

**SPACECRAFT MAXIMUM ALLOWABLE
CONCENTRATIONS FOR
AIRBORNE CONTAMINANTS**

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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/m3 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. #: 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	

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Spacecraft Maximum Allowable Concentrations

POTENTIAL EXPOSURE DURATION

Chemical Name

Bromotrifluoromethane

Synonyms: Halon 1301

NRC Vol. #: 3 CAS #: 75-63-8

Year SMAC was Set/ Reviewed: 1993

1- Butanol

Synonyms:

NRC Vol. #: 3 CAS #: 71-36-3

Year SMAC was Set/ Reviewed: 1994

tert- Butanol

Synonyms: 2-Methyl-2-propanol

NRC Vol. #: 3 CAS #: 75-65-0

Year SMAC was Set/ Reviewed: 1995

Carbon dioxide

Synonyms:

NRC Vol. #: 2 CAS #: 124-38-9

Year SMAC was Set/ Reviewed: 1992

Carbon monoxide

Synonyms:

NRC Vol. #: 1 CAS #: 630-08-0

Year SMAC was Set/ Reviewed: 1991

1 hr		24 hr		7 d		30 d		180 d		Remarks
ppm	(mg/m³)	ppm	(mg/m³)	ppm	(mg/m³)	ppm	(mg/m³)	ppm	(mg/m³)	
3500	(21000)	3500	(21000)	1800	(11000)	1800	(11000)	1800	(11000)	
<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>	
Heart	Arrhythmia	Heart	Arrhythmia	CNS	Depression	CNS	Depression	CNS	Depression	
50	(150)	25	(80)	25	(80)	25	(80)	12	(40)	
<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 CNS	Irritation Depression	Eye	Irritation	Eye	Irritation Systemic Injury	Eye	Irritation Systemic Injury		Systemic Injury	
50	(150)	50	(150)	50	(150)	50	(150)	40	(120)	
<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	Kidney CNS	Nephrotoxicity Depression	Kidney CNS	Nephrotoxicity Depression U. Blad Injury	
13000	(23000)	13000	(23000)	7000	(13000)	7000	(13000)	7000	(13000)	
<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 CNS	Hyperventil'n Visual	CNS CNS	Hyperventil'n Visual	CNS	Hyperventil'n	CNS	Hyperventil'n	CNS	Hyperventil'n	
55	(63)	20	(23)	10	(11)	10	(11)	10	(11)	Carboxyhemoglobin target
<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 Heart	Depression Arrhythmia	CNS Heart	Depression Arrhythmia	CNS Heart	Depression Arrhythmia	CNS Heart	Depression Arrhythmia	CNS Heart	Depression Arrhythmia	