Environmental Test Requirements: Thermal

- The LAT instrument will be tested[1] in various simulated on-orbit environments to demonstrate the flight hardware's compliance with vacuum and thermal requirements. Specifically, the tests will verify that:
    1. The instrument's thermal design maintains all hardware components within the required margined hot and cold temperature limits of a simulated space vacuum environment, under steady state conditions, while design hot and cold environmental heat fluxes are applied to the hardware.
    2. The instrument flight thermal math model (TMM) is validated through correlation with thermal balance tests results.
    3. The instrumentation performs within specification in a simulated space environment while instrument components are exposed to margined minimum and maximum temperature extremes. Performance within specification will also be demonstrated during hot and cold temperature transitions; i.e., during thermal cycling.
- The LAT instrument will be subjected to a hot thermal balance, a cold thermal balance and a survival thermal balance. Additionally, the LAT instrument will be subjected to a total of four thermal cycles.

1 Mission Assurance Requirements for the Large Area Telescope, 433-MAR-0001 [Rev. A, 8 April 2003]

Specific Test Requirements: Thermal Balance

- The threefold purpose[1] of the thermal balance tests is to:

1. Verify the thermal control system performance of the integrated flight hardware. Thermal control system performance will be demonstrated by applying design cold and hot environmental fluxes to the hardware while the hardware functions as it will on-orbit to verify that margined minimum and maximum temperatures requirements are satisfied.

2. Verify expected thermal design margins.

3. Provide a database with which to correlate the flight thermal math model.

Specific Test Requirements: Test Set-Up

- Test Configuration: the LAT Instrument will be fully integrated including the ACD, X-LAT Plate with electronic boxes, and radiators. The SC bus will be simulated as will the heat flux from the solar arrays. All parasitic paths will be monitored.

- The goal is to proceed from acoustic test to thermal vacuum test without breaking configuration with the radiators.
- Specialized Test Equipment: (TBD)
  - Individually controlled sink/source plates from TBD deg.C to TBD deg.C
    - 5 for ACD
    - 2 for radiators
    - 1 for SC bus
  - Level to horizontal; +/- 0.1 degree
  - Auxiliary heat exchangers, mounted on X-LAT plate (flyaway) and on Grid wings (removable).

Specific Test Requirements: Instrumentation

- Two data streams: LAT instrument and facility
- Currently 259 thermocouples (91 fly-away) in facility data stream
- Both data streams should be visible on one monitor and should have capability for TC grouping
- Both data streams stored in single data base

Specific Test Requirements: Thermal Cycle

- The LAT thermal vacuum cycle tests will satisfy the following four objectives:

1. Verify workmanship for hardware such as wiring harnesses, MLI, and cable support and strain-relief which will not have been fully verified at the subsystem level.

2. Demonstrate the ability of the instrument to perform within specification for all functional modes at temperatures 10°C above and below the design envelope of predicted on-orbit mission extremes. The required 10°C cold side temperature margin may be reduced to 5°C for components under active heater control assuming that design cold case analyses has shown that the heaters under thermostatic control have been sized with a minimum thirty percent design margin assuming minimum bus voltage.

3. Demonstrate the ability of the instrument to perform within specification after being exposed to the predicted nonfunctional cold and hot margined temperature extremes.

4. Demonstrate cold and hot turn-on from non-functional temperature extremes for components not designed with dedicated heaters to elevate the components' temperature from nonfunctional to operational temperature limits.

Specific Thermal Tests: Segments

Test Segment	Pumpdown	Bakeout	Hot QT	Hot Op TB		Hot Op Peak Power	Hot Op (TCS)	Hot Op (TCS) parameter upload	Cold Survival TB, primary/redundant functionals	Cold Op TB		Cold Op (TCS)	Cold Op (TCS) parameter upload	TCS Transition	Thermal cycle
Test Segment Description	evacuate chamber	maintain test article at 50°C +0C/-3C C forTBD hrs	maintain test article at hot OT +10C forTBD hours	symmetric orbit avg load without RIT control	symmetric orbit avg load with RIT control by primary reservoir heaters	symmetric orbit avg load with RIT control, 10 min ?	asymmetric transient load with RIT control by primary/redundant reservoir heaters	asymmetric transient load with RIT control by primary reservoir heaters	survival heater test,	symmetric orbit avg load without RIT control	symmetric orbit avg load with RIT control by primary reservoir heaters	asymmetric transient load with RIT control by primary/redundant reservoir heaters	asymmetric transient load with RIT control by primary reservoir heaters	Survival-to-OP	4 Thermal cycles
Radiator Shrouds, °C	--	TBD	TBD	TBD	TBD	TBD	profile	profile	TBD	TBD	TBD	profile	profile	TBD	TBD
Reservoir Shrouds, °C	--	TBD	TBD	TBD	TBD	TBD	profile	profile	TBD	TBD	TBD	profile	profile	TBD	TBD
Grid Mass, °C	--	50	50	float, initially < 15	float, initially < 15	float, initially < 15	float, initially < 15	float, initially < 15	float, initially > -20	float, initially > -10	float, initially > -10	float, initially > -10	float, initially > -10	float, initially > -20	
Bus Simulator, °C	--	50	50	50	50	50	50	50	-10	-10	-10	-10	-10	-10	+50 to -10C
LAT Power @ RIT, W	0	0	0	615	615	708	615	615	0	495	495	495	495	varies	615
S/C Support Strut Heat Leak Simulators, W	0	0	5	5	5	5	5	5	0	0	0	0	0	?	
Rad. Support Strut Heat Leak Simulators, W	0	0	5	5	5	5	5	5	0	0	0	0	0	?	
Grid Survival Heaters, W									150						
Primary									(dis)enabled, cycling						
Redundant									(dis)enabled, cycling						
Reservoir Heaters, W															
Primary									enabled, ON						
Redundant									enabled, ON to 15°C, then OFF						
Radiator Heaters, W									120						
Primary									(dis)enabled, cycling						
Redundant									(dis)enabled, cycling						
Requirements addressed															
433-MAR-0001[4.6; 4.6.1]			√	√	√	√	√	√	√	√	√	√	√	√	
LAT-SS-00010-02															
LAT-SS-00408-02															
LAT-MD-00408-03d															