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Space systems — Safety and compatibility of materials —

Part 3: Determination of off-gassed compounds from materials and assembled articles

Systèmes spatiaux — Sécurité et compatibilité des matériaux —

Partie 3: Détermination des composés issus du dégazage sous atmosphère des matériaux et des articles assemblés

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 14624-3:2005), which has been technically revised.

The main changes are as follows:

— updated the definitions;

— updated Clauses 10 and 12 as well as Table 2.

A list of all parts in the ISO 14624 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capability.

Recommended criteria are, while not mandatory, considered to be of primary importance in providing serviceable economical and practical designs. Deviations from the recommended criteria may be made only after careful consideration, extensive testing and thorough service evaluation have shown an alternative method to be satisfactory.

Space systems — Safety and compatibility of materials —

Part 3: Determination of off-gassed compounds from materials and assembled articles

1 Scope

This document specifies a method for determining the identity and quantity of volatile off-gassed compounds from materials and assembled articles utilized in manned, pressurized spacecraft.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
assembled article
combination of materials and/or subcomponents resulting in a complete assembly

3.2
average percent relative standard deviation
quotient of the standard deviations for each off-gassed constituent of *y* replicate samples of a standard material and the total number of off-gassed constituents

Note 1 to entry: For actual samples, the expected test results and average relative standard deviations for the quantities of *off-gassed compounds* (3.6) can be near 50 %. The calculations for standard deviation and average percent relative standard deviation are as follows:

The standard deviation, *s*, is given by:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where $\bar{x}$ is the mean for an individual off-gassed constituent.

Therefore, the calculation for the average percent relative standard deviation A_s, is given by:

$$A_s = \frac{\sum s}{y} \times 100\ \%$$

where

$\sum s$ is the summation of the standard deviations for each off-gassed constituent;

y is the total number of off-gassed constituents, for a standard material.

3.3
equilibrium plateau
point at which the quantified total hydrocarbon content (normalized to a certified laboratory gas standard such as propane or methane) shows <10 % change

3.4
good laboratory practice
GLP
practice which involves the testing of standard reference materials to verify data accuracy and repeatability

[SOURCE: ISO 14624-1:2023, 3.5, modified — Note 1 to entry has been removed.]

3.5
maximum limit
value indicative of the maximum mass of material or the maximum number of *assembled articles* (3.1) that can be safely utilized inside the habitable volume of the spacecraft without exceeding a total *toxic hazard index (T)* (3.14) of 0,5

Note 1 to entry: Maximum limit can be maximum limit mass (MLM) or maximum limit article (MLA).

Note 2 to entry: See Annex A for detailed calculations.

3.6
off-gassed compound
organic or inorganic compound evolved as a gas from a material or *assembled article* (3.1)

3.7
off-gassing
evolution of gaseous products from a liquid or solid material into an atmosphere

3.8
primary gas standard
gas mixtures that have gravimetric or analytical traceability and to which all measurements are ultimately compared

3.9
reportable quantities
quantities determined by each analytical laboratory and based on analysed concentrations of the specific compound

Note 1 to entry: Compounds that have been identified, but for which the specific compound is unavailable as a standard, may have reportable quantities based on analysed concentrations of a representative compound.

3.10
ambient temperature
temperature equal to (23 ± 5) °C

3.11
sample container
vessel which contains the test sample

3.12
spacecraft maximum allowable concentration
SMAC
maximum concentration of an *off-gassed compound* (3.6) allowed in the habitable area of the spacecraft for a specified flight duration

Note 1 to entry: SMAC values for manned spacecraft are determined by the cognizant procuring authority/user toxicologist. SMAC values vary with exposure duration; SMAC values for a seven-day flight duration are normally used to evaluate toxicity of off-gassed compounds. A current listing of NASA SMAC values is maintained on the Internet at https://maptis.ndc.nasa.gov/matsel/GasPage.aspx with registration via https://maptis.nasa.gov/.

3.13
thermal chamber
apparatus into which the *sample container* (3.11) is placed during thermal conditioning

3.14
toxic hazard index
T
dimensionless ratio of the projected concentration of each *off-gassed compound* (3.6) in the habitable volume of the spacecraft under consideration to its *spacecraft maximum allowable concentration (SMAC)* (3.12) value and summing the ratios for all off-gassed compounds without separation into toxicological categories

Note 1 to entry: See Annex A for detailed calculations of the *T* value for materials or *assembled articles* (3.1).

Note 2 to entry: *T* value calculations for materials assume the use of 45 kg of material in habitable volume of the spacecraft for concentration calculations. *T* value calculations for assembled articles assumes a single assembled article used in the in habitable volume of the spacecraft for concentration calculations.

3.15
trace
off-gassed compound (3.6) present in less than the threshold limit defined by an individual laboratory

Note 1 to entry: This category includes compounds that are labelled as unidentified components, because the concentration is too low for the spectral information to allow for identification. It does not include compounds that have adequate spectral information but are labelled as unidentified components because suitable standard spectra for identification are not available.

4 Principle

When this method is utilized for a toxicological assessment for a component or a material (assuming 45 kg of material use) and/or assembled article, the total toxic hazard index (*T*) values for all volatile off-gassed compounds shall be less than 0,5 (see Annex B). In addition, the toxic hazard index can be used to calculate the maximum limit mass (MLM) for use in the habitable volume of the spacecraft. See Annex B.

5 Health and safety of test operators

Testing outlined in this document may generate toxic substances in either the gas or condensed phase. Care shall be taken to protect test operators, other personnel and, if necessary, the environment from such substances.

6 Test conditions

6.1 The test atmosphere should be at least a volume fraction of (20,9 ± 2) % for oxygen with the balance nitrogen or argon, and the test pressure should be ±15 kPa of the ambient pressure of the test

facility. The maximum volume fraction limits (expressed as a volume fraction in µl/l[1)]) for impurities in the compressed gases are:

a) carbon monoxide 1;

b) carbon dioxide 3,0;

c) total hydrocarbons, as methane 0,1;

d) halogenated compounds 0,5;

e) water 7,0.

6.2 Batteries or assembled articles containing batteries should be tested in an inert atmosphere to reduce the risk of generating an explosive gas mixture. Batteries or assembled articles containing batteries tested in an inert atmosphere do not need to be tested again in an oxygen atmosphere.

6.3 The sample shall be subject to a thermal exposure for (72 ± 1) h at (50 ± 3) °C. Samples do not have to be tested in spacecraft anticipated oxygen concentration. Off-gassed compounds from materials and assembled articles which are sensitive to high temperatures shall be determined in accordance with Annex B.

7 Apparatus and materials

The test system shall comprise the following major components: sample container, thermal chamber with controlled temperature, and analytical instrumentation.

7.1 Sample container, being easy to clean and construct so that gas samples can be collected easily. The sample container, including any soft goods, shall not affect the concentration of products off-gassed from the samples.

7.2 Thermal chamber, having the capability to maintain the test temperature to within ±3 °C for the duration of the test. The thermal chamber instrumentation shall have the capability to continuously record the temperature.

7.3 Analytical instrumentation, capable of the separation, identification, and quantification of selected off-gassed compounds (indicated in Table 1 and Table 2), with reportable quantities at, or below, their SMAC concentrations.

If the instrumentation cannot achieve this sensitivity, the minimum reportable concentration for those off-gassed compounds (except formaldehyde) should be reported.

For formaldehyde, the analytical technique shall be capable of detecting a concentration of 0,1 µl/l or current SMAC.

The recommended analytical instruments include a gas chromatograph using primarily a flame ionization detector, gas chromatograph/mass spectrometer, and infrared spectrophotometer. Some analytical compounds can be more difficult to determine, therefore, special methods may be required to identify and quantify these compounds.

In some cases, where there is a specific target compound of concern that has a reporting limit greater than the SMAC, it is necessary to test more than the standard test material. The quantity of test material should be increased proportionally from the standard sample-mass-to-container-volume ratio (5,0 ± 0,25) g/l to a quantity that allows the analysis to meet the SMAC requirement.

EXAMPLE

1) 1 µl/l = 1 part per million (ppm). The use of "ppm" is deprecated.

Benzene SMAC = 100 parts per billion

Reporting limit = 500 parts per billion

Standard material mass per chamber volume = 5 g/l

Necessary material mass per chamber volume = 25 g/l

8 Test samples

8.1 Handling/receipt

Handling of test articles shall be in a manner that preserves the integrity of the sample surface without adding contaminants. Materials and assembled articles can be significantly compromised by sources of contamination, such as exposure to solvents, cleaning agents, abnormal temperatures, variations in humidity, environmental pollutants, particulate, and handling. It is important that exposure of the material(s) and assembled articles to these and other contamination sources be sufficiently controlled to minimize variation in test results.

Test samples shall be prepared from either materials or assembled articles. Preparation of samples for testing involves the following tasks:

a) receiving and inspecting the material or assembled article;

b) preparing samples to the proper dimensions, if required;

c) cleaning the samples, if specified by the requester;

d) inspecting the samples.

8.2 Preparation

8.2.1 When received, the test material shall be accompanied by proper identification. Appropriate safety data sheets should also be provided. Note flaws and any residual contamination. All materials shall meet the requirement of sample-mass-to-container-volume ratio of (5,0 ± 0,25) g/l, and record the approximate total sample geometric surface area (see 7.3 for special target compounds of concern). If the specimen mass cannot be met, the maximum practical quantity of specimen, (750 ± 50) cm^2/l of thermal chamber volume shall be tested, with the actual specimen mass and geometric surface area reported. Sample preparation for test materials based on mass shall be as specified in 8.2.2 to 8.2.4.

NOTE 1 Increased surface area of a sample (made of several smaller pieces vs. a single large piece) typically allow for increased off-gassing. Approximation of end use configuration (thickness, size of pieces, etc.) can help to minimize configurational variable impact.

NOTE 2 Examples of materials that often cannot meet the standard sample-mass-to-container-volume ratio are foams, coatings, paints, and other materials applied to substrates. Approximation of end use configuration (thickness, size of pieces, etc.) can help to minimize configurational variable impact. .

8.2.2 Materials that are essentially two-dimensional and require application to a substrate (e.g. coatings, primers, inks, paints, adhesives, tapes, thin film lubricants) shall be applied at their thickness of use to clean aluminium substrates. Samples may be applied to both sides of the substrate.

8.2.3 Materials that are essentially two-dimensional and are not applied to a substrate (e.g. fabrics, photographic film plastic, plastic film, elastometrics, non-adhesive tape) should be cut to approximate end use configuration as closely as the sample container allows. Shrink heat-shrinkable tubing so as to simulate actual use configuration. Place liquids and semi-solids in certified clean nonreactive vessels (e.g. glass) approximately 5 cm in diameter.

8.2.4 It shall be recognized that some specialized items and materials may not meet the above requirements and shall require special handling, most often with non-homogeneous materials. Test these materials in the manner designated by the responsible procuring activity or authority having jurisdiction. Report the manner of testing and sample preparation.

8.2.5 If a sample is an assembled article, configure the assembled article in intended use configuration per the direction of the test requester or authority having jurisdiction. Inspect it for parts that are not designated for flight, such as dust covers, tape, or test leads. Remove these items before testing. Record the absence of such items as batteries or photographic film included during flight but not included with the sample. The ratio of sample volume to sample container volume should be approximately 1:3. Pre-test and post-test photos may be taken when needed or requested.

8.3 Cleaning

Samples should be cleaned and dried to the end-use specifications by the requester prior to receipt at the test facility. The cleaning of assembled articles shall be the responsibility of the requester. If a sample received by the test facility is visibly contaminated, clear instructions shall be received from the requester as to proper procedures for continuing testing. For samples prepared by the test facility, all preparation and cleaning shall be in accordance with user or requester specifications. All cleaning procedures shall be first approved by the requester, and verified to have no influence on analytical results. As a minimum, particulate on sample surfaces should be removed with filtered, gaseous nitrogen.

8.4 Inspection

Inspect the sample and note any flaws. If the flaws result from sample preparation at the test facility, new samples should be prepared.

9 Pretest procedure

9.1 The pretest procedure includes cleaning of sample containers, certification of container cleanliness, and calibration of the quantitative analytical instruments.

9.2 Clean the sample containers by heating to drive off residual container contamination then purge them with clean air or nitrogen before each use. Solvent cleaning should be avoided.

9.3 Before loading the sample into the container, fill the container with the test atmosphere or nitrogen then condition it for at least (72 ± 1) h at (50 ± 3) °C. Alternatively, the sample container can be conditioned for at least 24 h at (70 ± 3) °C. Analyse the sample container atmosphere for residual contamination. Certify the sample container as clean for use if the concentrations of residual gases are sufficiently low that they do not interfere with interpretation of results of the off-gas analysis.

9.4 Ensure methods of quantitative analysis (7.3) are traceable to primary gas standards. When available, ensure standards used to quantify specific compounds are traceable to the national, international or intrinsic standard.

10 Test procedure

10.1 Weigh the sample and place it in the sample container. Replace the room atmosphere in the sample container with the test atmosphere, either by purging or by evacuation. Ensure the requesting organization indicates if the sample can or cannot withstand a vacuum. Expose samples to vacuum less than 3 min. Ensure the sample container, with the test atmosphere, is at the requested test pressure when the test temperature is achieved.

NOTE 1 Purging can be used for samples that can be damaged under vacuum, such as closed cell foams, and assembled articles having sealed volumes.

NOTE 2 In some cases any losses of off-gassed compounds are strictly minimized by enclosing and analysing the sample in room air without purging with test atmosphere. A separate room air analysis can be performed for background subtraction.

10.2 Place the sample container in a test thermal chamber and heat to the test temperature of (50 ± 4) °C, unless otherwise specified and maintain this temperature for (72 ± 1) h. Then cool the sample container to (23 ± 3) °C, record the pressure, and sample and analyse the off-gassed compounds. Perform the sampling and analysis of off-gassed compounds as soon as ambient temperature is achieved and no later than 24 h subsequent to reaching ambient) temperature. In cases where ambient temperature is not within the specified range, perform the sampling and analysis within 24 h of the test facility's laboratory reaching its own ambient temperature. Determine and record the identity and quantity of each analysable off-gassed compound (7.3).

NOTE 1 In some cases where a material or assembled article possesses adsorbent properties, testing immediately after removal from thermal chamber to minimize cooling (as approved by the authority having jurisdiction) provides conservative data.

NOTE 2 Under rare conditions where operational temperatures higher than 50 °C are anticipated and with the approval of the cognizant toxicologist and approval of the authority having jurisdiction, the article can be tested at temperatures above or below 50 °C. These tests would be considered and reported as non-standard.

10.3 An abbreviated screening test for total organics may be used to determine if a full analysis is to be performed. However, it is necessary to evaluate all organics quantitated but not identified using a worst-case scenario of SMAC value equal to 0,1 mg/m^3. The abbreviated screening test procedure may include specific methods to detect critical components of the target list, i.e. formaldehyde, carbon monoxide and ammonia. This abbreviated screening shall be reported as non-standard.

11 Precision

Measurements shall be made to the following precision:

a) absolute pressure ±1 % of reading;

b) temperature ±3 °C;

c) oxygen concentration ±0,5 % of reading;

d) mass ±0,01 g. for standard materials, greater allowed for assembled articles.

12 Test report

The test report shall:

a) reference this document;

b) include a unique report number;

c) include the sample identification, test container free volume (l), sample mass (g), specialized preparation, specialized method, test conditions and observations from the test; for materials also report geometric surface area (cm^2); clearly identify any preconditioning of the article or materials that was conducted prior to the current test;

NOTE Final use articles or materials require replicate preconditioning before they are flown.

d) include the quantity as µg/g of material or µg/assembled article for each off-gassed compound;

e) include the toxic hazard index (T);

f) be submitted to the authority having jurisdiction and/or test requester;

g) be identified as non-standard when there is a deviation from standard test parameters, such as non-standard sample preparation or test conditions;

Additionally, the test report should include trace constituents [although they are not used in the calculation of the toxic hazard index (T)].

13 Good laboratory practices (GLP)

13.1 Calibrate the quantitative analytical instrumentation before use. Evaluate accuracy by analysing the standard gas mixtures given in Table 1 at least every three months, and measure the concentrations to within 25 % of the specified concentrations. Ethyl alcohol, methyl alcohol, tetrachloroethylene, tetrachloromethane, and acrylonitrile shall be measured to within 30 % of the gas standard specified concentrations. The accuracy analysis of furfural in Table 1 for mixture B is not required; however, this compound is useful as a diagnostic tool because it presents a meaningful challenge to the analytical system.

As a good practice to further assess performance, it is recommended that the linear correlation coefficient (R^2) be evaluated for Table 1 compounds via regression analysis to >0,95 R^2.

Evaluate precision every three months using average percent relative standard deviation of gas standard (Table 1) triplicates. Precision within 10 % is preferred. Excluded compounds (ethyl alcohol, methyl alcohol, tetrachloroethylene, tetrachloromethane, and acrylonitrile) may demonstrate increased variability. Furfural in Table 1 for mixture B is not required.

13.2 In addition, the test facility shall successfully demonstrate the ability to obtain repeatable data when testing a selected material. The authority having jurisdiction shall choose appropriate GLP materials and shall determine the frequency of testing these materials for its test facilities. Handle GLP materials in a manner that preserves the integrity of the sample surface without adding contaminants. Inspect all GLP materials prior to preparation. Prepare all GLP material to the proper dimensions and mass as determined by the authority having jurisdiction. Inspect all GLP material prior to loading into the sample container. Sample, store and transport all GLP materials in a manner that preserves the integrity of the material.

Table 1 — Standard gas mixtures and recommended concentrations (as gravimetric standards)

Mixture	Suggested volume fraction (µL/L)	Component	CAS No.	Formula	Molecular mass	7-day ppm SMAC (µl/l)	7-day SMAC (mg/m^3)
A	5,0	Tetrachloromethane	56-23-5	CCl_4	153,82	2	13
	10,0	Ethyl alcohol	64-17-5	C_2H_6O	46,07	1 000	2 000
	10,0	Methyl alcohol	67-56-1	CH_4O	32,04	20	26
	10,0	Isopropyl alcohol	67-63-0	C_3H_8O	60,10	60	150
	1,0	Benzene	71-43-2	C_6H_6	78,11	0,5	1,5
	1,0	Vinyl chloride	75-01-4	C_2H_3Cl	62,50	1	2,6
	5,0	Acetonitrile	75-05-8	C_2H_3N	41,05	20	34
	1,0	Trichloroethylene	79-01-6	C_2HCl_3	131,39	9	50
	10,0	1-Butene	106-98-9	C_4H_8	56,11	50	115
	10,0	Toluene	108-88-3	C_7H_8	92,14	4	15
	10,0	Tetrachloroethylene	127-18-4	C_2Cl_4	165,83	5	34
	1,0	Dichloroethylene	540-59-0	$C_2H_2Cl_2$	96,94	50	198

Table 1 *(continued)*

Mixture	Suggested volume fraction (µL/L)	Component	CAS No.	Formula	Molecular mass	7-day ppm SMAC (µl/l)	7-day SMAC (mg/m³)
B	5,0	Acetone	67-64-1	C_3H_6O	58,08	22	52
	5,0	Acetaldehyde	75-07-0	C_2H_4O	44,05	2	4
	10,0	Methyl ethyl ketone	78-93-3	C_4H_8O	72,11	10	30
	5,0	Furfural	98-01-1	$C_5H_4O_2$	96,08	2	7,89
	1,0	Acrolein	107-02-8	C_3H_4O	56,06	0,015	0,03
	5,0	Acrylonitrile	107-13-1	C_3H_3N	53,06	0,2	0,4
	10,0	Methyl isobutyl ketone	108-10-1	$C_6H_{12}O$	100,16	35	140
	1,0	Furan	110-00-9	C_4H_4O	68,07	0,025	0,07
	5,0	Propionaldehyde	123-38-6	C_3H_6O	58,08	5	12
	5,0	1,4-Dioxane	123-91-1	$C_4H_8O_2$	88,11	20	72

Table 2 — Additional target compounds for method performance evaluation

Component	CAS No.	Formula	Molecular mass	7-day ppm SMAC (µl/l)	7-day SMAC (mg/m³)
Formaldehyde	50-00-0	CH_2O	30,03	0,1	0,12
Carbon disulfide	75-15-0	CS_2	76,14	0,3	1,1
Carbonyl sulfide	463-58-1	COS	60,08	36	88
Carbon monoxide	630-08-0	CO	28,01	55	63
Norflurane	811-97-2	$C_2H_2F_4$	102,03	2 263	9 441
Trimethyl silanol	1066-40-6	$C_3H_{10}OSi$	90,20	1	4
Sulfur dioxide	7446-09-5	SO_2	64,06	0,5	1,31
Ammonia	7664-41-7	NH_3	17,03	3	2

Annex A
(informative)

Materials and assembled articles toxic hazard index and maximum limit mass/article example calculations

A.1 Material toxic hazard index (*T*) calculation and maximum limit mass application

The calculation for the concentration of compound detected per material tested is given by:

$$C_{pm_i} = \frac{Q_i}{M}$$

where

C_{pm_i} is the concentration of compound detected per material tested, expressed in micrograms per gram (µg/g);

Q_i is the quantity of each off-gassed compound detected, expressed in micrograms (µg);

M is the mass of material tested, expressed in grams (g).

The calculation for the concentration of compound detected, extrapolated to applicable spacecraft volume, normalized to 45 kilograms (kg) of material, is given by:

$$C_{svm_i} = C_{pm_i} \times \frac{45}{V}$$

where

C_{svm_i} is the concentration of compound detected, extrapolated to applicable spacecraft volume, normalized to 45 kilograms (kg) of material, as expressed in milligrams per cubic meter (mg/m^3);

C_{pm_i} is the concentration of compound detected per material tested, expressed in micrograms per gram (µg/g);

V is the habitable volume of the spacecraft under consideration, as expressed in cubic meters (m^3).

The calculation for the individually detected compound toxic hazard contribution (dimensionless) normalized to 45 grams (g) of material is given by:

$$T_{material\,i} = \frac{C_{svm_i}}{S}$$

where

T_{material_i} is the individually detected compound toxic hazard contribution (dimensionless), normalized to 45 kilograms (kg) of material;

C_{svm_i} is the concentration of compound detected, extrapolated to applicable spacecraft volume, normalized to 45 kilograms (kg) of material, as expressed in milligrams per cubic meter (mg/m^3);

S is the spacecraft maximum allowable concentration or maximum concentration of an off-gassed compound allowed in the habitable area of the spacecraft for a specified flight duration, as expressed in milligrams per cubic meter (mg/m^3).

The summation for a total toxic hazard index for n T_{material_i} values is calculated as:

$$T_{\text{material}} = \sum_{i=1}^{n} T_{\text{material}_i}$$

where

T_{material} is the toxic hazard index or summation of all individually detected compound toxic hazard contributions for a total toxic hazard index for the entire material (dimensionless), normalized to 45 kilograms (kg) of material;

T_{material_i} is the individually detected compound toxic hazard contribution (dimensionless), normalized to 45 kilograms (kg) of material.

Therefore, the maximum limit mass (MLM) in kilograms (kg) can be calculated as:

$$W = \frac{0{,}5}{T_{\text{material}}} \times 45$$

where

T_{material} is the toxic hazard index or summation of all individually detected compound toxic hazard contributions for a total toxic hazard index for the entire material (dimensionless), normalized to 45 kilograms (kg) of material;

W is the maximum limit mass (MLM) or the maximum mass of material, expressed in kilograms (kg), that can be safely utilized inside the habitable volume of the spacecraft without exceeding a total toxic hazard index (T) of 0,5.

A.2 Assembled article toxic hazard index calculation and maximum limit article application

The calculation of the individually detected compound toxic hazard contribution (limitless) is given by:

$$T_{\text{article}_i} = \frac{Q_i\left(\frac{1}{1\,000}\right)}{V} \times \frac{1}{S}$$