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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 21347

Space systems — Fracture and damage control

Systèmes spatiaux — Maîtrise des fissurations et des dommages

ICS: 49.140

ISO/TC 20/SC 14

Secretariat: **ANSI**

Voting begins on:
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2024-12-13

This document is circulated as received from the committee secretariat.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 21347:2005), which has been technically revised.

The main changes are as follows:

- Reflection of the systematic review comments for ISO 21347:2005.
- Updates for the normative references and the citations from the normative sections. Requirements in structural related standards have been organized to avoid duplication.
- Updates for the terms and definitions to harmonize with the other ISO structural related standards.
- Document construction changes to meet the requirements in ISO/IEC Directives Part 2.
- Update for approaches to classify nonfracture critical item (non-FCI)
- Supplemental information has been added to [Annex A](#).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

To prevent premature structural failure due to the propagation of cracks or crack-like defects during a structure's service life, fracture control policy is being imposed on space systems. These systems include civil and military space vehicles, launch systems, and their related ground support equipment. For manned space flight systems, most procurement agencies have considered fracture control a mandatory human safety related requirement. For example, the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) have required fracture control for all payloads using the NASA Space Shuttle (Shuttle) and all equipment items installed on the International Space Station (ISS). These systems have established specific fracture control requirements. These requirements have been implemented on all the payloads and equipment items using the Shuttle and ISS.

Recently, many procurement agencies and range safety authorities have imposed fracture control requirements on critical hardware items such as main propellant tanks of expendable launch vehicles (ELVs) and high-pressure gas bottles used in unmanned spacecraft in order to prevent loss of life and/or launch site facilities. Mechanical damage control is also being required by many range safety authorities on impact damage prone composite-overwrapped pressure vessels (COPVs). This document provides uniform fracture and mechanical damage control requirements to the non-Shuttle and non-ISS hardware. It can be applied to safety and mission critical structures and other hardware items.

Space systems — Fracture and damage control

1 Scope

This document establishes general requirements for the application of fracture control technology to fracture-critical items (FCIs) fabricated from metallic, non-metallic or composite materials. It also establishes mechanical damage control requirements for mechanical-damage-critical items (MDCIs) fabricated from composite materials. These requirements, when implemented on a particular space system, can assure a high level of confidence in achieving safe operation and mission success.

The requirements set forth in this document are the minimum fracture control and mechanical damage control requirements for FCIs and MDCIs in general space systems, including launch vehicles, spacecraft and ground support equipment. With necessary modifications, these requirements may also be applicable to reusable launch vehicles (RLVs). This document is not applicable to the Shuttle and its payloads or the ISS and its equipment, since they already have a set of specific requirements suitable for their special applications.

This document is not applicable to processing detected defects.

2 Normative references

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

ISO 10786, *Space systems — Structural components and assemblies*

ISO 14623, *Space systems - Pressure vessels and pressurized structures — Design and operation*

ISO 21648, *Space systems — Flywheel module design and testing*

ISO 24638, *Space systems — Pressure components and pressure system integration*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 burst strength after impact

BAI

actual burst pressure of a pressure vessel after it has been subjected to an impact event

[SOURCE: ISO 21347:2005, 3.1]

3.2

catastrophic hazard

potential risk situation that can result in loss of life, life-threatening or permanently disabling injury, occupational illness, loss of an element of an interfacing manned flight system, loss of launch site facilities, or long-term detriment to the environment

[SOURCE: ISO 21347:2005, 3.2]

3.3

composite material

combination of materials different in composition or form on a macro scale

Note 1 to entry: The constituents retain their identities in the composite.

Note 2 to entry: The constituents can normally be physically identified, and there is an interface between them.

Note 3 to entry: Composites include:

- fibrous (composed of fibres, usually in a matrix),
- laminar (layers of materials), and
- hybrid (combination of fibrous and laminar).

Note 4 to entry: A bonded structure such as metallic honeycomb sandwich is not considered as a composite structure in this International Standard.

[SOURCE: ISO 10786:2011, 3.10, modified— EXAMPLE has been deleted and the note 3 to entry has been added, reflecting the contents of EXAMPLE. Note 4 to entry has been added.]

[SOURCE: ISO 16454:2007, 3.6, modified— Note 3 and Note 4 to entry has been added.]

[SOURCE: ISO 21347:2005, 3.3, modified — The wording, “which differ” has been replaced by “different”. The wording in Note 1 to entry, “Normally, the constituents can be physically identified, and there is an interface between them. A bonded structure such as metallic honeycomb sandwich is not considered as a composite structure in this International Standard.” has been deleted. Note2 to entry has been added separating from Note 1 to entry. Note 3 and Note 4 to entry has been added.]

[SOURCE: ISO 21648:2011, 2.1.6, modified — The wording, “which differ” has been replaced by “different”. The wording in Note 1 to entry, “i.e. they do not dissolve or otherwise merge completely into each other, although they act in concert. Normally, the composites can be physically identified and exhibit an interface between one another” has been deleted. Note2 to entry has been added separating from Note 1 to entry. Note 3 and Note 4 to entry has been added.]

[SOURCE: ISO 23020:2021, 3.1.6, modified— Note 3 and Note 4 to entry has been added.]

3.4

composite-overwrapped pressure vessel

COPV

pressure vessel ([3.31](#)) with a fibre-based composite system fully or partially encapsulating a liner

Note 1 to entry: The liner serves as a liquid or gas permeation barrier and may or may not carry substantial pressure loads. The composite overwraps generally carry pressure and environmental loads.

Note 2 to entry: The COPV containing a metallic liner is referred to as a metal-lined COPV while the COPV containing a nonmetallic liner is referred to as a nonmetal-lined COPV.

[SOURCE: ISO 10786, 3.11, modified —Note 2 to entry has been added.]

[SOURCE: ISO 14623:2003, 2.11, modified — The wording in Note 1 to entry, “fluid” has been replaced by “liquid”. Note 2 to entry has been added.]

[SOURCE: ISO 21347:2005, 3.4, modified —re-numbered from former Note 1 and Note 2 to entry to Note 2 and Note 1 to entry. The wording in former Note 2 to entry, “fluid” has been replaced by “liquid” in current Note 1 to entry.]

3.5

critical flaw

specific shape of *flaw* ([3.12](#)) with sufficient size such that unstable growth will occur under the specific operating load and environment

[SOURCE: ISO 14623:2003, 2.13]

[SOURCE: ISO 21347:2005, 3.5]

3.6

critical hazard

potential risk situation that can result in temporarily disabling but not life-threatening injury, or temporary occupational illness; loss of, or major damage to, flight systems, major flight system elements or ground facilities; loss of, or major damage to, public or private property, or short-term detrimental environmental effects

[SOURCE: ISO 21347:2005, 3.6]

[SOURCE: ISO 10795:2019, 3.75]

3.7

damage tolerance

ability of a structure or a component of a structural assembly to resist failure due to the presence of *flaws* ([3.12](#)), for a specified period of unrepaired usage

[SOURCE: ISO 10786:2011, 3.13, modified —The wording, “cracks, or other damage” placed after “flaws”, has been deleted.]

[SOURCE: ISO 14623:2003, 2.15 modified — The wording, “a material/structure”, has been replaced by “a structure or a component of a structural assembly”. The wording, “cracks, delaminations, impact damage or mechanical other damage” placed after “flaws”, has been deleted.

[SOURCE: ISO 21347:2005, 3.7, modified — The wording, “a material/structure”, has been replaced by “a structure or a component of a structural assembly”]

[SOURCE: ISO 21648:2008, 2.1.7, modified — The wording, “structure/material”, has been replaced by “a structure or a component of a structural assembly”]

[SOURCE: ISO 24638:2021, 3.5, modified — The wording, “a material/structure”, has been replaced by “a structure or a component of a structural assembly”]

3.8

damage tolerance threshold strain level

strain level below which no crack or damage propagation will occur when subjected to expected load or environmental conditions

[SOURCE: ISO 21347:2005, 3.8]

3.9 design burst pressure

burst pressure

ultimate pressure

differential pressure that pressurized hardware must withstand without burst in the applicable operational environment

Note 1 to entry: Design burst pressure is equal to the product of the *maximum expected operating pressure (MEOP)* (3.25) or *maximum design pressure (MDP)* (3.24) and a design burst factor.

[SOURCE: ISO 14623:2003, 2.16, modified — In Note 1 to entry, “the MEOP or MDP” has been changed to “the maximum expected operating pressure (MEOP) or maximum design pressure (MDP)”.]

[SOURCE: ISO 24638:2021, 3.7]

3.10 design safety factor safety factor

design factor of safety

factor of safety

multiplying factor to be applied to the *limit loads* (3.22) and/or *maximum expected operating pressure (MEOP)* (3.25)

Note 1 to entry: The factor is defined in order to account for the statistical variations of loads and structural strength, and inaccuracies in the knowledge of their statistical distributions.

Note 2 to entry: On above definition, the word, *maximum expected operating pressure (MEOP)* (3.25), may be replaced by *maximum design pressure (MDP)* (3.24).

[SOURCE: ISO 14623:2003, definition 2.17, modified — The preferred term “safety factor” and the admitted terms “design factor of safety” and “factor of safety” have been added; “MEOP (or MDP)” has been changed to “maximum expected operating pressure (MEOP) “. Note 1 and Note 2 to entry has been added.]

[SOURCE: ISO 10785:2011, 3.11, modified — The preferred term “safety factor” has been added; “MEOP (or MDP)” has been changed to “maximum expected operating pressure (MEOP) “. Note 1 and Note 2 to entry has been added.]

[SOURCE: ISO 24638:2021, 3.8, modified — The word “or maximum design pressure (MDP)” has been deleted from the definition statement. Note 1 and Note 2 to entry has been added.]

3.11 fail-safe structure

structural item (3.47) for which it can be shown by analysis or test that, as a result of structural redundancy, the structure remaining after the failure of any element of the *structural item* (3.47) can sustain the redistributed *limit loads* (3.22) with an ultimate *design safety factor* (3.10) of 1,0

Note 1 to entry: For this entry, it is possible to verify that the *structural item* (3.47) can withstand the fatigue induced by cyclic loads for all the mission life for multi-mission applications, without *damage tolerance* (3.7) life verification.

[SOURCE: ISO 21347:2005, 3.10, modified – Note 1 to entry has been modified.]

[SOURCE: ISO 10786:2011, 3.20]

3.12 flaw

local discontinuity in a structural material

EXAMPLE Crack, cut, scratch, void, delamination or disbond, impact damage and other kinds of *mechanical damage* (3.26).

[SOURCE: ISO 14623:2003, 2.25, modified—The wording, “such as a scratch, notch or crack” has been deleted from the definition of the term, and EXAMPLES have been added.]

[SOURCE: ISO 21347:2005, 3.11, modified—In EAMPLES, the wording, “cut”, “scratch”, “void”, impact damage and other kinds of mechanical damage” has been added, and the wording, “debonding”, has been replaced by “disbond”.]

[SOURCE: ISO 21648:2008, 2.1.12, modified—In EAMPLES, the wording, “cut”, “scratch”, “void”, “disbond”, “impact damage and other kinds of mechanical damage” has been added.]

[SOURCE: ISO 10785:2011, 3.16]

[SOURCE: ISO 10786:2011, 3.23]

3.13

fracture control

application of design philosophy, analysis methods, manufacturing technology, verification methodology, quality assurance, including *non-destructive evaluation (NDE)* (3.30) and operating procedures to prevent premature structural failure caused by the presence and/or propagation of *flaws* (3.12) during fabrication, testing, transportation, handling, and service events such as launch, in-orbit operation, and return

[SOURCE: ISO 10786:2011, 3.24]

[SOURCE: ISO 14623:2003, 2.27, modified —The wording, “including non-destructive evaluation (NDE)” has been added after the wording “quality assurance”. The wording, “the propagation of cracks or crack-like flaws” has been replaced by “the presence and/or propagation of flaws”. The wording, “service” has been replaced by “service events such as launch, in-orbit operation, and return”]

[SOURCE: ISO 21347:2005, 3.12, modified —The wording, “including non-destructive evaluation (NDE)” has been added after the wording “quality assurance”. The wording, “the propagation of cracks or crack-like flaws” has been replaced by “the presence and/or propagation of flaws”. The wording, “service” has been replaced by “service events such as launch, in-orbit operation, and return”]

[SOURCE: ISO 21648:2008, 2.1.17, modified —The wording, “including non-destructive evaluation (NDE)” has been added after the wording “quality assurance”. The wording, “the propagation of cracks or crack-like flaws” has been replaced by “the presence and/or propagation of flaws”. The wording, “ground-handling and service” has been replaced by “handling, and service events such as launch, in-orbit operation, and return”]

3.14

fracture-critical item

fracture-critical part

structural part whose failure due to the presence of a flaw would result in a *catastrophic hazard* (3.2)

[SOURCE: ISO 10786:2011, 3.25, modified — The wording, “failure” has been replaced by “hazard”]

3.15

fracture-limited life item

structural part that requires periodic re-inspection or replacement to comply with *damage tolerance* (3.7) requirements

Note 1 to entry: Applicability to this entry is demonstrated by showing that the *structural item* (3.47) can withstand the propagation of cracks or crack-like *flaws* (3.12) induced by the cyclic loads during the flight missions implemented within the intervals between appropriate ground maintenance, including periodic re-inspection or replacement of the *structural item* (3.47).

[SOURCE: ISO 21347:2005, 3.13, modified —The wording, “any hardware item” has been replaced by “structural part”. Note 1 to entry has been added.]

3.16

fracture mechanics

engineering discipline that describes the behaviour of cracks or crack-like *flaws* (3.12) in materials under stress