INTERNATIONAL STANDARD

ISO 15865

Second edition
2022-10

Space systems — Qualification assessment

Systèmes spatiaux — Évaluation de la qualification

Reference number
ISO 15865:2022(E)

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Published in Switzerland

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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 documents 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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 15865:2005), which has been technically revised.

The main changes are as follows:

— alignment of terms and definitions with ISO 10795;

— introduction of space system's components;

— completion of criteria to be verified during qualification assessment;

— additional information on the recognized applicable methods;

— update of bibliography.

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.

Space systems — Qualification assessment

1 Scope

This document establishes general rules for qualification assessment of space systems and products used in space systems against their functional and technical specifications. It establishes general requirements for determining system or product readiness for any stage of the life cycle. This includes, for example, readiness for development, manufacture, test, operation, modification, or disposal.

This document is applicable to systems and products used in flight or ground support and to products at all levels in a product tree. It applies to systems and products consisting of hardware, software, facilities, materials, methods, processes, procedures or any combination of these.

It establishes common:

a) general requirements for qualification assessment of item readiness;

b) approaches to qualification.

This document is intended for use as the basis for a design justification plan. It is intended to be used either in establishing an agreement for such a plan between a customer and a supplier or as the basis for a supplier's internal qualification practices.

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)

ISO 10795, *Space systems — Programme management and quality — Vocabulary*

ISO 14300-1, *Space systems — Programme management — Part 1: Structuring of a project*

ISO 21349, *Space systems — Project reviews*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10795 and the following 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/

3.1.1
qualification process
process that covers all the verification activities including all the items of the product (component, equipment, subsystem and system)

3.1.2
review
documented process of the requirement conformity or nonconformity objective evaluation against the requirements specified by standards or specifications and their incomes on reaching any milestone

Note 1 to entry: Additional activities performed during the review include:

— analysis of the reasons of nonconformities;

— elaboration of recommendations on improving.

3.1.3
technical specification
TS
specification expressing technical requirements for designing and developing the solution to be implemented

Note 1 to entry: The technical specification evolves from the functional specification and defines the technical requirements for the selected solution as part of a business agreement.

[SOURCE: ISO 21351:2005, 3.1.11, modified — The abbreviated term "TS" has been added.]

3.2 Abbreviated terms

DJDF	design justification data file
DJP	design justification plan
EEE	electrical, electronic, and electromechanical
GTP	ground test plan
TS	technical specification

4 Objectives and principles

4.1 Objectives

The qualification process should ensure that the following goal is achieved: confirmation of suitability of the space system and the space system's components.

Simultaneously the following objectives should be achieved:

a) ensuring that the product meets specified requirements;

b) ensuring that the product matches production drawings;

c) confirming product operability after tests, verifications, flight tests and landing;

d) ensuring the safety of the space system's products in accordance with ISO 14620-1;

e) ensuring that the quality level required by the space system's customers is reached;

f) assisting customers in the selection of proper products and services of the space system on a competitive basis;

g) providing objective evidences of the quality of the space system to make a positive decision on the insurance of the space system;

h) ensuring that the product meets the disposal requirements;

i) ensuring that each component is operated in accordance with the requirements of the operational documentation.

4.2 Principles

The space system's qualification assessment should be based on the following principles:

a) consistency of qualification assessment for different levels of the space systems and the structural scheme of the space systems;

b) proper definition of the requirements to be verified by qualification;

c) use of only approved items for qualification assessment with deviations justified and agreed upon by the customer and the supplier;

d) use of all appropriate information obtained in all phases of the programme;

e) sequential analysis of the results obtained during all phases and levels of the programme, taking into account the results obtained in the previous phase and other levels as appropriate;

f) lowering the uncertainty of the assessment as the additional information becomes available, particularly when the development transitions from one phase to the next or when it proceeds to the next level;

g) proper planning of the qualification assessment;

h) early detection of problems potentially capable of impacting cost, schedule, safety or quality of the programme (or any combination of these) and implementation of corrective actions with customer approval;

i) tailoring of the execution of the qualification assessment and its precision during the item life cycle.

4.3 General requirements and recommendations

A supplier can develop a space system's component either in compliance with a customer-supplier contract, or without a contract when there is an expected market for the item after the development is complete. In either case, a supplier acts as a customer towards its own suppliers.

When this document is used as a part of a contractual agreement between a customer and a supplier, the agreement shall establish the customer and supplier responsibilities and authorities, as appropriate, concerning the qualification processes and item acceptance. This agreement shall define the qualification logic (stages, list of results and justifications required for customer acceptance at each stage). The following considerations should be included in the agreement:

a) specific development items that are subject to the qualification process;

b) designation of responsibility and the processes to be used for approval of items for qualification assessment,

c) customer approvals required for supplier implementation of the DJP;

d) content and scheduling of status, progress, or completion reports from the supplier to the customer;

e) participation of the customer in reviews.

To achieve the qualification goals, the supplier shall be responsible for qualification of its product, whether the development is done in fulfilment of a customer-supplier contract or as an independent development.

When this document is used in a contractual situation, the supplier shall ensure that the supplier's product definition is valid with respect to the customer's TS.

When this document is used as a basis for qualification of a product that is developed independently by a supplier (outside of a customer-supplier contract), the supplier shall perform an internal qualification to ensure that the product meets the design input data requirements. At each order, the supplier should justify the ability of the product to satisfy the requirements expressed in the customer's supply specification.

The supplier shall determine when the item is qualified, based on the theoretical and experimental justification established by the supplier and the results of qualification testing. In a contractual situation, this determination is in accordance with contract provisions.

In a contractual situation, the customer shall have final responsibility for endorsing the qualification and declaring that the product meets its design requirements and can be manufactured. This endorsement and declaration are based on the contractually agreed-upon conditions.

A preparatory process of internal qualification may be carried out by the supplier for his own purposes in advance of the contractually agreed-upon qualification process.

The results of the qualification activity (verification process) shall be compiled in the DJDF by the supplier.

4.4 Levels

Qualification assessment should be implemented sequentially according to the different levels of the product tree as defined in ISO 14300-1. Typical qualification levels are the following:

a) part (e.g. an EEE part);

b) component;

c) subsystem;

d) system.

Items to be qualified at any level can include hardware, software, facility, material, processes, methods, and procedures.

4.5 Design justification data file (DJDF)

The DJDF aims at integration of all information confirming the design item compliance to specified requirements. It provides a record of the values of specified technical characteristics that are subject to qualification. The DJDF includes data from all qualification assessments obtained during all phases of the project. It is developed under the supplier's responsibility and authority during design, production, qualification, operation, and disposal. The DJDF integrates information from qualification process documents and is based on functional and technical characteristics that are subject to qualification.

Each characteristic recorded in the DJDF is periodically assessed to detect trends. All measurement results are maintained in the DJDF. For characteristics displaying uncertainties or deviations, their values are entered into the DJDF prior to and after corrective measures are taken.

The use and contents of a DJDF are described in Annexes A and B, respectively.

NOTE The purpose of trend detection is to enable early application of corrective actions that are necessary to control a characteristic and maintain its value within a specified range.

5 Qualification assessment approach

5.1 General

5.1.1 General features

Qualification assessment is based on the obligatory or voluntary principle - in terms of legislation - of the space system's qualification assessment in accordance with the normative documents.

Qualification assessment of a space system's elements depends on first achieving a specified level of precision in the estimated or measured values of the specified technical characteristics. The qualification decision is based on comparing these values with the specified values for these characteristics.

Qualification assessment is based on the DJP. Before each new phase, the results of the previous phase should be used to prepare revisions to the DJP.

The qualification strategy shall be a reasonable compromise between cost, schedule, risk, and effectiveness.

5.1.2 Specific features

5.1.2.1 Qualification assessment for space systems is characterized by unique features (i.e. features not present in the qualification assessment of other products), such as:

a) sparseness of data and (generally) an insufficient quantity of data for the use of statistical methods;

b) limited access to the product during space operation;

c) limited number of like products available for assessment;

d) requirements for high reliability and safety;

e) significant number of new technical problems due to lack of similarity to previous items;

f) insufficient knowledge of environmental conditions and their impact on space system;

g) inability to reproduce some space environmental conditions on the ground;

h) necessity to solve complex scientific and technical problems in a short, fixed time due to external factors (e.g. meteorological factors).

5.1.2.2 The space system's qualification process utilizes documentation and other results of activities performed during phases 0, A, B, C, D, E, and F specified in ISO 14300-1. In the general case, these results include:

— issue and co-ordination of the TS;

— design;

— working documentation;

— production set-up and prototype manufacturing results;

— ground test results;

— flight-test results;

— results of full-scale production and operation.

5.1.3 Criteria

The following criteria shall be verified during qualification assessment of the space systems or the space system's elements.

a) The space systems or the space system's elements are completed and their documentation is approved.

b) Requirements traceability is established.

c) All specified operational constraints (i.e. mechanical, thermal, electrical mechanical compatibility/ EMC, radiations constraints) and environment load limitations are taken into account.

d) All the assumptions inherent in the design of the system are defined and justified.

e) The range of all technical characteristics (parameters) subject to qualification assessment is defined.

f) Assessment tolerances are established to allow for uncertainties of the applied qualification assessment method.

g) The applied method provides both nominal values and worst-case values of technical characteristics.

5.1.4 Design justification plan (DJP)

The supplier develops the DJP. Depending on contractual arrangements, the customer reviews and coordinates the plan submitted by the supplier and accepts the reports.

A typical example of DJP is given in Annex C.

The space system's qualification assessment matrix may include the space system's quality assessment for the development and production phases and space system item inspection during the production and operation phases.

Implementation of the DJP shall be aligned with the program implementation schedule.

5.2 Arrangement of work

5.2.1 Principles for selection of an organization or a group of specialists for qualification reviews

5.2.1.1 Selection principles

The following principles should be followed when selecting any organization or group of specialists for qualification assessment review (see ISO 21349).

a) The candidates should be administratively or materially independent on the assessment results;

b) The candidates should be competent, which can be estimated by the frequency of expert assessments accomplished, practical confirmation of their assessments, and the extent to which their assessment recommendations were followed.

5.2.1.2 Examples of suitable personnel

The following are examples of sources of suitable personnel for performing qualification assessment review (in order of increasing level of independence):

a) for an internal review, any part of the supplier's organization;

b) any part of the customer organization;

c) specially established commissions composed of skilled experts from the customer's organization, who are not responsible for the space system's item program or project;

d) other industrial organizations (research and development institutes or laboratories are advisable).

5.2.2 Objectivity and adequacy of results

5.2.2.1 The unbiased confirmation of the space system's qualification with respect to the specified requirements is supported by the following factors:

a) traceability of DJP implementation;

b) completeness and adequacy of procedures for qualification assessment;

c) completeness and adequacy of test and control programs;

d) capability of the applied methods used (as defined in 5.2.3).

5.2.2.2 The following actions also support the unbiased confirmation of the space system's qualification:

— implementing preliminary (local) qualification reviews performed by the organizations taking part in space system's development, production, or operation;

— accounting for all of the factors impacting the space system's item quality, reliability, and safety in the process of the space system's development, design, testing, manufacturing, and operation;

— ensuring that the test equipment (test control equipment) and measuring equipment meet the necessary technical levels;

— ensuring the competence of the laboratories (centres) by periodic verifications.

5.2.3 Applicable methods

Table 1 lists the recognized applicable methods.

Selection of the applicable methods and their level of detail is determined by a number of factors including the qualification tasks to be accomplished, available prior information, project innovation, risk, product tree level, life cycle phase, item reliability, lot size, and supplier's experience. Methods resulting in quantitative estimates (e.g. statistical methods) are preferable for analysis, when appropriate.

Table 1 — Descriptions of applied methods

ID	Name of method	Description
1	Analysis	Determination of essential qualities, performance, and limitations of an item by cognitive or computational methods.
2	Acceptance tests	Tests and verifications performed during product acceptance, including waiver and input control.
3	Estimation tests	Tests for detailed estimation of item capabilities.
4	Qualification tests	Tests for confirmation of meeting TS requirements, including safety factors.
5	Delta-qualification method	Specific tests of a part of an item in a limited area in which the loads and environment have changed (due to modification, use, etc.).
6	Qualification by similarity	Method of qualification of a new item based on the qualification of similar items in the past.
7	Quality system certification	Confirmation that the supplier has procedures to ensure the manufacture of products meet customer requirements.