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Space systems — Adhesives — General requirements

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Contents

Page

Foreword

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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*.

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

The organic adhesive materials have been widely applied in most components of space systems, not only for structural adhesion but also in embedding electronic units and fixing little devices. Hence, the reliability and performance of adhesive materials is essential to the space system performance and safety. Especially for space applications, the environmental adaptability and reliability of adhesive materials is the critical factor to mission schedule and success. This document establishes primary characteristics requirements, selection criterion and procedure for helping space system designer or manufacturer select the best-fit adhesive. Manufacturing process requirements and quality assurance for adhesive materials selection are provided to confirm their compliance with the requirements of space applications. Annex A provides references for general test methods for property characterization, additional surface preparation and cleaning requirements, and verification of the adhesive lifetime.

Space systems — Adhesives — General requirements

1 Scope

This document specifies general requirements for adhesive selection with the adhesive bonding process and quality assurance used in space systems.

This document can be applied to different types of adhesive materials in space systems, such as launch vehicles, satellites, spacecraft and space station for the following applications: bonding, components embedding (only for space application), sealing, fixing and repairing.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14624-3, *Space systems — Safety and compatibility of materials — Part 3: Determination of offgassed products from materials and assembled articles*

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
coefficient of linear thermal expansion
reversible increase of a material per unit length per degree change in temperature

3.2
coefficient of moisture expansion
α_{CME}

$$\alpha_{CME} = \frac{\Delta l / l}{m_{water} / m_{sample}}$$

where

$\Delta l/l$ is the relative length change referred to as strain;

m_{water} is the weight of the absorbed water;

m_{sample} is the dry weight of the sample

3.3
curing
process of converting a prepolymeric or polymeric composition into a more stable, usable condition by polymerization and/or crosslinking

Note 1 to entry: With adhesives, curing results in the development of the strength properties.

[SOURCE: ISO 472:2013, 2.243, modified — The alternative preferred term "cure, noun" has been removed; the original note 1 to entry has been removed; the original note 2 to entry has become note 1 to entry.]

3.4
glass transition temperature
T_g
approximate midpoint of the temperature range over which the glass transition takes place

Note 1 to entry: The glass transition temperature varies significantly, depending upon the specific property and the test method and conditions selected to measure it.

[SOURCE: ISO 472:2013, 2.441, modified — The symbol T_g has been added.]

3.5
liner
treated sheet to cover the adhesive temporarily to facilitate handling or unrolling

[SOURCE: ISO 29862:2018, 3.6]

3.6
pot life
maximum period of time during which a multi-part adhesive can be used after mixing the components

[SOURCE: ISO 10364:2015, 3.1, modified — The alternative preferred term "working life" has been removed.]

3.7
substrate
object or semi-manufactured product (e.g. wire, extruded metallic section or plastic profile, sheet, film, paper, textile product) on which a coating or layer of another material is applied from the gas, liquid or solid phase by coating, by laminating or generated by a chemical process

Note 1 to entry: In adhesion, the term “substrate” often is a synonym of adherend.

[SOURCE: ISO 472:2013, 2.1128, modified — Note 2 to entry has been removed.]

3.8
surface preparation
physical and/or chemical treatments applied to adherends to render them suitable (or more suitable) for bonding

[SOURCE: ISO 472:2013, 2.1613, modified — The alternative preferred term "surface pretreatment" has been removed.]

3.9
thermal conductivity
proportionality coefficient that represents the relationship of heat flux and temperature gradient, where heat flux on an isothermal surface is proportional to the temperature gradient in the normal direction on the isothermal surface

Note 1 to entry: It is expressed in watt per meter kelvin (W/m*k).

[SOURCE: ISO 16525-3:2014, 3.6, modified — The symbol *k* has been removed.]

3.10
thermal decomposition
process whereby the action of heat or elevated temperature on an item causes changes in the chemical composition

[SOURCE: ISO 472:2013, 2.1285, modified — Note 1 to entry has been removed.]

3.11
volume resistivity
electrical resistance of the isotropic electrically conductive adhesive for a given cross-sectional area or given length

Note 1 to entry: Electrical volume resistivity is converted to resistance per given cross-sectional area or given length of the isotropic electrically conductive adhesive. ISO 16525-2 specifies measurement methods for an isotropic electrically conductive adhesive, which is applied to a circuit board that is similar to the one used in practice.

Note 2 to entry: It is expressed as ohm metre (Ω·m).

[SOURCE: ISO 16525-2:2014, 3.2, modified — The symbol ρ has been removed.]

4 Selection requirements for adhesive materials

4.1 General requirements

4.1.1 Classification of adhesive application

The application of adhesives used in space systems includes fixing, bonding, sealing, embedding and repairing, as shown in Figure 1.

a) Fixing: using the adhesive to reinforce the joints of connected components.

b) Bonding: state in which two materials surfaces are held together by interfacial forces formed by the adhesive.

c) Sealing: application of the adhesive to the seam of two components, in order to keep the vacuum or decrease the inner gas releasing.

d) Embedding: process of encasing completely a component by pouring the adhesive over it and curing.

e) Repairing: the damage part is repaired by the adhesive.

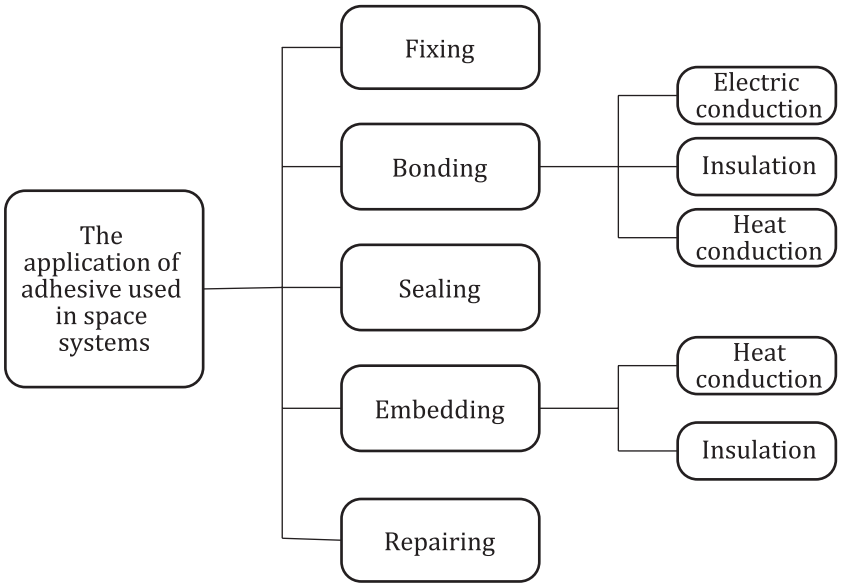

Figure 1 — Application of adhesive used in space systems

4.1.2 Selection criterion

a) The workability of adhesive materials is highly dependent on the environmental conditions under which the spacecraft is operated. The designer shall fully consider the application environment of the space mission. Adhesive materials shall cope with the performances required during the life on-ground and during its service life.

b) For a new mission or product, materials already qualified for other missions or products should be evaluated before the final selection. This evaluation should be based on the environmental conditions of the new mission and design requirements of the new product, the joint design, and performance requirements of the new product. If there is no available adhesive that can meet the mission requirement, the designer can start the selection of a new adhesive.

c) For a new adhesive and process, a series of experimental qualification shall be done according to the mission requirements.

d) Verification reports and procedures shall be approved by the designer, project manager and quality manager. When requested by the customer and agreed by contract, verification documents shall be also approved by the customer.

e) The designer shall choose an adhesive supplier that can provide the manufacturing process data for traceability.

4.2 Selection procedure

4.2.1 Primary characteristics before selection

The selection of the adhesive is based on the knowledge of key characteristics depending on the application as described in Figure 1. These characteristics are listed in Table 1.

Table 1 — Primary characteristics considered for adhesive selection

Properties	Application classification					Remarks on selection
	Bonding	Sealing	Embedding	Fixing	Repairing	
Shrinkage	+	+	+	+	+	The shrinkage determines the volume change in curing process; it also determines the internal stress and apparent planeness.
Adhesion	+	+	+	+	+	The adhesion requirement differs between structural bonding and sealing. The strength of structural bonding strongly depends on the type of the adhesive, the type of the substrate and the type of design of the joint; the test method should be chosen based on the system structure.
Glass transition temperature	+	+	-	-	+	For organic adhesives, the glass transition temperature should be outside of the operating temperature range for the adhesive to ensure the stability of the adhesive's properties. But with regard to cold-setting adhesives, the glass-melting temperature cannot be beyond operating temperature limits. For T_g characterization, the designer shall remove the moisture factor. T_g characterization shall be determined in wet condition for launchers.
Electrical volume resistivity	+	+	+	-	-	When the adhesive is used for electric conduction or electrically insulating adhesion (adhesives used in wiring, die attach of semiconductor, and surface assembly of printed circuit boards), electrical resistivity should have low sensitivity to temperature in the working temperature range.
Thermal conductivity	+	+	+	-	-	When a thermal conductive adhesive is used for embedding and bonding, thermal conductivity should meet the design requirement.
Thermal decomposition temperature	+	+	+	-	+	Thermal decomposition temperature limits the highest operating temperature of the adhesive; it also can be used to judge the change of the adhesive's molecule structure after the environment adaptability test.
Outgassing	+	+	+	+	+	Outgassing characters of the adhesive shall fulfil the contamination requirement of the space systems. The quantity of outgas is different depending on the adhesive molecule and the moisture structure.
Operating temperature	+	+	+	+	+	The minimum and maximum temperature values, at which properties of bonding, sealing embedding, fixing and repairing variate according to the designer requirement.