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Nationales Vorwort

Dieses Dokument (EN 16602-70-15:2021) wurde vom Technischen Komitee CEN-CLC/JTC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

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

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

ISO 18563-1:2015	siehe	DIN EN ISO 18563-1:2015-11
ISO 9606-1:2012, einschließlich Cor 1:2012 und Cor 2:2013	siehe	DIN EN ISO 9606-1:2017-12

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Nationaler Anhang NA
(informativ)

Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen ist 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 gilt der Begriff nach ECSS-E-ST-32-01:

1) bruchanfälliges Bauteil mit sicherer Lebensdauer.

ANMERKUNG Diese Definition entspricht der Definition von „schadenstolerante bruchanfällige Bauteile“ in den NASA-Normen, wie z. B. NASA-STD-5019.

3.2 Für diese Norm spezifische Begriffe

3.2.1
Schwarzlicht
UVA-Licht
nahe ultraviolette Strahlung zur Anregung der Fluoreszenz

3.2.2
genaue visuelle Prüfung
intensive visuelle Untersuchung der Innen- und Außenflächen eines Bauwerks, einschließlich struktureller Details oder Stellen, aus nächster Nähe auf Anzeichen von Aufprallschäden, Rissen und anderen Oberflächendefekten

ANMERKUNG 1 Die Prüfbarkeit wird durch die Messung der Oberflächenverformung (Einschlagtiefe) bewertet.

ANMERKUNG 2 Es wird davon ausgegangen, dass eine enge visuelle Prüfung eine Verformung, die größer als der Schwellenwert für sichtbare Beschädigung (VDT) ist, zuverlässig erkennt.

3.2.3
Bildgütetestkörper
IQI, en: Image Quality Indicator
Reihe von Drähten oder Reihe von Platten, die Löcher mit unterschiedlichen Durchmessern enthalten

3.2.4
NDT-Verfahren
Verfahren, bei dem ein physikalisches Prinzip für die zerstörungsfreie Prüfung und die zerstörungsfreie Inspektion eingesetzt wird

ANMERKUNG Beispiele für die verschiedenen Techniken sind: Ultraschall und Radiographie.

[basierend auf EN 4179:2017]

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3.2.5
NDT-Anweisung
schriftliche Beschreibung der genauen Schritte, die bei der Prüfung nach einer festgelegten Norm, Vorschrift, Spezifikation oder einem NDT-Verfahren einzuhalten sind

ANMERKUNG Diese Norm legt in allen Fällen ein NDT-Verfahren fest.

3.2.6
NDT-Technik
spezifische Art und Weise der Anwendung einer NDT-Verfahren

ANMERKUNG Beispielsweise Ultraschalltauchtechnik.

[in Anlehnung an EN 4179:2017]

3.2.7
NDT-Verfahren
schriftliche Beschreibung aller wesentlichen Parameter und Vorkehrungen, die anzuwenden sind, wenn Produkte einer zerstörungsfreien Prüfung in Übereinstimmung mit (einer) Norm(en), Vorschrift(en) oder Spezifikation(en) unterzogen werden

ANMERKUNG Ein NDT-Verfahren kann die Anwendung von mehr als einer NDT-Verfahren oder NDT-Technik umfassen.

3.2.8
verantwortliche Person der Stufe 3
vom Arbeitgeber benannte Person der Stufe 3 mit der entsprechenden Verantwortung und Befugnis und die im Auftrag des Arbeitgebers die Qualifizierung und Zertifizierung des NDT-Personals durchführt

[EN 4179:2017]

3.2.9
besondere NDT-Verfahren zur Überwachung des Rissfortschritts
NDT-Verfahren, die im Rahmen der Rissfortschrittüberwachung an Teilen mit sicherer Lebensdauer angewendet werden, um Risse oder rissartige Fehler zu erkennen, die kleiner sind als die, von denen angenommen wird, dass sie mithilfe der Standard-NDT-Verfahren zur Überwachung des Rissfortschritts erkennbar sind, oder die nicht den Anforderungen der Standard-NDT-Verfahren zur Überwachung des Rissfortschritts entsprechen

[in Anlehnung an der Definition der „besonderen NDT-Verfahren“ von ECSS-E-ST-32-01C (2008)]

ANMERKUNG Die besonderen NDT-Verfahren beschränken sich nicht auf die fluoreszierende Eindringprüfung, die Durchstrahlungsprüfung, die Ultraschallprüfung, die Wirbelstromprüfung und die Magnetpulverprüfung.

3.2.10
Standard-NDT-Verfahren zur Überwachung des Rissfortschritts
NDT-Verfahren für metallische Werkstoffe, für die das erforderliche, auf Statistiken basierende Vermögen zum Erkennen von Fehlern festgelegt wurde

[in Anlehnung an der Definition der „besonderen NDT-Verfahren“ von ECSS-E-ST-32-01]

ANMERKUNG Die in diesem Dokument behandelten Standard-NDT-Verfahren beschränken sich auf die fluoreszierende Eindringprüfung, die Durchstrahlungsprüfung, die Ultraschallprüfung, die Wirbelstromprüfung und die Magnetpulverprüfung.

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3.2.11
Qualifikation des Personals
Fertigkeiten, Ausbildung, Kenntnisse, Prüfungen, Erfahrungen und visuelle Fähigkeiten, die Personal aufweisen muss, um die Anforderungen einer bestimmten Stufe fachgerecht zu erfüllen

[in Anlehnung an EN 4179:2017]

3.2.12
Zertifizierung des Personals
schriftliche Bestätigung eines Arbeitgebers, dass eine Person die zutreffenden Anforderungen erfüllt

[in Anlehnung an EN 4179:2017]

ANMERKUNG In einigen Normen wird der Arbeitgeber als Zertifizierungsbehörde oder Zertifizierungsstelle bezeichnet.

3.2.13
Produktfamilie
Kombination der folgenden Eindringprüfmittel: Eindringmittel, Zwischenreiniger und Entwickler

[in Anlehnung an EN ISO 3452-2:2013]

3.2.14
Verifizierung des NDT-Verfahrens
Prozess zur Zertifizierung der Wirksamkeit eines Inspektionsprozesses durch einen Nachweis, der auf einer repräsentativen Struktur in einer repräsentativen Umgebung und durch repräsentatives Inspektionspersonal erbracht wird

[in Anlehnung an MIL-HDBK-6870B]

ANMERKUNG 1 Ausrüstungen, in Bezug genommene Normen und schriftliche Verfahrensanweisungen sind Beispiele für den Inspektionsprozess.

ANMERKUNG 2 Der Begriff „Qualifizierung“ nach ECSS-Q-ST-70-15 ist gleichbedeutend mit dem Begriff „Verifizierung“, der in der ECSS-Dokumentation verwendet wird.

ANMERKUNG 3 Beispiele für Prozesse, die zertifiziert werden müssen, sind Prüfprozesse und Herstellungsprozesse.

3.3 Abkürzungen und Symbole

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

Abkürzung	Bedeutung	
AMS	Werkstoffspezifikation in der Luft- und Raumfahrt	(en: Aerospace Material Specification)
ASTM	Amerikanische Gesellschaft für Materialprüfung	(en: American Society for Testing and Materials)
CR	Computerradiographie	(en: computed radiography)
CT	Computertomographie	(en: computed tomography)
DDA	digitales Detektorarray	(en: digital detector array)
DRD	Definition der Anforderungen an Dokumente	(en: document requirements definition)

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Abkürzung	Bedeutung	
DR	digitale Radiographie	(en: digital radiography)
ET	Wirbelstromprüfung	(en: eddy current testing)
EEE	elektrisch, elektronisch und elektromechanisch	(en: electrical, electronic and electromechanical)
EN	Europäische Norm	(en: European Standard)
FMECA	Fehlermöglichkeits-, Einfluss- und Kritikalitäts-Analyse	(en: failure modes, effects and criticality analysis)
FSW	Rührreibschweißen	(en: friction stir welding)
MMC	Metallmatrix-Verbundwerkstoffe	(en: metal matrix composites)
MPCB	Werkstoff- und Prozesskontrollausschuss	(en: materials and processes control board)
MT	Magnetpulverprüfung	(en: magnetic particle testing)
NAS	Nationale Luft- und Raumfahrtspezifikation	(en: National Aerospace Specification)
NCR	Nichtkonformitäten/Fehler-Bericht	(en: nonconformance report)
NDT	zerstörungsfreie Prüfung	(en: non-destructive testing)
NRB	Nichtkonformitäten-Prüfausschuss	(en: nonconformance review board)
PFCI	möglicherweise rissgefährdetes Bauteil	(en: potential fracture control critical)
POD	Nachweiswahrscheinlichkeit	(en: probability of detection)
PSM	Eindringsystemüberwachung	(en: penetrant system monitoring)
PT	Eindringprüfung	(en: penetrant testing)
RFD	Antrag auf Abweichung	(en: request for deviation)
RT	Durchstrahlungsprüfung	(en: radiographic testing)
QQI	quantitativer Qualitätsindikator	(en: quantitative quality indicator)
QMS	Qualitätsmanagementsystem	(en: quality management system)
TIG	Wolfram-Inertgas-Schweißen	(en: tungsten inert gas welding)
UT	Ultraschallprüfung	(en: ultrasonic testing)
UTG	Ultraschall-Dickenmessgerät	(en: ultrasonic thickness gauge)
UV	ultraviolett	(en: ultraviolet)
VDT	Schwellenwert für sichtbare Beschädigung	(en: visual damage threshold)

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Literaturhinweise

DIN EN ISO 18563-1:2015-11, *Zerstörungsfreie Prüfung — Charakterisierung und Verifizierung der Ultraschall-Prüfausrüstung mit phasengesteuerten Arrays — Teil 1: Prüfgeräte (ISO 18563-1:2015); Deutsche Fassung EN ISO 18563-1:2015*

DIN EN ISO 9606-1:2017-12, *Prüfung von Schweißern — Schmelzschweißen — Teil 1: Stähle (ISO 9606-1:2012, einschließlich Cor 1:2012 und Cor 2:2013); Deutsche Fassung EN ISO 9606-1:2017*

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NORME EUROPÉENNE

EUROPÄISCHE NORM

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European Foreword

This document (EN 16602-70-15:2021) has been prepared by Technical Committee CEN-CENELEC/TC 5 “Space”, the secretariat of which is held by DIN.

This standard (EN 16602-70-15:2021) originates from ECSS-Q-ST-70-15C.

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 March 2022, and conflicting national standards shall be withdrawn at the latest by March 2022.

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

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Introduction

This standard specifies general requirements for flight parts. It also covers specific requirements for flight metallic components, structures and composite parts used for space missions. It does not explicitly cover all the flight parts, components, structures and techniques. Consequently, some techniques as acoustic emission, shearography, IR thermography or specific guided waves techniques are not addressed in detail and are to be agreed per NDT plan, in line with the general requirements of clauses 5 and 9 (and covered by Annexes).

Non-destructive testing (NDT) covers a wide range of processes used in quality control. The generic term NDT covers several sub processes such as Dye Penetrant testing (PT), Radiographic testing (RT), Magnetic particle testing (MT), Ultrasonic testing (UT) and Eddy current testing (ET). The processes are applied at the discretion of the design authority depending on the criticality of the part or component and inherent risk of the manufacturing process to create detrimental discontinuities. It is expected that every component used in spaceflight is subjected to some level of NDT in accordance with the present standard, which complements the ECSS-Q-ST-70-39 “Welding of metallic materials for flight hardware”.

The lack of NDT control throughout the supply chain has been evident in all space projects across the Europe. As no standard was in place at that time this has resulted in inconsistency in the rationale and application for NDT selection. NDT is generally applied for quality control to ensure that components are free of unacceptable discontinuities. NDT is used in cases, in which the damage or destruction of the item under test is not desired. Examples for this are root cause analysis and quality control to ensure that components are free of discontinuities.

For some components the NDT methods used form the basis of the fracture and fatigue verification and thus the assurance of design margins. The level of NDT (testing level) is expected to be decided based on the manufacturing processes applied and the criticality of the part or component and the impact if that part fails in service.

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1 Scope

This standard specifies NDT requirements for flight parts, components and structures used for space missions. It covers the NDT methods and stipulates the certification levels for personnel. The qualification of such processes are also specified for non-standard NDT techniques or where complex components are concerned. This standard also identifies the best practice across the large range of international and national standards. When international or national NDT standards are referenced within this document, alternative equivalent standards can be considered acceptable subject to customer approval.

Visual testing included in this standard is not intended to include incoming inspection of, for example, raw materials, damage during transport, storage and handling and parts procurement verification. Furthermore, the visual testing performed in the NDT (discontinuities, surface structure) does not cover the visual testing in the Cleanliness and Contamination standard.

The minimum requirements for NDT documentation are specified in the DRDs of the Annexes.

This standard does not cover the acceptance criteria of components, structures and parts submitted to this examination; it is expected that these criteria are identified on specific program application documentation.

This Standard does not apply to EEE components.

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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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 16601-40	ECSS-M-ST-40	Space management – Configuration and information management
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 16602-70-39	ECSS-Q-ST-70-39	Space product assurance -Welding of metallic materials for flight hardware
EN 16603-32	ECSS-E-ST-32	Space engineering – Structural general requirements
EN 16603-32-01	ECSS-E-ST-32-01	Space engineering – Fracture control
	EN 4179:2017	Aerospace series – Qualification and approval of personnel for non-destructive testing
	EN 12668-1:2010	Non-destructive testing – Characterization and verification of ultrasonic examination equipment – Part 1: Instruments
	EN 12668-2:2010	Non-destructive testing – Characterization and verification of ultrasonic examination equipment – Part 2: Probes
	EN 13068-3:2001	Non-destructive testing – Radioscopic testing – Part 3: general principles or radioscopic testing of metallic materials by x- and gamma rays
	EN 1779:1999/A1:2003	Non-destructive testing – Leak testing – Criteria for method and technique selection
	EN ISO 17637:2016	Non-destructive testing of welds – Visual testing of fusion-welded joints
	EN ISO 3452-1:2013	Non-destructive testing — Penetrant testing — Part 1: General principles

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	EN ISO 3452-2:2013	Non-destructive testing – Penetrant testing – Part 2: Testing of penetrant materials
	EN ISO 3452-3:2013	Non-destructive testing – Penetrant testing – Part 3: Reference test blocks
	EN ISO 5579:2013	Non-destructive testing – Radiographic testing of metallic materials using film and X- or gamma rays – Basic rules
	EN ISO 9712:2012	Non-destructive testing – Qualification and certification of NDT personnel
	EN ISO 9934-1:2016	Non-destructive testing – Magnetic particle testing – Part 1: General principles
	EN ISO 9934-2:2015	Non-destructive testing – Magnetic particle testing – Part 2: Detection media
	EN ISO 9934-3:2015	Non-destructive testing – Magnetic particle testing – Part 3: Equipment
	EN ISO 15548-1:2013	Non-destructive testing – Equipment for eddy current examination – Part 1: Instrument characteristics and verification
	EN ISO 15548-2:2013	Non-destructive testing – Equipment for eddy current examination – Part 2: Probe characteristics and verification
	EN ISO 15548-3:2008	Non-destructive testing – Equipment for eddy current examination – Part 3: System characteristics and verification
	EN ISO 15549:2019	Non-destructive testing – Eddy current testing – General principles
	EN ISO 15708-2:2019	Non-destructive testing – Radiation methods for computed tomography – Part 2: Principles, equipment and samples
	EN ISO 15708-4:2019	Non-destructive testing – Radiation methods for computed tomography – Part 4: Qualification
	EN ISO 16810:2014	Non-destructive testing – Ultrasonic testing – General principles
	EN ISO 16811:2014	Non-destructive testing – Ultrasonic testing – Sensitivity and range setting
	EN ISO 17635:2016	Non-destructive testing of welds – General rules for metallic materials
	EN ISO 17636-1:2013	Non-destructive testing of welds – Radiographic testing – Part 1: X- and gamma-ray techniques with film
	EN ISO 17636-2:2013	Non-destructive testing of welds – Radiographic testing – Part 2: X- and gamma-ray techniques with digital detectors
	EN ISO 17640:2018	Non-destructive testing of welds – Ultrasonic testing – Techniques, testing levels and assessment

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	ASTM E 127:2019	Standard Practice for Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks
	ASTM E 164:2019	Standard Practice for Contact Ultrasonic Testing of Weldments
	ASTM E 426:2016	Standard Practice for Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys
	ASTM B 594:2019	Standard Practice for Ultrasonic Inspection of Aluminium-Alloy Wrought Products
	ASTM E 1254:2013(2018)	Standard guide for storage of radiographs and unexposed industrial radiographic films
	ASTM E 1417/1417M-11:2016	Standard Practice for Liquid Penetrant Testing
	ASTM E 1444/ E1444M:2016	Standard Practice for Magnetic Particle Testing
	ASTM E 1734:2016	Standard Practice for Radioscopic Examination of Castings
	ASTM E 1742/ E1742M:2018	Standard Practice for Radiographic Examination
	ASTM E 1814:2014	Standard Practice for Computed Tomographic (CT) Examination of Castings
	ASTM E 2375:2016	Standard Practice for Ultrasonic Testing of Wrought Products
	ASTM E 2445/M2445M:2020	Standard Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems
	ASTM E 2698:2018-e1	Standard Practice for Radiological Examination Using Digital Detector Arrays
	IR99: 1999	Ionizing Radiation Regulations 1999
	NAS 410:2014	NAS Certification and Qualification of Non Destructive Test Personnel
	SAE-ARP-4402:2013	Eddy Current Inspection of Open Fastener Holes in Aluminium Aircraft Structure
	SAE-AS-4787:2013	Eddy Current Inspection of Circular Holes in Nonferrous Metallic Aircraft Engine Hardware
	SAE-AMS-2154D:202020	Process for Inspection, ultrasonic, wrought metals
	SAE-AMS-2647:2009	Fluorescent Penetrant Inspection Aircraft and Engine Component Maintenance
	SAE-AMS-2644:2006	Inspection material penetrant
	QPL-AMS-2644:2016	Inspection material, penetrant

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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 purposed of this Standards, the term and definition from ECSS-E-ST-32-01 apply:

1. safe life potential fracture critical item

NOTE This definition is equivalent to the definition of "damage tolerant fracture critical items" in NASA standards like NASA-STD-5019.

3.2 Terms specific to the present standard

3.2.1 black light (UVA light)

near ultraviolet radiation used for exciting fluorescence

3.2.2 close visual testing

close proximity, intense visual examination of the internal and external surfaces of a structure, including structural details or locations, for indications of impact damage, flaws, and other surface defects

NOTE 1 The testing capability is evaluated by the surface deflection measurement (impact depth).

NOTE 2 Close visual testing is considered to detect reliably a deflection larger than the visual damage threshold (VDT).

3.2.3 Image Quality Indicator (IQI)

series of wires or series of plates-containing holes having different diameters

3.2.4 NDT method

disciplines of non-destructive testing within which different techniques exist

NOTE Example of the different techniques are: ultrasonic and radiography.

[Based on EN 4179:2017]

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3.2.5 NDT instruction

written description of the precise steps to be followed in testing to an established standard, code, specification or NDT procedure

NOTE This standard specifies in all cases an NDT procedure.

3.2.6 NDT technique

specific way of utilizing an NDT method

NOTE For example, ultrasonic immersion technique.

[adapted from EN 4179:2017]

3.2.7 NDT procedure

written description of all essential parameters and precautions to be applied when non-destructively testing products in accordance with standard(s), code(s) or specification(s)

NOTE An NDT procedure can involve the application of more than one NDT method or technique.

3.2.8 responsible Level 3

a level 3 designated by the employer with the responsibility and authority to ensure that the requirements of this standard are met to act on behalf of the employer

[EN 4179:2017]

3.2.9 special fracture control NDT

NDT methods applied in the context of fracture control implementation on safe life items that are capable of detecting cracks or crack-like discontinuities smaller than those assumed detectable by standard fracture control NDT or do not conform to the requirements for standard fracture control NDT

[adapted from “Special NDI” definition of ECSS-E-ST-32-01C (2008)]

NOTE Special NDT methods are not limited to fluorescent penetrant, radiography, ultrasonic, eddy current, and magnetic particle.

3.2.10 standard fracture control NDT

NDT methods of metallic materials for which the required statistically based detection capability has been established.

[adapted from “Special NDT” definition of ECSS-E-ST-32-01]

NOTE Standard NDT methods addressed by this document are limited to fluorescent penetrant, radiography, ultrasonic, eddy current, and magnetic particle.

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3.2.11 personnel qualification

skills, training, knowledge, examinations, experience and visual capability required for personnel to properly perform to a particular level

[adapted from EN 4179:2017]

3.2.12 personnel certification

written statement by an employer that an individual has met the applicable requirements

[adapted from EN 4179:2017]

NOTE In some standards employer is called certifying agency or body.

3.2.13 product family

combination of the following penetrant testing materials: penetrant, excess penetrant remover and developer

[adapted from EN ISO 3452-2:2013]

3.2.14 NDT procedure verification

process of certifying the efficacy of a testing process through a demonstration, on a representative structure, in a representative environment, and by representative testing personnel

[adapted from MIL-HDBK-6870B]

NOTE 1 Equipment, reference standards and written procedures are all examples of items that are included in the procedure verification process.

NOTE 2 The term "qualification" from the ECSS-Q-ST-70-15 is synonymous with the term "verification" used in ECSS documentation.

NOTE 3 Examples for processes to be certified are testing process and manufacturing process.

3.3 Abbreviated terms and symbols

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

Abbreviation	Meaning
AMS	Aerospace Material Specification
ASTM	American Society for Testing and Materials
CR	computed radiography
CT	computed tomography
DDA	digital detector array
DRD	document requirements definition
DR	digital radiography

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Abbreviation	Meaning
ET	eddy current testing
EEE	electrical, electronic and electromechanical
EN	European Standard
FMECA	failure modes, effects and criticality analysis
FSW	friction stir welding
MMC	metal matrix composites
MPCB	materials and processes control board
MT	magnetic particle testing
NAS	National Aerospace Specification
NCR	nonconformance report
NDT	non-destructive testing
NRB	nonconformance review board
PFCI	potential fracture control critical
POD	probability of detection
PSM	penetrant system monitoring
PT	penetrant testing
RFD	request for deviation
RT	radiographic testing
QQI	quantitative quality indicator
QMS	quality management system
TIG	tungsten inert gas welding
UT	ultrasonic testing
UTG	ultrasonic thickness gauge
UV	ultraviolet
VDT	visual damage threshold

3.4 Nomenclature

3.4.1 Formal verbs

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”.

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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.

3.4.2 Conventions

The term "qualification" from the ECSS-Q-ST-70-15 is synonymous with the term "verification" used in ECSS documentation. This is not applicable to the qualification of personnel.

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4
Principles

The NDT of materials is carried out in such a way that product integrity and surface texture remain within specifications. The NDT of parts is particularly important for products or components where failure or malfunction can have serious implications.

These include loss of mission hardware and for flight hardware.

If NDT methods are selected but not covered by the current version of this standard, then the generic processes defined in clause 5 and clause 9 are followed.

This is presented in the following Figure 4-1 which shows the steps taken and the choice of NDT method and technique.

NOTE Additional complementary material information can be found in Annex G.

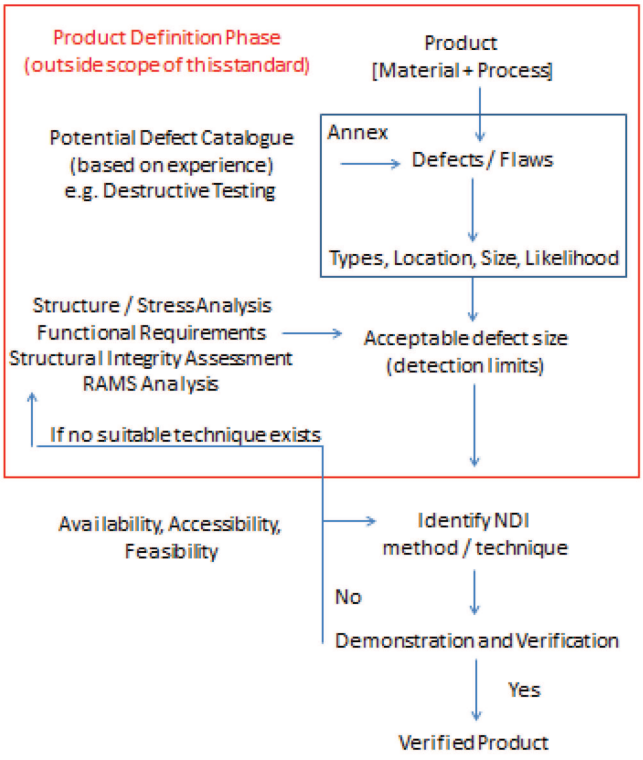

Figure 4-1: Flow chart showing steps to be taken for a part and choice of NDT method and technique

Examples for potential discontinuities are presented in Annex D.

ECSS-E-ST-32-01 requires many parts subjected to fracture control are subjected to NDT and proof testing to screen for internal and external cracks. Specific additional requirements are addressed in clause 9.

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5
Generic requirements

5.1 General

a. The supplier shall, for each part or assembly to be tested, establish and maintain documented NDT procedures in compliance with Annex C.

b. NDT procedures shall be made available for review at customer request.

c. The design definition authority shall specify NDT acceptance criteria.

NOTE It is assumed that accept and reject criteria reflect the possible need to ensure that cracks smaller than the targeted crack size are reported as "detected cracks" in line with ECSS-E-ST-32-01 clause 10.7 (for example > 50 % of the targeted crack size).

d. The NDT procedure shall be written in accordance with the DRD in Annex C.

e. All NDT procedures shall be verified to assure repeatable sensitivity needed for classification of the part.

NOTE This can include capability demonstration in accordance with clause 5.5.

f. The NDT plan shall be prepared in accordance with Annex A, prior to performing NDT.

g. The NDT plan prepared by the supplier responsible for the NDT, shall be submitted to the customer for approval.

h. The areas of the part identified in the design definition file shall be tested.

i. NDT shall be performed by certified NDT inspectors in accordance with requirements from clause 5.7 of the present standard and requirements from clause 5.1.2 of ECSS-Q-ST-20.

j. All Work instructions, which in general are specific to a part number, shall be prepared by a NDT Level 2 inspector as a minimum and approved by a Level 3, both of whom are certified in the corresponding method in compliance with requirements from clause 5.7.

NOTE Definition of Level is given in the EN 4179 clause 5 (Qualification and Certification Levels).

k. The Work Instruction shall as a minimum include:

1. Identification of parts
2. Applicable documentation
3. Sketch of the part, indicating testing zones
4. Preparation operations of the parts, prior to testing

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5. Inspection equipment or systems, accessories and ancillary materials
6. Inspection method to be used
7. Parameters of testing equipment or systems
8. Calibration procedure
9. Inspection procedure
10. Reference standard
11. Scanning parameters for the applicable techniques:
    (a) Speed;
    (b) Index;
    (c) Positioning of the part in the testing area.
12. Evaluation criteria
13. NDT Acceptance criteria
14. Control data for a procedure:
    (a) Unique Number;
    (b) Issue;
    (c) Preparation date;
    (d) Record of revisions and dates;
    (e) Author and qualification;
    (f) Authorization and qualification;
    (g) Date.

NOTE 1 to item 5.1k.7: the examples of parameters of testing equipment or systems are frequency and kV.

NOTE 2 to item 5.1k.9: reference can be made to the general procedures established in the specifications.

l. Generic Instruction may be used when considered applicable by the responsible Level 3 within the method.

m. All parts subject to an NDT examination shall be recorded for traceability in a logbook raised and controlled by the organisation performing the NDT.

n. All NDT plans shall be subject to agreement between customer and supplier, at the latest during MPCB, in accordance with ECSS-Q-ST-70 in consultation with responsible Level 3.

o. Supplier shall raise NCRs about any discontinuities detected during NDT testing not meeting the customer specifications.

p. For any deviations from the customer requirements an RFD shall be raised in conformance with ECSS-M-ST-40.

NOTE In case of cracks see requirement 5.2c.

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q. The processing of the NCR shall be in compliance with requirements from ECSS-Q-ST-10-09.

NOTE This can lead to new testing or to re-testing of parts after identification of discontinuities to be performed by using the same NDT plan and procedure, and to the need of customer agreement.

r. If NDT methods are selected that are not covered by this standard, then the generic process specified in clause 5 and clause 9 shall be followed.

s. In the case of conflicting requirements, Clause 8 shall take precedence over Clause 6.

t. In the case of conflicting requirements, ECSS-Q-ST-70-39 shall take precedence over Clause 6 requirements.

5.2 Discontinuities and cracks

a. Any discontinuities outside of the acceptance limits shall be subject to the NCR process.

b. For the discontinuities identified in 5.2a, the responsible Level 3 in the method shall assess the need to raise an NCR in conformance with the DRD in Annex A from ECSS-Q-ST-10-09.

c. All detected cracks, regardless of size, constitute ground for rejection and shall lead to a Major NCR as specified in ECSS-Q-ST-10-09.

NOTE The NRB decision is likely to lead to a rejection unless the customer agrees otherwise.

5.3 NDT drawing callouts

a. NDT testing specifications for all parts to be tested shall be identified or referred to in all drawings.

b. The drawings shall identify or refer to each testing requirement by zone when different zones require different NDT testing requirements and acceptance criteria.

c. The drawings shall be updated when NDT testing requirements are updated.

5.4 NDT process and configuration control

a. A written NDT procedure, in conformance with DRD from Annex C, shall be developed for each part to be tested, and approved by the responsible Level 3 of the appropriate NDT method.

b. Configuration control shall be performed in compliance with ECSS-M-ST-40 for the following:

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1. Personnel qualification and certification
2. NDT specification
3. NDT standards
4. Part specific NDT procedures

NOTE It is important that the meaning of NDT procedure, instruction, and specification is clarified between customer and supplier.

c. All certification records, NDT reports, and associated paperwork shall be in accordance with requirements from ECSS-M-ST-40 clause 5.3.7 and ECSS-Q-ST-10 clause 5.2.6.

5.5 NDT procedure capability demonstration

a. Supplier shall demonstrate NDT capability in accordance with clause 9.1.3.

b. Capability demonstration test not covered by clause 9.1.3 shall be agreed between customer and supplier.

c. The test specimens shall be representative of the features of the part to be tested, which affect the testing method.

NOTE 1 NDT procedures can be verified on parts or on test pieces simulating the actual part and which provide the essential features of the part with regard to the important application variables which can affect sensitivity of detection and confidence level. These aspects can differ significantly between different NDT methods.

NOTE 2 Examples are similarity based on wetting behaviour for penetrant testing and microstructure features for eddy current and ultrasonic testing.

d. POD demonstration by "hit and miss" method needs not be performed for:

1. Guided manual testing
2. Manual testing of local area or volume with reference to the applied procedure and equipment, if coverage of the complete area or volume can be guaranteed.

NOTE The inspection procedure is approved by the customer according to 9.2.2.2h or 5.5b.

e. For detected discontinuities the accuracy of the sizing method shall be demonstrated.

NOTE The concept of POD does not apply to already detected discontinuities. POD evaluation example is given in Annex F.

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5.6 Organizational guidelines and documentation requirement

a. The NDT organization shall be specified in the suppliers QMS.

NOTE Examples for the definition of this organization are provided in EN 4179:2017 and NAS 410:2014. Further guidelines are presented in NASA-STD-5009:2019 Appendix B.

5.7 NDT personnel qualification and certification

a. For penetrant, magnetic particle, eddy current, ultrasonic, radiographic, thermographic and shearographic testing, personnel for non-destructive inspections shall be certified in accordance with EN 4179:2017 or NAS 410:2014.

b. For NDT methods not explicitly covered by EN 4179:2017 or NAS 410:2014, each organisation shall write a procedure detailing the Qualification and approval of personnel for non-destructive testing.

NOTE Clause 6.4 of EN 4179:2017 is called “Emerging NDT methods”.

c. The procedure document of 5.7b shall meet the minimum requirements of clause 6.4 of EN 4179:2017 or NAS 410:2014, commonly known as the Written Practice.

NOTE The procedure document is reviewed and approved by the responsible Level 3 of the organisation and finally authorised by a senior member of the organisation for example, Quality Manager or Director.

d. Other standards may be accepted on a case by case basis, if agreed between the customer and supplier.

NOTE Examples of commonly applied standards are: EN ISO 9712:2012 that covers leak testing and visual testing not covered by EN 4179:2017 and NAS 410:2014. For critical applications additional requirements can apply in order to ensure that e.g. training and experience are in line with EN 4179 and NAS 410.

e. Inspection personal shall be qualified in accordance with EN ISO 9712:2012 and documented within the company written practice, in compliance with 5.7c.

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6 NDT methods

6.1 Visual testing

6.1.1 Overview

6.1.1.1 General process for visual testing

Visual testing contains the detection and appraisal of surface attributes by use of the human eye. In difference to any other NDT method that provide indications to be interpreted, visual testing provides quality indications like material discontinuities, dimensional deviations and surface quality levels that can be tested directly.

To judge about the level of quality deviation it can be necessary to use auxiliary equipment like magnifiers, microscopes, mirrors, endoscopes or borescopes. The reporting criteria of the indications are specified by the individual test procedure and depend on the kind of test object, application and criticality rating.

6.1.1.2 Visual testing process variations

The visual testing can be performed as direct or indirect testing:

a. All techniques that do not interrupt the glance of the human eye to the testing surface are direct visual testing techniques. For example: visual testing by use of a magnifier or a microscope.

b. All techniques that interrupt the glance of the human eye to the testing surface are indirect visual testing techniques. For example: visual testing by use of a camera endoscope or a mirror.

6.1.2 General visual testing requirements

a. Visual testing of welds shall be performed in accordance with EN ISO 17637:2016.

b. Any deviations from EN ISO 17637:2016 called in 6.1.2a shall be agreed with the customer.

NOTE This is likely to apply to additional viewing conditions needed for items other than welds.

c. Additional viewing conditions shall be agreed with the customer, with the exception of welds.

d. The testing object shall be accessible in that way, that the surface can be tested within a distance of 600 mm and with a viewing angle $\geq$ 30°.

e. A written instruction shall be prepared and approved by the responsible Level 3 within the method.

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NOTE During visual testing special attention is given to optimization of the viewing and lighting conditions.

6.1.3 Visual testing equipment

6.1.3.1 Overview

Typical pieces of equipment in use for the visual testing are:

- Magnifiers
- Microscopes
- Endoscopes
- Lenses
- Mirrors
- Vernier callipers
- Scales
- Gauges
- Photometer
- Illuminations sources
- Comparison catalogues.

6.1.3.2 Requirements for visual testing equipment

a. Electrical equipment shall be serviced and calibrated at least once a year, within a period agreed with the customer.

b. All electrical and mechanical measurement instruments shall be calibrated at least once a year.

c. All devices shall be listed and controlled in the user's measurement instruments calibration list.

d. Comparison catalogues should be controlled within the company documentation management system.

6.1.4 Visual testing application

a. Visual testing sequence as a minimum shall include the following:

1. An overview of the part to be tested:

   (a) Check that the available documentation includes testing specification, drawings.

   (b) Check of the test designation

2. Check of testing conditions,

3. Check of testing sensitivity,

4. Check of surface indications against specification,

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5. Appraisal of found indications against the acceptance criteria,
6. Classification of indications.

b. The acceptance criteria of visual testing shall be agreed between customer and supplier.

6.1.5 Visual testing documentation

a. The visual testing documentation shall be in compliance with NDT report from the DRD from Annex B.

6.1.6 Visual testing process control

a. The visual testing techniques shall include a trial testing by use of a test body, unless agreed with the customer.

b. The test sample of requirement 6.1.6a shall be representative of the testing object with respect to reflection behaviour, surface texture, accessibility and contrast conditions.

c. The test sample may be replaced by an original test object or an approved reference system, subject to customer approval.

NOTE Special test cards are in use to demonstrate the performance of endoscopes and borescopes.

6.1.7 Visual testing process limitations and peculiarities

a. In the case of critical applications the visual testing should be combined with additional NDT processes to verify inspections results.

NOTE 1 Misinterpretation can result from peculiarities as for example grain boundaries at the surface which can be misinterpreted as cracks.

NOTE 2 Examples of additional NDT processes for metallic parts are dye penetrant, eddy current or magnetic particle testing.

b. The magnification of the visual testing should be chosen based on the size and characteristics and criticality of the object to be tested, features to be detected and subsequently specified in the relevant testing procedure or work instruction.

c. For small and smooth welds a magnification larger than five times shall be used.

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