INTERNATIONAL STANDARD

ISO 10785

First edition
2011-10-01

Space systems — Bellows — Design and operation

Systèmes spatiaux — Soufflerie — Conception et fonctionnement

Reference number
ISO 10785:2011(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 10785 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

The bellows for space systems is usually used under severe conditions, such as high pressure, extremely low temperatures, large deflection, or high inner flow speed. The design safety factor of the bellows tends to be small in order to satisfy two different function requirements simultaneously. One is the function of the pressure bearing component, which all pressure components have, and the other is the special function to accommodate installation misalignment, thermal expansion or contraction and displacement induced by large deformation of the pressurized propellant tank.

There are many items to be considered for design and manufacture such as hoop stress, bulging stress, buckling strength, flow-induced vibration, and cyclic deflection.

This International Standard establishes general and specific requirements for bellows in order to provide safe and reliable bellows hardware and operations.

Some examples of the design safety factors are shown in Annex A at the end of this International Standard.

Space systems — Bellows — Design and operation

1 Scope

This International Standard specifies general and detailed requirements for bellows used in space systems. It establishes requirements with regard to material, design, analysis, fabrication, material, testing, inspection and operation for space use.

This International Standard is applicable to metallic bellows which are used as pressure bearing components and are integrated into a pressure system. This International Standard is not applicable to engine bellows or valve bellows.

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

3 Terms and definitions

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

3.1
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

3.2
bellows
corrugated single-layer or multi-layer elastic casing, when integrated into a duct assembly, capable of performing linear, shear and angular movements

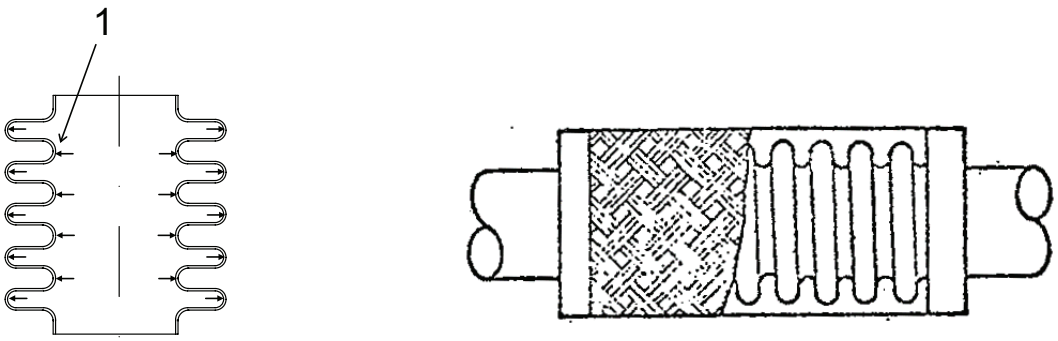
NOTE 1 A bellows consists of both a convolution section and a mechanical linkage section, which serves as a bellows restraint. The most common mechanical linkage types are gimbal-type and braided-type. In some cases a bellows contains an internal liner or flow tube for the purpose of improving flow capability.

NOTE 2 See Figure 1.

3.3
bellows stiffness
ratio between an applied force and the resulting bellows displacement

3.4
burst pressure
pressure level at which rupture or unstable fracture of the pressurized hardware item occurs

3.5
bulging stress
meridional or axial stress at the convolution section induced by pressure



Key

1 internal pressure

Figure 1 — Bellows

3.6
component
functional unit that is viewed as an entity for the purpose of analysis, manufacturing, maintenance, or record keeping

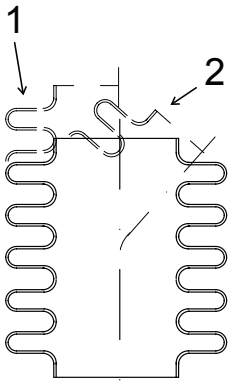
NOTE Adapted from ISO 14623:2003.

3.7
critical condition
most severe environmental condition in terms of loads, deflection, pressures and temperatures, or combination thereof, imposed on systems, subsystems, structures and components during service life

[ISO 14623:2003, definition 2.12]

3.8
deflection
contraction or expansion along its longitudinal axis, angular rotation, or lateral offset

NOTE See Figure 2.



Key

1 axial deflection
2 angular rotation

Figure 2 — Deflection

3.9
design burst factor
multiplying factor applied to maximum expected operating pressure (MEOP) or maximum design pressure (MDP) [3.20] to obtain the design burst pressure

3.10
design burst pressure
differential pressure that pressurized hardware must withstand without bursting in the applicable operational environment

NOTE Design burst pressure is equal to the product of the MEOP or MDP and a design burst factor.

[ISO 14623:2003, definition 2.16]

3.11
design safety factor
design factor of safety
factor of safety
multiplying factor to be applied to the limit load and/or maximum expected operating pressure (MEOP) or maximum design pressure (MDP) [3.20]

[ISO 14623:2003, definition 2.17]

3.12
detrimental deformation
structural deformation, deflection or displacement that prevents any portion of the structure or other system from performing its intended function or that jeopardizes mission success

NOTE Adapted from ISO 14623:2003, definition 2.19.

3.13
fatigue

process of progressive localized permanent structural change occurring in a material/structure subjected to conditions which produce fluctuating stresses and strains at some point or points and which may culminate in cracks or complete fracture after a sufficient number of fluctuations

[ISO 14623:2003, definition 2.23]

3.14
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 flaws) before failure of a specified nature occurs

NOTE Adapted from ISO 14623:2003, definition 2.24.

3.15
fracture
type of failure mode in a material/structure which is generally preceded by a large amount of plastic deformation

3.16
flaw
local discontinuity in a structural material

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

NOTE Adapted from ISO 14623:2003, definition 2.25.

3.17
hoop stress
circumferential stress at the convolution section induced by pressure

3.18
leak-before-burst
LBB
design concept which shows that at maximum expected operating pressure (MEOP) [3.20] potentially critical flaws will grow through the wall of a metallic pressurized hardware item and cause pressure relieving leakage rather than burst or rupture (catastrophic failure)

NOTE Adapted from ISO 14623:2003, definition 2.35.

3.19
limit load
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.

NOTE 4 Adapted from ISO 14623:2003, definition 2.36.

3.20
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 projects may replace MEOP with maximum design pressure (MDP), which takes into account more conservative conditions.

NOTE 3 Adapted from ISO 14623:2003, definition 2.41.

3.21
mechanical linkage section
section within bellows assembly that will serve as the bellows restraint for thrust force by pressure, deflection, or other factors

3.22
personnel's approach
action or state of a ground crew approach when near to the bellows or another component while the component is pressurized

3.23
proof factor
multiplying factor applied to the limit load or maximum expected operating pressure (MEOP) or maximum design pressure (MDP) [3.20] to obtain proof load or proof pressure for use in acceptance testing

[ISO 14623:2003, definition 2.50]

3.24
proof test pressure
pressure level used to give evidence of satisfactory workmanship and material quality and/or establish maximum initial flaw sizes for safe-life demonstration

3.25
qualification test
required formal contractual tests conducted at load levels and durations in order 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 programme, including test techniques, procedures, equipment, instrumentation, and software.

3.26
repair
action on a nonconforming product to make it acceptable for the intended use

NOTE 1 Repair includes remedial action taken on previously conforming product to restore it for use, for example as part of maintenance.

NOTE 2 Unlike rework, repair can affect or change parts of the nonconforming product.

3.27
refurbishment
renovation and restoration to intended use condition

3.28
service life
period of time (or number of 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 may be required or specified for the item

[ISO 14623:2003, definition 2.57]

3.29
work hardening effect
effect of strengthening material by plastic deformation

NOTE The representative material is 300 series corrosion-resistant steel.

4 Abbreviated terms

LBB leak-before-burst

MDP maximum design pressure

MEOP maximum expected operating pressure

NDI non-destructive inspection

QA quality assurance

S-N stress versus number of cycles to failure

NOTE Plots of S-N data are used in the fatigue test.

5 Requirements

5.1 General

Clause 5 presents the requirements for design, stress analysis, material selection and characterization, fabrication and process control, and quality assurance, as well as operational requirements including maintenance, repair, refurbishment and storage for bellows in a pressure system.