BS ISO 10786:2011

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Space systems — Structural components and assemblies

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National foreword

This British Standard is the UK implementation of ISO 10786:2011.

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Systèmes spatiaux — Composants et assemblages de structure

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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.

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

ISO 10786 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

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Introduction

Structures are the backbones of all spaceflight systems. A structural failure could cause the loss of human lives for manned space systems or could jeopardize the intended mission for unmanned space systems. Currently, there is no International Standard that covers all the aspects that can be used for spaceflight structural items such as spacecraft platforms, interstage adaptors, launch vehicle buses and rocket motor cases.

The purpose of this International Standard is to establish general requirements for structures. It provides the uniform requirements necessary to minimize the duplication of effort and the differences between approaches taken by the participating nations and their commercial space communities in developing structures. In addition, the use of agreed-upon standards will facilitate cooperation and communication among space progammes.

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Space systems — Structural components and assemblies

1 Scope

This International Standard establishes requirements for the design; material selection and characterization; fabrication; testing and inspection of all structural items in space systems, including expendable and reusable launch vehicles, satellites and their payloads. This International Standard, when implemented for a particular space system, will assure high confidence in achieving safe and reliable operation in all phases of its planned mission.

This International Standard applies specifically to all structural items, including fracture-critical hardware used in space systems during all phases of the mission, with the following exceptions: adaptive structures, engines and thermal protection systems.

2 Normative references

The following referenced documents are indispensable for the application 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 14622:2000, *Space systems —Structural design — Loads and induced environment*

ISO 14623:2003, *Space systems — Pressure vessels and pressurized structures — Design and operation*

ISO 14953:2000, *Space systems — Structural design — Determination of loading levels for static qualification testing of launch vehicles*

ISO 14954:2005, *Space systems — Dynamic and static analysis — Exchange of mathematical models*

ISO 15864:2004, *Space systems — General test methods for space craft, subsystems and units*

ISO 16454:2007, *Space systems — Structural design — Stress analysis requirements*

ISO 21347:2005, *Space systems — Fracture and damage control*

ISO 21648:2008, *Space systems – Flywheel module design and testing*

ISO 22010:2007, *Space systems — Mass properties control*

ISO 24638:2008, *Space systems — Pressure components and pressure system integration*

ISO 24917:2010, *Space systems — General test requirements for launch vehicles*

MIL-STD-1540, *Revision D Test Requirements for Space Vehicles*

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3 Terms and definitions

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

3.1
A-basis allowable
A-basis design allowable
A-value
mechanical strength value above which at least 99 % of the population of values is expected to fall, with a confidence level of 95 %

[ISO 16454:2007]

3.2
acceptance test
required formal test conducted on flight hardware to ascertain that the materials, manufacturing processes, and workmanship meet specifications and that the hardware is acceptable for intended usage

[ISO 14623:2003]

3.3
adaptive structures
autonomous structural systems which incorporate sensors, processors, and actuators to enable adaptation to changing environmental conditions, thereby enhancing safety, stability, vibration damping, acoustic noise suppression, aerodynamic performance and optimization, pointing accuracy, load redistribution, damage response, structural integrity, etc.

3.4
allowable load
maximum load that can be accommodated by a structure or a component of a structural assembly without potential rupture, collapse, or detrimental deformation in a given environment

NOTE 1 “Allowable loads” commonly correspond to the statistically based ultimate strength, buckling strength, and yield strength, or maximum strain (for ductile materials).

NOTE 2 “Allowable load” is often referred to as just “allowable”.

3.5
assembly
combination of parts, components and units which forms a functional entity

3.6
B-basis allowable
B-basis design allowable
B-value
mechanical strength value above which at least 90 % of the population of values is expected to fall, with a confidence level of 95 %

[ISO 16454:2007]

3.7
buckling
failure mode in which an infinitesimal increase in the load could lead to sudden collapse or detrimental deformation of a structure

EXAMPLE Snapping of slender beams, columns, struts and thin-wall shells.

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3.8
catastrophic failure
failure which results in the loss of human life, mission or a major ground facility, or long-term detrimental environmental effects

3.9
collapse
failure mode induced by quasi-static loads (compression, shear or combined stress) accompanied by irreversible loss of load-carrying capability

3.10
composite material
combination of materials different in composition or form on a macro scale

NOTE 1 The constituents retain their identities in the composite.

NOTE 2 The constituents can normally be physically identified, and there is an interface between them.

[ISO 16454:2007]

EXAMPLE Composites include

— fibrous (composed of fibres, usually in a matrix),

— laminar (layers of materials), and

— hybrid (combination of fibrous and laminar).

3.11
composite overwrapped pressure vessel
COPV
pressure vessel with a fibre-based composite system fully or partially encapsulating a liner

NOTE 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.

[ISO 14623:2003]

3.12
composite structure
structural components that are made of composite materials

3.13
damage tolerance
ability of a structure or a component of a structural assembly to resist failure due to the presence of flaws, cracks, or other damage for a specified period of unrepaired usage

[ISO 21347:2005]

3.14
design parameter
physical feature which influences the design performance of the design of structural items

NOTE According to the nature of the design variables, different design problems can be identified such as:

— structural sizing for the dimensioning of beams, shells, etc.;

— shape optimization;

— material selection;

— structural topology.

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3.15
design safety factor
factor by which limit loads are multiplied in order to account for uncertainties and variations that cannot be analysed or accounted for explicitly in a rational manner

NOTE Design safety factor is sometimes referred to as design factor of safety, factor of safety or just safety factor.

3.16
detrimental deformation
structural deformation, deflection or displacement that prevents any portion of the structure or some other system from performing its intended function or that jeopardizes mission success

3.17
development test
test to provide information that can be used to check the validity of analytic techniques and assumed design parameters, uncover unexpected system response characteristics, evaluate design changes, determine interface compatibility, prove qualification and acceptance procedures and techniques, check manufacturing technology, or establish accept/reject criteria

[ISO 16454:2007]

3.18
dynamic load
time-dependent load with deterministic or stochastic variation

3.19
failure mode
rupture, collapse, detrimental deformation, excessive wear or any other phenomenon resulting in an inability to sustain loads, pressures and corresponding environments, or that jeopardizes mission success

NOTE This definition applies to structural failure.

3.20
fail-safe structure
structural item 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 can sustain the redistributed limit load, with an ultimate safety factor of 1,0

[ISO 21347:2005]

3.21
fatigue life
number of cycles of stress or strain of a specified character that a given structure or component of a structural assembly can sustain (without the presence of flaw) before failure of a specified nature could occur

3.22
failure mode effects and critically analysis
FMECA
analysis performed to systematically evaluate the potential effect of each functional or hardware failure on mission success, personnel and system safety, system performance, maintainability and maintenance requirements

NOTE It is also used to rank by the severity of its effect.

3.23
flaw
local discontinuity in a structural material

EXAMPLES Crack, cut, scratch, void, delamination disbond, impact damage and other kinds of mechanical damage.

[ISO 21347:2005]

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3.24
fracture control
application of design philosophy, analysis methods, manufacturing technology, verification methodology, quality assurance, including non-destructive evaluation (NDE) and operating procedures to prevent premature structural failure caused by the presence and/or propagation of flaws during fabrication, testing, transportation, handling, and service events such as launch, in-orbit operation, and return

3.25
fracture-critical item
fracture-critical part
structural part whose failure due to the presence of a flaw would result in a catastrophic failure

3.26
full scale article
full-size test article which represents the whole flight structure or a part of the flight structure with representative loading and boundary conditions

3.27
hydrogen embrittlement
mechanical-environmental process that results from the initial presence or absorption of excessive amounts of hydrogen in metals, usually in combination with residual or applied tensile stresses

[ISO 14623:2003]

3.28
human vibration
vibration transmitted to and/or induced by the crew members

3.29
life factor
coefficient by which the number of cycles or time is multiplied in order to account for uncertainties in the statistical distribution of loads and cycles, as well as uncertainties of the methodology used in the life related analyses

NOTE 1 Life factor and scatter factor are interchangeable terms in some documents.

NOTE 2 Life factor is sometimes referred to as scatter factor when uncertainties are material uncertainties.

EXAMPLE Factors used in fatigue (life) analysis and damage tolerance life (crack growth safe-life) analysis.

3.30
limit load
LL
maximum expected load, or combination of loads, which a structure or a component in a structural assembly is expected to experience during its service life in association with the applicable operating environments

NOTE 1 Load is a generic term for thermal load, pressure, external mechanical load (force, moment, or enforced displacement) or internal mechanical load (residual stress, pretension, or inertial load).

NOTE 2 The corresponding stress or strain is called limit stress or limit strain.

NOTE 3 Limit load is sometimes referred to as design limit load. See informative Annex A.

3.31
loading case
combined loading case
particular condition of single (or combined) mechanical load, pressure and temperature, which can occur for some structural components or a structural assembly at the same time during their service life

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3.32
loading spectrum
representation of the cumulative loading levels and associated cycles anticipated for the structure or component of a structural assembly according to its service life under all expected operating environments

NOTE Significant transportation, test, and handling loads are included in this definition.

3.33
margin of safety
MS
measure of a structure's predicted reserve strength in excess of the design criteria

NOTE 1 For a single loading condition, MS is expressed as:

MS = { [Allowable Load (Yield or Ultimate)] / [Limit Load x Factor of Safety (Yield or Ultimate)]} -1

NOTE 2 Load may mean force, stress, or strain, if the load-stress relationship is linear.

NOTE 3 The relation also can be expressed for a combined loading case, when the load-stress relationship remains linear for all the contributors of the loading case. Also see alternative methods in Annex D.

3.34
mass and inertia properties
mass and inertia properties of a structure comprise its mass, the location of its centre of gravity, its moments and products of inertia, and, where applicable, its balancing masses

3.35
maximum expected operating pressure
MEOP
highest differential pressure which a pressurized hardware item is expected to experience during its service life and retain its functionality, in association with its applicable operating environments

NOTE 1 MEOP includes the effects of temperature, transient peaks, relief pressures, regulator pressure, vehicle acceleration, phase changes, transient pressure excursions, and relief valve tolerance.

NOTE 2 Some particular project may replace MEOP by Maximum Design Pressure (MDP), which takes into account more conservative conditions.

3.36
metallic structural item
structural item made of metals

NOTE In this document, load bearing metallic liners of COPVs are also referred to as metallic structural items.

3.37
moving mechanical assembly
MMA
mechanical or electromechanical device that controls the movement of one mechanical part of a vehicle relative to another part

EXAMPLES Gimbals, actuators, despin and separation mechanisms, motors, latches, clutch springs, dampers, or bearings.

3.38
POGO
instability due to the coupling between the vehicle axial motion and the dynamic response characteristic of the propulsion system

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3.39
pressure component
component in a pressurized system, other than a pressure vessel, pressurized structure that is designed largely by the internal pressure

[ISO 24638:2008]

EXAMPLES Valves, pumps, lines, fittings, hoses and bellows.

3.40
pressure vessel
container designed primarily for storage of pressurized fluid that (1) contains gas or liquid with an energy level of 19,310 joules (14,240 foot-pounds) or greater, based on adiabatic expansion of a perfect gas; or (2) contains gas or liquid that will create a mishap (accident) if released; or (3) will experience a MEOP greater than 700 kPa (100 psi)

NOTE Pressurized structures, pressure components and pressurized equipment are excluded from this definition.

3.41
pressurized equipment
special pressurized equipment
piece of equipment that meets the pressure vessel definition, but for which it is not feasible or cost effective to comply with the requirements applicable to pressure vessels

EXAMPLES Batteries, heat pipes, cryostats and sealed containers.

3.42
pressurized hardware
pressurized hardware includes pressure vessels, pressurized structures, pressure components and pressurized equipment

3.43
pressurized structure
structure designed to carry both internal pressure and vehicle structural loads

[ISO 14623:2003], [ISO 24638:2008]

EXAMPLES Main propellant tanks and solid rocket motor cases of launch vehicles, and crew cabins of manned modules.

3.44
primary structure
part of a structure that carries the main flight loads and defines the overall stiffness of the structure, thus influencing its natural frequencies and mode shapes

3.45
proof factor
multiplying factor applied to the limit load or MEOP to obtain proof load or proof pressure for use in the acceptance testing

3.46
protoqualification test
test of the flight-quality article to a higher load level and duration than the acceptance test applied to flight units under prototype qualification strategy

NOTE The testing consists of the same types and sequences as used in qualification testing.

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3.47
qualification test
required formal contractual test conducted at load levels and durations to demonstrate that the design, manufacturing, and assembly of flight-quality structures have resulted in hardware that conforms to specification requirements

NOTE In addition, the qualification test may validate the planned acceptance progamme including test techniques, procedures, equipment, instrumentation, and software.

3.48
random load
vibrating load or fluctuating load whose instantaneous magnitudes are specified only by probability distribution functions giving the probable fraction of the total time that the instantaneous magnitude lies within a specified range

NOTE A random load contains non-periodic or quasi-periodic constituents.

3.49
residual strength
maximum value of load and/or pressure (stress) that a flawed or damaged structural item is capable of sustaining without further damage or collapse, considering appropriate environmental conditions

3.50
residual stress
stress that remains in a structure after processing, fabrication, assembly, testing or operation

EXAMPLE Welding-induced residual stress.

[ISO 14623:2003]

3.51
S-basis allowable
mechanical strength value specified as a minimum by the governing industrial specification, or a particular contractor's specification

EXAMPLES Properties given in MMPDS (Metallic Materials Properties Development and Standardization).

3.52
safe life
(1) design criterion under which failure does not occur in the expected environment during the service life

(2) required period during which a structural item, even containing the largest undetected flaw, is shown by analysis or testing not to fail catastrophically under the expected service load and environment

NOTE 1 An equivalent definition is “period during which the structure is predicted not to fail in the expected service life environment”.

NOTE 2 Safe life is also referred as damage tolerance life or fatigue life.

3.53
safe-life structure
structure designed according to the safe-life design criterion

3.54
scatter factor
coefficient by which the number of cycles or time defined in service life is multiplied in order to account for uncertainties in material properties when performing fatigue and/or crack growth analysis

NOTE Scatter factor is sometimes referred to as life factor, which is usually used for just the difference in material data used in the analysis; for example, S-N data used in fatigue life analysis, or da/dN data used in crack grow analysis.

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3.55
secondary structure
structure attached to the primary structure with negligible participation in the main load transfer and overall stiffness

3.56
service life
period of time (or cycles) that starts with item inspection after manufacturing and continues through all testing, handling storage, transportation, launch operations, orbital operations, refurbishment, retesting, re-entry or recovery from orbit, and reuse that can be required or specified for the item

3.57
shock load
special type of transient load, where the load shows significant peaks and the duration of the load is well below the typical response time of the structure

3.58
stiffness
ratio between an applied force and the resulting displacement

3.59
stress-corrosion cracking
mechanically and environmentally induced failure process in which sustained stress and chemical attack combine to initiate and/or propagate a crack or a crack-like flaw in a metal part

[ISO 21347:2005]

3.60
stress-rupture life
minimum time during which a non-metallic structural item maintains structural integrity, considering the combined effects of stress level(s), time at stress level(s), and associated environments

3.61
structural component
mechanical part(s) in a functional hardware item designed to sustain load and/or pressure or maintain alignment

EXAMPLES Antenna support structure, instrument housing, and pressure vessel.

3.62
structural design
process used to determine geometries/dimensions and to select materials of a structure

3.63
structural item
structure, structural subsystem (assembly), or structural component

EXAMPLES Spacecraft trusses, launch vehicle fairings, pressure vessels and pressurized structures; also fasteners, instrument housing and support brackets.

3.64
structural mathematical model
analytical or numerical representation of a structure

NOTE It is advisable that the model provides an adequate description of the structure's response under loads/pressures/temperatures.

[ISO 16454:2007]

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3.65
structure
structural assembly
set of mechanical components or assemblies designed to sustain (carry) internal and/or external loads or pressures; provide (maintain) stiffness, alignment, and/or stability; and provide support or containment for other systems or subsystems

NOTE The space vehicle structure is usually categorized into primary and secondary structures.

3.66
system threat analysis energy level
maximum expected energy level due to an impact resulting from a credible threat event determined in a system threat analysis

3.67
static load
quasi-static load
load which is independent of time or are varying slowly with time, so that the dynamic response of the structure is insignificant

NOTE Quasi-static loads comprise both static and dynamic loads and are applied at a frequency sufficiently below the natural frequency of the considered part, thus being equivalent to static loads in their effects on the structure.

3.68
transient load
load whose magnitude or direction varies with time and for which the dynamic response of the structure is significant

[ISO 14622:2000]

NOTE These loads can be induced by transportation, gusts, engine ignition or shutdown, separation, orbital docking, physical impact, or deployment of appendages.

3.69
ultimate load
UL
maximum design load that the structure shall withstand without rupture or collapse, which is expressed as a limit load multiplied by an ultimate design safety factor

NOTE The corresponding stress and/or strain is called ultimate stress and/or strain.

3.70
ultimate strength
maximum load or stress that a structure or material can withstand without incurring rupture or collapse

3.71
vibroacoustic
environment induced by high-intensity acoustic noise associated with various segments of the flight profile

NOTE It manifests itself throughout the structure in the form of transmitted acoustic excitation and as structure-borne random vibration.

3.72
visual damage threshold
VDT
impact energy level shown by test(s) to create an indication that is barely detectable by a trained inspector using an unaided visual inspection technique

[ISO 21347:2005]

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3.73
yield load
YL
maximum design load that the structure shall withstand without detrimental deformation, which is expressed as a limit load multiplied by a yield design safety factor

NOTE The corresponding stress and/or strain is called yield stress and/or strain.

3.74
yield strength
maximum load or stress that a structure or material can withstand without incurring a specified permanent deformation or yield

NOTE The yield is usually determined by measuring the departure of the actual stress-strain diagram from an extension of the initial straight proportion. The specified value is often taken as an offset unit strain of 0,002.

4 Symbols and abbreviated terms

The following abbreviated terms are defined and used within this document:

ε - N	fatigue strain-life data
$\sum n/N$	Miner's rule
AIT	assembly, integration and tests
AOCS	attitude and orbit control system
BIT	built-in testing
CAD	computer aided design
CAE	computer aided engineering
CAM	computer aided manufacturing
COPV	composite overwrapped pressure vessel
da/dN	fatigue crack growth rate
DDF	design definition file
DJF	design justification file
DOF	degree(s) of freedom
DSF	design safety factor
ECLS	environment control and life support
EMC	electromagnetic compatibility
EVA	extra-vehicular activity
FCI	fracture critical item
FEA	finite element analysis

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FE	finite element
FM	flight model
FMECA	failure mode effects and criticality analysis
FOS	factor of safety
FSI	fluid structure interaction
HDBK	handbook
Hz	hertz
ICD	interface control document
K_c	fracture toughness
KPP	key process parameter
LBB	leak-before-burst
LCDA	launcher coupled dynamic analysis
LL	limit load
MDP	maximum design pressure
MEOP	maximum expected operating pressure
MEOS	maximum expected operating speed
MMPDS	Metallic Materials Properties Development and Standardization
M/OD	meteoroid and orbital debris
MS	margin of safety
NASA	National Aeronautics and Space Administration
NDE	non-destructive evaluation (examination)
NDI	non-destructive inspection
NDT	non-destructive test
PFO	particle fall out
RMS	root-mean-square
SEP	system engineering plan
S-N	fatigue stress-life data
VDT	visual damage threshold

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5 Tailoring

For a specific progamme or project, the requirements defined in this International Standard may be tailored to match the actual requirements of the particular progamme or project. Tailoring of requirements shall be undertaken in agreement with the procuring authority where applicable.

Tailoring is a process by which individual requirements or specifications, standards, and related documents are evaluated and made applicable to a specific progamme or project by selection, and in some exceptional cases, by modification and addition of requirements in the standards.

Requirements for a human-rated progamme or project can be adjusted for a specified use by a procurement agency.

6 Requirements

6.1 General

Clause 6 presents the general requirements for the design; material selection and characterization; fabrication and process control; quality assurance; storage and transportation; repair and refurbishment for all structural items.

6.2 Design requirements

6.2.1 Static strength

6.2.1.1 Ultimate strength

All structural items shall have the strength and stiffness in all necessary configurations to support the ultimate loads, pressure and operating environments throughout their respective service lives without catastrophic failure or collapse.

6.2.1.2 Yield strength

All structural items shall have the strength and stiffness in all necessary configurations to support the yield loads, pressure and operating environments throughout their respective service lives, including the expected tests without detrimental (excessive or permanent) deformation, yielding, gapping, sliding, or losing rigidity that can jeopardize the mission objectives.

NOTE 1 For functional requirements (e.g. no excessive deformation, gapping, sliding, loss of rigidity) some projects may consider limit loads only instead of yield loads.

NOTE 2 For metal structural components, local yielding may exist. This local yielding is acceptable if it does not cause overall permanent set instability or fatigue failure of the structure, and remains compliant with the functional requirements.

6.2.2 Buckling strength

Buckling shall not cause structural failure when ultimate loads are applied, nor shall it cause excessive deformations to degrade functioning of any system or produce changes in any loads that shall be accounted for. All structural items subjected to significant in-plane stresses (compression and/or shear) or external pressure under any combination of ground loads, flight loads, or loads resulting from temperature changes, shall be analysed or tested for buckling failure. Buckling evaluation shall address local or global instability, crippling, and creep. Design loads for buckling shall be ultimate loads, except that the minimum anticipated value shall be used for any load component that tends to alleviate buckling.

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Local buckling shall be prevented unless:

a) the buckling is reversible;

b) the resulting stiffness and deformations still conform to the structural and functional requirements.

6.2.3 Margin of safety (MS)

The MS for every structural strength or buckling calculation shall be positive under single or combined loads, pressures, and accompanying environments such as temperature for each design condition.

NOTE "Positive" means equal to or greater than the margin specified in the margin policy for the structural item.

6.2.4 Stiffness

All structural items shall possess adequate stiffness to preclude detrimental deformations due to loads corresponding to the expected test and operating environments throughout their respective service lives.

They shall also possess adequate stiffness to preclude collapse at design ultimate load. The cumulative elastic, permanent, and thermal deformations shall not degrade structural capability or adversely affect aerodynamic characteristics. In addition:

a) the structure shall be designed to conform to required stiffness under the specified load and boundary conditions, and

b) the stiffness of subassemblies and components and interfaces shall be such that the structural and functional performance requirements are met.

NOTE Stiffness is often expressed in terms of a minimum natural frequency requirement.

Deformations leading to the following failure modes shall be avoided: violations of specified envelopes, gapping at joints, the creation of inefficient load paths and dynamic coupling with other subsystems, e.g. Attitude and Orbit Control System (AOCS).

6.2.5 Dynamic behaviour

The natural frequencies of a structure shall be within specified bandwidths to prevent dynamic coupling with major excitation frequencies (e.g. launch vehicle fundamental frequencies).

Spacecraft structures shall be designed to avoid coupling with the launch vehicle control system. The stiffness of each structural item shall be consistent with the minimum required stiffness to ensure structural adequacy under transient dynamic loads. In addition, the body-bending frequencies shall be within the limits imposed by the vehicle flight control system.

The spacecraft shall be designed to avoid load-inducing dynamic coupling of flexible modes during launch, in-orbit operations, and landing. When avoiding such coupling is not practical, careful evaluation of the resulting dynamic loads, and their simulation by analysis or test, shall be required.

Structural components and assemblies shall be capable of performance within specification after exposure to sinusoidal vibration, random vibration, vibroacoustic and shock environment as appropriate.

6.2.6 Dimensional stability

Structural materials shall remain dimensionally stable under given environments during ground, flight, landing, and post-landing operations. The structural item shall not lose alignment that would impact the mission under the action of applied loads, including the effects of temperature, humidity, and venting. In addition:

a) Dimensional stability of the structure shall conform to mission specified system and payload requirements.

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b) The design of a structure shall ensure that no loss of alignment which jeopardizes or degrades the mission objectives can be caused by the action of applied loads (e.g. launch loads, deployment loads, thermal stress and moisture release).

c) Selected materials shall take into account the stability of the material under the specified environment in-service.

NOTE Dimensional stability requirements address the short, medium and long-term alignment stability of a space structure under the operational environment.

6.2.7 Tolerances and alignments

The accuracy of the system of tolerances applied to the mechanical design shall guarantee conformance to geometrical interface requirements.

The angular and position tolerances shall be consistent with the alignment or pointing accuracy of the assembly to achieve the mission objectives.

In cases where alignment adjustability is specified, either at assembly level or at spacecraft level, these provisions shall be included in the mechanical design together with the devices (e.g. alignment cubes) and procedures required for measurement or checking of the alignment.

6.2.8 Thermal

The design of space structures shall conform to the constraints imposed by thermal design to meet the mission objectives.

The temperatures and temperature variations and gradients during all phases of a mission, including manufacturing and storage, shall be taken into account, both in the material selection and in the design in order to achieve the specified functional and structural performance.

6.2.9 Thermal distortion

Detrimental distortion of structural items due to thermal loading shall be prevented during transfer orbit, in orbit, or in safe mode operation including the effects of the molecular heating.

It is necessary that thermal distortion effects for spacecraft pointing and/or co-alignment of sensors be reduced.

6.2.10 Interface requirements

Interfaces of structural parts that include joints and connections shall be taken into consideration in the structural design. The structural integrity of bond joints, weld joints, and other forms of joints and connections shall be assessed, including the potential interaction among failure modes.

The design of bolted joints shall include sufficient thread engagement.

6.2.11 Electromagnetic compatibility

Structural requirements imposed by electromagnetic compatibility (EMC) of the equipment and payload structures shall be taken into account.

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