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Space systems — Pressure components and pressure system integration

Systèmes spatiaux — Intégration des composants sous pression et des systèmes sous pression

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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 24638 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

Space vehicles and their launch systems usually have a series of engines to use for both primary propulsion and secondary propulsion functions, such as attitude control and spin control.

Different engines have different propellant feed systems; for example, the gas-pressure feed system is typically used for liquid propellant engines, and it consists of a high-pressure gas tank, a fuel tank and an oxidizer tank, valves and a pressure regulator. All these components are referred to as pressurized hardware.

Due to their specific usage, the liquid propellant tanks and the high-pressure gas bottles are often referred to as pressure vessels, while valves, regulators and feed lines are usually called pressure components.

ISO 14623 sets forth the standard requirements for pressure vessels in order to achieve safe operation and mission success. However, the requirements for pressure components are not covered in ISO 14623. Furthermore, the standard requirements for pressure system integration are lacking.

Significant work has been done in the area of design, analysis and testing of pressure components for use in space systems. This International Standard establishes the preferred methods for these techniques and sets forth the requirements for assembly, installation, test, inspection, operation and maintenance of the pressure systems in spacecraft and launch vehicles.

Space systems — Pressure components and pressure system integration

1 Scope

This International Standard establishes the baseline requirements for the design, fabrication and testing of space flight pressure components. It also establishes the requirements for assembly, installation, test, inspection, operation and maintenance of the pressure systems in spacecraft and launch vehicles. These requirements, when implemented on a particular space system, ensure a high level of confidence in achieving safe and reliable operation.

This International Standard applies to all pressure components other than pressure vessels and pressurized structures in a pressure system. It covers lines, fittings, valves, bellows, hoses and other appropriate components that are integrated to form a pressure system.

The requirements for pressure vessels and pressurized structures are set forth in ISO 14623.

This International Standard does not apply to engine components.

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

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

3 Terms and definitions

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

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

NOTE See also **B-basis allowable** (3.3).

3.2
applied load
applied stress
actual load (stress) imposed on the hardware in the service environment

3.3
B-basis allowable
mechanical strength value above which at least 90 % of the population of values is expected to fall, with a confidence level of 95 %

NOTE See also **A-basis allowable** (3.1).

3.4
component
functional unit that is viewed as an entity for the purpose of analysis, manufacturing, maintenance, or record keeping

3.5
critical condition
most severe environmental condition in terms of loads, pressures and temperatures, or combinations thereof, imposed on systems, subsystems, structures and components during service life

3.6
damage tolerance
ability of a material or structure to resist failure due to the presence of flaws, cracks, delaminations, impact damage or other mechanical damage for a specified period of unrepaired usage

3.7
damage tolerance analysis
safe-life analysis
fracture mechanics-based analysis that predicts the flaw growth behaviour of a flawed hardware item which is under service load spectrum with a pre-specified scatter factor

3.8
design burst pressure
burst pressure
ultimate pressure
differential pressure that pressurized hardware needs to withstand without burst in the applicable operational environment

NOTE Design burst pressure is equal to the product of the maximum expected operating pressure or maximum design pressure and a design burst factor.

3.9
design safety factor
design factor of safety
factor of safety
multiplying factor to be applied to limit loads and/or maximum expected operating pressure (or maximum design pressure)

3.10
detrimental deformation
structural deformation, deflection or displacement that prevents any portion of the structure or other system from performing its intended function

3.11
fittings
pressure components of a pressurized system used to connect lines, other pressure components and/or pressure vessels within the system

3.12
hazard
existing or potential condition that can result in an accident

3.13
hydrogen embrittlement
mechanical-environmental failure 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

3.14
limit load
highest predicted load or combination of loads that a structure can experience during its service life, in association with the applicable operating environments

NOTE The corresponding stress is called “limit stress”.

3.15
lines
tubular pressure components of a pressurized system provided as a means for transferring fluids between components of the system

NOTE Flexhoses are included.

3.16
loading spectrum
representation of the cumulative loading anticipated for the structure under all expected operating environments

NOTE Significant transportation and handling loads are included.

3.17
maximum allowed working pressure
MAWP
maximum differential pressure of a component designed to withstand safety and continue to operate normally when installed in any pressure system

3.18
maximum design pressure
MDP
highest differential pressure defined by maximum relief pressure, maximum regulator pressure and/or maximum temperature, including transient pressures, at which a pressurized hardware item retains two-fault tolerance without failure

3.19
maximum expected operating pressure
MEOP
highest differential pressure that a pressurized hardware item is expected to experience during its service life and yet retain its functionality, in association with its applicable operating environments

NOTE In this International Standard, the use of the term “maximum expected operating pressure (MEOP)” also signifies “maximum design pressure (MDP)”, “maximum operating pressure (MOP)” or “maximum allowed working pressure (MAWP)”, as appropriate, for a specific application or programme.

3.20
maximum operating pressure
MOP
maximum differential pressure at which the component or the pressure system actually operates in an application

NOTE MOP is synonymous with MEOP.

3.21
pressure component
component in a pressure system, other than a pressure vessel, or a pressurized structure that is designed largely by the internal pressure

EXAMPLE Lines, fittings, pressure gauges, valves, bellows and hoses.

3.22
pressure vessel
container designed primarily for the storage of pressurized fluids, which either contains gas/liquid with high energy level, or contains gas/liquid that will create a mishap (accident) if released, or contains gas/liquid with high pressure level

NOTE 1 This definition excludes pressurized structures and pressure components.

NOTE 2 Energy and pressure levels are defined by each project and approved by the procuring authority (customer). If appropriate values are not defined by the project, the following levels are used:

— stored energy is at least 19 310 J, based on adiabatic expansion of perfect gas;

— MEOP is at least 0,69 MPa.

3.23
pressurized structure
structure designed to carry both internal pressure and vehicle structural loads

EXAMPLE Launch vehicle main propellant tank, crew cabins, manned modules.

3.24
pressure system
system that consists of pressure vessels or pressurized structures, or both, and other pressure components such as lines, fittings, and valves, which are exposed to, and structurally designed largely by, the acting pressure

NOTE The term “pressure system” does not include electrical or other control devices required for system operations.

3.25
proof factor
multiplying factor applied to the limit load or MEOP (or MAWP, MDP and MOP) to obtain proof load or proof pressure for use in the acceptance testing

3.26
proof pressure
product of MEOP (or MAWP, MDP and MOP) and a proof factor

NOTE The proof pressure is used to provide evidence of satisfactory workmanship and material quality and/or to establish maximum initial flaw sizes for damage tolerance life (safe-life) demonstration

3.27
scatter factor
multiplying factor to be applied to the number of load/pressure cycles, for the purpose of covering the scatters that potentially exist in the material’s fatigue or crack growth data

3.28
service life
period of time (or cycles) that starts with the manufacturing of the pressurized hardware and continues through all acceptance testing, handling, storage, transportation, launch operations, orbital operations, refurbishment, re-testing, re-entry or recovery from orbit, and reuse that can be required or specified for the item

4 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

COPV composite overwrapped pressure vessel

MAWP maximum allowed working pressure

MDP maximum design pressure

MEOP maximum expected operating pressure

MOP maximum operating pressure

NDI non-destructive inspection

QA quality assurance

5 General requirements

5.1 General

This clause presents the general requirements for pressure components in a pressure system regarding

— design and analysis,

— material selection and characterization,

— fabrication and process control,

— quality assurance (QA),

— operation and maintenance (including repair and refurbishment), and

— storage.

The general pressure system requirements are presented in Clause 6. The integration requirements for specific pressure systems are presented in Clause 7.

5.2 Design requirements

5.2.1 Loads, pressures and environments

The anticipated load-pressure-temperature history and other associated environments throughout the service life of the pressure system shall be determined in accordance with specified mission requirements. As a minimum, the following factors and their statistical variations shall be considered appropriate:

a) environmentally induced loads and pressures;

b) environments acting simultaneously with these loads and pressures with their proper relationships;

c) frequency of application of these loads, pressures and environments, and their levels and durations.

These data shall be used to define the design load/environment spectra, which shall be used for both design analysis and testing. The design spectra shall be revised as the structural design develops and the loads analysis matures.

5.2.2 Strength

Pressure components and their interconnections in a pressure system shall possess sufficient strength to withstand limit loads and MEOP in the expected operating environments throughout the service life without incurring detrimental deformation. The pressure components shall sustain proof pressure without leaking or incurring detrimental deformation. They shall also withstand ultimate loads and design burst pressure in the expected operating environments without rupturing or collapsing.

The minimum proof test factor for pressure components shall be 1,5. The minimum design burst factor varies depending on the type of pressure component. Table A.1 presents recommended minimum proof test factors and design burst factors for various pressure components.

A pressure system shall possess sufficient strength at the component interfaces, attachments, tie-downs and other critical points. The pressure system shall sustain proof pressure without experiencing leakage and incurring detrimental deformation.

5.2.3 Stiffness

The mounting and arrangement of all components in a pressure system shall provide adequate stiffness not to generate destructive vibration, shock and acceleration, and to prevent excess stresses at the interfaces between components and at mounting brackets when subjected to limit loads, MEOP and deflections of the supporting structures in the expected operating environments. Connections between adjacent components shall be designed to prevent excessive stresses at their interfaces from combined effects of limit loads, MEOP and deflections of the supporting structures in the expected operating environments.

5.2.4 Thermal effects

Thermal effects, including heating and cooling rates, temperatures, thermal gradients, thermal stresses and deformations, and changes with temperature of the physical and mechanical properties of the material of construction, shall be factored into the design of the flight pressure system. Thermal effects shall be based on temperature extremes that simulate those predicted for the operating environment, plus a predefined design margin. The design margin shall be based on national industry heritage, including experience in thermal effects that are important to a specific pressure component.

5.2.5 Stress analysis

A detailed stress analysis shall be performed on the pressure components and assembled and installed pressure system to demonstrate acceptable stress levels and deflections at the interfaces between components, at component attachments and tie-downs to support structures, and at other critical points in the system. The effects of flexure of lines, as well as supporting structures being acted on by the flight loads, pressures and temperature and thermal gradients, shall be accounted for in the analysis. The stress analysis shall also take into account the ground loads.

5.2.6 Fatigue analysis/damage tolerance (safe-life) analysis

In addition to the stress analysis, conventional fatigue-life analysis shall be performed, as appropriate, on the pressure component and the assembly. Nominal (average) values of fatigue-life (S-N) data shall be used in the analysis. A scatter factor of four shall be used on service life as specified in ISO 14623. In some cases, fatigue analysis shall be replaced by damage tolerance (safe-life) analysis in accordance with ISO 21347.