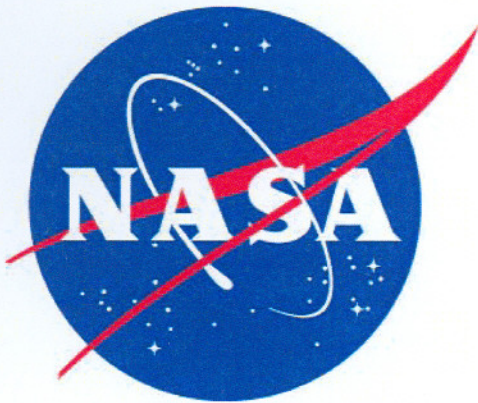


Spacecraft Maximum Allowable Concentrations for Airborne Contaminants

**Toxicology Group
Environmental Factors Office
Habitability and Environmental Factors Division
Space Life Sciences Directorate**

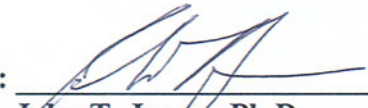
November 2008

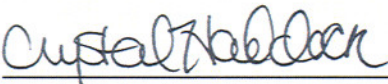


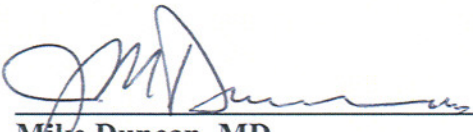
**National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas**

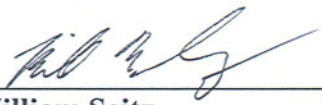
SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS
FOR AIRBORNE CONTAMINANTS

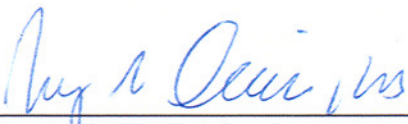
2008

Compiled by:  10-16-08
John T. James, Ph.D.
Chief Toxicologist

Concurred By:  10/17/08
Crystal Haddock
Chief, Environmental Factors Branch

 10/21/08
Mike Duncan, MD
Chief, Space Medicine Division

 10/20/08
William Seitz
Chief, Habitability and Environmental Factors Division


Jeff Davis, MD
Director, Space Life Sciences



Errata

Correct CAS numbers are below:

Freon 11	75-69-4
Glutaraldehyde	111-30-8
Hydrogen chloride	7647-01-0
Limonene	5989-27-5

SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS FOR AIRBORNE CONTAMINANTS 2008

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 the astronauts, and the absence of pregnant or very young individuals. Documentation of the values is given in a 5 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://books.nap.edu/openbook.php?record_id=9786&page=3.

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 1000 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.

Early editions of this document contained many SMACs "developed" before 1990 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.



Documents

Document Sharing Hub

SMACs (Spacecraft Maximum Allowable Concentrations)

POTENTIAL EXPOSURE DURATION

Chemical

Acetaldehyde

Synonyms:

NRC Vol. #: 1 CAS #: 75-07-0

Year SMAC was Set/ Reviewed: 1992

Remarks: Carcinogen

Acetone

Synonyms: 2-Propanone

NRC Vol. #: 4 CAS #: 67-64-1

Year SMAC was Set/ Reviewed: 1994

Remarks:

Acrolein

Synonyms: Propenal

NRC Vol. #: 5 CAS #: 107-02-08

Year SMAC was Set/ Reviewed: 2008

Remarks: Ceiling values

C2-C9 Aliphatic Alkanes

Synonyms:

NRC Vol. #: 5 CAS #: various

Year SMAC was Set/ Reviewed: 2005

Remarks:

	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	Mucosa	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation	Organ	Effect
Acetone	500	(1200)	200	(500)	22	(52)	22	(52)	22	(52)	Not Set	(Not Set)
Organ	CNS	Effect Fatigue	Organ	Effect Fatigue	Organ	Effect Fatigue Headache	Organ	Effect Fatigue Headache	Organ	Effect Fatigue Headache	Organ	Effect
Acrolein	0.075	(0.2)	0.035	(0.08)	0.015	(0.03)	0.015	(0.03)	0.008	(0.02)	0.008	(0.02)
Organ	Mucosa	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation	Organ	Effect Irritation
C2-C9 Aliphatic Alkanes	150	(varies)	80	(varies)	60	(varies)	20	(varies)	3	(varies)	Not Set	(Not Set)
Organ	CNS	Effect Depression	Organ	Effect Depression	Organ	Effect Depression	Organ	Effect Depression	Organ	Effect Ototoxicity	Organ	Effect
Organ	Eye	Effect Irritation	Organ	Effect Irritation	Organ	Effect Ototoxicity	Organ	Effect Ototoxicity	Organ	Effect Ototoxicity	Organ	Effect
Organ	Nose	Effect Irritation	Organ	Effect Irritation	Organ	Effect Ototoxicity	Organ	Effect Ototoxicity	Organ	Effect Ototoxicity	Organ	Effect

Abbreviations: CNS: Central Nervous System
CV: Cardiovascular

DCD: Decreased Color Discrimination
RespSys: Respiratory System

GI: Gastrointestinal tract
U.Blad: Urinary bladder

NRC: National Research Council

PNS: Peripheral Nervous System

jsc-txcology@mail.nasa.gov

SMACs (Spacecraft Maximum Allowable Concentrations)

POTENTIAL EXPOSURE DURATION

Chemical

C3-C8 Aliphatic Saturated Aldehydes

Synonyms:

NRC Vol. #: 5 CAS #: various

Year SMAC was Set/ Reviewed: 2008

Remarks:

Ammonia

Synonyms:

NRC Vol. #: 5 CAS #: 7664-41-7

Year SMAC was Set/ Reviewed: 2008

Remarks: Ceiling values

Benzene

Synonyms:

NRC Vol. #: 5 CAS #: 71-43-2

Year SMAC was Set/ Reviewed: 2008

Remarks: Leukemogen

Bromotrifluoromethane

Synonyms: Halon 1301

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

Year SMAC was Set/ Reviewed: 1993

Remarks:

	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)
C3-C8 Aliphatic Saturated Aldehydes	45	(varies)	45	(varies)	4.5	(varies)	4.5	(varies)	4.5	(varies)	4.5	(varies)
Organ		Effect	Organ	Effect	Organ	Effect	Organ	Effect	Organ	Effect	Organ	Effect
Mucosa		Irritation	Mucosa	Irritation	Nasal Cavity	Injury	Liver Nasal Cavity	Hepatotoxicity Injury	Liver Nasal Cavity	Hepatotoxicity Injury	Nasal Cavity	Injury
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
Eye		Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation	Eye	Irritation
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
Blood		Immunotoxicit ..	Blood	Immunotoxicit ..	Blood	Immunotoxicit ..	Blood	Immunotoxicit ..	Blood Blood	Immunotoxicit Leukemia	Blood	Hematological
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
Heart		Arrhythmia	Heart	Arrhythmia	CNS	Depression	CNS	Depression	CNS	Depression		

Abbreviations: CNS: Central Nervous System
CV: Cardiovascular

DCD: Decreased Color Discrimination
RespSys: Respiratory System

GI: Gastrointestinal tract
U.Blad: Urinary bladder

NRC: National Research Council

PNS: Peripheral Nervous System

jsc-txcology@mail.nasa.gov