05
CARBON DISULFIDE	TRACE	TRACE
2-METHYL-2-PROPENAL	TRACE	<0.05
3-BUTEN-2-ONE	<0.05	<0.05
DIMETHYLDISULFIDE	<0.05	TRACE
2-ETHOXYETHANOL	<0.05	<0.05
OCTAMETHYLCYCLOTETRASILOXANE	0.79	0.54
NON-TARGET COMPOUNDS		
OCTAFLUOROPROPANE***	332.4	334.3
CHLOROPENTAFLUOROETHANE	0.03	0.04
2-METHYLPROPANE	0.03	0.03
HEXAMETHYLCYCLOTRISILOXANE	0.78	1.05
LIMONENE	0.06	0.06
TOTAL ALCOHOLS PLUS ACETONE	**4.93**	**3.59**
TARGET COMPOUNDS (GC)* **		
ETHYLENE	<0.6	<0.6
CARBON MONOXIDE	<1.1	<1.1
METHANE	20.0	20.0
HYDROGEN	22.0	22.0
CARBON DIOXIDE	5200	5800
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	**340.0**	**340.6**

< : Value is less than the laboratory report detection limit, and summed as 0.0.

TRACE: Amount detected is sufficient for compound identification only. Calculations are based on one-half of the laboratory report detection limit (1.1 mg/m3 for CO; 0.65 mg/m3 for CH4; 0.41 mg/m3 for H2; 0.05 mg/m3 for VOCs; and 0.02 mg/m3 for propenal.)

***Measurements are calibrated by multi-point initial calibration and verified by mid-point continuing calibration.

NOTE: Reported methanol level was above GC/MS calibration range (1500ppb) therefore was measured by GC-FID

TABLE 2
ANALYTICAL RESULTS OF
ISS CONTAINER AIR SAMPLES RETURNED ON SOYUZ NOVEMBER 2001

CHEMICAL CONTAMINANT	T-VALUE	
	AA03223 S/N 1070 FGB 9/13/01@18:08GMT	AA03224 S/N 1018 LAB 9/13/01@18:15 GMT
TARGET COMPOUNDS (TO-14/POLAR)* **		
FREON 12	0.000	0.000
CHLOROMETHANE	ND	ND
FREON 114	ND	ND
METHANOL	0.233	0.060
ACETALDEHYDE	0.042	0.037
VINYL CHLORIDE	ND	ND
BROMOMETHANE	ND	ND
ETHANOL	0.001	0.001
CHLOROETHANE	ND	ND
ACETONITRILE	0.004	0.004
PROPENAL	0.333	0.333
ACETONE	0.005	0.006
PROPANAL	0.007	0.007
2-PROPANOL	0.001	0.002
FREON 11	ND	ND
FURAN	ND	ND
ACRYLONITRILE	0.009	0.009
PENTANE	ND	ND
2-METHYL-2-PROPANOL	0.000	0.000
METHYL ACETATE	0.000	ND
1,1-DICHLOROETHENE	ND	ND
DICHLOROMETHANE	0.011	0.015
3-CHLOROPROPENE	ND	ND
FREON 113	ND	ND
N-PROPANOL	0.001	0.001
1,1-DICHLOROETHANE	ND	ND
BUTANAL	0.006	0.006
2-BUTANONE	0.001	0.001
1,2-DICHLOROETHENE	ND	ND
2-METHYLFURAN	ND	ND
ETHYL ACETATE	0.000	0.000
HEXANE	ND	ND
CHLOROFORM	ND	ND
2-BUTENAL	0.015	0.015
1,2-DICHLOROETHANE	0.025	0.025
1,1,1-TRICHLOROETHANE	ND	ND
N-BUTANOL	0.003	0.004
BENZENE	ND	ND
CARBON TETRACHLORIDE	ND	ND
2-PENTANONE	0.000	0.000
PENTANAL	0.005	0.005
1,2-DICHLOROPROPANE	ND	ND
1,4-DIOXANE	ND	ND
TRICHLOROETHENE	ND	ND
2,5-DIMETHYLFURAN	ND	ND
4-METHYL-2-PENTANONE	ND	ND
CIS-1,3-DICHLOROPROPENE	ND	ND

CHEMICAL CONTAMINANT	T-VALUE	
	AA03223 S/N 1070 FGB 9/13/01@18:08GMT	AA03224 S/N 1018 LAB 9/13/01@18:15 GMT
TARGET COMPOUNDS (TO-14/POLAR)* **		
2-PENTENAL	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND
TOLUENE	0.000	0.000
HEXANAL	0.004	0.004
MESITYL OXIDE	ND	ND
1,2-DIBROMOETHANE	ND	ND
BUTYL ACETATE	0.000	0.000
TETRACHLOROETHENE	ND	ND
CHLOROBENZENE	0.001	0.001
ETHYL BENZENE	0.001	0.001
M- + P-XYLENES	0.000	0.000
2-HEPTANONE	ND	ND
CYCLOHEXANONE	0.000	0.000
HEPTANAL	0.004	0.004
STYRENE	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND
O-XYLENE	0.000	0.000
1,3,5-TRIMETHYLBENZENE	ND	ND
1,2,4-TRIMETHYLBENZENE	ND	ND
1,3-DICHLOROBENZENE	ND	ND
1,4-DICHLOROBENZENE	ND	ND
1,2-DICHLOROBENZENE	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND
HEXACHLORO-1,3-BUTADIENE	ND	ND
TARGET COMPOUNDS (TOXIC)		
1,3-BUTADIENE	ND	ND
ETHYLENE OXIDE	ND	ND
CARBON DISULFIDE	0.002	0.002
2-METHYL-2-PROPENAL	0.015	ND
3-BUTEN-2-ONE	ND	ND
DIMETHYLDISULFIDE	ND	0.125
2-ETHOXYETHANOL	ND	ND
OCTAMETHYLCYCLOTETRASILOXANE	0.066	0.045
NON-TARGET COMPOUNDS		
OCTAFLUOROPROPANE***	0.004	0.004
CHLOROPENTAFLUOROETHANE	0.000	0.000
2-METHYLPROPANE	0.000	0.000
HEXAMETHYLCYCLOTRISILOXANE	0.087	0.117
LIMONENE	0.000	0.000
TARGET COMPOUNDS (GC)* **		
ETHYLENE	ND	ND
CARBON MONOXIDE	ND	ND
METHANE	0.005	0.005
HYDROGEN	0.065	0.065
CARBON DIOXIDE	0.400	0.446
TOTAL T-VALUE	1.355	1.348

* ND : Value is less than the laboratory report detection limit.

& BL: Area below the search routine limit (< 20% of the fluorobenzene peak area).

*** Measurements are calibrated by multi-point initial calibration and verified by mid-point continuing calibration.