NASA-STD-3001 Technical Brief

Behavioral Health and Performance

OCHMO-TB-016
Rev A

Executive Summary

Crew behavioral health and performance are affected by missions in isolated, confined, and extreme (ICE) environments. Future exploration missions will involve humans moving further away from low Earth orbit (LEO) with longer mission durations and will have a greater risk for behavioral health and performance decrements. These hazards could lead to (a) adverse cognitive or behavioral conditions affecting crew health and performance during the mission; (b) the development of psychiatric disorders if adverse behavioral health conditions are undetected or inadequately mitigated; and c) long-term health consequences, including late-emerging cognitive and behavioral changes. Ensuring crew behavioral health over the long term is essential. Behavioral health standards optimize crewmembers' health, well-being, and productivity and reduce the risk of behavioral and psychiatric conditions before, during, and after missions.

Relevant Technical Requirements

NASA-STD-3001 Volume 1, Rev B

[V1 3001] Selection and Recertification
[V1 3002] Pre-Mission Preventive Health Care
[V1 3003] In-Mission Preventive Health Care
[V1 3004] In-Mission Medical Care
[V1 4011] Mission Cognitive State
[V2 4014] Completion of Critical Tasks
[V1 5002] Astronaut Training
[V1 6001] Circadian Shifting Operations and Fatigue Management
[V1 6002] Private Medical Communication (PMC) Schedule
[V1 6004] Behavioral Health and Performance Provisions
[V1 6008] Crew Health Operations Concept Document
[V1 6009] Medical and Crew Health Requirements Document
Appendix D Health and Medical Care Standard

NASA-STD-3001 Volume 2, Rev C

[V2 3006] Human-Centered Task Analysis
[V2 4102] Functional Anthropometric Accommodation
[V2 5004] Cognitive Capabilities
[V2 6012] Crew Health Environmental Limits
[V2 6013] Crew Performance Environmental Zone
[V2 6017] Atmospheric Control
[V2 6022] Atmospheric Monitoring and Alerting

Executive Summary (continued)

Relevant Technical Requirements

[V2 6077] Hazardous Noise Limits for All Phases Except Launch, Entry, and Abort
[V2 6078] Continuous Noise Limits
[V2 6079] Crew Sleep Continuous Noise Limits
[V2 6080] Intermittent Noise Limits
[V2 6082] Annoyance Noise Limits for Crew Sleep
[V2 6083] Impulse Noise Limit
[V2 6085] Narrow-Band Noise Limits
[V2 6092] Vibration Exposure Limits during Sleep
[V2 6095] Ionizing Radiation Protection Limit
[V2 6097] Crew Radiation Exposure Limits
[V2 6098] Radiation Environments
[V2 6099] Space Weather Monitoring
[V2 6109] Water Quantity
[V2 7008] Food Preparation
[V2 7016] Personal Hygiene Capability
[V2 7017] Body Cleansing Privacy
[V2 7021] Body Waste Management System Location
[V2 7022] Body Waste Management Privacy
[V2 7038] Physiological Countermeasures Capability
[V2 7050] Stowage Provisions
[V2 7051] Personal Stowage
[V2 7061] Nomenclature Consistency
[V2 7062] Unique Item Identification
[V2 7063] Interchangeable Item Nomenclature
[V2 7070] Sleep Accommodation
[V2 7071] Behavioral Health and Privacy
[V2 7073] Partial-g Sleeping
[V2 8001] Volume Allocation
[V2 8005] Functional Arrangement
[V2 8013] Intravehicular Translation Paths
[V2 8033] Restraints for Crew Tasks
[V2 8049] Window Light Blocking

Relevant Technical Requirements

[V2 8050] Window Accessory Replacement/Operation without Tools
[V2 8055] Physiological Effects of Light (Circadian Entrainment)
[V2 8056] Lighting Controls
[V2 9057] Hearing Protection Provision
[V2 5007] Cognitive Workload
[V2 10200] Physical Workload
[V2 10001] Crew Interface Usability
[V2 10002] Design Induced Error
[V2 10003] Crew Interface Operability
[V2 10015] Use of Cognitive Aids
[V2 10017] System Health and Status
[V2 10022] Maximum System Response Times
[V2 10083] Communication System Design
[V2 10084] Communication Capability
[V2 10085] Communication Speech Levels
[V2 10086] Communication Operational Parameters
[V2 10087] Communication Environmental Parameters
[V2 10088] Communication Controls and Procedures
[V2 10089] Communication Transmitter and Receiver Configuration
[V2 10090] Audio Communications Quality
[V2 10091] Speech Intelligibility
[V2 10093] Private Audio Communication
[V2 10094] Video Communication Visual Quality
[V2 10100] Automated and Robotic System Provision
[V2 11010] EVA Suit Radiation Monitoring

Background

Space flight occurs in an extreme environment that has unique stressors. Common behavioral health conditions or concerns in the spaceflight environment may include stress, depression, anxiety, relationship problems, and grief. The condition can be temporary, resolving with time and/or intervention, or can develop into a psychiatric disorder. Assessing predictive and contributing factors related to behavioral health can help prevent the onset of distress.

Behavioral Health Contextual Factors

Individual Factors

- Demographics and biological resilience
- Personality(social drive, need for novelties.)
- Coping Styles
- Culture and language

Social/Crew Dynamics

- Crew size
- Social climate/cohesion
- Group living and team care skills

Family –life stressors and major world events

Behavioral Health Decrements Contributing Factors

- Sleep
- Immune
- Workload
- Human System Integration Architecture
- Pharmacotherapeutics (adverse effects)
- Medical Conditions
- Hypoxia
- Food-Nutrition
- Carbon Dioxide

Behavioral Health Decrements Consequences

- Operational performance decrement (that might lead to loss of mission objectives or loss of mission (e.g., evacuation/early return)
- Psychiatric disorders
- Neurocognitive or neurodegenerative disorders

Background

Factors that affect crewmembers behavioral health

Exposure Sources
- Carbon dioxide
- Celestial dust
- Toxic
- Sunlight
- Radiation

Isolation
- Cognitive, behavioral, psychiatric disorders
- Cooperation, coordination, psychosocial adaptation
- Inadequate cooperation and communication within a team

Work
- Sleep loss
- Circadian desynchronization
- High / low Work load

Gillian Blease/Getty Images

Altered body function
- Immune response
- Hypobaric hypoxia
- Decompression
- Renal stone
- Bone fracture
- Host-microorganism interactions
- Urinary retention
- Orthostatic intolerance
- Cardiac rhythm
- Back pain

Preparedness
- Food and nutrition
- Inflight medical conditions
- Medication

Reduced capacities
- Hearing loss
- Intracranial hypertension/vision alteration
- Vestibular/sensorimotor alteration
- Muscle mass, strength, endurance
- Aerobic capacity

Injury sources
- Dynamic loads
- EVA
- Electrical shock

*Primary factors that affect crewmembers behavioral health

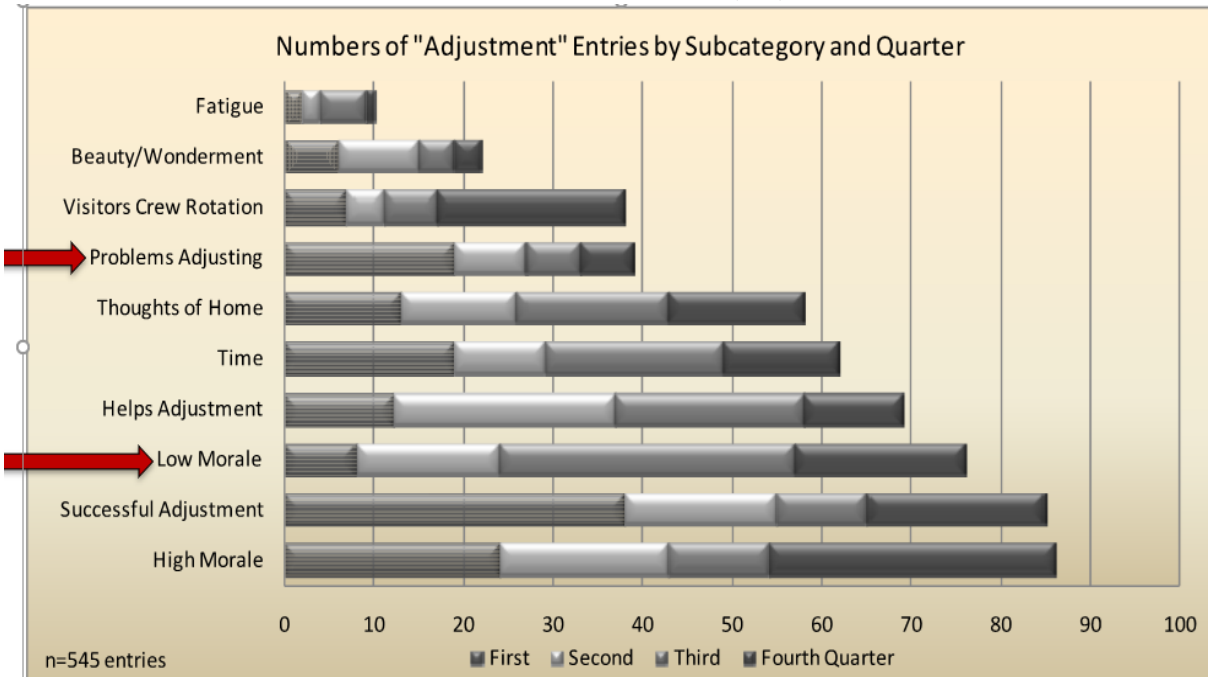
Background

Reported Behavioral Health Issues during Spaceflight

- Soyuz T10-Salyut 7 (1984): Crew reported possible hallucinations to mission control.
- Soyuz T14-Salyut 7 (1985): Depression may have contributed to evacuation and early termination of the mission.
- 2 of 7 (29%) of NASA Shuttle-Mir astronauts reported depressive symptoms. (Human Research Evidence Report, April 11, 2016)
- An STS Payload specialist became despondent when their experiment failed. The crew reported concerns about the potential for dangerous behavior, including opening a hatch. As a result, the STS hatches were fitted with locks.
- Delayed notification to a Russian crewmember of a family member's death led to acute social withdrawal, depression, and isolation.
- Soyuz 21 reportedly ended prematurely due to unspecified "interpersonal issues" with the crew.

Reference the NASA OCHMO Behavioral Health Mishaps technical brief and the NASA OCHMO Cognitive Workload technical brief for additional information.

Astronaut Journals (ISS)

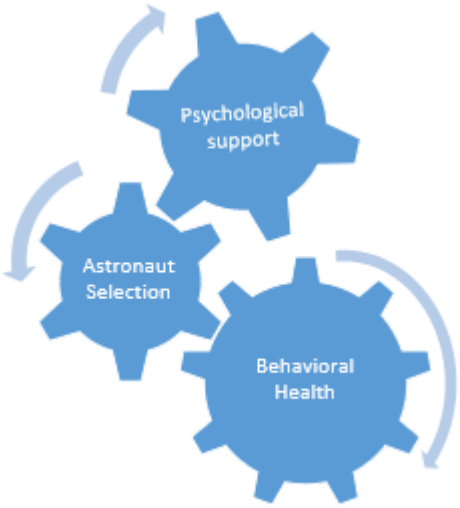


Stuster J. (2010) *Behavioral Issues Associated with Long-Duration Space Expeditions: Review and Analysis of Astronaut Journals -- Experiment 01-E104 (Journals): Final Report*, NASA Technical Document, TM-2010-216130

Application

Behavioral Health Support

The following outlines the mitigation strategies currently utilized to prevent decrements in behavioral health and performance of the crew during a space flight mission. It should be noted that current behavioral health support is provided before, during, and after the mission.



These behavioral health support services fall within six broad categories:

1. **Selection**
   Includes things such as clinical and suitability evaluations of applicants throughout the selection process, and, while not currently facilitated, composition assignments for crew flight selections and composition strategies to address technical and non-technical compatibility of the crew.
2. **Training**
   Training will ensure effective adaptation for both individuals and teams. Focuses include managing stress, dealing with cultural differences, working as an effective team, small group living, and optimizing sleep and circadian adaptation strategies.
3. **In-Flight Psychological and Neurobehavioral Support**
   Private psychological conferences (PPCs) are currently provided; additional psychological support includes crew care packages, crew support events (e.g., talking with movie star during the mission), and other support services (e.g., movies, books, magazines, favorite TV shows).
4. **In-Flight Psychological and Neurobehavioral Monitoring**
   Cognitive testing is currently fulfilled by the monthly administration of the Spaceflight Cognitive Assessment Tool for Windows (**WinSCAT**). A preflight baseline is obtained for each astronaut and is then compared using a monthly in-flight test. A traumatic injury or illness on-orbit would dictate additional testing and assessment.

   For missions beyond 6 months and/or beyond LEO, additional minimally obtrusive measures that objectively evaluate psychological and behavioral states within the mission context should be provided.

Relevant Technical Requirements
[V1 3001] Selection and Recertification, [V1 3002] Pre-Mission Preventive Health Care, [V1 3003] In-Mission Preventive Health Care, [V1 3004] In-Mission Medical Care Crewmembers, [V1 4011] Mission Cognitive State, [V1 6001] Circadian Shifting Operations and Fatigue Management, [V1 6004] Behavioral Health and Performance Provisions, [V1 6008] Crew Health Operations Concept Document, [V1 6009] Medical and Crew Health Requirements Document

From: NASA-STD-3001 Volume 1, Rev B

Application

5. **Family Psychological Support:**

   The current program includes support for crewmembers' families; examples of support include Private Family Conferences (PFCs).

   For missions beyond six months and/or beyond LEO, additional resources to support families, significant others, and friends and to facilitate crew-ground communication should be provided.

6. **Repatriation:**

   Repatriation briefings are conducted pre-flight and normally 6 weeks before landing with the astronauts and their family members. Additional behavioral support is provided on an as-needed basis to facilitate the repatriation and reintegration of the astronauts with their families and work lives.

Astronauts aboard the ISS open a crew care package. Crew care packages are one means of keeping astronaut motivation and morale high, especially during long missions.
Credit: NASA

Photographing Earth and Journaling are important outlets for astronauts to manage their stress.
Credit: NASA

Relevant Technical Requirements

[V1 3004] In-Mission Medical Care
[V1 6002] Private Medical Communication (PMC) Schedule

From: NASA-STD-3001 Volume 1, Rev B

Application

Habitat Design Guidance to Mitigate Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Lack of Personal Space / Lack of Private Space	• Provide individual, separate sleeping/personal quarters w/auditory isolation and physical separation (if possible) for each crew member. • Separation of private spaces from spaces allocated for common, social areas, and congested translation paths is preferred. • Visual separation of private spaces from each other to allow for the perception of increased privacy. **[V2 7070] Sleep Accommodation; [V2 7071] Behavioral Health and Privacy, [V2 8001] Volume Allocation, [V2 8005] Functional Arrangement**
Lack of Privacy in Waste & Hygiene Compartment	• Dedicated, private area for waste and hygiene with hygiene areas away from the dining area and medical station. • Separation of Waste & Hygiene Compartment area from translation areas. **[V2 7016] Personal Hygiene Capability, [V2 7017] Body Cleansing Privacy, [V2 7021] Body Waste Management System Location, [V2 7022] Body Waste Management Privacy**
Lack of Sleep Quality and/or Quantity	• Provide restraints to secure blankets and maintain positioning, with a range from knees to chest to full body stature. • Provide individual control of the sleep environment in order to ensure adequate sleep and maintain well-being during missions. • Environmental factors such as noise, temperature, vibration, and light inhibit sleep and affect well-being in space. • Examples of sleep accommodations include clothing, bedding, ear plugs, light blockers, eye masks, etc. **[V1 4014] Completion of Critical Tasks, [V2 7070] Sleep Accommodation, [V2 6078] Continuous Noise Limits, [V2 6079] Crew Sleep Continuous Noise Limits, [V2 6080] Intermittent Noise Limits, [V2 6082] Annoyance Noise Limits for Crew Sleep, [V2 6083] Impulse Noise Limit, [V2 6085] Narrow-Band Noise Limits, [V2 6092] Vibration Exposure Limits during Sleep, [V2 8049] Light Blocking, [V2 8055] Circadian Entrainment, [V2 9057] Hearing Protection**

Application

Habitat Design Guidance to Mitigate Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Sense of Poorly Placed Stowage	• Ensure stowage types are near designated areas (i.e., food near dining). • Ensure that not all materials are stowed in one place. **[V2 7051] Personal Stowage, [V2 7050] Stowage Provisions, [V2 7008] Food Preparation**
Long periods of low workload Bursts of high workload Lack of meaningful work /activity	• Provide individual development plans for each person's work goals, progress, and achievements. • Allocation of space and resources to accommodate everyone's work and activities (i.e., science, laboratory equipment, electronic curriculum, etc.). • The user must be able to cognitively process all information sources and physically execute all actions within the time required. **[V1 4011] Mission Cognitive State, [V2 5004] Cognitive Capabilities, [V2 7061] Nomenclature Consistency, [V2 7062] Unique Item Identification, [V2 7063] Interchangeable Item Nomenclature, [V2 10001] Crew Interface Usability, [V2 10002] Design Induced Error, [V2 10003] Crew Interface Operability, [V2 10015] Use of Cognitive Aids, [V2 10017] System Health and Status, [V2 10022] Maximum System Response Times**
Lack of Individual Controls Over Temperature, Ventilation, Lighting, Humidity, or Noise	• Place individual controls and distribution vents in crew quarters and at workstations. **[V2 6012] Crew Health Environmental Limits, [V2 6013] Crew Performance Environmental Zone, [V2 6017] Atmospheric Control, [V2 6022] Atmospheric Monitoring and Alerting, [V2 6077] Hazardous Noise Limits for All Phases Except Launch, Entry, and Abort, [V2 8049] Light Blocking, [V2 8056] Lighting Controls**

Reference the NASA Human Integration Design Handbook (HIDH) for additional information on habitat design for long-duration missions.

Application

Habitat Design Guidance to Mitigate Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Limited Communication with Home	• Communication system should be provided in each private quarter • System that facilitates voice and text should be provided • Private communication with family • Private space with pictures of family members **[V2 10083] Communication System Design, [V2 10084] Communication Capability, [V2 10085] Communication Speech Levels, [V2 10086] Communication Operational Parameters, [V2 10087] Communication Environmental Parameters, [V2 10088] Communication Controls and Procedures, [V2 10089] Communication Transmitter and Receiver Configuration, [V2 10090] Audio Communications Quality, [V2 10091] Speech Intelligibility, [V2 10093] Private Audio Communication, [V2 10094] Video Communication Visual Quality**
Crew Composition	• Characteristics of the crew (team size, gender makeup, job roles, and cultural backgrounds), which are established before the mission, should be considered when defining the habitat requirements. **[V1 3001] Selection and Recertification**
Lack of Hygiene Separation	• Provide separation between clean areas (medical treatment, food prep, crew quarters, etc.) and dirty areas (hygiene, dusty areas, etc.) • Provide olfactory or other partitions to prevent contamination of clean areas. This can include closed, separately ventilated areas. **[V2 7022] Body Waste Management Privacy**
Lack of "Backup Plan" / "Rescue Scenario"	• Placement of hatches to allow for alternate escape routes. • Provision of radiation shelter. **[V2 6095] Ionizing Radiation Protection Limit, [V2 6097] Crew Radiation Exposure Limits, [V2 6098] Radiation Environments, [V2 6099] Space Weather Monitoring, [V2 10100] Automated and Robotic System Provision, [V2 11010] EVA Suit Radiation Monitoring**

Back-Up

Major Changes Between Revisions

Original → Rev A

- Updated information and standards to be consistent with NASA-STD-3001 Volume 1 Rev B and Volume 2 Rev C.

Referenced Technical Requirements

NASA-STD-3001 Volume 1 Revision B

[V1 3001] Selection and Recertification Crewmembers shall be medically and psychologically selected and annually recertified following the guidance in OCHMO-STD-100.1A, NASA Astronaut Medical Standards Selection and Annual Recertification.

[V1 3002] Pre-Mission Preventive Health Care Pre-mission preventive strategies shall be used to reduce in-mission and long-term health medical risks including, but not limited to: Flight surgeon monitoring of crewmembers during hazardous training and pre-flight science testing.

[V1 3003] In-Mission Preventive Health Care All programs shall provide training, in-mission capabilities, and resources to monitor physiological and psychosocial well-being and enable delivery of in-mission preventive health care based on epidemiological evidence-based probabilistic risk assessment (PRA) that takes into account the needs and limitations of each specific design reference mission (DRM), and parameters such as mission duration, expected return time to Earth, mission route and destination, expected radiation profile, concept of operations, and more. The term “in-mission” covers all phases of the mission, from launch, through landing on a planetary body and all surface activities entailed up to landing back on Earth. In-mission preventive care includes but is not limited to: (see NASA-STD-3001, Volume 1 Rev B for full standard).

[V1 3004] In-Mission Medical Care All programs shall provide training, in-mission medical capabilities, and resources to diagnose and treat potential medical conditions based on epidemiological evidence-based PRA, clinical practice guidelines and expertise, historical review, mission parameters, and vehicle-derived limitations. These analyses should consider the needs and limitations of each specific DRM and vehicle. The term “in-mission” covers all phases of the mission, from launch, through landing on a planetary body and all surface activities entailed, up to landing back on Earth. In-mission capabilities (including hardware and software), resources (including consumables), and training to enable in-mission medical care are to include but are not limited to: see NASA-STD-3001, Volume 1 Rev B for full standard).

[V1 4011] Mission Cognitive State Pre-mission, in-mission, and post-mission crew behavioral health and crewmember cognitive state shall be within clinically accepted values as judged by behavioral health evaluation.

[V1 4014] Completion of Critical Tasks The planned number of hours for completion of critical tasks and events, workday, and planned sleep period shall have established limits to assure continued crew health and safety.

[V1 5002] Astronaut Training Beginning with the astronaut candidate year, general medical training, including first aid, cardiopulmonary resuscitation (CPR), altitude physiological training, carbon dioxide exposure training, familiarization with medical issues, procedures of space flight, psychological training, and supervised physical conditioning training shall be provided to the astronaut corps.

[V1 6001] Circadian Shifting Operations and Fatigue Management Crew schedule planning and operations shall be provided to include circadian entrainment, work/rest schedule assessment, task loading assessment, countermeasures, and special activities.

[V1 6002] Private Medical Communication (PMC) Schedule A PMC shall be scheduled on a routine basis as determined by the Flight Surgeon, at a frequency dictated for short- or long-duration missions.

Referenced Technical Requirements

[V1 6004] Behavioral Health and Performance Provisions Provisions shall be made to implement appropriate psychological support programs for the crew, key ground personnel, and crew families throughout the mission

[V1 6008] Crew Health Operations Concept Document The program(s) shall develop a crew health operations concept document to define the medical and health care concepts during all phases of the spaceflight program

[V1 6009] Medical and Crew Health Requirements Document The program(s) shall develop a medical and crew health requirements document based on the concepts outlined in the CHOC document and NASA-STD-3001.

NASA-STD-3001 Volume 2 Revision C

[V2 3006] Human-Centered Task Analysis Each human space flight program or project shall perform a human-centered task analysis to support systems and operations design.

[V2 4102] Functional Anthropometric Accommodation The system shall ensure the range of potential crewmembers can fit, reach, view, and operate the human systems interfaces by accommodating crewmembers with the anthropometric dimensions and ranges of motion as defined in data sets in Appendix F, Physical Characteristics and Capabilities, Sections F.2 and F.3.

[V2 5004] Cognitive Capabilities The system shall accommodate anticipated levels of crew cognitive capabilities under expected tasks demands.

[V2 6012] Crew Health Environmental Limits The system shall maintain levels of cabin humidity and temperature within the boundaries of the Operating Limit as shown in Figure 2, Crew Health Environmental Limits, to protect for crew health during pressurized operations when crew occupies the cabin, excluding suited operations, ascent, entry, landing, and post landing.

[V2 6013] Crew Performance Environmental Zone The system shall be capable of reaching atmospheric humidity and temperatures of nominally occupied habitable volumes within the zone provided in Figure 3, Crew Performance Environmental Zone, during all nominal operations, excluding suited operations, ascent, entry, landing, and post landing.

[V2 6017] Atmospheric Control The system shall allow for local and remote control of atmospheric pressure, humidity, temperature, ventilation, and ppO_2.

[V2 6022] Atmospheric Monitoring and Alerting The system shall alert the crew locally and remotely when atmospheric parameters, including atmospheric pressure, humidity, temperature, ppO2, and ppCO2 are outside safe limits.

[V2 6077] Hazardous Noise Limits for All Phases Except Launch, Entry, and Abort For off-nominal operations, broadcast communications, depressurization valves, and maintenance activities, the A-weighted sound level (excluding impulse noise and alarm signals) shall be less than 85 dBA, regardless of time duration; except in the case of depressurization valves, the noise attenuation effectiveness of hearing protection or communications headsets may not be used to satisfy this requirement.

Referenced Technical Requirements

[V2 6078] Continuous Noise Limits In spacecraft work areas, where good voice communications and habitability are required, SPLs of continuous noise (not including impulse noise) shall be limited to the values given by the Noise Criterion (NC)-50 curve in Figure 9, NC Curves, and Table 8, Octave Band SPL Limits for Continuous Noise, dB re 20 µPa (micropascals); hearing protection cannot be used to satisfy this requirement.

[V2 6079] Crew Sleep Continuous Noise Limits For missions greater than 30 days, SPLs of continuous noise shall be limited to the values given by the NC-40 curve (see Figure 11, NC Curves, and Table 8, Octave Band SPL Limits for Continuous Noise, dB re 20 µPa) in crew quarters and sleep areas. Hearing protection cannot be used to satisfy this requirement.

[V2 6080] Intermittent Noise Limits For hardware items that operate for eight hours or less (generating intermittent noise), the maximum noise emissions (not including impulse noise), measured 0.6 m from the loudest hardware surface, shall be determined according to Table 9, Intermittent Noise A-Weighted SPL and Corresponding Operational Duration Limits for any 24-hour period (measured at 0.6 m distance from the source). Hearing protection cannot be used to satisfy this requirement.

[V2 6082] Annoyance Noise Limits for Crew Sleep With the exception of communications and alarms, the system shall limit impulse and intermittent noise levels at the crewmember's head location to 10 dB above background noise levels during crew sleep periods. Hearing protection cannot be used to satisfy this requirement.

[V2 6083] Impulse Noise Limit The system shall limit impulse noise measured at the crewmember's head location to less than 140 dB peak SPL during all mission phases except launch and entry. Hearing protection cannot be used to satisfy this requirement.

[V2 6085] Narrow-Band Noise Limits Infrasonic SPLs, including frequencies from 1 to 20 Hz but not including impulse noise, shall be limited to less than 150 dB at the crewmember's head location. Hearing protection cannot be used to satisfy this requirement.

[V2 6092] Vibration Exposure Limits during Sleep The system **shall** limit vibration to the crew such that the acceleration between 1.0 and 80 Hz in each of the X, Y, and Z axes, weighted in accordance with ISO 20283-5, Mechanical Vibration—Measurement of Vibration on Ships; Part 5 - Guidelines for the Measurement, Evaluation, and Reporting of Vibration with Regard to Habitability on Passenger and Merchant Ships, Annex A, is less than 0.01 g (0.1 m/s^2) RMS for each two-minute interval during the crew sleep period.

[V2 6095] Ionizing Radiation Protection Limit The program shall set system design requirements to prevent potential crewmembers from exceeding PELs as set forth in NASA-STD-3001, Volume 1.

[V2 6097] Crew Radiation Exposure Limits The program/project shall design systems using the ALARA principle to limit crew radiation exposure.

[V2 6098] Radiation Environments The program shall specify the radiation environments to be used in verifying the radiation design requirements.

[V2 6099] Space Weather Monitoring The program shall set requirements specifying appropriate capabilities to be provided for real-time monitoring of space weather (solar particle events (SPE), galactic cosmic rays (GCR), etc.) for characterization of the radiation environment and operational response by ground personnel and the crew.

Referenced Technical Requirements

[V2 7008] Food Preparation The system shall provide the capability for preparation, consumption, and stowage of food.
[V2 7016] Personal Hygiene Capability Personal hygiene items shall be provided for each crewmember, along with corresponding system capabilities for oral hygiene, personal grooming, and body cleansing.
[V2 6109] Water Quantity The system shall provide a minimum water quantity as specified in Table 4, Water Quantities and Temperatures, for the expected needs of each mission, which should be
[V2 7017] Body Cleansing Privacy The system shall provide for privacy during personal hygiene activities.
[V2 7021] Body Waste Management System Location The body waste management system shall be isolated from the food preparation and consumption areas for aesthetic and hygienic purposes.
[V2 7022] Body Waste Management Privacy The system shall provide privacy during use of the body waste management system.
[V2 7038] Physiological Countermeasures Capability The system shall provide countermeasures to meet crew bone, muscle, sensorimotor, thermoregulation, and aerobic/cardiovascular requirements defined in NASA-STD-3001, Volume 1.
[V2 7050] Stowage Provisions The system shall provide for the stowage of hardware and supplies, to include location, restraint, and protection for these items.
[V2 7051] Personal Stowage The system shall provide a stowage location for personal items and clothing.
[V2 7061] Nomenclature Consistency The nomenclature used to refer to the items tracked by the inventory management system shall be consistent with procedures and labels.
[V2 7062] Unique Item Identification Items that need to be uniquely identified shall have a unique name.
[V2 7063] Interchangeable Item Nomenclature Items within the inventory management system that are identical and interchangeable shall have identical nomenclature.
[V2 7070] Sleep Accommodation The system shall provide volume, restraint, accommodations, environmental control (e.g., vibration, lighting, noise, and temperature), and degree of privacy for sleep for each crewmember to support overall crew health and performance.
[V2 7071] Behavioral Health and Privacy For long-duration missions (>30 days), individual privacy facilities shall be provided.
[V2 7073] Partial-g Sleeping The system shall provide for horizontal sleep surface areas for partial-g and 1-g environments.
[V2 8001] Volume Allocation The system shall provide the defined habitable volume and layout to physically accommodate crew operations and living.
[V2 8005] Functional Arrangement Habitability functions shall be located based on the use of common equipment, interferences, and the sequence and compatibility of operations.
[V2 8013] Intravehicular Translation Paths The system shall provide intravehicular activity (IVA) translation paths that allow for safe and unencumbered movement of suited and unsuited crew and equipment.
[V2 8033] Restraints for Crew Tasks The system shall provide restraints for expected crew operations.
[V2 8049] Window Light Blocking Each system window shall provide a means to prevent external light from entering the crew compartment, such that the interior light level can be reduced to 2.0 lux at 0.5 m (20 in) from each window.

Referenced Technical Requirements

[V2 8050] Window Accessory Replacement/Operation without Tools System window accessories designed for routine use shall be operable by one crewmember and be removable or replaceable without the use of tools.
[V2 8055] Physiological Effects of Light (Circadian Entrainment) The system shall provide the levels of light to support the physiological effects of light in accordance with Table 17, Physiological Lighting Specifications.
[V2 8056] Lighting Controls Lighting systems shall have on-off controls.
[V2 9057] Hearing Protection Provision Appropriate personal hearing protection shall be provided to the crew during all mission phases for contingency or personal preference.
[V2 5007] Cognitive Workload The system shall provide crew interfaces that result in Bedford Workload Scale ratings of 3 or less for nominal tasks and 6 or less for off-nominal tasks.
[V2 10200] Physical Workload The system shall provide crew interfaces that result in a Borg-CR10 rating of perceived exertion (RPE) of 4 (somewhat strong) or less.
[V2 10001] Crew Interface Usability The system shall provide crew interfaces that result in a NASA-modified System Usability Scale (SUS) score of 85 or higher.
[V2 10002] Design Induced Error The system shall provide crew interfaces that result in the maximum observed error rates listed in Table 29, Maximum Observed Design-Induced Error Rates.
[V2 10003] Crew Interface Operability The system shall provide interfaces that enable crewmembers to successfully perform tasks within the appropriate timeframe and degree of accuracy.
[V2 10015] Use of Cognitive Aids The system shall provide cognitive aids to reduce the demand on crewmember memory to allow the crew to accomplish their tasks within the required performance parameters.
[V2 10017] System Health and Status The system shall provide system health and status information to the crew, either automatically or by request.
[V2 10022] Maximum System Response Times The system shall provide unique feedback when a data parameter is stale, missing, or unavailable.
[V2 10083] Communication System Design Communication systems shall be designed to support coordinated and collaborative distributed teamwork.
[V2 10084] Communication Capability The system shall provide the capability to send and receive communication among crewmembers, spacecraft systems, and ground systems to support crew performance, behavioral health, and safety.
[V2 10085] Communication Speech Levels Audio communication systems shall allow crew to communicate with one another and with the ground at normal speech levels and with expected background SPLs.
[V2 10086] Communication Operational Parameters The audio communication system shall provide intelligible speech by addressing system operational parameters, including frequency, dynamic range, noise cancelling and shields, pre-emphasis, and peak clipping.
[V2 10087] Communication Environmental Parameters The audio communication system shall provide intelligible speech by addressing appropriate background sound levels and architectural acoustical characteristics for both transmitter and receiver area.

Referenced Technical Requirements

[V2 10088] Communication Controls and Procedures To ensure intelligibility, audio communications shall address operating controls and procedures, including volume, squelch, natural language, acknowledgement feedback, and muting.

[V2 10089] Communication Transmitter and Receiver Configuration To ensure intelligibility, audio communications shall address transmitter and receiver configuration, e.g., headsets, microphones, air conduction, and bone conduction.

[V2 10090] Audio Communications Quality The audio communication system shall provide speech quality that does not impact crew performance.

[V2 10091] Speech Intelligibility For critical communications, the system shall ensure 90% English word recognition, using ANSI/ASA S3.2-2009, Method for Measuring the Intelligibility of Speech over Communication Systems.

[V2 10093] Private Audio Communication The system shall provide the capability for private audio communication with the ground.

[V2 10094] Video Communication Visual Quality Video communications shall employ digital encoding or alternate coding of equivalent visual quality.

[V2 10100] Automated and Robotic System Provision Automated or robotic systems shall be provided when crew cannot reliably, safely, or efficiently perform assigned tasks.

[V2 11010] EVA Suit Radiation Monitoring The suit shall provide or accommodate radiation monitoring and alerting functions to allow the crew to take appropriate actions.

Reference List

1. NASA-STD-3001 Volume 1, Rev B
2. NASA-STD-3001 Volume 2, Rev C
3. Human Integration Design Handbook, Rev 1
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