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Space systems — Safety and compatibility of materials —

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

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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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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:—, 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.

