Spacecraft Maximum Allowable Concentrations for Airborne Contaminants

Human Health and Performance Directorate

Toxicology Group

Environmental Sciences Branch

Biomedical Research and Environmental Sciences Division

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NASA AND NASA CONTRACTOR EMPLOYEES, AS REQUIRED

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Baseline

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National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

Houston, Texas

NASA APPROVAL SHEET

Spacecraft Maximum Allowable Concentrations for Airborne Contaminants

COMPLIED BY:

Valerie E. Ryder, Ph.D., DABT
Toxicologist
Human Health and Performance Directorate

10/4/17
DATE

CONCURRED BY:

J. Torin McCoy
Chief, Environmental Sciences Branch
Human Health and Performance Directorate

10/4/17
DATE

Judith C. Hayes
Chief, Biomedical Research and Environmental Sciences Division
Human Health and Performance Directorate

10.5.17
DATE

Catherine A. Koerner
Director, Human Health and Performance Directorate

10/13/17
DATE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lyndon B. Johnson Space Center
Houston, Texas

CHANGE HISTORY

Requested changes shall be submitted on Change Request (CR) Form and approved by the BRES Configuration Control Board (CCB).

Revision/ PCN	Date	Authorization /Originator/Phone	Description
Baseline	09/2017	CR# SA-00308 Valerie E. Ryder 281-483-4989	**NOTE: Previous versions of the document were baselined through the STIC Library and not "BASELINED" through a Board. Therefore, the versioning of the document will start at BASELINE for Configuration Management purposes.** **PREVIOUS INFORMATION FROM STIC BASELINE:** ***Errata*** Correct CAS numbers are below: • 75-69-4 (Freon 11) • 111-30-8 (Glutaraldehyde) • 7647-01-0 (Hydrogen chloride) • 5989-27-5 (Limonene) **CURRENT UPDATES:** Introductory page revised CAS number for Acrolein corrected to 107-02-8 Compound names revised to match published NRC Vol. 5: 1-Butanol to n-Butanol; Unsymmetrical Dimethylhydrazine to Dimethylhydrazine C3-C8 Aliphatic Saturated Aldehydes 7-d, 30-d, 180-d, 1000-d values revised to match NRC Vol. 5 (5 ppm) **Carbon dioxide (CO_2) SMACs have been deleted** – CO_2 does not fit SMAC paradigm and is being managed based on expected performance and health decrements and the associated risks. NASA Standard 3001 is currently under revision to provide guidance on acceptable CO2 levels. Linear Siloxanes group SMACs added Octamethyltrisiloxane SMACs deleted (replaced by Linear Siloxanes)

SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS FOR AIRBORNE CONTAMINANTS

2017

The enclosed table lists official Spacecraft Maximum Allowable Concentrations (SMACs) for selected airborne contaminants. These are guideline values set by the NASA/JSC Toxicology Group in cooperation with the National Research Council Committee on Toxicology (NRCCOT) or through publication in the peer-reviewed scientific literature. Based on documented guidance (NRC, 1992), NASA has established SMACs for 56 chemical compounds that are particularly relevant to atmospheric contamination of the International Space Station (ISS). Some long-term limits (1000-days) have also been established to support manned deep-space exploration. Summaries of these SMACs are presented in tabular form as part of this publication. Complete documentation of the rationale used to establish the values summarized here is provided in the reference section below.

Short-term (1- and 24-hour) SMACs apply to off-nominal situations, such as accidental releases aboard a spacecraft. These limits permit risk of minor, reversible effects, such as mild mucosal irritation. In contrast, the long-term SMACs are set to fully protect healthy crewmembers from adverse effects resulting from continuous exposure to specific air pollutants for up to 1000 days. Because allergic reactions or chemical idiosyncrasy to certain airborne pollutants are very difficult to predict, crewmembers with allergies or unusual sensitivity to trace pollutants may not be afforded complete protection, even when long-term SMACs are not exceeded. Conversely, exceedance of a SMAC does not mean that health impairment is certain (there are many other factors that influence ultimate health outcomes), although it does indicate that the crew may be subject to increased risks that must be closely evaluated. Environmental pollutant control to mitigate exposure will likely be triggered.

These values have been specifically established for human spaceflight and are not intended to apply to other situations, such as ground operations. The SMACs take into account a number of unique factors such as the effect of space-flight stress on human physiology, the uniform good health of the astronauts, and the absence of pregnant or very young individuals.

Crewmember exposures involve a mixture of contaminants, each at a specific concentration (C_n). These contaminants could interact to elicit symptoms of toxicity even though individual contaminants do not exceed their respective SMACs. We assume that the effects of a toxicologically similar group of compounds are additive. The air quality is therefore considered acceptable when the toxicity index (T_{grp}) for each toxicological group of compounds is less than 1, where T_{grp} is calculated as follows:

$$T_{grp} = C_1/SMAC_1 + C_2/SMAC_2 + \ldots + C_n/SMAC_n$$

Toxicological groups are defined according to the target organ and the nature of the toxic response from exposure to the compounds in the group. As shown in the table of SMACs, the target organ and toxic effect can change depending on the duration of exposure.

In addition to official SMACs used for the evaluation of space craft air, the JSC Toxicology Group sets interim 7-day SMAC values that are posted to the “MAPTIS” database, which is used to evaluate materials and hardware off-gassing data. These values can be accessed at: http://maptis.nasa.gov/index.html.

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Acetaldehyde	10	(18)	6	(10)	2	(4)	2	(4)	2	(4)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 75-07-0	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation		
REFERENCE: Wong, King Lit, (1994), Acetaldehyde, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants Vol 1: 19-38, National Academy Press, Washington, DC									Throat	Cancer		
REMARKS: Carcinogen												
Acetone	500	(1200)	200	(500)	22	(52)	22	(52)	22	(52)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 67-64-1	CNS	Fatigue	CNS	Fatigue	CNS	Fatigue	CNS	Fatigue	CNS	Fatigue		
REFERENCE: Garcia, Hector D. (2000), Acetone, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:17-41, National Academy Press, Washington, DC					CNS	Headache	CNS	Headache	CNS	Headache		
REMARKS:												
Acrolein	0.075	(0.17)	0.035	(0.08)	0.015	(0.03)	0.015	(0.03)	0.008	(0.02)	0.008	(0.02)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 107-02-8	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation
REFERENCE: Langford, Shannon D. (2008), Acrolein, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:13-33, National Academy Press, Washington, DC												
REMARKS: Ceiling values												
C3-C8 Aliphatic Saturated Aldehydes	45	(varies)	45	(varies)	5	(varies)	5	(varies)	5	(varies)	5	(varies)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: various	Mucosa	Irritation	Mucosa	Irritation	Nasal Cavity	Injury	Nasal Cavity	Injury	Nasal Cavity	Injury	Nasal Cavity	Injury
REFERENCE: Langford, Shannon D. (2008), C3-C8 Aliphatic Saturated Aldehydes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:34-47, National Academy Press, Washington, DC												
REMARKS: The mg/m3 value depends on the molecular weight of the particular aldehyde.												

Abbreviations: CNS: Central Nervous System DCD: Decreased Color Discrimination DCV: Decreased Conduction Velocity GI: Gastrointestinal tract PNS: Peripheral Nervous System
CV: Cardiovascular RespSys: Respiratory System U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
C2-C9 Alkanes	150	(varies)	80	(varies)	60	(varies)	20	(varies)	3	(varies)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: various	CNS / Depression		CNS / Depression		CNS / Depression		CNS / Depression		CNS / Ototoxicity			
REFERENCE: McCoy, J. Torin. (2008), C2-C9 Alkanes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:85-111, National Academy Press, Washington, DC	Eye / Irritation		Eye / Irritation				CNS / Ototoxicity					
REMARKS: Does not include n-hexane. The mg/m3 value depends on the molecular weight of the particular alkane.	Nose / Irritation		Nose / Irritation									
Ammonia	30	(20)	20	(14)	3	(2)	3	(2)	3	(2)	3	(2)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 7664-41-7	Eye / Irritation		Eye / Irritation		Eye / Irritation		Eye / Irritation		Eye / Irritation		Eye / Irritation	
REFERENCE: Garcia, Hector D. (2008), Ammonia, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:48-61, National Academy Press, Washington, DC	CNS / Headache		CNS / Headache		CNS / Headache		CNS / Headache		CNS / Headache		CNS / Headache	
REMARKS:												
Benzene	10	(35)	3	(10)	0.5	(1.5)	0.1	(0.3)	0.07	(0.2)	0.013	(0.04)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 71-43-2	Blood / Immunotoxicity		Blood / Immunotoxicity		Blood / Immunotoxicity		Blood / Immunotoxicity		Blood / Immunotoxicity		Blood / Hematological	
REFERENCE: Kahn-Mayberry, Noreen N. (2008), Benzene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:62-72, National Academy Press, Washington, DC	Blood / Anemia				Blood / Hematological				Blood / Leukemia			
REMARKS: Leukemogen	CNS / Grip/strength											
Bromotrifluoromethane	3500	(21000)	3500	(21000)	1800	(11000)	1800	(11000)	1800	(11000)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 75-63-8	Heart / Arrhythmia		Heart / Arrhythmia		CNS / Depression		CNS / Depression		CNS / Depression			
REFERENCE: Lam, Chiu-Wing. (1996), Bromotrifluoromethane, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:21-52, National Academy Press, Washington, DC	CNS / Cognition		CNS / Cognition		Heart / Arrhythmia							
REMARKS:												

Abbreviations: CNS: Central Nervous System; DCD: Decreased Color Discrimination; DCV: Decreased Conduction Velocity; GI: Gastrointestinal tract; PNS: Peripheral Nervous System; CV: Cardiovascular; RespSys: Respiratory System; U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
n- Butanol	50	(150)	25	(80)	25	(80)	25	(80)	12	(40)	12	(40)
CAS #: 71-36-3	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: James, John T. (2008), n-Butanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:73-84, National Academy Press, Washington, DC	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation
REMARKS: The odor threshold and noxious odor concentrations are uncertain. These concentrations may not preclude odor detection by the crew.	CNS	Depression				Systemic Injury		Systemic Injury		Systemic injury		Systemic injury
tert- Butanol	50	(150)	50	(150)	50	(150)	50	(150)	40	(120)	Not Set	(Not Set)
CAS #: 75-65-0	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: James, John T. (1996), tert-Butanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:78-104, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	CNS	Depression	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity		
REMARKS:							CNS	Depression	CNS	Depression		
							U. Blad	Injury	U. Blad	Injury		
Carbon monoxide	425	(485)	100	(114)	55	(63)	15	(17)	15	(17)	15	(17)
CAS #: 630-08-0	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: James, John T. (2008), Carbon Monoxide, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:125-143, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression
REMARKS: Carboxyhemoglobin target	CV	Arrhythmia	CV	Arrhythmia	CV	Arrhythmia	CV	Arrhythmia	CV	Arrhythmia	CV	Arrhythmia
Chloroform	2	(10)	2	(10)	2	(10)	1	(5)	1	(5)	Not Set	(Not Set)
CAS #: 67-66-3	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Garcia, Hector D. (2000), Chloroform, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:264-306, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
REMARKS:	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity		
					Kidney	Nephrotoxicity						

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; RespSys: Respiratory System; DCV: Decreased Conduction Velocity; U.Blad: Urinary bladder; GI: Gastrointestinal tract; PNS: Peripheral Nervous System

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Decamethylcyclopentasiloxane	Not Set	(Not Set)	Not Set	(Not Set)	7	(100)	5	(75)	1	(15)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 541-02-6					RspSys	Injury	RspSys	Injury	RspSys	Injury		
REFERENCE: James, John T. (2000), Polydimethylcyclosiloxanes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:151-174, National Academy Press, Washington, DC					Gonad	Toxicity	Gonad	Toxicity	Gonad	Toxicity		
REMARKS: Documented as a polydimethylcyclosiloxane												
Diacetone alcohol	50	(250)	50	(250)	20	(100)	6	(30)	4	(20)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 123-42-2	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Liver	Hepatomegaly		
REFERENCE: James, John T. (1996), Diacetone alcohol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:105-116, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
REMARKS:												
Dichloroacetylene	0.6	(2.4)	0.04	(0.16)	0.03	(0.12)	0.025	(0.10)	0.015	(0.06)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 7572-29-4	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
REFERENCE: James, John T. (1996), Dichloroacetylene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:117-134, National Academy Press, Washington, DC	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity		
REMARKS:	Liver	Hepatotoxicity	Liver	Hepatotoxicity								
1,2- Dichloroethane	0.4	(1.6)	0.4	(1.6)	0.4	(1.6)	0.4	(1.6)	0.4	(1.6)	0.4	(1.6)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 107-06-2	G.I.	GI Toxicity	G.I.	GI Toxicity	G.I.	GI Toxicity	G.I.	G.I. Toxicity	G.I.	G.I. Toxicity	G.I.	G.I. Toxicity
REFERENCE: Ramanathan, Raghupathy (2008), 1,2-Dichloroethane, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:144-161, National Academy Press, Washington, DC	.		.		.		.				Liver	Hepatotoxicity
REMARKS: Impairs host defenses against bacteria.												

Abbreviations: CNS: Central Nervous System DCD: Decreased Color Discrimination DCV: Decreased Conduction Velocity GI: Gastrointestinal tract PNS: Peripheral Nervous System
CV: Cardiovascular RespSys: Respiratory System U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Dimethylhydrazine	3	(7.5)	0.12	(0.3)	0.03	(0.075)	0.017	(0.0425)	0.003	(0.0075)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 57-14-7	CNS		CNS		Blood	Anemia	Blood	Anemia	Liver	Anemia		
REFERENCE: Khan-Mayberry, Noreen N. (2008), Dimethylhydrazine, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:162-189, National Academy Press, Washington, DC									Liver	Hepatotoxicity		
REMARKS:												
Ethanol	5000	(10000)	5000	(10000)	1000	(2000)	1000	(2000)	1000	(2000)	1000	(2000)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 64-17-5	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation
REFERENCE: McCoy, J. Torin (2008), Ethanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:190-205, National Academy Press, Washington, DC	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation
REMARKS:	Skin	Flushing	Skin	Flushing	Skin	Flushing	Skin	Flushing	Skin	Flushing	Skin	Flushing
	CNS	Depression	CNS	Depression	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity
2- Ethoxyethanol	10	(40)	10	(40)	0.8	(3)	0.5	(2)	0.07	(0.3)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 110-80-5	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity		
REFERENCE: Wong, King Lit (1996), 2-Ethoxyethanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:189-212, National Academy Press, Washington, DC	Mucosa	Irritation	Mucosa	Irritation	Testes	Toxicity	Testes	Toxicity	Testes	Toxicity		
REMARKS:												
Ethylbenzene	180	(800)	60	(250)	30	(130)	30	(130)	12	(50)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 100-41-4	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Testes	Necrosis		
REFERENCE: Garcia, Hector D. (1996), Ethylbenzene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:208-231, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	Testes	Necrosis	Testes	Necrosis				
REMARKS:												

Abbreviations: CNS: Central Nervous System; DCD: Decreased Color Discrimination; DCV: Decreased Conduction Velocity; GI: Gastrointestinal tract; PNS: Peripheral Nervous System; CV: Cardiovascular; RespSys: Respiratory System; U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Ethylene glycol	25	(60)	25	(60)	5	(13)	5	(13)	5	(13)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 107-21-1	Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation			
REFERENCE: Wong, King Lit (1996), Ethylene glycol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:232-270, National Academy Press, Washington, DC	CNS / Depression		CNS / Depression		CNS / Depression		CNS / Depression		CNS / Depression			
REMARKS:					Kidney / Nephrotoxicity		Kidney / Nephrotoxicity		Kidney / Nephrotoxicity			
Formaldehyde	0.8	(1.0)	0.5	(0.6)	0.1	(0.12)	0.1	(0.12)	0.1	(0.12)	0.1	(0.12)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 50-00-0	Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation		Mucosa / Irritation	
REFERENCE: McCoy, J. Torin (2008), Formaldehyde, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:206-249, National Academy Press, Washington, DC											Nose / Cancer	
REMARKS: Ceiling values, Carcinogen												
Freon 11	140	(790)	140	(790)	140	(790)	140	(790)	140	(790)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 75-69-4	Heart / Arrhythmia		Heart / Arrhythmia		Heart / Arrhythmia		Heart / Arrhythmia		Heart / Arrhythmia			
REFERENCE: Garcia, Hector D. (2000), Trichlorofluoromethane (Freon 11), Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:211-226, National Academy Press, Washington, DC												
REMARKS:												
Freon 113	50	(400)	50	(400)	50	(400)	50	(400)	50	(400)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 76-13-1	Heart / Arrhythmia		Heart / Arrhythmia		Heart / Arrhythmia		Heart / Arrhythmia		Heart / Arrhythmia			
REFERENCE: Garcia, Hector D. and James, John T. (1994), Freon 113, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 1:121-138, National Academy Press, Washington, DC												
REMARKS:												

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; RespSys: Respiratory System; DCV: Decreased Conduction Velocity; U.Blad: Urinary bladder; GI: Gastrointestinal tract; PNS: Peripheral Nervous System

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Freon 12	540	(2600)	95	(470)	95	(470)	95	(470)	95	(470)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 75-71-8	Heart	Tachycardia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia		
REFERENCE: Garcia, Hector D. (2000), Dichlorodifluoromethane (Freon 12), Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:227-239, National Academy Press, Washington, DC												
REMARKS:												
Freon 21	50	(210)	50	(210)	15	(63)	12	(50)	2	(8)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 75-43-4	Heart	Tachycardia	Heart	Tachycardia	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity		
REFERENCE: Garcia, Hector D. (2000), Dichlorofluoromethane (Freon 21), Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:175-189, National Academy Press, Washington, DC												
REMARKS:												
Freon 22	1000	(3500)	1000	(3500)	1000	(3500)	1000	(3500)	1000	(3500)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 75-45-6	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia		
REFERENCE: Garcia, Hector D. (2000), Chlorodifluoromethane (Freon 22), Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:190-210, National Academy Press, Washington, DC												
REMARKS:												
Furan	4	(11)	0.36	(1)	0.025	(0.07)	0.025	(0.07)	0.025	(0.07)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 110-00-9	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Cancer	Liver	Cancer	Liver	Cancer		
REFERENCE: Garcia, Hector D. and James, John T. (2000), Furan, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:307-329, National Academy Press, Washington, DC												
REMARKS:												

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; RespSys: Respiratory System; DCV: Decreased Conduction Velocity; U.Blad: Urinary bladder; GI: Gastrointestinal tract; PNS: Peripheral Nervous System

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Glutaraldehyde	0.12	(0.50)	0.04	(0.08)	0.006	(0.025)	0.003	(0.012)	0.0006	(0.002)	Not Set	(Not Set)
CAS #: 111-30-8	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Garcia, Hector D. (1996), Glutaraldehyde, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:271-291, National Academy Press, Washington, DC	Mucosa	Irritation	Mucosa	Irritation	RspSys	Lesions	RspSys	Lesions	RspSys	Lesions		
REMARKS:	CNS	Headache	CNS	Headache								
Hexamethylcyclotrisiloxane	Not Set		Not Set		10	(90)	5	(45)	1	(9)	Not Set	(Not Set)
CAS #: 541-05-9	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: James, John T. (2000), Polydimethylcyclosiloxanes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:151-174, National Academy Press, Washington, DC					RspSys	Injury	RspSys	Injury	RspSys	Injury		
REMARKS: Documented as a polydimethylcyclosiloxane					CNS	Depression	CNS	Depression				
Hydrazine	4	(5)	0.3	(0.4)	0.04	(0.05)	0.02	(0.03)	0.004	(0.005)	Not Set	(Not Set)
CAS #: 302-01-2	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Garcia, Hector D. and James, John T. (1996), Hydrazine, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:213-233, National Academy Press, Washington, DC		Death	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity		
REMARKS: Carcinogen							Liver	Hyperplasia	Nose	Cancer		
							Nose	Cancer				
Hydrogen	4100	(340)	4100	(340)	4100	(340)	4100	(340)	4100	(340)	Not Set	(Not Set)
CAS #: 1333-74-0	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Wong, King Lit (1994), Hydrogen, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 1:139-141, National Academy Press, Washington, DC	.	Explosion		Explosion		Explosion		Explosion		Explosion		
REMARKS: Ceiling values are 10% of the Lower Explosive Limit												

Abbreviations: CNS: Central Nervous System; DCD: Decreased Color Discrimination; DCV: Decreased Conduction Velocity; GI: Gastrointestinal tract; PNS: Peripheral Nervous System; CV: Cardiovascular; RespSys: Respiratory System; U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Hydrogen chloride	5	(8)	2	(3)	1	(1.5)	1	(1.5)	1	(1.5)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 7647-01-0	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation		
REFERENCE: Lam, Chiu-Wing and Wong, King Lit (2000), Hydrogen Chloride, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:60-88, National Academy Press, Washington, DC	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation		
REMARKS:												
Hydrogen cyanide	8	(9)	4	(4.5)	1	(1.1)	1	(1.1)	1	(1.1)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 74-90-8	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
REFERENCE: Lam, Chiu-Wing and Wong, King Lit (2000), Hydrogen Cyanide, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:330-365, National Academy Press, Washington, DC	CNS	Headache	CNS	Headache	CNS	Headache	CNS	Headache	CNS	Headache		
REMARKS:	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea		
					Testes	Testicular toxicity	Testes	Testicular toxicity	Testes	Testicular toxicity		
							Thyroid	Thyroid effects	Thyroid	Thyroid effects		
Indole	1.0	(5)	0.3	(1.5)	0.05	(0.25)	0.05	(0.25)	0.05	(0.25)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 120-72-9	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea		
REFERENCE: Lam, Chiu-Wing and James, John T. (1996), Indole, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:235-249, National Academy Press, Washington, DC			Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity		
REMARKS: Normal turnover of indole was used to establish a lower bound of 0.05 ppm.								Death		Death		
Isoprene	50	(140)	25	(70)	2	(6)	2	(6)	1	(3)	Not Set	(Not Set)
	Organ	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
CAS #: 78-79-5	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Lung	Injury		
REFERENCE: James, John T. (2000), Isoprene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:89-118, National Academy Press, Washington, DC					Blood	Anemia	Blood	Anemia	Blood	Anemia		
REMARKS:									CNS	Neurotoxicity		

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; RespSys: Respiratory System; DCV: Decreased Conduction Velocity; U.Blad: Urinary bladder; GI: Gastrointestinal tract; PNS: Peripheral Nervous System

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Limonene	80	(450)	80	(450)	20	(115)	20	(115)	20	(115)	20	(115)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 5989-27-5	Eye / Irritation		Eye / Irritation		Eye / Irritation		Eye / Irritation		Eye / Irritation		Eye / Irritation	
REFERENCE: Lam, Chiu-Wing (2008), Limonene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:250-274, National Academy Press, Washington, DC	Lung / Irritation		Lung / Irritation		Lung / Irritation		Lung / Irritation		Lung / Irritation		Lung / Irritation	
REMARKS:												
Linear Siloxanes	600	(varies)	100	(varies)	100	(varies)	50	(varies)	50	(varies)	50	(varies)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: various	Lung / Neurotoxicity		Lung / Neurotoxicity		Liver / Hepatotoxicity		Liver / Hepatotoxicity		Liver / Hepatotoxicity		Liver / Hepatotoxicity	
REFERENCE: Meyers, Valerie E., Hector D. Garcia, Tami S. McMullin, Joseph M. Tobin, and John T. James. Safe human exposure limits for airborne linear siloxanes during spaceflight. *Inhal Toxicol*, 2013: 25(13): 735-746.												
REMARKS: Includes hexamethyldisiloxane, octamethyltrisiloxane, decamethyltetrasiloxane, dodecamethylpentasiloxane												
Mercury	0.01	(0.1)	0.002	(0.02)	0.001	(0.01)	0.001	(0.01)	0.001	(0.01)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 7439-97-6	Lung / Irritation		Lung / Irritation		CNS / Neurotoxicity		CNS / Neurotoxicity		CNS / Neurotoxicity			
REFERENCE: James, John T. and Kaplan, Harold L. (1996), Mercury, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:251-276, National Academy Press, Washington, DC					Kidney / Nephrotoxicity		Kidney / Nephrotoxicity		Kidney / Nephrotoxicity			
REMARKS:												
Methane	5300	(3500)	5300	(3500)	5300	(3500)	5300	(3500)	5300	(3500)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 74-82-8	/ Explosion		/ Explosion		/ Explosion		/ Explosion		/ Explosion			
REFERENCE: Garcia, Hector D. and James, John T. (1994), Methane, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 1:143-148, National Academy Press, Washington, DC												
REMARKS: Ceiling values are 10% of the Lower Explosive Limit. Methane is a non-toxic simple asphyxiant.												

Abbreviations: CNS: Central Nervous System; DCD: Decreased Color Discrimination; DCV: Decreased Conduction Velocity; GI: Gastrointestinal tract; PNS: Peripheral Nervous System; CV: Cardiovascular; RespSys: Respiratory System; U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Methanol	200	(260)	70	(90)	70	(90)	70	(90)	70	(90)	23	(30)
CAS #: 67-56-1	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Garcia, Hector D. (2008), Methanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:275-288, National Academy Press, Washington, DC	Eye	Visual disturbance	Eye	Visual disturbance	Eye	Visual disturbance	Eye	Visual disturbance	Eye	Visual disturbance	Eye	Visual disturbance
REMARKS:												
Methyl ethyl ketone	50	(150)	50	(150)	10	(30)	10	(30)	10	(30)	Not Set	(Not Set)
CAS #: 78-93-3	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Wong, King Lit (1996), Methyl Ethyl Ketone, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:307-329, National Academy Press, Washington, DC	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation		
REMARKS: Ceiling values												
Methyl hydrazine	0.002	(0.004)	0.002	(0.004)	0.002	(0.004)	0.002	(0.004)	0.002	(0.004)	Not Set	(Not Set)
CAS #: 60-34-4	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Garcia, Hector D. (2000), Methylhydrazine, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:119-136, National Academy Press, Washington, DC	Nose	Lesions	Nose	Lesions	Nose	Lesions	Nose	Lesions	Nose	Lesions		
REMARKS: Carcinogen												
4- Methyl-2-pentanone	35	(140)	35	(140)	35	(140)	35	(140)	35	(140)	Not Set	(Not Set)
CAS #: 108-10-1	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Wong, King Lit (2000), 4-Methyl-2-Pentanone, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:240-263, National Academy Press, Washington, DC	CNS Mucosa	Depression Irritation	CNS Mucosa	Depression Irritation	CNS Mucosa	Depression Irritation	CNS Mucosa	Depression Irritation	CNS Mucosa	Depression Irritation		
REMARKS:												

Abbreviations: CNS: Central Nervous System; DCD: Decreased Color Discrimination; DCV: Decreased Conduction Velocity; GI: Gastrointestinal tract; PNS: Peripheral Nervous System; CV: Cardiovascular; RespSys: Respiratory System; U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Methylene chloride CAS #: 75-09-2 REFERENCE: Ramanathan, Raghupathy (2008), Methylene Chloride, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:289-313, National Academy Press, Washington, DC REMARKS: CO formation, carcinogen	100	(350)	35	(120)	14	(49)	7	(24)	3	(10)	1	(3.5)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
	CNS / Depression		CNS / Depression		CNS / Depression		Liver / Hepatotoxicity		Liver / Hepatotoxicity		Kidney / Nephrotoxicity	
Nitromethane CAS #: 75-52-5 REFERENCE: Wong, King Lit (1996), Nitromethane, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:331-350, National Academy Press, Washington, DC REMARKS:	25	(65)	15	(40)	7	(18)	7	(18)	5	(13)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
	Blood / Anemia		Blood / Anemia		Blood / Anemia		Blood / Anemia		Blood / Anemia			
Octamethylcyclotetrasiloxane CAS #: 556-67-2 REFERENCE: James, John T. (2000), Polydimethylcyclosiloxanes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:151-174, National Academy Press, Washington, DC REMARKS: Documented as a polydimethylcyclosiloxane	Not Set		Not Set		23	(280)	5	(60)	1	(12)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
					Gonads / Toxicity CNS / Depression		Gonads / Toxicity		Gonad / Toxicity			
Perfluoropropane and Other Aliphatic Perfluoroalkanes CAS #: 76-19-7 REFERENCE: Lam, Chiu-Wing (2000), Perfluoropropane and Other Aliphatic Perfluoroalkanes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 4:137-150, National Academy Press, Washington, DC REMARKS: This group SMAC is not applicable to perfluorocycloalkanes. SMACs in mg/m3 apply only to perfluorpropane.	11,000	(85,000)	11,000	(85,000)	11,000	(85,000)	11,000	(85,000)	11,000	(85,000)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
	CNS / Symptoms		CNS / Symptoms		CNS / Symptoms		CNS / Symptoms		CNS / Symptoms			

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; RespSys: Respiratory System; DCV: Decreased Conduction Velocity; U.Blad: Urinary bladder; GI: Gastrointestinal tract; PNS: Peripheral Nervous System

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
2- Propanol	400	(1000)	100	(240)	60	(150)	60	(150)	60	(150)	Not Set	(Not Set)
CAS #: 67-63-0	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: James, John T. and Kaplan, Harold L. (1996), 2-Propanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 2:351-371, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
REMARKS:	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation		
			Liver	Hepatotoxicity	Liver	Hepatotoxicity	PNS	DCV	PNS	DCV		
							Liver	Hepatotoxicity	Liver	Hepatotoxicity		
Propylene glycol	32	(102)	17	(54)	9	(29)	3	(9.6)	1.5	(4.8)	1.5	(4.8)
CAS #: 57-55-6	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Ramanathan, Raghupathy (2008), Propylene Glycol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:314-328, National Academy Press, Washington, DC	Eye	Irritation	Eye	Irritation	Eye	Discharge	Eye	Discharge	Nose	Epithelium	Nose	Epithelium
REMARKS:	Throat	Irritation	Throat	Irritation	Nose	Hemorrhage	Nose	Hemorrhage		thickening		thickening
	Lung	Irritation	Lung	Irritation								
Toluene	16	(60)	16	(60)	4	(15)	4	(15)	4	(15)	4	(15)
CAS #: 108-88-3	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: Garcia, Hector D. (2008), Toluene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:329-347, National Academy Press, Washington, DC	CNS	Depression	CNS	Dizziness	Ear	Ototoxicity	Ear	Ototoxicity	Ear	Ototoxicity	Ear	Ototoxicity
REMARKS:									Gonads	Hormone	Gonads	Hormone
Trichloroethylene	50	(270)	11	(60)	9	(50)	4	(20)	2	(10)	Not Set	(Not Set)
CAS #: 79-01-6	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*	*Organ*	*Effect*
REFERENCE: James, John T., Kaplan, Harold L., and Coleman, Martin E. (1996), Trichloroethylene, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 3:292-320, National Academy Press, Washington, DC	CNS	Depression	CNS	Depression	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Multi.	Cancer		
REMARKS: See dichloroacetylene if alkali scrubber is present. Possible carcinogen.	Heart	Arrhythmia			Liver	Hepatotoxicity	Liver	Hepatotoxicity	Kidney	Nephrotoxicity		
									Liver	Hepatotoxicity		

Abbreviations: CNS: Central Nervous System DCD: Decreased Color Discrimination DCV: Decreased Conduction Velocity GI: Gastrointestinal tract PNS: Peripheral Nervous System
CV: Cardiovascular RespSys: Respiratory System U.Blad: Urinary bladder

SMACs (Spacecraft Maximum Allowable Concentrations)

Chemical	1 hr		24 hr		7 d		30 d		180 d		1000 d	
	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)	ppm	(mg/m^3)
Trimethylsilanol	15	(55)	2	(7)	1	(4)	1	(4)	1	(4)	1	(4)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 1066-40-6	CNS / Depression		CNS / Depression		CNS / Depression		CNS / Depression		CNS / Depression		CNS / Depression	
REFERENCE: James, John T. (2008), Trimethylsilanol, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:348-355, National Academy Press, Washington, DC												
REMARKS:												
Vinyl chloride	130	(330)	30	(77)	1	(2.6)	1	(2.6)	1	(2.6)	Not Set	(Not Set)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 75-01-4	Liver / Hepatotoxicity		Liver / Hepatotoxicity		Testes / Necrosis		Testes / Necrosis		Testes / Necrosis			
REFERENCE: Wong, King Lit (1994), Vinyl Chloride, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 1:185-219, National Academy Press, Washington, DC	CNS / Headache		CNS / Headache		Liver / Hepatotoxicity		Liver / Hepatotoxicity		Liver / Cancer			
REMARKS: Carcinogen	CNS / Depression		CNS / Depression									
Xylenes	50	(215)	17	(73)	17	(73)	17	(73)	8.5	(37)	1.5	(6.5)
	Organ / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*		*Organ* / *Effect*	
CAS #: 1330-20-7 (mixed)	Mucosa / Irritation		Mucosa / Irritation		CNS / Neurotoxicity		CNS / Neurotoxicity		Ear / Ototoxicity		Ear / Ototoxicity	
REFERENCE: Ramanathan, Raghupathy (2008), Xylenes, Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol 5:356-386, National Academy Press, Washington, DC	CNS / Depression		CNS / Depression									
REMARKS: Applies to each individual xylene isomer and mixtures of xylene isomers.	Eye / Irritation		Eye / Irritation									

Abbreviations: CNS: Central Nervous System; DCD: Decreased Color Discrimination; DCV: Decreased Conduction Velocity; GI: Gastrointestinal tract; PNS: Peripheral Nervous System; CV: Cardiovascular; RespSys: Respiratory System; U.Blad: Urinary bladder

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