



**International Conference  
on Environmental Systems**



# **JPL Thermal Testing Standards**

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**41<sup>st</sup> International Conference on Environmental Systems  
(ICES-2011)**

**July 17 – 21, 2011**

**Portland, Oregon**



## Background - JPL Thermal Testing Documents

### 1. Flight Project Practices

- Captures the approaches and methods for a standardized execution of flight projects.
- **Specifies requirements for thermal testing at the assembly and spacecraft level.**

### 2. Design Principles

- Captures the institutional standards for designing, verifying, validating, and operating flight systems.
- **Specifies temperature control design margins and thermal design temperature ranges.**

### 3. Spacecraft System Thermal Testing

- Specifies the standards and parameters for spacecraft-level thermal testing.

### 4. Assembly and Subsystem Level Environmental Verification

- Specifies the standards and parameters for assembly and subsystem level environmental testing and verification.
- **Specifies detailed thermal testing requirements.**



# Thermal Testing Practices – Assemblies and Subsystems

		Qualification (Qual) or Protoflight (PF) Test		Flight Acceptance (FA) Test	
Hardware Type	Test Media	Temperature Levels (margins)	Test Duration at Temperature (cumulative)	Temperature Levels (margins)	Test Duration Operational (cumulative)
Electronics	Vacuum	<p>Cold: (AFT-15°C) or -35°C (whichever is colder)</p> <p>Hot: (AFT+20°C) or +70°C (whichever is warmer)</p>	<p>Operational: 72 hrs hot / 24 hrs cold (or longer as needed to run tests of all required functions).</p> <p>Non-Operational: 6 hrs hot/ 6 hrs cold</p>	<p>Cold: (AFT-5°C) or -25°C (whichever is colder)</p> <p>Hot: (AFT+5°C) or +55°C (whichever is warmer)</p>	<p>Operational: 60 hrs hot / 8 hrs cold (or longer as needed to run tests of all required functions).</p> <p>Non-Operational: 6 hrs hot/ 6 hrs cold</p>
Non-Electronics	Vacuum (or Ambient Pressure, if appropriate)	<p>Cold: (AFT-15°C)</p> <p>Hot: (AFT+20°C)</p>	<p>Operational: Hot and cold dwell times as needed to run tests of all required functions, as applicable.</p> <p>Non-Operational: 6 hrs hot/ 6 hrs cold</p>	<p>Cold: (AFT-5°C)</p> <p>Hot: (AFT+5°C)</p>	<p>Operational: Hot and cold dwell times as needed to run tests of all required functions, as applicable.</p> <p>Non-Operational: 6 hrs hot/ 6 hrs cold</p>

AFT = Allowable Flight Temperature (is the operating/non-operating temperature range, which the thermal design must maintain for the flight hardware system during all phases of the mission for non-fault conditions. )



## Thermal Testing Practices – Additional Test Parameters

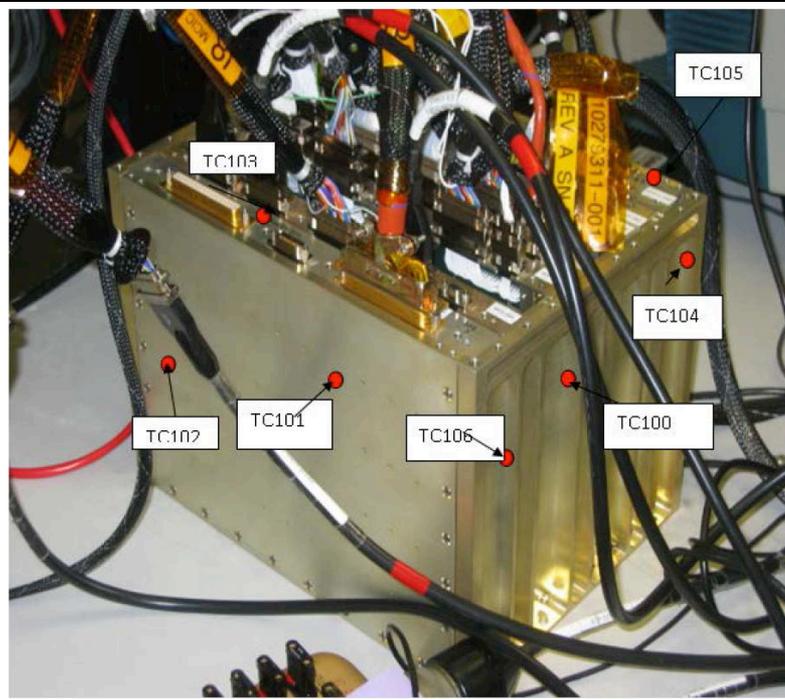
- **Number of thermal cycles:**
  - 3 to 10 cycles.
- **Test media:**
  - Vacuum  $\leq 1.0 \times 10^{-5}$  torr for thermal-vacuum test
  - GN<sub>2</sub> for thermal atmosphere test
  - Mission specific: e.g. 2-12 torr CO<sub>2</sub> or GN<sub>2</sub> gas for Mars surface landed hardware.
- **Ramp rate:**
  - $\leq 5^{\circ}\text{C}$  /minute.
- **Number of operating hot and cold startups:**
  - 3 each, minimum.
- **Number of non-operating cold startups:**
  - 3 minimum.
- **Operational “ON” time during temperature extremes:**
  - Exercise all functional modes during the hot and cold temperature plateaus.



# Thermal Testing Practices – Examples with MSL

MSL = Mars Science Laboratory mission (the large Mars rover to be launched in November, 2011)

Hardware Type	Test Media	Qualification (Qual) or Protoflight (PF) Test		Flight Acceptance (FA) Test	
		Test Temperature and Duration (cumulative)	Other Test Parameters	Test Temperature and Duration (cumulative)	Other Test Parameters
Rover Control Electronics	Vacuum	Operational: +70°C/-55°C 164 hrs/ 67 hrs Non-Operational: +75°C/-55°C 13 hrs/ 12 hrs	Cycles: 3 Startups: 17 hot, 9 cold  Cycles: 3		

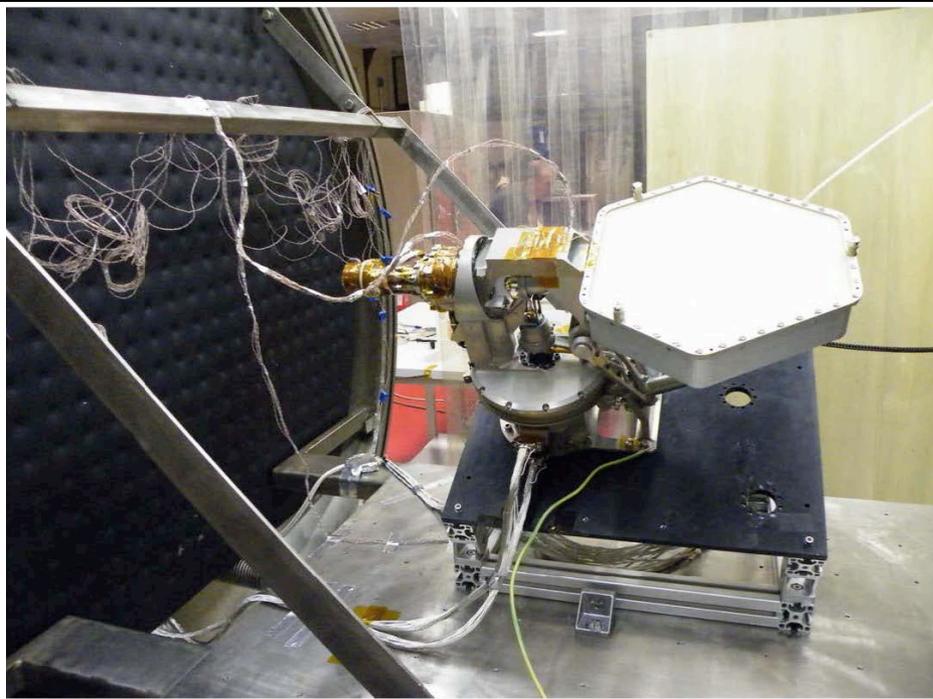




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		Qualification (Qual) or Protoflight (PF) Test		Flight Acceptance (FA) Test	
Hardware Type	Test Media	Test Temperature and Duration (cumulative)	Other Test Parameters	Test Temperature and Duration (cumulative)	Other Test Parameters
High Gain Antenna	Vacuum	Operational: +90°C/-70°C 16 hrs/ 16 hrs Non-Operational: +90°C/-135°C 4 hrs/ 4 hrs	Cycles: 1  Cycles: 3	Operational: +90°C/-70°C 2 hrs/ 2 hrs Non-Operational: +110°C/-135°C 52 hrs/ 4 hrs	Cycles: 1  Cycles: 2 (110°C, 52 hrs for planetary protection)

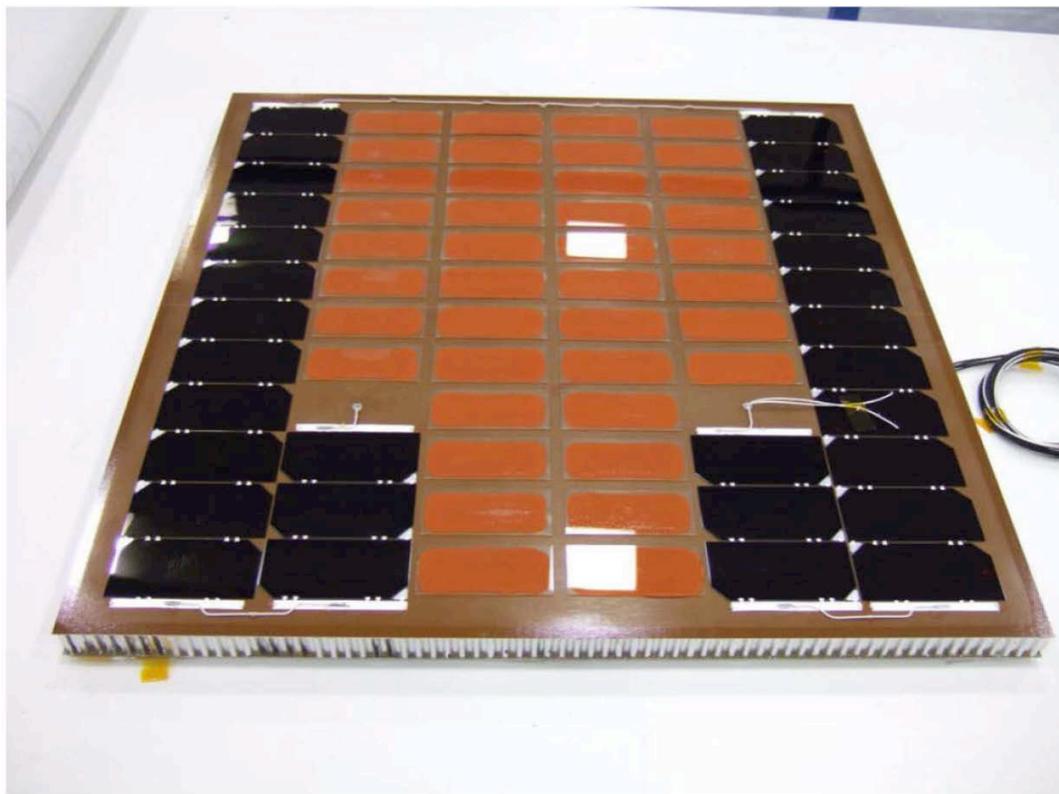




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MSL = Mars Science Laboratory mission (the large Mars rover to be launched in November, 2011)

		Qualification (Qual) or Protoflight (PF) Test		Flight Acceptance (FA) Test	
Hardware Type	Test Media	Test Temperature and Duration (cumulative)	Other Test Parameters	Test Temperature and Duration (cumulative)	Other Test Parameters
Solar Array	Vacuum /GN <sub>2</sub>	Non-Operational: +135°C/-80°C 25 hrs/ 25 hrs	Qual: w/Coupon Cycles: 5 cycles vacuum, 20 cycles 1 atm GN <sub>2</sub>	Non-Operational: +115°C/-75°C 6 hrs/ 6 hrs	Cycles: 4 cycles vacuum





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		Qualification (Qual) or Protoflight (PF) Test		Flight Acceptance (FA) Test	
Hardware Type	Test Media	Test Temperature and Duration (cumulative)	Other Test Parameters	Test Temperature and Duration (cumulative)	Other Test Parameters
Descent Pressure Transducer	Vacuum	Operational: +70°C/-115°C 6 hrs/ 6 hrs Non-Operational: +110°C/-115°C 8 hrs/ 8 hrs	Cycles: 3  Cycles: 3		



## Acknowledgements

- This work is sponsored by NASA and performed at JPL/Caltech.
- Thanks to Dr. Rajeshuni Ramesham and John Forgrave for reviewing and providing selected information for this presentation.