JPL D-20549

SPIRE Test Plan

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1 Introduction

1.1 Purpose

This documents a comprehensive plan for the testing of the SPIRE JPL deliverables. The JPL deliverables are (as listed in the Business Agreement):

1. Bolometer Detector Array Assemblies (BDA)
2. JFET Modules
3. RF Filter Modules
4. Cryo-cable from the BDA to the JFET Modules

It also describes the qualification plan for the BDA, JFET Modules and RF Filter Modules.

This document is part of the Agreed Documents list as listed in the Business Agreement.

1.2 Applicability

This Plan is applicable to all the SPIRE JPL deliverables at the assembly/modules level. Only a few component level tests are listed in this document.

1.3 Approach

1.3.1 BDA

The five different varieties of BDAs are explained in Section 1.6.

a) Two CQM BDA structures will be manufactured and assembled. Two of them will have active detector arrays, both of which will eventually be used as flight spares (FS). The two CQM BDAs, will have SLW and PLW type of detector arrays and will undergo testing at acceptance levels.

b) A third BDA will be manufactured during the CQM build phase, which will be used as a qual unit and will undergo qualification level testing. This unit will have active detectors and will be of the PLW type. This unit will not get delivered in the baseline plan. However, under schedule pressure we may be forced to deliver the qualification model as a CQM BDA and replace it for the FS instrument in which case appropriate modifications to the business agreement will be renegotiated. Some limited amount of performance measurements (TBD) will be performed on this unit, both before and after the environmental qual testing. In addition, to the PLW qual BDA unit, there will be a qual structural unit with no active detectors. This structural unit will undergo environmental testing (Warm vibration, Cold vibration and thermal cycling) at qualification levels.

[*Note*: CQM phase, a fourth BDA will be delivered UNTESTED for the CQM instrument testing, and will be returned to JPL for the FS phase and will be tested during that time. This will be of the SSW type.]

c) Five PFM BDA units will be manufactured and assembled. All five will be tested at Protoflight/Flight Acceptance Levels at JPL. All five of them will have active detector arrays.
d) Three FS BDA units will be delivered. Two of these [the SMW and the PSW] will be manufactured and assembled during this phase. The SSW BDA unit is the one returned to JPL as noted in Section 1.3.1 (a) and will be tested in this phase. All three will be tested at Protoflight/Flight Acceptance Levels at JPL. All three will have active detector arrays [SMW, PSW and SSW].

1.3.2 JFET Modules

a) In the CQM phase, three JFET modules will be manufactured and tested. JFET modules will include savers and will be fully functional. These modules will be re-used for FS instrument.
b) In the PFM phase, eight JFET modules will be assembled and tested.
c) In the FS phase, five JFET modules will be assembled and tested.

All Units have connector savers.

1.3.3 RF Filter Modules

12 RF Filter Modules will be tested and delivered in the STM/CQM phase. There are 12 RF Filter Modules with connector savers in the PFM phase.

1.3.4 Cryocable

The cryocable from the BDAs to the JFET modules will be procured from an outside vendor. The cable will be tested by the vendor prior to delivery.

1.4 Applicable Documents

1. Herschel-SPIRE Business Agreement, SPIRE-UCF-PRJ-000822
2. Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456
3. Environmental Requirements Document (ERD) document for Herschel/Planck, JPL D-19155
4. JPL Herschel/Planck Mission Assurance Requirements Document, JPL D-16642
5. Interoffice Memorandum: Germanium Bolometer Displacement Effects, Ref.# SSM-514-C-008-01
6. Herschel/Planck Contamination Control Plan, JPL D-19156

1.5 Reference Documents

1. SPIRE Bolometer Detector Array Assembly Process and Test Qualification Plan (JPL D-19152)
2. SPIRE Vibration Test Plan-JPL D-20550
3. SPIRE Thermal Cycling Procedure- JPL TP518518

1.6 Hardware Description

The SPIRE detector sub-system consists of five Bolometric Detector Arrays (BDA) – three for the SPIRE photometer channel:

PLW – Long wavelength photometer array
PMW – Medium wavelength photometer array
PSW – Short wavelength photometer array

And two for the SPIRE spectrometer channel:

SLW – Long wavelength spectrometer array
SSW – Short wavelength spectrometer array

For the CQM testing, two BDA units will be fabricated. These will be fully functional units with active detector elements and will have the PLW and the SLW arrays. Both the CQM BDA units will undergo full performance characterization: dark testing and optical testing.

As part of the qualification program, a qual model (QM) BDA will be fabricated. The QM BDA will have a PLW detector array installed in it and will undergo qualification level testing. It will be subjected to limited performance testing (Dark Testing) before and after environmental testing. In addition, to the PLW qual BDA unit, there will be a qual structural unit with no active detectors. This structural unit will undergo environmental testing (Warm vibration, Cold vibration and thermal cycling) at qualification levels.

The test program will have five PFM BDA units and three FS BDA units (one of which is the SSW BDA returned to JPL after the instrument CQM testing). The fabrication and assembly techniques for each BDA suspension units will be identical (and also identical to the QM and the CQM units). The hardware for the five types of units is identical except for the size of the feedhorns and the design of the specific arrays. All five BDA units will undergo environmental testing. For performance testing, the BDA units will undergo only dark testing as defined in Section 3.3.1.

The differences in the five CQM units can be summarized as follows:

Table1: CQM BDA units

BDA type	Environmental Testing	Performance Testing	Used as Flight Spares
PLW	Yes	Yes	Yes
PMW	No	No	No
PSW	No	No	No
SLW	Yes	Yes	Yes
SSW **(FS)**	No	No	Untested FS BDA used in CQM instrument testing at RAL and returned to JPL for testing.

1.7 Verification and Performance Characterization Matrix

1.7.1 BDA: Test Verification Matrix

Specification ID	**Description**	**Verified By Test Or Measurement On**				
		Prototype	**EM**	**CQM**	**PFM**	**FS**
BDA-FUN-04	The **positional repeatability** of the focal plane structure shall be < 125 um (TBC) orthogonal to the optical axis, and < 625 um (TBC) along the optical axis. The rotational repeatability around the optical axis shall be < 0.5 degrees (TBC).	X	X	X	X	X
BDA-TEC-03	The **BDA mass** will have a design value of 600 g (TBC) average over 5 detector arrays, including output connectors.	X	X	X	X	X
BDA-TEC-04	The **first resonant frequency** of the BDA will be > 200 Hz (TBC), with a goal of > 250 Hz.	X	X	X	X	X

1.7.2 BDA: Performance Characterization Test Matrix

Specification ID	**Description**	**Verified By Test Or Measurement On**				
		Prototype	EM	CQM	PFM	FS
BDA-PER-01	BDA detector yield.	X	X	X	X	X
BDA-PER-02	The ratio of photon NEP due to radiation absorbed at the detector and total NEP, given as (NEPphoton/NEPtotal)^2 NEP includes all sources of noise at 1 Hz, measured at 300 mK, assuming a total readout noise of 10 nV/rtHz and an operating impedance of 5 MOhm.	X		Y	Y	Y
BDA-PER-03	The optical efficiency of the BDA horn and bolometer assembly for the photometer arrays over the optical passband.	X	-	X	X	X
BDA-PER-04	The optical efficiency of	-	-	-	X	X

	the short wavelength spectrometer horn arrays and bolometer assembly over the optical passband.					
BDA-PER-05	The optical efficiency of the long wavelength spectrometer horn arrays and bolometer assembly between the short-wavelength edge of the band and 400 μm.	-	-	X	X	X
BDA-PER-06	The photometer detector time constant, assuming a maximum modulation frequency of 2 Hz.	X	**-**	**Z**	**Z**	**Z**
BDA-PER-07	The spectrometer detector time constant, assuming a maximum modulation frequency of 20 Hz.	-	-	Z	Z	Z
BDA-PER-08	The uniformity of the calibrated responsivity.	-	-	YY	YY	YY
BDA-PER-09	Detector cross-talk.	ZZ	-	ZZ	ZZ	ZZ
BDA-PER-10	The 1/f knee frequency (total noise is sqrt(2) larger than white level).	Y	-	Y	Y	Y

Y: Noise tests are carried out under dark conditions. The detector noise model and optical efficiency will be used to predict detector noise under optical loading. The model will be confirmed under the optical testing with optical loads approximate to the loads encountered in flight on the CQM BDA units.
Z: The detector speed of response will be measured under optical loads approximate to the loads encountered in flight.
YY: Responsivity calibrated by electrical load curves. Stability of responsivity derived from noise measurements.
ZZ: Optical cross-talk will be tested to the limits of our apparatus, on selected pixels, and from electrical cross-talk on resistor channels. Full cross-talk matrix acquired at instrument level.

1.7.3 JFET: Test Verification Matrix

Specification ID	Description	Verified By Test Or Measurement On				
		Prototype	EM	CQM	PFM	FS
JFET-FUN-02	The RF filters will operate without power dissipation	-	-	-	-	-
JFET-FUN-03	The JFET modules must be capable of functioning, without meeting noise specifications, over a temperature range from 4 K to 300 K	-	X	X	X	X
JFET-FUN-04	The JFET module and RF filters will operate from a base	-	X	X	X	X

	temperature between 4 – 20 K.					
JFET-TEC-01	The JFET modules will have a mass less than 305 g.	-	X	X	X	X
JFET-TEC-03	The RF filters are to provide –40 dB attenuation from 500 MHz to 3 GHz (minimum), -60 dB attenuation from 500 MHz to 10 GHz (goal).	-	X	AA	AA	AA
JFET-TEC-05	The maximum allowed total JFET power dissipation for photometer mode (all three arrays operating) is 42 mW. The design value for JFET module dissipation is 7 mW per 48-channel module. Some JFET modules for the 250 µm array may be switched off in operation if necessary to keep within the maximum allowed power limit. The 250 µm array layout and wiring will be configured to allow contiguous portions of the array to be switched off 24 detectors at a time. Note: The design of JFET rack and cryoharness are to be examined to see if base temperature of the rack can be increased above that of the optical bench, reducing the dissipation for a given JFET temperature. (TBC by JPL)	X	X	X	X	X

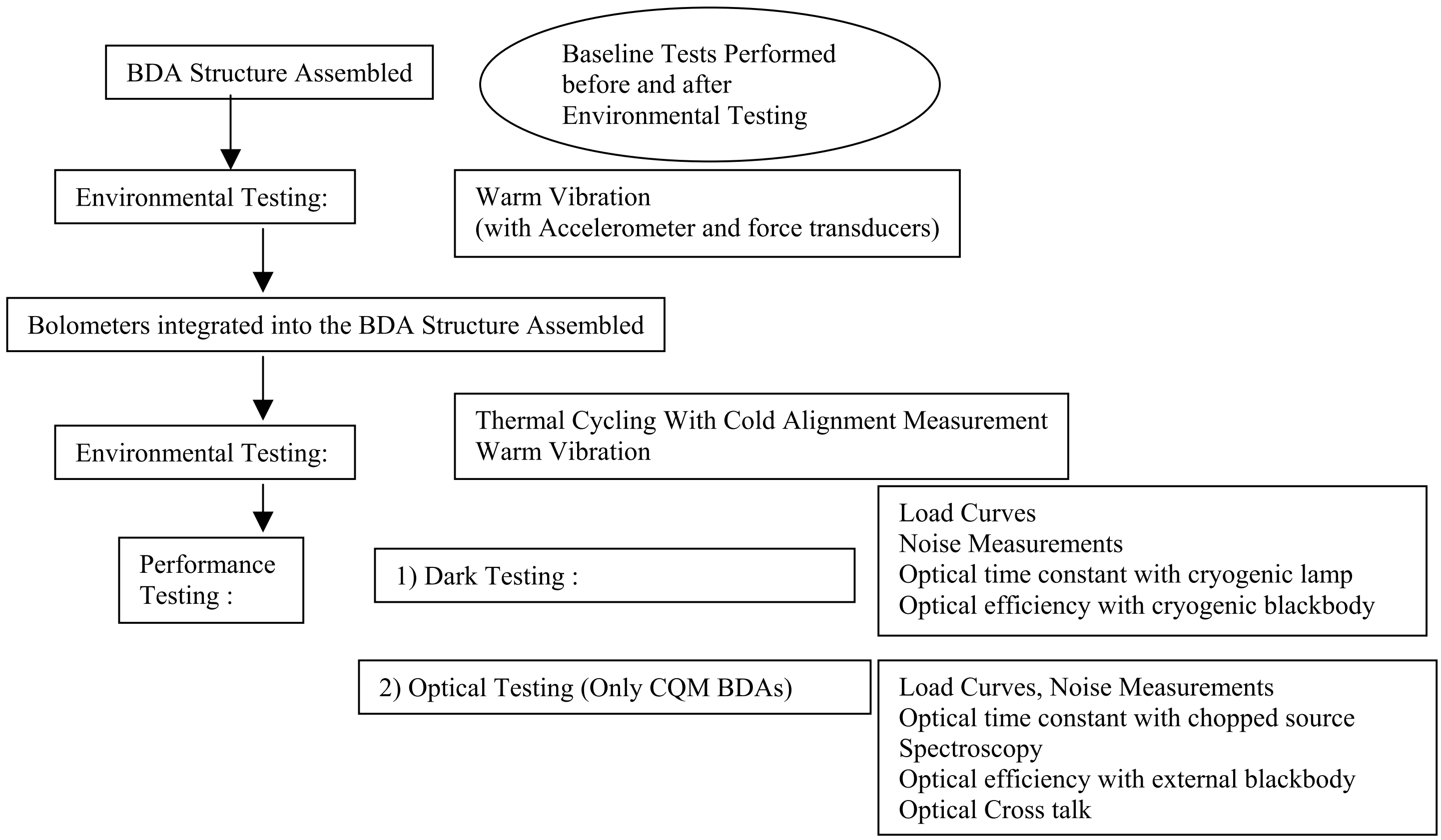
AA: On selected channels

1.7.4 JFET: Performance Characterization Test Matrix

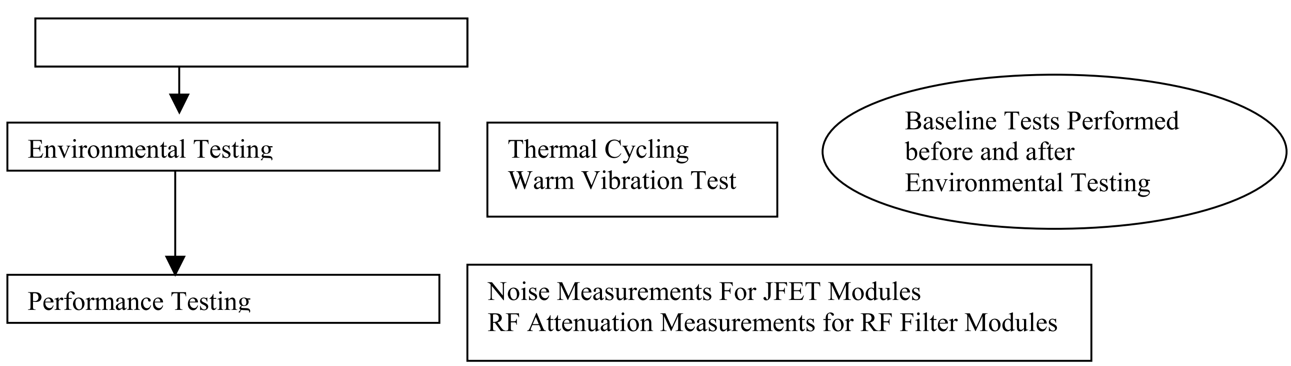
Specification ID	Description	Verified By Test Or Measurement On				
		Prototype	EM	CQM	PFM	FS
JFET-PER-01	Median noise of JFET module over 100 – 300 Hz.	X	X	X	X	X

1.8 Test Flow

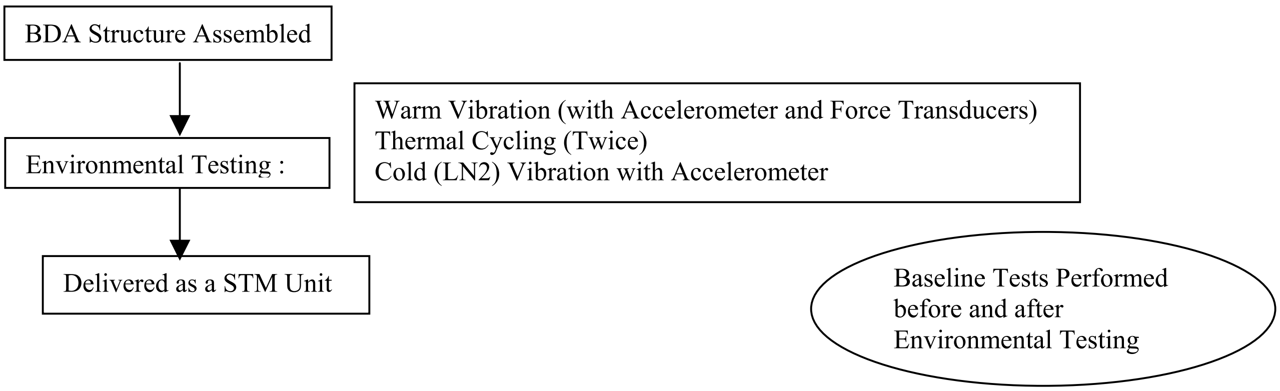
1.8.1 BDA



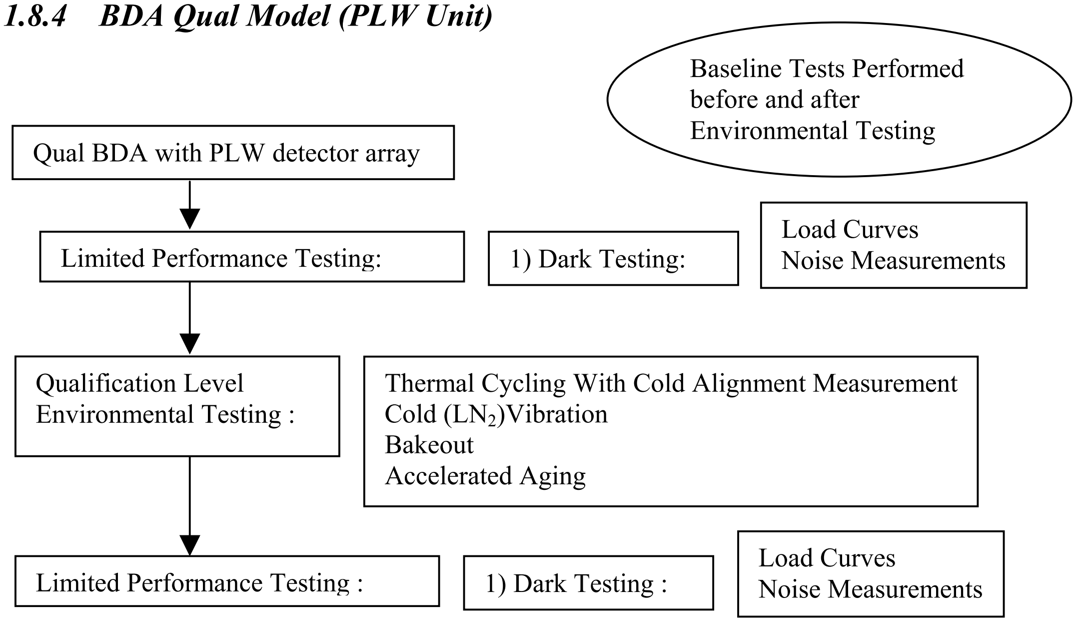
1.8.2 JFET Modules and RF Filter Modules



1.8.3 BDA Qual Structural Unit



1.8.4 BDA Qual Model (PLW Unit)



2 Documentation

2.1 Process Documentation

Processes and documentation for the CQM and the PFM units will be identical to the flight build processes. This shall be documented on the AIDS for the CQM and the PFM units. Other documentation includes discrepancies reported on Inspection Reports and Problem/Failure Reports.

2.2 Test Documentation

Documentation for planning and reporting testing shall meet the requirements of the ERD, D-19155.

3 BDA Structure

3.1 Baseline Test

Baseline tests will be performed before and after environmental testing of the BDA units. In the case of the qual structural model BDA, the baseline tests will be performed before and after EACH separate environmental test.

3.1.1 Metrology

Metrology will be used as a baseline test for the environmental testing. This will be done before and after each of the environmental tests. The test will be performed at the JPL Measurement Assurance Center (MAC), Bldg. 170-118, Section 512 or in Building 103 Hybrid laboratory, Section 349. Dimensional inspection in the metrology test will consist of measuring the locations of the kevlar suspended parts of the BDA in relation to reference points on the mounting flange.

3.1.2 Tension

The tension in the Kevlar suspension will be measured before and after the environmental tests as an additional baseline test.

3.1.3 Continuity Check

This test will be used as a baseline test (in addition to the metrology) before and after environmental test for the BDA units with active detectors. A continuity check will be performed on all the channels in the detector array at room temperature. In addition, a continuity check will be performed on a representative sample number of channels (~20) at 77 K during thermal cycling.

3.2 Environmental Tests

The environmental testing listed below will be performed on the two CQM BDA units and the PFM BDA units. The tests will also be performed on the qual BDA unit at a higher qual levels.

3.2.1 Bakeout

Test Objective: To subject the unit to bakeout temperatures to ensure survival of the detector subsystem units when the Herschel satellite is baked out.(80C for 72 hours) as specified in the "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).
Item tested: BDA P/LW Qual Model only. For the other BDA units, the only bakeout planned is as part of the assembly procedure
When to Perform: After the initial limited performance testing
Equipment used in test: Vacuum Oven
Procedure: TBD
Data Output: Visual inspection for degradation if any. Followed by a tension and metrology test to measure the movement of the kevlar-supported piece.
Pass-Fail Criteria: Movement of the designated control points have to be less than 0.125 mm (TBC) in the plane orthogonal to the optical axis and less than 0.625 mm (TBC) along the optical axis as specified in the document "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).

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3.2.2 Warm Vibration Test

Test Objective: To subject the unit to a vibration regimen at room temperature as specified in the "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456). The BDA structural units will be subjected to a reduced level workmanship random vibe. The BDA units with detector array will be subjected to acceptance level random vibe. [The qual unit will be subjected to qualification level vibe.]
Item tested: All BDA structural units with accelerometer on the simulated mass and with force transducers. And all BDAs with detector arrays.
When to Perform: After assembling the BDA unit but without the bolometer arrays and also after assembling the detector array into the BDA strcuture.
Equipment used in test: Warm vibration fixture
Procedure: SPIRE Vibration Test Plan, JPL D-20550
Data Output: Visual inspection for degradation if any. Followed by a tension and metrology test to measure the movement of the kevlar-supported piece.
Pass-Fail Criteria: Movement of the designated control points have to be less than 0.125 mm (TBC) in the plane orthogonal to the optical axis and less than 0.625 mm (TBC) along the optical axis as specified in the document "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).

3.2.3 Cold Vibration Test

Test Objective: To subject the unit to a vibration regiment at 77 K as specified in the "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).
Item tested: Only the qual BDA units. [Structural unit and QM unit with detectors.]
When to Perform: After warm vibration testing of the structural Qual unit. After limited performance testing of the QM BDA
Equipment used in test: Cold vibration fixture
Procedure: SPIRE Vibration Test Plan, JPL D-20550
Data Output: Visual inspection for degradation if any. Followed by a tension and metrology test to measure the movement of the kevlar-supported piece.
Pass-Fail Criteria: Movement of the designated control points have to be less than 0.125 mm (TBC) in the plane orthogonal to the optical axis and less than 0.625 mm (TBC) along the optical axis as specified in the document "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).

3.2.4 Thermal Cycling

Test Objective: To subject the devices to one thermal cycle between room temperature and 77 K at a pressure of less than 10^-5 Torr for acceptance testing. And thus simulate the conditions they will experience during testing and during operation and to ensure that the units are qualified for those conditions. The qual BDA unit will be subjected to a minimum of 15 (not to exceed 20) thermal cycles (TBC). [The total number of thermal cycles on the hardware including the cycles during performance characterization is not to exceed five.]
Item tested: Only the BDA units with active detectors after integration of the bolometers into the BDA unit. [Plus, the qual structural unit and the QM BDA unit with detectors.]
When to Perform: After warm vibration Testing. [After cold vibration testing in the case of the QM BDA unit with detectors.]
Equipment used in test: Thermal Cycling Cryostat equipped with thermometers and a heater.
Procedure: SPIRE Thermal Cycling Procedure, JPL TP 518518
Data Output: Visual inspection for degradation if any. Followed by a tension and metrology test to measure the movement of the Kevlar-supported piece. In-situ measurement of the position of the designated control points at 77 K vs. at room temperature and thus measuring the cold alignment shift.
Pass-Fail Criteria: Movement of the designated control points have to be less than 0.125 mm (TBC) in the plane orthogonal to the optical axis and less than 0.625 mm (TBC) along the optical axis as specified in the document "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).

3.3 Performance Characterization

After being subjected to the environmental testing, the SLW and PLW CQM units will be subjected to performance Characterization/ testing both dark and optical testing.

All PFM and FS BDA units will undergo performance characterization/testing but only the dark testing.

The performance testing for the bolometers can be categorized into two groups: Dark testing and Optical testing. The dark and optical testing will be done in the Bodac dewar Unit #1. The equipment along with the cables and cryo-harnesses will be separately tested.

3.3.1 Dark Testing

Dark testing is done under conditions such that close to zero optical power is incident upon the bolometer arrays. Dark testing will be done after completion of environmental tests on the active detector BDA units. For the active PLW qual model BDA unit, the dark testing will be performed both before and after the environmental tests at the University of Colorado.

3.3.1.1 Load Curves

Test Objective: To measure the load curves at different (TBD) temperatures from 300 mK to less than 1 K.. This will also measure the yield within the bolometer arrays.
Item tested: All active detector BDA units
When to Perform: After completion of environmental tests on the active detector BDA units. And before and after the environmental tests on the active PLW qual BDA unit.
Equipment used in test: BDA Dewar #1, ^{3}He fridge,
Procedure: Test Procedure Document TBD

Data Output: The bolometer voltage as a function of bias voltage at different temperatures. The resistance of each bolometer in the array both at room temperature and at 300 mK which is its nominal operating temperature. Results in a derivation of the detector parameters R_0, Δ, G_0, and β, and a model of the detector responsivity.
Pass-Fail Criteria: N/A

3.3.1.2 Noise

Test Objective: To measure detector noise
Item tested: Bolometer array incorporated into the BDA unit.
When to Perform: After Load Curve measurement
Equipment used in test: BDA Dewar #1, ^{3}He fridge,
Procedure: Test Procedure Document TBD
Data Output: Measured Detector Noise as compared with the predicted noise.
Pass-Fail Criteria: Performance characterization only, no pass/fail. NEP design and minimum performance values are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456 under a specified optical loading. We have translated these values to NEP under dark conditions in the following table, and detector NEP under the flight optical loading. The detector performance under loading will be estimated based on the data obtained in the laboratory under dark conditions.

Array	Detector NEP under zero background (design value) [1e-17 W/Hz$^{1/2}$]	Detector NEP under flight loading (design value) [1e-17 W/Hz$^{1/2}$]	Detector NEP under flight loading loading (min performance) [1e-17 W/Hz$^{1/2}$]
P/LW	2.2	3.2	4.1
P/MW	2.6	3.7	4.9
P/SW	2.9	4.1	5.8
S/LW	4.6	6.7	8.6
S/SW	4.6	6.8	9.5

1. NEPs are derived at optimal bias under dark conditions.
2. NEP assumes 7 nV/rtHz from amplifier noise in test apparatus.
3. Responsivity to be derived from dark load curve data.

3.3.1.3 Optical time constant with cryogenic lamp

Test Objective: To measure detector speed of response or the time-constant of the response.
Item tested: Bolometer array incorporated into the BDA unit.
When to Perform: During dark test characterization. Results will be compared with optical measurements on CQM units.
Equipment used in test: BDA Dewar #1, ^{3}He fridge, lamp with known response time housed inside cryogenic blackbody calibration unit.
Procedure: Test Procedure Document TBD
Data Output: Detector speed of response compared with predicted value.
Pass-Fail Criteria: Performance characterization only.

3.3.1.4 Optical Efficiency with cryogenic blackbody

Test Objective: To measure optical efficiency of filter, feedhorn, and bolometer.
Item tested: Bolometer array incorporated into the BDA unit.
When to Perform: During dark test characterization. Results will be compared with optical measurements on CQM units.
Equipment used in test: BDA Dewar #1, ^{3}He fridge, variable-temperature beam-filling

cryogenic blackbody calibrator housed inside blackbody calibration unit.
Procedure: Test Procedure Document TBD
Data Output: Measured efficiency compared with predicted value.
Pass-Fail Criteria: Performance characterization only.

3.3.2 Optical Testing

Only the CQM BDAs will undergo optical testing prior to delivery to RAL.

3.3.2.1 Load Curves

Test Objective: To measure the load curves with bolometers looking into two different optical loads, LN2 and room temperature.
Item tested: Bolometer array incorporated into the BDA unit.
When to Perform: After Dark Testing
Equipment used in test: BDA Dewar #1, ^{3}He fridge,
Procedure: Test Procedure Document TBD
Data Output: The bolometer voltage as a function of bias voltage at different temperatures.
Pass-Fail Criteria: Performance characterization only.

3.3.2.2 Optical Time Constant

Test Objective: To measure the optical time constant of the bolometer array with a chopped source.
Item tested: Bolometer array incorporated into the BDA unit.
When to Perform: After Load curve measurements under optical loads.
Equipment used in test: BDA Dewar #1, ^{3}He fridge, a chopped source
Procedure: Test Procedure Document TBD
Data Output: The amplitude of the signal should vary as $1/\sqrt{(1 + \omega^2\tau^2)}$, where ω is the angular frequency and equals to $2\pi f$, and τ is the optical time constant.
Pass-Fail Criteria: Performance characterization only. Time constant design and minimum performance values are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456.

3.3.2.3 Spectroscopy

Test Objective: To measure the bandpass of the BDA array using an FTS in the lab.
Item tested: Bolometer array incorporated into the BDA unit for a limited number of pixels.
When to Perform: After beam mapping
Equipment used in test: BDA Dewar #1, ^{3}He fridge,
Procedure: Test Procedure Document TBD
Data Output: Spectral response
Pass-Fail Criteria: Performance characterization only. Anticipated spectral characteristics are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456.

3.3.2.4 Optical Efficiency

Test Objective: To measure the optical efficiency of the arrays over the optical passband with an external blackbody.
Item tested: Detector array incorporated into the BDA unit.
When to Perform: After spectroscopy
Equipment used in test: BDA Dewar #1, ^{3}He fridge,
Procedure: Test Procedure Document TBD

Data Output:
Pass-Fail Criteria: Performance characterization only. Optical efficiency design and minimum performance values are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456.

3.3.2.5 Optical Cross-talk

Test Objective: To measure the optical cross-talk between pixels.
Item tested: Bolometer array incorporated into the BDA unit for a limited number of pixels (maybe limited by BoDac optics).
When to Perform:
Equipment used in test: BDA Dewar #1, ^{3}He fridge
Procedure: Test Procedure Document TBD
Data Output: Percentage cross-talk between nearest neighbors.
Pass-Fail Criteria: Performance characterization only. Optical cross-talk design and minimum performance values are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456.

4 JFET Modules

4.1 Baseline Test: Characteristic Offset Voltage Measurement

This test will be used as a baseline test for the environmental testing. This will be done before and after each of the environmental tests. The characteristic offset voltages and gains of all the channels will be measured. The procedure for this test is detailed in TBD.

4.2 Environmental Tests

4.2.1 Thermal Cycling

Test Objective: To subject the devices to one thermal cycles between room temperature and 77 K at a pressure of less than 10^-5 Torr for acceptance testing. And thus simulate the conditions they will experience during testing and during operation and to ensure that the units are qualified for those conditions. For qualification testing the qual JFET Module will be subjected to a minimum of 15 (not to exceed 20) thermal cycles (TBC). [The total number of thermal cycles on the hardware including the cycles during performance characterization is not to exceed five.]
Item tested: All JFET Modules
When to Perform: After assembly
Equipment used in test: Thermal Cycling Cryostat equipped with thermometers and a heater.
Procedure: SPIRE Thermal Cycling Procedure, JPL TP 518518
Data Output: Visual inspection for degradation if any. Followed by measurement of the characteristic offset voltages on all channels.
Pass-Fail Criteria: Structural Integrity of the JFET membrane. Not more than 2 mV (TBC) shift in the Characteristic offset voltages. More than 2 mV (TBC) shift will result in further inspection, but not failure.

4.2.2 Warm Vibration Test

Test Objective: To subject the unit to a vibration regimen at 77 K as specified in the "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).
Item tested: All JFET Module except the qual JFET module
When to Perform: After thermal cycling
Equipment used in test: Warm vibration fixture
Procedure: SPIRE Vibration Test Plan, JPL D-20550
Data Output: Visual inspection for degradation if any. Followed by measurement of the characteristic offset voltages on all channels.
Pass-Fail Criteria: Structural Integrity of the JFET membrane. Not more than 2 mV (TBC) shift in the Characteristic offset voltages. More than 2 mV (TBC) shift will result in further inspection, but not failure.

4.2.3 Cold Vibration Test

Test Objective: To subject the unit to a vibration regimen at 77 K as specified in the "Herschel SPIRE Detector Subsystem Specification Document", (SPIRE-JPL-PRJ-000456).
Item tested: Only qual JFET Module
When to Perform: After thermal cycling
Equipment used in test: Cold vibration fixture
Procedure: SPIRE Vibration Test Plan, JPL D-20550
Data Output: Visual inspection for degradation if any. Followed by measurement of the characteristic offset voltages on all channels.
Pass-Fail Criteria: Structural Integrity of the JFET membrane. Not more than 2 mV (TBC) shift in the Characteristic offset voltages. More than 2 mV (TBC) shift will result in further inspection, but not failure.

4.3 Performance Characterization

4.3.1 Noise Measurements

Test Objective: To measure the noise performance over 100 – 300 Hz
Item tested: All JFET Modules
When to Perform: After environmental testing
Equipment used in test: TBD.
Procedure: TBD
Data Output: Noise spectra at design and minimum performance power levels, yield. Power will be measured. The Offset voltages, gain and the noise levels will be measured at 2 or 3 different values of the power.
Pass-Fail Criteria: Performance characterization only. Design and minimum performance values for noise and yield are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456.

5 RF Filter Modules

5.1 Baseline Test: Continuity check

This test will be used as a baseline test for the environmental testing. This will be done before and after each of the environmental tests. A continuity check will be performed on all channels.

5.2 Environmental Tests

5.2.1 Thermal Cycling

Test Objective: To subject the devices to one (or two? TBD) number of thermal cycles between room temperature and 77 K at a pressure of less than 10^-5 Torr for acceptance level testing and thus simulate the conditions they will experience during testing and during operation and to ensure that the units are qualified for those conditions. The qual module/connector will be subjected to a minimum of 15 (not to exceed 20) thermal cycles. [The total number of thermal cycles on the hardware including the cycles during performance characterization is not to exceed five.]
Item tested: All RF Modules
When to Perform: After vibration testing
Equipment used in test: Thermal Cycling Cryostat equipped with thermometers and a heater.
Procedure: SPIRE Thermal Cycling Procedure, JPL TP 518518
Data Output: Visual inspection for degradation if any, before and after continuity test for all channels and Isolation test for all channels (Check for shorts to ground and shorts between channels)
Pass-Fail Criteria: Continuity failure

5.3 Performance Characterization

5.3.1 RF Attenuation

Test Objective: To determine RF attenuation of filter module.
Item tested: All RF Modules. Measured on a minimum of one pin(s) at room temperature.
When to Perform: After thermal cycling
Equipment used in test: RF source and analyzer.
Procedure: TBD
Data Output: RF attenuation plot of selected channels to confirm performance.
Pass-Fail Criteria: Performance characterization only. RF attenuation performance values are described in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456.

6 Cryocable

Procured from outside vendor. Vendor will be contracted to thermally cycle the wiring TBD times to liquid nitrogen temperature. The vendor will perform in-situ measurements of the continuity at 77 K, and reject cables that show a pin with open or intermittent continuity at 77 K. Cables that show continuity variation from the first thermal cycle more than TBD Ohms will also be rejected.

7 Qualification Testing

Some of the following tests will be performed on the qualification model BDA in addition to the temperature cycling and warm and cold random vibration tests described above.

7.1 Accelerated Aging / Lifetime

Test Objective: To perform accelerated aging tests on the qual hardware. The accelerated aging test will be conducted by heating the devices to 70 C (TBC) at 75% (TBC) relative humidity for TBD duration.
Item tested: Qualification Model BDA unit with PLW detector array
When to Perform: After assembly.
Equipment used in test: Temperature/humidity chamber
Procedure: TBD
Data Output: Visual inspection for degradation if any, continuity check
Pass-Fail Criteria: N/A

7.2 Thermal Range/Bakeout

Test Objective: To subject hardware to 80C (TBC) for 72 hours. We anticipate component level bakeouts for the feedhorns, kapton cables, load resistors, distribution boards, and BDA mechanical hardware for much shorter durations as part of the assembly process.
Item tested: Qualification Model BDA unit, Qual JFET module, Qual RF Module.
When to Perform: After assembly.
Equipment used in test: Vacuum oven
Procedure: TBD
Data Output: Visual inspection for degradation if any. Continuity check.
Pass-Fail Criteria: N/A

7.3 Vacuum cycling

We cannot identify any qualification issues related to vacuum cycling. Vacuum cycle testing will only occur as part of the thermal cycle and performance testing.

7.4 Soak/Cycle

Electrical soak test to be carried out on JFET modules at operating temperature followed by cycle to ambient temperature followed by soak test on qualification units as part of testing. Number of cycles and details of applied voltages etc to be defined.
TBD

7.5 Radiation Tolerance / Ionizing Radiation

Radiation testing is not expected on the BDA hardware. As per the report on the study done by Steve McClure, particle testing the NTD Germanium is not necessary. (Interoffice Memorandum: Germanium Bolometer Displacement Effects, Ref.# SSM-514-C-008-01).

7.6 EMI/EMC

The susceptibility of the bolometers to EMI/EMC has resulted in a requirement on the instrument environment in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456. EMI/EMC qualification and acceptance testing will therefore take place at instrument and/or spacecraft level.

7.7 Microphonics

The susceptibility of the bolometers to microphonics has resulted in a requirement on the instrument environment in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456. Microphonics qualification and acceptance testing will therefore take place at instrument and/or spacecraft level.

There will be a best effort attempt at measuring the microphonics in the BoDAC dewar during performance characterization with equipment provided by RAL. The equipment includes an accelerometer with the necessary cables and a shaker in order to induce the microphonics that will be attached to the outside of the BoDAC. Noise spectrums from a few pixels will be measured at frequencies up to 60 Hz.

7.8 Thermal Stability

The susceptibility of the bolometers to the 300 mK temperature stability has resulted in a requirement on the instrument environment in the Herschel SPIRE Detector Subsystem Specification Document, SPIRE-JPL-PRJ-000456. Thermal stability qualification and acceptance testing will therefore take place at instrument and/or spacecraft level.