INTERNATIONAL STANDARD

ISO 15389

First edition
2001-01-15

Space systems — Flight-to-ground umbilicals

Systèmes spatiaux — Ombilicaux bord-sol

Reference number
ISO 15389:2001(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.ch
Web www.iso.ch

Printed 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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15389 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard establishes the general requirements and criteria for flight-to-ground umbilical systems used by space systems. The purpose of this International Standard 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 International Standard is not intended to define how to design umbilicals but to define the minimum requirements umbilicals must meet.

Space systems — Flight-to-ground umbilicals

1 Scope

This International Standard defines the general criteria for the development of flight-to-ground umbilical systems used by a space system. The criteria specified herein is limited to the service arms or equivalent mechanisms, umbilical carriers and plates, couplings, connectors, withdrawal and retract devices, handling mechanisms and control systems for mechanisms.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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 International Standard, the following terms and definitions apply.

3.1
carrier
device that groups coupling and connector halves together to provide a common means for their positioning, retention, unlocking, and separation

NOTE The term is commonly used in relation to the facility ground-side of umbilical interfaces.

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

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

3.4
ground control
equipment, fluids, or signals, provided for command or control purposes, which are neither on board nor originate on board the launch vehicle

3.5
handling mechanism
device used to provide positioning, manipulation, and physical dead-weight support of an object

3.6
inflight
term that denotes an occurrence or function after vehicle lift-off

3.7
interface
region of mating or boundary between separating or cooperating elements established by a governing characteristic

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

3.8
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

3.9
lift-off
term designating the instant of flight at which the vehicle's contact is terminated with all areas of hold-down and/or support devices

NOTE Lift-off is commonly called "first motion" of the vehicle.

3.10
plate
device that groups coupling and connector halves together to provide a common means for retention

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

NOTE 2 The term is commonly used in relation to the vehicle side of umbilical interfaces or with the carrier.

EXAMPLE Carrier plate.

3.11
preflight
term that denotes an occurrence or function before vehicle lift-off

3.12
rise-off
term applied to a device to denote that its actuation is solely caused by a vehicle's vertical motion

3.13
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 A service arm is commonly called access arm, umbilical arm, or swing arm, depending upon whether it provides services for access only, umbilicals only, or both, respectively.

NOTE 2 The service-arm retracting motion may be along an arc or in a vertical or horizontal plane.

3.14
T–0
time minus zero
last moment in the launch countdown, measured in seconds, at which time the launch vehicle lifts off the ground

3.15
tail service mast
retractable structure used to provide umbilical requirements to the aft portion (tail) of a space vehicle

NOTE Movement is usually a rotation about a pivot point away from the vehicle.

3.16
umbilical
device that provides fluid (supply/return and purge) and electrical requirements at physical interfaces between ground facilities and various areas of a space vehicle

3.17
umbilical assembly
mated carrier and plate containing all couplings and connectors for a specified umbilical region of the vehicle

3.18
umbilical service line
any fluid line or electrical cable routed through an umbilical such as a service arm or equivalent mechanism that is to be disconnected prior to engine ignition or at T–0 or in flight

3.19
umbilical supply device
movable structure used to connect and/or disconnect the umbilical plates at various locations on a space vehicle

3.20
umbilical system
functional assembly of all items required for providing fluid and electrical servicing to a launch vehicle and/or a payload

NOTE 1 This system usually includes the following:

— service arms or equivalent umbilical supply device mechanisms;

— umbilical carriers and plates;

— couplings and connectors, 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 The mating-half interface 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.

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 a launch vehicle's first motion during launch by gravity is the preferred system over 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 hazardous fluids shall have a purge, scrubbers, etc., as required for safe connect and disconnect operations. There shall be only one purge in a cavity between the carrier and the plate.

4.7 Leak detection

When hazardous fluids are present, such as hypergols or nitrogen, umbilical couplings shall utilize primary and secondary seals and shall have sensors to detect primary and secondary seal leakage to the extent possible. Redundant seals and integrity monitoring are desirable to achieve this goal in most instances.

4.8 Leakage disposal

Disposal of hazardous media leakage from couplings shall be provided during vehicle servicing.

4.9 Fluid couplings

The design of couplings for liquid or gas service lines to the umbilical shall ensure that it is impossible to mate a coupling improperly.

4.10 Electrical connectors

Electrical connectors shall be dead-faced and self-aligning. Data bus, power, and command functions shall be in separate connectors to the extent possible. Connectors contained in the carrier shall not be self-locking. The design of electrical connectors shall prevent incorrect mating of the connector.

4.11 Grounding

Umbilicals shall be grounded in accordance with the requirements of IEC 60364-5-54.

4.12 Electromagnetic compatibility (EMC)

Umbilical electrical and electronic systems shall be designed to minimize the generation of and susceptibility to electromagnetic interference in order to eliminate any possible deterioration of the performance of the system and surrounding systems. EMC requirements shall be in accordance with the requirements established by the flight hardware system.

4.13 Lightning current paths

Umbilical connections above the base area of a space vehicle shall be eliminated or minimized to reduce the number of electrical paths through the vehicle from a lightning strike on the facility structure.

4.14 Environmental conditions

4.14.1 General

A flight-to-ground umbilical shall meet natural and induced environments to which it is to be subjected during its life cycle. The natural and induced environmental conditions shall be defined and taken into consideration during the umbilical development.

4.14.2 Natural environment

Flight-to-ground umbilicals shall function properly at their respective geographical locations after exposure to the natural environment and shall be tailored to reflect program-defined risks and exposure times.

4.14.3 Launch-induced environment

Flight-to-ground umbilicals shall function properly when subjected to the launch-induced environment such as launch-induced acoustics, vibration, plume impingement, heat, and blast pressures, as applicable.

4.14.4 Fire- and/or explosion-hazard environment

Umbilicals operated in locations where fire or explosion hazards may exist due to flammable gases, vapours, and/or flammable liquids shall be hazard-proofed to prevent such hazardous conditions.

4.15 Component selection

Components used in the design of umbilical systems for a space vehicle shall be qualification tested for the intended application.

4.16 Corrosion control

The natural atmosphere and the induced environment contain residue that is readily deposited on exposed surfaces. This, combined with substantial moisture and generally high temperatures, results in an environment conducive to extensive corrosion of metals. The designer shall provide for corrosion control due to these environmental conditions by selecting materials and coatings and designing equipment for the prevention of crevice, stress, and galvanic corrosion.

4.17 Maintainability

Flight-to-ground umbilicals shall minimize the complexity and frequency of maintenance, the maintenance resources required to keep the system operational, and maintenance downtime. High-failure-rate items should be identified for accessibility concerns. Fault detection and isolation should be considered based on criticality and cost of failures.

4.18 Accessibility

The umbilical shall provide ready access for operating, testing, fault detecting, repairing, and replacing components. The design shall allow these functions to be performed without interfering with other components or assemblies.

4.19 Component position feedback

All remotely operated components used for an umbilical's ground controls shall have position feedback signalling to the extent possible. Command and feedback signals shall not usually be combined in the same connector or cable, regardless of source.

4.20 Connection inspection

The umbilical system shall provide for inspection of the proper mating of all connections between the flight and ground portions of the umbilical.

5 Design guidelines

5.1 Preflight disconnect

It is recommended that the design of the umbilical system has all preflight disconnects. Inflight disconnects are not recommended. In some situations, inflight disconnects are unavoidable. Acceptable alternatives are described in subclause 5.2.

5.2 Inflight umbilical assembly

5.2.1 Inflight preferences

When the vehicle requirement cannot be met by a preflight umbilical assembly only, the preferred design alternative for all inflight disconnects is the rise-off type. The second alternative is to have only those services that are to remain connected to achieve a safe abort routed through the rise-off umbilical assembly. The third preference should be to use a transverse disconnected umbilical activated at T–0, such as a tail service mast.

5.2.2 Rise-off umbilical assembly

5.2.2.1 General

The rise-off umbilical is characterized by the inflight umbilical plate being disconnected as a direct result of a vehicle's vertical motion. The ground carrier remains at a fixed elevation after mating and tracks the vehicle's

motion during pre-launch and launch conditions. The ground carrier may be removed by a device that provides for the unrestrained lift-off of the launch vehicle and protection from plume impingement.

The vehicle plate is subjected to relative motion with respect to the launcher due to the various induced forces (wind, temperature changes, fuel-loading operations, firing effects from the engine, etc.) between the time of umbilical mating and launch. The ground carrier shall be capable of tracking the vehicle to allow for these motions after mating without inducing premature disconnect. The couplings and connectors shall be designed to allow for these motions relative to the carrier plate and ground system.

The ground carrier shall use an alignment device to engage with mating receptacles such as an alignment pin. The device shall ensure the ground carrier is aligned with the vehicle's plate before any of the couplings and connectors start to engage. The carrier shall be elevated for connections by self-locking mechanisms, such as worm screw actuators. Provisions shall be made to limit loads transferred to the vehicle by such systems. Each of the couplings and connectors shall be self-aligning to ensure proper final engagement. Horizontal movement shall be inhibited by appropriate devices.

Disconnection lanyards or mechanisms should include redundant backup in case of failure of the primary mode.

5.2.2.2 Umbilical couplings and connectors

Umbilical couplings and connectors shall be of the nonlatching type. For the fluid couplings, partial motion of the vehicle shall be accommodated by a sliding seal between the coupling halves or by flexible elements of the system (e.g. hose or cable). The electrical connector halves on the ground carrier shall accommodate the vehicle's vertical motion and lateral motion, if applicable. This design shall overcome the dynamic loading due to noise and vibration generated by the engine.

5.2.2.3 Cryogenic coupling

The preferred cryogenic coupling can be of the slip type with dual self-forming lip seals. A tertiary seal may be used to contain a gaseous purge adjacent to the dual seals. The gaseous purge would prevent cryo-pumping and ice build-up on the sliding seal surface.

The cryogenic coupling shall not require the application of additional insulation after mating. The volume between the dual lip seals of the cryogenic coupling should preferably be vented through a tubing connection on the ground carrier side. This vent tubing shall then be monitored for leaks during verification of the connection phase when the coupling is pressure tested with gaseous helium. The couplings shall also provide for the mounting of leak detection devices.

The mounting provisions for the ground-carrier-half of the coupling and the attached flexible duct shall allow lateral and angular motion with respect to the ground carrier to ensure the coupling halves align during engagement and disengagement. The vehicle-half of the coupling shall be rigidly attached to the vehicle plate.

5.2.2.4 Electrical connectors

Data bus, low frequency, command signals, and ground power circuits shall not be in the same electrical connector to the extent possible. The electrical connectors for data bus signals greater than 500 kHz, command circuit connectors, low frequency signal connectors, and ground power connectors shall be grouped within the umbilical and separated from each other to the maximum extent practical. Connectors shall be spaced so physical attachment can be easily accomplished without interference from adjacent connectors. All connectors shall incorporate provisions for carrier-mounting alignment and gaseous-nitrogen purge.

The connector design shall incorporate the necessary devices to ensure proper connection while accommodating vertical relative motion. The connectors should preferably be of the dead-face type.

The faceplate may be purged with gaseous nitrogen. The back-shell shall be sealed or may be purged with gaseous nitrogen. Strain relief devices shall be incorporated in the back-shell design of all connectors to prevent stress-loading of wire terminations.