

Bioburden Constraints for Mars Category IV Missions.

Adapted from Frick, A. F., Mogul, R., Stabekis, P., Conley, C. A., Ehrenfreund, P. Overview of Current Capabilities and Research and Technology Developments for Planetary Protection. Adv. Space Res. 54, 221-240 (2014).

Category			Soft-Landed Hardware ^a (SL)		Hard-Impacting Hardware ^b	Total Spacecraft ^c		
Sub-Category	Type	System Level	Surface Bioburden ^d (sBb _{SL}) (spores)	Surface Bioburden Density ^d (ρ _s Bb _{SL}) (spores/m ²)	Hard-Impacting Bioburden ^e (spores)	Accountable Bioburden ^f (spores)	Enclosed Bioburden Density ^g (spores/m ²)	Total Bioburden ^h (spores)
IVa	No Life Detection	Full-System	< 3x10 ⁵	< 300	5x10 ⁵ - sBb _{SL}	< 5x10 ⁵	1000	–
IVb	Life Detection	Full-System	< 30	< 0.03	5x10 ⁵ - sBb _{SL}	< 5x10 ⁵	1000	–
	Life Detection	Sub-System	< 30 subsystem < 3x10 ⁵ Total sBb _{SL}	< 0.03 subsystem < 300 Total ρ _s Bb _{SL}	5x10 ⁵ - Total sBb _{SL}	< 5x10 ⁵	1000	–
	Life Detection	Full-System Sub-System	<i>Bioburden levels or other values are dependent upon experimental needs.</i>					
IVc	Special Region is Within the Landing Ellipse	Full-System	< 30	< 0.03	1.5x10 ⁴ - sBb _{SL}	–	0.1	< 1.5x10 ⁴
	Special Region is Outside or Sub-Surface to the Landing Ellipse	Full System ⁱ	< 30	< 0.03	1.5x10 ⁴ - sBb _{SL}	–	0.1	< 1.5x10 ⁴
	Special Region is Outside or Sub-Surface to the Landing Ellipse	Sub-System ^j	< 30 subsystem < 3x10 ⁵ Total sBb _{SL}	< 0.03 subsystem < 300 Total ρ _s Bb _{SL}	5x10 ⁵ - Total sBb _{SL}	< 5x10 ⁵	1000	–
	Missions that May Induce or Create a Special Region	Full-System ^k Sub-System ^l	<i>Bioburden levels or other values are dependent upon experimental needs.</i>					

- a. For all missions, the soft-landed hardware must be protected from recontamination due to the hard-impacting hardware and other components of the spacecraft.
- b. Includes only hard-impacting hardware that is within 3σ of the landing ellipse.
- c. Includes all hardware (soft-landed and hard-impacting hardware) that is within 3σ of the landing ellipse.
- d. Includes only accessible or exposed surfaces.
- e. Includes all surfaces and encapsulated and mated materials of the hard-impacting hardware.
- f. Includes components of the spacecraft that may release spores into the environment, including the accessible surfaces of the soft-landed hardware and all components of the hard-impacting hardware.
- g. Includes all non-accessible surfaces of the soft-landed hardware.
- h. Includes all surfaces and encapsulated and mated materials of the soft-landed and hard-impacting hardware.
- i. Full-system option will be employed if the spacecraft carries a long-term heat source (e.g., plutonium) or failure modes analysis of the landing event indicates that debris field could contaminate a special region at a probability $>1\%$.
- j. Sub-system option may be employed if failure modes analysis of the landing event indicates that debris field would not contaminate a special region at a probability $>1\%$.
- k. Full-system option will be employed if failure modes analysis of the landing event indicates that debris field could create a special region at a probability $>1\%$.
- l. Sub-system option may be employed if failure modes analysis of the landing event indicates that debris field will not create a special region.