LAT PROJECT DOCUMENT CHANGE NOTICE (DCN)	**DCN No.** LAT-XR-02838-01
	SHEET 1 **OF** 1

ORIGINATOR: Nick Virmani	**PHONE:** 202-767-3455	**DATE:** 1/15/04
CHANGE TITLE: DCN for Calorimeter Contamination Control Plan		**ORG.:**

DOCUMENT NUMBER	TITLE	NEW REV.
LAT-MD-00228	**Calorimeter Contamination Control Plan**	**05**

CHANGE DESCRIPTION (FROM/TO):
The following changes were made to Calorimeter Contamination Control Plan:

Section 3.1: Special Requirements for the CAL

Exterior windows in the work areas for Crystal Detector Assembly (CDE) shall be treated to provide 65% blockage (i.e. 35% transmission) of visible light and 99% blockage (i.e. 1% transmission) of UV light.
Crystals can be stored below 30% RH and this will not affect the performance of the crystal.
Photodiode Assemblies (PDAs) and CDEs can be stored below 30% RH if they are not handled.

NOTE: This document primarily impacts the Calorimeter Contamination Control Plan and the LAT Contamination Control Plan

REASON FOR CHANGE:

ACTION TAKEN: ☒ **Change(s) included in new release** ☐ **DCN attached to document(s), changes to be included in next revision**
☐ **Other (specify):**

DISPOSITION OF HARDWARE (IDENTIFY SERIAL NUMBERS):	DCN DISTRIBUTION:
☒ **No hardware affected (record change only)**	
☐ **List S/Ns which comply already:**	
☐ **List S/Ns to be reworked or scrapped:**	
☐ **List S/Ns to be built with this change:**	
☐ **List S/Ns to be retested per this change:**	
☐	

SAFETY, COST, SCHEDULE, REQUIREMENTS IMPACT? ☐ **YES** ☒ **NO**
If yes, CCB approval is required. Enter change request number:

APPROVALS	DATE	OTHER APPROVALS (specify):	DATE
ORIGINATOR: N. Virmani (signature on file)	1/16/04		
ORG. MANAGER: N. Johnson (signature on file)	1/28/04		
TKR- Robert Johnson (signature on file)	1/19/04		
Electronics- G. Haller (signature on file)	1/28/04		
DCC RELEASE: Natalie Cramar (signature on file)	2/4/04	Doc. Control Level: ☒ Subsystem ☐ LAT IPO ☐ GLAST Project	

DCN No: LAT-XR-02838-01

	LAT Project Change Request (CR)	CR No. LAT-XR-02837-01	LEVEL 3

ORIGINATOR: Nick Virmani	PHONE: 202-767-3455	DATE: January 15, 2004

CHANGE TITLE: Updates to Calorimeter Contamination Control Plan Revision 5

Change Description:

Section 3.1 had an adjustment to the Special Requirements for CAL

6. Exterior windows in the work areas for Crystal Detector Assembly (CDE) shall be treated to provide 65% blockage (i.e. 35% transmission) of visible light and 99% blockage (i.e. 1% transmission) of UV light.
7. Crystals can be stored below 30% RH and this will not affect the performance of the crystal.
8. Photodiode Assemblies (PDAs) and CDEs can be stored below 30% RH if they are not handled.

This change primarily affects the CAL Contamination Control Plan & The LAT Contamination Control Plan

IMPACTS (ESTIMATE THE IMPACTS OF IMPLEMENTING OR NOT IMPLEMENTING THE PROPOSED CHANGE):

COST: N/A

WBS No.	Work Pkg No.	Description	Escalated Baseline (K$)	Proposed Escalated Baseline (K$)	Changes (K$)
					0
					0
					0
		TOTAL	0	0	0

	FY 2003	FY 2004	FY 2005	TOTAL
Escalated Baseline (K$)				0
Proposed Escalated Baseline (K$)				0
Net Change	0	0	0	0

SCHEDULE:

Documents Impacted: LAT-MD-00228; LAT-MD-00404; LAT-SS-00238
LAT-SC-ICD 1196 EI-Y46311-000 (Spectrum Astro)

Other (specify – i.e. safety, reliability, requirements, hardware):

Continuation:

The CAL Contamination Plan (LAT-MD-00228)- updates to be made by Neil Johnson/ Nick Virmani

The CAL Interface Control Document (LAT-SS-00238)- updates to be made by Rich Bielawski/Neil Johnson

LAT Contamination Control Plan (LAT-MD-00404) - updates to be made by Joe Cullinan

LAT-SC-ICD (Spectrum Astro)- updates to be made by Rich Bielawski

CCB ACTION:	☐ APPROVE ☐ REJECT ☐ OTHER	CCB Minutes: LAT-LR-	

EXPLANATION:

APPROVALS:

	NAME	SIGNATURE	DATE
ORIGINATOR	N. Virmani	(signature on file)	1/16/04
CR Subsystem Manager	N. Johnson	(signature on file)	1/28/04
CCB MEMBERS			
Instrument Project Manager, Chair	L. Klaisner	(signature on file)	2/4/04
Deputy Project Manager	D. Horn	(signature on file)	2/4/04
Asst. Project Manager	J. Martin	(signature on file)	2/3/04
Chief Engineer	L. Klaisner	(signature on file)	2/4/04
Instrument Scientist	S. Ritz	(signature on file)	1/29/04
Project Control Manager, Secretary	T. Boysen	(signature on file)	1/28/04
Instrument Systems Engineer	D. Horn	(signature on file)	2/4/04
Chief Electronics Engineer	G. Haller	(signature on file)	1/16/04
Chief Mechanical Engineer	M. Nordby	(signature on file)	1/27/04
Mechanical Systems Manager	M. Campell	(signature on file)	1/29/04
I & T Manager	E. Bloom	(signature on file)	2/3/04
Performance & Safety Assurance Manager	D. Marsh	(signature on file)	1/19/04
Science Analysis SW Manager	R. Dubois	N/A	
Tracker Manager	R. Johnson	(signature on file)	1/19/04
Calorimeter Manager	N. Johnson	(signature on file)	1/28/04
E/PO Manager	L. Cominsky	N/A	
IOC Manager	D. Lung (acting)	N/A	
ACD Manager	D. Thompson	(signature on file)	1/28/04
DOE LAT Project Manager (L2 and above)	E. Valle	N/A	
NASA GLAST Project Manager (L2 and above)	K. Grady	N/A	
INFN Project Manager	R. Bellazzini	N/A	
IN2P3 Program Manager	H. Videau	N/A	

GLAST LAT SYSTEM SPECIFICATION	Document # **LAT-MD-00228-05**	Date Effective 15 January 2004
	Prepared by(s) Nick Virmani	Supersedes LAT-MD-00228-04
	Subsystem/Office Calorimeter, Tracker, and T&DF Subsystem	
Document Title **Calorimeter, Tracker, and Trigger & Data Flow Contamination Control Plan**		

Gamma-Ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter, Tracker, and Trigger & Data Flow

Contamination Control Plan (CCP)

Document Approval

Prepared by:

Nick Virmani Date
CAL Contamination Engineer / QA Manager

Approved by:

W. Neil Johnson Date
CAL Subsystem Manager

Robert Johnson Date
Tracker Subsystem Manager

Gunther Haller Date
Trigger & Data Flow Subsystem Manager

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1	-	Initial Draft	
2	-	Incorporated comments	
3	April 2002	Updated Temperature and Humidity details	LAT-XR-00706-01
4	December 2003	Updated Humidity Details and Purge Requirements	LAT-XR-02754-01
5	January 2004	Updated Special Requirements for CAL	LAT-XR-02838-01

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this Contamination Control Plan (CCP) is to define the overall contamination control requirements associated with the Calorimeter, Tracker, and Data Acquisition (DAQ), which will be called as subsystems herein. This plan defines the requirement for the contamination control up to the point of integration with the GLAST LAT at SLAC.

1.1 Scope

The contamination control requirements for all phases will be addressed, from design, through fabrication, assembly, integration, and testing. Sensitivities and allowable contamination requirements will be presented, along with the planned methods for limiting contamination throughout all phases. Plans for analyses, clean room and hardware monitoring, will also be addressed. We will utilize existing methods, plans, documents, and lessons learned from previous, similar missions. Wherever possible, the program will utilize existing contamination control methods and documentation of contractor/subcontractor as long as they meet the intent of this plan.

1.2 Responsibilities

Contamination control on this project will be a team effort, and as such will have the participation of all personnel whose work will include design of and direct contact with flight hardware. Engineering personnel, to the extent possible, will design-in the requisite cleanliness through the specification of proper materials, processes, and physical features such as vents, covers, purges, etc. Those involved with contamination sensitive fabrication, and Integration and Test (I&T) will receive training in the necessary contamination control protocol and will be responsible for meeting the requirements of this training throughout the course of the project, through delivery at SLAC.

The Contamination Engineer has the responsibility of overseeing the contamination control effort, disseminating the information necessary to educate all personnel in the area of contamination control through documentation and training. The Contamination Engineer must also see that all contamination-related facilities, equipment, and materials are available and functioning properly at each point in the fabrication assembly and I&T process, ensuring the ability to comply with all contamination requirements with reasonable effort, expense, and schedule impact. The Contamination Engineer will specify and oversee all cleaning, bagging, and cleanliness inspections of flight hardware, tools, and GSE. The Contamination Engineer will be responsible for overseeing the housekeeping, maintenance, upgrading, and environmental monitoring of all facilities (clean rooms) occupied by the subsystem and its components.

1.3 Applicable and Reference Documents

The following subsections list the applicable and reference documents mentioned in this Contamination Control Plan. All documents are available through the GLAST LAT Project Office at SLAC.

1.3.1 <u>Contamination Control Specifications</u>

<u>FEDERAL</u>

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment

<u>MILITARY</u>

MIL-STD- 1246	Product Cleanliness Levels and Contamination Control

MSFC-HDBK-527 JSC 09604 Rev E or later	Material Selection List for Space Hardware

<u>NASA</u>

GSFC-TLS-PR-7324-O 1	Contamination Control Procedures for the Tape Lift Sampling Surfaces
JSC SN-C-0005D	Contamination Control Requirements for the Space Shuttle Program
JSC SP-R-0022A	Specification Vacuum Stability Requirements of Polymeric Materials for Spacecraft Applications
NASA Contractor Report 4740	Contamination Control Engineering Design Guidelines for the Aerospace Community
NASA MAPTIS	Materials and Process Technical Information System Database
NASA Materials	Outgassing Data for Selecting Spacecraft Publication 1124 Materials

<u>OTHER</u>

ASTM E-595	Methods of Test, Total Mass and Controlled Volatile Condensable Materials from Outgassing in a Vacuum Environment
IES-RP-CC-018-89-T	Cleanroom Housekeeping – Operating and Monitoring Procedures

2.0 IMPORTANT DEFINITIONS

2.1 Bakeout Test

A thermal vacuum procedure in which total outgassing is accelerated by heating the test article to the highest allowable temperature. Outgassing is monitored by a thermoelectric quartz crystal microbalance (TQCM), and is measured with the test article at a lower temperature (orbital predict) for comparison with a pre-determined bakeout requirement.

2.2 Bakeout Certification

The phase of a bakeout test (before, to determine the need for the bakeout an after, to determine the success of the bakeout) in which the test article is allowed to outgas at a typical on-orbit temperature while the TQCM is operated at a temperature typical of a contamination-sensitive surface. These temperatures are supplied by the Thermal Engineer.

2.3 Cleanroom

An enclosed area where temperature, humidity, and airborne contaminants are controlled as required. Clean rooms are classified by such numbers as 100, 1,000, 10,000, etc., in accordance with FED-STD-209, which prescribes the maximum number of particles, larger than 0.5 μm in size, permitted per cubic foot of air. For practical purposes of Project contamination control, these classifications also prescribe sets of protocol (for gowning, cleaning, processes, materials, etc.) which experience has shown increase the likelihood of achieving the desired air cleanliness. This project requirement is for a class 100,000 clearoom, no more than 100,000 particles with a diameter of 0.5µm and/or 700 particles with a diameter of 5.0µm are allowed as per FED-STD-209.

2.4 Collected Volatile Condensable material (CVCM)

The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time. It is expressed as a percentage of the original specimen mass, and is a result of the ASTM E-595 outgassing screening test.

2.5 Critical Surface

A surface, which, if contaminated, causes detrimental reduction of signal throughput to a flight instrument. Examples are thermal control surfaces, crystal surfaces, Silicon Strip Detectors (SSDs), etc.

2.6 Gross Cleaning

Initial rough cleaning designed to remove visible contamination such as weld scale, heat treat scale, corrosion, oils, grease, shop films, dust, dirt, and other deposits. It is typically performed in preparation for precision cleaning, and may be performed in areas that are not clean rooms.

2.7 Molecular Contamination

Undesired foreign matter without definite dimension, including corrosive and non-corrosive films resulting from oil, greases, chemical residues, fingerprints, heat and vacuum applications, chemical action, and incompatible materials.

2.8 Non-Volatile Residue (NVR)

Soluble material remaining after controlled evaporation of a volatile liquid or determined by special purpose analytical instruments, usually measured in milligrams per unit volume or per unit area for surfaces.

2.9 Particle Size

The maximum linear dimension of the particle.

2.10 Particle Contamination

Undesired foreign matter of miniature size with observable length, width, and thickness. This includes fibers.

2.11 Precision Cleaning

Cleaning of hardware surfaces to meet a specific surface cleanliness level. It may be accomplished by ultrasonic cleaning (where permitted), solvent flush, solvent wiping, vacuuming, or blow-off cleaning. Precision cleaning must be performed in a controlled clean area, and cleaned items must be packaged, protected, or stored in an appropriately clean area to avoid re-contamination.

2.12 Surface Level Cleanliness

The contamination of a surface, typically expressed as defined by MIL-STD-1246C. Particulate levels are expressed as the size (in µm) of the particle present in the concentration of one or fewer per square foot of surface, indicating a size distribution of particles such that numbers increase with decreasing size. Molecular film level is also defined by MIL-STD-1246C as the mass (in mg) of molecular contamination per square foot.

2.13 Solvent Flush

Method of cleaning surfaces with a stream of filtered solvent under pressure, which is directed against a surface to dislodge and rinse away any foreign material.

2.14 Solvent Wash Sample

A quantitative method of verifying MIL-STD-1246C molecular cleanliness levels by measuring molecular contamination in a solvent, which was washed over a surface and collected.

2.15 Swab Sample

A qualitative method of identifying contaminants by analyzing the residue on a solvent-soaked swab that was wiped over a surface.

2.16 Tape Lift

The sampling of surface particulate contamination by removal with clean, clear adhesive tape. With the proper equipment, particles can be counted and sized for the purpose of determining surface contamination level, per MIL-STD-1246C.

2.17 Visibly Clean

Free of particle contamination to the unaided eye (except for normal vision correction, if required) when inspected at a distance of 2 – 4 feet with white light illumination of at least 50 ft. – candles.

2.18 Witness Plates

Witness Plates are used to determine NYR levels, particulate levels and fallout rates. Witness plates collect passively during cleanliness monitoring procedures. Witness plates should be placed as close as possible to contamination sensitive areas, to obtain the most accurate particulate readings.

2.19Light Inspections

Visual Inspection is done periodically using black (UV) light or white light, per JSC-SNC005C. Visibly clean, using white light, is the absence of all particulates and nonparticulates visible to the normal unaided eye (except corrected vision). UV inspection light sources are no less than 100 watts and located no more than 50cm from the inspected item. During UV inspection, light from other sources should not be more than 5 ft candles. If visual contamination is evident, the hardware must be cleaned and then reinspected under the same light conditions. If during UV inspection there is any evidence of fluorescence the item/surface must be re-cleaned. If re-cleaning does not reduce the fluorescence, it must be determined whether the fluorescing material is a contaminant or the substrate surface.

2.20Visual Inspection (Black and White Light)

Careful checking of a surface using ultraviolet and intense white light for illumination. These forms of light, combined with very close viewing, can be used to verify surface cleanliness typically as low as Level 350 per MIL-STD-1246C. Visual inspection accuracy depends upon color contrast between the contamination and the inspected surface.

3.0 CONTAMINATION CONTROL REQUIREMENTS

The overall Contamination Control program has been developed based on the sensitivities and performance goals of the GLAST LAT instrument. This section will present baseline contamination sensitivities and requirements.

All design, fabrication, assembly, integration, testing, packaging, transportation, integration of subsystems with LAT must be performed in a manner, which will minimize the probability of contamination.

An active contamination monitoring program will be in effect, using a number of methods, including visual inspections, black light and white light measurements, tape lifts and/or witness plates. Outgassing requirements will be met by all subsystems and/or components through proper selection of materials and appropriate vacuum bakeout of parts, components, and subsystems.

Fabrication (wire bonding, crystal bonding), Assembly of Silicon Strip Detectors (SSD), Pre-Electronics Module (PEM), Multi Chip Module (MCM), and PIN Photodiode assembly with crystals) and Integration will take place in a class 100,000 clean room environment. When a subsystem is outside of the class 100,000 cleanroom it must be bagged. The only exception is when I&T activity would prohibit bagging. During any type of transportation or storage, the subsystems will be bagged in approved cleanroom bagging material.

3.1 Special Requirement for Calorimeter

Thallium Doped Cesium Iodide, CsI (TD) crystals used for the Calorimeter subsystem are sensitive to humidity (RH), hence it is necessary to prevent condensation from forming on the crystals. The following precautions should be taken:

1. The Calorimeter temperature must never be below the dew point in the room.
2. RH should be maintained below between 30-50% and the temperature of the crystals should never be significantly lower than the room air temperature. This shall be controlled by controlling the temperature rate of change of the crystals and the air temperature around them. The air temperature around the crystals must never be below the dew point.
3. Continuous temperature and humidity monitoring records shall be maintained and shall be made available for review.
4. If the humidity of the environment is beyond 55% for more than 3 hours, the humidifier in the clean room shall be shut down until the RH level is within the specification. Calorimeter QA shall be informed immediately of this deviation. If the humidity cannot be brought down to the required level then the Calorimeter shall be bagged and flushed with a continuous pure nitrogen purge.
5. Due to ESD requirements, the Calorimeter shall never be touched if the humidity goes below 30% and must also meet the requirement of section 5.0.
6. Exterior windows in the work areas for Crystal Detector Assembly (CDE) shall be treated to provide 65% blockage (i.e. 35% transmission) of visible light and 99% blockage (i.e. 1% transmission) of UV light.
7. Crystals can be stored below 30% RH and this will not affect the performance of the crystal.
8. Photodiode Assemblies (PDAs) and CDEs can be stored below 30% RH if they are not handled.

3.2 Special Requirements for Calorimeter Crystal Bonding

The following precautions are to be taken to avoid a contamination hazard due to the use of two silicone-based Dow Corning products (92-023 and 93-500). The purpose of these precautions is to 1) prohibit any cross contamination by contact or bad house keeping practice, 2) meet all health and safety requirements established by the facility and 3) assist in gaining success in a manufacturing process.

a. All mixing and degassing of the silicone encapsulant shall be performed only in the ante-room under a hooded bench who's outlet is directly connected to the outside air. At no time will the air from the hood's exhaust system be circulated to the clean room air. A separate trash can marked as the "silicone trash can" shall be used in the ante-room. The silicone trash can shall be emptied at the end of each working day.
b. All abrading, priming, mixing, and degassing processes shall be done in the ante-room under the hooded work bench. Only a premixed silicone adhesive shall be brought into the clean room.
c. Establish and cordon off a controlled work area in the clean room for the silicone bonding process. Silicone work may be performed and handled only in this designated area.
d. Keep the control area clear of all hardware, tools, gloves, and miscellaneous items that **do not** pertain to the CAL crystal bonding project.
e. Keep a trash can within the work area that is specifically designated for disposal of all potential silicone-contaminated items. Empty the trash can at the end of each working day.
f. Completely cover all work tables and benches with llumaloy before handling any silicone material. When the work day is done, remove all llumaloy covers and discard them into the "silicone-trash can" and replace the covers with clean fresh sheets of llumaloy.
g. Keep all tools, hardware, gloves, smock and miscellaneous items used for the silicone project in the defined work area. No items shall be removed from the silicone work area for any other operation unless it is completely covered and bagged for protection.
h. Do not open the clean room exit door with contaminated gloves.
i. Remove and dispose of all used gloves in the "silicone trash can" located near the exit door of the clean room when exiting the clean room.
j. All bonding operations shall be carried out in the class 100,000 clean room environment and bonding surfaces should be kept clean.
k. Contamination from human sources such as small particles of skin, hair, sweat, spit, and mucus can degrade the bond between the CsI crystal and the PIN Photodiode. Proper precaution and clean room rules shall be enforced to avoid this type of contamination.
l. Only unpowdered nitrile gloves shall be used when handling the bare crystals prior to bonding or during bonding procedures.
m. Only approved solvents will be allowed for cleaning surfaces to be bonded. Approved solvents that are compatible with Dow Corning 93-500 epoxy are: acetone, ethanol, iso-propanol, 2-propanol, and methyl ethyl alcohol.

3.3 Special Requirements for the Tracker

1. Contaminants on bondpads can degrade both the bondability and the reliability of wire bonds. All bonding operations shall be carried out in the clean room environment and bonding surfaces should be kept clean.
2. Contamination from human sources such as small particles of skin, hair, sweat, spit, and mucus can degrade the bondability and long-term reliability of silicon detectors. Proper precaution and clean room rules shall be enforced to avoid this type of contamination.
3. Considering the large number of possible bond-degrading contaminants, precautions shall be taken to keep all surfaces of SSDs and MCMs clean.
4. SSDs should not be cleaned with alcohol or other solvents. Only deionized water should be used if required. A dry nitrogen blow clean is acceptable.
5. Cleaning after assembly of Tracker tower if required shall not be done without permission from the subsystem manager and QA.
6. ESD control of all operations shall meet the requirement of section 5.0.

3.4 Surface Cleanliness

The subsystem critical surfaces shall meet the surface particulate and molecular requirements of level 750A per MIL-STD-1246. The subsystem components will be cleaned periodically, where possible, throughout the fabrication integration and assembly process. Where contamination levels cannot be measured through contact test methods (tape lifts or rinses on optics for example), the levels will be inferred through black light inspection or measurement of witness plates maintained in the same environment as the sensitive surface.

Contamination sensitive subsystems (such as Calorimeter and Tracker) should be bagged and purged during shipping, transportation, and storage. This surface contamination and outgassing must be limited through efforts on the ground so that redistribution associated with thermal vacuum testing, integration of LAT instrument, and flight does not risk raising the contamination of sensitive surfaces of subsystems to unacceptable levels.

3.5 Purge Requirements

Calorimeter and other hardware sensitive to moisture requires continuous dry nitrogen gas or dry air purge during assembly, integration and testing operations that otherwise would expose the hardware to unacceptable relative humidity levels. It is required that assembled purge gas delivery systems (including all lines, regulators, valves, etc.) and purge gas supply be pre-certified at the point of use to meet cleanliness requirements prior to connection to the spacecraft hardware.

The purity of the dry nitrogen purge gas (99.99% purity grade) shall be certified for moisture and hydrocarbon requirements per Grade B, Type I nitrogen gas requirements of MIL-P-27401C:

Moisture = 11.5 ppm
Hydrocarbon = 5 ppm (methane equivalent)

If the purge gas is air, the purity shall be Ultra High Purity (UHP)/Zero Grade manufactured air (not medical grade breathing air) with the same moisture and hydrocarbon requirements for dry nitrogen gas as stated above. An acceptable purge rate for each component shall be defined. The gas sampling locations for pre-certification shall be at or close to the point of use. Any time a connectionbreak occurs, the ends of the purge connectors must be immediately bagged (or capped) and then tape-sealed to prevent recontamination. Recertification of the purge line is required when the line was not tape-sealed for protection. A maximum period of purge interruption will be specified for each component. Temporary purge line disconnection will be required for some transport, integration and test operations. Final purge line disconnection prior to launch shall be defined for each component.

4.0 CONTAMINATION SOURCES

Possible sources of contamination must be identified in order to protect the subsystem from contamination and to effectively clean contaminated components. Table 4-1 is a listing of possible contamination sources at the various development stages.

Table 4-1 Contamination Sources for Calorimeter

Mission Phase	Molecular	Particulate
Fabrication	Materials outgassing, machining oils, fingerprints, air fallout	Shedding, flaking metal chips, filings, air fallout, personnel
Assembly & Integration	Air fallout, outgassing, personnel, cleaning solvents, soldering, lubricants, bagging material	Air fallout, personnel, soldering, drilling, bagging material, shedding, flaking
Test	Air fallout, outgassing, personnel, test facilities, purges	Air fallout, personnel, test facilities, purges, shedding, flaking, redistribution
Storage	Bagging material, outgassing, purges, containers	Bagging material, purges, containers, shedding, flaking
Transport	Bagging material, outgassing,	Bagging material, purges, containers,

	purges, containers	vibration, shedding, flaking
LAT I&T	Bagging material, air fallout, outgassing, personnel, purges	Bagging material, air fallout, personnel, shedding, flaking, checkout activities
Launch	Outgassing, venting, engines, companion payloads separation maneuvers	Vibration and/or redistribution, venting, shedding, flaking

5.0 ELECTRO-STATIC DISCHARGE (ESD) REQUIREMENT DURING CLEAN ROOM OPERATIONS

ESD is a significant cause of failure at all stages of device and equipment production, assembly, test, and I & T. All personnel who perform any activities or handle any Electro-Static Discharge Sensitive (ESDS) hardware should be familiar with ESD control techniques. This is applicable to production, inspection, test, storage, procurement, shipping, receiving, handling, installation, maintenance, and repair of the hardware.

5.1 Identification and Access – ESD Areas

The ESD-protected area, where ESDS items are to be processed, shall be clearly identified by prominently placed signs. Access to such areas shall be limited to trained and equipped personnel. A partition, rope guard, or similar means shall be set up to assist in prohibiting unauthorized and untrained personnel from entering the ESD-protected area. All other personnel shall be escorted and be equipped with standard protective clothing, as required.

5.2 ESD – Protective Surfaces

1. All work surfaces in an ESD-protected area shall be static dissipative and electrically connected to the common point ground.
2. Homogeneous materials shall have surface resistivity in the range of 10^5 to 10^9 ohms/square. Non-homogeneous materials should have comparable static dissipative properties. A low resistance ground connection is recommended. However, if safety codes and/or other authorities require inclusion of a series resistor, it is permitted.
3. The protective work surface shall be sufficiently large to encourage the resting of common hand tools on the protective surface rather than on an adjacent nonprotected surface.
4. The protective work surface shall not release particle contaminants and shall resist attack by common solvents or cleaners. Solvent resistance shall be determined during initial verification by exposing test specimens to 1-hour exposure to each of the solvents that can be expected to be used at the work station.

5.3 Personnel Grounding Devices

Personnel grounding devices shall be supplied to all personnel working with or handling ESDS items to prevent the accumulation of dangerous electrostatic charge levels. A grounding device shall be worn by all personnel coming within 1 meter (3.3 feet) of any ESDS items.

5.4 Equipment and Facilities Grounding

The preferred practice is to use the third wire AC line ground for grounding all items at the ESD-protected work station. When a separate grounding line is present or used in addition to the equipment ground, it should be bonded to the equipment ground at each ESD-protected work station to minimize the difference in potential. The resistance of the conductor from the common point ground to the equipment ground (AC ground) should not be greater than 1.0 ohm. The impedance from the work station common point ground to the neutral bond at the main service box should not be greater than 2.0 ohms.

5.5 Humidification

The relative humidity (RH) shall be maintained in ESD-protected work areas at 30% to 50%. At levels below 30%, no hardware shall be touched, additional precautions shall be employed (e.g., air ionizers, humidifiers), and work shall be halted until the required humidity level is obtained.

NOTE: SURFACE RESISTIVITY CHANGES EXPONENTIALLY WITH HUMIDITY CHANGES. THEREFORE, RELATIVE HUMIDITY LEVELS MAINTAINED BETWEEN 30% AND 50% ARE RECOMMENDED**.**

CAUTION: THE RH LEVEL SHALL NOT EXCEED MORE THAN 55% FOR MORE THAN 3 HOURS FOR CSI(TI) CRYSTALS, WHICH ARE USED IN THE CALORIMETER, EXCEPT AS DEFINED IN SECTION 3.0. THIS ALSO APPLIES FOR LAT INSTRUMENT AND SPACECRAFT INTEGRATION. IF THE HUMIDITY CANNOT BE BROUGHT DOWN TO THE REQUIRED LEVEL THEN THE CALORIMETER SHALL BE BAGGED AND FLUSHED WITH A CONTINUOUS PURE NITROGEN PURGE.

6.0 DESIGN PHASE CONTAMINATION CONTROL

Contamination prevention is a basic design consideration and will be examined throughout the development process.

6.1 Materials Selection

In order to control contamination and protect sensitive surfaces, the use of minimal contaminating materials and the use of covers and protective shields must be considered. Manufacturing materials should be low outgassing, non-shedding and non-flaking. Generally, materials must meet the JSC SP-R-022A outgassing requirements. Efforts will be made to select low outgassing materials (CVCM level of 0.1% and TML of 1.0% by weight) for all applications. For questionable materials, or materials where data does not exist, it may be necessary to test outgassing characteristics, in accordance with the ASTM E595; “Methods of Test, Total Mass and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment” procedure.

Particular attention must be paid to the selection, application, and curing of organics such as adhesives, conformal coatings, sealants, electrical and thermal insulators and transfer materials, foams, potting compounds, films, paints, lubricants, marking inks, tapes, etc. NASA Reference Publication 1124 may be used as a database of outgassing test results for materials. All subsystems shall maintain and provide a comprehensive materials list, which shall include the following information for each item:

- Manufacturer
- Manufacturer’s nomenclature and part number
- Functional description of material
- As-used curing information (such as time, temperature, pressure, humidity, mix ratio)
- Similar information pertaining to requisite primer
- Description of any additional treatment of material to reduce outgassing

In addition, instrumenters shall select materials that are resistant to particle generation. Scrims, cloths, films and other fibrous or woven materials that can release particles shall have cut edges that are taped or sealed to prevent shedding. Surface finishes shall be selected for low particle generation and excellent compatibility with the surface to be finished.

6.2 Restricted Materials

Materials questions shall be referred to the Contamination Engineer. Restricted structural materials include, but are not limited to, the following:

- Silicone-based materials unless specifically approved by the Contamination Engineer.
- High-outgassing adhesives, sealants, lubricants, conformal coatings, marking inks, films, foams, potting compounds, thermal transfer materials, etc.
- Non-flight adhesives. Tapes used temporarily for bonding activities shall be flight-qualified.
- Excess adhesive residues from bonding processes. This material shall be removed prior to curing.
- Corrosive agents and strong solvents.
- Paints that are prone to particle-generation due to improper cure, excessive thickness, or overspray.
- Materials whose surfaces are prone to corrosion or oxidation.
- Scrims and perforated materials that are prone to continuous release of particles, often due to excessive handling and flexing.
- Materials with rough surfaces that may be difficult to clean.

6.3 Venting for Outgassing

Structure composed of or containing non-metals and organic materials shall be subjected to bakeout testing. A bakeout test shall consist of a pre-certification test phase followed, if necessary, by a bakeout and post-certification. Gloves shall be required for handling baked-out items. Smaller items may be bagged as they are removed from the bakeout facility. To the extent possible, bonding operations shall be completed prior to bakeout.

The vent shall be designed to vent to a cryogenic plate or similar molecular trap during thermal vacuum testing if the effluent from the vent is expected to be large enough to pose a threat to the instrument during thermal vacuum. The number of vents shall be limited to facilitate thermal vacuum testing. The venting design shall be adequate to provide for launch-ascent depressurization.

7.0 ASSEMBLY PHASE CONTAMINATION CONTROL

Assembly of subsystems will generally take place in controlled class 100,000 environments. During assembly phases and associated storage/transportation periods, contamination control measures will be instituted. Surfaces will be kept clean, and if any debris is generated during the assembly process it will be cleaned/vacuumed off. During assembly, mating surfaces will be cleaned to visibly clean sensitive prior to attachment. All interior volumes will be cleaned thoroughly prior to final assembly and attachment. All ground support equipment will be kept visibly clean during assembly. Any cables, hamesses, etc. will be cleaned before attachment to flight hardware, and if necessary vacuum baked prior to outgassing certification.

Subsystems will be maintained at a visibly clean level throughout the assembly processes. Trained personnel will perform inspections. Cleanliness requirements during subsystems assembly are as follows:

1. Machining, welding and soldering contaminants should be cleaned off of the hardware by wiping and/or vacuuming. Lubricants and cutting oils (i.e. oils and greases) should be cleaned off as soon as possible after the assembly operation using appropriate solvents.
2. Prior to priming or painting a surface it should be free of particulate or molecular deposits and be inspected at a visibly clean level.
3. If an area becomes inaccessible during assembly it must be cleaned and inspected to a visibly clean level before becoming inaccessible.
4. Upon the completion of the assembly operation, the components will be subjected to a gross cleaning procedure involving solvent washes and particulate removal, yielding a visibly clean sensitive product with less than 1 mg/ft^2 NVR. Parts with less than 1 square foot of area may be grouped together into one NVR rinse for verification purposes. The assembled components will then be bagged to negate contamination effects.

5. Parts, surfaces, holes and so forth must be cleaned with isopropyl alcohol (IPA) moistened wipes. Wiping should be in one direction only and each pass should be with a clean area on a wipe or using a new wipe for each pass. In some instances wipes will be ineffective and swabs moistened with alcohol maybe used. Cleaning will continue until all surfaces are visibly clean, upon inspection.
6. Prior to any final assembly, all surfaces must be vacuumed giving special attention to holes, crevices and riveted regions.
7. During assembly, all fasteners shall be lubricated with an approved low-outgassing lubricant, such as Braycote 602 grease, in order to minimize galling of the threads. This lubricant shall meet 1% TML and 0.1% CVCM in accordance with the ASTM E-595 Methods of Test, Total Mass and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment" test procedure.
8. Assemblies will be visually inspected with a blacklight for external oil or grease deposits, and if any are found, the areas will be wiped with IPA moistened wipes, using a clean wipe area for each pass and wiping in one direction.

8.0 SUBSYSTEM INTEGRATION AND TESTING PHASE CONTAMINATION CONTROL

Integration of the subsystem will occur in a class 100,000 environment. Regular monitoring of the cleanroom, GSE, and flight hardware will be accomplished. The subsystem will remain bagged after integration and testing.

During downtimes when hardware is not actively being worked on, or for weekends and other non-operational times, flight hardware will be kept covered with an approved cleanroom certified, ante-static bagging material. Bagging materials and drapes must be contamination and electrostatic discharge (ESD) approved.

To prevent electrostatic discharge (ESD) damage to any of the electronic components precautions beyond contamination control measures may be required. This may mean using ante-static packaging films, ESD approved garments and grounded wrist straps. Additionally the temperature and humidity of the work environment will be controlled.

9.0 LAT AND SPACECRAFT INTEGRATION AND TESTING PHASE CONTAMINATION CONTROL

The subsystem will be delivered to SLAC with a double bag in shipping containers. First, the outer bag will be removed, followed by cleaning and inspection of the exposed areas of the subsystems. Then, the inner bag will be carefully removed inside the clean room only. The subsystem will be bagged at all times unless testing of subsystem integration and test activities of LAT starts. It is assumed that SLAC will have continuous dry nitrogen purge when required. Requirements for temperature, humidity, and contamination of this plan shall apply for LAT and spacecraft integration.

10.0 VACUUM BAKEOUT REQUIREMENTS

Along with the selection of low outgassing materials for the subsystems a thermal vacuum bakeout program will be established if required. The maximum temperature during bakeout shall not exceed +50°C.

In general:

1. The outgassing rate will be measured during thermal vacuum certification. The materials, parts, and subsystems will undergo a vacuum bakeout only if they do not meet their outgassing requirement.
2. All other structure, materials, assemblies, or components, which may be mounted without MLI or controlled venting, will be evaluated on a case-by-case basis to assess the need for vacuum bakeouts.

10.1 Vacuum Chamber Background Outgassing

A TQCM shall be used to monitor outgassing during the certification phases of each bakeout. Because the TQCM records all outgassing in the vacuum chamber, it is necessary to first record the background TQCM readings in the facility containing all test cabling and fixturing but without the test article. These readings are later subtracted from the certification readings to obtain the outgassing contribution of the item under bakeout test.

For accuracy in determining the final outgassing rate of the test article, it is desirable to have chamber background outgassing (TQCM rate) that is less than 10% of the outgassing requirement (TQCM rate, as determined through modeling) for the test article. To achieve this outgassing level, it may be necessary to perform a bakeout of the empty chamber. Carefully cleaning a vacuum chamber by IPA wipedown increases the likelihood of expeditiously achieving low background outgassing. Sufficient time must be allowed after any such cleaning for the complete dissipation of IPA fumes prior to the installation of flight hardware that is sensitive to chemical vapors.

10.2 Test Cables

Many cables will be fabricated for the purpose of connecting the subsystem to ground-based test equipment during I&T. To the extent possible, these cables will be kept outside of the clean rooms occupied by the flight hardware. Special precautions shall be taken in the fabrication and handling of these test cables, both for clean room use and for ensuring that the required cables are compatible with thermal vacuum testing. Wire bundles present special challenges to cleanliness, as it is impossible to effectively clean them once fabrication is complete. This is particularly true when the bundles are bound together with netting material, such as Expando.

10.2.1 Test Cables for Cleanroom Use

After each cable is assembled, it will be cleaned via the standard vapor degreasing process. Following this cleaning, gloves will be used for any handling of test cables. Low outgassing Expando will be installed on completed wire bundles. When these cables arrive for use in the I&T clean rooms, the lengths that will be placed inside the clean facility shall be sleeved in bagging film. This will serve to maintain the cleanability of the bundles, as the bagging film creates a smooth, uniform outer surface. The control-room ends of these test cables will not require sleeving, as they will be kept outside the clean rooms.

10.2.2 Test Cables for Vacuum Facility Use

The bakeout shall be performed prior to final sleeving in bagging film. Test cables intended for use in thermal vacuum testing shall be sleeved for their entire length, protecting them from handling and unclean conditions associated with the control room. The sleeving shall remain in place until the cables are installed in the chamber at the time of the thermal vacuum test.

10.2.3 Materials

All materials used in the harness shall meet or exceed the standard outgassing requirements for flight components: 1% TML and 0.1% CVCM per the ASTM E-595 outgassing test. This applies to wire insulation, adhesives, potting materials, connectors, tie wraps, staking adhesives, tape, etc. NASA Reference Publication 1124 may be used as a database of outgassing test results for materials in question. Flight harness materials must also be non-shedding. Lacing cord is a particular concern, and must have sealed cut ends.

10.2.4 Handling

Much of the harness fabrication work requires high levels of dexterity for handling small parts and performing precise assembly steps, so it is not always possible to work with gloves. However, for avoiding the deposition of skin oils and other contaminants in large quantities and over significant lengths of wire, gloves should be worn for as much of the flight harness handling as possible.

10.2.5 Bakeout

The flight harness shall be baked out in vacuum. The certification phase of the bakeout shall be monitored with a TQCM. Spare wire sufficient to cover future harness rework shall be included in the bakeout. As with any baked out item, the harness is to be handled with strict attention to contamination following the bakeout. It shall be fully bagged as it is removed from the bakeout facility (vacuum chamber). Gloves and smocks shall be worn when handling this item outside the clean room if the harness is not bagged.

10.3 Electronic Boxes

Electronics assemblies are not generally considered contamination-sensitive. However, they must be fabricated so as to meet the contamination requirements of the Project.

Outgassing of electronics packages is of particular concern due to the use of adhesives, conformal coatings, potting and encapsulation compounds, staking materials, sealants, etc. All of these non-metallic materials shall be selected and cured to meet the flight outgassing requirement of 1% TML and 0.1% CVCM. Metal electronics enclosures shall receive chemical surface treatments (such as alodine, irridite, or anodize) or flight-qualified paint to prevent particle generation due to oxidation. All fasteners and other small hardware used in box fabrication shall be free of manufacturing lubricants.

11.0 VIBRATION TESTING

Surfaces of the subsystem will be bagged during vibration testing except when prohibited by the performance of the test. During periods of inactivity, the subsystem will be draped.

12.0 THERMAL VACUUM TESTING

The subsystems will undergo a TV testing sequence, in conjunction with a period of outgassing certification. The temperature during thermal vacuum testing and bakeout shall not exceed +50°C. All tests will be monitored with a combination of the following instrumentation:

1. Temperature controlled quartz crystal microbalances (TQCMs),
2. Cold fingers and scavenger plates

In addition, cold plates will be used as required to minimize contamination from known high outgassing sources.

The chamber will be maintained at a class 100,000 environment. Clean room garments will be worn while working within the chamber. The thermal vacuum test will be monitored with a series of TQCMs and with the aforementioned monitoring instrumentation. All temperature transitions will be controlled to minimize contamination.

Prior to thermal vacuum testing, the instrument will be cleaned and verified for cleanliness requirements, double bagged, then transported to the thermal vacuum-testing chamber.

Prior to loading the instrument into the chamber, the chamber background and ground support equipment outgassing levels will be measured and verified to meet the chamber certification levels.

Outgassing certification will be performed during the last hot cycle of thermal vacuum testing. During certification, the flight hardware must be maintained at its maximum on-orbit operation temperature. The hardware-outgassing rate will be measured with two TQCMs for at least eight consecutive hours. The TQCMs must be mounted within the chamber such that the TQCMs have a representative view of the flight hardware. If the flight hardware does not meet its outgassing requirements the hardware will be subjected to a bakeout.

13.0 HANDLING RESTRICTIONS

All flight items are to be handled with gloves during and after precision cleaning. Items that are to be stored in areas that are not Class 100,000 or better clean zones shall be double-bagged in heat-sealed approved bagging film for the duration of this storage. The outer bag shall be removed outside the clean room and the inner bag shall be removed inside. Bags shall be cut open with clean scissors rather than torn. All hardware handling equipment such as lift fixtures and tools shall meet the same surface cleanliness requirements to avoid cross-contamination.

14.0 PROCESS RESTRICTIONS

Certain I&T activities are restricted or, if unavoidable, must be performed in combination with other precautions in order to avoid serious contamination risk to the hardware and facilities. These include machining operations such as (but not limited to) drilling, cutting, abrading, thread cutting or chasing, unstaking threaded fasteners, etc. When machining operations such as these are unavoidable, they must be performed using simultaneous vacuum cleaning (either using the house vacuum system or a portable machine with HEPA-filtered exhaust) directly at the site of particle generation. Nearby contamination-sensitive items must be protected using clean bagging (Llumalloy) and approved tape (Kapton/Y966). Prior to removal of this bagging, the machining area and the outside of the bagging must be cleaned by wipedown with IPA and non-shedding wipes.

Soldering operations shall be similarly restricted and require the same precautions when unavoidable. Solder smoke contains particles and chemicals that can redeposit on surfaces and, if detectable, be difficult to remove.

Curing of adhesives in the clean room shall be limited as much as possible, as this process often releases molecular products that can contaminate surfaces.

Contamination bagging shall be removed, whenever possible, from cleaned items in the gowning area just as the items are entering the clean room. This avoids bringing contaminants into the clean room on the outer surfaces of the bags. If bags must be removed inside the clean room, they must be quickly wiped down and then cut open with scissors rather than torn. Tearing of bagging, clean room paper, and other materials inside the clean rooms shall be forbidden during I&T activities.

15.0 CLEAN ROOM AND OPERATIONAL REQUIREMENTS

Integration will occur in certified clean room facility, which operates at class 100,000 (or better) per Fed. Std. 209. The following list highlights the planned contamination procedures to be implemented during integration activities:

1. The most sensitive hardware will be placed closest to the HEPA filters in the clean room and less sensitive hardware will be kept downwind from the more sensitive hardware.
2. Parts from a less controlled fabrication and assembly area will be cleaned to a visibly clean level prior to entry into the clean room.
3. The room temperature will be maintained at 65°F to 78°F (18.3°C to 25.7°C) and the relative humidity will be maintained between 30-50%. If at any time environmental conditions are not within these values, it must be reported to the QA immediately except as defined herein. The RH shall not exceed 55% for more than 3 hours. If the humidity cannot be brought down to the required level then the Calorimeter shall be bagged and flushed with a continuous pure nitrogen purge.
4. The clean room will include an air particle monitor, and a group of contamination witness plates, which will be evaluated, on a periodic basis.
5. All surfaces will be cleaned to Visibly Clean Sensitive throughout integration activities. A solvent rinse will be used to verify the molecular levels meet the budgeted requirement.
6. Parts, which are machined, welded or riveted, will be inspected and re-cleaned, if necessary to meet the Visibly Clean Sensitive levels. A solvent rinse may be used to verify the molecular levels meet the budgeted requirement.
7. Personnel working in the clean room will wear appropriate clean room clothing, shoe coverings, etc. and unpowdered nitrile rubber gloves. When working with solvents, these gloves are acceptable.

   NOTE: NO LATEX GLOVES OR POWDERED GLOVES ARE ALLOWED WHEN HANDLING GLAST CALORIMETER BARE CRYSTALS PRIOR TO BONDING OR DURING BONDING PROCEDURES. ONLY UNPOWDERED NITRILE GLOVES ARE ACCEPTABLE.

8. Ground support equipment (GSE) required for testing will be cleaned with IPA to a visibly clean level, and bagged before going into the clean room. Surfaces, which will contact the instrument, must meet the requirements.
9. Oils, greases and other similar agents, which may be contamination hazards, will not be used during integration without the permission of the materials engineer and contamination engineer.
10. Joints or crevices will be covered during integration to minimize the build up of contaminating debris. Areas, which become inaccessible for cleaning must be cleaned and inspected prior to integration, and be bagged following that time. Fasteners must be lubricated with an approved low-outgassing lubricant, such as Braycote 602 grease, prior to being used during integration.
11. All integration GSE, testing equipment, etc. will meet the visibly clean level.
12. If an instrument or hardware is removed for testing, or some other reason, it must reverified to a cleanliness level visibly clean, highly sensitive before it can reenter the clean room.
13. The instrument support team is responsible for cleaning and maintaining their respective instruments during satellite integration and testing.

16.0 CLEAN ROOM PROTOCOL

16.1 Required Garments

Garment requirements for entry will be posted on the doors to each of the clean rooms. To ensure the maintenance of cleanliness levels, it is essential that all personnel wear he required garments in each of the facilities. As a general rule, garments are donned in the order of top-to-bottom and removed in the reverse order; bottom to top.

Class 100,000 requires the wearing of a hair net or hood, smock, shoe covers, and gloves at all times in the clean room. The gloves are to cover the sleeve ends and, if necessary, taped in place with wrist tape. Gloves are to be changed (in the gowning area) whenever they are damaged or known or suspected to be contaminated.

16.2 ESD Protection

The ESD wrist straps and cords are to be donned in the gowning area in conjunction with the clean room garments. (These items are not to be donned or removed inside the clean rooms, as doing so exposes the skin to the clean room environment.)

17.0 CONTAMINATION CONTROL DURING TRANSPORTATION AND STORAGE

17.1 Packaging for Transportation

All flight hardware shall be bagged and sealed (heat sealed or taped) with approved materials prior to shipping. Transparency of bagging material may dictate the material chosen. The inner surface of the bag shall be charge dissipative for ESD sensitive hardware and cleaned to the requirement of the flight hardware. As a guideline for bagging moisture sensitive hardware, the bag can be evacuated and filled completely 3 times with pre-certified dry nitrogen gas, then sealed. A moisture indicator may be used inside the first sealed layer of bagging. As a guideline, contamination sensitive hardware typically requires double-layer bagging.

Prior to any transport operation, any shipping container used shall be pre-cleaned to the requirement of the flight hardware. Shipping containers must be able to accommodate any required nitrogen purge for the duration of the transport, and must also provide temperature and relative humidity control. Shock absorbing material and mechanical shock indicators should be used to protect and monitor the hardware being shipped. Any environmental control system integrated into the shipping container to provide temperature and relative humidity control should utilize an air filtration system to maintain an acceptable airborne particulate level when required. Shipping containers should also be equipped with pressure equalization vents to accommodate air transportation. These vents should be designed to prevent unnecessary particulate or other contamination from entering the container.

Temperature and relative humidity shall be monitored continuously inside the shipping container during hardware transport. In addition, witness samples may be mounted inside the container and/or inside the hardware bagging layer to monitor hardware exposure to contamination during transport.

17.2 Packaging for Storage

Flight hardware that requires storage during extended scheduled periods of inactivity shall be protected from damage and contamination. As a guideline, hardware should be cleaned to a level of Visibly Clean (VC) (unless cleanliness requirements dictate a higher level of surface cleanliness) and bagged. Whenever practical, hardware should be protected from damage by keeping hardware stored in a shipping container or similar acceptable protective enclosure. Tent enclosures built with approved clean room materials may also be constructed to protect hardware stored in a clean room if personnel access and protection from particulate fallout is desired. Contamination and humidity sensitive hardware should be stored bagged and enclosed inside a clean room environment with continuous temperature, relative humidity and airborne particulate monitoring performed, and a continuous nitrogen purge when required. For short term storage in clean rooms, hardware can be protected with a cover of static dissipative sheeting material.

18.0 CLEANING

Only approved solvents will be allowed for cleaning surfaces to be bonded. Approved solvents that are compatible with Dow Corning 93-500 epoxy are: acetone, ethanol, iso-propanol, 2-propanol, and methyl ethyl alcohol.

18.1 Pre-Cleaning

One of the major components that will be in place throughout I&T will be the requirement that all items (including, hand tools, GSE, supplies, facility maintenance equipment, furniture, flight hardware, etc.) entering the clean room be cleaned. The facility should be equipped to support a variety of cleaning methods i.e. solvent spray cleaning, vacuum cleaning, ensuring compatibility with most flight material and surfaces. Safe storage of solvents ensures that there is no risk to hardware that may be sensitive to the presence of chemical vapors.

<u>For Solvent Wipe Cleaning</u>: Preclean hardware by general dry vacuum cleaning. Preclean difficult areas, such as threaded holes, both heads, nuts and crevices, with HPLC or VLSI grade iso-propanol dampened clean room approved swabs. Remove clean room approved wiper from the container, carefully, so as not to touch wiper to outside of container or other contaminated surfaces. Fold the wiper into quarters. Moisten the wiper with HPLC or VLSI grade iso-propanol. Wipe the test article critical surface using the first surface of the wiper with a horizontal unidirectional movement covering the entire width of the test article with one sweep. For the next wipe, overlap 25% of the first wiped horizontal strip area with one unidirectional movement. Work from the top down after each wipe. Continue cleaning the test article with unidirectional wiping motions until the wiper is visibly dirty.

<u>For Solvent Spray Flush</u> Cleaning: Mask areas to be protected from solvent with an approved bag/drape covering material and seal using 3M 480 polyethylene tape. Prepare bagging, or vacuum collection system under surface to be cleaned, to collect contaminated effluent for proper disposal. When using solvents, clean room approved latex gloves with a polypropylene or equivalently protective overglove will be worn. Rinse gloves thoroughly with HPLC or VLSI grade 100% IPA prior to use. The flushing solvent shall be HPLC or VLSI grade 100% IPA dispensed with pressure from a polyfluorocarbon or low-density polyethylene hand-held bottle. The precision flushing process shall consist of a series of horizontal and vertical unidirectional strokes, from top to bottom. All flushing shall be unidirection from left to right, top to bottom.

<u>For Vacuum Cleaning</u>: The vacuum to be used in this operation shall deliver its exhaust outside of the facility being worked or it shall be HEPA filtered to meet or exceed the environmental air cleanliness requirement in that area. All vacuum cleanliness shall meet ESD requirements. When vacuuming, the bristles shall lightly contact the surface so as to disturb the particles sufficiently to be picked up by the vacuum. The nozzles shall not be pressured or aggressively rubbed against the surface in order to prevent surface damage. In crevice areas, a narrow flat nozzle attachment shall be used. The actual vacuuming operation shall consist of getting the crevice tool as close as possible to the crevice area with a light touch contact.

18.2 Cleanliness Inspection And Monitoring Methods

Cleanliness Inspection methods which will be used for the GLAST LAT mission are witness plates, black and white light inspections, washes, swab sampling and tape lifts. Descriptions of these techniques are as defined in section 2.0 of this document.

18.3 Cleaning and Monitoring Schedules

Cleaning of flight hardware, GSE, and cleanrooms shall occur on a scheduled basis and as required by activities. The Contamination Control Implementation Plan (CCIP) shall present the planned cleaning and monitoring schedule.

19.0 EMPLOYEE TRAINING

Contamination Control and Cleanroom Practices training will be conducted for all personnel involved in the fabrication, assembly, integration, testing, transportation and integration to the LAT instrument. Areas which will be studied in the training sessions are as follows: Definition of contamination and how it affects the mission; the importance of maintaining contamination control in all the program phases, that is, fabrication through to launch; reviewing instrument sensitivities; knowledge of the instrument and contamination control plans and related contamination documents; specific techniques for cleaning, inspection, and packaging; monitoring techniques in the cleanroom and in the shipping containers; and cleanroom dressing procedures and rules for working in a controlled cleanroom area. Samples of training details are attached in Appendix A.

20.0 CONTAMINATION DOCUMENTATION REQUIREMENTS

There are a number of contamination-related documents, which must be produced and periodically updated throughout the development process. These include:

- Contamination Control Plan
- Cleanroom History Logs
- Hardware Cleanliness History Logs
- Testing Results Reports
- Temperature and Humidity Records for clean room, transportation, and storage.

21.0 ACRONYMS and DEFINITIONS

21.1 Acronyms

CCE	Contamination Control Engineer
CCM	Contamination Control Manager
CCP	Contamination Control Plan
CVCM	Collected Volatile Condensable Materials
ESD	Electrostatic Discharge
FED-STD	Federal Standard
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HEPA	High Efficiency Particulate Air
IPA	Isopropyl Alcohol
I & T	Integration and Test
MIL-STD	Military Standard
MLI	Multi-Layer Insulation
NASA	National Aeronautics and Space Administration
NVR	Non-Volatile Residue
PAR	Performance Assurance Requirements (Document)
QA	Quality Assurance
QCM	Quartz Crystal Microbalance
TML	Total Mass Loss
TQCM	Temperature-Controlled Quartz Crystal Microbalance
VCS	Visibly Clean Sensitive

Appendix A

Class 100,000 Clean Room Operations Sample Training Course Outline

Topics:

- What is Contamination
- Contamination Requirements
- Contamination Effects
- Sources Of Contamination
- Clean room Entry Procedure
- Cleaning Technique
- Clean room Rules
- Common Mistakes
- Prevention
- Electro Static Discharge (ESD)

What is Contamination?

- Particles as small as 1 micron
    - The unaided eye can see particles as small as 50 microns on a good background
    - The thickness of a human hair is 100 microns
    - Time to fall 1 meter in still air for a 10 micron particle is 33 seconds, for a 1 micron particle is 48 minutes

- Molecular films
    - Uncured epoxy resins or hardener, oils, deposited vapors
    - Most thin films of contaminant are invisible to the unaided eye

- Outgassing / Offgassing
    - Low molecular weight compounds such as plasticizers, etc.

- Federal Standard 209
    - Airborne particulate cleanliness for clean rooms and clean work areas

  "This document is not a design specification for clean rooms or clean air devices, nor does it apply to supplies or equipment which may be used in clean rooms." "Rather it provides a means for specifying and measuring particulate air cleanliness levels." "Because air cleanliness levels are affected by the people, activity, and equipment within the space as well as the room design, cleanliness classes normally apply only to operational facilities."

- Classification

Class	**0.1**	**0.3**	**0.5**	**5.0**
1	35	3	1	
10	350	30	10	
100		300	100	
1,000			1,000	7
10,000			10,000	70
100,000			100,000	700

Contamination Requirements

- The Contamination Control Plan LAT-MD-00228 defines, in detail, the definition, sources of contamination, how to control the contamination, etc.
- These requirements will be enforced by QA.
- LAT subsystems shall meet the requirement of class 100,000 clean room.
- Temperature humidity control shall be implemented as per LAT-MD-00228.

Special Requirements for Calorimeter

Thallium Doped Cesium Iodide, CsI (TD) crystals used for the Calorimeter subsystem are sensitive to humidity (RH), hence it is necessary to prevent condensation from forming on the crystals. The following precautions should be taken:

1. The Calorimeter temperature must never be below the dew point in the room.
2. RH should be maintained below between 30-50% and the temperature of the crystals should never be significantly lower than the room air temperature. This shall be controlled by controlling the temperature rate of change of the crystals

and the air temperature around them. The air temperature around the crystals must never be below the dew point.

3. Continuous temperature and humidity monitoring records shall be maintained and shall be made available for review.
4. If the humidity of the environment is beyond 55% for more than 3 hours, the humidifier in the clean room shall be shut down until the RH level is within the specification. Calorimeter QA shall be informed immediately of this deviation. If the humidity cannot be brought down to the required level then the Calorimeter shall be bagged and flushed with a continuous pure nitrogen purge.
5. Due to ESD requirements, the Calorimeter shall never be touched if the humidity goes below 30% and must also meet the requirement of section 5.0.

Special Requirements for Calorimeter Crystal Bonding

The following precautions are to be taken to avoid a contamination hazard due to the use of two silicone- based Dow Corning products (92-023 and 93-500). This guideline defines cautions for the CAL project only and by no means should be used for any other project with out the written consent. The purpose of these precautions is to 1) prohibit any cross contamination by contact or bad house keeping practice, 2) meet all health and safety requirements established by the facility and 3) assist in gaining success in a manufacturing process.

a. All mixing and degassing of the silicone encapsulant shall be performed only in the ante-room under a hooded bench who's outlet is directly connected to the outside air. At no time will the air from the hood's exhaust system be circulated to the clean room air. A separate trash can marked as the "silicone trash can" shall be used in the ante-room. The silicone trash can shall be emptied at the end of each working day.
b. All abrading, priming, mixing, and degassing processes shall be done in the 5015 ante-room under the hooded work bench. Only a premixed silicone adhesive shall be brought into the clean room.
c. Establish and cordoned off a control work area in the clean room for the silicone bonding process. Silicone work may be performed and handled only in this designated area.
d. Keep the control area clear of all hardware, tools, gloves, and miscellaneous items that **do not** pertain to the CAL crystal bonding project.
e. Keep a trash can within the work area that is specifically designated for disposal of all potential silicone-contaminated items. Empty the trash can at the end of each working day.
f. Completely cover all work tables and benches with llumaloy before handling any silicone material. When the work day is done, remove all llumaloy covers and discard them into the "silicone-trash can" and replace the covers with clean fresh sheets of llumaloy.
g. Keep all tools, hardware, gloves, smock and miscellaneous items used for the silicone project in the defined work area. No items shall be removed from the silicone

work area for any other operation unless it is complete covered and bagged for protection.

h. Do not open the clean room exit door with contaminated gloves.

i. Remove and dispose of all used gloves in the “silicone trash can” located near the exit door of the clean room as exiting the clean room.

j. All bonding operations shall be carried out in the class 100,000 clean room environment and bonding surfaces should be kept clean.

k. Contamination from human sources such as small particles of skin, hair, sweat, spit, and mucus can degrade the bond between the CsI crystal and the PIN Photodiode. Proper precaution and clean room rules shall be enforced to avoid this type of contamination.

l. Only unpowdered nitrile gloves shall be used when handling the bare crystals prior to bonding or during bonding procedures.

m. Only approved solvents will be allowed for cleaning surfaces to be bonded. Approved solvents that are compatible with Dow Corning 93-500 epoxy are: acetone, ethanol, iso-propanol, 2-propanol, and methyl ethyl alcohol.

<u>Special Requirements for Tracker</u>

1. Contaminants on bondpads can degrade both the bondability and the reliability of wire bonds. All bonding operations shall be carried out in the clean room environment and bonding surfaces should be kept clean.
2. Contamination from human sources such as small particles of skin, hair, sweat, spit, and mucus can degrade the bondability and long-term reliability of silicon detectors. Proper precaution and clean room rules shall be enforced to avoid this type of contamination.
3. Considering the large number of possible bond-degrading contaminants, precautions shall be taken to keep all surfaces of SSDs and MCMs clean.
4. SSDs should not be cleaned with alcohol or other solvents. Only deionized water should be used if required. A dry nitrogen blow clean is acceptable.
5. Cleaning after assembly of Tracker tower if required shall not be done without permission from the subsystem manager and QA.
6. ESD control of all operations shall meet the requirement of section 5.0.

ESD Requirements

All personnel who perform any activities or handle any Electro-Static Discharge Sensitive (ESDS) hardware should be familiar with ESD control techniques.

- Identification and Access - ESD Areas (see section 5.1)
- ESD – Protective Surfaces (see section 5.2)
- Personnel Grounding Devices (see section 5.3)
- Equipment and Facilities Grounding (see section 5.4)
- Humidification (see section 5.5)

Contamination Effects

- Particles
  - Can degrade wire bonding reliability performance
  - Change thermal properties of materials
  - Obscure optics thus reducing efficiency
- Molecular films
  - Reduce instrument throughput
  - Change thermal properties
- Outgassing
  - Create buildup of molecular film on cold surfaces on orbit

Sources of Contamination

- Primary Source
  - Exposed Skin/Hair
  - Non-clean room Paper
  - Garments
  - Vinyl, PVC, Rubber, Ink
  - Operations: drilling, cutting, filing
  - Environment
  - Equipment
  - People
  - Chemicals
  - De-Ionized Water

- Process

- Secondary Sources
  - Gloves
  - Tools
  - Work Surfaces
  - Floor

- Personnel as a Source
  - A person motionless, sitting or standing, will generate 100,000 particles > 0.3 micron in diameter per minute.
  - A person with arms, head, and body in motion will generate 1,000,000 particles > 0.3 micron in diameter per minute.
  - A person walking at 2 mph generates 5,000,000 particles > 0.3 micron per minute.
  - Fingerprints cannot be completely removed by an alcohol wipe, and on many materials they etch the surface causing permanent changes to the surface properties.
  - Human Contamination
    - Normal talking (saliva) – 2 to 3 Ft.
    - Coughing (saliva/lung tissue) – 4 to 6 Ft.
    - Sneezing – 10 to 15 Ft. (200 MPH)

Clean Room Rules and Regulations

The recommended regulations necessary for the successful operation based upon the best class of air cleanliness attainable for the type of facility and equipment are as follows:

- NO eating, smoking, or chewing gum or tobacco.
- Garments specified as applicable to a given facility must be worn when entering the area.
- Only approved clean room paper shall be allowed in the area.
- Clean room approved ballpoint pens shall be the only writing implements used.
- NO cosmetics of any type shall be worn by anyone entering the area. This includes: rouge, lipstick, eye shadow, eyebrow pencil, mascara, eye liner, false eye lashes, fingernail polish, hair spray, and the heavy use of aerosols, aftershaves lotions, and perfumes.
- The use of paper or fabric towels should be forbidden. Washrooms should have electrically powered air blowers.
- Gloves should not be allowed to touch any item or surface that is not known to have been thoroughly cleaned. Specifically, they should not touch any part of the anatomy covered or uncovered.
- Approved lint-free gloves, pliers, or tweezers should be used to handle material or parts if feasible. Fingerprints are a form of contamination and should be avoided.
- Only unpowdered nitrile gloves shall be used when handling the bare crystals prior to bonding or during bonding procedures.
- Solvent contact with the bare skin should be avoided, as most solvents will remove natural skins oils, and lead to excess skin flaking.

- Skin lotions or lanolin-based soaps are a good means of skin tightening and should help prohibit epidermal scale.
- All personal items such as keys, cigarettes, watches, matches, lighters, etc., should not be carried into the clean room.
- Valuable items such as wallets may be permitted in the clean room provided that they are NEVER removed from street clothing and are concealed by the clean room garment.
- All parts of material, containers, racks, jugs, fixtures, and tools, should be cleaned to the same level of cleanliness specified for the product being processed.
- No tool should be allowed to rest on the surface of the bench or table, but should be placed on a clean room wiper or a re-cleaned surface to guard against contamination, which has settled on the work surface being transferred to the tool.
- All material, containers or equipment introduced into the sterile room must be subjected to stringent sterilization procedures prior to entering the clean area.
- NO ONE who is physically ill, especially with a stomach or respiratory disorder, may enter the sterile rooms or clean rooms.

<u>Prohibited Personnel Actions</u>

- Scratching Head
- Combing Hair (in gowning room area)
- Removing clean room garments prior to gowning area
- Horseplay, fast motions
- Using external medications i.e., lens solution.
- Wearing a torn or soiled clean room garment.
- Removing items from under the clean room garment.
- Bringing non-approved items into the clean area.
- Not cleaning items before bringing them into the clean area.
- Blowing off work areas.
- Improper changing of gloves.
- Wearing clean room garments OUTSIDE the clean room area.
- Storing clean room garments in personal article locker.

The 10 Rules of a Good Clean Room Management

- Enforce Discipline.
- Train and certify all levels of personnel.
- Write & update process procedures.
- Establish quality assurance.
- Write a clean room standard.
- Come up with a good attitude in the clean room.
- Make the clean room a safe environment.
- Maintain stock of supplies.
- Someone to supervise all housekeeping activities.
- Someone to cross-train people and maintain records.

Clean Room Materials

Garment Construction

Generic/Brand Name	Configuration
Polytetrafluoroethylene/Gore-Tex	Membrane bonded to polyester fabric
Non-woven/Tyvek	Non-woven fabric

Glove Construction

Generic/Brand Name	Configuration
Polytetrafluoroethylene/Gore-Tex	Membrane bonded to polyester fabric
Latex/rubber	Film (elastomer)
Nitrile/rubber	Film (elastomer)

NOTE: NO LATEX GLOVES OR POWDERED GLOVES ARE ALLOWED WHEN HANDLING BARE CRYSTALS PRIOR TO BONDING OR DURING BONDING PROCEDURES. ONLY UNPOWDERED NITRILE GLOVES ARE ACCEPTABLE

Surface Cleaning Techniques

- Dry Cleaning Methods
    - Jet blowing
    - Vacuuming
    - Mechanical Brushing
    - Plasma sputtering

- Wet Cleaning Methods
    - Liquid jets
    - Washing
    - Solvent washing
    - Combined techniques

Maintenance Questions (to be answered for clean room maintenance)

- Where are your housekeeping supplies stored?
- Do you have DI water available for cleaning? Where?
- What type of mop are you using?
- What type of surfactant?
- How often are you cleaning?
- What determines the frequency?
- Who is responsible for determining the efficiency of cleaning procedures?
- How often is the gowning area cleaned?
- How is trash removed from the clean room?
- What type and where are the trash receptacles located?
- What type of garments are the cleaning personnel wearing?
- Are the cleaning personnel wearing gloves?
- How often and who cleans the work surfaces?
- Do you have an in-house vacuum?
- Do you have a portable vacuum?
- Who changes the light bulbs and how are they changed?
- What is the particle burden limit of the surfaces in you clean room?

Clean Room Personnel Entry Procedure

- Wash hands after eating or smoking
- Remove items you will need from pockets
- Pick up garments: Smock, booties, cap, face mask. Dress from top down
- Do not let booties touch “dirty” side of floor
- Put on ESD wrist strap then glove.

Clean Room Equipment Entry Procedure

- Hand carried items
    - Items already clean and double bagged may be taken directly into clean room. Remove first bag in ante room, second bag in clean room.
    - Items not already clean should be cleaned in the ante room until no particles are visible from 2 feet away. Vacuuming followed by wiping with isopropyl alcohol will usually be sufficient.

- Large equipment
    - Bring in through equipment access door. Coordinate cleaning with the engineer in charge of contamination.

<u>Cleaning Technique</u>

- Bolts, nuts, fasteners
    - Place in ultrasonic bath for 10 minutes (do a lot at one time)

- Lager Items
    - Vacuum holes and crevices.
    - Tape over chipping paint, etc.
    - Wipe unidirectionally, changing wipe every 2-3 strokes. Continue until the wipe looks clean after wiping.

<u>Lubrication Technique</u>

- Bolts (lubricated with an approved lubricant)
    - Clean fasteners in the ultrasonic bath for 10 minutes
    - Apply enough lubricant to the thread grooves near the end of the bolt (opposite of the bolt head) so that only one to three threads are lubricated
    - Lubricant should not form a drop larger in diameter than the major thread diameter of the bolt. For greases, the thickness of the grease should not exceed the major thread diameter of the bolt.

<u>Common Mistakes</u>

- Touching face or hair with gloves
- Keeping face mask below the nose
- Using tools that have fallen on the floor without recleaning them
- Not changing gloves when a questionable surface has been touched
- Picking up gloves by the fingers instead of the wrist when gowning up
- Bringing tools into the clean room without cleaning them (usually carried in a pocket, such as a pen)

Prevention

- Keep clean room wipes and alcohol in a squeeze bottle handy for recleaning tools and work surfaces.
- Be aware of the contamination sources and change your gloves as often as necessary.
- If you have to wipe your forehead while wearing gloves, use a clean room wipe (dry), not your sleeve.
- Follow clean room rules
- Use only approved materials for flight hardware, including lubricants and fasteners.