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Space Administration

**NOT  
MEASUREMENT  
SENSITIVE**

MSFC-STD-3598  
REVISION D  
EFFECTIVE DATE: JULY 26, 2021

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**George C. Marshall Space Flight Center**  
Marshall Space Flight Center, Alabama 35812

EM22

MSFC TECHNICAL STANDARD

**STANDARD FOR FOREIGN  
OBJECT  
DAMAGE/FOREIGN  
OBJECT DEBRIS (FOD)  
PREVENTION**

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<b>MSFC Technical Standard EM22</b>		
<b>Title: Standard for Foreign Object Damage/Foreign Object Debris (FOD) Prevention</b>	<b>Document No.: MSFC-STD-3598</b>	<b>Revision: D</b>
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## DOCUMENT HISTORY LOG

<b>Status (Baseline/ Revision/ Canceled)</b>	<b>Document Revision</b>	<b>Effective Date</b>	<b>Description</b>
Baseline		11-AUG-2010	Initial Release
Revision	A	10-DEC-2015	Updated document numbers, deleted references to MSFC FOD Measurement, Trending, and Feedback System. During EE12 verification (Post Review), changed MID 5340.1 to MPD 5340.1 in Section 1.3 and 1.3.3 since it had been corrected through-out the document. Also changed MID Marshall Interim Directive to MPD Marshall Policy Directive in Section 3.1 Acronyms.
Revision	B	21-MAY-2019	General document review. Updated document titles and corrected grammatical errors. Removed all org codes and spelled out titles for offices, labs and branches throughout the document. Removed all references of SHE 418 FOD Critical Zone Training including the entire 5.11.5 section. Added the acronym "MCP" Marshall Center Plan to section 3.1. Updated the training section with the correct refresher periods for SHE 415, SHE 416, and SHE 417. Updated the following sections to be general and for MAF inclusion: Forward, 1.3.3, 4.3, 4.3.1, 4.3.1b, 4.3.1c, 4.3.1f, and 5.5.1. Added a Note to section 2.3 on additional training. Removed Footnote and link on page 30. Added verbiage in 5.5.7.3 to include "equivalent" signs. Added "equipment" to ESD in 3.2.21 for clarification. Removed Appendix C and D from TOC and from the document; updated document to reference the FOD Incident Report and Lost Tool/Item Reports "to be recorded in the FOD Database." Updated sections 5.12.3.2-6 referencing the FOD Database Updated section 5.12.2.1 removing "MSFC" for MAF inclusion.
Revision	C	01-FEB-2021	Section 4.3 replaced with new text. Section 5.1 revised deleting some information that is now in section 4.3. Section 5.5.8.1 revised. Duties of FOD Monitor removed from this section because they are now listed in section 4.3.3.3. Section 5.5.8.2 deleted because this information is also now in section 4.3.3.3. There were 2 figures listed as Figure 5. FOD Area Agreement figure changed to Figure 6, and list of figures in index updated. Recommended Checklist in Appendix B was replaced with an updated checklist. Removed ORG. codes due to frequent changes.
Revision	D	26-JUL-2021	Appendix B was updated to include previously omitted content only. A missing FOD Facility Risk Checklist page was added, and the checklist page numbers were updated.

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## **FOREWORD**

This standard sets forth the requirements and standard practices for Foreign Object Damage/Foreign Object Debris (FOD) Prevention for Marshall Space Flight Center (MSFC) and the Michoud Assembly Facility (MAF). This document establishes a standard to prevent foreign object damage and impact damage to products and hardware being designed, developed, manufactured, assembled, tested, operated, repaired, modified, refurbished, and maintained for MSFC and MAF.

Most FOD can be attributed to poor housekeeping, facilities deterioration, improper maintenance, careless assembly, or inadequate operational practices. An effective FOD prevention program identifies potential problems, corrects negative factors, promotes awareness, provides for effective employee training, and uses “lessons learned” for continual improvement.

The objective of this FOD prevention standard is to prevent (1) damage to critical program items, including but not limited to unique tooling, test hardware, ground support equipment, and flight hardware; (2) injury to the flight crew by FOD entrapped within manned flight articles; and (3) damage from FOD to other National Aeronautics and Space Administration (NASA) assets.

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## 1. SCOPE

### 1.1 Scope.

This standard establishes general practices and standard terms for the prevention of Foreign Object Damage (FOD) to Marshall Space Flight Center (MSFC) products, which include flight hardware and associated test hardware, facilities, Ground Support Equipment (GSE), and related components for MSFC-managed projects/programs.

This standard applies the following: all mandatory actions (i.e., requirements) are denoted by statements containing the term, “shall.” The terms: “may” or “can” denote discretionary privilege or permission, “should” denotes a good practice and is recommended, but not required, “will” denotes expected outcome, and “are/is” denotes descriptive material.

### 1.2 Authority.

The MSFC is responsible for implementing this standard in accordance with Marshall Policy Directive MPD 5340.1, Foreign Object Damage/Foreign Object Debris Prevention Operations. This standard is prepared by MSFC for its internal use and that of contractors. This document is derived from National Aerospace Standard NAS-412, Foreign Object Damage/Foreign Debris (FOD) Prevention, as required by NASA-STD-6016, Standard Manned Spacecraft Requirements for Materials and Processes. NASA-STD-6016 requires that a FOD prevention program be established for all ground operations of mechanical and electrical systems of flight hardware, including the design, development, manufacturing, assembly, repair, processing, testing, maintenance, operation, and check out of the equipment to ensure the highest practical level of cleanliness. This document also addresses the protection of hardware identified as susceptible to impact damage that requires an Impact Damage Management Plan (IDMP) to mitigate risk in accordance with NASA-STD-5019, Fracture Control Requirements for Spaceflight Hardware.

### 1.3 Responsibility.

1.3.1. The Manager of each Project Office that designs, tests, or manufactures FOD sensitive hardware shall be responsible for implementing the requirements of this standard.

1.3.2. The Manager of a manufacturing or test facility, designated as FOD sensitive even when no Project hardware is present, shall be responsible for implementing the requirements of this standard for that area.

1.3.3. A MSFC FOD Focal Point, designated within the Materials & Processes (M&P) Laboratory, Materials Test, Chemistry and Contamination Control Branch, in accordance with MPD 5340.1, shall be responsible for the coordination of FOD prevention measures at MSFC. A MAF FOD Focal Point designee shall be responsible for coordinating the requirements within this standard with MAF and MSFC.



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#### 1.4 Exclusions.

This FOD Prevention Program is not intended to protect personnel from injury, although a FOD-free workplace is often a safer workplace. FOD incidents or near-misses that result in, or could have resulted in, injury to personnel are reported as a mishap or close call in accordance with MWI 8621.1, Mishap and Close Call Reporting and Investigation Program, in addition to being reported to the Project FOD Focal Point. FOD concerns may also be reported via the Safety Concerns Reporting System (SCRS) in accordance with MWI 8715.13, Safety Concerns Reporting System (SCRS).

#### 1.5 Relationship to Contamination Control.

FOD control and contamination control are closely related and are addressed within the same Data Requirement Description (DRD) within NASA-STD-6016. While some cleanrooms and clean work areas will be also designated as FOD Sensitive Areas, not all FOD Sensitive Areas require specialized environmental controls. MSFC-STD-246, Standard Design and Operational Criteria for Controlled Environmental Areas, establishes requirements for cleanrooms and clean work areas at MSFC. While the objective of a contamination control program is to control contamination to within acceptable, established limits, the objective of a FOD prevention program is to prevent FOD. In a FOD prevention program, the acceptable limit for FOD is always zero.

## 2. DOCUMENTS

The documents listed below provide requirements, specifications, standards, and procedures applicable to this standard to the extent specified herein. For each of these documents, the latest revision shall apply unless other revision levels are specifically authorized.

### 2.1 Applicable Documents.

MPD 5340.1	Foreign Object Damage/Foreign Object Debris Prevention Operations
MPR 6410.2	Identifying, Packaging, Handling, and Moving Program Critical Hardware
MPR 6430.1	Lifting Equipment and Operations
MWI 8730.2	Temporarily - Installed Hardware Control
NAS-412	Foreign Object Damage/Foreign Debris (FOD) Prevention
NASA-STD-5019	Fracture Control Requirements for Spaceflight Hardware

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NASA-STD-6016 Standard Materials and Processes Requirements for Spacecraft

NASA-STD-8719.9 Standard for Lifting Devices and Equipment

## 2.2 Reference Documents.

MSFC-STD-246 Standard Design and Operational Criteria for Controlled Environmental Areas

MGM 1280.1 Guidance for Continual Improvement

MCP 1040.2 MSFC Emergency Plan

MPR 8730.3 Control of Nonconforming Product

MWI 8621.1 Mishap and Close Call Reporting and Investigation Program

MWI 8715.13 Safety Concerns Reporting System (SCRS)

MWI 8715.15 Ground Operations Safety Assessment Program

## 2.3 FOD Training Courses.

SHE 415 Foreign Object Debris Awareness Training

SHE 416 Foreign Object Debris Prevention Training

SHE 417 Foreign Object Debris Monitor Training

*Note:* Certain FOD sensitive areas such as Test Stands, Critical Zones, and other special areas may require additional training to gain access.

## 3. DEFINITIONS

### 3.1 Acronyms.

The acronyms used in this standard are defined as follows:

CWA Clean Work Area

DR Discrepancy Record

DRD Data Requirement Description

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DTA	Damage Threat Assessment
FOD	Foreign Object Debris/Foreign Object Damage
ESD	Electro-Static Discharge
GSE	Ground Support Equipment
IDMP	Impact Damage Mitigation Plan
IDS	Impact Damage Susceptible JHA Job Hazard Analyses
M&P	Materials and Processes
MAF	Michoud Assembly Facility
MCP	Marshall Center Plan
MGM	Marshall Guidance Manual
MPD	Marshall Policy Directive
MPR	Marshall Procedural Requirements
MSFC	Marshall Space Flight Center
MWI	Marshall Work Instruction
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
O&M	Operations and Maintenance
QA	Quality Assurance
RTD	Residual Threat Determination
SATERN	System for Administration, Training, and Education Resources for NASA
SCRS	Safety Concerns Reporting System
SHE	Safety, Health, and Environmental

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## 3.2 Glossary of Terms.

3.2.1 **Clean-As-You-Go:** An operations approach in which the area is cleaned after each planned operation and before the end of each work shift; established to remove unnecessary items and to prevent process-generated Foreign Object Debris/Foreign Object Damage (FOD). Required steps, in accordance with NAS 412, include:

- Clean the immediate area when work cannot continue.
- Clean the immediate area when work debris has the potential to migrate to an out-of-sight or inaccessible area and cause damage and/or give the appearance of poor workmanship.
- Clean the immediate area after work is completed and before inspection.
- Clean at the end of each shift.
- If you drop an item or hear something drop, pick it up!

3.2.2 **Consumables:** Materials, supplies, equipment, or tools that are considered to be, or have the potential to be, expendable or used up during performance of a task. Examples include but are not limited to:

- Issued apparel.
- Safety glasses.
- Glues, paints, sealants, solvents, tape, room-temperature vulcanized products.
- Sandpaper, brushes, scrapers, applicators, rags, wipes.
- Stock items such as rivets, washers, fasteners, cable ties, and other hardware.

3.2.3 **Contamination:** Unwanted material that may adversely affect component or system performance. Acceptable contamination limits are specified on engineering drawings. FOD is a form of large-scale contamination, not specified on the engineering drawing, for which the acceptable limit is zero.

3.2.4 **Flight Hardware:** Program hardware controlled by engineering drawings that will become a part of a vehicle or system delivered for integration and launch or for qualification or acceptance test of a flight article. Critical development test articles may be treated as flight hardware where FOD may degrade the test article's required safety or performance characteristics.

3.2.5 **FOD Awareness Area:** An area where FOD sensitive hardware is in place or in transit but there is a low potential for FOD entrapment, FOD migration, or impact damage from foreign objects. This designation may also be used to establish a buffer zone to minimize the risk of FOD migration to an adjacent FOD Control Area or FOD Critical Zone.

3.2.6 **FOD Control Area:** An area where FOD sensitive hardware is in place and there is a high potential for FOD entrapment or migration to the hardware or for FOD-caused impact damage.

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**3.2.7 FOD Control Program:** A documented program or process used to assure a FOD-free product and to minimize program economic impacts related to FOD incidents. May also be referred to as a FOD Prevention Program.

**3.2.8 FOD Critical Zone:** A region, generally within a FOD Control Area, that is at the highest risk for potential FOD incidents. Exposure to foreign objects within this area would potentially cause a system or product failure due to deterioration, malfunction, or damage.

**3.2.9 FOD Incident:** Any occasion when a foreign object, liquid, or stain is detected on or in FOD sensitive hardware, whether or not it has caused damage. All FOD incidents require recording and investigation. Stains or impacts that are exempted by drawing, surface treatment process, or IMPD document are not considered FOD.

**3.2.10 FOD Database:** A computer-based system designed for the recording and tracking of FOD incidents and the results of FOD walk downs for the purpose of providing feedback and continual improvement.

**3.2.11 FOD Monitor:** An individual in the operational processing area who is designated to promote FOD awareness, check for potential FOD hazards, work with the proper personnel/management to correct discrepancies, and lead the performance of FOD walk downs to make observations of the specified areas concerning FOD.

**3.2.12 FOD Sensitive Area:** A facility where FOD sensitive hardware is in place or in transit and specified FOD prevention methods are applied. This term includes the following classifications: FOD Awareness Area, FOD Control Area, and FOD Critical Zone.

**3.2.13 FOD Sensitive Hardware:** An item of equipment or a part of flight hardware that is considered mission essential and may be susceptible to entrapment of foreign objects, damage from foreign object impact, or damage from leaks and spills. Development test hardware, GSE, special test equipment, fixtures, tooling, and jigs may also be identified as FOD sensitive hardware where FOD may degrade the asset's required safety or performance characteristics or may create a migration path for FOD entry to flight hardware. This designation includes Impact Damage Susceptible (IDS) items.

**3.2.14 Foreign Object Debris:** A substance, debris, or article alien to the hardware that would potentially cause damage. Examples include metal shavings, wire clippings, construction debris, dropped tools or fasteners, oil drips, and water spills. Flight piece parts can be FOD if they are dropped or lost in flight hardware where they do not belong.

**3.2.15 Foreign Object Damage:** Any damage attributed to a foreign object that can be expressed in physical or economic terms; this may or may not degrade the product's required safety and/or performance characteristics.

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3.2.16 **Housekeeping:** The responsibility of employees to maintain a clean and orderly work area, with necessary tools, materials, and equipment in their places of orderly arrangement.

3.2.17 **Impact Damage:** The injury or harm inflicted by impingement of another object, such as a dropped tool, hail, or runway debris, upon the hardware in question; or by bumping or striking between the hardware in question and another object such as a support cradle or building during handling or lifting.

3.2.18 **Impact Damage Susceptible:** Any item determined to be susceptible to impact damage that may degrade the product's required safety and/or performance characteristics. Items are determined to be IDS by a Damage Threat Assessment (DTA) in accordance with NASA-STD-5019, Fracture Control Requirements for Spaceflight Hardware. Composite and bonded primary structures are IDS items unless a DTA shows otherwise. A Project may also identify metallic structures that are Impact Damage Susceptible.

3.2.19 **Near Miss:** An occurrence within a FOD Sensitive Area where a FOD incident would have occurred had the event remained undetected or where an item is dropped from a height or spilled within a FOD Sensitive Area but misses contacting FOD sensitive hardware. Some, but not all, FOD near miss incidents will meet the criteria for reporting as a Close Call in accordance with MWI 8621.1.

3.2.20 **Operational Processing Area:** A site where flight hardware is present or flight hardware processing activities are taking place and specific work rules are enforced.

3.2.21 **Potential FOD:** The condition where foreign object debris may cause damage and/or failure should the product be put into use. Examples are:

- Metal or wire clippings, solder balls and debris lying in the vicinity of flight hardware.
- Tools, equipment, hardware, personal items, or debris left in the vicinity or on stands, lifts, ladders, cranes, and other overhead structures or locations, or items carried into work areas or used in operations that could fall or be dropped onto hardware.
- Debris lying on roads, ramps, and throughways used to transport flight hardware.
- Drips or leaks from overhead structures or utilities.
- Inclement weather.
- Ice and salt.
- Birds and other animals.
- Construction debris.
- Electro-Static Discharge (ESD) equipment.

3.2.22 **Shadowbox/Shadowboard:** A tool box or storage board with specific, marked locations for each tool so that a missing tool will be readily noticeable.

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3.2.23 **Site Manager:** For the purposes of this document, an individual who has primary responsibility for Project hardware processing tasks in a designated operational processing area.

3.2.24 **Sponge Count:** A procedure wherein every item to be brought into an area is counted and logged before entry and then counted again upon exit, such that every item is accounted for. The term “sponge count” is based on the use of this practice during surgical procedures in a hospital setting.

3.2.25 **“Stumble On”:** For the purposes of this document, FOD, not under the control of an individual performing a specific task, which is found at any time other than during a scheduled FOD walk down.

3.2.26 **Tether:** A lanyard of sufficient strength attached to a tool or equipment and to the user or fixed secure object to prevent the item from dropping.

3.2.27 **Tote Tray:** A device for storing/carrying/transporting tools or equipment in a secure manner to prevent inadvertent droppings, i.e., a tool holder, an apron with pocket rings to which tools can be secured. Tote trays with lids will have the lid secured to the tote tray body.

3.2.28 **Walk down:** Physical inspection, by visual sweep, of an assigned area, zone, or operational processing area for FOD and documentation of the resulting data.

## 4. GENERAL REQUIREMENTS

MSFC flight hardware projects shall establish a FOD prevention program for all ground operations of mechanical and electrical systems of flight hardware, including the design, development, manufacturing, assembly, repair, processing, testing, maintenance, operation, and checkout of the equipment, planned and implemented using a continual improvement approach. MSFC Projects or laboratories that design, assemble, or test hardware that is not for flight but is vulnerable to FOD may establish a FOD prevention program at the discretion of the project or laboratory manager.

### 4.1 Criteria for FOD Sensitive Hardware.

FOD sensitive hardware shall be identified based on Project identification of hardware criticality and the susceptibility of hardware to FOD entrapment, impact damage, and/or damage from leaks or spills. The following criteria may be applied, at the discretion of the Project, to designate non-flight hardware as FOD sensitive.

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#### 4.1.1 Hardware Susceptible to Entrapment.

4.1.1.1 All flight hardware that is susceptible to entrapment of FOD within enclosed volumes that could later be released during operation or pose a potential risk to flight hardware or flight crew shall be designated as FOD sensitive.

4.1.1.2 All flight hardware that is susceptible to entrapment of FOD within the materials of construction, such as solid rocket motor propellants or composite structures, shall also be designated as FOD sensitive.

4.1.1.3 Non-flight hardware containing enclosed volumes that interface with flight hardware or that may be a source for FOD to migrate to flight hardware may also be designated as FOD sensitive.

#### 4.1.2 Hardware Susceptible to Impact Damage.

Structural composite and bonded flight hardware that are determined to be IDS per the Damage Threat Assessment (DTA) in accordance with NASA-STD-5019, “Fracture Control Requirements for Spaceflight Hardware” shall be designated as FOD sensitive. Critical metallic flight hardware structures that are susceptible to impact damage and are either not inspectable or would result in an unacceptable loss to the program if damaged may also be designated as IDS and FOD sensitive.

#### 4.1.3 Hardware Susceptible to Leaks and Spills.

Most flight hardware is susceptible, to some extent, to damage caused by leaks and spills. Hardware that is determined by the Project to be highly susceptible to damage caused by leaks and spills may, at the discretion of the Project Manager, be identified as FOD sensitive even when it is not vulnerable to entrapment or impact damage.

#### 4.1.4 Protection of FOD Sensitive Hardware.

FOD sensitive hardware shall be listed in the Project FOD control program document and shall require FOD preventive measures in accordance with this document.

### 4.2 Project FOD Control Program Elements.

Each flight hardware Project shall develop a written Project FOD control program that includes the following basic elements:

- a. A Project FOD Focal Point.
- b. Identification of FOD sensitive hardware.



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- c. Early design consideration for FOD prevention, resistance to damage, foreign object entrapment, etc.
- d. Manufacturing, assembly, test, and operations planning and sequencing to minimize FOD generation and incorporate part protection devices where appropriate.
- e. Designation and control of FOD Sensitive Areas, with access control and control of overhead operations.
- f. Housekeeping to control and eliminate FOD.
- g. Control of tools, hardware, consumables, and personal items.
- h. Control of hazardous material.
- i. FOD prevention training
- j. Measuring techniques for analysis, trending, and feedback.
- k. Incident investigation, reporting, and “lessons learned”.
- l. Employee awareness and feedback.

#### 4.2.1 Limitation of FOD Control Program Elements.

Some flight hardware items, because of their simplicity or small size, may require only a limited FOD prevention effort to assure that they are FOD-free upon delivery. Hardware items that meet all of the following criteria may be exempted from the requirement for a FOD Control Program:

- a. The hardware item internal and external surfaces are fully inspectable to assure that there is no FOD present before final closeout of the hardware item for flight. This will be true for hardware that contains no internal volume or complex geometry and may be true for hardware items such as avionics boxes that are fully inspectable for FOD entrapment before close out of the avionics box cover.
- b. The hardware item is not susceptible to impact damage in accordance with the above criteria.
- c. The hardware item internal volume is either sealed on closeout or is protected from the introduction of FOD by protective packaging during all subsequent handling, test, and integration operations up to launch.
- d. Protective measures for final inspection for FOD and subsequent packaging to prevent FOD are addressed in the hardware Contamination Control Plan required by NASA-STD-6016.

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### **4.3 Responsibilities**

#### **4.3.1 Designation of FOD Personnel**

**4.3.1.1 MSFC FOD FOCAL POINT** - The Engineering Directorate, Materials & Processes Laboratory, and the Chief, Materials Test, Chemistry, & Contamination Control Branch shall designate a MSFC FOD Focal Point within the Materials Test, Chemistry, and Contamination Control Branch.

The responsibilities of the MSFC FOD Focal Point are detailed in section 4.3.3.1.

**4.3.1.2 FOD SITE MANAGER** - The Manager of a Department/Laboratory/Office managing a project operation (Project Manager) in a facility where FOD sensitive hardware is present, or designee, shall designate a FOD Site Manager as point of contact for each FOD Sensitive Area.

The Manager of a manufacturing or test facility may designate an area as a FOD Sensitive Area, even when no Project hardware is present, when the manufacturing tooling or test equipment itself is FOD sensitive or may entrap FOD that could later migrate to Project FOD sensitive hardware. When such a FOD Sensitive Area designation is established, the manufacturing / test facility manager shall designate a FOD Site Manager for the designated FOD Sensitive Area.

The responsibilities of the FOD Site Manager are detailed in section 4.3.3.2.

**4.3.1.3 PROJECT FOD FOCAL POINT / FOD MONITOR** – The Manager of each Project who designs, tests, or manufactures FOD sensitive hardware shall designate a Project FOD Focal Point/ FOD Monitor for the Project. The Project Manager will ensure that each designated FOD Control Area has an assigned FOD Monitor and FOD Monitor Alternate, as a minimum. An operator or technician assigned to work in the FOD Control Area will typically be selected to serve as the FOD Monitor. A FOD Monitor is not required in a FOD Awareness Area.

The responsibilities of the Project FOD Focal Point / FOD Monitor are detailed in section 4.3.3.3

**4.3.1.4 MAF FOD FOCAL POINT** - The Manager, MAF Operations Office, or designee, shall designate a MAF FOD Focal Point to coordinate FOD prevention measures and FOD training at MAF in accordance with MSFC-STD-3598.

#### **4.3.2 Responsibilities of Management and Supporting Personnel**

**4.3.2.1 PROJECT MANAGER** – The Manager of each Project who designs, tests, or manufactures FOD sensitive hardware, or the Manager of a Department/Laboratory/Office managing a project operation in a facility where FOD sensitive hardware is present (or designee) shall:

- a) Designate a FOD Site Manager (per section 4.3.1.2).

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- b) Designate a Project FOD Focal Point / FOD Monitor and an Alternate FOD Monitor (per section 4.3.1.3).
- c) Ensure that written operational procedures are established (per governing Organizational Issuances) that include appropriate FOD control requirements for each designated FOD Sensitive Area. This should include any requirements from hardware DTAs, IDMPs, or RTDs.
- d) Ensure that FOD prevention controls are incorporated in work area activation planning and work authorizing documents for Project operations.
- e) Ensure that FOD prevention protocols are enforced in all applicable work activities
- f) Determine the interval for review of FOD prevention and incident report metrics.

**4.3.2.2 MANUFACTURING / TEST FACILITY MANAGER** - The Manager of a manufacturing or test facility may designate an area as a FOD Sensitive Area, even when no Project hardware is present, when the manufacturing tooling or test equipment itself is FOD sensitive or may entrap FOD that could later migrate to Project FOD sensitive hardware. When such a FOD Sensitive Area designation is established, the manager shall:

- a) Coordinate with the Project FOD Focal Point to tailor the required FOD control protocols for personnel, tool controls, and operations for the FOD Sensitive Area when Project hardware is present, to assure that both the Project hardware and the FOD sensitive manufacturing tooling or test equipment are adequately protected.
- b) Designate a FOD Site Manager (per section 4.3.1.2).
- c) Ensure that written operational procedures are established (per governing Organizational Issuances) that include appropriate FOD control requirements for the designated FOD Sensitive Area.
- d) Ensure that FOD prevention controls are incorporated in facility activation planning, facility modification planning, and work authorizing documents for operations within the FOD sensitive facility.
- e) Ensure that FOD prevention protocols are enforced in all applicable work activities within the FOD Sensitive Area.
- f) The Supervisor of personnel assigned to work in FOD Sensitive Areas shall ensure that the required FOD training is incorporated into employees' learning plans.

**4.3.2.3 SAFETY AND MISSION ASSURANCE DIRECTORATE** - The Director, Safety and Mission Assurance Directorate, or designee, shall:

- a) Consider the potential for damage to components/hardware caused by foreign object entrapment or impact damage in Safety Hazard Analyses.
- b) Provide feedback to the MSFC FOD Focal Point, FOD Site Manager and the Project FOD Focal Point / FOD Monitor on recommended modifications and improvements to the FOD prevention program.

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- c) Perform audits, incorporate (or ensure incorporation of) applicable FOD prevention protocols (as required by the Project) in the review of work/inspection planning and during surveillance of operations, within identified FOD Sensitive Areas.
- d) Support the Project FOD Focal Point in the investigation of FOD incident reports.
- e) Coordinate with the Project FOD Focal Point and applicable Site Managers in the disposition of Discrepancy Reports and Material Review Board (MRB) actions (reference MPR 8730.3) relating to FOD.
- f) Participate periodically in FOD walk downs; frequency to be established by Project FOD control requirements.
- g) Participate in FOD Sensitive Area activation planning and recommend techniques, methods, and continual improvements to the Project FOD Focal Point and Site Manager.

#### **4.3.2.4 ENVIRONMENTAL ENGINEER / OCCUPATIONAL HEALTH MANAGER -**

The Manager, Environmental Engineering and Occupational Health Office, or designee, shall:

- a) Coordinate environmental engineering and occupational health functions to be performed within or above FOD Sensitive Areas with the Site Manager to assure that these operations do not create a risk to FOD sensitive hardware.
- b) Ensure that personnel assigned to perform environmental engineering or occupational health functions within FOD Sensitive Areas receive FOD awareness training and are escorted within FOD Control Areas by trained FOD escorts designated by the FOD Site Manager.

#### **4.3.2.5 FACILITIES MANAGER -** The Manager, Facilities Management Office, or designee, shall:

- a) Support FOD risk reviews of facilities containing areas, which are to be designated as FOD Sensitive Areas by a Project.
- b) Coordinate Facilities Operations and Maintenance Office operations to be performed within or above FOD Sensitive Areas with the FOD Site Manager to assure that these operations do not create a risk to FOD sensitive hardware. Additional inspections or preventive maintenance may be required for cranes or other overhead facility equipment to identify and remove potential FOD sources. Additional controls on custodial cleaning operations and techniques may also be required.
- c) Ensure that personnel assigned to perform custodial services, maintenance, or repairs within FOD Awareness Areas receive FOD awareness training and are permitted to perform their tasks without escort. Custodial personnel assigned to routinely perform services within FOD Control Areas may also require FOD prevention training.
- d) Require that personnel entering FOD Sensitive Areas to perform custodial services, maintenance, or repairs comply with the applicable FOD protocols for that area and are escorted in FOD Control Areas by trained FOD escorts designated by the FOD Site

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Manager. FOD escort requirements are waived when an emergency such as a facility pipe break occurs that presents an imminent hazard to the FOD sensitive hardware.

**4.3.2.6 LOGISTICS SERVICES MANAGER** - The Manager, Logistics Services Office, or designee, shall:

- a) Coordinate with the Project FOD Focal Point to ensure that adequate precautions are included in lifting, handling, and transportation plans to protect FOD sensitive items from damage during logistic operations.
- b) Ensure that personnel performing transportation, handling, and lifting operations of FOD sensitive hardware are trained for FOD control operations. Contact the Materials Test, Chemistry, and Contamination Control Branch for training requirements.
- c) Ensure that personnel assigned to perform maintenance or repair of research, development, test and evaluation equipment within FOD Sensitive Areas receive FOD awareness training and are escorted within FOD Control Areas by trained FOD escorts designated by the FOD Site Manager.

**4.3.2.7 PROTECTIVE SERVICES / EXPORT CONTROL MANAGER** - The Manager, Protective Services and Export Control Office, or designee, shall:

- a) Require that Protective Services personnel entering FOD Sensitive Areas for non-emergency purposes comply with the applicable FOD protocols for that area and are escorted within FOD Control Areas by trained FOD escorts designated by the FOD Site Manager. FOD escort and access control requirements are waived when emergency response is required per MCP 1040.2, or when an emergency such as a facility pipe break occurs that presents an imminent hazard to the FOD sensitive hardware.
- b) Ensure that Protective Services personnel required to enter FOD Sensitive Areas to perform security functions receive FOD awareness training.

**4.3.2.8 TRAINING AND INCENTIVES OFFICE MANAGER** - The Manager, Training and Incentives Office, or designee, shall:

- a) Track FOD training courses as SHE courses in the System for Administration Training and Education Resources for NASA (SATERN).
- b) Maintain records of civil service personnel trained for FOD control via the SATERN system in accordance with MPR 3410.1.
- c) Coordinate with MSFC FOD Focal Point to schedule instructor-led FOD training courses.

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**4.3.2.9 MAF OPERATIONS MANAGER** - The Manager, MAF Operations Office, or designee, shall:

- a) Designate a MAF FOD Focal Point (per section 4.3.1.4) to coordinate FOD prevention measures and FOD training at MAF in accordance with MSFC-STD-3598.
- b) Perform Facilities Management and Logistics, for FOD prevention at MAF.
- c) Perform oversight/insight and coordination of Project FOD Control Programs and Project FOD measurement, trending, and feedback data.

**4.3.2.10 MAF SAFETY AND MISSION ASSURANCE / QUALITY MANAGER** – The MAF Safety and Mission Assurance / Quality Manager shall:

- a) Implement local operating instruction, AS60-OI-031, MAF Foreign Object Debris (FOD) and Contamination Control Program, to comply with the appropriate MSFC documents.

### **4.3.3 Responsibilities of Designated FOD Personnel**

**4.3.3.1 MSFC FOD Focal Point Responsibilities** – The MSFC FOD Focal Point shall:

- a) Coordinate FOD prevention measures at MSFC in accordance with MSFC-STD-3598.
- b) Develop and maintain common FOD prevention training materials for MSFC.
- c) Train personnel performing FOD training as required.
- d) Perform oversight/insight and coordination of Project FOD Control Programs and Project FOD measurement, trending, and feedback data.
- e) Coordinate with Project FOD Focal Point / FOD Monitor to review FOD operational procedures, perform site assessments, and provide feedback and recommendations to the Project FOD Focal Point / FOD Monitor.
- f) Provide guidance to the FOD Site Managers and Project FOD Focal Points / FOD Monitors as to the level of FOD control required for specified areas per MSFC-STD-3598.
- g) Help FOD Site Managers develop a FOD Agreement per MSFC-STD-3598.
- h) Maintain a list of FOD Awareness Areas and their designated Site Managers. Update as necessary.
- i) Maintain a list of active FOD Sensitive Areas (FOD Control and FOD Critical areas) at MSFC and their designated Site Managers. Update as necessary.
- j) Participate in Project FOD incident investigations where cause and corrective action may have applicability beyond the scope of that project.
- k) Communicate FOD-related lessons learned from MSFC projects, other NASA Centers, and the aerospace industry.
- l) Maintain the MSFC-STD-3598 document and the associated Marshall Directive.

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#### **4.3.3.2 FOD SITE MANAGERS – FOD Site Managers shall:**

- a) Complete SHE-417 FOD training and keep this training up-to-date as required per MSFC-STD-3598.
- b) Coordinate with the MSFC FOD Focal Point and Project FOD Focal Point / FOD Monitor to determine the level of FOD control required for the activities to be performed per MSFC-STD-3598.
- c) Coordinate with the Project FOD Focal Point / FOD Monitor to develop and implement the required protocols for personnel, tool controls, and operations including ensuring that operating procedures are maintained for their FOD Sensitive Area when the Project FOD sensitive hardware is present.
- d) If the Project Manager delegates this responsibility, the FOD Site Manager shall designate a Project FOD Focal Point / FOD Monitor and alternate FOD Monitor, as a minimum, for each facility designated as a FOD Control Area or FOD Critical Area, to perform daily FOD control monitoring tasks when the area is active, and to enter data into a FOD Measurement, Trending, and Feedback System or approved equivalent. A FOD Monitor is not required in a FOD Awareness Area.
- e) Assure that personnel entering the FOD Sensitive Area have the required FOD training or are escorted as required per the FOD Area Agreement.
- f) Establish personnel access controls for the FOD Sensitive Area to prevent inadvertent access, including security locks, stanchions, integrity seals on sealed access doors, and other methods as appropriate, and including overhead utility areas as required.
- g) Arrange for escort (by a trained individual from the organization responsible for operations in the facility) of visitors and MSFC Center Operations personnel and contractors requiring access to the FOD Control Area for non-emergency purposes.
- h) Assure that controls are in place for any lifting and handling of FOD sensitive hardware during operations to prevent FOD entrapment or damage to hardware from FOD impact.
- i) Coordinate with the Marshall Lead Representative (MLR), for any Customer Supplied Product (CSP) with FOD requirements, to assure that the CSP FOD requirements are addressed at MSFC facilities.

#### **4.3.3.3 PROJECT FOD FOCAL POINT / FOD MONITOR – Generally, the Project FOD Focal Point and the FOD Monitor are the same person. The Project FOD Focal Point / FOD Monitor shall:**

- a) Complete SHE-417 FOD training and keep this training up-to-date as required per MSFC-STD-3598.
- b) Coordinate with the MSFC FOD Focal Point and FOD Site Manager to determine the level of FOD control required for the activities to be performed per MSFC-STD-3598.

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- c) Establish and coordinate FOD prevention measures for the Project in accordance with MSFC-STD-3598.
- d) Verify that personnel entering the FOD Control Area and FOD Critical Zone (if applicable) have had the required training. Arrange for escort of visitors when permitted.
- e) Familiarize newly trained and assigned personnel with the FOD control tools and supplies specific to the area.
- f) Conduct a walk down of the FOD Control and FOD Critical Areas at the beginning of the shift when the area is active, to confirm the following items:
  - Area is visually FOD free. Collect any loose FOD found during the walk down and record it, by FOD type, in the FOD Database. Remove or note any equipment, supplies, or facility features that show signs of wear or damage that could create FOD and bring them to the attention of the Site Manager.
  - Tools in designated tool storage areas are all accounted for.
  - FOD control supplies required for the area are available and are in satisfactory condition for use (FOD organizer belt pouches, tool tethers, eyeglass tethers, tape, etc.). Damaged items are to be removed and discarded or tagged for repair.
- g) In addition for FOD Critical Zones at the beginning of the shift:
  - Verify that all shop consumables and small parts are counted and kitted before entry into the FOD Critical Zone.
  - Verify that tools and eyeglasses are tethered, and remind personnel to remove loose items before entry into the FOD Critical Zone.
  - Verify that sponge count procedures are followed for consumables and cut-to-fit items to assure that no debris is left behind.
- h) At the end of the shift:
  - Be the last person exiting the FOD Control or Critical Zone, and perform a visual scan upon exiting to verify that no FOD has been left behind.
  - Perform an end-of-shift tool inventory to verify that all tools have been returned to their designated locations. This inventory may be accomplished by a visual sweep of tool shadow-boards and shadowboxes.
- i) Report the completion of required FOD walk downs and any exceptions noted in the FOD Database and notify the Site Manager if corrective action is required.
- j) Inform the FOD Site Manager immediately in the event of a lost tool or FOD incident.
- k) Report FOD metrics to the MSFC FOD Focal Point, Project management, and active FOD Sensitive Area workers in accordance with the methods prescribed in MSFC-STD-3598.



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## **5. DETAILED REQUIREMENTS**

### **5.1 Designation for FOD Sensitive Areas**

The Center FOD Focal Point shall designate the level of FOD control required for each Project facility (where FOD sensitive hardware is present) based on Project identification of hardware criticality and using the following classifications of FOD Sensitive Areas:

- (1) FOD Awareness Area: An area where FOD sensitive hardware is in place or in transit but there is a low potential for FOD entrapment, FOD migration, or impact damage from foreign objects. This designation may also be used to establish a buffer zone to minimize the risk of FOD migration to an adjacent FOD Control Area or FOD Critical Zone.
- (2) FOD Control Area: An area where FOD sensitive hardware is in place and there is a high potential for FOD entrapment or migration to the hardware or for FOD-caused impact damage.
- (3) FOD Critical Zone: A region within a FOD Control Area that is at the highest risk for potential FOD incidents. Exposure to foreign objects within these areas would potentially cause a system or product failure due to deterioration, malfunction, or damage.

### **5.2 Identification and Protection of FOD Sensitive Hardware.**

FOD sensitive hardware, identified in accordance with the criteria in section 4.1, shall be listed in the Project FOD Control Program document, along with the nature of its sensitivity and the required FOD preventive measures in accordance with this document. Development hardware or customer supplied product may be identified as FOD sensitive in the applicable test plan or task agreement/Space Act Agreement.

### **5.3 Design Consideration for FOD Prevention.**

Reduction of damage potential and elimination of FOD hazards begin with the design process. Early design considerations for flight hardware, FOD sensitive non-flight hardware, and equipment used around FOD sensitive hardware (GSE, test equipment, and manufacturing tooling) shall include:

- a. Identification and elimination or minimization of foreign object entrapment areas.
- b. Identification and sealing of areas through which a foreign object can migrate.
- c. Use of covers, screens, or barriers over exposed openings when appropriate, e.g., fluid system openings, vents.
- d. Installation of special access panels or ports for inspection and cleanout of foreign objects that could potentially cause damage.

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- e. In critical areas, use of blind fasteners that are not prone to leaving debris during installation.
- f. Use of fasteners with self-retaining features within enclosed hardware volumes or to secure high usage access panels.
- g. Location of service points, ground points, and built-in test equipment in areas which are least FOD sensitive.
- h. Use of compatible metals and seals to prevent accelerated deterioration, subsequent failure of seal materials, and the generation of debris.
- i. Use of coatings as a positive seal against entry of minute foreign objects, including dust and water vapor.
- j. Design of openings and vents to minimize traps where water can collect and freeze. Openings should be easily plugged and completely sealed against water when plugged.
- k. Elimination of chafing potential through the design of hardware brackets, special protective material, and special routing.
- l. Provision of screens or other means of foreign object blockage within large supply or drain lines.

Impact Damage Sensitive hardware that requires an IDMP may require the design of protective blankets or tethers, or incorporate the use of accelerometers, pressure sensitive paint or tape, barriers, etc. to prevent and detect damage to the hardware.

#### **5.4 Operations Planning and Sequencing.**

Assembly sequencing and manufacturing techniques shall include a clean-as-you-go approach, proper care and use of assembly/maintenance/test equipment, and parts protective devices.

##### **5.4.1 Planning and Sequencing to Preclude FOD**

Manufacturing, assembly, test, maintenance, integration, and launch site operations tasks shall be planned and sequenced to preclude foreign object damage, impact incidence, and entrapment of debris or contamination.

##### **5.4.2 Containment and Removal of FOD**

Planning paper shall contain processes and procedures for the containment and removal of contamination and debris that is generated during fabrication and assembly operations.

##### **5.4.3 Work Instructions**

As applicable, the following shall be included in work instructions:

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- a. Include FOD Control Area activation dates in integrated management schedules to ensure that the facility is FOD-free and under FOD control before the introduction or exposure of FOD sensitive hardware.
- b. Upon completion of a final machining operation, clean or flush the machined component to assure that it is free of debris and immediately cap or seal exposed openings to deny foreign object entry.
- c. Protect hardware and equipment from splatter accumulation during brazing, soldering, welding, and like operations.
- d. Inspect components and equipment for damage before installation, and repair as necessary; ensure part integrity before installation.
- e. Verify required protective devices (dust covers, temporary seals, cushioning, etc.) are present and properly installed. Items with protective devices missing are to be inspected for FOD, cleaned if necessary and protective devices re-installed.
- f. After fluid and pneumatic system lines and tubing are cut and de-burred, remove debris and other contaminants by cleaning, and then cap ends of the lines.
  - g. Perform a visual inspection of the hardware with good lighting. Inspect for and remove extraneous material as part of the assembly step, conduct a foreign object inspection, and remove debris. Inspect for impact or structural damage as well.
- h. Inspect production tooling (jigs, fixtures, handling equipment, etc.) to assure these are clean, undamaged and free of foreign material before installation and build-up of components or assemblies. Exercise this same care for work stands, ladders, cranes, lifts, special test equipment, etc., which must be placed or used on, in, around or above production hardware to accomplish specific tasks.
  - i. Protect sensitive areas and potential FOD entrapment points by using FOD barriers, foam pads, covers, etc. For instance, cover composite structures with protective covers; place pads between a tool and the hardware or assembly. Additional protective measures may be required by hardware IDMPs.
- j. Impose access controls for physical entry into flight hardware or onto work stands, ladders, lifts, cranes, etc., above flight hardware.

## **5.5 Designation and Control of FOD Sensitive Areas.**

The Project FOD Control Program document shall identify operational areas where FOD sensitive hardware is present as FOD Awareness Areas, FOD Control Areas, or FOD Critical Zones (per section 5.5 of this document), based on the sensitivity and criticality of the hardware at each phase of program operations. FOD Critical Zones, which require the most stringent controls, are contained (nested) within FOD Control Areas.

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### 5.5.1 FOD Control Area Agreement.

The Project FOD Focal Point shall develop a FOD Control Area Agreement for each FOD Control Area and FOD Critical Zone. A recommended template is shown in Appendix A. The FOD Focal Point maintains the masters for these templates. Similar FOD Area Agreements may be used for FOD Awareness Areas at the discretion of the Project.

5.5.1.1 The start date identified in the FOD Control Area Agreement shall be the date of activation of the area under FOD control.

5.5.1.2 The FOD Area Agreement shall list the required work rules, tailored from the requirements of this document to meet specific project requirements and hardware sensitivities, including:

- a. People: Requirements and restrictions for people entering the area.
- b. Tools: Control methods for tools, consumables, and hardware entering or used in the area.
- c. Operations: Requirements and procedures for daily operation within the area.

A quick reference guide to FOD Sensitive Area work rules is shown in section 6.1.

5.5.1.3 The signed and dated FOD Control Area Agreement shall be kept on file by the Project FOD Focal Point until the FOD Control Area is terminated.

5.5.1.4 The FOD Control Area Agreement shall be coordinated with and approved by the applicable Site Manager and signed by the Facilities Operations & Maintenance (O&M) representative for that building.

5.5.1.5 A copy shall be posted at the entrance to the FOD Sensitive Area.

5.5.1.6 If the FOD Sensitive Area is delineated by ropes and stanchions, the FOD Control Area Agreement shall be posted in a visible location, on one of the ropes or nearby, and next to a FOD Sensitive Area sign.

### 5.5.2. Access Controls.

FOD Sensitive Areas shall have personnel access controls, established by the Site Manager, to prevent inadvertent access.

5.5.2.1 Where feasible, the entire room, wall-to-wall, should be designated a FOD Sensitive Area, with signs posted and access controlled at the entrance doors.

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5.5.2.2 When wall-to-wall control is not feasible because of co-location of the FOD sensitive operation within an area along with other operations where FOD control would be impractical, the FOD Sensitive Area shall be segregated with stanchions or other barriers.

5.5.2.3 Areas segregated with stanchions or barriers shall include a buffer zone around the FOD sensitive hardware. A 3-foot wide or more buffer zone is recommended.

5.5.2.4 Access Restrictions.

a. FOD Awareness Areas:

- (1) Access to FOD Awareness Areas is not required to be restricted; however, signs, barriers, and other visual cues shall be used to alert personnel that they are entering a FOD Awareness Area. Visitors are permitted with the authorization of the Site Manager.
- (2) Personnel assigned to work in FOD Awareness Areas or expected to access these areas as a part of their assigned duties shall be trained in FOD Awareness.

b. FOD Control Areas:

- (1) Unescorted access to FOD Control Areas shall be restricted to personnel required for processing in those areas and trained in FOD prevention. Visitors are permitted within FOD Control Areas, provided they are escorted by a trained person and comply with the applicable FOD controls for the area visited.
- (2) Visitors shall be limited to numbers that can be supervised without encroaching upon FOD sensitive hardware. Tour groups are not permitted.
- (3) Access doors to FOD Control Areas that encompass an entire room shall be controlled by locks, key cards, or other secure method.
- (4) When feasible, access to rooms containing a localized FOD Control Area shall also be controlled at the access doors.
- (5) Key card access should be restricted to personnel required for hardware processing and required emergency response personnel.

c. FOD Critical Zones

- (1) Access to FOD Critical Zones shall be strictly limited to personnel trained for the specific risks and procedures associated with that FOD Critical Zone and required for the task at hand.
- (2) Visitors shall not be permitted in FOD Critical Zones.
- (3) In an emergency situation, when a technical expert who has not been trained is required to enter a FOD Critical Zone, he or she shall be coached before entry, escorted by the FOD Monitor for that FOD Critical Zone, and comply with the applicable FOD controls for that zone.

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d. FOD escort and access control requirements are waived when emergency response is required in accordance with MCP 1040.2, MSFC Emergency Plan, or when an emergency such as a facility pipe break occurs, which presents an imminent hazard to the FOD sensitive hardware.

#### 5.5.2.5 Designated Access Points for FOD Control Areas and FOD Critical Zones.

- a. Designated access control points shall be established for personnel entry for each FOD Control Area and FOD Critical Zone.
- b. A FOD control supply station shall be established at the access point.
- c. The FOD control supply station shall include a copy of the FOD Control Area Agreement, tool control logs, and personnel entry/exit logs as specified in the area operating document, and required FOD supplies for that area such as tool tethers, eyeglass retainers, tape for jewelry, FOD personal organizer packs, and FOD collection bags.

#### 5.5.2.6 Control of Access to Overhead Areas.

- a. Control mechanisms shall be established for access to bridge cranes and utility areas directly overhead of FOD sensitive hardware to limit the opportunity for personnel operating in these areas to create a FOD hazard to hardware below. Access to the roof directly overhead of a FOD Sensitive Area may be required to be controlled when warranted by the configuration or condition of the roof and the sensitivity of the hardware below.
- b. Control mechanisms for access to overhead areas shall be selected based on the sensitivity and criticality of FOD sensitive hardware below and may include:
  - (1) Signs posted on access doors, ladders, and stairwells noting the presence of a FOD Sensitive Area below.
  - (2) Physical barriers blocking access to overhead areas.
  - (3) Locks or key card access restrictions.
  - (4) Tamper-evident integrity seals or lock-out/tag-out seals on access doors.
  - (5) Facility O&M orders prohibiting overhead facility service or construction activities without prior notification and approval of the FOD Site Manager.

#### 5.5.3 Activation, Suspension, and Termination of FOD Sensitive Areas.

##### 5.5.3.1 Activation of FOD Sensitive Areas.

Prior to activation of a FOD Sensitive Area, the following conditions shall be met:

- a. Within newly constructed or refurbished facilities, all construction debris (including overhead welding slag) shall be removed.

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- b. The facility shall be inspected and cleaned to remove all FOD, to include all overhead or wall-mounted structures, cranes, and utilities that may pose a FOD hazard to the hardware below.
- c. Facility deterioration, such as flaking paint or ceiling leaks, shall be repaired.
- d. A facility FOD risk review shall be performed to identify potential FOD hazards and to plan corrective action.
  - (1) This risk review shall include a physical walk down of the facility.
  - (2) Required participants in the FOD review and walk down include the hardware manager, the FOD Site Manager, the building manager, the Facility Operations project manager for that building, and the Project FOD Focal Point.
  - (3) The following items shall be assessed:
    - (a) Condition of overhead and adjacent building utilities, to include condition and integrity of fire suppression systems, piping, and other potential sources of leaks, drips, and spills.
    - (b) The potential for dripping from overhead condensation.
    - (c) Condition and integrity of roof, doors, windows, cranes, moveable platforms and other systems that may pose a risk to FOD sensitive hardware because of leaks or failure.
    - (d) Identification of previously planned facility maintenance, modifications, or upgrades, to identify those activities that must be completed before FOD Sensitive Area activation or postponed until after FOD Sensitive Area suspension or termination.
    - (e) General cleanliness and condition of surfaces, such as painted items, lubricated mechanisms, overhead cranes, and rafters, which could be a source of FOD during facility use.
    - (f) Risk to program hardware and operations from pest entry (birds, rodents, insects, reptiles, etc.)
  - (4) A recommended checklist for a facility FOD risk review is shown in Appendix B.
  - (5) A list of required corrective actions shall be generated as an output of this review and walk down, with assigned action items.
- e. Corrective actions identified during the facility FOD risk review shall be completed before FOD area activation or accommodations made to ensure that the remaining FOD issues will not create an unacceptable risk to FOD sensitive hardware.
- f. Personnel shall be trained and ready to conform to FOD prevention protocols.
- g. Access controls shall be established and FOD awareness signs posted.
- h. FOD control supplies, required by the FOD Control Area Agreement, shall be available at the designated entrance point.

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- i. Tool controls, including shadowboxes and tracking systems as required, shall be in place.
- j. Access to a FOD database shall be available for FOD Monitors to enter data for FOD Control Areas and Critical Zones.
- k. An initial FOD walk down shall be performed by the Site Manager, FOD Monitor, and Project FOD Focal Point to verify that the area is FOD free and ready for operation. A recommended checklist for FOD control area activation is shown in Appendix B.
- l. The FOD Control Area Agreement shall be signed, dated, and posted, as required, indicating that the area is an active FOD Sensitive Area.

#### 5.5.3.2 Suspension of FOD Controls.

A FOD Sensitive Area may be suspended when all FOD sensitive hardware has been removed from the facility or has been packaged to preclude the risk of FOD entrapment or impact damage, if the facility is planned to be reactivated as a FOD Sensitive Area in the near future.

- a. When a FOD Sensitive Area is suspended, the FOD Sensitive Area signs and FOD Control Area Agreement shall be removed or posted as “suspended.” Physical barriers, floor tape, and awareness posters may be left in place.
- b. Before reactivation of a FOD Sensitive Area that was suspended, a FOD walk down shall be performed to assure that the area is FOD free.
- c. The facility FOD risk review is not required to be repeated.
- d. On reactivation, the FOD Sensitive Area signs and FOD Control Area Agreement shall be re-posted.

#### 5.5.3.3 Termination of FOD Controls.

A FOD Sensitive Area may be terminated when FOD sensitive hardware has been removed from the facility or has been packaged to preclude the risk of FOD entrapment or impact damage.

- a. When a FOD Sensitive Area is terminated, the FOD Sensitive Area signs and FOD Area Agreement shall be removed.
- b. Physical barriers, floor tape, FOD posters, and other FOD control visual cues shall be removed.

#### 5.5.4 FOD Awareness Area Operations.

FOD Awareness Areas are established to protect sensitive hardware that is in place or in transit but for which the potential for FOD entrapment or migration is low and the risk of impact damage from foreign objects is low during planned project operations.



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- a. FOD Awareness Areas shall be clearly marked at entrances or on barrier stanchions with FOD Awareness Area signs. Awareness signs such as “Clean-As-You-Go” are recommended.
- b. Housekeeping and clean-as-you-go standards shall be strictly enforced.
- c. Eating and drinking shall not be allowed. This includes snacks, gum, bottled water, and smokeless tobacco. Food and drink may be present provided they are contained in spill-proof containers and are not opened in the FOD Awareness Area.
- d. Operations above FOD sensitive hardware shall be approved by the FOD Site Manager and controlled via tethers and other precautions to minimize the potential for spills or dropped items.
- e. Personnel assigned to work in or have recurring access to the FOD Awareness Area shall have Safety, Health and Environmental SHE 415, Foreign Object Debris Awareness Training.

#### 5.5.5 FOD Control Area Operations.

FOD Control Areas are established to protect FOD sensitive hardware where there is a high potential for FOD entrapment or migration to the hardware or for FOD-caused impact damage.

- a. FOD Control Areas shall be clearly marked at entrances with FOD Control Area signs and copies of the signed FOD Control Area Agreement. FOD awareness media such as “Clean-As-You-Go” posters are recommended.
- b. Housekeeping and clean-as-you-go standards shall be strictly enforced.
- c. Food and drinks shall not be allowed. This includes snacks, gum, bottled water, and smokeless tobacco.
- d. Personal items shall be controlled in accordance with section 5.7.
- e. Tools shall be limited to those items required in accordance with written manufacturing instructions, test instructions, facilities maintenance instructions, or other written work authorizations.
- f. Tools, small parts, and shop consumables shall be controlled in accordance with section 5.8.
- g. No loose items above the waist shall be permitted.
- h. No loose items shall be permitted anywhere on the body when working overhead of FOD sensitive hardware.
- i. Personnel assigned to the FOD Control Area shall have SHE 416, Foreign Object Debris Prevention Training.
- j. Each FOD Control Area shall have an assigned FOD Monitor and FOD Monitor Alternate, as a minimum, who have completed SHE 417, Foreign Object Debris Monitor Training.
- k. FOD walk downs shall be performed at the beginning of each shift during which project operations are planned and the results recorded in the Project FOD Database.

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### 5.5.6 FOD Critical Zone Operations.

FOD Critical Zones are established within FOD Control Areas where FOD sensitive hardware is at the highest risk for potential FOD incidents. Within these zones, damage may be caused by dropping of items from elevated stands or work areas onto IDS hardware. Damage may also result from misplacement or migration of small parts or FOD into an enclosed space where detection or retrieval may be difficult. Significant enclosed spaces where personnel entry is required and work stands over or adjacent to complex entrapment-sensitive or IDS assemblies are designated as FOD Critical Zones.

- a. FOD Critical Zones shall be clearly marked at the entrance to the stand or the work zone with FOD Critical Zone signs and a copy of the signed FOD Critical Zone Agreement. FOD awareness media are not placed within FOD Critical Zones.
- b. “Clean-as-you-go” standards shall be strictly enforced.
- c. Small parts and shop consumables shall be counted and kitted before entering the FOD Critical Zone.
- d. A “sponge count” procedure shall be used for all small parts and shop consumable items, including parts that are cut to fit, in accordance with section 5.8.5.1.
- e. Food and drinks shall not be allowed. This includes snacks, gum, bottled water, and smokeless tobacco.
- f. Personal items shall be controlled in accordance with section 5.7. No loose items are permitted anywhere on the body.
- g. Tools, parts, and expendable materials shall be limited to those items required in accordance with written MANUFACTURING instructions, test instructions, facility maintenance instructions, or other written work authorizations.
- h. Tools, parts, and shop supplies shall be controlled in accordance with section 5.8.
- i. FOD Critical Zones shall have a controlled entry station where tools, parts, and expendable materials are logged in and out.
- j. Personnel assigned to the FOD Critical Zone shall have SHE 416, Foreign Object Debris Prevention Training, and SHE 417, Foreign Object Debris Monitor training.
- k. The FOD Monitor for the FOD Control Area containing the FOD Critical Zone shall monitor entrance and exit controls from the FOD Critical Zone.
- l. A FOD walk down or visual sweep shall be performed upon entry and exit and the results recorded in the FOD Database.

### 5.5.7 FOD Control Signage.

5.5.7.1 Signs shall be posted at entrances to FOD Awareness Areas, FOD Control Areas, and FOD Critical Zones that clearly indicate the level of control.

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5.5.7.2 In addition, awareness signs and media shall also be posted to remind workers and visitors of the requirement for FOD prevention.

5.5.7.3 The following standard FOD images (or equivalent) shall be used:

a. Figure 1, No FOD Logo, is a recognized logo<sup>1</sup> used for FOD control in the United States and should be used on all FOD media.



**Figure 1. No FOD Logo**

b. FOD Awareness Areas shall be identified by a blue diamond (or equivalent) as shown in Figure 2 below.

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Figure 2. FOD Awareness Area Logo

c. FOD Control Areas shall be identified by a yellow “Yield” sign (or equivalent), as shown in Figure 3 below.



Figure 3. FOD Control Area Logo

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d. FOD Critical Zones shall be identified by a bold red “Stop” sign (or equivalent), as shown in Figure 4 below.



**Figure 4. FOD Critical Zone Logo**

#### 5.5.8 FOD Monitors.

5.5.8.1 Each designated FOD Control Area shall have an assigned FOD Monitor and FOD Monitor Alternate, as a minimum, appointed by the FOD Site Manager. An operator or technician assigned to work in the FOD Control Area will typically be selected to serve as the FOD Monitor. A FOD Monitor is not required in a FOD Awareness Area. The responsibilities of the FOD Monitor (or Alternate) are described in section 4.3.3.3 of this document.

#### 5.6 Housekeeping.

FOD Sensitive Areas are to be maintained clean and FOD free. To achieve this objective, the following housekeeping requirements shall be incorporated into daily operations:

5.6.1 Employees shall be informed that housekeeping is a part of their job and that compliance with FOD housekeeping protocols will be a part of their performance evaluation.

5.6.2 Employee training and daily operations shall incorporate “clean-as-you-go” as a required work ethic to prevent debris from migrating into flight hardware.

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5.6.3 Floors, aisles, support structures, access platforms, and other facility surfaces shall be cleaned on a routine schedule to maintain good housekeeping standards that enhance FOD elimination.

5.6.3.1 Sweeping, dusting, vacuuming, and other facility cleaning methods shall remove debris in a manner that precludes migration or distribution onto flight hardware or onto work surfaces that could provide a migration path to flight hardware.

5.6.3.2 Cleaning methods that continuously remove debris rather than relocate it, such as filtered vacuum cleaners, externally exhausted house vacuum, and damp wiping, are preferred.

5.6.4 Grounds and surfaces on which aerospace vehicles and GSE are transported shall be maintained free of FOD that could cause damage.

5.6.5 In the refurbishment or maintenance of existing facilities or construction of new facilities, all construction debris shall be removed at the end of each task or at the end of each shift. If applicable, this requirement should be entered into contractual agreements.

5.6.6 FOD prevention considerations shall be included in the design, contracting award, and construction management for projects around or adjacent to flight hardware areas.

5.6.7 The FOD Site Manager shall determine which areas within the FOD Sensitive Area are to be cleaned by project personnel and which areas are to be cleaned by Facilities O&M custodial personnel.

5.6.8 The areas requiring cleaning and the extent of cleaning shall be reviewed with all involved parties (custodial contractor, Facilities O&M representative, and facility operators responsible for cleaning hardware) and agreed upon for FOD Sensitive Areas both in active and suspended states.

5.6.9 Facilities custodial personnel shall not enter FOD Critical Zones.

## 5.7 **Personal Item Control.**

Personal items are any items an individual brings into a FOD Sensitive Area that are not identified as required for the manufacturing, test, or quality assurance operation via work instructions. Personal items include clothing, badges, eyeglasses and other personal medical devices, keys, jewelry, office supplies, cell phones, wallets, coins, etc. Personal items shall be controlled within FOD Control Areas, FOD Critical Zones, and during overhead operations in FOD Awareness Areas as specified below to prevent them from becoming FOD.

### 5.7.1 **Storage of Personal Items.**

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All personal items shall be removed and stored or secured in accordance with the work rules for the specific FOD Sensitive Area.

5.7.1.1 The Project may issue personal FOD organizer pouches, shown in Figure 5, Example of a Personal FOD Organizer Pouch, to safely contain personal items while the employee is in the FOD Sensitive Area. As an alternative to personal FOD organizer pouches, the Project may provide personal lockers, badge boards, or other means to store these items.

5.7.1.2 When used by the Project, pouches shall be made available at a FOD control station near the entrance for use while working in the FOD Control Area or FOD Critical Zone

5.7.1.3 Personal items shall not be placed or stored in tool bags or tool storage locations.



**Figure 5: Example of a Personal FOD Organizer Pouch**

### 5.7.2 Badges.

Identification badges shall not be clipped to shirts or worn on lanyards inside FOD Control Areas. Hanging or loose badges could scratch sensitive hardware or become dislodged. When the personal FOD organizer pouch is used, the NASA identification badge should be placed in the clear window of the pouch where it is clearly visible.

### 5.7.3 Jewelry.

5.7.3.1 Jewelry shall not be worn in FOD Control Areas and FOD Critical Zones.

5.7.3.2 All removable jewelry shall be removed and may be placed inside the zippered portion of the personal FOD organizer belt pouch. Jewelry that cannot be easily removed may be permitted inside FOD Control Areas at the discretion of the Project FOD Focal Point, provided it does not present a scratch or catch hazard to the hardware within that FOD Control Area.

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5.7.3.3 Before entering a FOD Critical Zone, jewelry that cannot be removed shall be taped in place to prevent it from being lost or becoming a scratch or catch hazard.

5.7.3.4 Watches shall be worn only when required by work instructions.

5.7.3.5 Required watches shall be secured to assure that they cannot come loose and cannot become a scratch or catch hazard.

#### 5.7.4 Medical Devices and Personal Protective Equipment.

5.7.4.1 Eyeglasses, safety glasses, required medical devices, and personal protective equipment shall be securely tethered or taped to the individual while in a FOD Control Area or FOD Critical Zone.

5.7.4.2 Contact Lenses may be prohibited in some FOD Critical Zones, such as inside liquid oxygen tanks.

5.7.4.3 Medical devices that cannot be tethered or secured shall be evaluated for accommodation on a case-by-case basis by the Site Manager and the Project FOD Focal Point.

#### 5.7.5 Clothing Accessories.

5.7.5.1 Accessories attached to clothing, such as cell phones, pagers, key fobs, chains, pins, or all-purpose tools, shall not be worn within FOD Control Areas and FOD Critical Zones.

5.7.5.2 Hats shall not be worn except for hoods or snoods issued for control of hair within the work area or required hard hats.

#### 5.7.6 Pockets.

5.7.6.1 Before entering a FOD Control Area, all loose items shall be removed from pockets above the waist.

5.7.6.2 Before entering a FOD Critical Zone, all pockets shall be emptied. The contents may be secured within the zippered compartment of the personal FOD organizer pouch or stowed outside of the FOD Critical Zone.

5.7.6.3 Personal FOD organizer pouches shall not be opened to retrieve items within a FOD Critical Zone.



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### 5.7.7 Shoes.

Street shoes are not permitted to be in direct contact with flight hardware. When personnel are required to step onto or inside a flight article, protective mats shall be used and personnel shall wear approved soft-soled shoes or program-issued shoe covers.

### 5.7.8 Clean Work Area Apparel.

5.7.8.1 In some FOD Sensitive Areas, Clean Work Area (CWA) apparel will also be required. (Reference MSFC-STD-246.)

5.7.8.2. Pockets in personal clothing shall be emptied as required for the FOD control level before donning CWA apparel.

5.7.8.3 The personal FOD organizer pouch and the CWA apparel shall be worn in accordance with the specific operating instructions for the CWA.

## 5.8 Control of Tools, Small Parts, and Shop Consumables.

The objective of a tool and small parts control program is to eliminate damage to hardware from dropped items and entrapment of FOD in flight hardware related to lost tools, small parts, or consumables that are inadvertently left behind or migrate into flight hardware. An effective tool and small parts control program will also reduce the potential for production delays required to search for and remove a dropped or lost item.

### 5.8.1 Tethers.

Tethers shall be used on elevated work stands, within FOD Critical Zones, or in any other location where a dropped article could result in damage to FOD sensitive hardware or where difficulty in retrieval would result if the tool were dropped.

5.8.1.1 Hand tools shall be tethered to the user.

5.8.1.2 Equipment, tote boxes/bags, and other loose articles shall be tethered or suitably restrained.

5.8.1.3 Tether devices shall be examined regularly to assure that they are in good condition and will not break during use or shed debris.

5.8.1.4 The tether should be a minimum length to preclude or minimize damage from tool swing or impact, should the tool or equipment be dropped or bumped.

5.8.1.5 Tethers shall be approved by the Project FOD Focal Point.

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**CAUTION:** A tether device, if not regularly examined, may itself become FOD. Frayed tether material and lost tether hardware (rings, snaps, etc.) can all become FOD.

#### 5.8.2 Accountability Methods for Tools, Small Parts, and Consumables.

There are numerous methods available to facilitate control and accountability of tools, small parts, and consumables. The Project FOD Focal Point, with the Site Manager, shall establish a tools, small parts, and consumables accountability system for each FOD Control Area or FOD Critical Zone to implement controls, tailored from the following requirements, for the specific required operations.

##### 5.8.2.1 Tool Control and Accounting.

- a. All tools used within FOD Sensitive Areas shall be maintained clean and in good working condition.
- b. Only those tools required for use within the FOD Control Area shall be stored there.
- c. Tools shall not be stored inside a FOD Critical Zone.
- d. Tools assigned to and stored within FOD Control Areas shall be recorded in a written record kept at the work site.
  - (1) These tools shall be stored in shadowboxed tool kits or on shadowboards such that tools that are in use or missing are visually apparent.
  - (2) Tools not installed in a fixture shall be returned to the designated storage location at the end of each shift.
  - (3) A chit or other tracking method shall be used to account for tools not returned to the tool storage location at the end of a shift or when removed for repair or calibration.
- e. Tools temporarily brought into a FOD Control Area for use during a shift shall be logged in and out on a tool entry log, identifying the user of the tool and the date and time of entry.
- f. Tools required for use inside a FOD Critical Zone shall be logged at the controlled entry station before entry into the FOD Critical Zone.
  - (1) The log shall include the name of the individual using the tool.
  - (2) The tool shall be visually inspected to assure that it is clean and in good working condition.
  - (3) The tool shall be tethered to the wrist or to a waist belt to preclude accidental dropping.
  - (4) Upon exiting the FOD Critical Zone, the individual using the tool shall log it in and return the tool to the designated storage location.
  - (5) At the conclusion of each work shift or tool operation, the area FOD Monitor shall inspect the tool log and the tool storage area to verify that all tools have been removed from the FOD Critical Zone and returned to their proper storage location.

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- (6) Users should minimize the number of tools taken into FOD Critical Zones to the maximum extent possible.

5.8.2.2 When a tool is broken during use, all pieces of the broken tool shall be recovered and inspected by a FOD Monitor or Quality Assurance (QA) representative to verify that no broken pieces remain in the hardware.

5.8.2.3 If all pieces of a broken tool cannot be located, a Lost Tool/Item procedure shall be initiated in accordance with section 5.12.3.4.

### 5.8.3 Quality Assurance Stamps, Chits, and Pens.

QA date stamps, inspection stamps, chits, or pens may be stored in personal FOD organizer pouches until required.

5.8.3.1 The personal FOD organizer belt pouch shall remain closed except when retrieving such an item used to buy off work performance or record required information.

5.8.3.2 The stamp, chit, or pen shall be retrieved carefully, in a location where a dropped item will not fall directly on hardware and may be easily retrieved if dropped.

5.8.3.4 When expected to be used on a recurring basis inside FOD Control Areas or FOD Critical Zones, QA stamps, chits, and pens should be secured to the inspector via a retractable device.

### 5.8.4 Control of Small Parts and Shop Consumables.

Within FOD Control Areas and FOD Critical Zones, small parts and shop consumables (stock fasteners, wipers, gloves, etc.) shall be controlled to prevent these items from becoming FOD.

5.8.4.1 Only parts and shop consumables required for operations within the FOD Control Area shall be stored there.

5.8.4.2 Small parts and consumables shall be stored in closed bins or storage trays away from FOD sensitive hardware.

5.8.4.3 These items shall not be placed on or in FOD sensitive hardware during use but be held in closed tote trays or tote bags.

5.8.4.4 Small parts and shop consumables pose an increased hazard to hardware within FOD Critical Zones because of the possibility of dropping an item from a height that could damage hardware or dropping an item into an enclosed area where it may be overlooked or may be difficult to retrieve. Parts and consumables shall be controlled and accounted for within FOD Critical Zones using some or all of the following methods:

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- a. Small parts to be installed within a FOD Critical Zone shall be counted and kitted within a spill-proof container. Only parts to be installed during that shift or operation should be included in the kit.
- b. Shop consumables shall be counted and logged before kitting for entry into the FOD Critical Zone.
- c. For operations expected to generate debris or used consumables (such as contaminated cleaning wipers) within a FOD Critical Zone, provision shall be made for collection and control of this waste as it is generated. For example, personnel may wear a belt pouch with secure closure to capture process waste.
- d. A “sponge count” shall be performed on all small parts and shop consumables and verified against the kit log upon leaving the FOD Critical Zone to assure that no loose items have been left behind.
- e. Logs shall be retained with the shop records when verification is required for QA purposes.
- f. Items that are cut to fit, such as cable ties, shall be counted and logged before kitting.
  - (1) As each item is cut, the loose end shall be captured and contained in a FOD capture pouch.
  - (2) Upon leaving the FOD Critical Zone, the captured loose ends shall be counted and reconciled with the number of cut-to-fit items installed.
  - (3) Cutting devices that capture and hold the debris until removed by the operator are recommended.

## **5.9 Control of Hazardous Material.**

### **5.9.1 Control of Chemicals and Process Fluids.**

Cleaning solvents and process fluids, including water, shall be controlled to prevent accidental spillage.

5.9.1.1 Only chemicals specified on the work instructions shall be permitted within FOD Control Areas and FOD Critical Zones.

5.9.1.2 Fluids shall be contained in pre-moistened wipes or in small, unbreakable, spill-proof dispenser bottles commensurate with the specific need to minimize the spill hazard.

5.9.1.3 Dispenser bottles containing fluids shall not be placed directly on flight hardware.

### **5.9.2 Light Bulbs and Inspection Lamps.**

Overhead light bulbs and inspection lamps containing mercury present a potentially serious FOD hazard to flight hardware should they fall and break. Bulbs containing mercury should be

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avoided when possible. Overhead mercury light bulbs shall not be serviced or replaced while flight hardware is underneath unless capture bags are used to prevent accidental dropping of the bulbs onto hardware.

## **5.10 Handling and Packaging of FOD Sensitive Hardware.**

Written lifting, handling, and moving plans for FOD sensitive hardware shall identify the required protective containers, caps, covers, purges, bagging, and other precautions to be used to protect the hardware during transportation.

### **5.10.1 Lifting, Handling, and Transportation of FOD Sensitive Hardware.**

5.10.1.1 Logistics shall confer with the Project FOD Focal Point to perform a FOD risk assessment before each type of hardware move to assure that potential FOD sources have been identified and appropriate precautions have been instituted.

5.10.1.2 The FOD risk assessment shall identify the transportation route and consider the equipment and product protection to be used for the move, road conditions, weather conditions and general surroundings.

5.10.1.3 Lifting devices used for the lifting and handling of FOD sensitive hardware shall be designed and controlled in accordance with NASA-STD-8719.9, Standard for Lifting Devices and Equipment, and Marshall Work Instruction MWI 6430.1, Lifting Equipment and Operations.

5.10.1.4 All mechanical lifting operations of IDS items shall require a written lifting and handling procedure.

5.10.1.5 The potential for damage from foreign objects shall be a consideration in Job Hazard Analyses (JHAs) performed before critical lifts in accordance with MPR 6410.2, Identifying, Packaging, Handling, and Moving Program Critical Hardware. The JHA should identify requirements for nets, screens, crane hook drip/drop shields, and other protective devices to be incorporated into lifting and handling devices and procedures for critical lifts. A final visual inspection shall be conducted once the hardware has been lifted, moved, or transported to inspect for FOD and impact damage.

### **5.10.2 Part Protection and Packaging.**

Packaging materials and methods, including temporary covers, must be selected and controlled to assure that they adequately protect the hardware from FOD and do not become FOD themselves. To prevent impact damage and preclude FOD entry during handling, shipment, and storage, the following techniques shall be employed, where applicable:

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5.10.2.1 Employees shall be trained to assure compliance with packaging, handling, shipping, and storage requirements.

5.10.2.2 Materials and accessories used in the packaging, handling, shipping, and storage that have intimate contact with the part or assembly shall be free of general contamination.

5.10.2.3 Parts and assemblies shall be packaged in a manner that will preclude any chance of one item making contact with another during normal handling operations.

5.10.2.4 Protective and packaging materials shall be chosen based on their ability to adequately resist shedding of particulate and penetration by tearing or piercing caused by forces either external or internal during normal handling operations.

5.10.2.5 Specific instructions shall be provided for packaging, un-packaging, and handling.

5.10.2.6 Protective devices (edge protectors, caps, plugs, covers, filters, rub strips) shall be secured to prevent accidental damage or dislodging.

5.10.2.7 Unauthorized removal of protective devices shall be prohibited.

5.10.2.8 Removal of protective devices shall be authorized through written work instructions, and the hardware shall be inspected for FOD and impact damage.

5.10.2.9 When preparing hardware to deliver to the launch site, temporary protective covers and other temporary, non-flight hardware installations shall be controlled in accordance with MWI 8730.2, Temporarily Installed Hardware Control, to ensure that they do not themselves become a source of FOD.

## **5.11 FOD Awareness and Prevention Training.**

A FOD awareness and prevention training program shall be developed and made available, via the System for Administration, Training, and Education Resources for NASA (SATERN), to personnel who are assigned to work in or support FOD Sensitive Areas. MPD 5340.1 identifies MSFC organizations that are required to ensure that their personnel are trained in FOD awareness and prevention.

### **5.11.1 General FOD Training Content.**

FOD training courses shall include awareness of FOD entrapment hazards and susceptibility of hardware to impact damage and to leaks and spills.

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### 5.11.2 FOD Awareness Training.

A FOD awareness training course shall be developed and made available to personnel who are assigned to work in FOD Awareness Areas or who occasionally require entry into FOD Sensitive Areas.

5.11.2.1 This course shall include an introduction to the causes and effects of FOD on hardware, FOD prevention approaches, the concept and concerns for IDS hardware, and familiarization with FOD control logos, signs, area agreements, and general work rules.

5.11.2.2 FOD Awareness Training shall be required for personnel assigned to work in FOD Awareness Areas.

5.11.2.3 FOD Awareness Training shall be required for personnel who occasionally require entry into FOD Sensitive Areas.

5.11.2.4 FOD Awareness Training shall be required every three years.

5.11.2.5 This course is available in SATERN as SHE 415, Foreign Object Debris Awareness Training.

5.11.2.6 Personnel who complete SHE 416, Foreign Object Debris Prevention Training, are not required to take SHE 415, Foreign Object Debris Awareness Training.

### 5.11.3 FOD Prevention Training.

A FOD prevention training course shall be developed and made available to personnel who are assigned to work in FOD Control Areas or create written lifting and handling instructions for FOD sensitive hardware.

5.11.3.1 In addition to the concepts introduced in the FOD Awareness Training course, this course shall increase employee awareness to the causes and effects of FOD on hardware, to promote active involvement through specific FOD control techniques, and to stress good work habits and compliance with FOD control work disciplines. This course shall address control of tools, consumables, personal items, and “clean-as-you-go” processes, which are required to protect hardware from FOD damage or entrapment.

5.11.3.2 This course shall be required for personnel assigned to work in FOD Control Areas and FOD Critical Zones.

5.11.3.3 This course shall be required for personnel who create written lifting, handling, and transportation plans or instructions for FOD sensitive hardware.

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5.11.3.4 FOD Prevention Training shall be required every two years..

5.11.3.5 This course is available in SATERN as SHE 416, Foreign Object Debris Prevention Training. This course may be tailored by the Project FOD Focal Point for the specific project, FOD Control Area, and/or audience.

#### 5.11.4 FOD Monitor Training.

A training course shall be developed and made available to personnel assigned to serve as FOD Monitors and as Site Managers for FOD Control Areas.

5.11.4.1 This course shall include instruction in the performance of tasks that are the responsibility of the FOD Monitor. This includes the performance of FOD walkdowns, area monitoring, use of area tool control systems, use of the FOD Database, and procedures for lost tools and FOD incidents.

5.11.4.2 This course shall be required for personnel assigned to serve as FOD Monitors and as Site Managers for FOD Control Areas and FOD Critical Zones.

5.11.4.3 Annual refresher training shall be required.

5.11.4.4 This course is available in SATERN as SHE 417, Foreign Object Debris Monitor Training. This course should be tailored by the Project FOD Focal Point to address the tool control systems to be used in the specific FOD Control Area.

5.11.4.5 SHE 416, Foreign Object Debris Prevention Training, is a prerequisite for SHE 417, Foreign Object Debris Monitor Training.

#### 5.11.5 Training Records.

5.11.5.1 FOD training records for MSFC civil servants shall be recorded in SATERN.

5.11.5.2 FOD training records shall be maintained in accordance with MPR 3410.1, “Training.”

5.11.5.3 FOD training records for contractor personnel that do not use SATERN shall be recorded at the time of training and reported in accordance with the contract statement of work.

### 5.12 Measuring and Improving Performance.

Project FOD prevention programs shall provide to both management and workers visibility into problem areas and trends, inspection results, FOD incident reports, and feedback of progress toward achieving the objective of “zero FOD”.



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### 5.12.1 Project FOD Metrics.

The Project FOD Focal Point shall be responsible for the development and reporting of FOD metrics to Project management and to workers in active FOD Sensitive Areas commensurate with the level of activity in the FOD Sensitive Area and FOD sensitivity of the hardware. Methods of providing this information should include the following items:

5.12.1.1 Visibility Charts: Statistical graphics derived from audit or incident data, provided on an isochronic schedule, i.e., weekly or monthly.

5.12.1.2 Trend Analysis: Graphics that show the progress of a FOD Control Area or Project toward the objective of “zero FOD.”

5.12.1.3 Pareto Charts: Reports from areas routinely inspected that show specific problem areas such as type and quantity of FOD found and adherence to FOD walk down schedules.

5.12.1.4 Reports on Lost Item investigations and other FOD incidents, customer comments, concerns, or complaints.

### 5.12.2 FOD Measurement, Trending, and Feedback.

Project FOD prevention programs that require FOD Control Areas or FOD Critical Zones shall record FOD incidents and the results of FOD walk downs and FOD audits in a FOD Database that provides computer-based metrics for measuring the performance of the Project FOD prevention program.

5.12.2.1 The Project FOD Database shall be accessible by the FOD Focal Point for oversight/insight and coordination of Project FOD control programs.

5.12.2.2 This FOD Database, when used to record FOD incidents and FOD found during routine area walk downs, shall provide metrics for continual improvement as described in MGM 1280.1, Guidance for Continual Improvement, and as required by NAS 412.

5.12.2.3 Metrics generated from a FOD Database should include:

- a. Pareto charts of FOD Type Found per location and quantity of FOD Found per location within a specified time period. These charts are used to identify FOD sources and to prioritize efforts to reduce those FOD sources.
- b. Trend charts of Percent No FOD Found and Walk Down Completion Percentage. These charts are used to gauge overall Project adherence to FOD protocols and improvement over time.
- c. Tracking of specific types of FOD Found to demonstrate progress in source elimination.

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d. Isolation of types of FOD sources, such as operations-generated versus facility-generated debris.

### 5.12.3 Incident Investigation, Reporting, and Lessons Learned.

All incidents of actual or potential FOD shall be reported and investigated. FOD near-miss events are required to be noted as well as actual mishaps, so that they are considered in future corrective action and process improvements.

#### 5.12.3.1 FOD Incident Response.

- a. When a FOD incident occurs that contacts hardware or may pose a continuing risk (such as a nearby spill), operations should immediately cease and a FOD incident investigation be initiated by the FOD Site Manager to determine the cause.
- b. Cause and corrective action shall be attained in a timely manner to preclude similar occurrences from happening in the future. This is considered “lessons learned.”
- c. Cause may be determined by visual observation, forensic analysis, or by location of the object.
- d. The FOD Site Manager shall determine when the FOD has been adequately removed and recorded and when it is safe to resume operations.
- e. Near-miss FOD incidents, which generally do not warrant a cessation of operations, shall be reported, investigated, and corrective action attained with the same urgency as actual FOD incidents to prevent a recurrence that could result in hardware damage.
- f. Photographs should be taken of the FOD found, before removal if possible, and of visible damage caused by the FOD to aid in incident investigation and documentation.

#### 5.12.3.2 FOD Incident Reporting.

The following are considered FOD incidents and shall be reported to the Project FOD Focal Point and recorded in the FOD Database in a FOD Incident Report.:

- a. Any occasion when a foreign object, liquid, or stain is detected on or in FOD sensitive hardware in a FOD Control Area or FOD Critical Zone, that is not associated with the process actively being performed, and whether or not it has caused damage. Stains that are exempted by drawing or surface treatment process document are not considered FOD. In a FOD Awareness Area, this is reported as a FOD Incident only when the FOD has caused damage or is suspected to have caused damage to the flight hardware.
- b. Any occasion when a foreign object falls on or impacts IDS hardware in any FOD Sensitive Area or during transportation. Dropped items of no substantial weight, such as fabric cable lacing, are not required to be reported provided that they are immediately retrieved.

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- c. Items dropped near, but not directly on, IDS hardware; reported in the FOD Database in a FOD Incident Report as a near-miss.
- d. Lost tools, small parts, or consumables that come up missing during a tool accountability check or sponge count, if not located within 1 hour of searching.
- e. Chemical or water spills or facility drips within a FOD Control Area or FOD Critical Zone but not directly on hardware; reported in the FOD Database in a FOD Incident Report as a near-miss. Within a FOD Awareness Area, chemical or water spills or facility drips that do not contact hardware should be reported in a FOD Incident Report in the FOD Database as a near-miss if contact with the FOD sensitive hardware could have caused damage.
- f. Items such as tools, small parts, or facility debris, found in a FOD Control Area other than during a FOD walk down, may be reported in the FOD Database as “stumble on” FOD. “Stumble on” FOD is not reported in a FOD Incident Report; however, recording of this type of FOD in the FOD Database will assist in the tracking and elimination of FOD sources in the facility.

#### 5.12.3.3 FOD Incident Investigation and Corrective Action.

- a. The FOD Focal Point shall investigate all Lost Item Reports and FOD Incident Reports to determine and recommend corrective action to prevent recurrence. FOD Site Managers, FOD Monitors, and area workers should be a part of this process, as well as anyone else who might contribute creative ideas to resolve FOD incidents.
- b. When FOD results in damage or suspected damage to the hardware that leads to a Discrepancy Report or other non-conformance record, the disposition of that report or record shall be recorded in the FOD Database in a FOD Incident Report to capture the incident and corrective action as a part of the overall FOD trending and measurement systems.

#### 5.12.3.4 Lost Tool/Item Procedures.

- a. When in a FOD Control Area or FOD Critical Zone, the employee shall notify the FOD Site Manager **immediately** when a tool, shop supply, or personal item is found to be missing.
- b. Employees performing overhead operations in a FOD Awareness Area shall also notify the FOD Site Manager **immediately** when a tool, shop supply, or personal item is found to be missing.
- c. There shall be no disciplinary action taken as long as the lost tool/item is immediately reported, except in the case of repetitive and careless losing of tools or items or when the tool control procedures were intentionally circumvented.
- d. When a tool is reported lost or missing, work shall stop immediately and a search initiated for the lost item.

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e. If the lost item is not located within 1 hour, a Lost Tool/Item procedure shall be initiated as follows:

- (1) A FOD Lost Tool/Item report shall be recorded in the FOD Database.
- (2) If the item is noted as missing at the end of a shift, the FOD Lost Tool/Item report shall be initiated and, if possible, resolved before the responsible FOD Site Manager leaves the area.
- (3) The FOD Site Manager shall interview the individual reporting the lost item to identify the areas the person was working in when the item was lost.
- (4) If the lost item is a tool found to be missing from a tool storage shadowboard or shadowbox, the FOD Monitor and FOD Site Manager shall ascertain where the tool was likely last used and by whom and interview the likely user(s).
- (5) The FOD Site Manager shall provide leadership for a search for the lost item.
- (6) All employees and support personnel in the FOD Control Area shall participate in the search as required.
- (7) If the location of the missing item is known to be within the hardware but is not immediately retrievable, QA shall be notified to assure that the item is removed as soon as the appropriate recovery tools or methods are available.
- (8) The FOD Lost Tool/Item report shall remain open until the difficult-to-retrieve item is removed.
- (9) If the missing item is found in a location where it may have fallen onto and potentially damaged IDS hardware, QA shall be notified and the dropped tool/item procedure initiated as described below.
- (10) If a lost item is not found after all reasonable efforts have been exhausted, the Project FOD Focal Point shall confer with QA and, if required, Safety, to determine whether the missing item could present a safety hazard.

#### 5.12.3.5 Dropped Tool/Item Procedures.

When IDS hardware is present in a FOD Sensitive Area, tools and small parts dropped onto the hardware may cause unacceptable damage that is not visually apparent.

- a. Dropped items that are suspected or confirmed to have impacted IDS hardware shall be reported in the FOD Database in a Foreign Object Debris Incident Report.
- b. QA shall be notified, to determine whether a Discrepancy Report or other non-conformance record is required.
- c. When an item is dropped near, but not directly on, IDS hardware, a FOD Incident Report shall be recorded in the FOD Database, noting the item as a FOD near-miss.

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d. Any employee shall notify the FOD Site Manager immediately if they hear a noise that indicates that an item may have been dropped or fallen on or near IDS hardware, regardless of the suspected source.

e. If the source of the dropping noise is not immediately identified, a Lost Tool/Item Procedure shall be initiated by the Site Manager and appropriate risk assessment/corrective action taken.

**NOTE:** Items dropped on or near high-value hardware or personnel may also require reporting in accordance with MWI 8621.1 or MWI 8715.13. These documents should be referenced for guidance.

#### 5.12.3.6 Drip and Spill Procedures.

Liquid drips and spills are considered FOD and are treated as follows:

a. Significant leaks or spills shall be wiped up or contained immediately to prevent them from contacting hardware or, if already in contact, from doing further damage. Minor drips or spills in contact with the hardware should also be removed immediately if it is suspected that their continued presence may cause further damage to the hardware.

b. Drips or spills on hardware shall be recorded in the FOD Database in a FOD Incident Report whether or not they are required to be reported as a Discrepancy Record (DR). When the chemical nature of the drip or spill is not known or when a cleaning procedure is not identified in the shop planning paper as allowable rework, the contaminant must be reported on a DR.

c. When an oil drip or a water or chemical spill occurs within a FOD Control Area or FOD Critical Zone but does not contact hardware, it shall be reported in the FOD Database in a FOD Incident Report as a near-miss.

d. The source of the drip or spill shall be recorded in the FOD Database in the FOD Incident Report.

e. If the source of the drip or spill is not obvious, a sample of the spill shall be preserved (on a wiper, swab, or towel, or in a sample bottle) and provided to the Project FOD Focal Point for analysis.

#### 5.12.3.7 Discrepancy Records.

When FOD is suspected or known to have caused damage to flight hardware or test article hardware, the event will also trigger a DR, MSFC Form 460, in accordance with MPR 8730.3, Control of Nonconforming Product, or the appropriate customer nonconformance documentation for Customer Supplied Product. The Customer's representative shall be notified of the known or suspected damage as required per customer's directions. It should be noted that, while a DR is initiated to flag, investigate, and disposition damage to a hardware item, the purpose of the FOD Incident Report is to flag, investigate, and determine corrective action for the FOD item found on or near hardware to prevent recurrence.

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#### 5.12.4 Employee Awareness and Feedback.

Employee awareness and feedback is vital to continual improvement efforts. Workers need specific information about what is wrong before they can be expected to improve processes.

##### 5.12.4.1 FOD Awareness Media.

Signs and banners should be posted at entrances and within FOD Awareness Areas, FOD Control Areas, and FOD Critical Zones to serve as visual cues and reminders that one is operating within a FOD Sensitive Area. All awareness media should include the “No FOD” logo, shown in section 5.5.7.3.

##### 5.12.4.2 Incentives and Awareness Materials.

FOD prevention incentives such as T-shirts, hats, custom-printed eyeglasses tethers, etc., are recommended to improve FOD awareness and to encourage employee feedback and full participation in FOD prevention activities.




##### 5.12.4.3 Posting of FOD Metrics.

Metrics specific to the FOD Sensitive Area, generated from the Project Database for FOD Control Areas and FOD Critical Zones, shall be posted in a prominent location within or near the entrance to the FOD Sensitive Area. These metrics should be discussed in employee team meetings where all team members are encouraged to provide suggestions for improvement.

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## 6. NOTES



### 6.1 Quick Reference Guide to FOD Sensitive Area Work Rules

<b>FOD Control Area Work Rules - Quick Reference Guide</b>			
	<b>FOD Awareness Area</b>	<b>FOD Control Area</b>	<b>FOD Critical Zone</b>
Sign			
Training Requirements	FOD Awareness	FOD Prevention FOD Monitor <sup>1</sup>	FOD Prevention FOD Monitor <sup>1</sup> FOD Critical Zone
Visitors	Permitted with approval of the Site Manager	Permitted with trained escort	Not Allowed
Area Agreement Posted	Optional	Required	Required
FOD Awareness Banners	Recommended	Recommended	Not permitted
Food and Drinks	Not Allowed (except in closed containers)	Not Allowed	Not Allowed
Personal Items	Not restricted <sup>2</sup>	No loose items above the waist <sup>2</sup>	No loose items permitted
Jewelry	Not restricted <sup>2</sup>	Removed or secured	Removed or secured
Eyeglasses	Not restricted <sup>2</sup>	Tethered	Tethered
Tool Controls	Not required <sup>2</sup>	Controlled, tethered over IDS hardware	Tethered, logged, and tracked
Small Parts control	Not required <sup>2</sup>	Controlled	Kitted and counted
Lost Tools/Items	Report	Report Immediately	Report Immediately
Dropped Tools/Items	Report IDS hardware contact immediately	Report Immediately if IDS hardware is present	Report Immediately if IDS hardware is present
Scheduled FOD Walk Downs	Optional	Daily, beginning of shift	Visual inspection on entry and exit of Zone
1. Required for FOD Monitors and FOD Site Managers only. 2. All loose items shall be tethered, secured, or removed when over IDS hardware.			

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## APPENDIX A. FOD AREA AGREEMENT TEMPLATE

Figure 5, Sample Template for a FOD Sensitive Area Agreement, contains specific area controls for People, Tools, and Operations, which are to be listed by the Project FOD Focal Point before approval and posting. The Materials Test, Chemistry and Contamination Control Branch maintains the master for the FOD Sensitive Area Agreement template shown below and will provide this master to the Project FOD Focal Point on request.

 <div style="text-align: center;"> <p><b>Enter Project Name Here</b> Foreign Object Debris (FOD) Prevention Program</p> <p style="font-size: 2em; color: red; margin: 0;"><b>FOD CONTROL AREA</b></p> <p><b>FOD Sensitive Area Requirements</b></p> </div> 						
<b>Process:</b> State Operation Here	<b>Location:</b> Enter Building and Room or Zone here	<b>Start Date:</b> <a href="#">Click here to enter a date.</a>				
		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;"><b>FOD Focal Point</b></td> <td style="width: 50%;"><b>Phone</b></td> </tr> <tr> <td>Project FOD Focal Point</td> <td>Phone number</td> </tr> </table>	<b>FOD Focal Point</b>	<b>Phone</b>	Project FOD Focal Point	Phone number
<b>FOD Focal Point</b>	<b>Phone</b>					
Project FOD Focal Point	Phone number					
<b>FOD Risk:</b> Specify Impact Damage Susceptible Hardware, FOD entrapment concerns, other risks						
<b>FOD Work Rules for this Area</b>						
<p style="text-align: center;"><b>PEOPLE</b></p> <ul style="list-style-type: none"> <li>List work rules for operations</li> <li> </li> </ul>	<p style="text-align: center;"><b>TOOLS</b></p> <ul style="list-style-type: none"> <li>List work rules for operations</li> <li> </li> </ul>	<p style="text-align: center;"><b>OPERATIONS</b></p> <ul style="list-style-type: none"> <li>List work rules for operations</li> <li> </li> </ul>				
<b>APPROVALS</b>						
<b>Site Manager:</b> <a href="#">Click here to enter text.</a>	<b>Facility Operations POC:</b> <a href="#">Click here to enter text.</a>	<b>After Hours Emergency Contact</b> <a href="#">Click here to enter text.</a>				
<b>Phone</b> <a href="#">Click here to enter text.</a>	<b>Phone</b> <a href="#">Click here to enter text.</a>	<b>Phone</b> <a href="#">Click here to enter text.</a>				

**Figure 6. Sample Template for a FOD Sensitive Area Agreement**



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**APPENDIX B. RECOMMENDED CHECKLISTS**

**EM22/CHEMISTRY & CONTAMINATION CONTROL**

**Facility FOD Risk Review Checklist per MSFC-STD-3598**

<b>Project/Program:</b>			
<b>Hardware:</b>			
<b>Location:</b>		<b>Date:</b>	
<b>Name &amp; Org/Company:</b>			
<input type="text"/>	<i>Facility FOD Site Manager</i>	<input type="text"/>	<i>FOD Monitor</i>
		<input type="text"/>	<i>FOD Monitor Alternate</i>
<b>Check Performed By:</b>			
<b>Check Performed By:</b>			
<b>HVAC SYSTEM CONDITION</b>	Yes	No	N/A
Operating while occupied?			
Service and inspection current?			
System Performance Parameters Verified?			
Temperature _____ °F			
Humidity _____ %			
Positive Pressure _____ inches H <sub>2</sub> O			
Filtration                      Good                      Poor			
Air Filter Condition: _____ Good                      _____ Poor			
Filters recently changed?			
<input type="checkbox"/> ( Check box if filters inaccessible)			
Overhead ductwork integrity                      Good                      Poor			
Comments and General Condition of HVAC system: (Mold? Deteriorating? Insulation?)			

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<b>ENCLOSURE</b>	Yes	No	N/A
<b>Ceiling Condition</b>			
Materials and finish intact?			
Free from leaks?			
<b>Floor Condition</b>			
Floor finish intact?			
Will floor material survive tooling loads?			
<b>Walls</b>			
Wall finish intact			
<b>Doors and Windows</b>			
Operable?			
Recently Serviced?			
Do they seal?			
<b>Air Shower</b>			
Operating?			
Seals on doors in tact?			
Interlocks properly working?			

Comments and General Condition of Enclosure:

<b>UTILITIES</b>	Yes	No	N/A
Electrical utilities working?			
House Vacuum working (if available)?			
Serviced recently?			
Hose and tools present?			

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<b>UTILITIES (continued)</b>	Yes	No	N/A
Compressed air working?			
Quality check performed on air?			
<input type="checkbox"/> ( Check box if Missile Grade Air)			
Other fluid systems working? (H <sub>2</sub> O, He, Ar, etc...list below)			
1. _____			
2. _____			
3. _____			
4. _____			
In-room utilities that are not needed and not verified as working tagged out as "Not In Service" ?			
Grounding points required for this project? (Yes or N/A)			
Integrity of grounding points verified?			
Fire suppression system present?			
Service and inspection current?			
Fire extinguishers in room?			
Service and inspection current?			
Comments and General Condition of Utilities:			
<b>OVERHEAD RISKS - LIGHTING</b>	Yes	No	N/A
Type of overhead lighting _____			
Is room free of Mercury lighting?			
Light bulbs all working?			
Covers over bulb where they cannot fall?			
Verified bulbs secure and no Mercury lights can fall?			

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Comments and General Condition of Lighting:

<b>OVERHEAD RISKS</b>	Yes	No	N/A
Overhead piping?			
Do pipes appear free from risk for leaking?			
Do pipes appear to be in good service?			
Condition of Bridge Crane _____ Good _____ Poor			
Serviced Recently?			
Date service is due: _____			
Is Bridge Crane clean of FOD?			
Are all oil drip hazards mitigated?			
Are necessary oil drip umbrellas in place?			

Comments Concerning Overhead Risks:

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<b>GENERAL CONDITION OF ROOM</b>	Yes	No	N/A
<b>Overall Cleanliness</b>			
<input type="checkbox"/> Excellent			
<input type="checkbox"/> Good			
<input type="checkbox"/> Fair			
<input type="checkbox"/> Poor			
Area clean and FOD free?			
Clutter and equipment belonging to others removed or isolated?			
<b>Weather integrity</b>	Yes	No	N/A
<input type="checkbox"/> Excellent			
<input type="checkbox"/> Good			
<input type="checkbox"/> Fair			
<input type="checkbox"/> Poor			
Does wind and rain stay outside of building?			
Area free from rain accumulation where it will not pour in upon opening a door?			
<b>Pests</b>	Yes	No	N/A
Is the area free from any signs of:			
Birds?			
Rodents?			
Insects?			
Reptiles?			
<b>Comments Concerning General Condition of Room</b>			

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<b>FINDINGS</b>