



SLOVENSKI STANDARD
SIST EN 16602-70-54:2019

01-maj-2019

**Zagotavljanje kakovosti proizvodov v vesoljski tehniki - Ultra čiščenje letalske
strojne opreme**

Space product assurance - Ultracleaning of flight hardware

Raumfahrtproduktsicherung - Ultra-Reinigung von Flug-Hardware

Assurance produit des projets spatiaux - Ultra nettoyage des matériels de vol

STANDARD PREVIEW
(standards.iteh.ai)

Ta slovenski standard je istoveten z: EN 16602-70-54:2019

<https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78d1d/sist-en-16602-70-54-2019>

ICS:

49.140 Vesoljski sistemi in operacije Space systems and
operations

SIST EN 16602-70-54:2019

en,fr,de

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST EN 16602-70-54:2019

<https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019>

EUROPEAN STANDARD

EN 16602-70-54

NORME EUROPÉENNE

EUROPÄISCHE NORM

March 2019

ICS 49.140

English version

Space product assurance - Ultracleaning of flight hardware

Assurance produit des projets spatiaux -
Ultranettoyage des matériels de vol

Raumfahrtproduktsicherung - Ultra-Reinigung von
Flug-Hardware

This European Standard was approved by CEN on 9 November 2018.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists 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.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

[SIST EN 16602-70-54:2019](https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019)

<https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019>



**CEN-CENELEC Management Centre:
Rue de la Science 23, B-1040 Brussels**

Table of contents

European Foreword	7
Introduction	8
1 Scope	9
2 Normative references	10
3 Terms, definitions and abbreviated terms	11
3.1 Terms from other standards.....	11
3.2 Terms specific to the present standard	11
3.3 Abbreviated terms.....	13
3.4 Nomenclature	13
4 Principles	15
4.1 Cleaning techniques: Contamination removal.....	15
4.1.1 Introduction.....	15
4.1.2 Ultracleaning.....	18
4.1.3 Cleaning principles.....	19
4.1.4 Trade-off process.....	20
4.1.5 Selection of an end-to-end cleaning process.....	21
5 Requirements	23
5.1 Specifying process.....	23
5.1.1 General.....	23
5.1.2 Specifying process means	23
5.2 Definition of end-to-end cleaning process	24
5.2.1 Test samples.....	24
5.2.2 Definition of critical contamination and tracers	24
5.2.3 Application process for critical contaminants and tracers	25
5.2.4 Selection of analytical techniques	26
5.2.5 Definition of test matrix.....	26
5.2.6 Cleaning processes.....	26
5.2.7 Cleaning efficacy.....	27
5.3 Validation of end-to-end cleaning process	29

EN16602-70-54:2019 (E)

5.4	Packaging, containerization, transportation, storage.....	31
Annex A (normative) Request for ultracleaning - DRD		32
A.1	DRD identification.....	32
A.2	Purpose and objective	32
A.3	Expected response.....	32
A.3.1	Scope and content.....	32
A.3.2	Special remarks	32
Annex B (normative) Ultracleaning work proposal - DRD.....		33
B.1	DRD identification.....	33
B.2	Purpose and objective	33
B.3	Expected response.....	33
B.3.1	Scope and content.....	33
B.3.2	Special remarks	34
Annex C (normative) Ultracleaning process report - DRD		35
C.1	DRD identification.....	35
C.2	Purpose and objective.....	35
C.3	Expected response.....	35
C.3.1	Scope and content.....	35
C.3.2	Special remarks	36
Annex D (informative) Good cleanability design guidelines		37
D.1	Conception and design guidelines	37
D.1.1	General.....	37
D.1.2	Corners and edges.....	38
D.1.3	Weld seams at corners and edges.....	39
D.1.4	Transitions	40
D.1.5	Fixed/separable joins:	40
Annex E (informative) Cleaning techniques.....		42
E.1	Blasting cleaning techniques	42
E.1.1	Compressed air blasting.....	42
E.1.2	Wet compressed air blasting	42
E.1.3	Pressurized fluid blasting	43
E.1.4	Low-pressure water jet blasting.....	43
E.1.5	Elutriation blasting.....	44
E.1.6	Centrifugal blasting	44
E.1.7	Steam blasting	45

E.1.8	CO ₂ pellet cleaning	45
E.1.9	Accelerated CO ₂ snow cleaning	46
E.2	Mechanical cleaning	47
E.2.1	Wiping	47
E.2.2	Brushing and sweeping	48
E.2.3	Scraping and abrading	48
E.2.4	Grinding	49
E.2.5	Beating off	49
E.3	Fluidic cleaning	50
E.3.1	Washing and rinsing	50
E.3.2	Blowing off cleaning	50
E.3.3	Suction cleaning	51
E.3.4	Ultrasonic cleaning	51
E.4	Chemical cleaning	52
E.4.1	General principle of chemical cleaning	52
E.4.2	Etching and leaching	52
E.4.3	Chemical reaction	52
E.5	Solvent cleaning	53
E.5.1	Detaching and stripping	53
E.6	Thermal cleaning	53
E.6.1	General principle of thermal cleaning	53
E.6.2	Evaporating	53
E.6.3	Scarfig	54
E.6.4	Decomposing	54
E.7	Special cleaning	55
E.7.1	Hot vacuum purge	55
E.7.2	Hot N ₂ purge	55
E.7.3	Plasma Chamber cleaning	56
E.7.4	UV-light cleaning	56
E.7.5	LASER beam cleaning	57
E.7.6	Supercritical CO ₂ Cleaning	57
E.7.7	Liquid Peel Cleaning	58
Annex F (informative) Contamination detection techniques		59
F.1	Particulate contamination	59
F.1.1	General	59
F.1.2	Assessment matrix	59
F.2	Chemical molecular contamination	63

EN16602-70-54:2019 (E)

F.3	Microbiological contamination	63
Annex G (informative) Witness sample design.....		64
G.1	Example witness sample design	64
Annex H (informative) Examples for cleanliness classification.....		65
H.1	Particles.....	65
H.1.1	Classification system.....	65
H.1.2	Examples for cleaning efficacy	66
H.2	Molecular contamination	67
H.2.1	Classification system.....	67
H.2.2	Examples for cleaning efficacy	67
Bibliography.....		69
Figures		
Figure 4-1:	Typical types of molecular and particulate contamination	15
Figure 4-2:	Relationship between van der Waals force and weight in dependence upon particle diameter (model according to Hamaker for Al particles on Al substrate).....	16
Figure 4-3:	Influences on the cleaning efficacy.....	17
Figure 4-4:	Available cleaning principles and related techniques.....	19
Figure 4-5:	Two stage trade-off method.....	20
Figure 4-6:	Logic flow for the selection and optimisation of an end-to-end cleaning process for hardware.....	22
Figure 5-1:	Cleanliness validation logic for using witness plates.....	30
Figure 5-2:	Cleanliness validation logic for using products or components	30
Figure D-1 :	Design of corners and edges	39
Figure D-2 :	Material transitions joined by a weld seam.....	40
Figure D-3 :	Materials joined by a weld seam	40
Figure G-1 :	Test sample geometry to assess the cleaning efficacy of a certain cleaning technique (left) and composition of the test sample surface (right)	64
Tables		
Table 4-1:	Typical cleanliness levels and their verification techniques on spacecraft surfaces	18
Table F-1 :	Comparison of different direct particle detection methods	62
Table H-1 :	Selected SCP classes for cleanrooms and associated controlled environments	65

Table H-2 : Examples of cleaning efficacies on different substrates	66
Table H-3 : Overview of ISO SCC molecular contamination classes	67
Table H-4 : Examples of cleaning efficacies on different substrates	67

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[SIST EN 16602-70-54:2019](https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019)

<https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019>

European Foreword

This document (EN16602-70-54:2019) has been prepared by Technical Committee CEN-CENELEC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN16602-70-54:2019) originates from ECSS-Q-ST-70-54C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2019, and conflicting national standards shall be withdrawn at the latest by September 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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 has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This ECSS Standard describes the procedures to be used to clean to a level of cleanliness beyond the scope of the ECSS-Q-ST-70-01, and to control the cleanliness level of flight hardware prior to and following a posteriori to the application of the ultracleaning process. The intended objective of the ultracleaning process is to remove all surface contamination (particulates, biologic material cell debris and chemical molecular contamination) on flight hardware, with no specific limit in geometric dimension or contamination levels. This includes removal of biological material for avoidance of false positive results during investigation of extra-terrestrial samples or environments.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[SIST EN 16602-70-54:2019](https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019)

<https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019>

1 Scope

This standard addresses process descriptions, process validation, cleanliness control and monitoring, recontamination prevention, quality assurance as follows:

PROCESSES DESCRIPTIONS, including

- Detergent cleaning
- Alcohol cleaning
- Ultrapure water cleaning
- Liquid boundary layer disruption cleaning
- Multiple solvent cleaning (JPL procedure)
- Vacuum bakeout
- Supercritical fluids cleaning
- Carbon dioxide snow cleaning
- Plasma cleaning
- Pyrolysis

<https://standards.iteh.ai/catalog/standards/sist/6cc22591-310a-4510-8dcf-b17762a78df1/sist-en-16602-70-54-2019>

Criteria for selecting other/novel processes

PROCESS VALIDATION

- Test material selection
- Preparation of test materials for process application
- Deposition of contaminants
- Description of test conditions
- Verification of cleanliness level

CLEANLINESS CONTROL AND MONITORING, including

- Micro/nano imaging techniques
- Spectrometry techniques
- Spectroscopy techniques
- Chromatography techniques

RECONTAMINATION PREVENTION

- Packaging systems
- Protective covers
- Storage

QUALITY ASSURANCE

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

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 16602-10-09	ECSS-Q-ST-10-09	Space product assurance - Nonconformance control system
EN 16602-20-08	ECSS-Q-ST-20-08	Space product assurance - Storage, handling and transportation of spacecraft hardware
EN 16602-70	ECSS-Q-ST-70	Space product assurance - Materials, mechanical parts and processes
EN 16602-70-01	ECSS-Q-ST-70-01	Space product assurance - Cleanliness and contamination control
	ISO 14644-9: 2012	Cleanrooms and associated controlled environments - Part 9: Classification of surface cleanliness by particle concentration
	ISO 14644-10: 2013	Cleanrooms and associated controlled environments - Part 10: Classification of surface cleanliness by chemical concentration

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, in particular for the following terms:
1. cleanliness
 2. qualification
 3. test
 4. validation
 5. verification
- b. For the purpose of this Standard, the terms and definitions from ECSS-Q-ST-70-01 apply, in particular for the following terms:
1. cleanroom
 2. off-gassing

<https://standards.iteh.ai/catalog/standards/sist/8cca2351-340a-4310-8dcf-b17762a78dfd/sist-en-16602-70-54-2019>

3.2 Terms specific to the present standard

3.2.1 bioaerosol

dispersed biological agents in a gaseous environment

[ISO 14698-1:2003]

3.2.2 biological contamination

contamination of materials, devices, individuals, surfaces, liquids, gases or air with viable particles.

NOTE 1 Depending on the context, biological contamination can be considered as organic or as particulate contamination. A bacterial cell has about $1\text{E}-13$ g (organic content of one cell is below the detection limit of most chemical methods).

NOTE 2 Problem is that, apart from growing, cells and spores often have

extracellular material that can be more mass than the cell itself.

3.2.3 cleanliness (of a solid surface)

condition of a solid surface where the amount of contamination is controlled to a specific level

NOTE Example of amount of contamination include particle, chemical molecular or viable

3.2.4 contaminant

any particulate, chemical molecular, non-particulate and biological entity that can adversely affect the product or process

3.2.5 decontamination

reduction of unwanted matter to a defined level

3.2.6 direct measurement method (DMM)

measurement method where the contamination that is to be determined is being assessed without any intermediate steps

[adapted from ISO 14644-9:2012]

3.2.7 indirect measurement method (IMM)

measurement method where the contamination that is to be determined is being assessed with intermediate steps

[adapted from ISO 14644-9:2012]

3.2.8 surface cleanliness of chemicals (SCC)

presence on the surface of a product or instrument of molecular, chemical, non-particulate, species in the adsorbed or deposited state which can have a deleterious effect on the product, process or equipment in the cleanroom or controlled environment

[adapted from ISO 14644-10:2013]

3.2.9 surface cleanliness of particles (SCP)

class of surface particle cleanliness is a grading number stating the maximum allowable surface concentration, in particles per m², for a considered size of particles, SPC Classes 1 to 8

[adapted from ISO 14644-9:2012]

3.2.10 surface cleanliness particles (SCP) classification

level (or the process of specifying or determining the level) that represents maximum allowable surface concentrations, in particles per square metre, for considered sizes of particles, expressed in terms of an ISO SCP Class N

[ISO 14644-9:2012]

EN16602-70-54:2019 (E)

3.2.11 surface particle concentration

number of individual particles per unit of surface area under consideration
[ISO 14644-9:2012]

3.2.12 thin film contamination

layers of critical contaminants that range from the nanometre scale to the micrometre scale

3.2.13 viable particle

particle that consists of, or supports, one or more live microorganisms

3.2.14 cleaning efficacy

removal of specific contaminants from a surface by a cleaning process, determined by the final accomplished surface cleanliness, in respect to the initial surface cleanliness

NOTE 1 Cleaning efficacy can be expressed in absolute (surface concentration) or relative (percentage) terms.

NOTE 2 In general, repetitive application of the same cleaning process results in consecutive decreasing efficacy.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

3.3 Abbreviated terms

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

Abbreviation	Meaning
DRD	document requirements definition
ppm	parts per million (10^{-6})

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”.
- 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.

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