

**SPACECRAFT MAXIMUM ALLOWABLE
CONCENTRATIONS FOR
AIRBORNE CONTAMINANTS**

**TOXICOLOGY GROUP
Medical Operations Branch
Medical Sciences Division
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SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS FOR AIRBORNE CONTAMINANTS

The enclosed table lists official spacecraft maximum allowable concentrations (SMACs), which are guideline values set by the NASA/JSC Toxicology Group in cooperation with the National Research Council Committee on Toxicology (NRCCOT). These values should not be used for situations other than human space flight without careful consideration of the criteria used to set each value. 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 astronauts, and the absence of pregnant or very young individuals. Documentation of the values is given in a 4 volume series of books entitled "Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants" published by the National Academy Press, Washington, D. C. These books can be viewed electronically at <http://www.nap.edu/info/browse.htm> by selecting "Space Science."

Short-term (1 and 24 hour) SMACs are set to manage accidental releases aboard a spacecraft and 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 180 days. Crewmembers with allergies or unusual sensitivity to trace pollutants may not be afforded complete protection, even when long-term SMACs are not exceeded.

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. The air quality is 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:

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

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.

Previous editions of the document contained many SMACs "developed" before 1900 when the cooperative effort between NASA and the NRCCOT began. These values had been considered official; however, an effort to determine how these values were set revealed that there was not an adequate document trail to continue to consider these old values as official SMACs. These old values will continue to be posted in the "MAPTIS" database, which is used to evaluate materials and hardware offgassing data, but they have been deleted from the present edition of this document. Many unofficial SMACs for groups of compounds with structural similarities (e.g. aliphatic ethers, aliphatic ketones) have been set with limited documentation and no review by the NRCCOT. These unofficial group SMACs can be obtained from the JSC toxicology Group.



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Acetaldehyde Synonyms: NRC Vol. #: 1 CAS #: 75-07-0 Year SMAC was Set/ Reviewed: 1992	12	(22)	6	(10)	2	(4)	2	(4)	2	(4)	Carcinogen
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
Acetone Synonyms: 2-Propanone NRC Vol. #: 4 CAS #: 67-64-1 Year SMAC was Set/ Reviewed: 1994	500	(1200)	200	(500)	22	(52)	22	(52)	22	(52)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
Acrolein Synonyms: Propenal NRC Vol. #: 2 CAS #: 107-02-08 Year SMAC was Set/ Reviewed: 1992	0.075	(0.2)	0.035	(0.08)	0.015	(0.03)	0.015	(0.03)	0.015	(0.03)	Ceiling values
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
C3-C8 Aliphatic Saturated Aldehydes Synonyms: NRC Vol. #: 4 CAS #: various Year SMAC was Set/ Reviewed: 1998	50	(125-250)	50	(125-250)	6	(15-30)	1.5	(4-8)	1.5	(4-8)	The range of values listed in mg/m ³ is due to differences in the molecular weights of the various aldehydes.
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
					Liver	Hepatotoxicity					
Ammonia Synonyms: NRC Vol. #: 1 CAS #: 7664-41-7 Year SMAC was Set/ Reviewed: 1991	30	(20)	20	(14)	10	(7)	10	(7)	10	(7)	Ceiling values
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
Benzene Synonyms: NRC Vol. #: 2 CAS #: 71-43-2 Year SMAC was Set/ Reviewed: 1993	10	(35)	3	(10)	0.5	(1.5)	0.1	(0.3)	0.07	(0.2)	Leukemogen
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Blood	Immunotoxicity	Blood	Immunotoxicity	Blood	Immunotoxicity	Blood	Immunotoxicity	Blood	Immunotoxicity	
									Blood	Leukemia	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Bromotrifluoromethane Synonyms: Halon 1301 NRC Vol. #: 3 CAS #: 75-63-8 Year SMAC was Set/ Reviewed: 1993	3500	(21000)	3500	(21000)	1800	(11000)	1800	(11000)	1800	(11000)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Heart	Arrhythmia	Heart	Arrhythmia	CNS	Depression	CNS	Depression	CNS	Depression	
1- Butanol Synonyms: NRC Vol. #: 3 CAS #: 71-36-3 Year SMAC was Set/ Reviewed: 1994	50	(150)	25	(80)	25	(80)	25	(80)	12	(40)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation		Systemic Injury	
	CNS	Depression				Systemic Injury		Systemic Injury			
tert- Butanol Synonyms: 2-Methyl-2-propanol NRC Vol. #: 3 CAS #: 75-65-0 Year SMAC was Set/ Reviewed: 1995	50	(150)	50	(150)	50	(150)	50	(150)	40	(120)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	CNS	Depression	CNS	Depression	CNS	Depression	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	
							CNS	Depression	CNS	Depression	U. Blad Injury
Carbon dioxide Synonyms: NRC Vol. #: 2 CAS #: 124-38-9 Year SMAC was Set/ Reviewed: 1992	13000	(23000)	13000	(23000)	7000	(13000)	7000	(13000)	7000	(13000)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	CNS	Hyperventil'n	CNS	Hyperventil'n	CNS	Hyperventil'n	CNS	Hyperventil'n	CNS	Hyperventil'n	
	CNS	Visual	CNS	Visual							
Carbon monoxide Synonyms: NRC Vol. #: 1 CAS #: 630-08-0 Year SMAC was Set/ Reviewed: 1991	55	(63)	20	(23)	10	(11)	10	(11)	10	(11)	Carboxyhemoglobin target
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Chloroform Synonyms: Trichloromethane NRC Vol. #: 4 CAS #: 67-66-3 Year SMAC was Set/ Reviewed: 1999	2	(10)	2	(10)	2	(10)	1	(5)	1	(5)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	
Decamethylcyclotrasiloxane Synonyms: NRC Vol. #: 4 CAS #: 541-02-6 Year SMAC was Set/ Reviewed: 1998	N.S.		N.S.		7	(100)	5	(75)	1	(15)	Documented as a polydimethylcyclotrasiloxane
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
					RspSys	Injury	RspSys	Injury	RspSys	Injury	
					Gonad	Toxicity	Gonad	Toxicity	Gonad	Toxicity	
Diacetone alcohol Synonyms: NRC Vol. #: 3 CAS #: 123-42-2 Year SMAC was Set/ Reviewed: 1995	50	(250)	50	(250)	20	(100)	6	(30)	4	(20)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Liver	Hepatomegaly	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
Dichloroacetylene Synonyms: NRC Vol. #: 3 CAS #: 7572-29-4 Year SMAC was Set/ Reviewed: 1992	0.6	(2.4)	0.04	(0.16)	0.03	(0.12)	0.025	(0.10)	0.015	(0.06)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	
	Liver	Hepatotoxicity	Liver	Hepatotoxicity							
1,2- Dichloroethane Synonyms: NRC Vol. #: 3 CAS #: 107-06-2 Year SMAC was Set/ Reviewed: 1992	0.4	(2)	0.4	(2)	0.4	(2)	0.4	(2)	0.2	(1)	Carcinogen; impairs host defenses against bacteria.
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	G.I.	GI Toxicity	G.I.	GI Toxicity	G.I.	GI Toxicity	G.I.	GI Toxicity	Various	Cancer	
	.	Immunotoxicity	.	Immunotoxicity	.	Immunotoxicity	.	Immunotoxicity			



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P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Ethanol Synonyms: Ethyl alcohol NRC Vol. #: 3 CAS #: 64-17-5 Year SMAC was Set/ Reviewed: 1994	2000	(4000)	2000	(4000)	1000	(2000)	1000	(2000)	1000	(2000)	Skin "flushing" is a cardiovascular effect.
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
	Skin	Flushing	Skin	Flushing	Skin	Flushing	Skin	Flushing	Skin	Flushing	
					Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
2- Ethoxyethanol Synonyms: NRC Vol. #: 2 CAS #: 110-80-5 Year SMAC was Set/ Reviewed: 1992	10	(40)	10	(40)	0.8	(3)	0.5	(2)	0.07	(0.3)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	
	Mucosa	Irritation	Mucosa	Irritation							
Ethylbenzene Synonyms: NRC Vol. #: 3 CAS #: 100-41-4 Year SMAC was Set/ Reviewed: 1993	180	(800)	60	(250)	30	(130)	30	(130)	12	(50)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Testes	Necrosis	
	CNS	Depression	CNS	Depression	Testes	Necrosis	Testes	Necrosis			
Ethylene glycol Synonyms: NRC Vol. #: 3 CAS #: 107-21-1 Year SMAC was Set/ Reviewed: 1993	25	(60)	25	(60)	5	(13)	5	(13)	5	(13)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
			CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
					Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	
Formaldehyde Synonyms: NRC Vol. #: 1 CAS #: 50-00-0 Year SMAC was Set/ Reviewed: 1991	0.4	(0.5)	0.1	(0.12)	0.04	(0.05)	0.04	(0.05)	0.04	(0.05)	Ceiling values, Carcinogen
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Freon 11 Synonyms: Trichlorofluoromethane NRC Vol. #: 4 CAS #: 75-69-6 Year SMAC was Set/ Reviewed: 1998	140	(790)	140	(790)	140	(790)	140	(790)	140	(790)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	
Freon 113 Synonyms: 1,1,2-trichloro- 1,2,2-trifluoro-ethane NRC Vol. #: 1 CAS #: 76-13-1 Year SMAC was Set/ Reviewed: 1991	50	(400)	50	(400)	50	(400)	50	(400)	50	(400)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	
Freon 12 Synonyms: Dichlorodifluoromethane NRC Vol. #: 4 CAS #: 75-71-8 Year SMAC was Set/ Reviewed: 1998	540	(2600)	95	(470)	95	(470)	95	(470)	95	(470)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Heart	Tachycardia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	
Freon 21 Synonyms: Dichlorofluoromethane NRC Vol. #: 4 CAS #: 75-43-4 Year SMAC was Set/ Reviewed: 1998	50	(210)	50	(210)	15	(63)	12	(50)	2	(8)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Heart	Tachycardia	Heart	Tachycardia	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
Freon 22 Synonyms: Chlorodifluoromethane NRC Vol. #: 4 CAS #: 75-45-6 Year SMAC was Set/ Reviewed: 1998	1000	(3500)	1000	(3500)	1000	(3500)	1000	(3500)	1000	(3500)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	Heart	Arrhythmia	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Furan Synonyms: 1,4-Epoxy-1,3-butadiene NRC Vol. #: 4 CAS #: 110-00-9 Year SMAC was Set/ Reviewed: 1998	4	(11)	0.36	(1)	0.025	(0.07)	0.025	(0.07)	0.025	(0.07)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Cancer	Liver	Cancer	Liver	Cancer	
Glutaraldehyde Synonyms: 1,5-Pentanedial NRC Vol. #: 3 CAS #: 111-308 Year SMAC was Set/ Reviewed: 1993	0.12	(0.50)	0.04	(0.08)	0.006	(0.025)	0.003	(0.012)	0.0006	(0.002)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Mucosa	Irritation	Mucosa	Irritation	RspSys	Lesions	RspSys	Lesions	RspSys	Lesions	
	CNS	Headache	CNS	Headache							
Hexamethylcyclotrisiloxane Synonyms: NRC Vol. #: 4 CAS #: 541-05-9 Year SMAC was Set/ Reviewed: 1998	N.S.		N.S.		10	(90)	5	(45)	1	(9)	Documented as a polydimethylcyclotrisiloxane
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
					RspSys	Injury	RspSys	Injury	RspSys	Injury	
					CNS	Depression	CNS	Depression			
Hydrazine Synonyms: Diamine NRC Vol. #: 2 CAS #: 302-01-2 Year SMAC was Set/ Reviewed: 1993	4	(5)	0.3	(0.4)	0.04	(0.05)	0.02	(0.03)	0.004	(0.005)	Carcinogen.
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
		Death	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
							Liver	Hyperplasia	Nose	Cancer	
							Nose	Cancer			
Hydrogen Synonyms: NRC Vol. #: 1 CAS #: 1333-74-0 Year SMAC was Set/ Reviewed: 1990	4100	(340)	4100	(340)	4100	(340)	4100	(340)	4100	(340)	Ceiling values are 10% of the Lower Explosive Limit
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
		Explosion		Explosion		Explosion		Explosion		Explosion	
Hydrogen chloride Synonyms: NRC Vol. #: 4 CAS #: 7647-01-1 Year SMAC was Set/ Reviewed: 1998	5	(8)	2	(3)	1	(1.5)	1	(1.5)	1	(1.5)	
	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	<i>Organ</i>	<i>Effect</i>	
	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks	
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)		
Hydrogen cyanide Synonyms: NRC Vol. #: 4 CAS #: 74-90-8 Year SMAC was Set/ Reviewed: 1998	8	(9)	4	(4.5)	1	(1.1)	1	(1.1)	1	(1.1)		
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>		
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression		
	CNS	Headache	CNS	Headache	CNS	Headache	CNS	Headache	CNS	Headache		
	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea		
Indole Synonyms: NRC Vol. #: 2 CAS #: 120-72-9 Year SMAC was Set/ Reviewed: 1992	1.0	(5)	0.3	(1.5)	0.05	(0.25)	0.05	(0.25)	0.05	(0.25)	Normal turnover of indole was used to establish a lower bound of 0.05 ppm.	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>		
	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea	CNS	Nausea		
			Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity	Blood	Hematotoxicity		
Isoprene Synonyms: 2-Methyl-1,3-butadiene NRC Vol. #: 4 CAS #: 78-79-5 Year SMAC was Set/ Reviewed: 1998	50	(140)	25	(70)	2	(6)	2	(6)	1	(3)		
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>		
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Lung	Injury		
					Blood	Anemia	Blood	Anemia	Blood	Anemia		
									CNS	Neurotoxicity		
Mercury Synonyms: NRC Vol. #: 2 CAS #: 7439-97-6 Year SMAC was Set/ Reviewed: 1992	0.01	(0.1)	0.002	(0.02)	0.001	(0.01)	0.001	(0.01)	0.001	(0.01)		
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>		
	Lung	Irritation	Lung	Irritation	CNS	Neurotoxicity	CNS	Neurotoxicity	CNS	Neurotoxicity		
					Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity		
Methane Synonyms: Natural gas NRC Vol. #: 1 CAS #: 74-82-8 Year SMAC was Set/ Reviewed: 1990	5300	(3800)	5300	(3800)	5300	(3800)	5300	(3800)	5300	(3800)	Ceiling values are 10% of the Lower Explosive Limit. Methane is a non-toxic simple asphyxiant.	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>		
		Explosion		Explosion		Explosion		Explosion		Explosion		



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Methanol Synonyms: NRC Vol. #: 1 CAS #: 67-56-1 Year SMAC was Set/ Reviewed: 1992	30	(40)	10	(13)	7	(9)	7	(9)	7	(9)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Eye	Visual Disturbances	Eye	Visual Disturbances	Eye	Visual Disturbances	Eye	Visual Disturbances	Eye	Visual Disturbances	
Methyl Ethyl Ketone Synonyms: 2-Butanone NRC Vol. #: 2 CAS #: 78-93-3 Year SMAC was Set/ Reviewed: 1992	50	(150)	50	(150)	10	(30)	10	(30)	10	(30)	Ceiling values
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
Methyl hydrazine Synonyms: Monomethylhydrazine NRC Vol. #: 4 CAS #: 60-34-4 Year SMAC was Set/ Reviewed: 1991	0.002	(0.004)	0.002	(0.004)	0.002	(0.004)	0.002	(0.004)	0.002	(0.004)	Carcinogen
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Nose	Lesions	Nose	Lesions	Nose	Lesions	Nose	Lesions	Nose	Lesions	
4- Methyl-2-pentanone Synonyms: Methyl isobutyketone, MIBK NRC Vol. #: 4 CAS #: 108-10-1 Year SMAC was Set/ Reviewed: 1994	35	(140)	35	(140)	35	(140)	35	(140)	35	(140)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
Methylene chloride Synonyms: Dichloromethane NRC Vol. #: 2 CAS #: 75-09-2 Year SMAC was Set/ Reviewed: 1992	100	(350)	35	(120)	15	(50)	5	(20)	3	(10)	CO formation, Carcinogen
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	CNS	Depression	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
Nitromethane Synonyms: NRC Vol. #: 2 CAS #: 75-52-5 Year SMAC was Set/ Reviewed: 1992	25	(65)	15	(40)	7	(18)	7	(18)	5	(13)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Blood	Anemia	Blood	Anemia	Blood	Anemia	Blood	Anemia	Blood	Anemia	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Octamethylcyclotetrasiloxane Synonyms: NRC Vol. #: 4 CAS #: 556-67-2 Year SMAC was Set/ Reviewed: 1998	N.S.		N.S.		23	(280)	5	(60)	1	(12)	Documented as a polydimethylcyclsiloxane
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
					RspSys	Injury	RspSys	Injury	Gonad	Toxicity	
					CNS	Depression	Gonad	Toxicity	RspSys	Injury	
					Gonad	Toxicity					
Octamethyltrisiloxane Synonyms: MDM NRC Vol. #: 1 CAS #: 107-51-7 Year SMAC was Set/ Reviewed: 1992	400	(4000)	200	(2000)	100	(1000)	20	(200)	4	(40)	Based on structure activity relationships
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
		Death		Death	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Hepatotoxicity	
			Liver	Hepatotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	
			Kidney	Nephrotoxicity							
Perfluoropropane and Other Aliphatic Perfluoroalkanes Synonyms: Octafluoropropane NRC Vol. #: 4 CAS #: 76-19-7 Year SMAC was Set/ Reviewed: 1998	11,000	(85,000)	11,000	(85,000)	11,000	(85,000)	11,000	(85,000)	11,000	(85,000)	This group SMAC is not applicable to perfluorocycloalkanes.
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Symptoms	CNS	Symptoms	CNS	Symptoms	CNS	Symptoms	CNS	Symptoms	
2- Propanol Synonyms: Isopropanol NRC Vol. #: 2 CAS #: 67-63-0 Year SMAC was Set/ Reviewed: 1992	400	(1000)	100	(240)	60	(150)	60	(150)	60	(150)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
			Liver	Hepatotoxicity	Liver	Hepatotoxicity	PNS	Decr. cond'n.			
							velocity				
Toluene Synonyms: Methyl benzene NRC Vol. #: 2 CAS #: 108-88-3 Year SMAC was Set/ Reviewed: 1992	16	(60)	16	(60)	16	(60)	16	(60)	16	(60)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
					Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	



Spacecraft Maximum Allowable Concentrations

P O T E N T I A L E X P O S U R E D U R A T I O N

Chemical Name	1 hr		24 hr		7 d		30 d		180 d		Remarks
	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	ppm	(mg/m ³)	
Trichloroethylene Synonyms: NRC Vol. #: 3 CAS #: 79-01-6 Year SMAC was Set/ Reviewed: 1992	50	(270)	11	(60)	9	(50)	4	(20)	2	(10)	See dichloroacetylene if alkali scrubber is present. Possible carcinogen.
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	Kidney	Nephrotoxicity	Kidney	Nephrotoxicity	Multi.	Cancer	
	Heart	Arrhythmia			Liver	Hepatotoxicity	Liver	Hepatotoxicity	Kidney	Nephrotoxicity	
									Liver	Hepatotoxicity	
Trimethylsilanol Synonyms: Trimethylhydroxysilane NRC Vol. #: 1 CAS #: 1066-40-6 Year SMAC was Set/ Reviewed: 1991	150	(550)	20	(74)	10	(37)	10	(37)	10	(37)	
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	CNS	Depression	
Vinyl chloride Synonyms: Chloroethene; chloroethylene NRC Vol. #: 1 CAS #: 75-01-4 Year SMAC was Set/ Reviewed: 1992	130	(330)	30	(77)	1	(2.6)	1	(2.6)	1	(2.6)	Carcinogen
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Testes	Necrosis	Testes	Necrosis	Testes	Necrosis	
	CNS	Headache	CNS	Headache	Liver	Hepatotoxicity	Liver	Hepatotoxicity	Liver	Cancer	
	CNS	Depression	CNS	Depression							
Xylene Synonyms: Dimethylbenzene, xylol NRC Vol. #: 3 CAS #: 1330207 Year SMAC was Set/ Reviewed: 1992	100	(430)	100	(430)	50	(220)	50	(220)	50	(220)	Applies to each individual xylene isomer and mixtures of xylene isomers.
	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	<u>Organ</u>	<u>Effect</u>	
	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	Mucosa	Irritation	
	CNS	Depression	CNS	Depression							

Abbreviations:

CNS - Central Nervous System
 GI - Gastrointestinal System
 NRC - National Research Council
 N.S. - Not Set

PNS - Peripheral Nervous System
 RBC - Red Blood Cells
 RspSys - Respiratory System