STEREO *IMPACT*

Contamination Control Plan

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1.1. *Scope*

The IMPACT experiment suite is a cluster of instruments and components to study magnetic and charged particle environment of the Sun and solar wind. It will fly on the (STEREO) mission. The STEREO mission is an effort to create stereoscopic models and images of the Sun and the environment around it. Instruments and components come from several organizations. This document will:

1. Establish the maximum allowable contamination levels at end of life (EOL) taking into consideration cross contamination concerns with other STEREO instruments.
2. Identify contamination sources for the IMPACT science instruments and control operations for each phase of operation.
3. Establish contamination budgets and budget allocations for the various phases of IMPACT science instrument operations.
4. Establish a hardware cleaning plan for the IMPACT science instruments, including a summary of IMPACT cleaning procedures and cleanliness requirements for subcontracted hardware.
5. Establish contamination controls for each phase of operation to maintain the cleanliness and to prevent the need for re-cleaning of cleaned IMPACT components and assemblies.
6. Outline a cleanliness monitoring and verification program for the IMPACT science instruments.
7. Provide the spacecraft integrator with the information necessary to conduct Integration and Test (I and T) operations without degradation to instrument performance.

1.2. *General Overview of IMPACT*

1.2.1. Scientific Objectives (provided for reference only)

The overall science objective of IMPACT is to measure the solar wind temperature, density, speed and magnetic field from the two vantage points afforded by the STEREO mission. To accomplish this IMPACT utilizes a suite of sensors sharing the same power and data processing units. Sensors are mounted both on the body of the spacecraft and at the end of the IMPACT boom (see Figure 1.2.2-1). Table 1.2.-1 contains a list of the various sensors and the measurements they will perform.

Table 1.2-1: Instrumentation Required to Meet Science Objectives (reference only)

Sensor	Measurement	Critical Measurement Requirements
SW Sensor Suite		
STE	Electron flux and anisotropy	2-100 keV, 16 s resolution
SWEA	3D electron distribution, core and halo density, temperature, and anisotropy	0 to 3 keV, 3D 1 min, 2D 8s; Mom.=2s resolution
MAG	Vector Field	+/-500nT, +/- 66536nT, 1 min resolution
SEP sensor Suite		
SIT	He to Fe Ions	0.03-2 MeV/nuc, 1 min resolution
	He	0.15-0.25 MeV/nuc, 1 min resolution
SEPT	Diff. Electron Flux	20-400 keV, 1 min resolution
	Diff. Proton Flux	50-7000 keV, 1 min resolution
	Anisotropies of e and p	As above, 15 min resolution
LET	Ion mass numbers 2-28 and anisotropy	3-30 MeV/nuc, 15 min resolution
	He ions flux and anisotropy	2-15 MeV/nuc, 15 min resolution
	H ions flux and anisotropy	1.5- 6 MeV, 1-15 min
HET	Electrons Flux	1-6 MeV, 1-15 min
	H	13-100 MeV, 1-15 min
	He	13-100 MeV, 1-15
	He	15-50 MeV/nuc, 15 min

Figure 1.2.2 STEREO Ahead Spacecraft with IMPACT

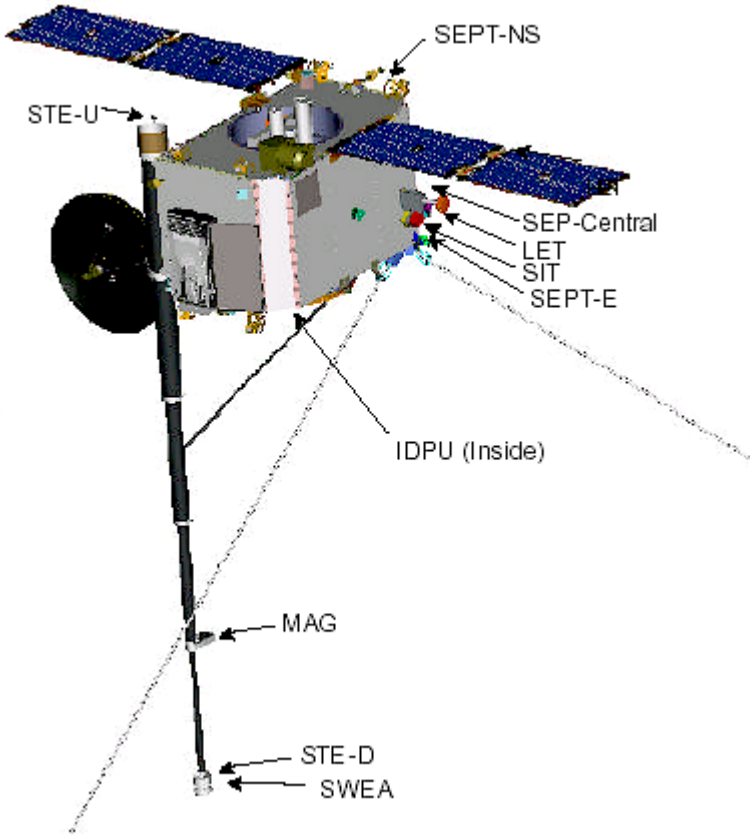


Figure 1.2.2-2a

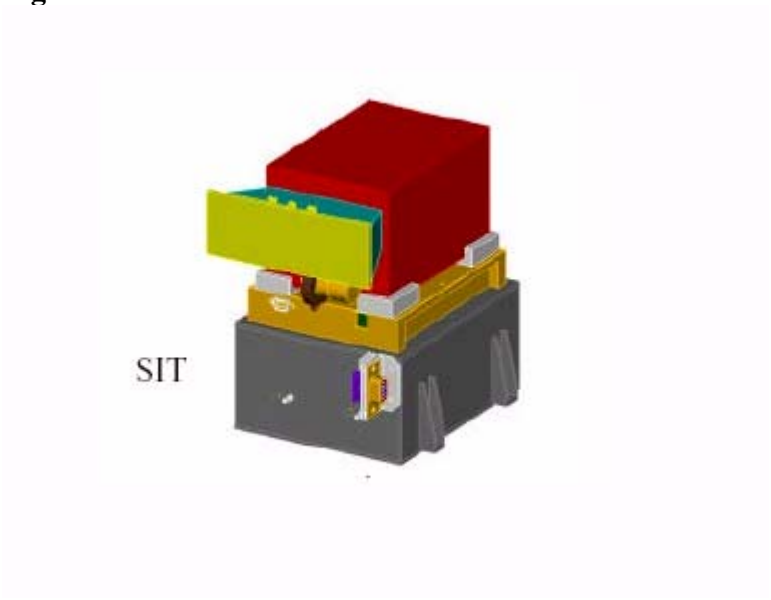


Figure 1.2.2-2b

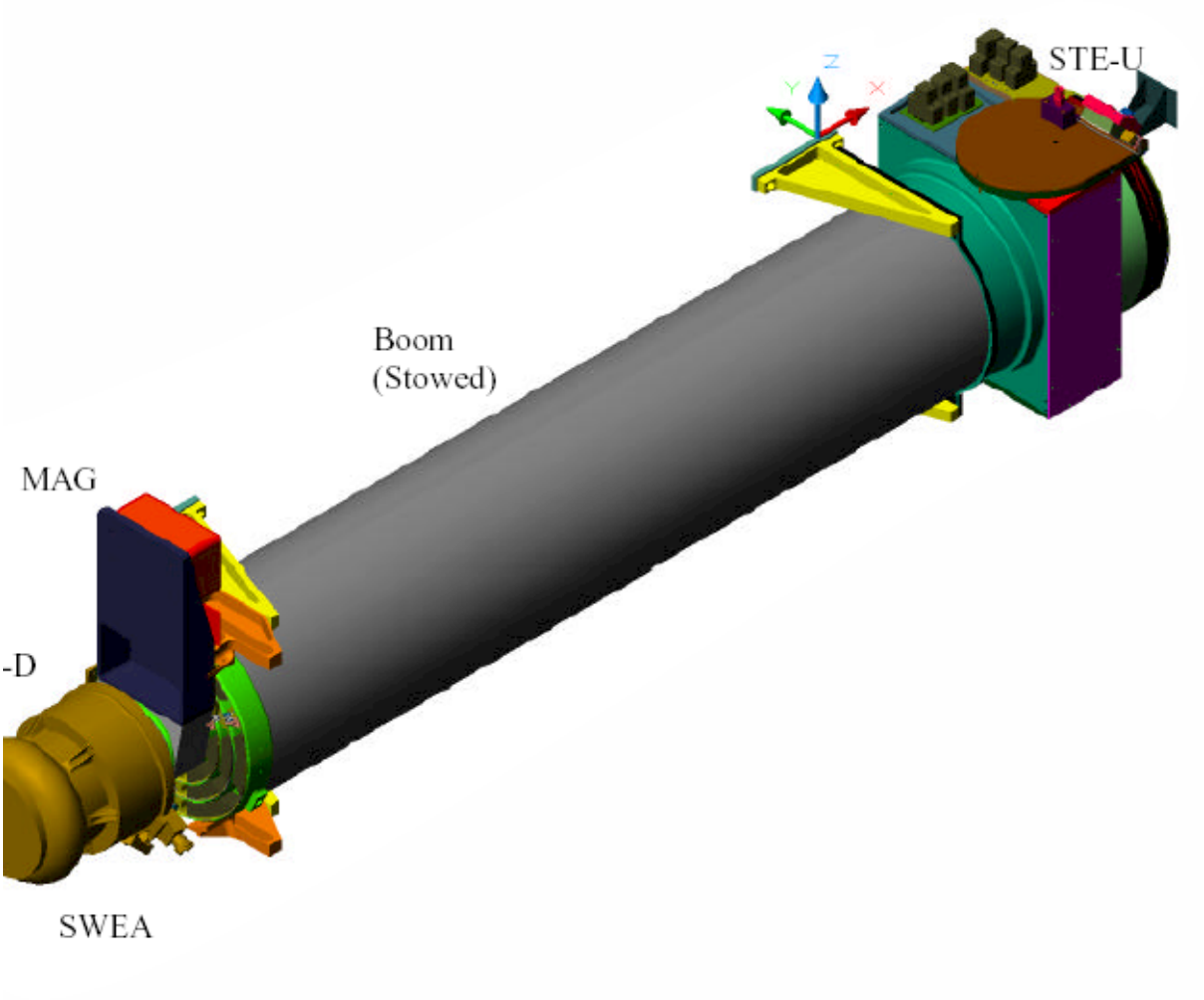
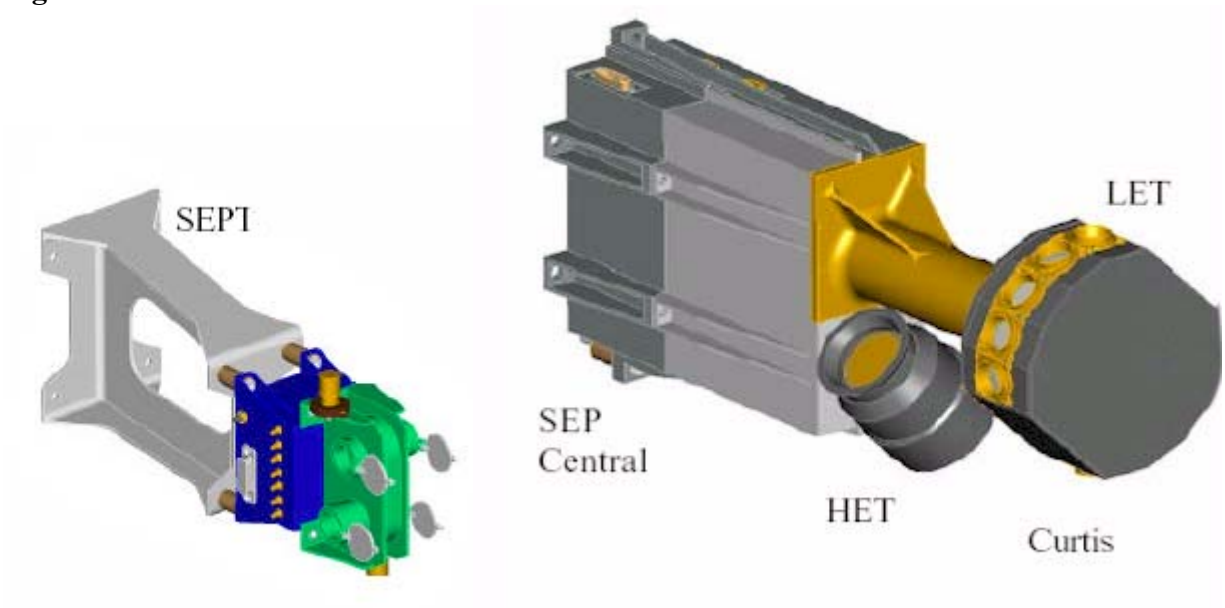


Figure 1.2.2-2a



1.3. *Importance of Contamination Control for IMPACT*

IMPACT is one of four instrument packages on the STEREO spacecraft. Contamination requirements for IMPACT instruments are driven by IMPACT's own sensitivity as well as cross-contamination concerns with other instruments packages. Science sensors on IMPACT are sensitive to contamination. Table 1.3-1 lists the sensor and subsystem components that are adversely affected by contamination.

Table 1.3-1: IMPACT Components Affected by Contamination

REVISE TABLE!!!!

Sensitive Surface	Contamination	Effect on performance
Solid state detectors	hydrocarbons (condensed organic material)	increase of noise, degradation of energy resolution
	acid vapour (molecular contamination)	increase of noise or breakthrough
	water vapour (molecular contamination)	increase of noise or breakthrough
	particle deposition	degradation of energy resolution
Micro-channel plates		
Rare earth magnets	humidity	corrosion
	acids, alkaline solutions	corrosion
Parylene foil	particle deposition	degradation of energy resolution

1.4. *Responsibilities for Contamination Control*

The overall IMPACT program is being led by Dr. David Curtis of University of California at Berkely (UCB). It is UCB's overall responsibility to ensure that the contamination control requirements are met for the mission. Science sensors are being provided by teams throughout the U.S. and abroad. The individual sensor teams are responsible for providing sensors and hardware that meet the contamination control herein. The IMPACT Contamination Control Engineer and Program Manager have primary responsibility for the cleanliness of IMPACT. Any deviations from this plan shall be approved by them or their designated representative and

must be documented in accordance with Product Assurance requirements applicable to the institution which identifies the deviation.

A unique feature to the IMPACT suite of instruments and sensors is that there are multiple levels of sharing of electronics and software from the component to the system level. Consequently, components and subsystems can and will be tested and calibrated in multiple facilities. Each institution responsible for integrating contamination sensitive components will be responsible for providing the appropriate class of cleanroom facility. Whenever this is not possible (environmental test facilities), components shall be kept bagged. It is anticipated that the individual IMPACT institutions will have their own unique operating procedures for proper clean room operations. This document provides minimum requirements for facilities and procedures.

2. APPLICABLE DOCUMENTS AND TERMINOLOGY

Government and Industry General Standards and Specifications

ASTM

ASTM E595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment
ASTM E1234	Standard Practice for Handling, Transporting, and Installing Nonvolatile Residue (NVR) Sample Plates Used in Environmentally Controlled Areas for Spacecraft
ASTM E1559-93	Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials
ASTM E1560	Method for Gravimetric Determination of Non Volatile Residue from Cleanroom Wipers

Federal

FED-STD-209E	Federal Standard Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

Military

MIL-STD-1246C	Product Cleanliness Levels and Contamination Control Program
MIL-P-27401C	Propellant Pressuring Agent, Nitrogen

NASA

GSFC-TLS-PR-7324-01	Contamination Control Procedure for the Tape Lift Sampling of Surfaces
GSFC-MLS-PR-7324-01	Contamination Control Procedure for the Molecular Wipe Sampling of Surfaces
JSC SP-R-0022A	Vacuum Stability Requirements of Polymeric Materials for Spacecraft Application – General Specification
NASA-JSC-08962	Compilation of VCM Data of Nonmetallic Materials
NASA Reference	Outgassing Data for Selecting Spacecraft Materials, ONLINE at http://outgassing.gsfc.nasa.gov/og/
NASA MAPTIS	Materials and Process Technical Information System Database Center
MSFC-HDBK-527	Material Selection List for Space Hardware Systems -JSC 09604, Rev. E or later
SN-C-0005	Contamination Control Requirements for the Space Shuttle Program

Program Specific Government and Contractor Documents

APL

7381-9006	CONTAMINATION CONTROL PLAN STEREO

UCB

	Electrostatic Handling and Discharge Procedure

2.1. *Terminology*

2.1.1. List of Acronyms

Caltech	California
CESR	Centre d'Etude Spatiale des Rayonnements
CVCM	Collected Volatile Condensable Material
ESD	Electrostatic Discharge
EOL	End of Life
FOV	Field of View
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HET	High Energy Telescope
JPL	Jet Propulsion Laboratory
IPA	Isopropyl Alcohol
LET	Low Energy Telescope
MAG	Magnetometer
MCP	Micro-channel Plate
NVR	Non-Volatile Residue
PAC	Percent Area Coverage
PWB	Printed Wiring Board
QCM	Quartz Crystal Microbalance
SEP	Solar Energetic Particle Package
SEPT	Solar Electron and Proton Telescope
SIT	Suprathermal Ion Telescope
STE	Suprathermal Electron Telescope

SWEA	Solar Wind Electron Analyzer
TML	Total Mass Loss
UCB	University of California Berkeley
U of MD	University of Maryland

2.1.2. General Terminology

Clean Area	An enclosed, environmentally conditioned area where airborne contaminants are controlled. Clean areas are classified by a number such as 100, 10,000, 100,000, etc., in accordance with FED-STD-209, which describes the maximum number of particles, 0.5 microns in size and larger, permitted per cubic foot of air under certain performance and operating requirements.
Contamination	Unwanted foreign or native material that degrades the intended function of an instrument or flight hardware. Contamination is usually separated into two types, particles and non-volatile residue (NVR).
Contamination Control	Organized action to control contamination levels.
Fiber	Particle with a length-to-width ratio exceeding 10:1 and a minimum length (100 μm.
Particle	Small quantity of solid or liquid material with definable shape or mass.
Particle Size	Maximum linear dimension or diameter of a particle.
Gross Cleaning	A cleaning operation performed to achieve a level of product cleanliness as part of good workmanship and good housekeeping practice, for example the removal of oils, grease, oxide films, etc. Gross cleaning does not usually require verification beyond visual appearance as observed without optical aids other than normal corrected vision. This step precedes precision cleaning.
Precision Cleaning	Cleaning of hardware surfaces according to approved engineering methods and procedures to meet specific criteria.
Sensitive Surface	Flight hardware surface requiring a specific cleanliness level to meet minimum performance requirements.
Solvent Flushing	Pressurized stream of filtered solvent directed against a surface to dislodge and rinse away contaminants.
Solvent Washes	Quantitative method of verifying MIL-STD-1246C levels by measuring molecular contamination in a solvent washed over a

	surface.
Surface Cleanliness Level	An established level of maximum allowable particulate and/or nonvolatile residue (NVR) contamination ranging from visibly clean to specific MIL-STD-1246 levels.
Swab Sample	Qualitative method of identifying contaminants by analyzing residue on a solvent soaked swab that was wiped over a surface.
Nonvolatile Residue (NVR)	Soluble material remaining after evaporation of a volatile solvent, or determined by special purpose analytical instruments, usually in milligrams per unit area.
Tape Lifts	Qualitative method of verifying MIL-STD-1246C particle cleanliness levels by measuring particle contamination on a tape sample that has contacted a surface.
Vapor Degrease	Item to be cleaned is exposed to heated solvent vapors that condense on the part and wash away contaminants. (NOTE: Halogenated solvents used to vapor degrease plastics are often outgassed or leached our later. Therefore, plastics vapor degreased with halogenated solvents must be baked out.)
Visibly Clean	The achievement of a visibly clean surface when viewed without optical aids (except corrected vision) as measured by a specific method. This requirement will be accompanied by a description of the method of verification (e.g., when viewed from an approximate distance using oblique white light of an approximate intensity or under normal shop lighting, etc.).
VC	Cleanliness inspection which specifies and incident light of 50 to 75 foot-candles. The surface to be inspected shall be observed by the unaided (except for corrected vision) eye at a distance of 2 to 5 feet.
VC-S	Cleanliness inspection which specifies an incident light of 50-75 foot-candles. The surface to be inspected shall be observed by the unaided eye (except for corrected vision at a distance of 12-24 inches).
VC-HS	Cleanliness inspection which specifies an incident light level of 100-125 foot-candles. The surface to be inspected shall be observed by the unaided eye (except for corrected vision) at a distance of 6 to 18 inches.
Plus Ultraviolet	Visibly clean (as defined above) and inspected with the aid of an

ultraviolet light (black light) of 3200 to 3800 Angstrom wavelength (320 to 380 nanometers).

2.1.3. Surface Terminology

Precision Clean	Surface having a specific particulate size and count and NVR weight
Visibly Clean	Surface showing no visible contaminants when inspected with corrected vision and viewed from 6 to 18 inches with: (i) incident white light level over 200 footcandles (ii) a UV (blacklight) lamp, pen-ray or high intensity fiber optic lamp

2.1.4. Area and Volumetric Terminology

Clean Area	Defined work area in which the concentration of airborne particles is controlled
Clean Class	The maximum level of airborne particles for a clean area, defined by the number of particles 0.5 microns or larger per cubic foot; The clean class of a clean area is regarded as the maximum allowed level, and actual measured airborne contamination is expected to be less than the specified level.
As-built clean area	A clean area that is complete and ready for operation, with all airflow equipment operating, but without any equipment, furniture, or personnel
At-rest clean area	A clean are that is complete, with all airflow and production equipment operating, but without personnel in the facility
Operational clean area	A clean area in normal operation, with all services functioning and with personnel present at a normal level of activity

2.1.5. Cleaning Terminology

Gross cleaning	Cleaning operation performed to achieve a level of product cleanliness as a part of good workmanship and good housekeeping practice It does not require verification beyond visual appearance.
Precision cleaning	Cleaning operation performed to achieve specific particle and NVR level requirements; It usually requires verification by measuring contamination from sample surfaces
Solvent flushing	Method of cleaning surfaces by flowing solvent across a surface to remove contamination

Vapor Degrease	Method of cleaning in which a part is exposed to heated solvent vapors which condense on the part and wash away contaminants

3. Contamination Requirements

3.1. *Contamination Sensitivities for Sensors and Subsystems*

IMPACT contains microchannel plates (MCPs), solid state dectectors (SSD's), foils, deployment mechanisms and high voltage surfaces which are sensitive to particles, NVR, and high levels of outgassing. Some of the solid state detectors have coatings which make them sensitive to chemical vapors and humidity – both of which react with the coating and degrade it. Table 3.1-1 lists the elements of each sensor that are sensitive.

Sensor/Suite	Sensitivities	Purge Yes (Y) No (N)	Red Tag Cover Yes (Y) No (N)	Cleanliness Environment and Precautions (Class per FED-STD-209)	
				Pre-delivery	Post-delivery
MAG					
Boom	Large particles jamming boom deployment mechanism	No	No	Class 10,000 unbagged	May be exposed to Class 100,000 but this will require deployment of limited life mechanism to permit cleaning. Bag to remain in place to prevent debris and contaminants from falling into recesses.
SW					
SWEA		See below	See below	Class 100 for SWEA integration when MCP's are exposed or surfaces that will be near them. Class 10,000 (with red tag cover in place)	Dust cover removed only for short periods of time Cover may also be removed for thermal vacuum testing. IMPACT team member required to be present during solvent cleaning near IMPACT (within 1 meter). Supplemental purge to bag whenever an airborne chemical threat is possible – e.g., launch pad cleaning with alcohol. .
MCP	Particles, NVR, Humidity Corona arcing if pressure is not low enough.	YES	YES	Class 100 without red tag cover	Soft cover to replace red tag during some environmental tests: spin balance and vibration.
Internal Surfaces					
STE		YES	Reclosable doors	Class 100 until door is sealed. Class 10000 preferred afterwards.	Inspect and reclean surfaces prior to opening doors if

				Class 100,000 acceptable but unit must be thoroughly cleaned before doors are opened.	exposed unless protected from cleanroom fallout. Doors closed during thruster operations, sensitive to thruster by-products and local rises in pressure.
Solid State Detector	NVR, particles, chemical vapors including humidity	YES		Class 100 with doors open	Detectors must be stored in dry nitrogen purge or vacuum. Unbagged detectors must be on Class 100 clean bench. IPA only permitted cleaning solvent. IPA cleaning permitted near detectors only when detectors are bagged and purged and quantity of alcohol is limited.
SEPT					
Solid State Detector	NVR, particles, chemical vapors including acids and humidity	YES		Class 100 with door open or telescope unbagged	Detectors must be stored in dry nitrogen purge or vacuum. Unbagged detectors must be on Class 100 clean bench. IPA only permitted cleaning solvent. IPA cleaning permitted near detectors only when detectors are bagged and purged and quantity of alcohol is limited. Door opens onetime on-orbit; it is designed to protect sensor from direct sunlight. It does not seal well enough to prevent ingress of contaminants. Brief (4 to 6 hours) exposures to class 3000 permissible with unit unbagged

Parylene Foil	NVR, particles	NO	NO	Class 100 with door open or unit unbagged	Class 100 with door open or unit unbagged. Brief exposures (4 to 6 hours) to class 3000 permissible with unit unbagged
SIT					
SIT		YES	One time door		
Thin entrance foil	Particles				Particles can puncture during acoustic testing. Acoustic cover required to protect foils from vibration damage.
Solid State Detector	NVR, particles, chemical vapors including acids and humidity	YES		Class 100 with doors open	Detectors must be stored in dry nitrogen purge or vacuum. Unbagged detectors must be on Class 100 clean bench. IPA only permitted cleaning solvent. IPA cleaning permitted near detectors only when detectors are bagged and purged and quantity of alcohol is limited.
MCP	Particles, NVR, Humidity Corona arcing if pressure is not low enough.	YES	YES	Class 100 without red tag cover	Soft cover to replace red tag during some environmental tests: spin balance and vibration.
HET					
Solid State Detector	NVR, particles, chemical vapors including acids and humidity	YES		Class 100 with doors open	Detectors must be stored in dry nitrogen purge or vacuum. Unbagged detectors must be on Class 100 clean bench. IPA only permitted cleaning solvent. IPA cleaning permitted near detectors only when detectors are bagged and purged and

					quantity of alcohol is limited.
LET					
Solid State Detector	NVR, particles, chemical vapors including acids and humidity	YES		Class 100 with doors open	Detectors must be stored in dry nitrogen purge or vacuum. Unbagged detectors must be on Class 100 clean bench. IPA only permitted cleaning solvent. IPA cleaning permitted near detectors only when detectors are bagged and purged and quantity of alcohol is limited.

4. Contamination Allowance and Verification

As IMPACT hardware passes through various phases from cleaning of piece parts to Mission EOL, contamination accrual/transfer is expected to increase contamination levels on hardware over time. Surfaces will be recleaned as necessary. Some surfaces will not be accessible after assembly, there is no requirement to re-verify these surfaces unless a contamination event affecting them is suspected. Therefore, contamination budget allocations have been established for various phases of I and T in order to provide controls over contamination accrual/transfer.

All sensors shall meet the contamination control levels specified herein. Prior to delivery at APL and at delivery, a tape lift verification test (or visual inspection if tape lift is not possible) will be made by IMPACT contamination representatives on all elements of the IMPACT suite to verify compliance. No instrument will be formally accepted for payload integration until the cleanliness level is verified. It is the each sensor team's responsibility to make certain that their sensor meets these requirements.

4.1. *Contamination Budget*

Unless stated in Table 3.2-1, external surfaces of all IMPACT components that are mounted externally on the spacecraft, shall meet a surface cleanliness level of 300 A (or equivalent PAC) per MIL-STD-1246. with Integration activities at UCB shall take place in Class 10,000 cleanroom environment, and purge shall be maintained at all times except when interruptions are explicitly permitted. The IPDU and any other items which will be located inside the STEREO spacecraft shall meet the STEREO spacecraft requirement of level 300 A (or equivalent PAC) per MIL-STD-1246. Thermal Control surfaces shall not exceed Level B per MIL-STD-1246 at End-of-Life.

5. Table 3.2.-1. IMPACT Internal Surface Contamination Sensitivities

Surface	Delivery to APL		Observatory Level BOL (pre-launch)		Observatory Level EOL
	MIL-STD-1246	**Visual SN-C-0005 or other**	**MIL-STD-1246**	**Visual SN-C-0005 Or other**	**MIL-STD-1246**
SWEA					
Microchannel plates	Level 100 A/3*	VCHS+UV White Light with Magnification No particles over 100 microns	Level 100 A/3*	VCHS+UV White Light with Magnification No particles over 100 microns	Level A/2 No particles over 100 microns
STE					
Silicon Solid State Detectors	50 A/5*	VCHS+UV White Light with Magnification	50 A/5*	VCHS+UV White Light with Magnification	50 A/5*
SIT					
Solid State Detector	Level 300 A/2*	VCHS+UV White Light with Magnification No particles over 100 microns	Level 300 A/2*	VCHS+UV White Light with Magnification No particles over 100 microns	Level 500 Level A No particles over 100 microns
Thin Foils	Level 300 A/2*	VCHS+UV White Light with Magnification No particles	Level 300 A/2*	VCHS+UV White Light with Magnification No particles	Level 500 Level A No particles over 100 microns

		over 100 microns		over 100 microns	
SEPT					
Solid State Detectors –	300 A/2*	VCHS+UV	300 A/2*	VCHS+UV	300 A
Parylene Foil -- Particle Deposition			300 A/2		300A
LET					
Silicon Solid State Detectors	300 A/2*	VCHS+UV	300 A/2*	VCHS+UV	VCHS+UV
HET					
Silicon Solid State Detectors	300 A/2*	VCHS+UV	300 A/2*	VCHS+UV	VCHS+UV

* MIL-STD levels are stated as goal levels. Many surfaces cannot be touched. Verification shall be via bright white and UV light inspection in a darkened room at a distance of 18 to 24 inches with corrected 20/20 vision and 3X to 10X magnification aides for levels of 100 or lower, witness plates or successful performance test.

5.1. *Outgassing Requirements*

IMPACT will be certified to meet the good neighbor outgassing requirements specified by the APL analyst in accordance with the general procedure described in 7381-9006, APL's Contamination Control Plan.

6. Verification

6.1. *Surface Cleanliness Verification Methods*

6.1.1. MIL-STD-1246 Particles

Direct verification of surface cleanliness maybe done using the tape lift method in accordance with GSFC-TLS-PR-7324-01. Alternatively the item may be rinsed with filtered Isopropyl Alcohol and the effluent run though particle filter paper with grids. The filter paper is counted per MIL-STD-1246.

6.1.2. MIL-STD-1246 Non-Volatile Reside (NVR)

NVR levels may be verified by rinsing 1 sq foot of the surface with Reagent Grade Isopropyl Alcohol and collecting the effluent in a clean container. The effluent is later evaporated, the residue weighed and, if desired, analyzed for chemical constituents using Fourier Transform Spectroscopy or Gas Chromography. NVR levels can also be inferred using

6.1.3. MIL-STD-1246 – Alternative Methods

When it is impossible to conduct the tests in paragraphs 6.1.1 and 6.1.2, due to incompatibility of the substrate with the solvent or adhesive, or when the MIL-STD level is listed as a goal, the following alternate tests may be conducted:

	Alternative Method
Tape Lift/Rinse for Particles	
Cleanliness 300 or greater	White and black light inspection per UVHS+UV per SN-C-0005.
Cleanliness level of less than 300	In addition to the above: white light inspection in a darkened room with grazing incidence and magnification of 3X to 10X as an aide. All visible particles are to be removed. Mandatory for surfaces which require particle surface cleanliness levels below 100.
All levels	Particle fallout witness plates analyzed per MIL-STD-1246
NVR	
A/2 or greater	Black Light inspection per SN-C-0005
A/5 or less launch requirement	MgF witness mirrors evaluated at 1216 angstroms for transmission or reflection loss.
All levels	Clean aluminum foils evaluated with FTIR

6.1.4. Visual Inspection per SN-C-0005

Inspections shall be carried out per SN-C-0005 using black or white light as indicated. White light inspections may be conducted under ambient lighting except when surface cleanliness levels are less than 300. In this case, a white light inspection shall be performed in a darkened room, with an illumination equivalent to 100 foot candles obliquely illuminating the item. The item shall be viewed from an oblique angle on for particles. This method words best on specular surfaces. Magnification aides of at least 3X and up to 10X may be employed to aide in the inspection of the most contamination critical items.

6.2. *Acceptance Criteria*

Items shall meet the acceptance criteria of the respective specifications. Contamination shall be removed if levels violate the acceptable maximum. Removal methods may include, vacuuming, solvent wiping, nitrogen blow off, ionized air blow-off, vibration or other method recommended by the manufacturer. Particles or films which cannot be safely removed shall be evaluated by the Contamination Engineer or designated representative and the responsible design engineer. If the hardware will meet its intended purpose and will not cross-contaminate or degrade the performance of other hardware, the contamination shall be acceptable. In the case of excess adhesive that may outgas, it is acceptable to encapsulate the adhesive using flight approved kapton tape with acrylic adhesive providing it will not interfere with the form, fit, or function of the item. Unremovable contaminants on contamination critical surfaces (mcp's or ssd's for example) shall be documented through sketches or photos for future reference.

6.3. *Outgassing Verification*

Completed IMPACT sensors and subassemblies will be certified either together or separately according to the APL Contamination Control Plan and the general thermal vacuum procedures described herein. UCB may elect to forgo the pre-certification phase of the APL Plan if UCB deems that a bakeout will be required based on past experience with similar hardware.

7. Facility REquirements

7.1. *Required Cleanliness Classes*

The required surface cleanliness of hardware shall determine the type of facility in which unbagged hardware may be exposed. Table 6-1 contains the requirements for the IMPACT instrument suite. At the lower levels of assembly IMPACT piece part hardware may be fabricated environments other than those shown, providing that the hardware can be cleaned to the proper levels. Examples of items which cannot be easily cleaned are items with recesses where particles may become trapped or items with surface finishes that cannot be touched or exposed to solvents. Should piece part and other hardware be fabricated in a non-cleanroom environment, care shall be taken to avoid contact with contaminants that cannot be removed by normal cleaning methods.

Surface Cleanliness Level	Facility Cleanroom Class	Comments
>300 or >A/2	Class 10,000	Until bakeout, items which can be easily re-cleaned to level 300 A/2 may be exposed to Class 100,000 environments. Items which cannot be cleaned should be handled in a Class 100 environment only – e.g.,solid state detectors and MCP's. The IMPACT Contamination Engineer may authorize exceptions on a case by case basis.
<300 or < A/3	Class 100, NVR less than 0.3 mg/sq foot per month.	If a clean bench is used, it is preferable that the bench be located in a clean room or else an isolated area with limited traffic and sources of contamination.

7.2. *Facility Surface Cleanliness Requirements*

The following table provides a summary of required cleanliness levels of cleanroom surfaces.

Table 5.2-2 Cleanroom Surfaces – Required Cleanliness Levels

Surface	Hardware Surface Cleanliness/ Required Facility Surface Cleanliness Level per SN-C-005C		
	Unbagged 100 or Sub Class 100 Surfaces exposed	**Bagged Surfaces Class 100 to class 10,000**	**Double Bagged Surfaces Class 10000 to 100,000 cleanroom**
Walls	VCHS +UV	VCHS	VC
Horizontal work surfaces	VCHS+UV	VCHS	VC
Vertical surfaces within 2 feet of flight hardware	VCHS+UV	VCHS	VC
Floors	VC	VC	VC

7.2.1. Restricted Materials and Activities in Facilities

IMPACT components are highly sensitive to condensable airborne molecular and particulate contaminants. It is imperative that all activities that could contaminate the air supply for any IMPACT facility be strictly monitored and controlled for the period extending 3 months before the arrival of IMPACT until just after its departure. This requires close coordination with facility managers and building managers to assure control of these activities. No facility modifications should be planned during this time period if possible.

To avoid accidental contamination of the air supply, the IMPACT CC engineer and the responsible I&T manager for that phase of the project shall be notified in writing of all such activities so that their contamination potential may be assessed. Activities posing a significant risk should be prohibited. If this is not possible, the cleanroom must be tested for airborne molecular and particulate contaminants during and after completion of the operation. Table 5.1.1-1 provides a summary of typical restricted materials and activities for cleanrooms.

Table 5.2.1-1 Restricted Materials and Activities in Facilities

Activity	Notes, Restrictions
Painting	Walls, GSE, doors, exteriors of adjacent buildings, etc.
Adhesive bonding, gluing	Installation of carpets, base board molding
Combustion engine operation	Near air intakes, cranes, forklifts, trucks, etc.
Insecticide/herbicide spraying	Inside the building
Aerial Insecticide/herbicide spraying	Outside of the building
Storage of materials that outgas	Storing large quantities of plastics, wood, laminates, lubricants, if air can enter the cleanroom make-up air intakes
Major roof or road sealing operations	Within 1000 feet or building air intakes.
Sealants, caulks	Windows, bathrooms, ceiling tiles, HEPA Filters
Sandblasting, sanding, grinding, jack hammering	Near make-up air intakes
Repair, replacement, or lubrication of cleanroom equipment	Air handling equipment, cranes, doors, etc.

Note: If Charcoal filters are installed in the make-up air intakes this will greatly reduce the risk of problems due to any of the activities listed above.

7.2.2. Restricted Activities in the Cleanroom

The activities listed below require approval of the responsible contamination engineer for each operation. The contamination engineer shall specify what precautions must be taken to protect hardware and/or the facility. Concurrence of the facility manager should also be obtained as some facilities may elect to prohibit the operation entirely (although in the aerospace industry these operations are normally allowed if proper precautions are taken).

- Drilling
- Sanding, dremeling or other processes that use friction to abrade material
- Curing adhesives
- Brazing/welding/soldering
- Use of solvents other than isopropyl alcohol
- Use of high intensity heat sources
- Tearing or ripping of plastics and paper
- Painting/conformal coating
- Erection/assembly of scaffolding or other large structures
- Moving large pieces of hardware

7.2.3. Garments

In class 10,000 cleanrooms, or better (per FED-STD-209E), personnel tend to generate the largest percentage of particulate fall-out because standard garment requirements leave large portions of the body uncovered. Sometimes only shoe covers, loose shower caps and smocks are worn in class 10,000 facilities. This results in high fall-out rates. To dramatically reduce these rates and avoid high cleaning costs, personnel shall wear class 100 garments for all activities requiring a class 10,000 or better cleanroom. The following garments shall be worn: hood, class 100 compatible low NVR gloves (should not deposit more than 0.1 mg/sq foot molecular

contamination), jumpsuits (smocks possible if worn with hood), and boots. Garments shall be certified to meet class 100 cleanroom requirements per IES-RP-CC003.2 after cleaning. Smocks and shoe covers may be worn in lieu of bunny suits and boots for activities on IMPACT hardware in the following situations:

- easily cleanable hardware
- operations in class 100 flow bench (bunny suits recommended to reduce ambient fiber loads – more frequent inspection of flow bench for contamination is required)

In order to meet the molecular cleanliness requirements, class 100 compatible low NVR gloves (should not deposit more than 0.1 mg/sq foot molecular contamination) be worn during all integration activities.

7.2.4. Training

The IMPACT Contamination Engineer or designated representative will provide cleanroom training to all personnel. Personnel entering the cleanroom shall either have received training or be escorted by an authorized person. Records of training will kept by each institution.

7.2.5. Facility Contamination Control Monitoring

7.2.5.1 Facility Monitoring—Molecular Contamination

Molecular witness plates will be installed in the cleanroom at least two months prior to instrument integration in order to establish that the cleanroom does not contain unacceptable levels of molecular contamination. The level of molecular contamination shall be measured on a monthly or bi-monthly basis per MIL-STD-1246 for facilities where SSD's, MCP's or other contamination critical IMPACT components are being fabricated.. Levels exceeding 0.5mg/sqft per month shall require corrective action.

7.2.5.2 Facility Monitoring—Particle Contamination

Particle levels for .5 and 0.5 micron level particles shall be monitored. Class 100 facilities shall be measured for 0.3 microns particles. Particle monitoring shall be within 6 to 8 feet of IMPACT work areas. Corrective action shall be implemented when the requirements for the facility cleanroom class are exceeded for more than a half hour or large excursions from the norm occur and persist. Flight hardware shall be covered as soon as possible after determining that the cleanroom is going out of specification and the condition is going to persist.

7.2.6. Facility Maintenance

Facility maintenance shall be performed per specific procedures, and using specific cleanroom-approved materials. Controls shall be established and documented in either in the Facility Contamination Control Procedure.

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7.3. *Cleaning*

Cleaning processes for each facility shall be documented and available for review. Processes used to clean flight hardware shall not use solvents, materials, and aids which will degrade a surface of class 50 A/5 cleanliness.

Cleaning process procedures shall address the following:

- Cleanliness requirements for materials used
- Cleanliness requirements for solvents used
- Vacuum requirements (e.g., HEPA filter, external exhaust, etc.)
- Cleaning and Verification Scheduling

Each instrument subassembly supplier, cleanliness verification and cleaning flowchart which shall be available for review at the supplier's facility. The flowchart shall list all cleanliness verification points from receiving to shipping. Mandatory verification points shall be as follows:

- achieved cleanliness for interior surfaces prior to enclosing
- achieved cleanliness for surfaces that will be covered by external MLI
- achieved cleanliness for exterior surfaces prior to and after shipping

Baseline processes for IMPACT hardware are one of the following depending on substrate:

- Ultrasonic cleaning aqueous using detergent deionized water, and lastly spectral grade alcohol
- Ultrasonic cleaning using acetone followed by alcohol (ethyl or spectral grade isopropyl)
- Hand wiping using low NVR, class 10 (levels under class 100) or Class 100 compatible cleaning wipes and highly purity, filtered solvents
- Nitrogen blow off using high purity gas gun with no lubricants and research grade nitrogen or boil-off.
- Vacuuming using adjustable suction tools and brushes

Each process shall be verified capable of achieving the level of cleanliness for the part. Operators shall be certified through training and testing of cleaned hardware to verify that it meets contamination levels. The goal is to establish a proven process that consistently produces parts of the desired cleanliness level.

Solvent use near solid state detectors must be strictly controlled and monitored by the detector representative. The detector must be under active purge and the quantity of solvent must be limited. IPA is the only approved solvent.

8. Contamination Control Operations for IMPACT

Possible sources of contamination for the IMPACT observatory are numerous and differ at various stages of hardware development. Potential sources of contamination which may adversely affect the IMPACT subsystems and instruments are summarized in Table 5.0. The contamination control plan described herein seeks to minimize the effect of these sources and maintain cleanliness of payload components with the allocated budget during all program phases.

8.1. *Design*

During the design phase of any spaceflight hardware program many decisions, trades and options are exercised that have a direct effect on the contamination levels of the flight hardware during later phases of the program. The IMPACT project will be active in evaluating designs of all subsystems to minimize future contamination sources.

8.1.1. Materials

It is required by the IMPACT project that a material list be provided for each subsystem for approval by UCB prior to fabrication. The list is to include material name, description, manufacturer, and usage. The characteristics of total mass loss and condensable volatile condensable materials are also to be included on this list. NASA Reference Publication 1124 or MAPTIS will be consulted to determine that all non-metallic materials have a Total Mass Loss (TML) of 1.0% or less and Collected Volatile Condensable Material (CVCM) of 0.1% or less. Acceptability of materials for flammability and odor will be determined from document ASTM E595.

8.1.2. Overall Design

The overall design of subsystems and instruments on the IMPACT observatory must make minimizing contamination one of the highest priority design requirements. The following "rules of thumb" should be used whenever possible;

1. TML and CVCM of all materials should be examined before committing the material to the design. If alternate materials are available, the lower outgassing material should be used.
2. In general, the use of non-metallic or ceramics should be minimized. Materials including plastics, elastomers, tapes etc. are typically high outgassing components.
3. Surface coatings such as paints, finishes, metal treatments must also be examined for their contamination contribution. In general, chem-filmed aluminum or passivated stainless steel is the best finish from a contamination standpoint.
4. Boxes, components and subsystems should be designed to be easily and thoroughly cleaned. Parts should minimize small pockets, blind holes etc., were it is difficult to physically clean. Materials must be suitable with cleaning solvents.
5. The use of trapped and unvented volumes should be minimized. Volumes such as blind holes partially filled with a fastener, non-vented honeycomb or thermal blankets all look like "virtual leaks" due to their high resistance path for venting of the trapped gases.
6. In general, surface area of boxes and subsystems should be minimized due to the surface trapping of water. Thermal blankets with their large area to volume ratio are notorious for contributing to the overall water contamination budget.
7. All enclosures should be designed to vent away from volumes on the IMPACT spacecraft containing contamination critical components.

8. Boxes, components and subsystems should be designed to minimize the need for being handled directly by personnel. Handling fixtures or other mechanical ground support equipment is useful in eliminating the need for direct handling of the flight hardware.
9. Because many manufacturing and assembly processes by their nature are dirty, parts should be designed for easy disassembly for required cleaning.

8.2. *Fabrication*

8.2.1. Manufacturing

Most piece part components and parts are fabricated in industrial areas with little or no contamination controls. Possible contamination sources are numerous. Machined parts may be contaminated with machine oils, welding flux, fingerprints, metal chips or room fallout. Electrical parts and printed wiring boards (PWBs) may be contaminated with mold release, solder flux, silkscreen or solder mask.

Appropriate cleaning processes must be used to remove contaminants prior to the integration of a part with the IMPACT assembly (Section 6). Initial cleaning of parts, following fabrication, will require a higher level of cleanliness than in any subsequent phase of operation such as at the end-of-life or at launch.

Most of this early stage hardware manufacturing will take place in areas exceeding a Class 300,000 cleanroorn specification. During manufacturing, the following handling requirements shall be followed:

- during contamination generating manufacturing operations such as drilling, welding, etc., contaminants (metal chips, dust, etc.) shall be cleaned off hardware as generated.
- prior to applying coatings, paints, etc., surfaces shall be cleaned and visually inspected, per the coating and application procedures.
- all areas which become inaccessible during the fabrication and assembly processes shall be thoroughly cleaned, with-vacuuming and solvent wiping, and visually inspected prior to becoming inaccessible.

Harness fabrication, printed circuit fabrication, machining, plastics application, part screening, part testing, and part inspection for experiment parts are performed in an area where environment is controlled to good housekeeping practices, primarily for personnel comfort. Smoking, eating, and drinking are forbidden in these areas. Steps should be taken to avoid cross contamination with difficult to remove contaminants in these areas.

8.2.2. Assembly

After manufacturing, all parts will be cleaned to level 300A and visually inspected. Assembly will take place in a Class 10000 cleanroom.

During assembly, hardware shall be cleaned and inspected at various points, with the following general guidelines. More specific instructions shall be written on the appropriate assembly process traveler.

With regard to the piece parts disassembled at the end of each building stage, proceed as follows:

a) Solvent wipe the component with lintless wipes or swabs.

b) All surfaces, holes, penetrations, and crevices shall be cleaned by vacuuming and solvent rinsing.

c) Clean all surfaces with solvent using lintless wipes. Painted surfaces must be treated separately with special procedures for them. Continue cleaning until surfaces appear visually clean and until no contamination is visually seen on wipes.

d) Inspect visually, and as called out on the assembly process traveler.

e) Vacuum any particulates as required and as generated.

Prior to final assembly:

a) Vacuum the entire surface of the previous assembly, paying special attention to crevices, riveting surfaces, rivet holes, etc.

b) Solvent wipe off any particulate matter that remains.

c) Inspect assembly with UV light for greasy marks and deposits.

d) Clean the surfaces and greasy marks with solvent wiping. (Painted surfaces must be treated separately.)

During and after assembly:

a) During assembly (riveting, etc.), solvent wipe and/or vacuum surfaces as contamination is generated.

b) Inspect next assembly surfaces for accumulated contamination and clean as required.

c) After assembly is complete, clean all surfaces of generated contamination. Follow the same cleaning procedures as done prior to assembly

8.3. ***Subsystem Test and Calibration***

8.3.1. Thermal Vacuum Bakeout Plan

IMPACT flight hardware shall be baked-out including flight or vacuum exposed purge hardware. Thermal Vacuum GSE must be fabricated using low outgassing materials and be baked out prior to use with flight hardware. Bakeout is not required for GSE that contains mostly inorganics, has been precision cleaned and which will be baked out at the same time as non-critical flight hardware. When possible bakeout should occur at the lowest possible level of assembly to maximize bakeout temperatures and minimize bakeout time. The following items especially should be baked out at lower assembly level: circular or potted connectors, harnesses, thick

elastomers (thermal gaskets, o-rings, potted items), and assemblies containing large amounts of potting or other organics. Bakeout for assemblies containing only inorganic components and cleaned using IMPACT approved precision cleaning processes but which will be later certified for outgassing, may be waived with the approval of the IMPACT Contamination Engineer or Analyst. Approval will depend on location and potential for cross contamination or residual contaminants even after cleaning.

8.3.2. Each bakeout should have a test document that documents test thermal profiles for chamber, bakeout boxes, TQCM's, cold fingers, flight hardware and other GSE. Outgassing certification bakeouts will also contain a data sheet for the contamination analyst to complete giving the certification requirements for the chamber and the flight hardware.

8.3.3. Thermal Vacuum Bakeout Conditions

IMPACT components shall undergo thermal vacuum bakeout in order to meet the required outgassing criteria. Whenever possible bakeout boxes shall be employed to permit more accurate measurements of rates, isolate components from chamber environments, and reduce costs of chamber certification and clean-up (boxes are vented to a cold plate to trap contaminants). The bakeouts and certifications shall be performed under the following conditions:

Table 7.1-1 IMPACT Thermal Vacuum Bakeout Conditions

Condition	Specification
Vacuum	At least 10^{-6} torr for certification
Modeling	Approximately 2 weeks before the test, the IMPACT Analyst shall be given the following information on the chamber: Description of the flight hardware and major materials of construction, approximate surface area of the flight hardware Drawing giving dimensions of chamber, location and dimensions of ports and pump orifices, cold plates, cold fingers Approximate TQCM and flight hardware locations If a bakeout box will be used, the dimensions of the box, location of TQCM and cold finger within the box The analyst will calculate the certification requirements (temperatures, outgassing rates) for the chamber/bakeout box and provide them for the start of the certification test The day of chamber closing the IMPACT analyst shall be given the following information: As Run location of the TQCM and flight hardware Approximate surface area of the hardware Digital photo of set-up (if possible) or sketch The analyst will complete the analyst data sheet including the as-run certification TQCM requirements; tend end criteria (including hz/hr/hr

	requirements signifying diminishing returns), certification temperature of flight hardware and TQCM. During the test TQCM Data shall be provided to the analyst at mutually agreed to times (as frequent as hourly but no longer as daily). The modeler will maintain a database of achieved bakeout rates and will have the authority to reallocate the outgassing budget based on achieved rates.
Temperature of instrument/component/assembly during bakeout	Highest possible temperature minus chamber temperature tolerance Exercise care in the following situations: -Heating adhesives under load above their cure temperatures (verify glass transition point and manufacturer's recommendations – some adhesives will soften as they start to cure at a higher temperature) -Heating adhesives in dimensionally critical or stress sensitive assemblies above temperatures they will see in flight (some adhesives shrink) -Heating optics or metals higher than temperatures at which they were stress relieved
Temperature of instrument/component/assembly during certification	Hot case survival temperature or 10 degrees over the hot case operating temperature (or as specified by analyst) It is acceptable to use a higher temperature in order to obtain a measurable outgassing rate especially when the temperature of the source and the sensitive surface are close to one another.
TQCM Sensitivity	10^{-9} g/cm^2 per HZ
TQCM temperature	10 degrees C below the coldest temperature of contamination critical surfaces (see paragraph 3.1-1) that are in the direct or indirect line-of-sight of the component.
Cold Finger	Operated at -100 or below for last eight hours of test or as specified in the test specification. Required for items in direct/indirect view of critical surfaces. Cold finger analysis will identify species that have not finished outgassing and permit identification of those species like silicones that pose particular contamination hazards.
Chamber Certification	Previous test data may be used to certify chambers. Cold finger analyses are required unless waived by the contamination engineer or analyst Particle fallout plates shall be installed for any test with exposed optics or other surfaces which cannot be cleaned Outgassing rate shall be low and stable enough to permit accurate measurement of the flight item outgassing. The contamination analyst will provide this rate. (Generally 10 percent of the expected outgassing rate of the flight item but there are circumstances where higher rates may be acceptable)

Chamber Cleanliness	Chamber shall show not have significant levels of silicones or other outgassing constituents which may form a stubborn. Lasting deposition on the flight hardware Surface cleanliness shall be equal to the item under test or provisions shall be taken to protect the item under test (vacuum bakeout box for example) Repressurization shall be accomplished at a slow enough rate to preclude redistribution of particles for any component which cannot be cleaned after test (optics for example) During repressurization cryo surfaces shall be kept below –60 degrees until 200 torr (or lowest temperature possible to prevent condensation) is reached. Flight hardware shall be warmer than walls by at least 5 degrees C prior to represurrization Backfill shall be with filtered, Grade B per MIL-P-27401 or boil off nitrogen Pumps shall not contain oil There shall be a gate valve between the roughing pump and the chamber and main pump Molecular witness plates shall be installed for any test where optics are present Particle fallout plates shall be installed for any test with optics or uncleanable surfaces
Recommendations	Highly modularized electronics or other enclosures with poor venting should be baked-out with the large possible vent area (remove lids, covers, etc.) When bakeout is combined with thermal performance testing it is usually advantageous to start with a mini-bakeout, calculate the total time required for bakeout, and include the hot-cycle time towards this bakeout time, any remaining bakeout can then be completed at the end of the test. This does not apply to tests with sensitive components like optics. If the desired particle cleanliness cannot be achieved then other means of protecting the surfaces must be used – possibly creation of TV tent.

8.3.4. IMPACT Outgassing Certification

Prior to acceptance to being integrated on STEREO, all payload components shall undergo a thermal vacuum certification with a Quartz Crystal Microbalance (QCM). This certification may be performed with on separate components of IMPACT or on all the components as an assembly. It shall be performed in accordance with paragraph 6.3.2.

8.3.4.1 Purging

Whenever possible, the science sensors listed in the table below will be supplied a dry nitrogen purge. Purge is to be maintained at all levels of testing and integration up through launch. UCB will be using Mott porous rate limiters to manage flow. Input pressure shall be 15 psi. All purge gas nitrogen will have at least the following composition:

99.999% pure
< 3 ppm water
<0.5 ppm total hydrocarbons

Table 5.3-1: Science Instrument Purging Requirements

Science Instrument	Liters per Hour	Hardware	Interruption/Comments
SWEA	5.0	Swagelock connector A-400-6-1 (1/4 -1/16)	Few hours if in class 10k environment with no hazardous airborne chemicals. Boom mounted GSE purge interrupted at last possible access on launch tower.
STE-D	1.0		Boom mounted GSE purge interrupted at last possible access on launch tower.
STE-U	1.0		Boom mounted GSE purge interrupted at last possible access on launch tower.
SEPT-NS	1.0		Spacecraft purge
SEPT-E	1.0		Spacecraft purge
HET	5.0		Spacecraft purge
SIT	15.0		Spacecraft purge

8.4. *Spacecraft Integration and Testing*

Spacecraft integration and testing will occur in a class 10,000 clean room – except for certain environmental tests – vibration or mass balance. Purge shall be maintained on all instruments to the maximum extent possible. Purge may be interrupted for short durations but only with the prior notification and approval of the IMPACT representative. Impact components shall be bagged whenever testing occurs outside of a class 10,000 cleanroom. Small dust covers made from bagging shall replace hard covers for mechanical tests so as not to affect the results of the test.

IMPACT will be solely responsible for cleaning IMPACT hardware unless the IMPACT Program Manager and Contamination Engineer elect to delegate that responsibility to an IMPACT approved and trained spacecraft representative to facilitate schedule or other concerns. IMPACT sensors are extremely sensitive to solvent and chemical vapors. Any cleaning activities on the spacecraft have to be carefully coordinated with IMPACT. The preferred protocol shall be installing a purge bag (which may also serve as a dust bag) and maintaining a

high flow rate nitrogen purge so as to obtain a positive nitrogen purge within the bag. Isopropyl alcohol is the only solvent that may be used. Cleaning may proceed providing the solvent levels do not exceed 20ppm when measured at a distance of 2.5 feet from the bag. If care is taken to limit the amount of solvents dispensed these levels should be easily maintained. All other activities involving solvents or chemical use including curing shall be discussed with the IMPACT representative in advance. Appropriate precautions shall be taken. In most cases the precautions used for cleaning should be adequate.

9. Packaging, Transportation, and Storage

Great care must be taken to avoid contaminating hardware during transport and storage activities. The following principles shall be applied:

- Protect flight hardware prior to all transports external to the cleanroom.
- Protect the hardware from vibration, condensation and other adverse environmental conditions
- Bag the hardware (GSE should be bagged too to prevent unnecessary cleaning and verification).
- Moves inside the cleanroom --esp. change of axis moves-- require an assessment of overall cleanliness and the potential for contamination of an instrument surface due to redistribution of particles during the move (additional cleaning may be required).
- Transport GSE must be visually clean, not produce fumes, and not cross-contaminate the spacecraft. Biggest area of concern is lubricated joints – they must be sealed and checked daily.
- All IMPACT hardware will be double bagged and purged during storage periods.

9.1. *Transportation and Storage Containers*

Transportation and storage containers for flight hardware and thermal vacuum GSE shall meet the following criteria:

- Fabricated from materials that will not outgas under ambient conditions (applies even if the item being transported is bagged). Wood is not acceptable.
- Have provisions for backfill with nitrogen if transporting optics or electronics.
- Have provisions for pressure equalization that will prohibit the ingress of unfiltered ambient air.
- Constructed of materials that can generate particles (bare aluminum, foams, rough paint surfaces, etc.) unless precautions have been taken to prevent particles from becoming dislodged.

9.2. *Packaging Materials and Methods*

9.2.1. General

1. All items shall be double/triple bagged if leaving the cleanroom.
2. Packaging shall be of the same cleanliness level as the item to be packaged.
3. Packaging materials shall be ordered on polyethylene or poly-propylene cores and double bagged in the same type of material to preserve cleanliness during shipment.
4. Packaging materials shall be stored on horizontal holding devices permitting ready access and providing maximum protection from contaminants whenever possible. If a roll must be stood on end, place a layer of layer of clean packaging material on the floor first. The packaging should extend at least 6 inches beyond the foot print of the roll of material or its stand. If stored in a non-cleanroom environment the packaging

material shall itself be bagged to preserve its cleanliness. If packaging a critical item discard or clean the two layers of material if there is any doubt as to their cleanliness.

5. The exterior bag shall provide a moisture barrier. IMPACT approved polyethylene shall be used for exterior bags. Polyethylene shall be heat sealed whenever possible or whenever humidity control is of special concern). Polyethylene shall NEVER be in contact with flight or thermal vacuum GSE hardware surfaces or with surfaces that will contact flight or thermal vacuum hardware surfaces.
6. The interior bag shall be IMPACT approved materials:
    - National Metallizing NMD-FR100 N PA1-N (no scrim), NMDFR,190 N PA1-NN (scrim) When ordering the following must be specified:
        - ✓ Cleanliness level 300A
        - ✓ Manufactured with no ESD coating or DOP
    - Courtald llumalloy. 2 mil thickness is not as fire resistant and requires special approval if used at the launch site. Be certain to package so that the outer layer is facing out. Courtald Llumalloy will hold a charge of about 100 volts so this should be taken into account when handling an item sensitive to this level of charge.
7. Take care to use IMPACT approved cushioning materials to avoid abrasion points. Cushioning can be fabricated by making rolling polypropylene and wrapping in an IMPACT approved ESD material according to the application.
8. Tapes the following tapes are approved for packaging applications: 3M1205, CHR K102, and Permacell 224 kapton tapes.
9. Care shall be taken to avoid contamination of materials as the result of abrasion of the packaging material with the item.

APPENDIX A TABLES FOR SURFACE AND AIR CLEANLINESS

Classification of MIL-STD 1246C Product Cleanliness Levels

Table A Particle Limits		
Cleanliness Level	**Particle Size (µm)**	**Number of Particles (#/ft^2)**
1	1	1.0
5	1	2.8
	2	2.3
	5	1.0
10	1	8.4
	2	7.0
	5	3.0
	10	1.0
25	2	53
	5	23
	15	3.4
	25	1.0
50	5	166
	15	25
	25	7.3
	50	1.0
100	5	1785
	15	265
	25	78
	50	11
	100	1.0
200	15	4189
	25	1240
	50	170
	100	16
	200	1.0
300	25	7455
	50	1021
	100	95
	250	2.3
	300	1.0
500	50	11817
	100	1100
	250	26
	500	1.0
750	50	95807
	100	8919
	250	214
	500	8.1

Table B NVR Limits	
Level	**Limit, NVR (mg/0.1m^2)**
A/10	0.1
A/5	0.2
A	1.0
B	2.0
C	3.0
D	4.0
E	5.0
F	7.0
G	10.0
H	15.0

	750	1.0
1000	100 250 500 750 1000	42658 1022 39 4.8 1.0

J	55.0

Other conversions may be obtained by using the following formula:

$$\log N = 0.9260 \ (\log {}^{2}X - \log^{2} Y)$$

N = no. of particles greater than size Y per square foot

X = cleanliness level per MIL-STD-1246A

Y = particle size in microns (μm)

$1\ ft^2 = 929\ cm^2$

FED-STD 209E Class Limits

Class Title		Class Limit									
		0.1 µm		0.2 µm		0.3 µm		0.5 µm		5.0 µm	
		Volume Units		Volume Units		Volume Units		Volume Units		Volume Units	
SI	English	(m^{-3})	(ft^{-3})	(m^{-3})	(ft^{-3})	(m^{-3})	(ft^{-3})	(m^{-3})	(ft^{-3})	(m^{-3})	(ft^{-3})
M 1		350	9.91	75.7	2.14	30.9	0.875	10	0.283	-	-
M 1.5	1	1240	35	265	7.5	106	3	35.3	1	-	-
M 2		3500	99.1	757	21.4	309	8.75	100	2.83	-	-
M 2.5	10	12400	350	2650	75	1060	30	353	10	-	-
M 3		35000	991	7570	214	3090	87.5	1000	28.3	-	-
M 3.5	100	-	-	26500	750	10600	300	3530	100	-	-
M 4		-	-	75700	2140	30900	875	10000	283	-	-
M 4.5	1000	-	-	-	-	-	-	35300	1000	247	7
M 5		-	-	-	-	-	-	100000	2830	618	17.5
M 5.5	10000	-	-	-	-	-	-	353000	10000	2470	70
M 6		-	-	-	-	-	-	1000000	28300	6180	175
M 6.5	100000	-	-	-	-	-	-	3530000	100000	24700	700
M 7		-	-	-	-	-	-	10000000	283000	61800	1750

NASA - JSC-SN-C-0005 Visibly Clean Levels

VC Level	Incident Light Level (1)	Observation Distance	Remarks
Standard	50 foot-candles	5 to 10 feet	(2) (3) (5)
Sensitive	50 foot-candles	2 to 4 feet	(2) (3) (5)
Highly Sensitive	100 foot-candles	6 to 18 inches	(3) (4)

NOTES:
(1) One foot-candle (lumens per ft^2) is equivalent to 10.76 lumens per m^2.
(2) Cleaning is required if the surface in question does not meet VC under the specified incident light and observation distance conditions.
(3) Exposed and accessible surfaces only.
(4) Initial cleaning is mandatory; Note (2) applies thereafter.

(5) Areas of suspected contamination may be examined at distances closer than specified for final verification.