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Space systems — Detailed space debris mitigation requirements for launch vehicle orbital stages

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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

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 was developed to support the implementation of the high-level space debris mitigation requirements in ISO 24113.

This document contains a detailed and practical set of requirements and recommendations to assist the space industry in conforming to the requirements in ISO 24113 which relate to launch vehicle orbital stages.

Space systems — Detailed space debris mitigation requirements for launch vehicle orbital stages

1 Scope

This document defines detailed space debris mitigation requirements and recommendations for the design and operation of launch vehicle orbital stages in Earth orbit.

The requirements defined in this document are applicable for:

— avoiding the release of space debris;

— disposing of a launch vehicle orbital stage after the end of its mission so as to avoid a break-up in orbit;

— disposing of a launch vehicle orbital stage after the end of its mission so as to minimize interference with the protected regions;

— safely re-entering a launch vehicle orbital stage.

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 24113, *Space systems — Space debris mitigation requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24113 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
decay orbit
orbit that will result in the re-entry of a launch vehicle orbital stage

3.2
disposal orbit
orbit in which launch vehicle orbital stage resides following the completion of its disposal maneuvers

4 Avoiding the intentional release of space debris into Earth orbit during normal operations

4.1 ISO 24113 specifies a limit for the total number of launch vehicle orbital stages and space debris objects that a launch vehicle may leave in Earth orbit during normal operations.

NOTE The space debris objects related to the launch include, but are not limited to, protective shrouds, inter-stage elements, clamp bands, jettisonable tanks, jettisonable attitude control or propellant settling systems.

4.2 If a launch vehicle, by design, leaves two launch vehicle orbital stages in Earth orbit during the launch of a single spacecraft, then at least one of the two stages shall be removed. It is preferred for both stages to be removed from orbit at the end of the launch vehicle's operations.

5 Avoiding break-ups in Earth orbit

5.1 Accidental break-up caused by an on-board source of energy

5.1.1 General

The following elements of a launch vehicle orbital stage are most likely to cause an accidental break-up:

a) residual propellants in propulsion systems;

b) pressure gasses in vessels including propellant tanks, high-pressure gas bottles, and pressure lines;

c) batteries;

d) range safety system when not decoupled from command chain, i.e. computer order and necessary energy.

5.1.2 Residual propellants in propulsion systems

5.1.2.1 Residual propellants shall be vented from a launch vehicle orbital stage as part of its passivation, the timing of such an operation being selected in order not to generate any adverse consequence to the stage or its payloads.

NOTE1 In case residual propellants are vented by combustion from the thrust chamber, the change of mixture ratio inside the chamber is a major factor of break-up risk of the thrust chamber.

NOTE2 In case residual propellants are vented in a sequential mode, without combustion, the pressure gradients of venting of liquid residual propellants are key control variables to avoid either boiling up or the generation of ice particle(debris) which can clog the passivation orifices and valves.

5.1.2.2 The venting of residual propellants shall be implemented in accordance with the requirements of launch vehicle orbital stage disposal.

NOTE Proper orientation of venting outlets can lower the final orbit and thus reduce the orbit lifetime of a launch vehicle orbital stage.

5.1.3 Pressurized gasses in pressure vessels

Pressure vessels shall be designed in accordance with standardised procedures, and made safe by one or more of the following means (in order of preference):

a) relieving the pressurized gasses totally, or

b) relieving the pressurized gasses until the internal pressures are lower than their validated critical values, or

c) designing with safety margins that do not allow rupture when considering thermal effects in orbit.

NOTE 1 Pressure vessels include propellant tanks and high-pressure gas bottles.

NOTE 2 ISO 14623 provides standardised procedures for pressure vessel design.

NOTE 3 Pressure vessel critical value[2][3] is the highest pressure under which an impact does not lead to an explosion, but a simple hole.

5.1.4 Batteries

5.1.4.1 The capacity margin of safety of batteries shall be evaluated in accordance with standardised design procedures to ensure mission safety and post-mission disposal.

NOTE ISO 17546 is an example of a battery design standard.

5.1.4.2 Batteries shall be designed and manufactured, both structurally and electrically, to prevent break-up.

5.1.5 Range safety systems

5.1.5.1 The definition and layout of the self-destruct explosive charge on a launch vehicle shall be such that it cannot reach its self-ignition temperature.

5.1.5.2 The command receiver of a command self-destruct system in a range safety system shall be turned off soon after a launch vehicle has passed through a range safety area.

5.1.6 Probability of accidental break-up due to internal causes

ISO 24113 specifies a limit for the probability of accidental break-up, due to an internal cause, that a launch vehicle orbital stage shall be designed to satisfy.

5.2 Accidental break-up caused by a collision

5.2.1 A launch vehicle orbital stage shall be launched to reduce the risk of collision among launch vehicle, injected payloads, mission related objects, and existing orbital objects (at least manned space systems) during ascent and after the injection according to the requirements set by approving agents.

NOTE Some approving agents use 10^{-4} as the threshold for the risk of collision.

5.2.2 Structural materials that generate less debris when impacted, should be preferentially considered in the design of a launch vehicle orbital stage.

6 Disposal of a launch vehicle orbital stage after the end of mission so as to minimize interference with the protected regions

6.1 Launch service provider — spacecraft mission designer coordination

6.1.1 The spacecraft mission designer and the launch service provider shall jointly design the launch phase of the mission to enable disposal of the launch vehicle orbital stage.

6.1.2 Using the information provided by the spacecraft mission designer (e.g. see ISO 14303, ISO 17401), the launch service provider shall estimate the orbit lifetime of all launch vehicle orbital stages, based on the spacecraft injection scenario and final orbit parameters at end of life (e.g. see ISO 27852).

6.1.3 The launch service provider shall estimate the casualty risk for an uncontrolled re-entry of all launch vehicle orbital stages for which a controlled re-entry is not planned.

6.1.4 The casualty risk for an uncontrolled re-entry of each launch vehicle orbital stage shall be computed using a standardised method.

NOTE ISO 27875 provides standardised methods for computing the casualty risk.