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Space systems — Flight-to-ground umbilicals

Systèmes spatiaux — Ombilicaux bord-sol

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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 15389:2001), which has been technically revised. It also incorporates the Amendment ISO 15389:2001/Amd 1:2005 and the Technical Corrigendum ISO 15389:2001/Cor 1:2006.

The main changes are as follows:

— addition of 4.9 on the prevention of accidental cross-connection.

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

This document establishes the general requirements and criteria for flight-to-ground umbilical systems used by space systems. The purpose of this document is to establish uniform engineering practices and methods and to ensure the inclusion of essential requirements in the design of reusable flight-to-ground umbilical systems that support the launch of space systems. This document is not intended to define how to design umbilicals but to define the minimum requirements for umbilicals.

Prevention of accidental cross-connection of umbilical system connectors and couplings is extremely important. Launch vehicle and spacecraft assemblies and features are often unique, requiring many connectors and couplings to be in close proximity to each other. The accidental cross-connection of service lines can result in very serious and even tragic consequences. For example:

— supplying other gas or fluids;

— supplying gas or fluid under other pressure;

— supplying the electric power with other parameters;

— supplying an error signal (command).

Therefore, differences in design of connectors and couplings that are located close to each other should be significant. Such differences can be both in design and in marking for identification.

International cooperation in space engineering assumes international cooperation in design, manufacture, and operation. The application of uniform methods increases the reliability of space systems by minimizing the accidental cross-connection of connectors and couplings. The application of unified symbols promotes mutual understanding and personnel training.

Space systems — Flight-to-ground umbilicals

1 Scope

This document defines the general criteria for the development of flight-to-ground umbilical systems used by a space system. These criteria apply to the service arms or equivalent mechanisms, umbilical carriers and plates, couplings, connectors, withdrawal and retract devices, handling mechanisms and control systems for mechanisms, as well as the prevention of accidental cross-connection.

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 14625, *Space systems — Ground support equipment for use at launch, landing or retrieval sites — General requirements*

IEC 60364-5-54, *Electrical installations of buildings — Part 5: Selection and erection of electrical equipment — Chapter 54: Earthing arrangements and protective conductors*

3 Terms and definitions

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

ISO and IEC maintain terminology 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
carrier
device that groups *coupling* (3.3) and *connector* (3.2) halves together to provide a common means for their positioning, retention, unlocking, and separation

Note 1 to entry: The term is commonly used in relation to the facility ground-side of umbilical *interfaces* (3.8).

3.2
connector
device, consisting of two halves, that permits engagement and disengagement of electrical circuits at an *interface* (3.8)

3.3
coupling
device, consisting of two halves, that permits transfer of fluid across and disconnection at an *interface* (3.8)

3.4
flanged connection
connection at which halves of *connectors* (3.2) or *couplings* (3.3) are mated by means of flanges

3.5
ground control
equipment, fluids, or signals, provided for command or control purposes, which are neither on board nor originate on board the launch vehicle

3.6
handling mechanism
device used to provide positioning, manipulation, and physical dead-weight support of an object

3.7
inflight
term that denotes an occurrence or function after vehicle *lift-off* (3.10)

3.8
interface
mechanical, thermal, electrical, or operational common boundary between two elements of a system

EXAMPLE Ground-to-vehicle interface, physical interface, or responsibility interface.

3.9
launch processing system
operating consoles, data handling and display equipment, and the associated transmission system configured to issue commands and analyse and display response data required in checkout and operation of ground support equipment (GSE) and flight hardware

3.10
lift-off
instant of flight at which the vehicle's contact is terminated with all areas of hold-down and/or support devices

Note 1 to entry: Lift-off is commonly called "first motion" of the vehicle.

3.11
nipple
half of a hydraulic or gas *coupling* (3.3) with an external sealing surface

3.12
plate
device that groups coupling and *connector* (3.2) halves together to provide a common means for retention

Note 1 to entry: The plate is a passive device, containing cooperating but usually immobile portions of positioning, locking, and separation machinery.

Note 2 to entry: The term is commonly used in relation to the vehicle side of umbilical *interfaces* (3.8) or with the *carrier* (3.1).

EXAMPLE Carrier plate.

3.13
pre-flight
<occurrence or function> occurring before vehicle *lift-off* (3.10)

3.14
rise-off
<device> actuated solely by a vehicle's vertical motion

3.15
service arm
retractable structure, usually attached to a tower used to provide either umbilical requirements, personnel access, or both to the flight vehicle

Note 1 to entry: A service arm is commonly called access arm, umbilical arm, or swing arm, depending upon whether it provides services for access only, *umbilicals* (3.19) only, or both, respectively.

Note 2 to entry: The service-arm retracting motion may be along an arc or in a vertical or horizontal plane.

3.16
T–0
time minus zero
last moment in the launch countdown, measured in seconds, at which time the launch vehicle lifts off the ground

3.17
tail service mast
retractable structure used to provide umbilical requirements to the aft portion (tail) of a space vehicle

Note 1 to entry: Movement is usually a rotation about a pivot point away from the vehicle.

3.18
threaded connection
connection at which halves of *connectors* (3.2) or *couplings* (3.3) are mated by means of a thread on each of the halves

3.19
umbilical
device that provides fluid (supply/return and purge) and electrical requirements at physical *interfaces* (3.8) between ground facilities and various areas of a space vehicle

3.20
umbilical assembly
mated *carrier* (3.1) and *plate* (3.12) containing all *couplings* (3.3) and *connectors* (3.2) for a specified umbilical region of the vehicle

3.21
umbilical service line
fluid line or electrical cable routed through an *umbilical* (3.19) such as a *service arm* (3.15) or equivalent mechanism that is to be disconnected prior to engine ignition or at *T–0* (3.16) or in flight

3.22
umbilical supply device
movable structure used to connect and/or disconnect the umbilical *plates* (3.12) at various locations on a space vehicle

3.23
umbilical system
functional assembly of all items required for providing fluid and electrical servicing to a launch vehicle and/or a payload

Note 1 to entry: This system usually includes the following:

— *service arms* (3.15) or equivalent *umbilical supply device* (3.22) mechanisms;

— umbilical *carriers* (3.1) and *plates* (3.12);

— *couplings* (3.3) and *connectors* (3.2), all separation, withdrawal, and retraction devices;

— control equipment;

— control fluids and electrical signals;

— all interconnecting lines across the service arms or the equivalent mechanism on the ground side.

Note 2 to entry: The mating-half *interface* (3.8) for the couplings/connectors and umbilical carrier should be located on the exterior surface of the launch vehicle at an orientation compatible with the launch structure.

3.24
union
half of a hydraulic or gas *coupling* (3.3) with an internal sealing surface

4 General requirements

4.1 Umbilical system principles

The umbilical design shall not require reconnection of disconnected umbilical service lines to abort safely on the launch pad. Passive umbilical systems disconnected at lift-off by gravity is the preferred system as opposed to active systems to minimize failure modes and potential damage to the flight hardware. Adequate safety margins and/or system redundancy shall be included in the design to preclude premature umbilical disconnect that can jeopardize the flight hardware environment or vehicle and/or personnel safety. System design shall be a balance between ensuring umbilicals remain engaged and sealed under all static and dynamic pre-launch environments and safely disconnecting at lift-off.

Disconnect after lift-off should have at least secondary and, if possible, tertiary modes to ensure vehicle safety as the primary feature and protection of the ground systems under the launch environment as a secondary feature. Umbilical failures shall not propagate into the flight vehicle system. Flight-to-ground umbilical systems shall conform to the general requirements specified in ISO 14625.

4.2 Mating

4.2.1 Time

The time required to connect and verify an umbilical assembly shall be minimized. Factors that should be considered include:

a) the number of steps required;

b) the number of component parts to be installed or manipulated in the connection process;

c) availability of, and accessibility with, mechanical handling aids;

d) available working space;

e) requirements for operating personnel;

f) safety requirements;

g) alignment requirements;

h) the adaptability to automated verification.

The goal for the time required to perform the mating operation is one work shift or less.

4.2.2 Handling and engagement

Rapid handling and engagement are necessary in order to minimize impact on the ground turnaround and crew size for launch support. To provide ease with which an umbilical assembly is mated and connected to a vehicle, consideration shall be given to mass, torque requirements, manual force required for connection, and rigidity of electrical cables, flex lines, propellant flex lines, ducts for environmental control systems, etc.

4.2.3 Alignment

The umbilical assembly shall be self-aligning. The design shall not require critical manual horizontal, vertical, or parallel alignment for mating.

4.2.4 Verification

Mated umbilical assemblies shall allow quick and reliable verification of integrity.

4.2.5 Materials

Umbilical materials shall be compatible with service line media, shall be corrosion-resistant, and shall meet flammability, odour, and off-gassing, or vacuum-stability requirements that may be required by the flight hardware system.

4.3 Mass

Umbilical parts shall be as lightweight as feasible to minimize launch-induced loads and ground-handling requirements.

4.4 Loads

4.4.1 General

Umbilical design shall accommodate all static and dynamic pre-launch loads, such as dead loads, fluid pressure loads, and catenary loads imposed on all lines running from the flight vehicle to the supporting structure coupled with wind loads. Connections shall be located on or within the carrier so as to evenly distribute the forces required for disconnect or retain the vehicle about the locking, release, and ejection mechanisms. The same consideration shall also be given to the design of the handling systems. Loads during lift-off (such as retractable, acoustical, vibrational, and heat- or blast-pressure loads, as applicable) shall also be accounted for during umbilical development.

4.4.2 Side loads

Carriers and plates shall be designed and used in a manner that prevents connectors or couplings and latching and/or carrier mechanisms from having side loads.

4.4.3 Tracking loads

The vehicle shall bear all loads associated with the tracking of vehicle motion by the umbilical assembly and the attached hardware and the loads shall be as low as possible, consistent with practical GSE design and reasonable vehicle interface structural requirements. Other than vehicle requirements, determining factors for loads shall include overall costs for the life of the program.

4.5 Contamination prevention

Both halves of all fluid couplings shall incorporate internal devices for the protection of the system from debris during the launch, flight, and recovery operations. The devices shall be normally in the closed position and shall be opened automatically by the engagement of the two coupling halves. The device shall close automatically as the two coupling halves are separated. The device may also be capable of being opened or closed upon command from the ground control system or launch processing system.

4.6 Purges

Electrical umbilical connectors shall be provided with an inert environment, to the extent required to ensure safety. Cryogenic connections should be purged as required to prevent moisture condensation as well as resulting ice build-up or liquefaction of air. Systems for hypergolic or other corrosive or