International Environmental Control and Life Support System (ECLSS) Interoperability Standards (IECLSSIS)

Draft C – February 2018

REVISION AND HISTORY

REV.	DESCRIPTION	PUB. DATE
Draft	Prerelease for I-SMT and FCSS Review	04-18-17
Draft A	Major update for September and Checkpoint Review	09-29-17
Draft B	Update based on NASA internal feedback	10-27-17
Draft C	Update based on Industry feedback	02-09-18

PREFACE

INTERNATIONAL ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM (ECLSS) INTEROPERABILITY STANDARDS

This International Environmental Control and Life Support System (ECLSS) Interoperability Standards document establishes standards to expand permanent human presence beyond low-Earth orbit through collaborative endeavors to develop the necessary ECLSS technical solutions. Interoperability standards enable collaboration with international and commercial industry partners, where practical.

Configuration control of this document is the responsibility of the International Space Station (ISS) Multilateral Coordination Board (MCB), which is comprised of the international partner members of the ISS. The National Aeronautics and Space Administration (NASA) will maintain the International Environmental Control and Life Support System (ECLSS) Interoperability Standards under Human Exploration and Operations Mission Directorate (HEOMD). Any revisions to this document will be approved by the ISS MCB.

INTERNATIONAL ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM (ECLSS) INTEROPERABILITY STANDARDS

CONCURRENCE

FEBRUARY 2018

Associate Administrator Human Exploration and Operations NASA	Date
Executive Director, Human Space Programs State Space Corporation "Roscosmos"	Date
Director of Human Spaceflight and Operations European Space Agency	Date
Director General, Space Exploration Canadian Space Agency	Date
Executive Director Japan Aerospace Exploration Agency	Date

TABLE OF CONTENTS

PARAGRAPH **PAGE**

APPENDIX

TABLE

FIGURE

1.0 INTRODUCTION

This International ECLSS Interoperability Standards is the result of a collaboration by the International Space Station (ISS) membership to establish, interoperable interfaces, terminology, techniques, and environments to facilitate collaborative endeavors of space exploration in cis-Lunar and deep space environments.

Standards that are established and internationally recognized have been selected where possible to enable commercial solutions and a variety of providers. Increasing commonality while decreasing unique configurations has the potential to reduce the traditional barriers in space exploration: overall mass and volume required to execute a mission. Standardizing interfaces reduces the scope of the development effort and allows more focus on performance instead of form and fit.

The information within this document represents a set of parameters enveloping a broad range of conditions, which if accommodated in the system architecture support greater efficiencies, promote cost savings, and increase the probability of mission success. These standards are not intended to specify system details needed for implementation nor do they dictate design features behind the interface, specific requirements will be defined in unique documents.

1.1 PURPOSE AND SCOPE

The purpose of the ECLSS Standards is to provide common basic performance parameters based on applicable, internationally recognized standards to allow developers to independently develop ECLSS technology solutions which can be easily compared and seamlessly integrated. These standards are expected to apply to both Deep Space Gateway (DSG) and Deep Space Transport (DST) elements. They are not intended to change requirements for the Orion spacecraft. They address areas covering cabin atmospheric conditions, potable water supply, urine stabilization, and special technical areas associated with ECLSS process technology or component compatibility.

For technical areas associated with ECLSS process technology or component compatibility, standards are provided to define appropriate constraints and/or guidance necessary to comply with the specific compatibility issue. In some cases, there are specific constraining technical solutions that are expected to be applied to the DSG&T to enable interoperability, based on current data available. These solutions are described in the rationale, and would be implemented in future verification.

For technical areas that have inconsistencies or conflicts between the applicable standard documents, the inconsistency or conflict is resolved by evaluating overlaps between the applicable standards to create reasonable technical compromise.

Standard requirements for other technical areas necessary to develop a suitable exploration ECLSS which require further evaluation by the ECLSS technical community are identified. Additional performance and design specification requirements will be necessary to achieve a detailed system design implementation. Some of these have been identified in the document as “Placeholders” for future research, discussion, and negotiation, and are listed in Section 5. These are not expected to be resolved for initial release of the standard. Content in these technical areas will be added to the document as common resolutions for standards in these technical areas are defined.

1.2 RESPONSIBILITY AND CHANGE AUTHORITY

Any proposed changes to this standard by the participating partners of this agreement shall be brought forward to the working group of ECLSS experts discussing these topics under the ECLSS International System Maturation Team (I-SMT) for review.

Configuration control of this document is the responsibility of the International Space Station (ISS) Multilateral Coordination Board (MCB), which is comprised of the international partner members of the ISS. The National Aeronautics and Space Administration (NASA) will maintain the International Environmental Control and Life Support System (ECLSS) Standards under the Human Exploration and Operations Mission Directorate (HEOMD). Any revisions to this document will be approved by the ISS MCB.

1.3 PRECEDENCE

This paragraph describes the hierarchy of document authority and identifies the document(s) that take precedence in the event of a conflict between content. Applicable documents include requirements that must be met. If a value in an applicable document conflicts with a value here, then the system may need to be able to meet both values in specific scenarios.

Reference documents are either published research representing a specific point in time, or a document meant to guide work that does not have the full authority of an Applicable document. If a value in this document conflicts with a value in a referenced document, then it should be assumed that the value here was deliberately changed based on new data or a special constraint for the missions discussed.

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. Applicable documents are levied by programs with authority to control system design or operations. The documents listed in this paragraph are applicable to the extent specified herein. Inclusion of applicable documents herein does not in any way supersede the order of precedence identified in Section 1.3 of this document.

The documents specified here are assigned by individual partner agencies to levy requirements on their own performance. However, these documents may not yet capture all of the relevant information for future missions. The requirements development in these activities may have early information or lead to changes in these documents that are more suitable for future missions.

NASA-STD-3001, Vol 2	NASA Space Flight Human-System Standard, Vol. 2: Human Factors, Habitability, and Environmental Health Note that Revision A is currently released, but many values in this document include content in work for Revision B draft. An future DSG&T parent program would levy the current version on contracts at the appropriate time.
GOST P 50804-95 Group D10	State Standard of the Russian Federation Cosmonaut's Habitable Environments on Board of Manned Spacecraft: General Medicotechnical Requirements (GOST)

2.2 REFERENCE DOCUMENTS

The following documents contain supplemental information to guide the user in the application of this document. These reference documents may or may not be specifically cited within the text of this document. Several of these documents are levied within the details of applicable documents above, but may be tailored for these missions.

NASA/SP-2010-3407/REV1	Human Integration Design Handbook Revision 1
JSC 20584	Spacecraft Maximum Allowable Concentrations for Airborne Contaminants
JSC 63414	Spacecraft Water Exposure Guidelines
Working Document Reference Numbers:	Draft ISO Standards for Human-Medical Requirements

ISO/DIS 16726, ISO/DIS 16157, ISO/DIS 17763	
AIAA 2009-01-2592	A Design Basis for Spacecraft Cabin Trace Contaminant Control

3.0 INTERNATIONAL ENVIRONMENTAL CONTROL AND LIFE SUPPORT (ECLSS) INTEROPERABILITY STANDARDS

3.1 GENERAL

The purpose of the ECLSS Standards is to provide common basic performance parameters based on applicable, internationally recognized standards to allow developers to independently develop ECLSS technology solutions which can be easily compared and seamlessly integrated. Use of standard assumptions makes technology development more efficient, especially when multiple partners are involved in a joint venture.

This document focuses on system performance parameters and technical areas that most directly affect interoperability between vehicle systems and ECLSS technology developer solutions.

The following subsections describe the key exploration ECLSS system interfaces and performance parameters that are pertinent to DSG&T missions.

3.2 INTERFACES AND SYSTEM COMPATIBILITY

This section describes constraints created by fluids that flow between systems, and will be expanded to include mechanical connections or other interfaces in future updates. Other applicable standards documents cover interfaces such as power, command and data avionics, and thermal control. Unless otherwise stated, the features called out in this section and its subsections shall be implemented by ECLS systems to ensure compatibility between and within ECLS systems. For ECLSS components, this interface may also be between the ECLSS component and the human crewmembers. Other interfaces are the result of technology and system choices, or the result of allocation of requirements and resources between systems. Each requirement is specified only once with its required value and tolerance, if relevant. For some standards, a minimum success requirement for crew health and safety and a goal value for optimal crew comfort and performance may both be specified. For physical connections, deviations from these dimensions may be possible.

3.2.1 ENGINEERING UNITS OF MEASURE

This standard will use the metric system (SI) as the primary units of measure, with appropriate decimal multipliers. Alternate units may be provided in addition to metric units. Values given may be described as maximums, minimums, nominal set points, or ranges. Margin of error and margin of control is not included in ranges provided because it is a result of system design choices.

3.2.2 POTABLE WATER BIOCIDE COMPATIBILITY

Potable water may be supplied by different logistics providers, visiting vehicles with crewmembers, or closed-loop recycling systems. Ground processing and vehicle or water processor system design concepts may vary, but the water provided should be able to be used across the DSG&T for a robust logistics plan and maximum flexibility and evolvability of the systems. Residual biocides are used in many potable water systems to maintain water quality and prevent microbial growth, but are not always compatible with other biocides or certain materials of construction.

To be compatible, mixing water sources with residual biocides:

- should not inactivate the antimicrobial properties of the residual biocide
- should not produce any byproducts that could be unacceptable for crew consumption or create a crew health risk
- should not create problems in the systems used to store, distribute, or process potable water such as particulate or free gas generation
- should not cause any other damaging effects to vehicle systems

Future verification details will require detailed definitions of each type of potable water. The current assumed definition of potable water with biocide will include silver with a concentration up to 0.4 mg/L. This is because potable water with silver ion residual biocide will be included in the Orion water system design, and is therefore the first example of potable water that must be compatible with other water supply. The form of silver and detailed test methods will be defined later.

ECLSS-01: Biocides used in the vehicle, element, or module potable water system shall be compatible with any other biocides used in the DSG&T ECLSS potable water system.

Rationale: When potable water is supplied to a distribution or delivery system, such as a galley, it will be mixed with water and any residual biocide already present in the system.

ECLSS-02: Biocides in the water transferred to the DSG&T from other systems or logistics, generated in the DSG&T, or otherwise used in the vehicle, element, or module potable water system shall be compatible with DSG&T potable water system hardware and materials of construction.

Rationale: Systems for water storage, distribution, and delivery to crewmembers may be present in multiple elements of the DSG&T system, and could be provided by a variety of suppliers or partners. Potable water from all sources should be able to be used in all potable water systems.

ECLSS-03: Biocides used in the vehicle, element, or module potable water systems shall be compatible with potable water that includes any contaminant identified in water quality specifications at levels up to human health limits.

Rationale: Potable water maintains contaminants below required levels, but is not free of contaminants or other added species, such as minerals sometimes added for taste. The potable water biocide should not create any byproducts that would be a threat to crew health when used in water with these contaminants.

ECLSS-04: Potable water biocides, and byproducts from combining biocides must be evaluated for toxicity by agency health and medical experts, even if they do not appear in the Spacecraft Water Exposure Guidelines (SWEGs) (JSC 63414).

Rationale: The Spacecraft Water Exposure Guidelines are not an exhaustive list of all contaminants that may have negative effects on human health. They include contaminants that have been considered risks in previous human spaceflight missions based on those systems and operations. The limits are not necessarily identical to other public health standards. Introduction of a new species in spacecraft potable water will require evaluation to set a SWEG level.

3.2.3 EMERGENCY AND FIRE SUPPRESSION SYSTEM COMMONALITY AND COMPATIBILITY

Responding to emergencies should be as simple and consistent as possible to minimize the opportunity for confusion or human error while making decisions in a challenging environment. Unfortunately, varying design standards and choices between the US and Russian segments of the ISS have resulted in having two separate systems for fire suppression, and two sets of protective equipment for the crew, such as breathing masks, for use while fighting the fires. On the DSG&T, the goal is to have one common system that can be used in all modules to simplify crew training and minimize resupply.

Handheld fire suppression devices will be expected to meet requirements for operation in microgravity. The DSG&T fire suppression system will be subject to the same storage life and temperature exposure requirements during dormancy as the rest of the system. Storage requirements may depend on logistics delivery plans, but for Mars transit missions would be at least 1200 days (TBR-8), and likely >4 years to accommodate logistics plans to deliver supplies a substantial period of time before the crew mission to Mars begins.

ECLSS-05: A common design for portable, crew operated fire suppression systems shall be used across the DSG&T vehicles, elements, and modules.

Rationale: Using common emergency systems across the crew vehicle will simplify crew training and improve emergency response speed.

ECLSS-06: The DSG&T vehicle, element, or module fire suppression system fluids shall be non-toxic.

Rationale: The DSG volume is smaller than the ISS. Therefore, fire suppressants will not be diluted across as large a volume. Fire suppressants that cause health hazards for the crew create challenges for protective equipment while fighting the fire, and a hazardous environment while recovering the vehicle status after the fire.

ECLSS-07: The DSG&T vehicle, element, or module fire suppression systems shall be compatible with vehicle systems.

Rationale: Extinguishing a fire should not create additional hazards for the crew when the fire suppressant comes into contact with vehicle systems. The fire suppressant should not damage systems so that they cannot be used after the fire is put out. Standards for power systems in the DSG&T dictate 120V power distribution to the systems. Trace contaminant control systems (TCCS) are another key system which needs to be considered for compatibility with the fire suppressant fluid. The extinguishing agent should not react in the TCCS to create toxic byproducts. The extinguishing fluid also should not poison or damage the TCCS.

ECLSS-08: The DSG&T vehicle, element, or module fire suppression system extinguishing agents shall be easily removed from the cabin environment to return to nominal conditions after an emergency event.

Rationale: The DSG will be located farther from Earth than ISS and resupply of consumables will be more difficult. Also, depressurizing and repressurizing a large transit habitat volume may require a prohibitively large quantity of consumables. Thus, there should be an option to recover after a fire.

ECLSS-09: The DSG&T vehicles, elements, and modules shall provide fire suppression methods that can be used while the crew is not present.

Rationale: The DSG&T will have periods of time in which the crew is not present, but some systems are powered on. Handheld, deployable fire extinguishers are an important part of an integrated fire suppression system design, especially when the crew uses equipment like laptops out in the cabin. But handheld systems will not be sufficient when the crew is not present. The options for suppressing a fire when the crew is not present may be broader, as long as vehicle environment can be returned to normal before the crew returns. Systems such as diluent nitrogen, carbon dioxide, or cabin depressurization could be used during periods when no crew is present on the spacecraft, since there is time to recover to a habitable atmosphere before the crew returns.

3.3 PERFORMANCE

In addition to the physical geometric interface requirements, a set of common design parameters enveloping the reference missions and conditions is provided. Many of the ECLSS performance standards define the environment that needs to be maintained in the spacecraft for the crewmembers. Other common design parameters increase the probability of successful integration of technologies from multiple providers.

3.3.1 INTERNAL ATMOSPHERE PRESSURE

Achieving different oxygen and pressure control points is not usually a substantial challenge for the ECLSS design, but it drives the design and materials of the other spacecraft systems and must be identified early in the design process since modules share atmosphere.

Figure 1 illustrates how the combination of oxygen and total pressure requirements in 3.3.1 and 3.3.2 create the nominal operation zone. This does not define control bands around a particular set point, but only describes possible allowable conditions within the vehicle or element.

The DSG&T airlock will have additional requirements for total pressure limits to allow complete depressurization.

ECLSS-10: The nominal internal atmosphere pressure for DSG&T vehicles, modules, and elements shall be 101 kPa (14.7 psia).

Rationale: The vehicles, modules, and elements covered by the DSG&T ECLSS Standards are expected to support crews for long duration, and have minimal extravehicular activity (EVA). An Earth-normal atmosphere is most appropriate for crew health in this type of mission.

ECLSS-11: DSG&T vehicles, modules, and elements shall be designed to operate at internal atmosphere pressures from 65 kPa (9.5 psia) to 115 kPa (16.7 psia) (TBR-1).

Rationale: A wider operating range improves the robustness of the system for more operating conditions.

Higher maximum pressures provide opportunities to pressurize a vehicle or module at launch above the 101 kPa nominal operating point, and then use that gas to pressurize vestibules or raise the pressure of another element or module after docking without storing the gas in tanks. Higher maximum pressures could also be useful when performing airsave from an airlock by pumping the gas into the rest of the pressurized volume.

Low pressures atmospheres are required because the DSG&T vehicles may need to occasionally accommodate EVA and allow the crew to acclimate to lower nitrogen levels to reduce decompression sickness risk, to manage off-nominal scenarios, or to dock with other vehicles that operate at reduced pressure. If the DSG&T pressurized volume is allowed to get cold during uncrewed periods, the pressure will drop.

This does not include airlock systems, which may require nominal functions at a wider range, and must operate some functions at pressures down to space vacuum.

ECLSS-12: The DSG&T vehicles, modules, and elements ECLSS shall control internal atmosphere pressures from 65 kPa (9.5 psia) to 115 kPa (16.7 psia) (TBR-1).

Rationale: The ECLSS is responsible for controlling the vehicle atmosphere so that it does not exceed design limits. The DSG&T

ECLSS will often be the prime system controlling atmosphere across many docked pressurized modules with hatches open.

ECLSS-13: The DSG&T vehicles, modules, and elements ECLSS shall control internal atmosphere pressure below 102 kPa (14.9 psia) when docked to the Orion spacecraft.

Rationale: The Orion spacecraft has a lower maximum pressure than is desired for the DSG&T elements. When Orion is docked and part of the shared pressurized volume, if the DSG&T ECLSS is prime it is responsible for controlling within the limits required for Orion.

3.3.2 ATMOSPHERE OXYGEN

Achieving different oxygen and pressure control points is not usually a substantial challenge for the ECLSS design, but it drives the design and materials of the other spacecraft systems and must be identified early in the design process since modules share atmosphere. The partial pressure of oxygen is driven by crew health requirements. Oxygen concentration is important for controlling risk of fire in the vehicle.

Figure 1 illustrates how the combination of oxygen and total pressure requirements in 3.3.1 and 3.3.2 create the nominal operation zone. This does not define control bands around a particular set point, but only describes possible allowable conditions within the vehicle or element. It is not expected that the vehicle would operate at the highest allowable pressure setpoints at the same time as allowing the highest oxygen concentrations.

There are several considerations that could motivate system designers to test at higher oxygen concentrations, even if not required for nominal functions. For maximum forward compatibility to surface exploration missions, components could be designed for 56 kPa (8.2 psia) and 34% oxygen environments to support frequent EVA. Ideally, to gather the most relevant information for future system operators, materials flammability tests should be conducted with additional margin for control bands and will have to meet appropriate testing standards levied such as those in NASA-STD-6001, or equivalents from other agencies as levied on contracts. Ideally, flammability tests to collect relevant data should be conducted to find the point of ignition, not just whether it passes at the design point. Flammability at partial gravity may be worse than flammability in microgravity.

The DSG&T airlock will have additional requirements for oxygen limits.

ECLSS-14: The DSG&T nominal atmosphere oxygen partial pressure set point shall be 21 kPa (3.1 psia) when the total atmosphere pressure set point is 101 kPa (14.7psia).

Rationale: The vehicles, modules, and elements covered by the DSG&T ECLSS Standards are expected to support crews for long duration, and have minimal extravehicular activity (EVA). An Earth-normal atmosphere is most appropriate for crew health in this type of mission.

ECLSS-15: The DSG&T vehicles, modules, and elements ECLSS shall control oxygen partial pressures to a selected set point within a range from 18.7 kPa (2.7 psia) to 23.4 kPa (3.4 psia).

Rationale: Controlling oxygen partial pressure within a medically acceptable range to avoid hypoxia or hyperoxia is required to protect crew health. Allowable oxygen levels for NASA vehicles are found in NASA-STD-3001 Volume 2A, in Section 6.2. The proposed range exceeds the range in Section 6.2, but is within the range acceptable for indefinite exposure without measurable impairments per NASA/SP-2010-3407/Rev1. NASA-STD-3001 is expected to be updated in the future to include lower oxygen levels that are acceptable after acclimatization for reduced pressure atmospheres.

ECLSS-16: The DSG&T vehicles, modules, and elements ECLSS shall control oxygen concentration below 25.9% oxygen with nominal operating functions at pressures above 80 kPa (11.8 psia)

Rationale: High oxygen concentration increases flammability risk. High oxygen concentrations should not be necessary at higher cabin pressures while still providing sufficient oxygen partial pressures for the crew.

ECLSS-17: The DSG&T vehicles, modules, and elements shall be designed to operate in conditions up to 25.9% oxygen with nominal operating functions above 80 kPa (11.8 psia).

Rationale: Vehicle systems should be designed for the possible nominal operating environments that the ECLSS is designed to provide.

ECLSS-18: The DSG&T vehicles, modules, and element ECLSS shall maintain oxygen partial pressure at or below 21k Pa (3.1 psia) when transitioning between atmosphere set points between 70 kPa (10.2 psia) and 80 kPa (11.8 psia)

Rationale: The ECLSS system needs intermediate control bounds when transitioning from 101 kPa (14.7 psia) atmospheres to lower pressure setpoints at 70 kPa

ECLSS-19: The DSG&T vehicles, modules, and element ECLSS shall control oxygen concentration below 30% under nominal operations for nominal atmosphere pressures up to 70 kPa (10.2 psia).

Rationale: Atmospheres with lower nitrogen content are needed before EVA operations to reduce risk of decompression sickness and make EVA operations more efficient. These EVAs may include nominal EVA preparation, or contingencies such as unpressurized, suited crew transfer to an Orion vehicle that cannot hold atmosphere pressure.

NASA has collected material flammability data at 70 kPa (10.2 psia) and 30% oxygen for the Space Shuttle and Orion vehicles, and made that data publically available through the Materials And Processes Technical Information System (MAPTIS).

ECLSS-20: The DSG&T vehicles, modules, and elements shall be designed to operate in conditions up to 30% oxygen with nominal operating functions for atmosphere pressures up to 70 kPa (10.2 psia).

Rationale: Vehicle systems should be designed for the possible nominal operating environments that the ECLSS is designed to provide.

ECLSS-21: DSG&T vehicles, modules, and elements ECLSS shall control oxygen concentration below 40% under emergency conditions for short durations (expected to be in the range of 1-24 hours, TBD-1).

Rationale: Elevated oxygen may be caused by system failures or operations in contingency scenarios, such as purging a spacesuit with oxygen. While concentrations up to 40% may be an acceptable risk for short periods of time, it is not reasonable to expect systems to be designed for very high oxygen concentrations. The contingency operations or ECLSS control should work to limit the oxygen related risk in a contingency.

ECLSS-22: The DSG&T vehicles, modules, and elements shall be designed to operate in conditions up to 40% oxygen under emergency conditions for short durations (expected to be in the range of 1-24 hours, TBD-1).

Rationale: High oxygen concentration should be considered as a contingency that may be experienced by DSG&T systems.

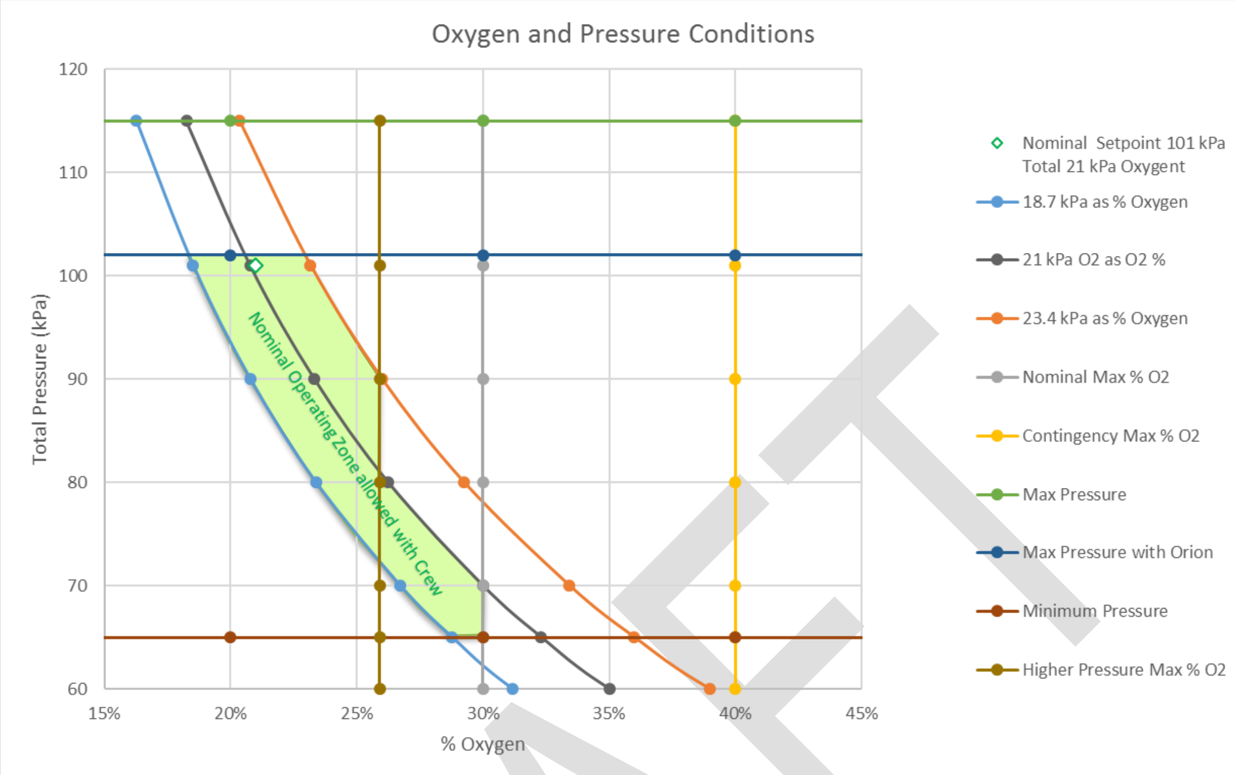

FIGURE 1 OXYGEN AND TOTAL PRESSURE CONDITIONS.

THIS FIGURE DOES NOT DESCRIBE THE CONTROL BOX AROUND ANY PARTICULAR SET POINT.

3.3.3 ATMOSPHERE CARBON DIOXIDE LEVELS

Carbon dioxide (CO_2) is produced as a waste product by crew metabolism and must be removed to maintain a safe and healthy environment for the crew. Typically, not every pressurized volume has a unique CO_2 removal system, so ventilation is required to move CO_2 to the system that removes it from the atmosphere. CO_2 concentration in the atmosphere determines whether a certain flow rate of air is sufficient for maintaining CO_2 levels with intermodule ventilation. The performance and design of the CO2 removal systems also depend on the CO2 levels in the atmosphere.

ECLSS-23: The DSG&T vehicles, modules, and elements ECLSS shall control the 24-hour average cabin CO_2 partial pressure to a goal of 267 Pa (2 mmHg) (2600 ppm) (TBR-2)

Rationale: Some evidence from long-term ISS missions suggests that microgravity increases crewmembers' susceptibility to CO_2-related symptoms, such as headache, lethargy, malaise, listlessness, and fatigue. Therefore, as a technical goal, CO_2 levels should be as low as possible in order to reduce or prevent crew symptoms. NASA medical experts recommend 267 Pa (2 mmHg) (2600 ppm) as the design level to minimize crew symptoms. New standards are expected to be levied in a future update of NASA-STD-3001.

3.3.4 ATMOSPHERE TEMPERATURE

Atmosphere temperature control is important for crew comfort and health. Atmosphere temperatures, especially at high and low extremes, may also be important for the design of vehicle systems inside the pressurized volumes. The combination of atmosphere and humidity must be maintained within a "comfort zone". Figure 2 illustrates the interactions between temperature and moisture content of the air that impact crew comfort and define at what temperatures 100% relative humidity is reached and condensation will occur.

ECLSS-24: The DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) shall control the internal atmosphere temperature between 21°C (70°F) and 27°C (81°F) when the crew is present.

Rationale: "Maintaining proper atmospheric temperature is important for maintaining a safe body core temperature, and is also important for comfort" per NASA/SP-2010-3407/Rev1.

ECLSS-25: The DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) shall provide crew selectable set points for internal atmosphere temperature in step sizes no greater than 1°C increments.

Rationale: Temperature preferences vary between crewmembers, and may vary depending on the workload and activity being performed at the time, such as sleep or exercise.

ECLSS-26: The DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) shall control the internal atmosphere temperature to within +/- 1.5°C (+/- 2.7°F) of the temperature set point.

Rationale: Per NASA/SP-2010-3407/Rev1, +/- 1.5°C (+/- 2.7°F) is sufficient precision to maintain crew comfort.

ECLSS-27: The DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) should provide crew selectable set points for atmosphere temperature in step sizes of 0.5°C (0.9°F) increments for crew comfort.

Rationale: More set points will provide more options for the crew to select the optimal temperature for crew comfort.

ECLSS-28: The DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) should design to control the DSG&T atmosphere temperatures to increments +/- 0.5°C (+/- 0.9°F) of the temperature set point for crew comfort.

Rationale: Tighter control bands and less temperature variation would allow control closer to the desired temperature selected by the crew.

ECLSS-29: The DSG&T vehicles, modules, and elements systems inside the pressurized volume shall be designed to survive, or operate if needed during dormant phases, in temperatures as low as 4°C (39°F) (TBR-3) during periods when crew is not present.

Rationale: During uncrewed periods, there is no need to maintain systems for crew health. Lower temperatures could aid in reducing growth of microbial contamination in wetted systems or on vehicle surfaces. The temperature should be maintained high enough that liquid water will not freeze and expand, which would damage systems. This requirement does not define the functional allocation or concept of operation that would describe what functions must operate during this uncrewed dormant phase. All systems onboard the spacecraft may be exposed to dormant conditions, unless functionality is included in part of the system to actively condition them. Other systems may be required to perform their functions, possibly in a modified mode, depending on the concept of operations of the mission, while other systems are dormant and the vehicle is controlling the environment to conditions that are different from conditions when the crew is present.

3.3.5 ATMOSPHERE RELATIVE HUMIDITY

Water content in the atmosphere can be described as a partial pressure or concentration, but relative humidity is more directly connected to crew comfort, and to the risk of condensation on vehicle surfaces.

ECLSS-30: The DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) shall nominally control relative humidity of the DSG&T pressurized volumes (vehicles and habitable modules) atmosphere from 40% to 75% when the crew is present.

Rationale: Relative humidity is controlled for crew comfort, and is a function of dew point temperature in the atmosphere and atmosphere temperature. NASA recommendations for the tolerable range for relative humidity are provided in NASA-STD-3001, Vol 2 Rev A, in Section 6.2.3.1, and in Section 6.2.3.2 of NASA/SP-2010-3407/Rev1 as 25%-75% relative humidity. The GOST P 50804-95 Group D10 document recommends a minimum of 40% relative humidity for crew comfort.

ECLSS-31: For short durations less than 24 continuous hours, the DSG&T vehicles, modules, and elements ECLSS (life support and thermal control system) can allow the relative humidity of the DSG&T atmosphere to be lower or higher than the nominal range, from 30% to 80% when the crew is present.

Rationale: Humans can tolerate a wide range of humidity for short periods of time. High humidity may make it difficult to control core body temperature if sweat does not evaporate well. Low humidity causes drying of the eyes, skin and mucous membranes of the nose and throat.

ECLSS-32: The DSG&T vehicles, modules, and elements ECLSS shall control the dew point temperature of the atmosphere below the DSG&T pressurized volumes (vehicles and habitable modules) internal wall or surface temperatures to prevent condensation at all times.

Rationale: Liquid water on surfaces is conducive to microbial growth, and can be damaging to system hardware. Local condensation can be created when the atmosphere dew point temperature is at or above the surface temperature in any location. When power is available to condition vehicle walls to higher temperatures, higher dew points can be permitted to achieve higher relative humidity if it is more comfortable for the crew.

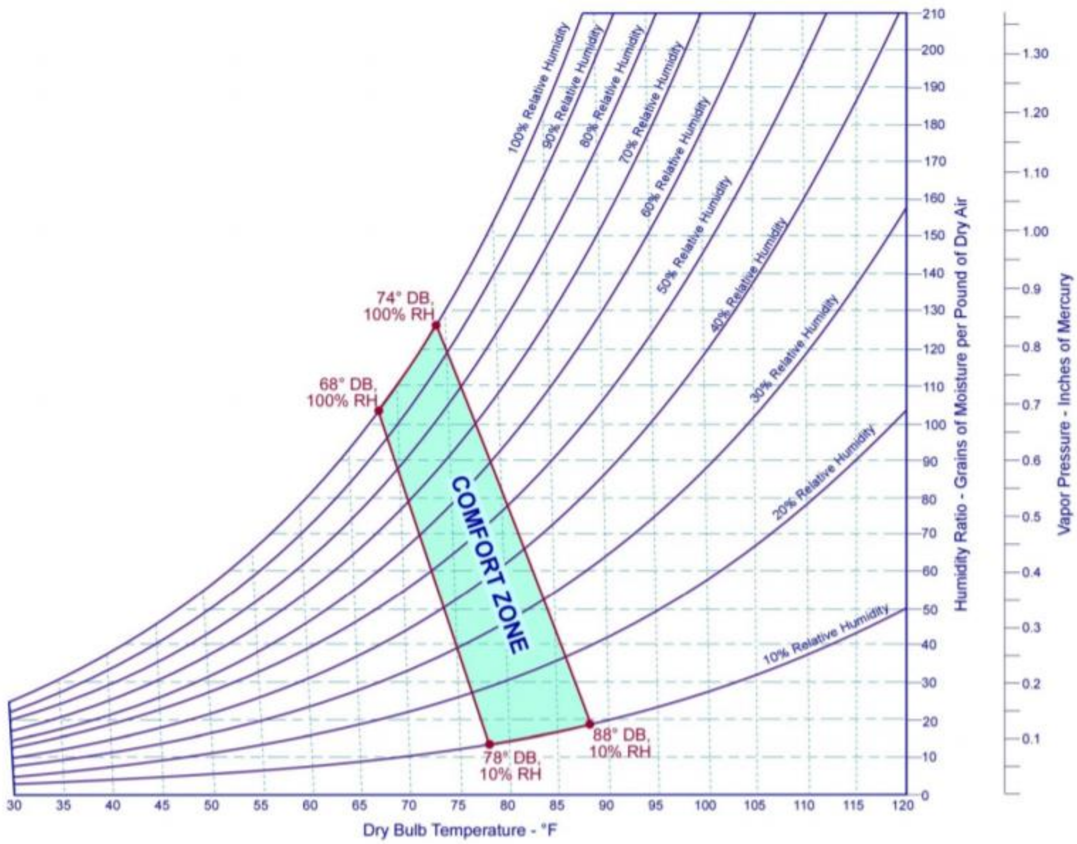

FIGURE 2 ENVIRONMENTAL COMFORT ZONE (NASA-STD-3001, SECTION 6.2.4 FIG 1)

ILLUSTRATES RELATIONSHIPS BETWEEN DEW POINT, TEMPERATURE, AND RELATIVE HUMIDITY. STANDARDS FOR TEMPERATURE, RELATIVE HUMIDITY, AND CONDENSATION AIM TO KEEP THE CREW COMFORTABLE WHILE MAINTAINING A CLEAN AND SAFE ENVIRONMENT.

3.3.6 POTABLE WATER QUALITY

Potable water quality must be defined so that water provided by any partner will be accepted for crew consumption by medical experts. Potable water quality limits are defined by crew health and medical experts. Several changes to existing standards are expected for the DSG&T vehicle.

ECLSS-33: The DSG&T vehicles, modules, and elements ECLSS shall provide potable water within standards for chemical and microbial contamination, and within acceptable aesthetic limits for crew consumption.

Key water quality standards include

Property	Limit or Range	Notes
Total Organic Carbon	< 5 mg/L (TBR-4) uncharacterized < 25 mg/L (TBR-5) characterized	Value change compared to NASA SWEG in JSC 63414
Ammonia	< 3 mg/L	Value change compared to NASA SWEG in JSC 63414
Silver	< 0.4 mg/L	Expected to be used at concentrations near the maximum allowable for biocide control
pH	5.5-9	Selected as a range that meets both NASA and GOST standards.
Free and Dissolved Gas	< 0.1%	Only appears as a health standard in NASA standards, not in GOST standards

ECLSS-34: DSG&T vehicles, modules, and elements ECLSS shall maintain individual chemical contaminants below toxicity limits defined by health and medical standards.

Rationale: Potable water quality limits are specifically set to be appropriately protective of the health and performance of spaceflight crews in consideration of the types of chemical/microbial risks relevant to this unique population. A current list of toxicity limits in NASA's SWEGs can be found in JSC 63414. A final list of critical contaminants will need to be reviewed after vehicle systems are selected. New limits could be added to those standards if new materials or operations introduce risks beyond what is currently managed for the International Space Station.

ECLSS-35: Microbial control shall maintain cleanliness equivalent to 50 cfu/mL counts (TBR-6), with non-detectable per 100 mL coliform bacteria, non-detectable per 100 mL fungus, and 0 parasitic protozoa.

Rationale: Potable water quality limits are specifically set to be appropriately protective of the health and performance of spaceflight crews in consideration of the types of chemical/microbial risks relevant to this unique population. These limits are what is set by NASA-STD-3001-Volume 2 Rev A. The method of measuring and validating microbial control may change based on new monitoring technology.

3.3.7 POTABLE WATER QUALITY AND MICROBIAL CONTROL PERFORMANCE

The compatibility of biocides in potable water is an important issue for system interoperability, and is described in Section 3-1. Performance requirements for the biocide in the potable water system must be met at the same time as the compatibility requirements.

ECLSS-36: The DSG&T vehicles, modules, and elements ECLSS shall maintain the quality, including chemical and microbial, of stored potable water within defined limits for at least 4 years (TBR-7) in open-loop systems.

Rationale: Water storage duration includes time between ground processing and launch, and storage on orbit before use. Long storage durations are important for the early DSG missions before closed-loop life support is delivered. The final scenario to define the mission operations concept that drive duration will be captured in official program documents. Until then, this assumes that one crew launch per year occurs to the DSG, and that not every major launch would be able to include water delivery. A robust system should also be designed for contingencies like delayed launches or lost resupply missions that could add another year of storage for the on-orbit assets before the crew returns. Some analysis cases may choose not to put water on logistics missions, especially if more perishable items like food are needed, or items specific to a particular crew (clothing spacesuits) need to be delivered. TBR-7 starts with 4 years as a life target based on time for ground processing, at least two years of nominal mission storage, plus margin for contingencies or providing flexibility for logistics choices.

For long duration missions with closed-loop water recycling, expired water can be processed to return to potable status. Therefore, transit to Mars, or dormancy in Mars orbit on the Mars surface are not driving durations for storage life. However, this would drive a requirement to supply ascent vehicles or predeployed landers with recently processed potable water before use.

3.3.8 URINE PRETREATMENT PERFORMANCE

Crew urine is a resource that can be recycled into useful water or oxygen when closed-loop recycling systems are provided as part of the ECLSS. In a system with many contributing partners, the provider of the waste collection system may not be the provider of the urine recycling system. Waste collection systems are likely provided earlier than water recycling systems. Defining performance requirements for these systems early will make it possible to compare technical solutions for the DSG&T, and test viable systems for compatibility with closed-loop urine recycling systems.

This is not intended to define the functional allocations in DSG&T and require that every vehicle, module, and element of the DSG&T must have a waste collection system with urine pretreatment. But if they do have a waste collection system, the urine pretreatment should meet these standards.

ECLSS-37: DSG&T vehicles, modules, and elements waste collection system(s) shall provide a urine pretreatment that protects the waste collection system.

Rationale: Pretreatment is initially used to protect the urine collection system components. Current systems assumptions include a spin-separator in the urine collection system that cannot accept particulate (e.g. precipitation of solids from urine), and bellows tank storage that cannot accept evolution of free gas (e.g. CO_2 or NH_3) or biological fouling. Free gas would cause tank pressurization, and failures in pumps, filters or other components.

ECLSS-38: DSG&T vehicles, modules, and elements waste collection system(s) shall provide a urine pretreatment that maintains effective microbial (bacterial and fungal) control in the pretreated urine for 3 months of storage.

Rationale: Urine pretreatment controls prevents microbial growth that would clog the urine recycling systems or fluid lines and tanks in the system. ISS experience shows that urine may need to be stored during maintenance and troubleshooting of water processing systems. The three-month requirement allows time for systems to store urine during startup of ECLSS systems, and during maintenance, and still be able to recover water.

ECLSS-39: DSG&T vehicles, modules, and elements waste collection system(s) shall provide a urine pretreatment that maintains the urine within specifications for processing by the water recovery system after 3 months of storage.

Rationale: In long duration missions, pretreating urine also allows water recovery from stored urine by making sure that it is still compatible with the water recovery system. The urine recycling system may have unique requirements such as free gas, particulate, or other constraints on what can successfully be processed by the system. ISS experience shows that urine may need to be stored during maintenance and troubleshooting of water processing systems. The three-month requirement allows time for systems to store urine during startup of ECLSS systems, and during maintenance, and still be able to recover water.

ECLSS-40: Urine pretreatment chemicals shall have stable shelf life of greater than 3 (TBR-8) years for Mars missions. Ideal performance would be stable shelf life greater than 5 years for pre-emplaced cargo delivery scenarios.

Rationale: The Deep Space Transport vehicle is expected to perform conjunction-class missions to Mars. The waste collection system for the DSG is expected to be common with the DST to simplify crew training and maximize common spares, especially since the waste collection system often has disposable components for cleanliness. Operation at the DSG will build experience with the system to be used on the DST, and thus should be designed to meet DST requirements.

4.0 VERIFICATION AND TESTING

The technical requirements listed in Section 3.0 will typically be verified through the roll-up of subsequent verifications of lower level allocated and derived technical requirements and analysis of integrated designs. These will be traced through bi-directional traceability matrices in the lower level requirements. When test or analysis of the individual elements is not adequate to show compliance at an integrated level, additional test or analysis will be performed. The specifics of the verification program will be captured in ESD and DSG&T V&V Documentation.

4.1 EARLY DISCUSSIONS ON TESTING STANDARDS

For some topic areas, early discussions on test methods are required for technology development, as well as for the final vehicle design. This section provides information or discussion on topics that would be implemented in the lower level verification requirements, but may be useful background to guide technology development.

4.1.1 AUGMENTED URINE TO REPRESENT SPACEFLIGHT CONDITIONS

Wastewater systems and water processors which process urine should perform testing with wastewater streams that represent urine from crewmembers during spaceflight. This is especially true for systems which add additional chemical species (such as a pretreatment), or are sensitive to particulates, or concentrate wastewater, or otherwise utilize phase change (such as distillation, evaporation, freeze-drying, precipitation). The document CTSD-ADV-1324 “Collection, Augmentation, Stabilization, and Disposal of Urine“ describes methods to augment human urine collected on Earth to represent key spacecraft urine properties, such as Calcium concentration of 230 mg/L. It also describes current available spacecraft methods for pretreating urine with added chemicals for stability and microbial control.

ISS operations history and failures have identified several lessons learned that demonstrate that ground testing did not sufficiently replicate spacecraft conditions. One example is increased concentration of key minerals such as calcium.

4.1.2 INOCULATION OF URINE FOR URINE PRETREATMENT TESTS

New pretreatment formulations shall be tested to see if they achieve the same levels of microbial and fungal control as state of the art pretreatment, using inoculated, augmented, human urine. A pretreatment that does not perform the same as the state of the art pretreatment could still be selected. If other pretreatments have different performance, they must be thoroughly tested with an integrated waste collection system, wastewater transport and storage, and water processing system to show successful operation.

Inoculation with fungus and bacteria is based on microbial load that has been found on ISS in the waste system. Testing in a lab is likely to have a cleaner environment than ISS and would not provide a consistent or sufficient challenge.

4.1.3 TECHNOLOGY VALIDATION TESTING

NASA and international partners need to agree on expectations for technology demonstration before systems can be considered ready for inclusion in DSG&T.

Note: Carbon dioxide removal is one of the first systems where discussions have begun. For example, ESA has negotiated a 1 year cumulative demonstration for the ACLS system on ISS. One possible agreement could be that CO_2 removal systems must be tested on orbit for at least one year cumulative time to verify their reliable performance in microgravity. On-orbit tests should be compared to ground tests that replicate ISS inlet conditions to validate that the system performs the same way in microgravity as it does on Earth. If on-orbit and ground tests are shown to have equivalent results, ground tests can be used to demonstrate system performance with different inlet CO_2 and flow conditions. These topics should be part of international contribution discussions.

5.0 FUTURE TOPICS FOR POSSIBLE STANDARDIZATION

Several topics are partially defined, or have been identified for work, to lead to future standards.

Several topics have been identified as forward work include waste management, waste processing and resource recovery, physical connections (in addition to the quick disconnect connections identified below), design standards related to repairability and system refurbishment and maintainability, any tailoring of human system interaction standards, requirements that enable joint spares tracking and management.

In the areas listed below, some technical discussion has already begun, but there is forward work needed before a requirements structure and values can be proposed.

5.1.1 URINE PRETREATMENT FORMULATION AND DOSING

The document CTSD-ADV-1324, "Collection, Augmentation, Stabilization, and Disposal of Urine", describes methods to augment human urine collected on Earth to represent key spacecraft urine properties. It also describes current available spacecraft methods for pretreating urine with added chemicals for stability and microbial control with phosphochromic and sulfochromic pretreatment formulations.

Additional updates may be required if technology development results in new, feasible formulations.

5.1.2 POTABLE WATER BIOCIDE FORMULATION AND MAINTENANCE

The primary residual biocide used in the vehicle will be silver based. Concentrations must meet requirements for potable water when it is consumed by humans. Specifics of the silver formulation or generation method are undefined at this time.

Additional updates may be required if technology development results in new, feasible methods.

5.1.3 LIQUID QUICK DISCONNECT CONNECTIONS

Placeholder for future content. Trade studies may be required.

5.1.4 GAS QUICK DISCONNECT CONNECTIONS

Placeholder for future content. Trade studies may be required.

5.1.5 EMERGENCY EQUIPMENT

Emergency systems, such as masks, should be standardized to simplify crew training and improve crew response in contingencies.

5.1.6 CREWMEMBER METABOLIC RATES

Placeholder for future standard.

Rationale: Crew metabolic rates define the oxygen use, carbon dioxide production, sensible heat production, water vapor production (respiration and latent heat through perspiration) of a crewmember as a result of *metabolic activity and individual crewmember size. These values are a reasonable maximum to be used for system design, but will vary significantly during actual missions for individual crewmembers. Total metabolic rate is expected to be higher for exploration missions than what is described in NASA/SP-2010-3407/Rev1 due to longer exercise periods.*

5.1.7 CREWMEMBER TRACE GAS GENERATION RATE

Placeholder for future standard.

Rationale: Trace gas generation rates are needed to design trace contaminant control systems. Trace gas generation includes both crewmember and materials off-gassing. Reference AIAA 2009-01-2592 for preliminary values.

5.1.8 VEHICLE TRACE GAS GENERATION RATE

Placeholder for future standard.

Rationale: Trace gas generation rates are needed to design trace contaminant control systems. Trace gas generation includes both crewmember and materials off-gassing. Reference AIAA 2009-01-2592 for preliminary values.

5.1.9 PLANT GROWTH SYSTEM GAS EXCHANGE RATES

Placeholder for future standard.

Rationale: Growing plants for food will introduce oxygen, carbon dioxide, and humidity production and consumption rates that will impact the design of pressure control, CO_2 removal, and especially humidity control systems. Plants will also create and destroy trace gas contaminants, but those rates are likely to be low and not substantially impact designs. Limited plant growth is expected as part of the Deep Space Gateway with a negligible effect on CO_2 and O_2. Transpiration of water into atmosphere humidity could have a detectable impact on the system even with small amounts of plant growth.

5.1.10 CREWMEMBER WASTE GENERATION RATES

Placeholder for maximum single events for design for urine, feces, and emesis

Placeholder for average planning rate for urine, feces, and emesis

Rationale: Crewmember urine and feces generation rates will drive waste collection system design, logistics supply planning (based on frequency of toilet use), and waste management and disposal planning.

5.1.11 WATER COMPATIBILITY WITH OTHER VEHICLE SYSTEMS

Placeholder for water interface with spacesuits

Placeholder for future standard.

> *Rationale: Water supply to spacesuits, oxygen generation, monitoring systems, medical systems, or supplying experiments may have unique interface requirements. This water does not necessarily also have to meet the potable water standard.*

5.1.12 VEHICLE TEMPERATURES DURING DORMANCY

Placeholder for maximum temperature during dormancy if analysis shows it is higher than nominal temperatures

> *Rationale: A close approach to the moon could induce a high temperature that would need to be defined if thermal control systems are in a dormant state. If analysis shows that high temperatures are possible during dormancy, internal vehicle temperature control analysis needs to be performed to examine what temperatures would actually be experienced, and where the limits of operation are for electronic components or others that might be sensitive at higher temperatures. High temperatures would drive higher rates of materials off gassing during this period.*

Placeholder for controlling vehicle internal temperature during dormancy if payloads require it

> *Rationale: It may also be necessary to define local temperatures for science payloads that are maintained separately from the overall vehicle temperature.*

5.1.13 AIRLOCK OXYGEN

DSG&T airlock will have unique oxygen requirements

5.1.14 AIRLOCK PRESSURE

DSG&T airlock will have unique pressure requirements

APPENDIX A - ACRONYMS AND ABBREVIATIONS

AIAA	American Institute of Aeronautics and Astronautics
ACLS	Advanced Closed Loop System
CO_2	Carbon Dioxide
CTSD	Crew and Thermal Systems Division
CWC	Contingency Water Container
DSG	Deep Space Gateway
DSG&T	Deep Space Gateway and Transport
DST	Deep Space Transport
ECLSS	Environmental Control and Life Support System
EVA	Extravehicular Activity
FCSS	Future Capabilities Systems Standards
HEOMD	Human Exploration and Operations Mission Directorate
HIDH	Human Integration Design Handbook
IECLSSIS	International Environmental Control and Life Support System Interoperability Standards
IECST	International Exploration Capabilities Study Team
I-SMT	International System Maturation Team
ISO	International Organization for Standardization
ISS	International Space Station
JSC	Johnson Space Center
MAPTIS	Materials And Processes Technical Information System
MCB	Multilateral Coordination Board
NASA	National Aeronautics and Space Administration
NH_3	Ammonia
SI	Le Système International d'Unités
SWEG	Spacecraft Water Exposure Guidelines
TBD	To Be Determined
TBR	To Be Reviewed

APPENDIX B GLOSSARY

Vehicle, Element, or Module

The phrase “vehicle, element, or module” is used in this document to describe all of the pressurized, habitable volume that will make up the Deep Space Gateway, Deep Space Transport, and other related elements. If any elements have special requirements, such as an airlock being exposed to the vacuum of space, those requirements are called out specifically. The document is not expected to change requirements for the Orion spacecraft. It does not yet extend to any lunar or Mars landers or surface habitats. It does not include spacesuits.

APPENDIX C OPEN WORK

Table C-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBD item is numbered based on the section where the first occurrence of the item is located as the first digit and a consecutive number as the second digit (i.e., <TBD 4-1> is the first undetermined item assigned in Section 4 of the document). As each TBD is solved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

The IECLSSIS contains many placeholder topics for which future standards need to be created. However, since the best structure for listing the various values for each topic has not been created, they are not included as TBDs at this point.

TABLE C-1 TO BE DETERMINED ITEMS

TBD	Section	Description
TBD-1	3.3.2	High oxygen levels may be necessary as part of certain emergency operations, such as attempting to purge a spacesuit into the habitat in order to perform transfer to an unpressurized Orion. Detailed operations concepts and processes do not exist to predict how long those conditions, or any other emergency that requires or temporarily results in high oxygen levels will last.

Table C-2 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBR issue is numbered based on the section where the first occurrence of the issue is located as the first digit and a consecutive number as the second digit (i.e., <TBR 4-1> is the first unresolved issue assigned in Section 4 of the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

TABLE C-2 TO BE RESOLVED ISSUES

TBR	Section	Description
TBR-1	3.3.1	A higher maximum vehicle pressure provides operational flexibility for leak checks, providing vestibule pressurization gas from a higher pressure spacecraft, resupplying gas by filling from visiting vehicle pressure control systems, and providing the ability to perform airsave from an airlock by pumping gas back into the rest of the pressurized volume. However, these higher pressures could increase the mass and cost of pressurized elements, such as those that rely on ISS heritage. Utimately, this requirement may depend on the heritage of the elements that make up the DSG&T system.
TBR-2	3.3.3	There is a known disagreement on this standard. Roscosmos/Energia does not concur with the 2 mmHg (2600 ppm) CO_2 level, and recommends 6 mmHg daily average. The ECLSS team recommends authorizing the Multilateral Medical Operations Panel (MMOP) to begin including exploration content to set a single, shared “Design Goal” for future missions, for nominal long duration, long-term exposure levels for CO2. This approach could be similar to the “design safety factor” that is applied to trace contaminant control levels. This allows a design goal for nominal operation that is lower than the maximum allowable level based on functional margin. (Functional margins may need to be greater for missions farther from Earth that do not have abort options or logistics resupply options.) This would apply to CO2 removal systems across all international partners to prepare for long-duration exploration missions. Additionally, the panel can also discuss what medical research is necessary to set a final requirement in the future.
TBR-3	3.3.4	Low temperatures are desired to slow microbial growth during dormancy. Analysis and testing has not been performed to determine what temperature is sufficiently low to inhibit microbial growth. Additionally, analysis has not been done to determine if any systems or payloads will be unable to operate at this low temperature and constrain the lower limit. 4°C was selected as a reasonable starting point for a dormancy temperature to control microbial growth based on public health recommendations to control bacteria growth in refrigerators.
TBR-4	3.3.6	Based on ISS experience, NASA expects to update requirements to allow higher total organic carbon levels in potable water. These changes have not yet been included in the applicable parent documents.
TBR-5	3.3.6	Based on ISS experience, NASA expects to update requirements to allow higher total organic carbon levels in potable water. These changes have not yet been included in the applicable parent documents.
TBR-6	3.3.6	Microbial quality standards for potable water are expected maintain a similar intent for future spacecraft, but a revision of the applicable parent documents may change the way viability, enumeration, or identification of microbial contamination is discussed.
TBR-7	3.3.7	Potable water shelf life is based on logistics delivery assumptions from ISCEWG Phase 1 analysis. More detail on ground processing time, risk tolerance for skip cycles, or updated logistics analysis could change the maximum time water is stored before it is consumed or a closed-loop water recycling system is provided to reprocess it.
TBR-8	3.3.8	Fire extinguisher and urine pretreatment shelf life is based on concepts for 1000-1200 day human Mars missions. If urine pretreatment must be delivered much earlier for habitat outfitting logistics, or ground processing time is very long, this minimum required number could increase.