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Space systems — Human-life activity support systems and equipment integration in space flight — Techno-medical requirements for space vehicle human habitation environments

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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 operation*.

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Introduction

This document is intended for developing life support, thermal control by systems of space vehicles and creating in those vehicles an environment needed to support crew life during a mission to space.

This document, which is a 2nd level standard with respect to ISO 17763 *Space systems — Human-life activity support systems and equipment integration in space flight* establishes the area for "Human Habitable Environment in Space Flight". The list of 3rd level standards specifies requirements for the habitable environment, which are supported by a suite of life support technical systems.

The objectives of this document are:

— to establish for the developers of life support systems a set of common technical and medical requirements for crew life support;

— to create a habitation environment for a crew that supports their life activities; and

— to establish common habitable environment standards for supporting crew life activities for the medical personnel.

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Space systems — Human-life activity support systems and equipment integration in space flight — Techno-medical requirements for space vehicle human habitation environments

1 Scope

This document is a second level standard is one of the several others regarding human-life activity support systems and equipment integration in space flight.

This document, along with first and third level standards, form a complex three-level international standard entitled "Space systems — Human-life activity support systems and equipment integration in space flight".

It is applicable to human space flight programs in all manned space objects, including spacecraft, space stations, lunar and planetary bases, as well as extravehicular activity. It covers all phases for developing a manned space object, such as design, production, tests, operation, and maintenance.

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 17763, *Space systems — Human-life activity support systems and equipment integration in space flight*[1)]

3 Terms and definitions

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

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

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

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

3.1
human habitation environment in spacecraft
complex issue that involves material, energy and information flows, as well as elements formed in SC habitable compartments

Note 1 to entry: Such elements are derived from life activity processes, human social-labour processes, space factors, space mobility, and hardware functioning processes, including the ones designed to arrange humans' interaction with the habitation environment in order to provide specified conditions for human life activity in space flights.

[SOURCE: ISO 17763, 3.1]

1) Under preparation. Stage at time of publication: ISO/FDIS 17763:2018.

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3.2
human living conditions in spacecraft
complex of human habitation environment parameters in SC, providing health maintenance, human safety and keeping of human's ability to work at a level needed to execute the planned work program

[SOURCE: ISO 17763, 3.2]

3.3
techno-medical requirements for human habitation environments
complex of biomedical, hygiene/sanitary, ergonomic and design requirements

Note 1 to entry: Those requirements take into account physiological and social-psychological human needs in the process of hardware development and operation in order to guarantee specified living conditions aboard space systems.

[SOURCE: ISO 17763, 3.3]

3.4
manned (habitable) spacecraft
MSC
spacecraft, spaceship, space station, Lunar or planetary base with pressurized components inside which human habitation environment is maintained

3.5
life support systems
LSS
systems supporting mass and energy exchange between space traveller's body and habitable environment inside MSC

3.6
Extravehicular Activity
EVA
spacesuited activities outside MSC

4 Symbols (and abbreviated terms)

SS space systems

SC spacecraft

5 Application of this document in space programs

5.1 Standard applicability

Implementing of space programs, integration with human life activity shall be considered at all levels — from individual components to full integration.

All requirements stated in this document, unless otherwise specified, shall be applicable to all phases of the flight program.

5.2 Specific program requirements

Each human space flight program shall establish its specific requirements for development of this document. These requirements shall be verifiable.

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5.3 Monitoring of the flight program compliance to this document

Each human space flight program shall be a subject to permanent monitoring to verify compliance with this document, including design, development, tests, and operation.

5.4 Verification of program requirements

Each human space flight program shall be verified for requirements in accordance with this document.

6 General

This document is a second level standard with respect to a first level standard ISO 17763. *All human-life activity support systems and equipment integration in space flight shall be in accordance with the requirements of ISO 17763*[2)] *and this document.*

This document applies to human beings' stay in space flight for up to 3 years.

This document contains environmental parameters specifications for missions of up to one year, and for missions of up to three years.

The human habitation environment in spacecraft in this document is limited to the following elements: atmosphere, water, food, sanitary hygiene (and waste management), microbiology, individual protection, safeguards against fire, maintaining crew health through physical methods.

Creating a habitable environment and maintaining its condition at a due level shall be supported by a suite of crew life support systems and measures to be taken prior to the launch of MSC.

The crew living environment in the MSC is a set of environmental parameters assuring the maintenance of health, safety and maintaining capacity for work at a level required for accomplishing the mission.

Life support systems (LSS) shall ensure that mass and energy exchange between space traveller's body and habitable environment inside MSC are maintained at a level required to meet the living environment specifications.

The living environment in MSC shall be created through consistently forming as an integrated whole the following elements of the crew habitation environment:

— gas environment for breathing and energy exchange;

— water supply;

— provision of food;

— sanitary and hygienic support;

— microbiological support;

— provision of personal protection;

— fire prevention; and

— provision of physical methods of maintaining health

7 The human body mass and energy exchange

Life support requirements are determined based on average physiological properties of mass and energy exchange depending on metabolic rate that corresponds to the level of crew activities in MSC.

2) Under preparation.

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Crew activity in long-term missions is determined by daily average energy consumption of (11,30 + 0,42) MJ/man-day or (2 700 + 100) kcal/man-day without taking into account crew working in spacesuit.

When calculating crew energy consumption per day, one shall take into account the energy consumption rate during activities of different strenuousness and during extravehicular activities (EVA). See Tables 1 to 3 below.

Table 1 — Energy consumption rate during activities of several strenuousness

Types of activities and work strenuousness categories	Energy consumption rate MJ/h (kcal/h)	
	Variation range	Average value
At rest	0,324–0,378 (77,4–90,3)	0,346 (82,5)
Light work load	0,432–0,626 (103–149,6)	0,522 (124,7)
Medium work load	0,630–1,044 (150,5–249,3)	0,828 (197,8)
Heavy work load	1,044–1,872 (249,3–447,0)	1,512 (361,0)
Working in a spacesuit (EVA)	1,089 ± 0,586 (260 ± 140)	—
Physical exercise[a]	1,465–2,428 (350–580)	—

NOTE The figures in this balance are intended for use in calculations.

[a] Energy cost of one training session is 250 kcal to 300 kcal per 45 min of exercise and 15 min of preparation.

Table 2 — Human body mass balance for major consumed and released products

Intake kg/day			Release kg/day		
Food	Dry mass	0,60	Fecal matter	Dry mass	0,15
	Water	0,50		Water	0,15
Respiration	Oxygen	0,86	Respiration	Carbon dioxide	0,96
Food preparation and drinks	Water	2,00	Urine	Water	1,20
			Moisture through lungs and skin	Atmospheric moisture condensate	1,50
Water consumption		2,5	Water elimination (metabolic water 0,35)		2,85
Consumption		3,96	Elimination		3,96

NOTE 1 The water balance is achieved through release of additional water generated in the human body — 0,35 kg of metabolic water.

NOTE 2 The figures in this balance are intended for use in calculations.

NOTE 3 The data in table for temperature from 20 °C to 22 °C and humidity from 50 % to 60 %.

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Table 3 — Data for calculations of organism-environment heat exchange

Parameter name	Range of measurement	Design value	Heat exchange conditions
1 Human metabolic heat release, MJ (kcal/day)	7,12–15,07 (1 700–3 600)	12,56 (3 000)	—
2 Average human's emission of heat, MJ (kcal/h) loss with evaporation, perspiration, convection, radiation	0,29–0,54 (70–129)	0,41 ± 0,02 (98,9 ± 4,3)	For light physical activity
	0,75–0,92 (180–220)		Heat emission for small volume
	0,63–1,13 (150–270)		Heat emission for large volume, for heat release from 10,47 MJ/man-day to 12,56 MJ/man-day (2 500 kcal/man-day to 3 000 kcal/man-day)
	0,77–0,84 (184–200)		For ambient temperature from 295 K to 298 K (22 °C–25 °C)
	0,97–1,20 (231–286)		For ambient temperature from 288 K to 292 K (15 °C–19 °C)
3 Thermal resistance of clothes, Clo ($м^2$·K/W)	4,00–0,03 (0,613–0,005)	1,5 (0,23)	—
4 Temperature of external layers of clothes, on the average, K (°C)	300–301 (27–28)		
5 Weighted average temperature of skin, K (°C)	304,5–308,8 (31,5–35,8)	306,5 (33,5)	Calculation of weighted average temperature of body for clothes with thermal resistance 1,5 Clo (0,23 $м^2$·K/W)
6 Temperature, specified with forced ventilation of free space of habitable module, K (°C)	290–301 (17–28)	297 (24)	—
7 Temperature, specified with convection-radiation heat exchanging in habitable module, K (°C)	288–303 (15–30)	295 (22)	—

8 Standard structure

This document is a second-level standard. The following is a list of third-level standards:

1) Requirements for atmosphere content regarding main gases (physical and chemical composition of the atmosphere, total pressure).

2) Requirements for atmosphere quality assurance regarding chemical impurity.

3) Requirements for atmosphere quality assurance regarding nontoxic aerosols.

4) Requirements for assurance of heat-humidity conditions.

5) Requirements for ventilation provision.

6) Requirements for water supply.

7) Requirements for habitat microbiological safety (atmosphere, water, interior and equipment surfaces).

8) Requirements for individual protection assurance (in case of toxic contamination of the atmosphere, including toxic emissions in contingencies such as equipment depressurization and fire).

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