Handling, Storage, Packaging, and Transportation Procedures for the EPS/HEPAD

Instruments for

GOES N, O, P, Q

prepared for

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1.0 Reference Documents

The below list of Panametrics documents is provided for reference only. Some of the material in those documents is appropriate backup material for this document.

Panametrics

GOESN-ENG-001	Contamination Control Plan for the Solar X-Ray and EUV Sensor (XRS/EUV), the Energetic Particle Sensor (EPS), and the High Energy Proton and Alpha Detector (HEPAD) for GOES NO/PQ
GOESN-RTP-124	Comprehensive Performance Test, EPS/HEPAD Subassembly
GOESN-RTP-197	Handling, Storage, Packaging, and Transportation Procedures for the XRS/EUV
GOESN-RTP-198	Handling, Storage, Packaging, and Transportation Procedures for the EPS/HEPAD (this document)
GOESN-ENG-005	Controlled Area Practices Guide
GOESN-SPL-001	SCDRL # 16, Summary of Parts List and Part Specifications
GOESN-M&P-001	SCDRL # 17, Materials and Processes List and Specifications

ASTM

ASTM E1234	Standard Practice for Handling, Transporting, and Installing Nonvolatile Residue (NVR) Sample Plates Used in Environmentally Controlled Areas for Spacecraft
ASTM E1235	Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft.

Military and Federal

MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program
MIL-P-27401	Propellant Pressuring Agent, Nitrogen
FED-STD-209	Airborne Particulate Cleanliness Classes in Cleanrooms and Cleanzones
SN-C-0005	Contamination Control Requirements for the Space Shuttle Program

2.0 Introduction and Purpose

The purpose of this document is to establish safe storage, packaging, and transportation procedures for the GOES EPS/HEPAD instruments. The EPS/HEPAD consists of a DPU and 5 instruments (two EPEADs, the MAGPD, the MAGED, and the HEPAD). These instruments are sensitive to contamination, so must be treated with care during all stages of assembly and testing prior to and following delivery to HSC. The following procedures also address the safe handling of the instruments with regard to electrostatic discharge, and excess shock and vibration.

2.1 General Considerations

The EPS/HEPAD instruments are spaceflight instruments, and while they have been designed to survive the specified launch conditions, they must not be subjected to excessive environmental conditions that might affect their performance. The following are a general set of guidelines for handling the instruments.

- Do not touch the instruments with bare skin - use approved, non-powdered, nitrile or latex gloves and always maintain a sound grip. Nitrile gloves are compatible with the approved solvents isopropyl and methyl alcohol. (Approved solvents are identified in the Materials and Processes List and Specifications, GOESN-M&P-001.) Approved, non-powdered latex gloves may also be used if desired, and must be used when it is necessary to handle acetone or MEK.
- Always use proper ESD handling procedures. The instrument and the operator must be well grounded during all lifting and transferring operations.
- Avoid mechanical shock. Excessive shock or vibration could damage internal components of the EPS/HEPAD.
- Do not expose the instruments to contaminating ambient conditions; e.g. non-approved organic solvents, mercury vapor, mechanical pump-oil vapor, ionic salts, acetylene vapor, caustic or acid fumes, soldering flux fumes, large quantities of water vapor, etc., or cleanroom class greater than 100k without protective covers.
- Observe the storage and handling, packaging, and transporting procedures described in Sections 3.0 - 5.0 of this document.
- EPS/HEPAD SSDs must be biased to prevent detector degradation when stored in a vacuum environment for an extended period.

2.2 Instrument Contamination Requirement

The contamination requirement for all exterior surfaces (and the goal for the interior surfaces) of the EPS/HEPAD is MIL-STD-1246C Level 500 C, visibly clean highly sensitive plus UV light per SN-C-0005. Descriptions of light inspection sensitivity are given in Table 3-1 below.

2.3 Quality Assurance Participation

Quality Assurance surveillance and monitoring of storage conditions and packaging shall be required. Quality Assurance shall be notified prior to carrying out any packaging or storage operations. Adherence

to storage conditions and packaging and transporting requirements shall be verified and monitored by Quality Assurance..

2.4 Nitrogen Purge-gas Requirements

The following purge-gas and plumbing requirements are reproduced from the Contamination Control Plan (which takes precedence over this document). These requirements shall be met for nitrogen used in all purge, back-fill, and blow-gun operations.

Use only liquid nitrogen boil-off (0.5 micron filtering) or Class C or better (per MIL-P-27401) research-grade bottled nitrogen for purging the EPS/HEPAD or shipping containers, back-filling vacuum chambers, and for drying parts after cleaning.

All nitrogen plumbing shall be fabricated from non-contaminating materials that do not degrade the cleanliness of the nitrogen. Panametrics 'lab-air,' for example, consists of filtered LN2 boil-off, and is plumbed into each room via stainless-steel tubing, and filtered at point of use. Where flexible tubing is required (such as for the EPS/HEPAD purge), use only Panametrics approved ultra-high-purity PFA Teflon tubing (400HP or better), or Freelin-Wade Fre-stat polyurethane tubing. Most 'soft' tubing contains plasticizers that will contaminate the instrument, and are therefore not acceptable for use.

2.5 Protective Covers

There are protective covers for the two EPEAD telescopes and the MAGPD and MAGED. These covers should be in place during all handling, packaging, transportation, and storage operations to prevent damage to the entrance apertures of the instruments. The covers are clearly denoted as "Not For Flight," and must be removed during the satellite prelaunch closeout activities.

3.0 Storage and Handling

During all handling operations and storage of the EPS/HEPAD, special attention must be given to observing contamination control and instrument temperature limits, protecting the instruments from possible performance degradation and ESD, as well as minimizing shock and vibration, as described below. Both short term (less than one week) and long term (more than one week) storage intervals are addressed.

3.1 Contamination Considerations During Storage and Handling

Storage and handling of the EPS/HEPAD shall be done in a manner that does not compromise the cleanliness level of the instrument, while maintaining instrument performance integrity along with ESD and other safety precautions suitable to spaceflight hardware. The EPS/HEPAD instruments shall be stored in one of the following manners:

- Under clean vacuum (<100 mTorr) (note SSD bias requirements)
- Bagged, or appropriately protected (with ESD-safe shroud or cover)

- In a sealed container that has been purged with dry GN2

ESD-safe shrouds or covers are used to protect the instrument from particle fallout, and to provide a barrier against molecular contamination. Bagging operations should be done according to Section 3.6.

During storage and handling operations, all attempts should be made to maintain the instruments to the cleanliness specifications given in Section 2.2, with definitions of light sensitivities given below. Periodic inspections shall be performed to verify that these levels are met, and the instruments shall be cleaned whenever such levels are exceeded.

Table 3-1, Cleanliness Inspection Levels per Ref. SN-C-0005

Inspection Level	Incident Light Level (1)	Requirement and Method	Remarks
Visibly Clean (VC)	≥ 50 foot-candles	Clean (free of dust, debris, or films) when viewed from a distance of 5 to 10 feet in normal room lighting conditions, ≥50 foot-candles. If cleaning with solvent or water dampened wipes, the wipe will show no visible contamination when viewed from the same distance.	(2) (3) (5)
Visibly Clean Sensitive (VCS)	≥ 50 foot-candles	Clean (free of dust, debris, or films) when viewed from a distance of 2 to 4 feet in normal room lighting conditions, ≥50 foot-candles. If cleaning with solvent or water dampened wipes, the wipe will show no visible contamination when viewed from the same distance.	(2) (3) (5)
Visibly Clean Highly Sensitive (VCHS)	≥ 100 foot-candles	Clean when viewed obliquely or normally at a distance of 0.5 to 1.5 feet. If cleaned with solvent dampened wipes, the wipes will show no visible contamination when viewed from the same distance.	(3) (4)
Visibly Clean Highly Sensitive + UV light (VCHS+UV)		Clean to VCHS level plus clean when viewed in a darkened room with ultraviolet light at a distance of 1 to 3 feet (see special instructions in Section 4.5 of GOESN-ENG-005). The presence of up to 3 visible particles per square foot is acceptable.	

NOTES:

(1) One foot-candle (lumens per square foot) is equivalent to 10.76 lumens per square meter.

(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.

3.1.1 Glove Use

While the molecular contamination requirements for the EPS/HEPAD are not as strict as for the XRS/EUV, the EPS/HEPAD will share certain workspaces and test facilities with the more sensitive instruments. For this reason, it is important to maintain low levels of molecular contamination. Once cleaned, the EPS/HEPAD instruments shall be handled only with approved powder-free gloves (Nitrile is preferred). Do not touch or handle the instruments with bare, ungloved hands.

3.2 Temperature Requirements During Storage

The DPU and sensors (two EPEADs, the MAGPD, the MAGED, and the HEPAD) should be stored in the Panametrics-supplied shipping/storage containers, with the protective aperture covers in place on the two EPEADs, the MAGPD, and the MAGED. These containers have the same temperature requirements as for storage on the spacecraft, and should be purged with dry nitrogen after initial closure. It is recommended that the maximum Survival-Non-Operating temperature limits be avoided for long-term storage.

The instruments must be stored within the temperature limits shown in the table below. The temperature ranges are shown for Acceptance, Protoflight, Survival – Operating, Survival – Non-operating, and Cold Turn On.

During long-term vacuum storage (defined as greater than one month, and expected only during on-orbit storage), the standby solid-state detector bias must be applied to prevent degradation of the sensors**.**

Table 3-2, EPS/HEPAD Temperature Range Requirements

	Acceptance, ˚C		Protoflight, ˚C		Survival – Operating, ˚C		Survival - Non-operating, ˚C		Cold Turn On, ˚C
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Min
DPU	5	60	-5	70	-40	70	-40	70	-5
EPEADs	-20	30	-25	35	-40	45	-40	45*	-25
HEPAD	-20	30	-25	35	-40	45	-40	45*	-25
MAGPD	-20	25	-25	30	-30	35	-30	40	-25
MAGED	-20	25	-25	30	-30	35	-30	40	-25

Note:* The maximum allowable temperature at the launch site is 38˚C, which is imposed by the XRS/EUV instruments.

3.3 ESD Precaution

The instruments must be properly grounded during long-term or temporary storage. Ensure that proper grounds are affixed to the instruments prior to any moving or lifting operations. The operator must also be properly grounded before handling the instruments. Wrist straps should be in contact with the operator's skin, not with the outside of gloves. Constant-monitoring wrist-straps with audible alarms are preferred. Avoid lifting and handling operations if the relative humidity is below 30%, or take extra ESD-safety precautions (such as redundant ground-clips) if such handling is unavoidable.

3.4 Non-vacuum Storage

Observing all necessary gloving and ESD safety precautions:

- Inspect the exterior of the instrument to VCHS+UV. Remove any dust or lint using approved, non-particulating cleanroom wipes or swabs lightly dampened with Panametrics approved IPA. A gentle flow of clean, dry GN2 may be used to dislodge particles. Exercise care while cleaning near apertures.
- Install 'Not For Flight' aperture covers, Panametrics part numbers C-6104(EPEADs two covers), D-7233 (MAGED and MAGPD), if not already installed.
- Place conductive covers on all of the EPS/HEPAD connectors that do not already have covers or mating connectors in place.
- Bag the instruments according to Section 4.1.
- Clean the storage cabinet or container with Panametrics approved IPA-dampened cleanroom wipers, and initiate the shipping-container purge according to Section 3.5 if necessary.
- Place the bagged instrument into the storage cabinet or shipping container, and close the cabinet or container according to Section 3.5.

3.5 Purge Requirements For Storage

The EPS/HEPAD should be stored in the Panametrics-supplied shipping/storage containers, with the protective aperture covers in place, and the containers purged with dry nitrogen. The purge procedure is as follows:

- Prepare shipping-container purge fittings, tubing, and purge gas in accordance with Section 2.4
- Attach purge lines and begin GN2 purge at a flow rate of 1 - 10 SCFH
- Place the bagged instrument(s) into the container and secure in place
- Open the pressure relief valve on the shipping container
- Close the container lid, and allow the purge to continue for at least 2 hours prior to tightly sealing
- Remove the GN2 purge lines, and seal the purge nipple and pressure relief valve

If the container is opened, the purge should be reinstated.

There is no requirement for fairing purge for the EPS/HEPAD (when the aperture covers have been removed) other than reasonable attempts to minimize exposure to moisture and contaminants during this period.

3.6 Bagging for Storage

There will be no vacuum storage except in orbit. The EPS/HEPAD should be stored in a sealed Llumalloy bag when not in use, and when not otherwise stored as in Section 3.0. The bag should be flushed with dry GN2 for 30 minutes before sealing. The aperture covers must be used to protect the EPS/HEPAD apertures during Satellite I&T, and whenever the satellite is transported outside of class 10,000 clean zones. The covers are intended to protect the instruments from particle fallout, and to provide a barrier against contamination.

3.7 Shock and Vibration

Do not subject the instruments to large shocks or undue vibration. Do not bump, drop, or 'slide' shipping containers. Do not leave instruments or shipping containers unsupervised in areas where untrained personnel may mishandle the instruments.

It has been shown on numerous instruments that the largest shock and vibration levels are realized during shipping or transportation, even with highly engineered shock-isolating shipping containers. Take extra precautions to minimize this risk, including the use of highly visible 'Fragile' stickers.

3.8 Periodic Testing

During long-term storage, the EPS/HEPAD must be tested at least once per year to verify proper operation. The testing shall be done within 30 calendar days of the one-year elapsed time from the prior testing or from the date that the EPS/HEPAD was first placed in long-term storage. The EPS/HEPAD shall also be tested prior to shipping if they have not been tested within the previous 60 days. A full Comprehensive Performance Test will be performed if required, per GOESN-RTP-124 Following completion of the tests, the results shall be reduced and compared with previous test results to verify that there has been no 'unacceptable' degradation. The instrument shall then be placed back into storage as described in Section 3.0, or packaged for shipping according to Section 4.0.

3.9 Operation or Storage in Ambient Air

The DPU shall not be exposed to relative humidity exceeding 95%.

The EPEADs, HEPAD, MAGED, and MAGPD shall not be operated at relative humidity exceeding 40%. Exposure to relative humidity exceeding 60% shall be minimized to the greatest extent possible. Following extended exposure (more than 4 hours) to relative humidity exceeding 40%, the detectors shall be "dried out" prior to operation. This can be accomplished by flushing with dry GN2 for a minimum of 24 hours or by outgassing at a pressure of 10^{-5} Torr or less for a minimum of 4 hours.

Prior to and during any low temperature ambient pressure exposure, the EPS/HEPAD components shall be purged with dry GN2 to prevent condensation. Such purging shall be applied continuously for a

minimum of 30 minutes before temperature transition, and until after the components have returned to ambient temperature.

4.0 Packaging

While packaging for storage or transport, the handling procedures in Section 3.0 must be observed. In addition, observe the following bagging and sealing protocols. Prior to bagging sub-assemblies or instruments, the exterior surfaces should be inspected and cleaned appropriately. Observe the procedures outlined in Section 3.4, 'Non-vacuum Storage'.

4.1 Bagging and Sealing

When transporting the instruments outside of a Class 100,000 clean area, they must be double bagged (see below for items that are to leave the building). The bags must be of an approved ESD-bagging material, such as Llumalloy. Re-sealable 'zip-lock' ESD bags may be used for small items (anything small enough to fit inside of a bag). Kapton tape seals may be used instead of, or in addition to, sealers or zip-lock bags. Only Panametrics approved Kapton tape should be used. Tapes should not contact the instrument, unless absolutely required. For transportation within the building, a precision cleaned ESD-safe Totebox (with cover) may be used in lieu of the outer ESD bag. These containers shall be clearly marked “Do not open except in a Class 100,000 or better area”.

If the item is to leave the building, it must be double bagged as above, and then a third moisture barrier bag must be used. The third, outer bag must be an approved, heavy gauge moisture-barrier material, and must be tightly sealed. Prior to sealing the bags, purge each bag with dry GN2 for at least 15 minutes. Seal the bag tightly before removing the purge, and then seal the purge inlet area.

Bag sealers may be used to seal small parts for storage or transportation. Be sure to seal the bag fully. Also be sure that the seal is intact (incorrect sealing time and temperature may result in a range of sealing conditions from loose seals to burn holes.) Always double-bag “precision cleaned” parts that will leave the clean area, so that they do not need to be re-cleaned following return if unopened.

4.2 Use and Removal of Tapes and Adhesives

Residues from tapes and other adhesives are a large source of contamination. Whenever tapes or adhesives are used on flight hardware, observe the following practices:

4.2.1 Tape Use

- Use only approved tapes (see the Materials and Processes List and Specifications, GOESN-M&P-0001. Use only tapes with polyethylene cores; no cardboard)
- Limit quantity of tape used and duration of use
- Minimize the temporary use of tapes to fasten items during ground operations
- Remove tape ASAP (the longer the tape is attached the harder it is to remove the residue); likewise clean off the residue immediately upon removing tape

- Do not use tape on surfaces that are impossible to clean without risk of damage (titanium, thermal control paints, sensor surfaces, etc.)
- Do not use flight surfaces to temporarily hold freshly-cut pieces of tape
- Be careful not to get adhesive residues on gloves (change them if this happens)
- When applying tapes that will be flown be sure to smooth down all surfaces to prevent exposure of adhesive surfaces
- Where possible, use approved (Tefzel) cable tie wraps instead of tape for temporarily fastening harnesses and other items
- Do not use tape to temporarily hold nuts, bolts, screws or other small parts
- Clean all residues thoroughly and inspect with black light as required

4.2.2 Tape and Adhesive Removal

When removing tapes, it is best to pull the tape at an angle of 145 degrees or more from the surface (almost doubled-back on itself). At this angle, the adhesive has a greater tendency to stick to the tape than to the hardware. All residues from tapes or other attached sensors (accelerometers, strain-gauges, thermocouples, etc.) must be thoroughly removed. If the residue cannot be removed, contact the contamination engineer. Do not use sharp instruments to remove adhesive or epoxy residues from the surfaces of the flight hardware. This can damage the surface, and alter the desired properties of the surface finish.

If a large quantity of adhesive does remain on the item following tape removal, attempt to 'ball-up' the adhesive residue, as you would do for rubber cement on paper. If the residue is too dry for this, moisten it with Panametrics approved IPA, let the IPA evaporate, and then attempt to ball it up again while the adhesive is still damp. After all large quantities of adhesive are removed, wipe away the remaining residue with a non-particulating cleanroom wipe or swab that has been moistened with IPA.

5.0 Transportation

5.1 Removing Hardware From Clean Zones

GSE or flight hardware that is removed from the cleanroom must be protected so that it does not need to be re-cleaned. Even if the hardware does need to be exposed to levels greater than class 100,000 (per FED-STD-209), it should be protected during this exposure to minimize contamination. Gloves should be worn when handling the flight hardware or any GSE that contacts the hardware. These practices will reduce the amount of cleaning required to return the item to the cleanroom. Follow the bagging procedures described in Section 4.1 prior to removing flight hardware from clean areas.

5.2 Shipping Containers

Shipping containers shall be used to transport the EPS/HEPAD instruments whenever they are to leave the confines of a building. Specially designed containers have been built for the EPS/HEPAD that provide:

- Shock and vibration isolation during shipping and handling, including shock indicators
- Protection from external environmental conditions (rain, snow, humidity, etc.)
- Isolation and protection from contaminating environments
- Handles and wheels as required for safety and ease of handling.

Do not expose the shipping containers to temperatures that exceed the allowable Non-Operating Storage limits in Table 3-2, EPS/HEPAD Temperature Range Requirements.

Do not expose the shipping containers to chemicals or environments that might leave a contaminating residue on the container surface.

5.3 Purge Requirements During Transportation

The EPS/HEPAD instruments do not need to be continuously purged during transportation. The instrument shipping-container should be purged according to Section 3.5 prior to shipping, however, and the purge should be reinstated if the container is opened.

5.4 Bagging Requirements During Transportation

All flight instruments must be triple bagged for transportation outside of a building, according to Section 4.1. The triple, outer bag is a moisture barrier bag which must be sealed well enough that unexpected exposure to high humidity does not penetrate the bag. All bags must be purged with dry GN2 for a minimum of 30 minutes prior to sealing, so that internal humidity does not condense on the interior of the bag.

5.5 Unpacking

The EPS/HEPAD instruments should be removed from the shipping containers as follows:

- Examine and clean the exterior of the shipping container prior to opening.
- Open the pressure-relief-valve and allow the pressure to equilibrate.
- Observing proper ESD handling procedures, open the shipping container and remove the instrument.
- Close the shipping container and pressure relief valve.
- Observing proper ESD handling procedures, remove the instrument from the ESD-bagging material in a clean environment.

6.0 List of Acronyms

CCE	Contamination Control Engineer
CPT	Comprehensive Performance Test
DI	De-ionized (water)
DPU	Data Processing Unit
EPEAD	Energetic Proton Electron and Alpha Detector
EPS/HEPAD	Energetic Particle Sensor/High Energy Proton and Alpha Detector
ESD	Electrostatic Discharge
GN2	Gaseous Nitrogen
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HEPA	High Efficiency Particulate Air (Filters)
HSC	Hughes Space and Communications Company
I&T	Integration and Test
IPA	Isopropyl Alcohol
LN2	Liquid Nitrogen
MAGED	Magnetospheric Electron Detector
MAGPD	Magnetospheric Proton Detector
PCB	Printed Circuit Board
SCFH	Standard Cubic Feet per Hour
SSDs	Solid State Detectors
UV	Ultraviolet
VCHS	Visibly Clean Highly Sensitive
VCHS	Visibly Clean Highly Sensitive plus Ultraviolet Light

7.0 Storage, Packaging, and Transportation Checklist

EPS/HEPAD Contact Information:
Fred Hanser or Paul Morel
Phone: (781)899-2719
c/o Panametrics, Inc.
221 Crescent Street
Waltham, MA 02454-3497

Date of storage/packaging/transport: _____ (circle one)

Instrument, S/N: _____

Operator: _____

Comments: _____

_____

Date of last container purge: _____

Date of last instrument CPT: _____

Initials/Date

Instrument has been purged as per GOESN-RTP-198 Section 3.5: _____

Instrument has been bagged as per GOESN-RTP-198 Section 4.1: _____

Instrument has been handled as per GOESN-RTP-198 Section 5.0: _____