

**DIN EN 16602-70-16**

ICS 49.025.50; 49.140

Einsprüche bis 2019-04-08

**Entwurf****Raumfahrtproduktsicherung –  
Kleben für Raumfahrzeug- und Trägeranwendungen;  
Englische Fassung prEN 16602-70-16:2018**

Space product assurance –  
Adhesive bonding for spacecraft and launcher applications;  
English version prEN 16602-70-16:2018

**Anwendungswarnvermerk**

Dieser Norm-Entwurf mit Erscheinungsdatum 2019-02-08 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal von DIN unter [www.din.de/go/entwuerfe](http://www.din.de/go/entwuerfe) bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter [www.entwuerfe.normenbibliothek.de](http://www.entwuerfe.normenbibliothek.de), sofern dort wiedergegeben;
- oder als Datei per E-Mail an [nl@din.de](mailto:nl@din.de) möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter [www.din.de/go/stellungnahmen-norm-entwuerfe](http://www.din.de/go/stellungnahmen-norm-entwuerfe) oder für Stellungnahmen zu Norm-Entwürfen der DKE unter [www.dke.de/stellungnahme](http://www.dke.de/stellungnahme) abgerufen werden;
- oder in Papierform an den DIN-Normenausschuss Luft- und Raumfahrt (NL), 10772 Berlin, Saatwinkler Damm 42/43, 13627 Berlin.

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 91 Seiten

DIN-Normenausschuss Luft- und Raumfahrt (NL)

## Nationales Vorwort

Dieses Dokument (prEN 16602-70-16:2018) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-06-02 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument (prEN 16602-80-16:2018) basiert auf ECSS-Q-ST-70-16C DIR2.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung von prEN 16602-80-16:2018.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtssystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischer Norm, die denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Für die in diesem Dokument zitierten internationalen Dokumente wird im Folgenden auf die entsprechenden deutschen Dokumente hingewiesen:

|                  |       |                            |
|------------------|-------|----------------------------|
| ISO 291:2008     | siehe | DIN EN ISO 291:2008-08     |
| ISO 527-1:2012   | siehe | DIN EN ISO 527-1:2012-06   |
| ISO 527-2:2012   | siehe | DIN EN ISO 527-2:2012-06   |
| ISO 3219:1993    | siehe | DIN EN ISO 3219:1994-10    |
| ISO 4578:1997    | siehe | DIN EN 1464:2010-06        |
| ISO 6721-1:2011  | siehe | DIN EN ISO 6721-1:2011-08  |
| ISO 8510-2:2006  | siehe | DIN EN ISO 8510-2:2010-12  |
| ISO 9142:2003    | siehe | DIN EN ISO 9142:2004-05    |
| ISO 9653:1998    | siehe | DIN EN ISO 9653:2000-10    |
| ISO 9664:1993    | siehe | DIN EN ISO 9664:1995-08    |
| ISO 11357-1:2016 | siehe | DIN EN ISO 11357-1:2017-02 |
| ISO 11357-2:2013 | siehe | DIN EN ISO 11357-2:2014-07 |
| ISO 11357-3:2018 | siehe | DIN EN ISO 11357-3:2018-07 |
| ISO 11357-4:2014 | siehe | DIN EN ISO 11357-4:2014-10 |
| ISO 11357-5:2013 | siehe | DIN EN ISO 11357-5:2014-07 |
| ISO 11358-1:2014 | siehe | DIN EN ISO 11358-1:2014-10 |
| ISO 22007-4:2017 | siehe | DIN EN ISO 22007-4:2017-11 |

## Nationaler Anhang NA (informativ)

### Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

#### 3.1 Begriffe aus anderen Normen

- a) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-S-ST-00-01.
- b) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-Q-ST-70 und insbesondere die folgenden Begriffe:
  - 1) kritischer Prozess;
  - 2) kritisches Material;
  - 3) besonderer Prozess.

#### 3.2 Für diese Norm spezifische Begriffe

##### 3.2.1

##### **Adhäsion**

Zustand, in dem zwei Flächen durch Grenzflächenkräfte zusammen gehalten werden, welche chemische, mechanische oder physikalische Grenzflächenkräfte umfassen können

##### 3.2.2

##### **Klebeprozess**

Werkstoff-Fügeprozess, bei dem ein Klebstoff hinzugegeben wird, um chemische, mechanische oder physikalische Grenzflächenkräfte zwischen Fügeteilen aufrecht zu erhalten

ANMERKUNG Der Fügemechanismus zwischen Klebstoff und zusammengefügteten Teilen, die auch als „Fügeteile“ bezeichnet werden, beruht auf Adhäsion. Nach ECSS-Q-ST-70 gehört Kleben zur Kategorie „besondere Prozesse“.

##### 3.2.3

##### **Klebstoff**

Stoff mit der Fähigkeit, zwei Oberflächen durch entweder chemische, physikalische oder mechanische Grenzflächenkräfte oder durch eine Kombination aus diesen zusammen zu halten

ANMERKUNG Der Begriff der Klebstoffe wird in ECSS-E-HB-32-21 behandelt.

##### 3.2.4

##### **Klebeverfahren**

ausführliche Anweisungen, Ausrüstungen und Werkzeuge, die für die Durchführung des Klebens benötigt werden

ANMERKUNG Für den ausführlichen Inhalt wird auf Anhang A verwiesen.

### 3.2.5

#### **Beanspruchung mit Umgebungsluftfeuchte in kontrollierter Umgebung**

ein Gegenstand wird mit Umgebungsluft mit einer Temperatur im Bereich von  $(22 \pm 3)^\circ\text{C}$  und einer relativen Luftfeuchte von  $(55 \pm 10) \%$  beansprucht

ANMERKUNG 1 Eine langfristige Beanspruchung mit diesen Bedingungen kann zur Verschlechterung der Leistungsfähigkeit der Klebverbindung führen.

ANMERKUNG 2 Trägt zum „intrinsischen Altern“ der Verbindungen bei.

### 3.2.6

#### **Mithärtung**

früheste Phase im Herstellungsprozess, die zu einem vollständig integrierten Bauteil führt

ANMERKUNG 1 Der Fügemechanismus ist chemische Vernetzung. Beide Fügeteile durchlaufen eine chemische Reaktion.

ANMERKUNG 2 Diese Norm behandelt keine Anforderungen an die Verifizierung von Mithärtungs-Prozessen.

### 3.2.7

#### **Verbundhaftung**

Zwischenstufe im Herstellungsprozess, in der ein ungehärtetes Teil mit einem oder mehreren ausgehärteten Teil(en) verbunden wird, üblicherweise mit einer zusätzlichen Schicht eines ungehärteten Klebstoffes

ANMERKUNG 1 Der Fügemechanismus zwischen dem Klebstoff und dem ausgehärteten Teil ist Adhäsion. Zwischen dem ungehärteten Teil und der ungehärteten Klebstoffschicht findet chemische Vernetzung statt.

ANMERKUNG 2 Der weitere Text bezieht sich ausschließlich auf Kleben oder Verbundhaftung (ungehärteter Klebstoff, ausgehärtetes Substrat) oder auf Verklebung mit druckempfindlichen Klebebändern.

### 3.2.8

#### **Verschlechterung**

zwischen zwei Messstellen über einen Zeitraum festgestelltes Nachlassen einer interessierenden Eigenschaft

### 3.2.9

#### **Beanspruchung mit hohen Temperaturen und hoher Luftfeuchte**

Beanspruchung, bei der der Prüfgegenstand dem Synergieeffekt aus gasförmiger Wasserphase und Temperatur ausgesetzt wird

ANMERKUNG 1 Üblicherweise wird der Prüfgegenstand Bedingungen unterzogen, bei denen die Temperatur und der Wasserdampfdruck höher sind als bei der Feuchtebeanspruchung in kontrollierter Umgebung ( $> 25^\circ\text{C}$  und  $> 65 \%$  relative Luftfeuchte).

ANMERKUNG 2 Durchgeführt im Rahmen einer Simulation einer Umgebung am Boden innerhalb einer Prüffolge zur Verifizierung des Klebverhaltens oder als Teil einer unabhängigen Prüfung bei hohen Temperaturen und hoher Luftfeuchte.

ANMERKUNG 3 Die Prüfung und Verifizierung des Prüfgegenstandes vor und nach der Beanspruchung mit hohen Temperaturen und hoher Luftfeuchte ist zerstörungsfrei und verhindert nicht, dass der Prüfgegenstand weiteren Prüfungen im Rahmen einer Verifizierungsprüffolge unterzogen wird.

ANMERKUNG 3 Auch bekannt als „Feuchtebeanspruchung“.

### 3.2.10

#### **Prüfung bei hohen Temperaturen und hoher Luftfeuchte**

Prüfung, bei der der Prüfgegenstand einer Beanspruchung mit hohen Temperaturen und hoher Luftfeuchte unterzogen wird, nach deren Durchführung die Auswirkung der Beanspruchung mit hohen Temperaturen und hoher Luftfeuchte verifiziert wird

ANMERKUNG 1 Die Beanspruchung mit hohen Temperaturen und hoher Luftfeuchte kann kombiniert mit zusätzlichen Beanspruchungen, wie z. B. mechanischen, chemischen oder elektrischen Beanspruchungen, durchgeführt werden.

ANMERKUNG 2 Funktionseigenschaften eines Prüfgegenstandes können bei „in-situ“-Bedingungen einer Beanspruchung mit hohen Temperaturen und hoher Luftfeuchte verifiziert werden.

ANMERKUNG 3 Bei einer Prüfung der Klebeverbindungen bei hohen Temperaturen und hoher Luftfeuchte erfolgt nach der Heiß-Nass-Beanspruchung üblicherweise eine mechanische Prüfung, um die Verschlechterung des Zustands der Verbindung und den mit der Heiß-Nass-Beanspruchung zusammenhängenden Minderungsfaktor zu verifizieren.

ANMERKUNG 4 Die Reihe von Prüfgegenständen, bei der eine Prüfung bei hohen Temperaturen und hoher Luftfeuchte durchgeführt wird, wird der weiteren Verifizierungsprüffolge nicht mehr unterzogen.

ANMERKUNG 5 Auch bekannt als Prüfung bei „feuchter Wärme“ oder „Feuchteprüfung“.

### 3.2.11

#### **Knockdown-Faktor (KDF)**

allgemeiner Faktor, der auf die Werkstoffeigenschaft angewendet wird, um Schwankungen der Werkstoffzusammensetzung, der Einsatzumgebung und der Gefügegeometrie zu berücksichtigen

ANMERKUNG Er kann mehrere Minderungsfaktoren umfassen.

### 3.2.12

#### **Minderungsfaktor**

Verhältnis zwischen dem Mittelwert einer bestimmten Werkstoffeigenschaft eines Bezugs-Prüfgegenstands und von beanspruchten Sätzen von Prüfgegenständen

ANMERKUNG Kann als Bruch oder als prozentualer Anteil des anfänglichen Bezugswertes (verbleibender prozentualer Anteil der interessierenden Eigenschaft) angegeben werden.

### 3.2.13

#### **Repräsentativitätsniveau des Prüfgegenstands**

Festlegung, wie gut oder genau der Prüfgegenstand die Ähnlichkeit mit der Flugmodell-Konfiguration wiedergibt

### 3.2.14

#### **Prüfgegenstand**

hergestellte Baugruppe, die einer Verifizierungs-Prüffolge unterzogen wird

ANMERKUNG Der Prüfgegenstand kann eine Norm-Untersuchungsprobe, ein Bauteil oder ein Teil sein, das für die Flug-Hardware vollständig repräsentativ ist.

### 3.2.15

#### **Grundgesamtheit von Prüfgegenständen**

Gruppe von Sätzen von Prüfgegenständen, die hergestellt wurden, um eine bestimmte Prüffolge auszuführen, einschließlich aller Bezugs-Prüfgegenstände, Prüfgegenstände für die Simulation am Boden, Prüfgegenstände für die Simulation einer Mission und Prüfgegenstände für die Simulation des Starts sowie Ersatz-Prüfgegenstände

ANMERKUNG Gruppe von Gegenständen mit derselben Fertigungshistorie.

### **3.2.16**

#### **Satz von Prüfgegenständen**

Prüfgegenstände, die eine identische Prüffolge einhalten

### **3.3 Abkürzungen**

Für die Anwendung dieser Norm gelten die Abkürzungen und Symbole nach ECSS-S-ST-00-01 und die folgenden Abkürzungen:

| <b>Abkürzung</b> | <b>Bedeutung</b>                                                                           |
|------------------|--------------------------------------------------------------------------------------------|
| <b>CME</b>       | Feuchtedehnkoeffizient (en: coefficient of moisture expansion)                             |
| <b>CTE</b>       | Wärmedehnkoeffizient (en: coefficient of thermal expansion)                                |
| <b>DMA</b>       | dynamisch-mechanische Analyse (en: dynamic mechanical analysis)                            |
| <b>DRD</b>       | Festlegung der Dokumentanforderungen (en: document requirements definition)                |
| <b>DSC</b>       | Differentialrasterkalorimetrie (en: differential scanning calorimetry)                     |
| <b>MLI</b>       | mehrlagige Dämmung (en: multi-layer insulation)                                            |
| <b>MMPP</b>      | Werkstoffe, mechanische Teile und Prozesse (en: materials, mechanical parts and processes) |
| <b>PA</b>        | Produktsicherung (en: product assurance)                                                   |
| <b>PSA</b>       | druckempfindlicher Klebstoff (en: pressure sensitive adhesive)                             |
| <b>Tg</b>        | Glasübergangstemperatur (en: glass transition temperature)                                 |
| <b>TGA</b>       | thermogravimetrische Analyse (en: thermo-gravimetric analysis)                             |
| <b>TMA</b>       | thermomechanische Analyse (en: thermo-mechanical analysis)                                 |
| <b>TVC</b>       | Temperaturwechselbeanspruchung unter Vakuum (en: thermal vacuum cycling)                   |
| <b>UV</b>        | ultraviolett (en: ultraviolet)                                                             |

## Nationaler Anhang NB (informativ)

### Literaturhinweise

DIN EN 1464:2010-06, *Klebstoffe — Bestimmung des Schälwiderstandes von Klebungen — Rollenschälversuch; Deutsche Fassung EN 1464:2010*

DIN EN ISO 291:2008-08, *Kunststoffe — Normalklimate für Konditionierung und Prüfung (ISO 291:2008); Deutsche Fassung EN ISO 291:2008*

DIN EN ISO 527-1:2012-06, *Kunststoffe — Bestimmung der Zugeigenschaften — Teil 1: Allgemeine Grundsätze (ISO 527-1:2012); Deutsche Fassung EN ISO 527-1:2012*

DIN EN ISO 527-2:2012-06, *Kunststoffe — Bestimmung der Zugeigenschaften — Teil 2: Prüfbedingungen für Form- und Extrusionsmassen (ISO 527-2:2012); Deutsche Fassung EN ISO 527-2:2012*

DIN EN ISO 3219:1994-10, *Kunststoffe — Polymere/Harze in flüssigem, emulgiertem oder dispergiertem Zustand — Bestimmung der Viskosität mit einem Rotationsviskosimeter bei definiertem Geschwindigkeitsgefälle (ISO 3219:1993); Deutsche Fassung EN ISO 3219:1994*

DIN EN ISO 6721-1:2011-08, *Kunststoffe — Bestimmung dynamisch-mechanischer Eigenschaften — Teil 1: Allgemeine Grundlagen (ISO 6721-1:2011); Deutsche Fassung EN ISO 6721-1:2011*

DIN EN ISO 8510-2:2010-12, *Klebstoffe — Schälprüfung für flexibel/starr geklebte Proben — Teil 2: 180-Grad-Schälversuch (ISO 8510-2:2006); Deutsche Fassung EN ISO 8510-2:2010*

DIN EN ISO 9142:2004-05, *Klebstoffe — Auswahlrichtlinien für Labor-Alterungsbedingungen zur Prüfung von Klebverbindungen (ISO 9142:2003); Deutsche Fassung EN ISO 9142:2003*

DIN EN ISO 9653:2000-10, *Klebstoffe — Prüfverfahren für die Scherschlagfestigkeit von Klebungen (ISO 9653:1998); Deutsche Fassung EN ISO 9653:2000*

DIN EN ISO 9664:1995-08, *Klebstoffe — Verfahren zur Prüfung der Ermüdungseigenschaften von Strukturklebungen bei Zugscherbeanspruchung (ISO 9664:1993); Deutsche Fassung EN ISO 9664:1995*

DIN EN ISO 11357-1:2017-02, *Kunststoffe — Dynamische Differenz-Thermoanalyse (DSC) — Teil 1: Allgemeine Grundlagen (ISO 11357-1:2016); Deutsche Fassung EN ISO 11357-1:2016*

DIN EN ISO 11357-2:2014-07, *Kunststoffe — Dynamische Differenz-Thermoanalyse (DSC) — Teil 2: Bestimmung der Glasübergangstemperatur und der Glasübergangsstufenhöhe (ISO 11357-2:2013); Deutsche Fassung EN ISO 11357-2:2014*

DIN EN ISO 11357-3:2018-07, *Kunststoffe — Dynamische Differenz-Thermoanalyse (DSC) — Teil 3: Bestimmung der Schmelz- und Kristallisationstemperatur und der Schmelz- und Kristallisationsenthalpie (ISO 11357-3:2018); Deutsche Fassung EN ISO 11357-3:2018*

DIN EN ISO 11357-4:2014-10, *Kunststoffe — Dynamische Differenz-Thermoanalyse (DSC) — Teil 4: Bestimmung der spezifischen Wärmekapazität (ISO 11357-4:2014); Deutsche Fassung EN ISO 11357-4:2014*

DIN EN ISO 11357-5:2014-07, *Kunststoffe — Dynamische Differenz-Thermoanalyse (DSC) — Teil 5: Bestimmung von charakteristischen Reaktionstemperaturen und -zeiten, Reaktionsenthalpie und Umsatz (ISO 11357-5:2013); Deutsche Fassung EN ISO 11357-5:2014*

DIN EN ISO 11358-1:2014-10, *Kunststoffe — Thermogravimetrie (TG) von Polymeren — Teil 1: Allgemeine Grundsätze (ISO 11358-1:2014); Deutsche Fassung EN ISO 11358-1:2014*

DIN EN ISO 22007-4:2017-11, *Kunststoffe — Bestimmung der Wärmeleitfähigkeit und der Temperaturleitfähigkeit — Teil 4: Laserblitzverfahren (ISO 22007-4:2017); Deutsche Fassung EN ISO 22007-4:2017*

December 2018

ICS 49.025.50; 49.140

English version

## Space product assurance - Adhesive bonding for spacecraft and launcher applications

Raumfahrtproduktsicherung - Kleben für  
Raumfahrzeug- und Trägeranwendungen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/CLC/JTC 5.

If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN and CENELEC in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation. Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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## European foreword

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This document (prEN 16602-70-16:2018) has been prepared by Technical Committee CEN/CLC/JTC 5 “Space”, the secretariat of which is held by DIN (Germany).

This document (prEN 16602-70-16:2018) originates from ECSS-Q-ST-70-16C DIR2.

This document is currently submitted to the CEN ENQUIRY.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and will therefore have precedence over any EN covering the same scope but with a wider do-main of applicability (e.g. : aerospace).

## Introduction

---

Adhesive materials have a wide range of uses within the space domain however they are often qualified as a minor or negligible part of a large subsystem or system. This frequently results in unforeseen effects arising directly from the adhesive selection which impacts either the functionality, integrity or AIT activities. As a consequence whilst the adhesive is often the lowest cost element of the system it frequently has a high cost associated with the necessary recovery and delta qualification activities need to ensure the system level functionality. Both the system level qualification and any recovery actions are further complicated by the intrinsic relationship between the adhesive performance, the substrate and all the processes associated with the manufacture of the adhesive bond.

European space agencies and the space industry at present have a general handbook available for adhesive bonding (ECSS-E-HB-32-21) however there is no fixed scheme detailing the minimum requirements for verification of adhesive bonding process nor validation of an adhesive material.

Standardisation of the verification processes for adhesives and adhesive bonding across the European space industry is allowing a harmonised and consistent approach.

The generic approach facilitates the correct selection of data thus allowing streamlining of the industrial development activities and enabling the validation of adhesives and verification of adhesive bonding process at an early stage of a programmes lifetime.

The use of this standard allows a given programme technical focus to be emphasised onto specific functional requirements since generic testing is already defined.

The document is further justified because of the high level of non-conformances (NCR) identified across industry due to limited early programmatic qualification programmes related to adhesive bonding.

# 1

## Scope

---

The scope of the document addresses the generic verification for all types of adhesive bonding for space applications including evaluation phases. It specifies all aspects of the adhesive bonding lifetime such as assembly, integration and testing, on-ground acceptance testing, storage, transport, pre-launch, launch and in-flight environments.

This standard does not cover requirements for:

- adhesive bonding used in EEE mounting on printed circuit boards (ECSS-Q-ST-70-61)
- adhesive bonding used in hybrid manufacturing (ESCC 2566000)
- adhesive bonding for cover-glass on solar cell assemblies (ECSS-E-ST-20-08)
- design of adhesive joint
- long term storage and long term storage sample testing
- performance of adhesive bond
- functional properties of adhesive joint
- co-curing processes

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

## Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

| EN reference   | Reference in text | Title                                                                                            |
|----------------|-------------------|--------------------------------------------------------------------------------------------------|
| EN 16601-00-01 | ECSS-S-ST-00-01   | ECSS system – Glossary of terms                                                                  |
| EN 16602-10    | ECSS-Q-ST-10      | Space product assurance -Product assurance management                                            |
| EN 16602-10-09 | ECSS-Q-ST-10-09   | Space product assurance -Nonconformance control system                                           |
| EN 16602-20    | ECSS-Q-ST-20      | Space product assurance -Quality assurance                                                       |
| EN 16602-40    | ECSS-Q-ST-40      | Space product assurance - Safety                                                                 |
| EN 16602-70    | ECSS-Q-ST-70      | Space product assurance – Materials, mechanical parts and processes                              |
| EN 16602-70-02 | ECSS-Q-ST-70-02   | Space product assurance - Thermal vacuum outgassing test for the screening of space materials    |
| EN 16602-70-09 | ECSS-Q-ST-70-09   | Space product assurance - Measurements of thermo-optical properties of thermal control materials |
| EN 16602-70-15 | ECSS-Q-ST-70-15   | Space product assurance - Non-destructive inspection                                             |
| EN 16602-70-22 | ECSS-Q-ST-70-22   | Space product assurance - Control of limited shelf-life materials                                |
| EN 16602-70-71 | ECSS-Q-ST-70-71   | Space product assurance - Materials, processes and their data selection                          |
|                | ISO 3696:1987     | Water for analytical laboratory use - Specification and test methods                             |

## Terms, definitions and abbreviated terms

---

### 3.1 Terms from other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-ST-00-01 apply.
- b. For the purpose of this Standard, the terms and definitions from ECSS-Q-ST-70 apply, in particular for the following terms:
  - 1. critical process
  - 2. critical material
  - 3. special process

### 3.2 Terms specific to the present standard

#### 3.2.1 adhesion

state in which two surfaces are held together by interfacial forces which can consist of chemical or mechanical or physical interfacial forces

#### 3.2.2 adhesive bonding process

material joining process where an adhesive material is added in order to maintain chemical, mechanical or physical interfacial forces between bonded parts

NOTE The joining mechanism between adhesive and bonded parts, also called "adherend", is adhesion-based. According to ECSS-Q-ST-70, adhesive bonding belongs to category of "special processes".

#### 3.2.3 adhesive material

substance with the capability of holding two surfaces together by either chemical, physical or mechanical interfacial forces or a combination of them

NOTE The concept of adhesive materials is addressed in ECSS-E-HB-32-21.

### 3.2.4 adhesive bonding procedure

detailed instructions, equipment and tools needed to perform the adhesive bonding

NOTE Refer to Annex A for the detailed content.

### 3.2.5 ambient humidity exposure in controlled environment

item is exposed to ambient air with temperature in the range of  $(22 \pm 3) ^\circ\text{C}$ , and relative humidity  $(55 \pm 10) \%$

NOTE 1 Long term exposure to this conditions can cause degradation of the adhesive joint's performance.

NOTE 2 Contributes to "intrinsic ageing" of the joints.

### 3.2.6 co-curing

earliest stage of manufacturing process, resulting in a fully integrated component

NOTE 1 The joining mechanism is chemical cross-linking. Both adherends are undergoing chemical reaction.

NOTE 2 This standard does not cover requirements for verification of co-curing processes.

### 3.2.7 co-bonding

intermediate stage of manufacturing process when uncured part is joined with one or more cured parts, typically with an additional layer of uncured adhesive

NOTE 1 The joining mechanism between the adhesive and the cured part is adhesion. Between the uncured part and uncured adhesive layer chemical cross-linking is taking place.

NOTE 2 Further text refers only to adhesive bonding or co-bonding (uncured adhesive, cured substrate) or to bonding with pressure sensitive tapes (PSAs).

### 3.2.8 degradation

reduction of property of interest detected between two measurement points over period of time

### 3.2.9 hot-wet exposure

exposure where the test item is subjected to synergistic effect of gaseous water phase and temperature

NOTE 1 Typically the test item is exposed to conditions, where temperature and water vapour pressure are higher than humidity exposure in controlled environment ( $>25 ^\circ\text{C}$  and  $>65 \% \text{ RH}$ )

NOTE 2 Performed in frame of simulation of on-ground environment within adhesive bonding

verification test sequence or as part of independent hot-wet testing

NOTE 3 Inspection and verification of the test item before and after hot-wet exposure is non-destructive and does not prevent test item to be submitted for further testing in frame of verification test sequence

NOTE 3 Also known as “humidity exposure”

### 3.2.10 hot-wet testing

test where the test item is subjected to hot-wet exposure and the effect of hot-wet exposure is verified after hot-wet exposure is performed

NOTE 1 Hot-wet exposure can be performed in combination with other additional stresses, e.g. mechanical, chemical or electrical

NOTE 2 Functional properties of test item can be verified during hot-wet exposure “in-situ” conditions

NOTE 3 In hot-wet testing of the adhesively bonded joints, hot-wet exposure is typically followed by mechanical test to verify degradation of the joint and reduction factor associated with hot-wet exposure

NOTE 4 Series of test item undergoing hot-wet testing are not following further the verification test sequence

NOTE 5 Also known as “damp-heat” testing or “humidity testing”

### 3.2.11 knock-down factor (KDF)

overall factor that is applied to the material property to account for variations in material composition, service environment and structural geometry

NOTE It can consist of several reduction factors.

### 3.2.12 reduction factor

ratio between mean value of given material property of reference test item and exposed test item sets

NOTE Can be expressed as fraction or as percentage of initial reference value (remaining percentage of the property of interest).

### 3.2.13 representativeness level of test item

definition of how well or accurately the test item reproduces the similarity to flight model configuration

### 3.2.14 test item

manufactured assembly undergoing verification test sequence

NOTE The test item can be standard test sample, component or part fully representative to the flight hardware.

### 3.2.15 test item population

group of test items sets manufactured to complete specific test sequence, including all reference test items, on-ground simulation test items, mission simulation test items and launch simulation test items and spare test items

NOTE Group of items with same manufacturing history.

### 3.2.16 test item set

test items that follow an identical test sequence

## 3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms and symbols from ECSS-S-ST-00-01 and the following apply:

| Abbreviation | Meaning                                   |
|--------------|-------------------------------------------|
| CME          | coefficient of moisture expansion         |
| CTE          | coefficient of thermal expansion          |
| DMA          | dynamic mechanical analysis               |
| DRD          | document requirements definition          |
| DSC          | differential scanning calorimetry         |
| MLI          | multi-layer insulation                    |
| MMPP         | materials, mechanical parts and processes |
| PA           | product assurance                         |
| PSA          | pressure sensitive adhesive               |
| Tg           | glass transition temperature              |
| TGA          | thermo-gravimetric analysis               |
| TMA          | thermo-mechanical analysis                |
| TVC          | thermal vacuum cycling                    |
| UV           | ultraviolet                               |

## 3.4 Nomenclature

The following nomenclature applies throughout this document:

- The word “shall” is used in this Standard to express requirements. All the requirements are expressed with the word “shall”.

- b. The word “should” is used in this Standard to express recommendations. All the recommendations are expressed with the word “should”.

NOTE It is expected that, during tailoring, recommendations in this document are either converted into requirements or tailored out.

- c. The words “may” and “need not” are used in this Standard to express positive and negative permissions, respectively. All the positive permissions are expressed with the word “may”. All the negative permissions are expressed with the words “need not”.

- d. The word “can” is used in this Standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS “may” and “can” have completely different meanings: “may” is normative (permission), and “can” is descriptive.

- e. The present and past tenses are used in this Standard to express statements of fact, and therefore they imply descriptive text.

## Principles of adhesive bonding

### 4.1 Overview

Adhesive bonding for space hardware varies from bonding of for example cable ties, to the complex structural bonding of load bearing parts. Some adhesive bonds can be inside the space craft, while others are exposed to space conditions including sometimes large temperature variations and radiation. Therefore the lifetime of each adhesive bond is carefully assessed before starting the bonding process. An overview of the different factors affecting the adhesive bonding performance is given in Figure 4-1.

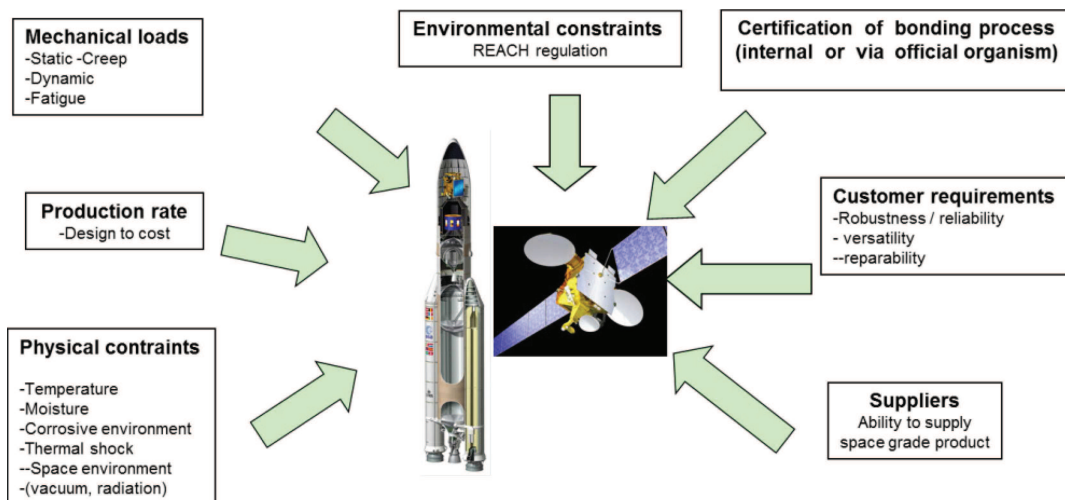


Figure 4-1: Overview of the constraints linked to adhesive bonds for space applications

### 4.2 Design of hardware

The design of bonded hardware involves parameters such as load directions, CTEs, bonding gaps, accessibility. A detailed overview on how to design an adhesive joint can be found in sections 8 to 11 of ECSS-E-HB-32-21.

Designers or sizing engineers have a good understanding of how stresses are distributed across the joint when loads (mechanical and thermal) are applied to it. Typically they consider the general guideline for thin adhesive bond (bond line thickness up to approx. 0,3 mm) to:

- a. Maximize shear and minimize peeling and cleavage load

- b. Maximize compression and minimize tension loads
- c. Increase the joint width rather than the overlap length
  - NOTE 1 If the length is small, plasticization (yielding) the adhesive governs the failure.
  - NOTE 2 If the length is larger, it is important to take in to account adhesive crack with plasticization (yielding) or crack only governs the rupture.
  - NOTE 3 If the length is very large, the adhesive bond can be more resistant than the adherend which can break (case of composite).
- d. In case of using composite adherends with unidirectional layup (0° being the best in accordance with maximum stress at failure) designers avoid for the first ply in contact with the adhesive 90° orientation ply and prefer a plain weave rather than unidirectional or ply with a lower stiffness (glass fabric for instance).

## 4.3 Performance of the adhesive bond

After having defined the basic design of the hardware and the parts that are bonded, the analysis of the adhesive bond is performed. This analysis can focus on joint design, adhesive material properties and environmental constraints, see Figure 4-2.

The needed performance of the adhesive bond has an influence on the choice of the adhesive itself, regarding for example strength, curing process, surface treatment of the adherend and temperature stability.

More information on surface treatments of the adherends can be found in section 12 of ECSS-E-HB-32-21.

In case the needed performance cannot be achieved with the adhesives and surface preparations available, the design is changed to generate a more bonding-friendly setup (see Figure 4-2) or change to another (for example mechanical) joining mechanism

## 4.4 Adhesive bonding process

The adhesive bonding process is generally taken into account in early stages of the project.

The amount of time and personnel needed to perform the bonding depends on parameters like, the overall surface area, type of surface treatment, possible primer application, pot life and curing of the adhesive.

The bonding process steps can be described in individual procedures. For example the adhesive bonding procedure can refer to sub- procedures.

Examples of adhesive bonding process steps:

- a. Preparation of bonded parts (degreasing, cleaning, ultrasonic bath with organic solvents, drying condition)

- b. Surface treatment (by mechanical, chemical and physical means)
- c. Surface post-treatment (incl. final surface cleaning, preservation if not bonded immediately)
- d. Surface activation (by mechanical, chemical and physical means)
- e. Surface quality verification (for example surface energy, roughness, wettability)
- f. Positioning and alignment of adherends
- g. Adherend priming (if any)
- h. Adhesive preparation (including mixing)
- i. Adhesive application
- j. Adhesive curing in bonded assembly
- k. Bonded assembly verification (NDI inspection after cure – visual, dimensional check, mechanical load proof test)

NOTE The same process steps are applicable for in-process samples.

In case of adherends are sensitive to ageing in storage conditions (UV, humidity, temperature over time) specific surface preparation process can be applied to remove the affected surface layer.

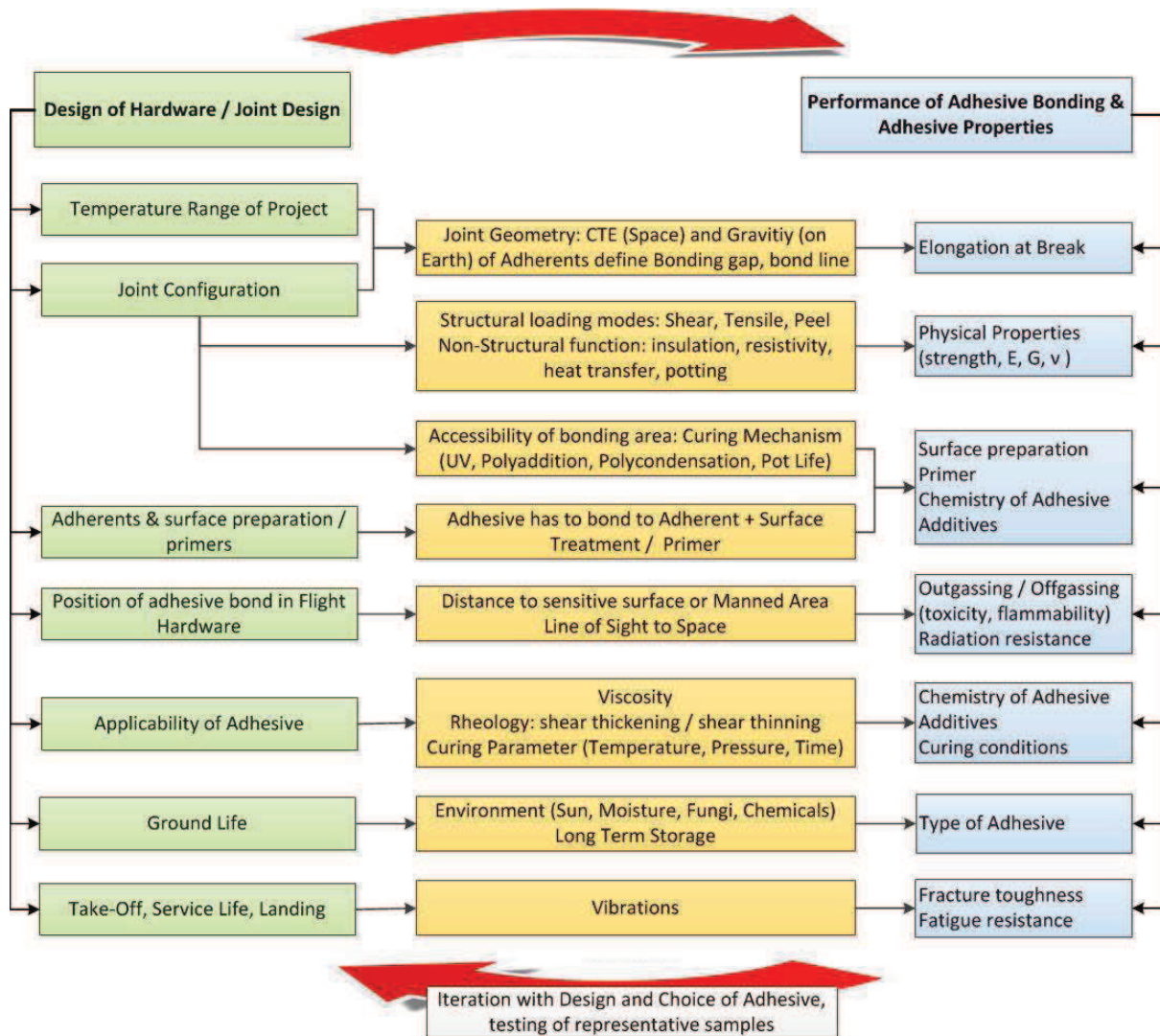


Figure 4-2: Overview on some parameters influencing the adhesive bond and its design

For more detailed design chart see Figure 10.16-1 in ECSS-E-HB-32-21.

## Selection of adhesive

---

### 5.1 Overview

The selection of an appropriate adhesive depends on a wide range of factors from early stage of manufacturing over service life till the end of mission. The ECSS Adhesive Bonding Handbook ECSS-E-HB-32-21 gives information about adhesive characteristics and properties and adhesive selection.

### 5.2 Analysis of adhesive application

- a. Selection of materials for adhesives shall be in compliance with requirements from clause 5 of ECSS-Q-ST-70.

NOTE Requirements from clause 5 of ECSS-Q-ST-70 include: for example: vacuum, radiation, moisture.

- b. Selection of adhesives shall be in compliance with clause 4.2.11 of ECSS-Q-ST-70-71.
- c. Depending on the cured adhesive properties, selection of adhesives shall be in compliance with requirements from clauses 4.2.17, 4.2.18 and 4.2.19 of ECSS-Q-ST-70-71.

NOTE Adhesive materials can be also grouped to elastomers (clause 4.2.17), thermoplastic (4.2.18) and thermosets (4.2.19).

- d. Selection of adhesive tapes shall be in compliance with clause 4.2.12 of ECSS-Q-ST-70-71.
- e. The outgassing characteristics of selected adhesive material in cured state shall be in compliance with requirements from clause 5 of ECSS-Q-ST-70-02.

NOTE For launcher applications when the adhesive material is not facing the spacecraft (for example lower stages of launcher, ground segment support applications), the requirements on cleanliness and contamination and outgassing specified in clause 5 of ECSS-Q-ST-70-02 can be tailored.