# DIN EN 16602-70-80

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***Entwurf***

## Raumfahrtproduktsicherung – Verarbeitungs- und Qualitätssicherungsanforderungen für metallische Pulver-Bett-Fusions-Technologien für Weltraumanwendungen; Englische Fassung prEN 16602-70-80:2021

Space product assurance –
Processing and quality assurance requirements for metallic powder bed fusion technologies for space applications;
English version prEN 16602-70-80:2021

Ingéniérie spatiale –
Mise en oevre et exigences d'assurance qualité pour les technologies de fusion sur lit de poudre pour applications spatiales;
Version anglaise prEN 16602-70-80:2021

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Gesamtumfang 83 Seiten

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## Nationales Vorwort

Dieses Dokument (prEN 16602-70-80:2021) wurde vom Technischen Komitee CEN/CLC/JTC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

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

| | | |
|---|---|---|
| ISO 2859-1:1999 | siehe | DIN ISO 2859-1:2004-01 |
| ISO 4490:2018 | siehe | DIN EN ISO 4490:2018-08 |

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# Nationaler Anhang NA
(informativ)

# Begriffe

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

## 3 Begriffe und Abkürzungen

### 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-E-ST-32, insbesondere der folgende Begriff:

   1) Struktur.

### 3.2 Für diese Norm spezifische Begriffe

**3.2.1**
**wie gebaut**
Zustand eines Bauteils oder eines Werkstoffmusters, das nach der Fertigstellung des AM-Baujobs keiner Behandlung unterzogen wurde

**3.2.2**
**Baujobkonfiguration**
Gestaltung des Bauteils, seine Position, die Anzahl der Bauteile und Nachweisproben, zusätzlich zur Stützstrategie im Bauvolumen

**3.2.3**
**Baujob**
einzelner vollständiger Durchlauf des pulverbettbasierten Schmelzprozesses, um Objekte im Pulverbett zu erzeugen

ANMERKUNG Üblicherweise werden in einem Baujob mehrere Objekte erzeugt.

[übernommen von NASA MSFC 3717]

**3.2.4**
**Strukturbauteil**
Erklärung durch die verantwortliche Entwicklungsstelle, ob eine Anwendung strukturbezogen ist oder nicht

ANMERKUNG Der Begriff „Strukturdesign“ ist nach ECSS-E-ST-32, 3.2.44 definiert und kann Leitlinien dazu angegeben, wie eine Anwendung als strukturbezogen oder nicht-strukturbezogen eingestuft wird.



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**3.2.5**
**ermüdungskritisches Bauteil**
Erklärung der verantwortlichen Entwicklungsstelle, ob ein Bauteil ermüdungskritisch ist oder nicht

ANMERKUNG 1 Bei typischen Fällen sind Ermüdungslasten ein signifikanter Faktor beim Prozess der Bemessung und Verifikation.

ANMERKUNG 2 Das kann zum Beispiel ein ermüdungsbelastetes Bauteil auf Grundlage des Ermüdungslastspektrums (Spannungsniveaus und Schwingspielzahl), der Werkstoffeigenschaften und jeglicher ergänzenden Faktoren wie Spannungskonzentrationen, Oberflächenrauheit und Restspannungen sein. Nicht ermüdungskritisch können Anwendungen sein, deren nachgewiesene Ermüdungsbeständigkeit einen Wert von unterhalb z. B. 4 aufweisen (das Bauteil wird die erforderliche Lebensdauer um voraussichtlich das 4-Fache übertreffen), auf Grundlage gemeinsam vereinbarter Ermüdungsdaten.

**3.2.6**
**Nachbearbeitungsverfahren**
Tätigkeiten, die nach Fertigstellung des Baujobs durchgeführt werden

**3.2.7**
**Pulvercharge**
Menge, die von einem zertifizierten Lieferanten stammt und in einem durchgehenden Fertigungslauf hergestellt wurde

ANMERKUNG Zum Beispiel Gasverdüsung.

**3.2.8**
**Pulverladung**
Menge einer Pulvercharge

ANMERKUNG Wenn eine große Pulvermenge beschafft wird (aus derselben Pulvercharge), wird die Pulvercharge häufig in verschiedene Ladungen aufgeteilt. Verschiedene Ladungen können gemischt werden, aber sie entstammen alle derselben Pulvercharge.

**3.2.9**
**erneute Verifikation**
vollständige oder teilweise Wiederholung eines Verifikationsprogramms

ANMERKUNG Die Bedingungen werden in Abschnitt 7.6 festgelegt.

**3.2.10**
**Ende-zu-Ende-Herstellungsprozess**
Fertigungsprozess von AM-Bauteilen, einschließlich Vor- und Nachbearbeitung

**3.2.11**
**Überlappungszone**
Teil eines Bauvolumens einer AM-Maschine, bei der Teilvolumen von Bauteilen durch zwei oder mehr Laser aufgebaut werden

**3.2.12**
**gleichmäßig im Bauvolumen verteilt**
so verteilt, dass die Orte in der X-Y-Ebene, aber auch in Z-Richtung bis zur maximalen Höhe des zu bauenden Teils belegt sind

**3.2.13**
**Stützkonstruktionen**
mechanische Verbindungen, um die Bauteilverzerrung zu begrenzen und um die Wärmeübertragung während der Herstellung zu ermöglichen



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## 3.3 Abkürzungen

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

| Abkürzung | Bedeutung |
|---|---|
| **AM** | additive Fertigung (en: additive manufacturing) |
| **AMP** | additives Fertigungsverfahren (en: additive manufacturing procedure) |
| **AMVP** | Verifikationsplan für die additive Fertigung (en: additive manufacturing verification plan) |
| **AMVR** | Verifikationsbericht zur additiven Fertigung (en: additive manufacturing verification report) |
| **AQL** | annehmbare Qualitätsgrenzlage (en: acceptance quality level) |
| **ASTM** | American Society for Testing and Materials (de: amerikanische Gesellschaft für Materialprüfung) |
| **CDR** | kritische Entwurfsüberprüfung (en: critical design review) |
| **CoC** | Konformitätsbescheinigung (en: certificate of compliance) |
| **DI** | entionisiert (en: de-ionised) |
| **DMLS** | direktes Metall-Lasersintern |
| **DRD** | Dokumenten-Anforderungsdefinition (en: document requirements definition) |
| **EBM** | Elektronenstrahlschmelzen (en: electron beam melting) |
| **ECSS** | Europäische Kooperation für Raumfahrtnormung (en: European Cooperation for Space Standardization) |
| **EDS** | energiedispersive Röntgenspektroskopie (en: energy-dispersive spectrometry) |
| **EIDP** | Endeinheit-Datenpaket (en: end item data pack) |
| **ELI** | extra niedrige Zwischenelemente (en: extra low interstitials) |
| **FM** | Flugmodell |
| **Ftu** | Zugfestigkeit (en: ultimate tensile strength) |
| **Fty** | Streckgrenze (en: yield strength) |
| **GSTP** | General Support Technology Program |
| **HFP** | Hardware-Fertigungsverfahren (en: hardware fabrication procedure) |
| **HIP** | heißisostatisches Pressen |
| **HP** | Hardware-Herstellung (en: hardware production) |
| **HPR** | Hardware-Herstellungsbericht (en: hardware production report) |
| **IPA** | Isopropylalkohol |
| **ISO** | International Organization for Standardization |
| **LBB** | Undichtheit vor dem Bersten (en: leak before burst) |
| **LBM** | Laserstrahlschmelzen (en: laser beam melting) |
| **LSSP** | Lasersintern in fester Phase (en: laser sintering in solid phase) |

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| Abkürzung | Bedeutung |
|---|---|
| **MMPDS** | Entwicklung und Normung von Werkstoffeigenschaften von Metallen (en: metallic materials properties development and standardization) |
| **MOC** | molekulare Verunreinigung (en: molecular contamination) |
| **mPBF** | metallpulverbettbasiertes Schmelzen (en: metal powder bed fusion) |
| **MPD** | Datenbank zu Materialeigenschaften (en: materials properties database) |
| **MRR** | Überprüfung der Herstellungsbereitschaft (en: manufacturing readiness review) |
| **NCR** | Nichtkonformitätsbericht (en: nonconformance report) |
| **NDI** | zerstörungsfreie Untersuchung (en: non-destructive inspection) |
| **OEM** | Originalgerätehersteller (en: original equipment manufacturer) |
| **PAC** | Verunreinigung durch Partikeln (en: particulate contamination) |
| **pAMP** | vorläufiges additives Fertigungsverfahren (en: preliminary additive manufacturing procedure) |
| **PBF** | pulverbettbasiertes Schmelzen (en: powder bed fusion) |
| **pHFP** | vorläufiges Hardware-Fertigungsverfahren (en: preliminary hardware fabrication procedure) |
| **PMCR** | Überprüfung des vorläufigen Herstellungskonzepts (en: preliminary manufacturing concept review) |
| **PVP** | Prototyp-Verifikationsplan (en: prototype verification plan) |
| **PVR** | Prototyp-Verifikationsbericht (en: prototype verification report) |
| **RFA** | Genehmigungsantrag (en: request for approval) |
| **RFW** | Antrag auf Sonderfreigabe nach Realisierung (en: request for waiver) |
| **SEM** | Rasterelektronenmikroskop (en: scanning electron microscope) |
| **SLM** | selektives Laserschmelzen (en: selective laser melting) |
| **SLS** | selektives Lasersintern |
| **SPC** | statistische Prozesskontrolle (en: statistical process control) |
| **Röntgen-CT** | Röntgen-Computertomografie |



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# Nationaler Anhang NB
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# Literaturhinweise

DIN EN ISO 4490:2018-08, *Metallpulver — Bestimmung der Durchflussrate mit Hilfe eines kalibrierten Trichters (Hall flowmeter) (ISO 4490:2018); Deutsche Fassung EN ISO 4490:2018*

DIN ISO 2859-1:2004-01, *Annahmestichprobenprüfung anhand der Anzahl fehlerhafter Einheiten oder Fehler (Attributprüfung) — Teil 1: Nach der annehmbaren Qualitätsgrenzlage (AQL) geordnete Stichprobenpläne für die Prüfung einer Serie von Losen — (ISO 2859-1:1999 + Cor.1:2001 + Amd.1:2011); Text in Deutsch und Englisch*

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# Space product assurance - Processing and quality assurance requirements for metallic powder bed fusion technologies for space applications

Ingéniérie spatiale - Mise en oevre et exigences d'assurance qualité pour les technologies de fusion sur lit de poudre pour applications spatiales

Raumfahrtproduktsicherung - Verarbeitungs- und Qualitätssicherungsanforderungen für metallische Pulver-Bett-Fusions-Technologien für Weltraumanwendungen

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.

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# European Foreword

This document (prEN 16602-70-80:2021) has been prepared by Technical Committee CEN/CLC/TC 5 “Space”, the secretariat of which is held by DIN (Germany).

This document (prEN 16602-70-80:2021) originates from ECSS-Q-ST-70-80C DIR1.

This document is currently submitted to the Enquiry.

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).



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# Introduction

This Standard specifies the processing and quality assurance requirements for the different types of Powder Bed Additive Manufacturing for Metallic Materials for space flight applications. It can also be used for Additive Manufacturing activities on space related ground equipment and development models for flight hardware. The Standard covers all Powder Bed Additive Manufacturing processes using Laser or Electron Beam as melting source. This includes, but is not limited to:

- Selective Laser Melting (SLM)
- Direct Metal Laser Sintering (DMLS)
- Laser Sintering in Solid Phase (LSSP)
- Laser Beam Melting (LBM)
- Electron Beam Melting (EBM)

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



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# 1 Scope

This Standard defines requirements for processing and quality assurance of powder bed fusion technologies for space applications.

Within this standard a set of phases are specified, each to be followed when defining, verifying and manufacturing parts using metallic powder bed fusion technologies. In addition, requirements for operating and supervision personnel and equipment facilities are described.

This Standard does not aim to prescribe process parameters relevant to the fabrication using metallic powder bed fusion technologies.

Although this standard is developed for powder bed fusion based techniques, its principles can also be used for other metal-based and polymer-based processes. These include Wire Arc Additive Manufacturing (WAAM), Laser Powder Build up Welding (LPBW), Stereolithography (with metals), Binder Jetting, but also Selective Laser Sintering, Stereolithography (with polymers), Fused Deposition Modelling (FDM), and others.


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# 2 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 16603-32 | ECSS-E-ST-32 | Space engineering - Structural general requirements |
| 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 16602-70-15 | ECSS-Q-ST-70-15 | Space product assurance - Non-destructive testing |
| EN 16602-70-45 | ECSS-Q-ST-70-45 | Space product assurance -Mechanical testing of metallic materials |
| | EN ISO ASTM 52921:2016 | Standard terminology for additive manufacturing - Coordinate systems and test methodologies |
| | DIN 35225:2017 | Welding for aerospace applications - Qualification testing of operators for powder bed based laser beam machines for additive manufacturing |
| | DIN 35224:2018 | Welding for aerospace applications - Acceptance inspection of powder bed based laser beam machines for additive manufacturing |
| | EN2003/009:2007 | Aerospace series. Test methods. Titanium and titanium alloys. Determination of surface contamination |
| | ASTM F3056:2014 | Standard Specification for Additive Manufacturing Nickel Alloy (UNS N06625) with Powder Bed Fusion |
| | ASTM F3302:2018 | Standard for Additive Manufacturing – Finished Part Properties – Standard Specification for Titanium Alloys via Powder Bed Fusion |



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| EN reference | Reference in text | Title |
|---|---|---|
| | NASA MSFC 3717:2017 | MSFC Technical standard specification for control and qualification of laser powder bed fusion metallurgical processes |
| | NASA MSFC 3716:2017 | Standard for additively manufactured spaceflight hardware by laser powder bed fusion in metals |
| | MMPDS-14:2019 | Metallic Materials Properties Development and Standardisation |
| | ISO 2859-1:1999 | Sampling procedures for inspection by attributes, Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection |


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# 3 Terms, definitions and abbreviated terms

## 3.1 Terms from other standards

a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

b. For the purpose of this Standard, the terms and definitions from ECSS-E-ST-32 apply, in particular for the following term:

1. structure

## 3.2 Terms specific to the present standard

### 3.2.1 as built

condition of a part or material sample that did not receive any treatment after completion of the AM build job

### 3.2.2 build job configuration

design of the part, its location, the number of the part(s) and witness specimens, in addition to supporting strategy in the build volume

### 3.2.3 build job

single complete operation of the powder bed fusion process to create objects in the powder bed

NOTE Multiple objects are commonly created during a build job.

[adopted from NASA MSFC 3717]

### 3.2.4 structural part

declaration by the design authority of an application to be structural or non-structural

NOTE The term “structural design” is defined in clause 3.2.44 of ECSS-E-ST-32 and can give some guidelines on how to declare an application structural or non-structural.

### 3.2.5 fatigue critical part

declaration by the design authority of a part to be fatigue critical or not

NOTE 1 Typical cases are where fatigue loads are a significant factor in the design and verification process.



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NOTE 2 For example, this can be a fatigue loaded part based on the fatigue load spectrum (stress levels and numbers of cycles), material properties and any additional factors like stress concentrations, surface roughness, and residual stresses. Not fatigue critical can be applications with demonstrated fatigue life below e.g. 4 (the part is predicted to survive 4 times the required life) based on commonly agreed fatigue data.

### 3.2.6 post process operations

action(s) performed after completion of the build job

### 3.2.7 powder lot

one quantity received from a certified supplier, produced in one continuous operation

NOTE For example gas atomisation.

### 3.2.8 powder batch

some quantity of a powder lot

NOTE When a large quantity of powder is procured (from the same powder lot), the powder lot is often split into different batches. Different batches can be blended, but they all originate from the same powder lot.

### 3.2.9 re-verification

repetition of a verification program or parts of it

NOTE The conditions are specified in clause 7.6.

### 3.2.10 end-to-end manufacturing process

process of producing AM parts, including any pre- and post-processing

### 3.2.11 overlap zone

part of the build volume of an AM machine, where sub-volumes of parts are built by two or more lasers

### 3.2.12 evenly distributed in the build volume

distributed such that locations in the x-y plane, but also in z-direction up to the maximum height of the part to be built are covered

### 3.2.13 manufacturing supports

mechanical connections to limit parts distortion and to allow heat transfer during manufacturing.


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## 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 |
|---|---|
| **AM** | additive manufacturing |
| **AMP** | additive manufacturing procedure |
| **AMVP** | additive manufacturing verification plan |
| **AMVR** | additive manufacturing verification report |
| **AQL** | acceptance quality level |
| **ASTM** | American Society for Testing and Materials |
| **CDR** | critical design review |
| **CoC** | certificate of compliance |
| **DI** | de-ionised |
| **DMLS** | direct metal laser sintering |
| **DRD** | document requirements definition |
| **EBM** | electron beam melting |
| **ECSS** | European Cooperation for Space Standardization |
| **EDS** | energy-dispersive spectrometry |
| **EIDP** | end item data pack |
| **ELI** | extra low interstitials |
| **FM** | flight model |
| **Ftu** | ultimate tensile strength |
| **Fty** | yield strength |
| **GSTP** | general support technology program |
| **HFP** | hardware fabrication procedure |
| **HIP** | hot isostatic pressing |
| **HP** | hardware production |
| **HPR** | hardware production report |
| **IPA** | isopropyl alcohol |
| **ISO** | International Organisation for Standardisation |
| **LBB** | leak before burst |
| **LBM** | laser beam melting |
| **LSSP** | laser sintering in solid phase |
| **MMPDS** | Metallic Materials Properties Development and Standardization |
| **MOC** | molecular contamination |



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| Abbreviation | Meaning |
|---|---|
| **mPBF** | metal powder bed fusion |
| **MPD** | materials properties database |
| **MRR** | manufacturing readiness review |
| **NCR** | nonconformance report |
| **NDI** | non-destructive inspection |
| **OEM** | original equipment manufacturer |
| **PAC** | particulate contamination |
| **pAMP** | preliminary additive manufacturing procedure |
| **PBF** | powder bed fusion |
| **pHFP** | preliminary hardware fabrication procedure |
| **PMCR** | preliminary manufacturing concept review |
| **PVP** | prototype verification plan |
| **PVR** | prototype verification report |
| **RFA** | request for approval |
| **RFW** | request for waiver |
| **SEM** | scanning electron microscope |
| **SLM** | selective laser melting |
| **SLS** | selective laser sintering |
| **SPC** | statistical process control |
| **X-Ray CT** | x-ray computed tomography |

## 3.4 Nomenclature

The following nomenclature applies throughout this document:

a. 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.


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