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Spacecraft Water Exposure Guidelines (SWEGs)

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

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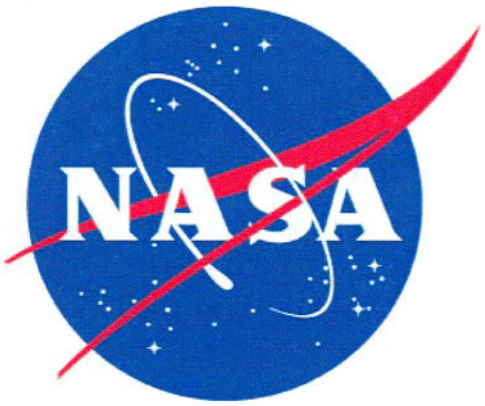

National Aeronautics and Space Administration

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SPACECRAFT WATER EXPOSURE GUIDELINES (SWEGs)

2008

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SPACECRAFT WATER EXPOSURE GUIDELINES (SWEGs)

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SWEG Background:

As the protection of crew health is a primary focus of the National Aeronautics and Space Administration (NASA), the Space and Life Sciences Directorate (SLSD) is vigilant in setting potable water limits for spaceflight that are health protective. Additionally, it is important that exposure limits not be set so stringently that water purification systems are unnecessarily over-designed. With these considerations in mind, NASA has partnered with the National Research Council Committee on Toxicology (NRCCOT) to develop spacecraft water exposure guidelines (SWEGs) for application in spaceflight systems. Based on documented guidance (NRC, 2000), NASA has established 28 SWEGs for chemical components that are particularly relevant to water systems on the International Space Station (ISS), the Shuttle, and in looking forward to Constellation. Summaries of these SWEGs are presented in tabular form as part of this publication.

The complete documentation for SWEGs is published by the National Academy Press in three different volumes (NRC 2004, 2006, and 2008) containing chapters authored by members of the JSC Toxicology Group. These SWEGs were carefully scrutinized by NASA and NRCCOT experts to ensure that the unique physiological changes that occur in spaceflight, the relatively robust nature of the astronaut corps, and chemical-specific toxicological data are all appropriately incorporated in established exposure limits.

SWEG Description and Application:

There are 2 groups of SWEGs that are set for each compound. Acute-exposure SWEGs are set for crew water consumption of 1 and 10 days with the understanding that these limits apply only to contingency conditions. These acute-exposure guidelines allow for a moderate risk that the crew will experience some dissatisfaction with the water, but not to the point where it would result in reduced water consumption. In addition, there is only a slight risk that the compound could cause mild symptoms (e.g., nausea, headache) at acute-exposure limits. Our goal in setting these limits is to help guide the management of a contingency event. Accordingly, these limits are not necessarily fully protective of crew health, and should not be used as design criteria.

The second group of SWEGs, for exposure periods of 100 or 1000 days, is set with prolonged consumption of water in mind, and allow for no appreciable risk to crew health. This includes considerations for the aesthetic properties of the water. Water that is perceived as smelling or tasting poorly may result in reduced crew consumption; an unacceptable condition for extended spaceflight missions. Longer-term SWEGs are protective against both immediate toxic effects (e.g., gastrointestinal irritation) as well as delayed health impairment (e.g., kidney disease, cancer). Exceedance of a SWEG 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. Combined effects from multiple chemicals in potable water are not specifically considered in SWEG development due to difficulty in predicting the health consequence of all potential chemical interactions.

In some cases, SWEGs decrease as the exposure duration increases (i.e., 1000 day limits are lower than 100 day limits). However, this is not always the case, as the relationship is dependent on the toxicological disposition of each chemical. What is predictable is that the 1000 day SWEGs will be the most stringent across the established SWEG exposure durations, and that application of those SWEGs in spaceflight design will afford the most flexibility in multi-vehicle uses.

Compounds without SWEGs:

This list of SWEGs is not meant to define the set of compounds that may be of toxicological concern in evaluating/designing a spacecraft water system. Given the relatively small number of available SWEGs, it is likely that chemicals will be encountered in spaceflight design or operations that do not have available SWEGs. In these cases, one may think to look to the 76 maximum contaminant levels (MCLs) established by the United States Environmental Protection Agency for municipal water systems (http://www.epa.gov/safewater/mcl.html). However, these limits are designed for a different target population and have a tendency to be overly conservative for direct application to spaceflight. Instead, in cases where SWEGs aren't available, the recommended course of action is to contact the SLSD Water and Food Analytical Laboratory (WAFAL) technical monitor. The technical monitor will determine if an interim SWEG/water quality guideline is needed, and will work with the JSC Toxicology group to develop an appropriate limit if that action is necessary. More complete documentation of the SWEGs can also be found on the JSC Toxicology web page (http://www.jsc.nasa.gov/toxicology).

References:

NRC(2000) Methods for Developing Spacecraft Water Exposure Guidelines, National Academy Press, Washington, D.C.

NRC (2004) Spacecraft Water Exposure Guidelines for Selected Contaminants, Volume 1, National Academy Press, Washington, D.C.

NRC (2006) Spacecraft Water Exposure Guidelines for Selected Contaminants, Volume 2, National Academy Press, Washington, D.C.

NRC (2008) Spacecraft Water Exposure Guidelines for Selected Contaminants, Volume 3, National Academy Press, Washington, D.C. (In Press)

SWEGS (Spacecraft Water Exposure Guidelines)*

POTENTIAL EXPOSURE DURATION

Chemical	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	Remarks
Acetone Synonyms: NRC Vol. #: 2 CAS #: 67641 Year SWEG was Set/ Reviewed: 2005	3500 *Organ*: Blood *Effect*: Marrow hypoplasia	3500 *Organ*: Blood *Effect*: Marrow hypoplasia	150 *Organ*: Blood *Effect*: Macrocytic anemia	15 *Organ*: Blood *Effect*: Macrocytic anemia	
Alkylamines (di) Synonyms: NRC Vol. #: 2 CAS #: Variable Year SWEG was Set/ Reviewed: 2004	0.3 *Organ*: Nose *Effect*: RWC	0.3 *Organ*: Nose *Effect*: RWC	0.3 *Organ*: Nose *Effect*: RWC	0.3 *Organ*: Nose *Effect*: RWC	
Alkylamines (mono) Synonyms: NRC Vol. #: 2 CAS #: Variable Year SWEG was Set/ Reviewed: 2004	2 *Organ*: Nose *Effect*: RWC	2 *Organ*: Nose *Effect*: RWC	2 *Organ*: Nose *Effect*: RWC	2 *Organ*: Nose *Effect*: RWC	
Alkylamines (tri) Synonyms: NRC Vol. #: 2 CAS #: Variable Year SWEG was Set/ Reviewed: 2004	0.4 *Organ*: Nose *Effect*: RWC	0.4 *Organ*: Nose *Effect*: RWC	0.4 *Organ*: Nose *Effect*: RWC	0.4 *Organ*: Nose *Effect*: RWC	

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* *See end of table for explanation of acronyms*

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Chemical	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	Remarks
Ammonia Synonyms: NRC Vol. #: 2 CAS #: 7664-41-7 Year SWEG was Set/ Reviewed: 2004	5 *Organ*: Nose *Effect*: RWC	1 *Organ*: Nose *Effect*: RWC	1 *Organ*: Nose *Effect*: RWC	1 *Organ*: Nose *Effect*: RWC	
Antimony (soluble salts) Synonyms: NRC Vol. #: 3 CAS #: variable Year SWEG was Set/ Reviewed: 2007	4 *Organ*: G.I. *Effect*: Emetic	4 *Organ*: G.I. *Effect*: Emetic	4 *Organ*: G.I. *Effect*: Emetic	2 *Organ*: Blood *Effect*: Hematotoxicity	
Barium (salts), soluble Synonyms: NRC Vol. #: 2 CAS #: variable Year SWEG was Set/ Reviewed: 2005	21 *Organ*: Heart *Effect*: Cardiotoxicity	21 *Organ*: Heart *Effect*: Cardiotoxicity	10 *Organ*: *Effect*: RWC	10 *Organ*: *Effect*: RWC	
Benzene Synonyms: NRC Vol. #: 3 CAS #: 71-43-2 Year SWEG was Set/ Reviewed: 2008	21 *Organ*: Blood *Effect*: Immunotoxicity	2 *Organ*: Blood *Effect*: Immunotoxicity	0.7 *Organ*: Blood *Effect*: Leukemia	0.07 *Organ*: Blood *Effect*: Leukemia	

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Chemical	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	Remarks
Cadmium (salts), soluble Synonyms: NRC Vol. #: 2 CAS #: variable Year SWEG was Set/ Reviewed: 2005	1.6 *Organ*: G.I. *Effect*: Emetic	0.7 *Organ*: RWC *Effect*: Taste	0.6 *Organ*: Bone *Effect*: Osteotoxicity	0.022 *Organ*: Kidney *Effect*: Nephrotoxicity	
Caprolactam Synonyms: 6-Aminocaproic acid NRC Vol. #: 2 CAS #: 105-60-2 Year SWEG was Set/ Reviewed: 2005	200 *Organ*: Liver *Effect*: Hepatotoxicity	100 *Organ*: Kidney *Effect*: Nephrotoxicity	100 *Organ*: Kidney *Effect*: Nephrotoxicity	100 *Organ*: Kidney *Effect*: Nephrotoxicity	
Chloroform Synonyms: NRC Vol. #: 1 CAS #: 67-66-3 Year SWEG was Set/ Reviewed: 2004	60 *Organ*: *Effect*: RWC	60 *Organ*: *Effect*: RWC	18 *Organ*: Liver *Effect*: Hepatotoxicity	6.5 *Organ*: Liver *Effect*: Hepatotoxicity	
Di(2-ethylhexyl) phthalate Synonyms: DEHP NRC Vol. #: 1 CAS #: 117-81-7 Year SWEG was Set/ Reviewed: 2004	1800 *Organ*: G.I. *Effect*: Gastric Upset	1300 *Organ*: Testes *Effect*: Injury	30 *Organ*: Liver *Effect*: Hematotoxicity *Organ*: Testes *Effect*: Injury	20 *Organ*: Testes *Effect*: Injury	

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Chemical	POTENTIAL EXPOSURE DURATION				Remarks
	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	
Di-n-butyl phthalate Synonyms: DBP NRC Vol. #: 1 CAS #: 84-74-2 Year SWEG was Set/ Reviewed: 2004	1200 *Organ* / *Effect* Testes / Injury	175 *Organ* / *Effect* Testes / Injury	80 *Organ* / *Effect* Blood / Hematotoxicity	40 *Organ* / *Effect* Blood / Hematotoxicity	
Dichloromethane Synonyms: DCM NRC Vol. #: 1 CAS #: 75-09-02 Year SWEG was Set/ Reviewed: 2004	40 *Organ* / *Effect* CNS / DCFF RWC	40 *Organ* / *Effect* CNS / DCFF RWC	40 *Organ* / *Effect* CNS / DCFF Liver / Hepatotoxicity RWC	15 *Organ* / *Effect* Liver / Hepatotoxicity	
Ethylene glycol Synonyms: NRC Vol. #: 3 CAS #: 107-21-1 Year SWEG was Set/ Reviewed: 2008	270 *Organ* / *Effect* CNS / Depression Kidney / Lesions	140 *Organ* / *Effect* Kidney / Lesions	20 *Organ* / *Effect* Kidney / Lesions	4 *Organ* / *Effect* Kidney / Lesions	
Formaldehyde Synonyms: NRC Vol. #: 2 CAS #: 50-00-0 Year SWEG was Set/ Reviewed: 2006	20 *Organ* / *Effect* G.I. / Gastric Upset	20 *Organ* / *Effect* G.I. / Gastric Upset	12 *Organ* / *Effect* G.I. / Gastric Upset	12 *Organ* / *Effect* G.I. / Gastric Upset	

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POTENTIAL EXPOSURE DURATION

Chemical	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	Remarks
Formate Synonyms: NRC Vol. #: 2 CAS #: 64-19-7 Year SWEG was Set/ Reviewed: 2005	10,000 *Organ* / *Effect* Eye / Decr. vision	2500 *Organ* / *Effect* Eye / Decr. vision	2500 *Organ* / *Effect* Eye / Decr. vision	2500 *Organ* / *Effect* Eye / Decr. vision	Decr. vision - decreased amplitude of electroretinograms
Manganese (Salts), soluble Synonyms: NRC Vol. #: 2 CAS #: variable Year SWEG was Set/ Reviewed: 2005	14 *Organ* / *Effect* Systemic	5.4 *Organ* / *Effect* Systemic	1.8 *Organ* / *Effect* CNS / Neurotoxicity	0.3 *Organ* / *Effect* CNS / Neurotoxicity	
2- Mercaptobenzothiazole Synonyms: MBT NRC Vol. #: 1 CAS #: 149-30-4 Year SWEG was Set/ Reviewed: 2004	200 *Organ* / *Effect* CNS / Depression	30 *Organ* / *Effect* Kidney / Nephrotoxicity	30 *Organ* / *Effect* Kidney / Nephrotoxicity	30 *Organ* / *Effect* Kidney / Nephrotoxicity Cancer	
Methanol Synonyms: NRC Vol. #: 3 CAS #: 67-56-1 Year SWEG was Set/ Reviewed: 2008	40 *Organ* / *Effect* CNS	40 *Organ* / *Effect* CNS	40 *Organ* / *Effect* CNS	40 *Organ* / *Effect* CNS	Subtle effects on EEG and neurobehavioral tests

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Chemical	Potential Exposure Duration				Remarks
	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	
Methyl Ethyl Ketone Synonyms: 2-butanone, methyl acetone, ethyl methyl ketone, methyl propanone NRC Vol. #: 3 CAS #: 78-93-3 Year SWEG was Set/ Reviewed: 2008	540 Organ: RWC Effect: RWC	54 Organ: RWC Effect: RWC	54 Organ: RWC Effect: RWC	54 Organ: RWC Effect: RWC	10-, 100-, and 1000-d SWEGs are set below the odor detection limit to avoid crew dehydration due to odor avoidance.
Nickel Synonyms: NRC Vol. #: 1 CAS #: 7440-02-0 Year SWEG was Set/ Reviewed: 2004	1.7 Organ: Bone Marrow Effect: Immuno-supression	1.7 Organ: Bone Marrow Effect: Immuno-supression	1.7 Organ: Bone Marrow Effect: Immuno-supression	0.3 Organ: Bone Marrow Effect: Immuno-supression	
Phenol Synonyms: Carbolic acid, phenic acid NRC Vol. #: 1 CAS #: 108-95-2 Year SWEG was Set/ Reviewed: 2004	80 Organ: G.I. Effect: Irritation	8 Organ: G.I. Effect: Irritation, Taste	4 Organ: G.I. Effect: Irritation, Taste	4 Organ: G.I. Effect: Irritation, Taste	
n- Phenyl-beta-naphthylamine Synonyms: PBNA NRC Vol. #: 1 CAS #: 135-88-6 Year SWEG was Set/ Reviewed: 2004	1600 Organ: G.I. Effect: Toxicity	1600 Organ: G.I. Effect: Toxicity	500 Organ: Kidney Effect: Lesions	260 Organ: Kidney Effect: Lesions	

** See end of table for explanation of acronyms*

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Chemical	1 day (mg/L)	10 days (mg/L)	100 days (mg/L)	1000 days (mg/L)	Remarks
Propylene glycol Synonyms: 1,2-Propane diol NRC Vol. #: 3 CAS #: 57-55-6 Year SWEG was Set/ Reviewed: 2008	25000 *Organ*: Blood; *Effect*: Metabolic effects	8000 *Organ*: Blood; *Effect*: Metabolic effects	8000 *Organ*: Blood; *Effect*: Metabolic effects	1700 *Organ*: Blood; *Effect*: Hematotoxicity	1-, 10-, and 100-d metabolic effects: increased lactic acid, pH and osmolality
Silver Synonyms: Argentum NRC Vol. #: 1 CAS #: 7440-22-4 Year SWEG was Set/ Reviewed: 2004	5 *Organ*: ; *Effect*: RWC	5 *Organ*: ; *Effect*: RWC	0.6 *Organ*: CNS; *Effect*: Hypoactivity	0.4 *Organ*: Skin; *Effect*: Argyria	Argyria is not considered an adverse toxic effect. The 1000-d value is similar to levels suggested by WHO (1984) for lifetime exposure.
Total Organic Carbon Synonyms: NRC Vol. #: 2 CAS #: NA Year SWEG was Set/ Reviewed: 2004	Not Set	Not Set	3	Not Set	
Zinc, soluble compounds Synonyms: NRC Vol. #: 2 CAS #: variable Year SWEG was Set/ Reviewed: 2005	11 *Organ*: ; *Effect*: Immunotoxicity	11 *Organ*: ; *Effect*: Immunotoxicity	2.0 *Organ*: Blood; *Effect*: Hematotoxicity, Immunotoxicity	2.0 *Organ*: Blood; *Effect*: Hematotoxicity	

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Chemical	Potential Exposure Duration				Remarks
	1 day	10 days	100 days	1000 days	
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	

Abbreviations

CNS - Central Nervous System
DCFF - Decreased Critical Flicker Frequency
GI - Gastrointestinal System
NRC - National Research Council
N.S. - Not Set
PNS - Peripheral Nervous System
RBC - Red Blood Cells
RspSys - Respiratory System
RWC - Reduced Water Consumption

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***** *See end of table for explanation of acronyms*