What is NASA-STD-3001?

NASA-STD-3001, NASA Spaceflight Human-System Standard Volume 1 and 2, establishes Agency-wide requirements that minimize health and performance risks for flight crew in human space flight programs. Human system risks are DRM- and mission concept-specific, and are the basis of 3001 standards. Applicability of Standards are determined based on each program's specific needs.

NASA-STD-3001 Volume 1 covers the requirements needed to support astronaut health and Volume 2 covers vehicle system design that will maintain astronaut safety and promote performance.

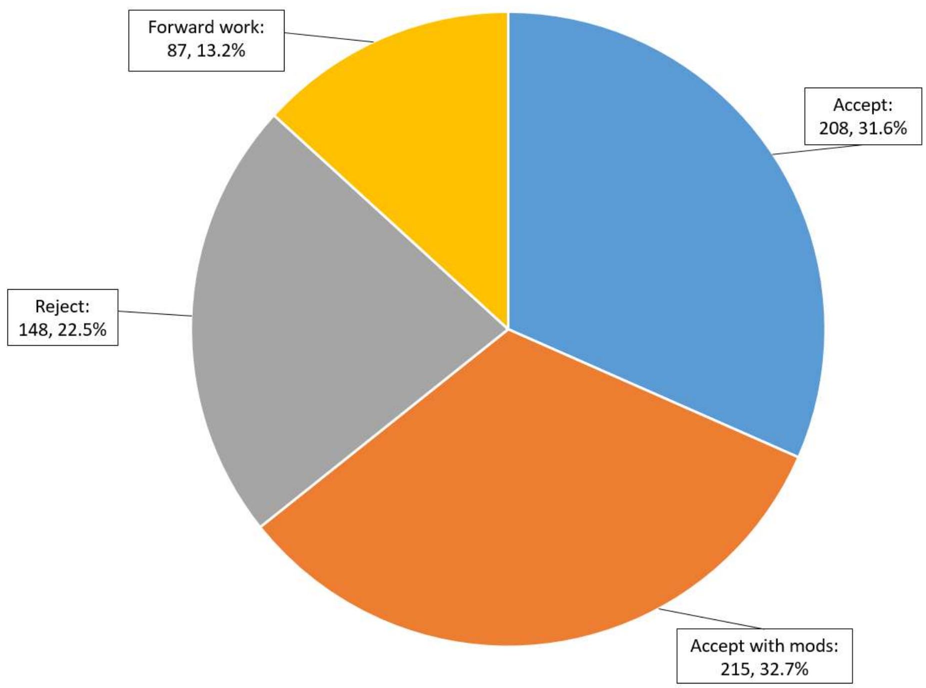
What is a standard?

The majority of NASA-STD-3001 Vols. 1 & 2 are performance standards, meaning they state requirements in terms of a desired results without stating a method for achieving it. All standards contain a "shall" statement and can be followed by a short, italicized rationale statement. Rationales are intended to provide additional information for the

Health and Medical Standards Update

Overview of Changes in NASA-STD-3001 Volume 2 Revision B

NASA-STD-3001 Vol. 2 Rev B has recently been baselined and contains significant changes from the previous revision. The newest revision can be found at: NASA-STD-3001 Vol. 2 RevB. Changes in the document were made on subject matter expert review and on the responses from an agency wide CR. We received 658 comments in total, 546 of which were technical comments. In regards to comment dispositions, we settled on the following proportions:



Disposition of comments from the NASA-STD-3001 Vol. 2 agency review

Notable changes included the addition of 19 new standards, the deletion of 27 standards, and major revisions of 12 standards and 1 section.

Major Standards Revisions

1. O_2 Partial Pressure Ranges for Crew Exposure: changed from a range in the standard to a table with normoxic, hyperoxic, and hypoxic limits; also added the word "inspired" to the standard

implementation of the standards.

The Standards Team continually works with programs (e.g. xEMU, Gateway, Human Lander System etc.) in order to provide the best standards possible. Via partnerships in the programs and throughout NASA, industry and academia, the standards are constantly evolving and being reworked in an effort to minimize human health and performance risks.

Links

The NASA-STD-3001 SharePoint (including where to submit recommendations for changes to the standards, links to standards documents, and SME lists) can be found at the following link:

https://sashare.sp.jsc.nasa.gov/Teams/NASA-STD-3001/SitePages/Home.aspx

NASA-STD-3001 Vol. 1 & 2 can be found at the following link:

https://standards.nasa.gov/human-factors-and-health

2. Total Pressure Tolerance Range for Indefinite Crew Exposure: increased the lower limit from 20.7 kPa (3.0 psia) to 26.2 kPa (3.8 psia)
3. Rate of Pressure Change: changed from a range to DNE 13.5 psi/min.
4. Particulate Matter: changed standard to limit the amount of total dust to <3 mg/m^3 and the respirable fraction of the total dust <2.5 µm in aerodynamic diameter to <1 mg/m^3
5. Surface Cleanability: increased limits for bacterial and fungal $CFUs/cm^2$
6. Surface Microbial Contamination During Nominal Systems Operations: increased limits for bacterial and fungal $CFUs/cm^2$ on internal surfaces with the caveat that no medically significant microorganisms are present during nominal system operations
7. Sustained Rotational Acceleration: changed language to prevent sustained cross-coupled rotations of >2 rad/s^2
8. Acceleration Injury Prevention: altered wording and added a table for acceptable injury risk due to dynamic loads
9. Electrical Current Limits: added for nominal physiological currents, catastrophic currents for all circumstances, and catastrophic currents for startle reactions; also added body impedance for voltage calculations
10. Controllability and Maneuverability: created specificity by adding that spacecraft shall exhibit Level 1 handling qualities, as defined by the Cooper-Harper Rating Scale, during manual control of flight path and attitude when manual control is the primary control mode or automated control is non-operational
11. Section 11 (Spacesuits): added multiple standards to cover topics such as suited CO_2, humidity, and atmospheric capabilities; moved multiple standards to section 8, including Suited Translation and Restraints for Suited Operations; and, changed several standards from a generalized suit to an EVA or LEA suit.

In addition, we added a 12th section (Ground Assembly Design and Emergency Egress Operations). This section focuses on the design of spaceflight systems, hardware, and equipment that are accessed, used, or interfaced in some way by personnel other than just the spaceflight crews (e.g., ground support personnel) and ground emergency egress operations.

Future Work: Volumes 1 & 2

As Rev B has been baselined, the Standards Team has begun assessing changes for Rev C. Some key topics we will look to address include:

- Coordinating standards between Volumes 1 and 2
- Streamlining and consolidating standards where applicable
- Defining Medical Levels of Care in Volume 1
- Addressing future work from Vol. 2 Rev B CR comments
- Updating and adding standards for Lunar missions
- Updating section 10, Crew Interaces.

Contact Us

There is a team, headed by NASA Technical Standards Manager Dave Francisco, which specializes in NASA-STD-3001. They have experience with the document and all standards, as well as the requirements that flow from them. They are willing to meet for consultations in order to clear any confusion regarding technical standards, provide clarification for the intent of specific standards, or further describe the formation of standards from risks.

They can be contacted via e-mail:

POC – Dave Francisco: david.r.francisco@nasa.gov

Kim Lowe: kimberly-michelle.p.lowe@nasa.gov

Aidan McCormick: aidan.f.mccormick@nasa.gov

Imene Mechkene: imene.mechkene@us.kbr.com

Shannon Melton: shannon.l.melton@nasa.gov

Mason Powell: mason.j.powell@nasa.gov

Anna Reddick: anna.reddick@nasa.gov

Ellen Snook: ellen.h.snook@nasa.gov

3001 is now available in Cradle!

The 3001 Cradle project has been baselined with Volume 2 Rev A and Rev B. It is now available for NDC users through a web-user interface at this link https://nasa-ice.nasa.gov/pdb/loginsetup?database=3001&webui=nasa (Not compatible with Internet Explorer. Copy link and open in Chrome or Mozilla FireFox.) Contact Ellen Snook for access. The 3001 Cradle WebUI enables user-friendly access to NDC users for navigating and searching the Standard. Enhancements that are in work include relationship mapping between standards, links to human system risks, standards trace to program requirements, and links to technical “cut sheets” that provide additional information on intent, background, and application.

Technical “Cut Sheets”

There will be technical “cut sheets” for most topics, which should help with the background and intent of some standards. Click the link below for an example (also embedded on following pages) of what will be provided to programs and other interested personnel via Cradle WebUI. The sheets provide a quick, informative resource that includes application notes for designers to reference when working with NASA-STD-3001. Furthermore, the ability to update these sheets will be far easier than attempting to update HIDH, or other longer documents.

Technical Cut Sheet – Electrical Shock

Example of a Technical "Cut Sheet"

Specification Sheet

Physiological Effects of Electrical Shock
V2 9019-21, 23
Overview

Overview

Physiological Current Limits

For spaceflight applications it is important to protect humans from unintended electrical current flow. These standards define the physiological limits for current flow for the following situations:

- *Nominal – Under all situations*
- *Catastrophic hazard threshold for all conditions*
- *Catastrophic Hazard threshold specifically for Startle Reaction*
- *Leakage Current* Designed for Human Contact

Current threshold were chosen (vs. voltage thresholds) because body impedance varies depending on conditions such as wet/dry, AC/DC, voltage level, large/small contact area but current thresholds and physiological effect do not change. By providing the electrical thresholds, engineering teams are able to provide the appropriate hazard controls usually provide additional isolation (beyond the body's impedance), providing current limiters and/or modifying the voltage levels.

"Catastrophic hazard" language was used to relate the physiological level that shall not be exceeded without additional controls.

Below is a summary of the electrical current thresholds:

	Nominal Perception Current Thresholds [V2 9019]	Leakage Currents – Equipment Designed for Human Contact [V2 9023]	Catastrophic Physiological **Startle** Reaction Current [V2 9021]	Catastrophic Physiological Threshold Current **For all situations** [V2 9020]
DC Limits	0.4 mA	0.1 mA	2.0 mA	40 mA
AC Limits	0.2 mA	0.1 mA	0.5 mA	8 mA

Body Impedance

Guidance is provided in order to determine the appropriate body impedance for calculating the associate voltage with a given current threshold.

Specification Sheet

Physiological Effects of Electrical Shock
V2 9019-21, 23
Background

Background

Physiological Current Limits

Data/evidence to determine the physiological thresholds are from International Electrotechnical Commission (IEC) documents along with associated rationale are as follows:

- *Nominal – Under all situations These values are below the physiological effect of sensation for the most sensitive members of the astronaut population. This requirement is intended to address typical exposure situations where human contact can routinely occur with conductive housing of electrical equipment and in these situations no perceptible current flow is the design requirement. Typically NASA engineering teams establish 1 MΩ isolation along with grounding to conductive surfaces with Class H or better bond to prevent current flow through crew members*

- *Catastrophic hazard threshold -These thresholds are used when a hazard analysis is considering failure scenarios and off nominal events where failures such as electrical short circuits have compromised system isolation and pose a risk of catastrophic electrical shock to the human*

    - *Catastrophic hazard threshold for all conditions -The current values were chosen based on the threshold for maintaining muscle control if shocked to protect 99.5% of the population (IEC TR 60479-2, Figure 7). This standard is intended to provide the threshold where additional engineering controls will be required to mitigate electrical shock/physiological effects to the human.*
    - *Catastrophic Hazard threshold specifically for Startle Reaction - The current values were chosen based on the threshold for a startle reaction if shocked (IEC TR 60479-5, Table 1). Under certain circumstances such as startle reaction, more restrictive thresholds than the physiological catastrophic limits of the [V2 9020] limits above shall be employed in hazard and risk assessments*

- *Leakage Current* Designed for Human Contact - *These levels of leakage current are consistent with those in IEC 60601-1, Medical Electrical Equipment–Part 1*

Body Impedance Guidance – *In order to determine appropriate voltage levels not to exceed the current thresholds the following guidance is provided: utilize 5th percentile values for the appropriate conditions (wet/dry, AC/DC, voltage level, large/small contact area) from IEC TR6049-1 to determine the appropriate body impedance to calculate the voltage associated with any current limit analysis.*

Specification Sheet

Physiological Effects of Electrical Shock V2 9019-21, 23 Reference Data

Reference Data

Data From IEC documents were utilized to set current thresholds.

[V2 9020] Catastrophic hazard threshold for all conditions.

The current values were chosen based on the threshold for maintaining muscle control if shocked to protect 99.5% of the population (IEC TR 60479-2, Figure 7).
The DC component is the x-axis (red arrow) and the peak AC component is the y-axis (yellow arrow). The 99.5[th] percentile for the most sensitive population (women) was chosen.

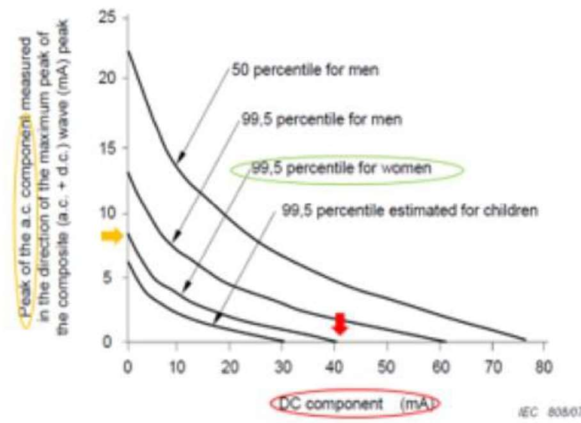


Figure 7 – Let-go thresholds for men, women and children

(IEC) *TR 60479-2, Figure 7.*

[V2 9021] Catastrophic Physiological Electrical Current Limits for Startle Reaction

[V2 9021] Startle Response is defined as a current level flowing through the body that is just enough to cause involuntary muscular contraction

The current values were chosen based on the threshold for a startle reaction if shocked (IEC TR 60479-5, Table 1).

Table 1 – Current threshold values for each condition and for long duration

Type of threshold	Current	Current path	mA
Current of startle reaction	a.c.	Hand-to-hand	0,5
		Both-hands-to-feet	0,5
		One-hand-to-seat	0,5
	d.c.	Hand-to-hand	2
		Both-hands-to-feet	2
		One-hand-to-seat	2
Strong muscular reactions	a.c.	Hand-to-hand	5
		Both-hands-to-feet (Note 1)	10
		One-hand-to-seat	5
	d.c.	Hand-to-hand	25
		Both-hands-to-feet	25
		One-hand-to-seat	25
Ventricular fibrillation (Note 3)	a.c.	Hand-to-hand	100
		Both-hands-to-feet	40

IEC TR 60479-5, Table 1

Reference Documents

Electrotechnical Commission (IEC) Documents

IEC TR 60479-1, Effects of current on human beings and livestock – Part 1: General aspects, 4[th] edition, 7/2007
IEC TR 60479-2, Effects of current on human beings and livestock – Part 2: Special aspects, 3[rd] edition, 5/2007
IEC TR 60479-5, Effects of current on human beings and livestock – Part 5: Touch voltage threshold values for physiological effects, Edition 1.0, 11/2007
IEC 60601-1, Medical Electrical Equipment–Part 1, Edition 3.1, 10/2013

Specification Sheet

Physiological Effects of Electrical Shock
V2 9019-21, 23
Application Notes

Application Notes

Standard Utilization Guidance

The electrical shock standards were written to: (1) provide parent standard for engineering requirement to limit current flow in routine operations (V2 9019 and 9026) and (2) Provide information for use in determining severity of hazards in all failure/off-nominal situations V2 9020 and for unique situations such as protecting for a startle reaction V2 9021. See below.

Nominal Operations	V2 9019 is the parent standard that ensure adequate isolation is maintained through the vehicle/operations for routine	V2 9023 is the parent standard that ensure adequate isolation is for devices in contact with the human body
Hazard Analysis	Catastrophic Physiological Electrical Current Limits V2 9020 is the limit that shall not be exceeded under all failure/off-nominal conditions	Catastrophic Physiological Electrical Current Limits for Startle Reaction V2 9020 is a lower limit that shall be used for unique situation where a startle reaction may be catastrophic

Body Impedance Guidance

In many instances application of these standards will require the determination of the appropriate body impedance for the calculation of voltage. V2 9022 requires that the 5th percentile is selected in order to protect 95% of the population.

- *To calculate the appropriate voltage not to exceed the electrical thresholds, the proper body impedance must be selected. Factors that must be considered are the condition of the human/environment wet vs. dry, AC/DC, voltage level, large/small contact area.*

- *An Example utilizing IEC TR 60479-1, Table 3, 850 Ω represents the 5th percentile of the population for a touch voltage of 125 volts and a large contact area (such as full hand or a surface area of 82 cm^2) in saltwater-wet conditions. (Note Table 10 of IEC 607479-1 may be used for dry conditions. For a catastrophic hazard analysis, V2 9020, the not to exceed voltage would be*

  V_{DC} threshold = 850 Ω x 40 ma = 34 V_{DC}

TS 60479-1 © IEC:2005 – 35 –

Table 3 – Total body impedances Z_T for a current path hand to hand a.c. 50/60 Hz, for large surface areas of contact in saltwater-wet conditions

Touch voltage V	Values for the total body impedances Z_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	960	1 300	1 755
50	940	1 275	1 720
75	920	1 250	1 685
100	880	1 225	1 655
125	850	1 200	1 620
150	830	1 180	1 590
175	810	1 155	1 560
200	790	1 135	1 530
225	770	1 115	1 505
400	700	950	1 275
500	625	850	1 150
700	575	775	1 050
1 000	575	775	1 050
Asymptotic value = internal impedance	575	775	1 050

NOTE 1 Some measurements indicate that the total body impedance for the current path hand to foot is somewhat lower than for a current path hand to hand (10 % to 30 %).

NOTE 2 Due to low skin impedances in this case it may be assumed that Z_T depends little on the duration of current flow; Z_T approaches the internal body impedance Z_i.

NOTE 3 For the standard value of the voltage 230 V (network-system 3N ~ 230/400 V) it may be assumed that the values of the total body impedance are the same as for a touch voltage of 225 V.

NOTE 4 Values of Z_T are rounded to 5 Ω.