SLOVENSKI STANDARD
SIST EN 16603-31:2015

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SIST EN 14607-1:2005

Vesoljska tehnika - Nadzor toplote, splošne zahteve

Space engineering - Thermal control general requirements

Raumfahrttechnik - Thermalkontrolle, allgemeine Andorderungen

Ingénierie spatiale - Contrôle thermique, exigences générales

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ICS:

49.140	Vesoljski sistemi in operacije	Space systems and operations

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Space engineering - Thermal control general requirements

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Foreword

This document (EN 16603-31:2014) has been prepared by Technical Committee CEN/CLC/TC 5 “Space”, the secretariat of which is held by DIN.

This standard (EN 16603-31:2014) originates from ECSS-E-ST-31C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2015, and conflicting national standards shall be withdrawn at the latest by March 2015.

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This document supersedes EN 14607-1:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

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1 Scope

ECSS-E-ST-31 defines requirements for the discipline of thermal engineering.

This Standard defines the requirements for the definition, analysis, design, manufacture, verification and in-service operation of thermal control subsystems of spacecraft and other space products.

For this Standard, the complete temperature scale is divided into three ranges:

- Cryogenic temperature range
- Conventional temperature range
- High temperature range.

The requirements of this Standard are applicable to the complete temperature scale. However, where applicable, requirements are stated to be applicable only for the cryogenic or high temperature range. References to these specific requirements have been summarized in Annex G and Annex H.

This standard is applicable to all flight hardware of space projects, including spacecraft and launchers.

This standard may be tailored for the specific characteristic and constrains of a space project in conformance with ECSS-S-ST-00.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply, However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system – Glossary of terms
EN 16603-10-02	ECSS-E-ST-10-02	Space engineering – Verification
EN 16603-10-03	ECSS-E-ST-10-03	Space engineering – Testing
EN 16603-10-04	ECSS-E-ST-10-04	Space engineering – Space environment
EN 16601-40	ECSS-M-ST-40	Space project management – Configuration and information management
EN 16602-20	ECSS-Q-ST-20	Space product assurance – Quality assurance
EN 16602-40	ECSS-Q-ST-40	Space product assurance – Safety
EN 16602-70	ECSS-Q-ST-70	Space product assurance – Materials, mechanical parts and processes
EN 16602-70-01	ECSS-Q-ST-70-01	Space product assurance – Cleanliness and contamination control

3
Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-ST-00-01 apply, in particular for the following terms:

acceptance test (system level)

assembly

item

part

For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-10-03 apply:

temperature cycle

3.2 Terms specific to the present standard

3.2.1 General

3.2.1.1 acceptance margin

contingency agreed between system authority and TCS to account for unpredictable TCS-related events

NOTE The acceptance margin is the difference between the upper or lower acceptance temperature and the upper or lower design temperature (for both operating and non - operating mode). See Figure 3-1.

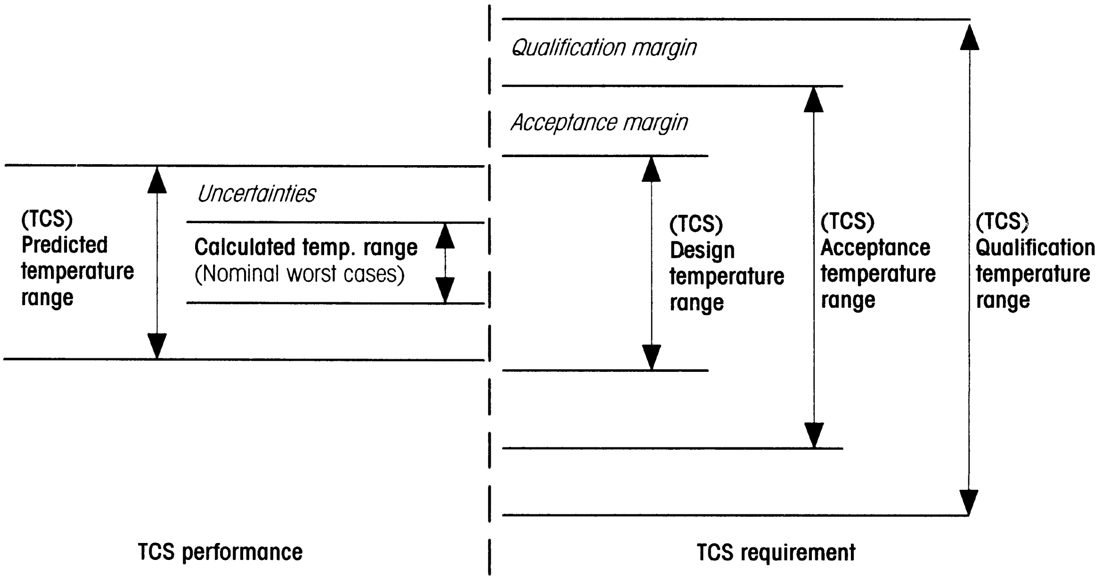

Figure 3-1: Temperature definitions for thermal control system (TCS)

3.2.1.2 acceptance temperature range

temperature range obtained from the qualification temperature range after subtraction of qualification margins specified for the operating and non-operating mode and the switch-on condition of a unit

NOTE 1 The acceptance temperature range is the extreme temperature range that a unit can reach, but never exceed, during all envisaged mission phases (based on worst case assumptions). See Figure 3-1.

NOTE 2 Temperature range used during acceptance tests to verify specified requirements and workmanship

3.2.1.3 calculated temperature range

temperature range obtained by analysis or other means for the operating and non-operating mode and the minimum switch-on condition of a unit, based on worst case considerations (i.e. an appropriate combination of external fluxes, materials properties and unit dissipation profiles to describe hot and cold conditions) excluding failure cases

NOTE See Figure 3-1. The calculated temperature range plus any uncertainties is limited to the specified design temperature range. During the course of a project these uncertainties change from initial estimates into a value determined by analysis.

3.2.1.4 climatic test

test conducted to demonstrate the capability of an item to operate satisfactorily or to survive without degradation under specific environmental conditions at predefined hot and cold temperatures, temperature gradients and temperature variations

NOTE Examples of environmental conditions are: pressure, humidity and composition of atmosphere.

3.2.1.5 thermal component

piece of thermal hardware which by further subdivision loses its functionality, but is not necessarily destroyed

3.2.1.6 correlation

correspondence between analytical predictions and test results

3.2.1.7 design temperature range

temperature range specified for the operating and non-operating mode and the switch-on condition of a unit, obtained by subtracting acceptance margins from the acceptance temperature range

NOTE 1 Temperature range representing the temperature requirement for the TCS design activities.

NOTE 2 The terms "operating temperature range" or "operational temperature range" should not be used for the design temperature range. The term "operating or non-operating temperature limits" is acceptable.

3.2.1.8 geometrical mathematical model (GMM)

mathematical model in which an item and its surroundings are represented by radiation exchanging surfaces characterised by their thermo-optical properties

NOTE The GMM generates the absorbed environmental heat fluxes and the radiative couplings between the surfaces.

3.2.1.9 heat dissipation

thermal energy divided by time produced by a source

3.2.1.10 heat flux

thermal energy (heat) divided by time and unit area perpendicular to the flow path

NOTE Heat flux is also referred to as heat flow rate density.

3.2.1.11 heat leak

unwanted heat exchange between a thermally protected item and the environment

NOTE The heat leak can be a heat gain or a heat loss depending of the environmental temperature

3.2.1.12 heat lift

transfer of a specified heat flow rate from a lower to a higher temperature

NOTE For example: Heat pump.

3.2.1.13 heat storage

capability to store heat at a defined temperature or within a defined temperature range

NOTE For example: Heat storage can be performed by sensible heat, latent heat as a PCM, by heat conversion into chemical energy.

3.2.1.14 induced environment

set of environmental conditions for a given item created by the operation or movement of the item itself

NOTE For example: Set of loading conditions due to atmospheric flight.

3.2.1.15 infrared test

thermal test method in which the solar and planetary radiation and aerodynamic heating are simulated by locally heating the spacecraft surface to the predicted input level using infrared techniques

NOTE For example: Infrared lamps and heaters.

3.2.1.16 minimum switch-on temperature

minimum temperature at which a unit can be switched from the non-operating mode to the operating mode and functions nominally when the unit temperature is brought back to the relevant operating mode temperatures

NOTE Also referred to as start-up temperature.

3.2.1.17 natural environment

set of environmental conditions defined by the external physical surrounding for a certain mission

NOTE For example: Heat flux by sun and planet, gas composition and pressure of planet atmosphere.

3.2.1.18 predicted temperature range

temperature range obtained from the calculated temperature range increased by the uncertainties

NOTE See Figure 3-1

3.2.1.19 qualification margin

contingency approved by the system authority to account for any unexpected events

NOTE For temperatures, the qualification margin is the difference between the upper or lower qualification temperature and the upper or lower acceptance temperature (for operating and non - operating mode). See Figure 3-1.

3.2.1.20 qualification temperature range

temperature range specified for the operating and non-operating mode and the switch-on condition of a unit, for which this unit is guaranteed to fulfil all specified requirements

NOTE See Figure 3-1.

3.2.1.21 qualification test (system level)

verification process that demonstrates that hardware fulfil all specified requirements under simulated conditions more severe than those expected during the mission

NOTE During the qualification tests, unit temperature reference points (TRP) are exposed to temperatures within but not exceeding the qualification temperature range.

3.2.1.22 radiative sink temperature

virtual black body radiation temperature used to define the equivalent radiative thermal load on an item

NOTE 1 The radiative sink temperature includes both the natural environment load (solar, planetary albedo and infrared fluxes) and the radiative exchanges with other items.

NOTE 2 The radiative sink temperature is typically used to provide a simplified interface for an item, to provide a means for parameter studies thus avoiding extensive calculations or to define adequate radiative boundary conditions for thermal tests.

NOTE 3 The sink temperature T_{Sink} of an item i with a temperature T_i in radiative exchange with n items j and submitted to external radiative environmental fluxes is calculated according to the formula:

$$T_{Sink,rad}(i) = \sqrt[4]{T_i^4 + \frac{\sum_{j=1}^{n} R_{ij}(T_j^4 - T_i^4)}{\in A_i} + \frac{P_s}{\sigma \varepsilon A_i} + \frac{P_A}{\sigma \varepsilon A_i} + \frac{P_{IR}}{\sigma \varepsilon A_i}}$$

where

ϵ emissivity of item i

P_s absorbed solar flux on item i

P_A absorbed (planetary) albedo flux on item i

P_{IR} absorbed infrared (planetary) flux on item i

R_{ij} radiative coupling between item i and item j

T_j temperature of item j

σ Stefan-Boltzmann constant

A_i radiative exchange area of item i

NOTE 4 The radiative sink temperature formula is defined for steady state and transient conditions. Depending on the degree of interaction between the item *i* (via its temperature, surface properties, dimensions, heat dissipation) and the radiative sink, the simplified approach using the radiative sink temperature is performed in an iterative way during the course of a project.

3.2.1.23 sensitivity analysis

analysis, which uses a variation of input parameters in order to evaluate the influence of inaccuracies on the analysis results

3.2.1.24 solar simulation test

test method in which the intensity, spectral distribution, uniformity and collimation angle of the solar radiation are reproduced within acceptable limits

3.2.1.25 success criteria

predefined value or set of values used for verification of a requirement and based on one or several parameters

NOTE 1 Success criteria can be defined for verification by analysis and test.

NOTE 2 Examples of such parameters are temperature, and temperature gradient.

3.2.1.26 system authority

organization responsible for the system

NOTE The "system authority" can be the "customer" as defined in ECSS-S-ST-00-01.

3.2.1.27 system interface temperature point

physical point appropriately located on the structure of the system which can be used to evaluate the heat exchanged by conduction between a unit and the spacecraft system

3.2.1.28 temperature difference

difference in temperature of two points at a given time

3.2.1.29 temperature gradient

spatial derivation of temperature in a point at a given time

NOTE It is expressed by a temperature divided by unit length.

3.2.1.30 temperature mean deviation (ΔT_{mean})

sum of temperature differences (measured minus analysed values) divided by the number of correlated temperatures

NOTE ΔT_{mean} can be positive or negative.

$$\Delta T_{mean} = \frac{1}{N}\sum_{i=1}^{N}(T_{Mi} - T_{Pi})$$

where