DUST TESTING STANDARD OVERVIEW

OCTOBER 2021

PI: KRISTEN JOHN

PM: CHUCK ROGERS

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

NASA-STD-1008

Classifications and Requirements for Testing Systems and Hardware to be Exposed to Dust in Planetary Environments

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Purpose

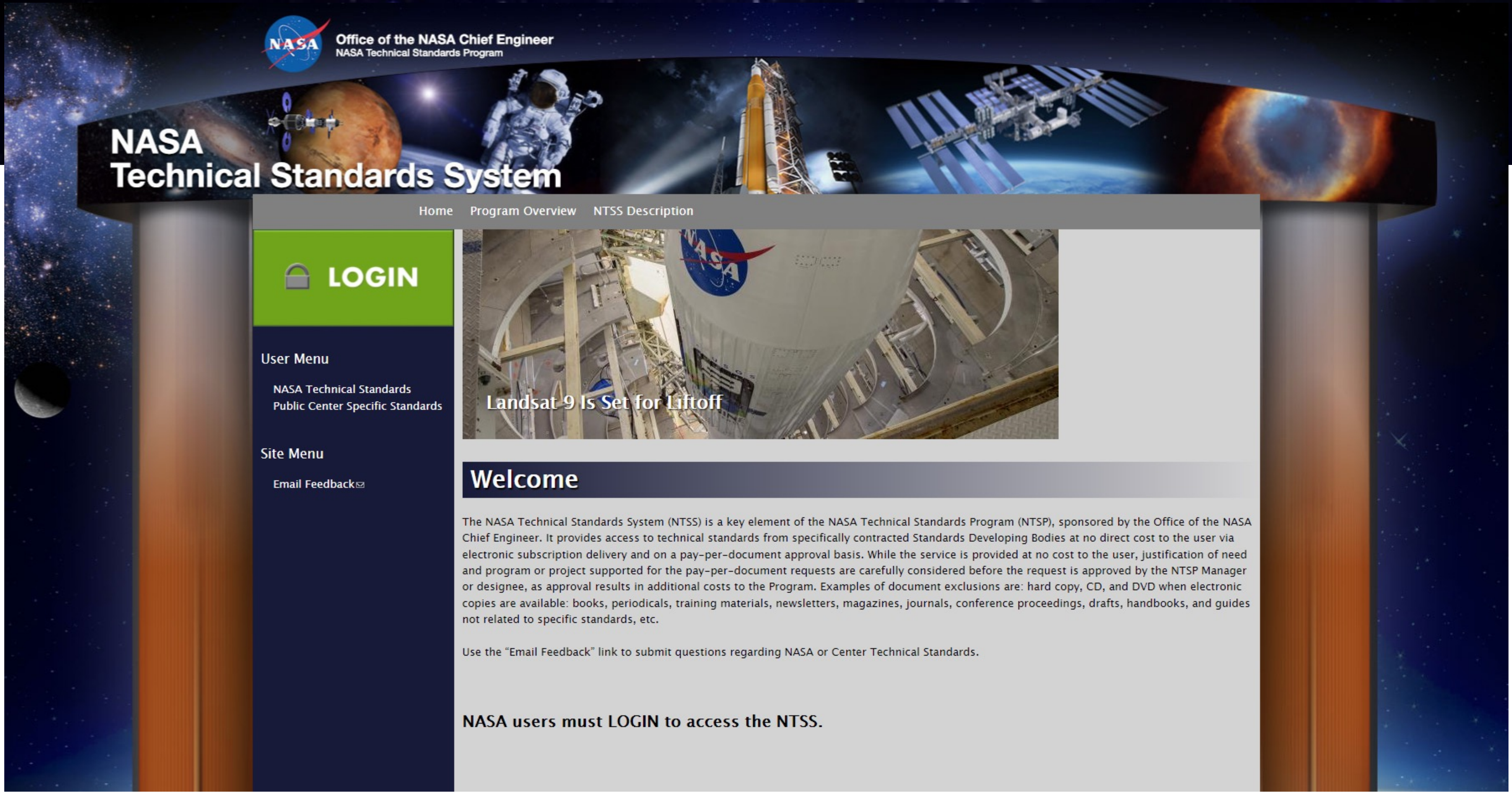
- Establish the minimum requirements for testing with dust
- Provide general guidance for testing methodologies and best practices
- Provide developers and end-users with information that will guide testing of systems and hardware for exposure to dusty environments
- Facilitate consistency and efficiency in the testing of space systems, subsystems, or components with operations and missions in dusty environments

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Current Status

- Document went through agency-wide review.
- **It was approved on Sept 21st and is available on https://standards.nasa.gov/standard/nasa/nasa-std-1008**

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.



Document is available publically at **standards.nasa.gov**

Click on "NASA Technical Standards," click "1000" link, then click on the document number. You will see the Summary Page. Scroll down to "Download Current Revision" and click the link below it.

Or go directly to: https://standards.nasa.gov/standard/nasa/nasa-std-1008

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

METRIC/SI (ENGLISH)

NASA TECHNICAL STANDARD

Office of the NASA Chief Engineer

NASA-STD-1008

Approved: 2021-09-21

CLASSIFICATIONS AND REQUIREMENTS FOR TESTING SYSTEMS AND HARDWARE TO BE EXPOSED TO DUST IN PLANETARY ENVIRONMENTS

Trade names and trademarks are used in this NASA Technical Standard for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by NASA.

APPROVED FOR PUBLIC RELEASE—DISTRIBUTION IS UNLIMITED

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Document Overview

SECTION 4.

Dust Requirements & Standards

4.1 Dust Impact Assessment Process

4.2 Sources of Dust

a. Planetary External (PE)

b. Planetary Pressurized (PP)

c. In-Space Pressurized (SP)

d. In-Space External (SE)

METRIC/SI (ENGLISH)

NASA TECHNICAL STANDARD

Office of the NASA Chief Engineer

NASA-STD-1008

Approved: 2021-09-21

CLASSIFICATIONS AND REQUIREMENTS FOR
TESTING SYSTEMS AND HARDWARE TO BE EXPOSED TO DUST
IN PLANETARY ENVIRONMENTS

Trade names and trademarks are used in this NASA Technical Standard for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by NASA.

APPROVED FOR PUBLIC RELEASE—DISTRIBUTION IS UNLIMITED

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

5.3 Testing Practices & Categories

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Document Overview

SECTION 4.

Dust Requirements & Standards

4.1 Dust Impact Assessment Process

4.2 Sources of Dust

a. Planetary External (PE)

b. Planetary Pressurized (PP)

c. In-Space Pressurized (SP)

d. In-Space External (SE)

METRIC/SI (ENGLISH)

NASA TECHNICAL STANDARD

Office of the NASA Chief Engineer

NASA-STD-1008

Approved: 2021-09-21

CLASSIFICATIONS AND REQUIREMENTS FOR TESTING SYSTEMS AND HARDWARE TO BE EXPOSED TO DUST IN PLANETARY ENVIRONMENTS

Trade names and trademarks are used in this NASA Technical Standard for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by NASA.

APPROVED FOR PUBLIC RELEASE—DISTRIBUTION IS UNLIMITED

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

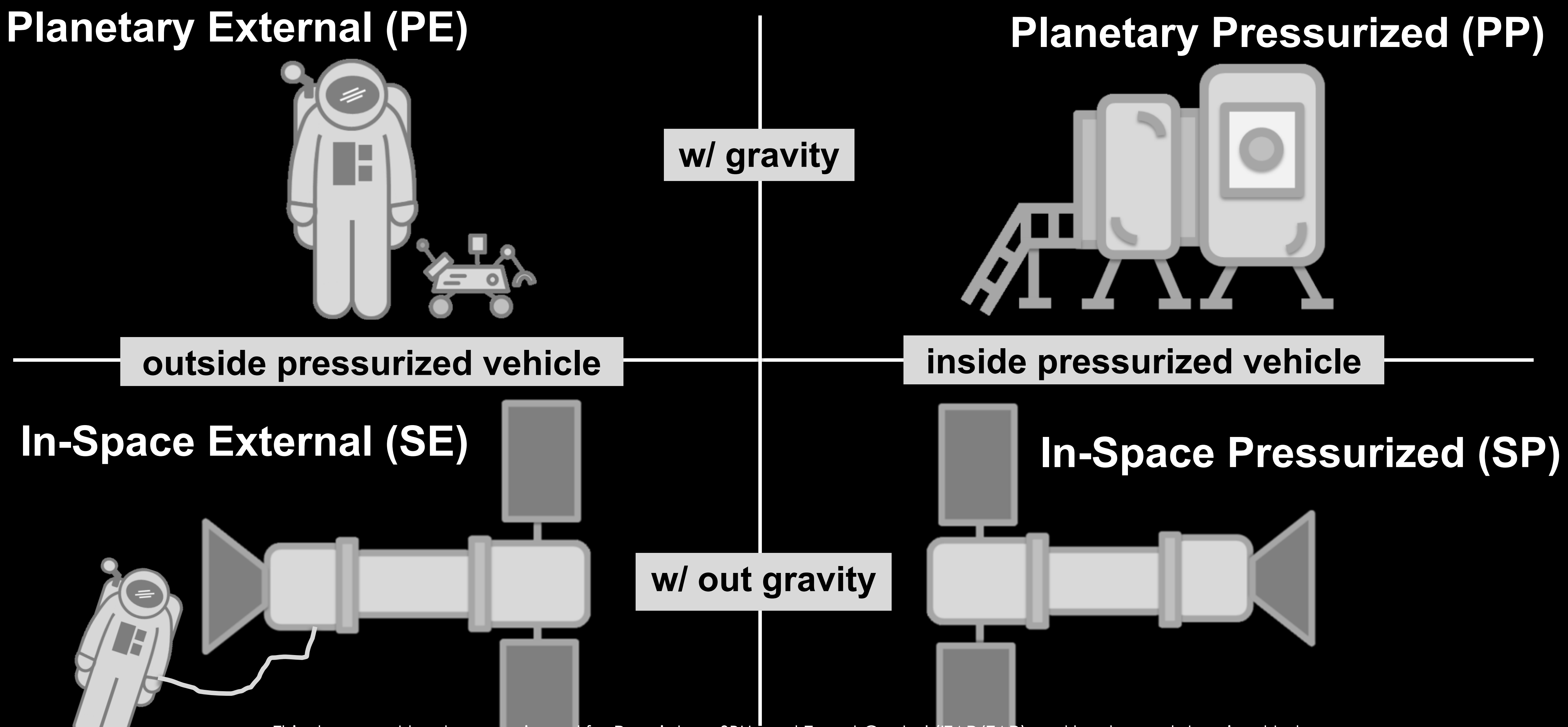
5.3 Testing Practices & Categories

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

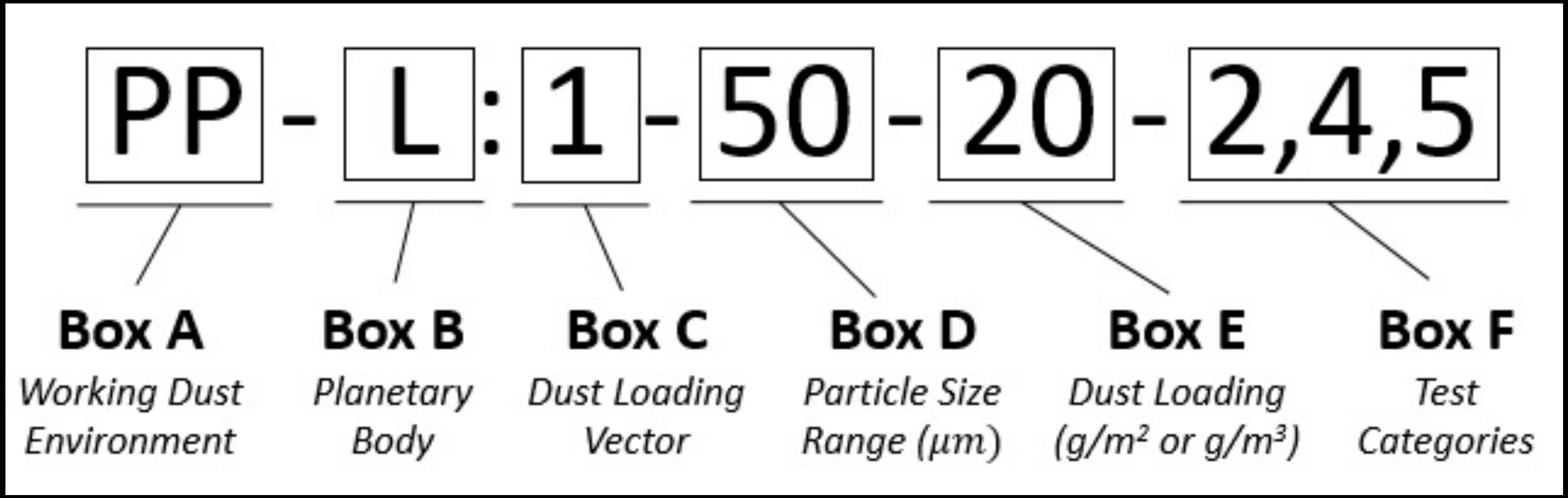
Working Environments Classification



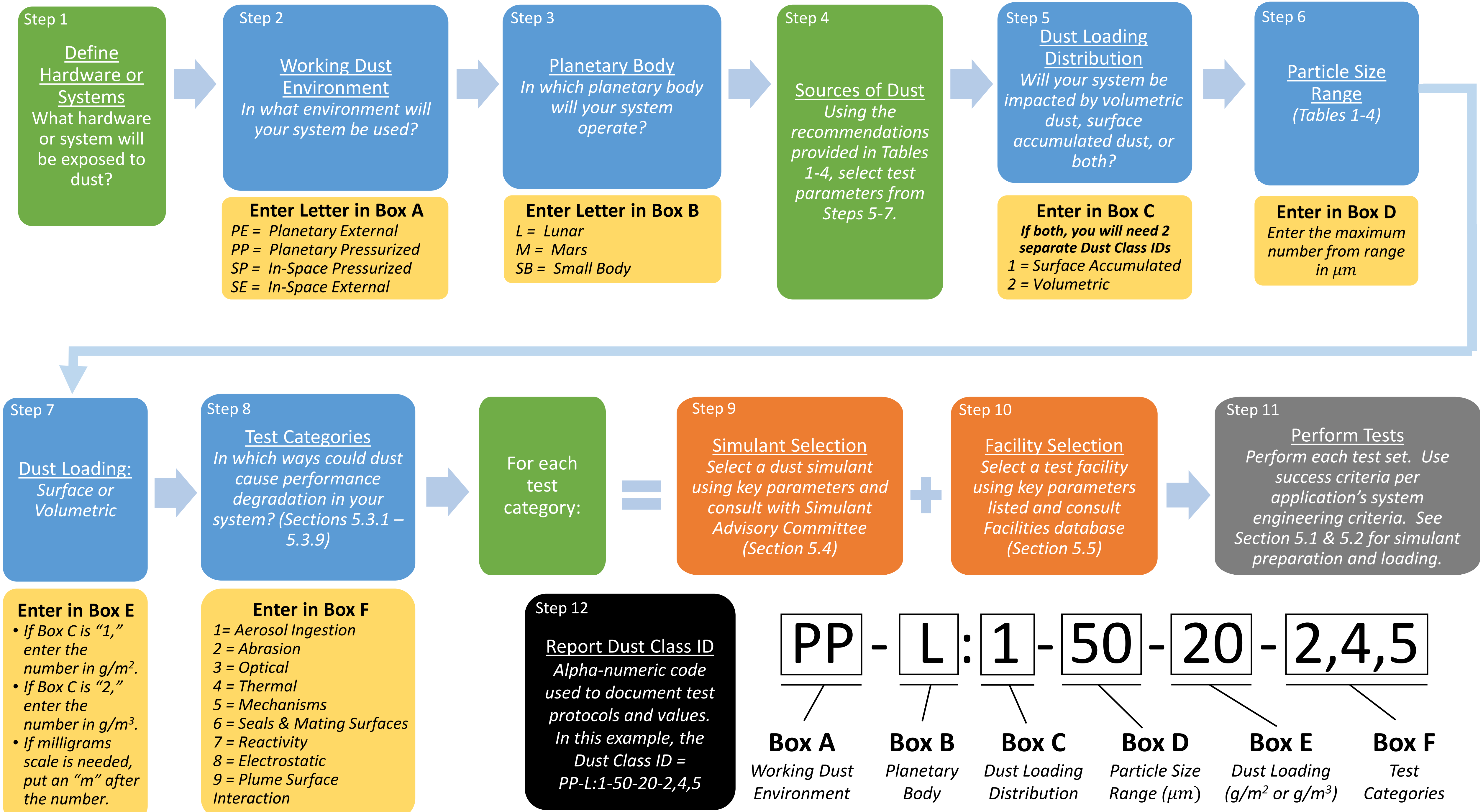
This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Dust Class ID

User may assign alpha-numeric code to identify protocol to which they validated their hardware



This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.



This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Step 1

<u>Define Hardware or Systems</u>

What hardware or system will be exposed to dust?

Step 2

<u>Working Dust Environment</u>

In what environment will your system be used?

Enter Letter in Box A

PE = Planetary External
PP = Planetary Pressurized
SP = In-Space Pressurized
SE = In-Space External

Step 3

<u>Planetary Body</u>

In which planetary body will your system operate?

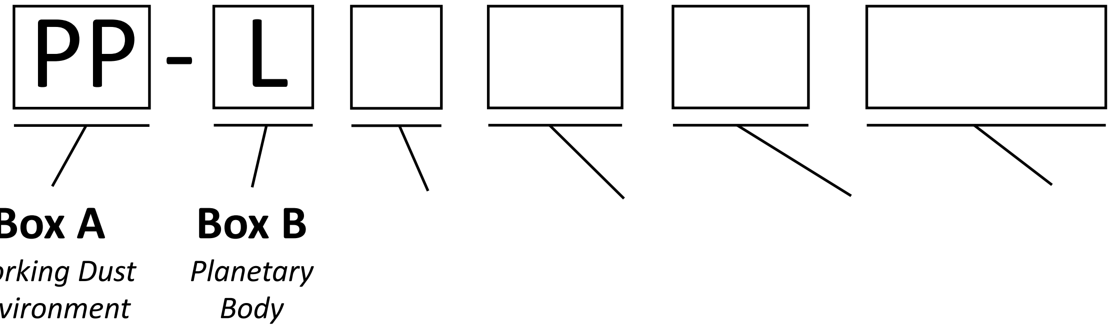
Enter Letter in Box B

L = Lunar
M = Mars
SB = Small Body

Step 12

<u>Report Dust Class ID</u>

Alpha-numeric code used to document test protocols and values. In this example, the Dust Class ID = PP-L:1-50-20-2,4,5



This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Step 1

<u>Define Hardware or Systems</u>

What hardware or system will be exposed to dust?

Step 2

<u>Working Dust Environment</u>

In what environment will your system be used?

Enter Letter in Box A

PE = Planetary External
PP = Planetary Pressurized
SP = In-Space Pressurized
SE = In-Space External

Step 3

<u>Planetary Body</u>

In which planetary body will your system operate?

Enter Letter in Box B

L = Lunar
M = Mars
SB = Small Body

Step 4

<u>Sources of Dust</u>

Using the recommendations provided in Tables 2-5, select test parameters from Steps 5-7.

Step 5

<u>Dust Loading Vector</u>

Will your system be impacted by volumetric dust, surface accumulated dust, or both?

Enter in Box C

If both, you will need 2 separate designators

1 = Surface Accumulated
2 = Volumetric

Step 6

<u>Particle Size Range</u>

(Tables 2-5)

Enter in Box D

Enter the maximum number from range in μm

Step 7

<u>Dust Loading:</u>

Surface or Volumetric

Enter in Box E

- *If Box C is "1," enter the number in g/m^2.*
- *If Box C is "2," enter the number in g/m^3.*
- *If milligrams scale is needed, put an "m" after the number.*

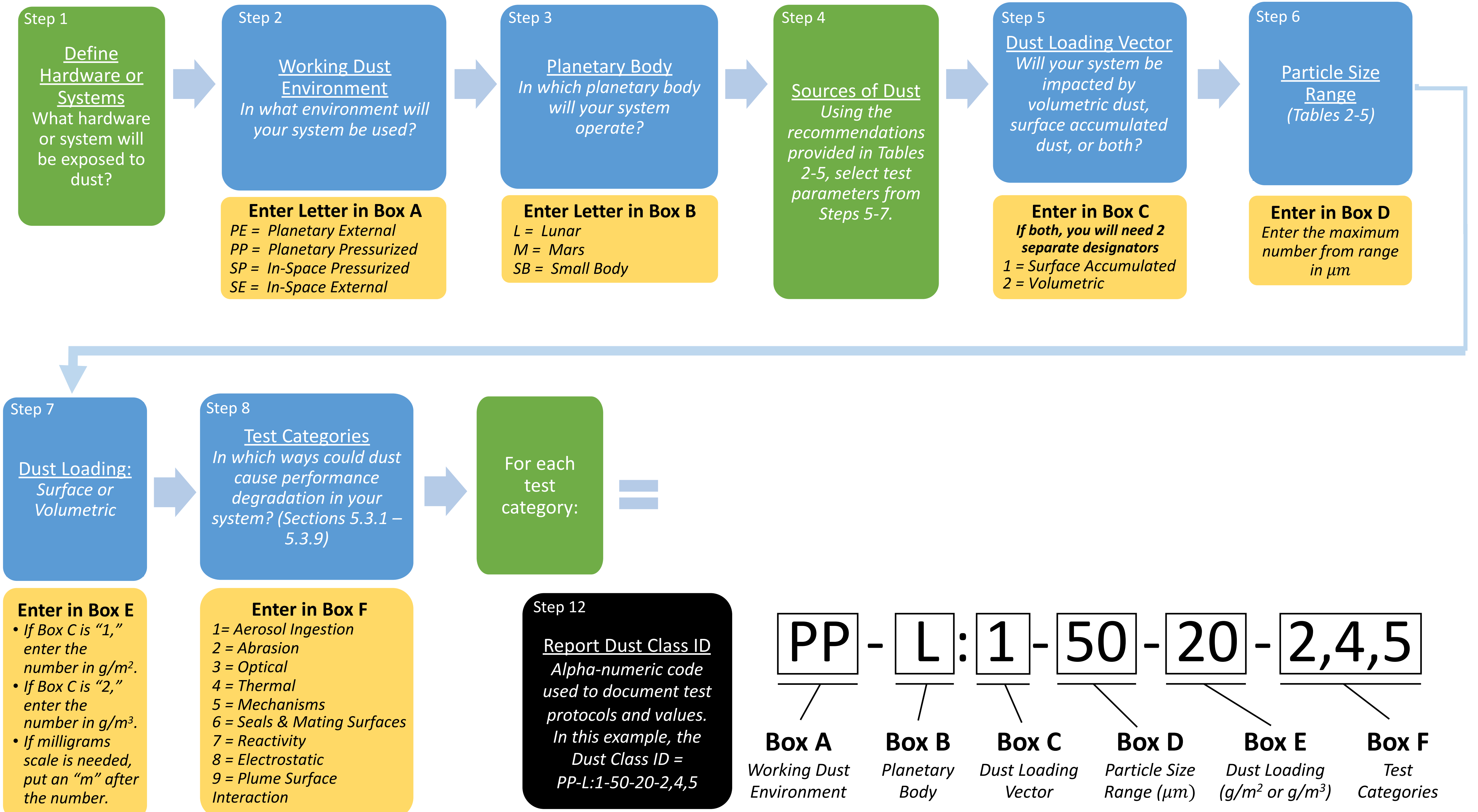
Step 12

<u>Report Dust Class ID</u>

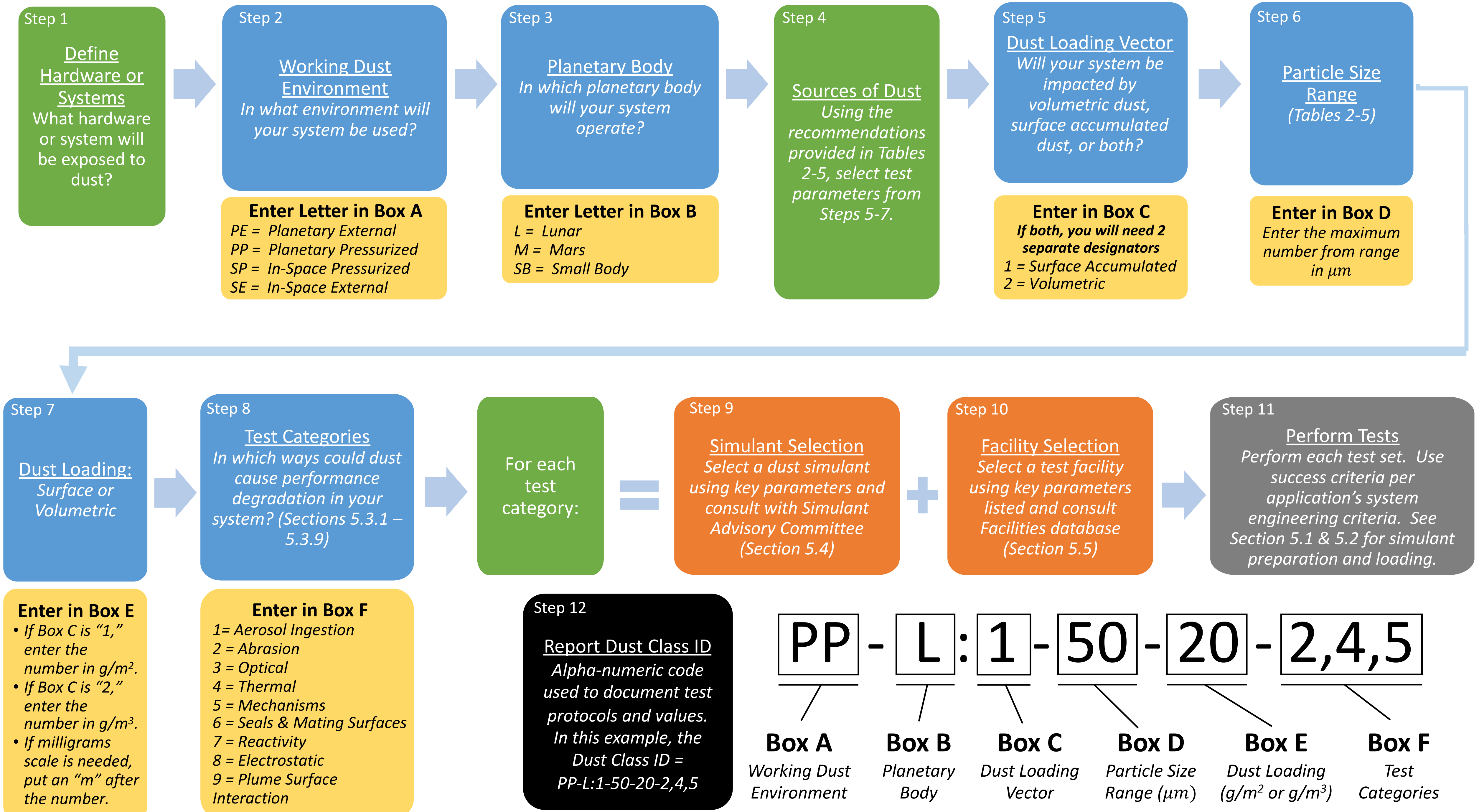
Alpha-numeric code used to document test protocols and values. In this example, the Dust Class ID = PP-L:1-50-20-2,4,5

PP	-	L	:	1	-	50	-	20	
Box A *Working Dust Environment*		**Box B** *Planetary Body*		**Box C** *Dust Loading Vector*		**Box D** *Particle Size Range (μm)*		**Box E** *Dust Loading (g/m^2 or g/m^3)*	**Box F** *Test Categories*

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

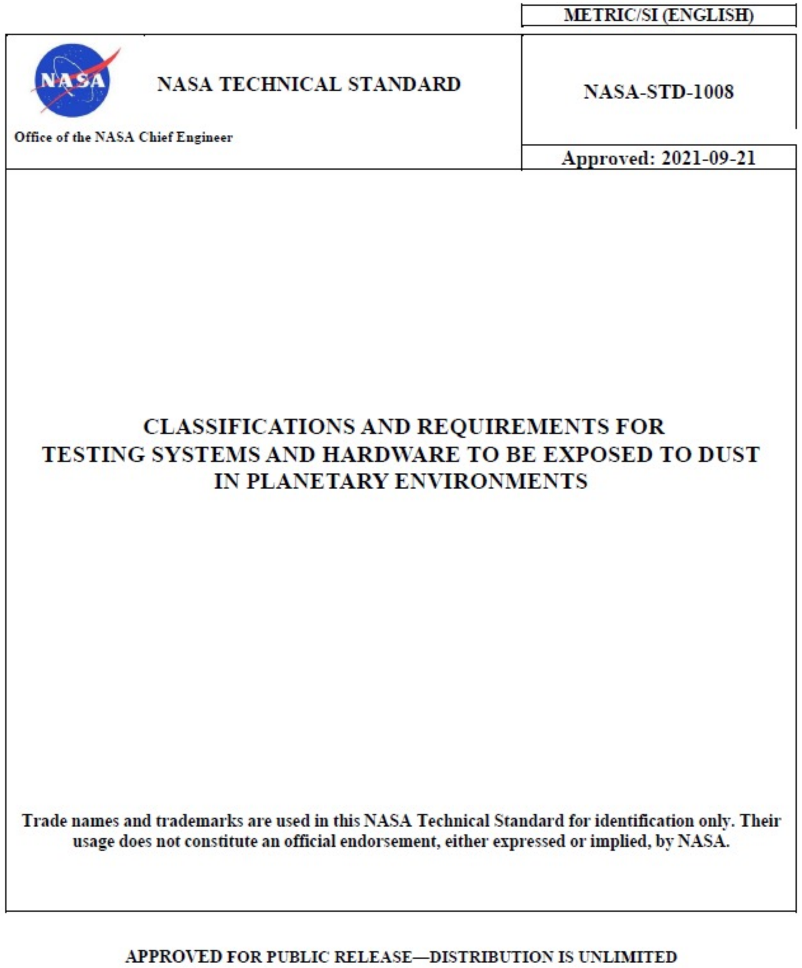


This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.



This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Document Overview



METRIC/SI (ENGLISH)

NASA TECHNICAL STANDARD

Office of the NASA Chief Engineer

NASA-STD-1008

Approved: 2021-09-21

CLASSIFICATIONS AND REQUIREMENTS FOR TESTING SYSTEMS AND HARDWARE TO BE EXPOSED TO DUST IN PLANETARY ENVIRONMENTS

Trade names and trademarks are used in this NASA Technical Standard for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by NASA.

APPROVED FOR PUBLIC RELEASE—DISTRIBUTION IS UNLIMITED

SECTION 4.

Dust Requirements & Standards

4.1 Dust Impact Assessment Process

4.2 Sources of Dust

a. Planetary External (PE)

b. Planetary Pressurized (PP)

c. In-Space Pressurized (SP)

d. In-Space External (SE)

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

5.3 Testing Practices & Categories

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Document Overview

SECTION 4.

Dust Requirements & Standards

4.1 Dust Impact Assessment Process

4.2 Sources of Dust

a. Planetary External (PE)
b. Planetary Pressurized (PP)
c. In-Space Pressurized (SP)
d. In-Space External (SE)

Table provided for each section that contains guidance on particle size, surface accumulated loading, volumetric loading, dust velocity, and charge to mass ratio. It provides this information for various sources of dust depending on the environment.

a. PE – Human generated surface transported dust, rocket plume dust, natural charged dust transport, natural impact ejecta
b. PP – EVA suit cross-hatch transported dust, hardware cross-hatch transported dust
c. SP – micro-G free floating dust, micro-G surface adhering dust
d. SE – rocket plume dust, natural charged dust transport, natural impact ejecta

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Document Overview

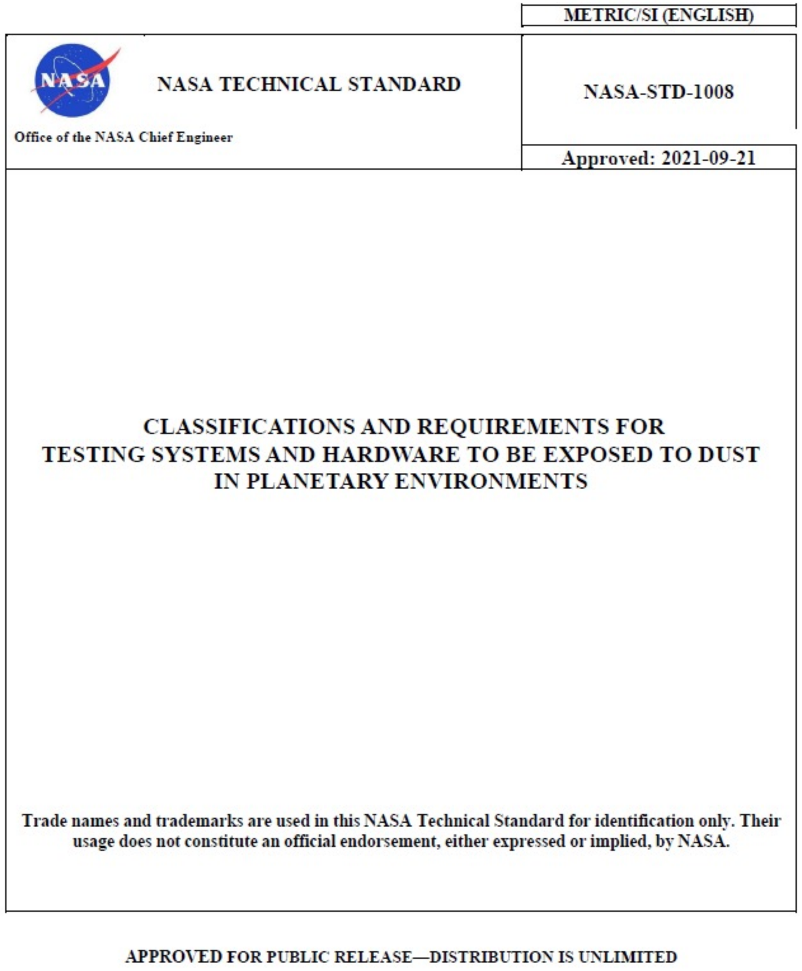
SECTION 4.

Dust Requirements & Standards

4.1 Dust Impact Assessment Process

4.2 Sources of Dust

- a. Planetary External (PE)
- b. Planetary Pressurized (PP)
- c. In-Space Pressurized (SP)
- d. In-Space External (SE)



METRIC/SI (ENGLISH)

NASA TECHNICAL STANDARD Office of the NASA Chief Engineer	NASA-STD-1008 Approved: 2021-09-21

CLASSIFICATIONS AND REQUIREMENTS FOR TESTING SYSTEMS AND HARDWARE TO BE EXPOSED TO DUST IN PLANETARY ENVIRONMENTS

Trade names and trademarks are used in this NASA Technical Standard for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by NASA.

APPROVED FOR PUBLIC RELEASE—DISTRIBUTION IS UNLIMITED

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

5.3 Testing Practices & Categories

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Section 5. Testing Methodologies & Best Practices

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

- 5.1.1 Particle Separation
  - 5.1.1.1 Sieve
  - 5.1.1.2 Cyclone Separation
- 5.1.2 Bake-out
  - 5.1.2.1 Forms of Water
  - 5.1.2.2 Moister Level Best Practices
  - 5.1.2.3 Moisture Considerations for Vacuum Testing
- 5.1.3 Storage

5.2 Simulant Loading Definitions

5.3 Testing Practices & Categories

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Section 5. Testing Methodologies & Best Practices

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

- 5.2.1 Surface Accumulated Loading
  - 5.2.1.1 Method 1: Pre-Load the Dust
  - 5.2.1.2 Method 2: Vacuum Chamber Dust Loading
- 5.2.2 Volumetric

5.3 Testing Practices & Categories

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Section 5. Testing Methodologies & Best Practices

SECTION 5.

Testing Methodologies & Best Practices

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Section 5. Testing Methodologies & Best Practices

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

5.3 Testing Practices & Categories

- 5.3.1 Aerosol Ingestion
    - 5.3.1 Simulant Characteristics
    - 5.3.2 Facility Capability
    - 5.3.3 Methodology
    - 5.3.4 Best Practices
- 5.3.2 Abrasion
- 5.3.3 Optical
- 5.3.4 Thermal

5.3 Testing Practices & Categories (cont.)

- 5.3.5 Mechanisms
- 5.3.6 Seals & Mating Surfaces
- 5.3.7 Reactivity
- 5.3.8 Electrostatic
- 5.3.9 Plume Surface Interaction

5.4 Simulants

5.5 Facilities

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Testing Categories

5.3.1 Aerosol Ingestion

Aerosol ingestion testing supports the development and use of hardware/system(s) that have the potential to ingest dust. This section is applicable to hardware/systems(s) exposed to dust within any pressurized habitable volumes/compartments and surface atmospheric environments.

5.3.2 Abrasion

Abrasion testing supports the development and use of materials used in hardware/system(s) that frequently interact and wear over time. This section is applicable to soft goods, which are flexible materials (e.g., textiles or thin films of synthetic or natural materials and hard goods, which are inflexible materials (e.g., rigid metals or ceramics).

5.3.3 Optical

Optical testing supports the development and use of hardware/system(s) that have the potential to have their properties and operation altered by dust. This section is applicable to optical equipment (e.g., solar panels, viewports, camera lenses, laser-based optical systems, all mirrors, wavelength filter lenses, and radiative measurement sensors) and relative navigation equipment (e.g., docking targets, reflectors.)

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Testing Categories

5.3.4 Thermal

Thermal testing supports the development and use of hardware/system(s) that have the potential to have their properties and operation altered by dust. This section is applicable to active thermal management components/systems, dust loading, and associated thermal impacts on hardware/systems. The primary focus is on radiators, as this is expected to be a key component directly impacted by dust buildup/coverage. However, consideration of other hardware/system(s) that generate heat (e.g., motors, power supplies) must be considered to determine potential impact to operational conditions.

5.3.5 Mechanisms

Mechanisms testing supports the development and use of hardware/system(s) that have the potential to have their properties and operation altered by dust. This section is applicable to hardware with interacting surfaces in relative motion (e.g., bearings, gears, screws, and slip rings), mechanism casings and soft goods (i.e., lubricants and grease), and their seals at the system level. Other applicable mechanisms can include, but are not limited to: deployable appendages including solar arrays, retention and release mechanisms, antennas and masts, actuators, transport mechanisms, switches, rotating systems including momentum wheels, reaction wheels, control moment gyroscopes, motors, and roll rings.

5.3.6 Seals & Mating Surfaces

Seals and mating surfaces testing supports the development and use of hardware/system(s) that have the potential to have their properties and operation altered by dust contamination. This section is applicable to static seals for hatches, docking systems, space suits, habitation modules, and sample containers.

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Testing Categories, con't

5.3.7 Reactivity

Reactivity testing supports the development and use of hardware/system(s) that have the potential to have their properties and operation altered by dust contamination or chemical reactivity. This section is applicable to surfaces and organic and inorganic materials that have the potential to react with activated dust surfaces. This section is different than previous sections in that it serves to show how simulants may be altered to recreate the natural reactivity of lunar surface environment dust particle reactivity.

5.3.8 Electrostatic Properties

Electrostatics testing supports the development and use of hardware/system(s) that have the potential to have their properties and operation altered by the electrical properties of dust. This section encompasses electrostatic properties of granular materials, electrostatic discharge (ESD) circuit shorts from accumulated dust, and electrical arcing.

5.3.9 Plume Surface Interaction

Rocket engines produce gas plumes that interact with the planetary surface environment. When vehicles conduct near-surface operations (e.g., landing or take-off), gas plumes interact with planetary surfaces and may cause erosion, lofting, and/or heating of surface materials. Ejected dust may strike the vehicle producing the plume, hardware/system(s) in the vehicle's immediate vicinity or objects on orbit. PSI may cause dust loading or impact damage (e.g., media blasting). The nature of PSI effects depends on the target body's regolith, atmospheric, topographic, and gravitational properties; the vehicle's architecture, engine configuration and duty cycle, and the flight path of the landing vehicle; and the proximity of nearby hardware/system(s).

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

Section 5. Testing Methodologies & Best Practices

SECTION 5.

Testing Methodologies & Best Practices

5.1 Simulant Prep & Storage

5.2 Simulant Loading Definitions

5.3 Testing Practices & Categories

5.4 Simulants → *Document points to Simulant Advisory Committee*

5.5 Facilities → *Document points to LSIC Facilities Directory*

Simulants https://ares.jsc.nasa.gov/projects/simulants/

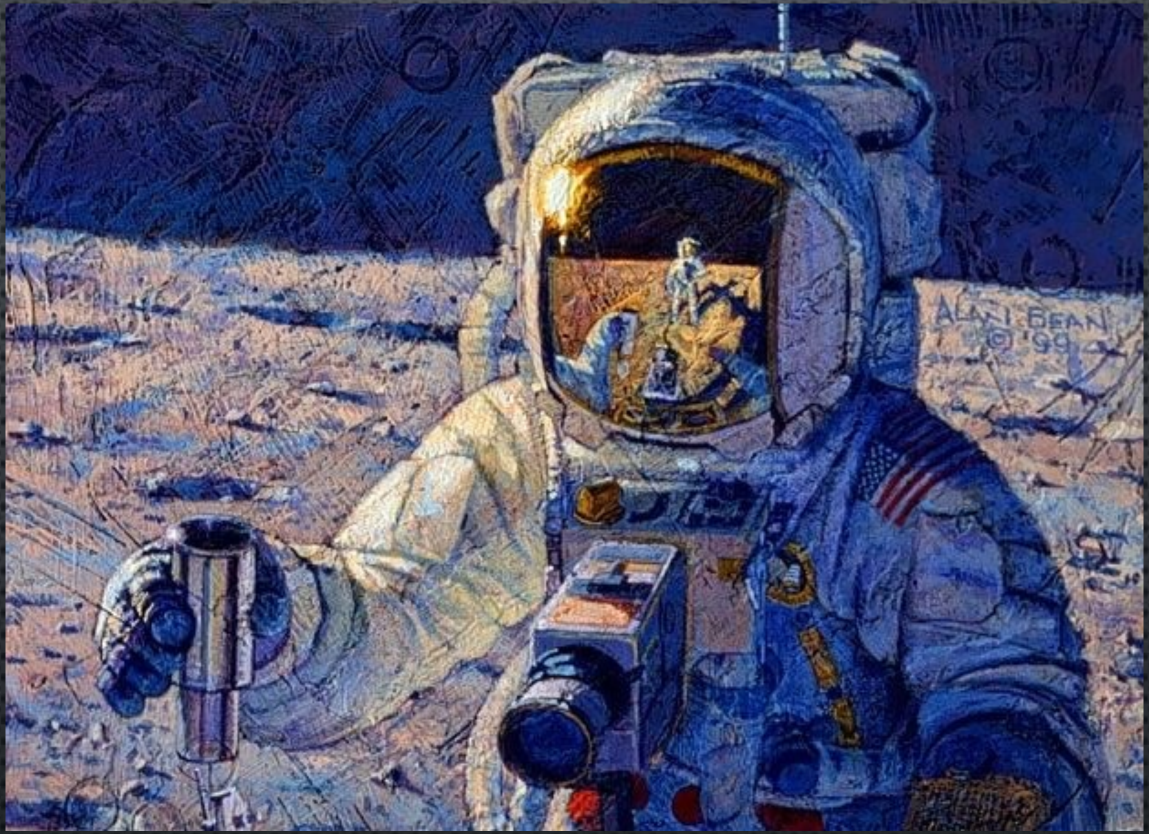
Facilities https://lsic-wiki.jhuapl.edu/x/HINf

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.

TESTING WITH DUST?

1. Look at Available Dust Testing Papers & Publications
   https://wiki.jsc.nasa.gov/fod/index.php/Lunar_Dust_Testing_Literature
2. Review Current Dust Testing Efforts
   https://wiki.jsc.nasa.gov/fod/index.php/Lunar_Dust_Testing_Campaigns
3. Read the Dust Mitigation Best Practices Guide (When Available)
4. Understand the NASA Standard for Dust Testing
   https://standards.nasa.gov/standard/nasa/nasa-std-1008
5. Select your Simulants (Simulant Advisory Committee)
   https://ares.jsc.nasa.gov/projects/simulants/
   https://wiki.jsc.nasa.gov/fod/index.php/Simulant_Advisory_Committee
6. Identify your Facilities (LSIC Facilities Directory)
   https://lsic-wiki.jhuapl.edu/x/hINf

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.



For more information, please reach out to
Kristen John/JSC
Charles (Chuck) E. Rogers/AFRC

This document has been reviewed for Proprietary, SBU, and Export Control (ITAR/EAR) and has been determined to be non-sensitive. It has been released to the public via the NASA Scientific and Technical Information (STI) Process.