Langley Procedural Requirements

LPR 5310.1 C-1
Effective Date: May 21, 2020
Expiration Date: May 31, 2025

Subject: Foreign Object Damage (FOD) Prevention Program

Responsible Office: Safety and Mission Assurance Office

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Change History Log

Revision	Date	Description of Change
C	10/9/2019	Five-year review. Updated formatting and document citations.
C-1	9/29/22	Minor change to update reference to canceled Agency directive NPD 8730.5 to NPR 8735.2.

PREFACE

P.1   PURPOSE

a.   This Langley Procedural Requirements (LPR) sets forth roles, responsibilities, and procedural requirements for the Langley Research Center (LaRC) Foreign Object Damage (FOD) Prevention Program.

b.   The purpose of the LaRC FOD Prevention Program is to prevent injury to personnel and to prevent damage to critical hardware, experiments, systems, aircraft, and facilities through proper classification of FOD areas, training of personnel, and implementing appropriate FOD prevention and detection techniques.

P.2   APPLICABILITY

a.   The LaRC FOD Prevention Program applies to all personnel performing fabrication, assembly, maintenance, operations, and inspections on LaRC aircraft, models, tunnels, facilities, and flight hardware for Center projects where FOD can potentially cause damage or loss of mission success.

b.   The program shall be used for operations both at LaRC and away from the Center.

c.   In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" denotes a discretionary privilege or permission, "can" denoted statements of possibility or capability, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

d.   In this directive, all document citations are assumed to be the latest version unless otherwise noted.

P.3   AUTHORITY

a.   NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects.

b.   LAPD 1700.1, Safety Program.

c.   LAPD 5300.1, Product Assurance Program.

d.   NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft.

P.4   APPLICABLE DOCUMENTS AND FORMS

a.   LMS-OP-0940, Langley Research Center General Aircraft Maintenance Manual for Research Services Directorate (RSD).

b.   LMS-TD-8735, Housekeeping Instruction for the Fabrication of Foreign Object Debris (FOD) Free Products in the Fabrication Facilities.

c.   LF 164, Report of LaRC Safety/Health Concern/Close Call.

d.   LF 360, Foreign Object (FO) and Foreign Object Damage (FOD) Incident Report.

e.   LF 361, FOD Prevention Survey Checklist.

f.   LF 588, FOD Awareness Area.

g.   LF 589, FOD Control Area.

h.   LF 590, FOD Critical Area.

P.5   MEASUREMENT/VERIFICATION

a.   Compliance with the requirements contained in this LPR will be verified through periodic audits conducted by the Mission Assurance Branch, under the Safety and Mission Assurance Office (SMAO), per Langley Form (LF) 361.

b.   Compliance with this LPR is verified through responses to the following questions:

(1)   Do organizations have the applicable processes in place that include provisions for the prevention, detection, and removal of FO debris?

(2)   Are inspections conducted in accordance with procedural requirements?

(3)   Do organizations maintain and verify records of FOD prevention training (e.g., training attendance sheets), incidents (i.e., LF 360), and corrective actions?

P.6   CANCELLATION

LPR 5310.1B, dated September 2, 2011

David F. Young   May 21, 2020
Deputy Director   Date

DISTRIBUTION:

Approved for public release via the Langley Management System; distribution is unlimited.

CHAPTER 1: INTRODUCTION

1.1   FOREIGN OBJECT

1.1.1   A Foreign Object (FO) is defined as a substance, debris, or article alien to the hardware or system that could potentially cause damage. The object may be foreign to an area or system and may be ingested by or lodged in a mechanism.

1.2   FOREIGN OBJECT DAMAGE

1.2.1   Foreign Object Damage (FOD) is defined as any damage attributed to a FO that can be expressed in physical or economic terms, which may or may not degrade the product's required safety and/or performance characteristics. Some examples of how a FO causes damage include the ingestion of loose hardware by an aircraft engine, the passing of debris through wind tunnel blades or causing the short circuiting of flight electronics, the contamination (e.g., dust, particles) of sensors and optics, the failure of mechanisms to operate properly due to object obstruction, and the change of physical properties of materials (e.g., dissimilar materials) brought on by chemical attack.

1.3   FOD PREVENTION PROGRAMS

1.3.1   Most FOD can be attributed to poor housekeeping, facilities deterioration, improper maintenance, or careless assembly; not keeping full account of hardware, tools, and materials; and inadequate operational practices. An effective FOD prevention program identifies potential problems, corrects negative factors, provides program awareness, conducts employee training, and uses industry "lessons learned" for continued improvement. A strong FOD prevention program is aligned with Langley Research Center (LaRC) management's commitment to strive for excellence in the conduct of operations to ensure the quality and safety of products and services. Organizational planning and processes shall include provisions for the prevention, detection, and removal of FOs in FOD-sensitive areas.

1.3.2   The requirements contained in this document describe the provisions that shall be followed to ensure the development, implementation, verification, and continuous improvement of a sound FOD prevention program at LaRC.

CHAPTER 2: ROLES AND RESPONSIBILITIES

2.1   LaRC FOD Prevention Program

2.1.1   The Langley Research Center (LaRC) Foreign Object Damage Prevention Program is designed to prevent injury to personnel and/or damage to critical hardware, experiments, systems, aircraft, and facilities from foreign objects. The organization of the LaRC FOD Prevention Program is shown in Figure 2.1. Additional FOD roles and responsibilities are described in detail below.
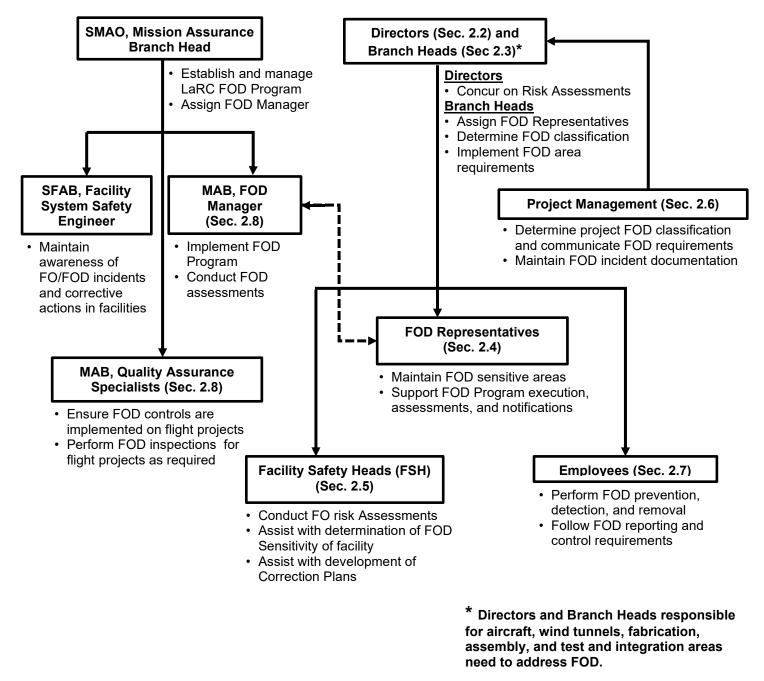

Figure 2.1: LaRC FOD Prevention Program Structure

2.2   ORGANIZATIONS WITH FOD-SENSITIVE AREAS

2.2.1   Directors of organizations with FOD-sensitive areas shall:

a.   Be responsible for managing FOD prevention program implementation within their organizations.

b.   Be cognizant of the FOD areas and the assigned levels for areas in their organizations.

2.3   BRANCH HEADS

2.3.1   Branch heads with FOD-sensitive areas shall:

a.   Assign a FOD Representative(s) for their organizations.

b.   Conduct risk assessments of all their respective work areas to determine the proper level of FOD classification (see Section 3.1). The risk assessment does not need to be documented.

c.   Ensure that proper signage, consistent with the FOD-sensitive area, is posted.

d.   Determine site-specific FO and FOD control methods, as described in Section 3.3 of this LPR, as well as the frequency of any needed inspections, and include these in the appropriate facility documentation.

e.   Ensure that all personnel with access to FOD-sensitive areas have the appropriate training and authorization to perform work in each respective area.

f.   Ensure employees performing work in FOD-sensitive areas follow the assigned FO elimination policies and procedures.

g.   Implement additional site-specific or project-specific requirements upon request by the customer.

h.   Ensure implementation of corrective actions relating to FO prevention, detection, and removal throughout the organization.

i.   Report any FO or FOD incidents by following the reporting requirements of Section 3.4 of this LPR.

j.   Maintain records of site-specific FOD inspections in a manner in which the records are readily accessible to support audits and assessments.

k.   Provide records to the FOD Program Manager during periodic FOD Prevention Program assessments or other Center audits and assessments.

2.4   FOD REPRESENTATIVES

2.4.1   FOD Representatives shall:

a.   Maintain a listing of all FOD-sensitive areas (e.g., building and room number), and their classifications, under their responsibility and provide the list, and any subsequent changes, to the FOD Program Manager.

b.   Perform and document periodic assessments of the execution of the LaRC FOD Prevention Program in their respective organizations and provide the assessments of the area to the branch head.

c.   Ensure walk-downs, inspections and site-specific requirements are documented to show implementation.

d.   Ensure that the FOD Program Manager is notified of any FO or FOD found, or of any other FO or FOD related issues, incidents, or concerns.

e.   Ensure that all Corrective Action Plans identified in LF 360s are completed and implemented.

f.   Provide support to the FOD Program Manager during periodic FOD Prevention Program assessments and other Center audits and assessments.

2.5   FACILITY SAFETY HEADS

2.5.1   Facility Safety Heads (FSHs) shall:

a.   Assist the branch head when determining the risk associated with a FO for the activities being performed in an area and the FOD sensitivity designation, per Section 3.1 of this LPR.

b.   Work with the supervisor and project manager to develop a Corrective Action Plan for an LF 360 if a FO and/or FOD is found, per Section 3.4 of this LPR.

2.6   PROJECT MANAGERS

2.6.1   Project Managers shall:

a.   Identify the proper FOD classification per the classification requirements in Chapter 3 of this LPR for the project and any project-specific FOD requirements.

b.   Determine project-specific FO and FOD control methods, as described in Section 3.3 of this LPR, as well as the frequency of any needed inspections, and include these in the appropriate project documentation.

c.   Ensure project-specific FOD requirements are provided to the appropriate branch head or implementing organization.

d.   Ensure all FO and FOD incidents are documented in project records (e.g., work packages) and investigated, and that corrective actions are taken to prevent recurrence.

e.   Include design considerations for FOD control to reduce the risk of FOD as a part of their system engineering approach per Chapter 4 of this LPR.

2.7   EMPLOYEES

2.7.1   All employees who work in FOD-sensitive areas shall:

a.   Conduct work in a manner that provides for the prevention, detection, and removal of FOs.

b.   Obtain an effective understanding of FO and FOD policies and requirements for project-specific and site-specific work.

c.   Complete required FOD Prevention Program training designated by each organization.

d.   Perform scheduled walk-downs on a frequency determined by management using site-specific FOD inspection checklists, as required, and document completion in a manner as directed by management of the organization.

e.   Report immediately any FO or FOD that is found and any other FO or FOD related issues or concerns to their immediate supervisors and FOD Representatives.

f.   Work with management to help develop specific inspections, control measures, and techniques for FOD-sensitive areas.

2.8   SAFETY AND MISSION ASSURANCE OFFICE (SMAO)

2.8.1   Mission Assurance Branch (MAB) personnel supporting flight projects shall:

a.   Look for FO and FOD during receipt inspection and quality assurance testing of safety critical products.

b.   Ensure the appropriate FO and FOD controls and inspections are included in project work packages and procedures.

c.   Ensure FOD controls are being followed as part of general project quality assurance duties.

d.   Ensure FO and FOD incidents are documented in the LaRC Nonconformance Reporting (NCR) and Anomaly System and become part of the project work package or records.

   Note: MAB personnel do not support operations in wind tunnels, aircraft, or research facilities.

2.8.2   The LaRC FOD Prevention Program Manager (FOD Program Manager) shall:

a.   Oversee implementation of the LaRC's FOD Prevention Program.

b.   Update Langley Procedural Requirements (LPR) FOD prevention processes and procedures, as required.

c.   Provide FOD Representatives training on the FOD Prevention Program requirements and changes, as needed.

d.   Provide general training materials, both for employee awareness and FOD Prevention Program requirements, when requested.

e.   Conduct FOD area assessments with FOD Representatives by evaluating site-specific FOD inspection checklists, FOD/tool control logs, and FO/FOD incident reports. Assessments shall also consist of sampling actual FOD-sensitive areas using Langley Form (LF) 361, and/or assessments of tools and checklist(s) created with approval by the Mission Assurance Branch Head by organizations with FOD-sensitive areas.

f.   Record results of assessments and maintain the results in the MAB document library.

g.   Arbitrate FO and FOD issues that are not resolved at the supervisor or FOD Representative level.

h.   Perform continuous improvement activities for the LaRC FOD Prevention Program by staying abreast of changes and improvements in FOD prevention programs and techniques.

2.8.3   Quality Assurance personnel shall:

a.   Ensure FOD controls are being followed as part of general project quality assurance duties.

b.   Include FO and FOD inspections during receipt inspection and quality assurance testing of safety critical products.

c.   Perform and sign off on FOD inspections as required by any project documentation.

2.9   TRAINING

2.9.1   Supervisors shall ensure employees directly involved with FOD-sensitive work receive the appropriate training prior to working in the area and on a biennial recurring basis thereafter.

2.9.1.1   Training shall consist of briefing the employees of the FOD Prevention Program content and/or requiring the employees to read and understand the information contained in this LPR.

2.9.1.2   Supervisors shall include any specific FO and FOD control techniques, procedures, documentation, and inspections for their respective areas in the required training for personnel working in those areas.

2.9.2   Supervisors shall keep records of all FOD training.

2.9.3   The FOD Program Manager shall provide briefing charts, when requested, to provide clarification of FOD Prevention Program content.

CHAPTER 3: FOD AREA DESIGNATION, INCIDENT REPORTING, AND CONTROL REQUIREMENTS

3.1   FOD AREA DESIGNATIONS

3.1.1   Risk assessments shall be performed for all FOD-sensitive areas using the guidelines in this chapter to ensure proper FOD area designations.

3.1.2   Figure 3.1, the guidelines provided in Section 3.1.8 of this LPR, and the factors in Section 3.1.9 provide qualitative guidance to assist in making a risk classification.

3.1.3   The designation shall be based on the risk associated with a FO causing facility/hardware damage during the activities being performed in the area. The risk assessment shall take into account both the consequences and probability a FO will not be found/controlled.
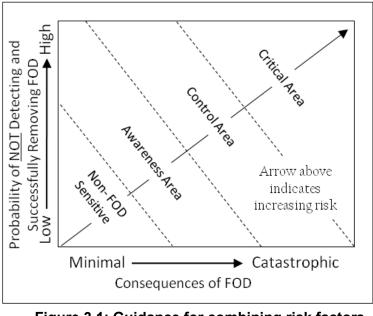
3.1.4   Input from customers and project managers shall be included in determining the FOD area designation.
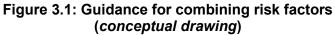
3.1.5   For assistance with determining the risk, branch heads shall consult with the area FSH or the FOD Program Manager.

3.1.6   The level of FOD sensitivity in a given area can increase or decrease based on the sensitivity and criticality of the system or product being worked on at any given time.

3.1.7   Using Figure 3.1 as a guide for combining the two risk factors (i.e., consequence and probability), FOD-sensitive work areas shall be designated as follows:

a.   **Non-FOD-Sensitive Area**: An area where the risk associated with a FO is negligible and no FOD control measures are needed.

b.   **FOD Awareness Area**:   An area where the risk associated with a FO resulting in hardware damage/contamination is low.

c.   **FOD Control Area**: An area where the risk associated with a FO resulting in hardware damage/contamination is medium.

d.   **FOD Critical Area**: An area where the risk associated with a FO resulting in hardware damage/contamination is high.

Figure 3.1: Guidance for combining risk factors
(*conceptual drawing*)

3.1.8   Guidelines to be considered when determining the consequences of not detecting and removing FO are provided below:

a.   The worst-case damage scenario should be considered. For example, a tool left in a wind-tunnel test section has the potential to destroy the tunnel blades.

(1)   Evaluation of this factor is a judgment call that can vary from low to high depending on several parameters such as the lighting during the inspection, the number of additional times inspection will occur, the number of locations for a FO to "hide," and the physical ease of conducting an inspection.

b.   Loose parts or tools causing loss of multi-million dollar flight project hardware should be considered catastrophic.

(1)   This factor should be evaluated at the high end of the probability axis if answered as "susceptible" or "highly susceptible."

c.   Contamination resulting in the need to repeat a low cost experiment may be considered minimal.

(1)   This factor should be evaluated at the high end of the probability axis if answered as "susceptible" or "highly susceptible," or if answered in the affirmative.

d.   The consequences of a FO impacting a wind-tunnel fan blade may lie between minimal and catastrophic, depending on the monetary loss expected and the programmatic impact.

3.1.9   Some factors to be considered when determining the probability a FO will not be detected and successfully removed are provided below:

a.   Can a FO be found easily during planned future inspections?

b.   How susceptible is the product or hardware to damage by a dropped object or tool?

c.   Is the activity being performed a final close-out inspection of a payload?

3.2   GENERAL FOD CONTROL GUIDANCE

3.2.1   The following statements are provided to establish general control requirements to prevent FOD to facilities, aircraft, and quality-sensitive aerospace products being designed, developed, manufactured, assembled, operated, repaired, modified, refurbished, or maintained.

3.2.2   Designated FOD-sensitive work areas shall be identified with proper signage using LF 588, LF 589, or LF 590, as appropriate.

3.2.3   Controls for FOD-sensitive area levels shall be established by the branch head using Section 3.3 of this LPR.

3.2.4   Personnel working in FOD-sensitive areas shall comply with the requirements for that level of sensitivity.

3.2.5   Personnel entering FOD-sensitive areas shall be held accountable for items carried into those areas.

3.2.6   Materials and parts received shall be checked or inspected for FOs and FOD prior to use.

3.2.7   All visitors entering FOD-sensitive areas shall be trained or escorted by the FOD Representative or other FOD-trained personnel, as determined by management, and consistent with the FOD classification area.

3.2.8   All tasks shall include the applicable level of provisions for the prevention, detection, and removal of FOs to ensure and preserve the conformity of product and service to the FOD control methods in this LPR.

3.3   FOD CONTROL METHODS

3.3.1   Fabrication facility personnel shall provide housekeeping of fabrication areas to prevent FOD in their facilities and products, per LMS-TD-8735.

3.3.2   Hangar complex personnel shall ensure grounds and surfaces on which aircraft and ground support equipment are operated are maintained free of objects that could cause damage due to ingestion of FOs or jet blast effects, per LMS-OP-0940.

3.3.3   All other FOD-sensitive areas shall have site-specific FO and FOD control techniques documented that meet the requirements of the area designations as stated below. Control techniques for a higher level of control can be included in controls for a lower level designation.

3.3.4 Non-Sensitive Areas

3.3.4.1   For Non-Sensitive Areas, customary janitorial practices shall be used to keep the area clean of trash.

3.3.5 FOD Awareness Areas

3.3.5.1   For FOD Awareness Areas, the following control techniques shall be implemented:

a.   FOD Awareness signs shall be posted.

b.   "Clean-As-You-Go" shall be performed to prevent debris from migrating into FOD-sensitive areas and hardware.

c.   Smoking, food, and drink shall be in authorized areas only.

d.   Walk-downs shall be performed at a periodicity determined by the branch head.

e.   Tools shall be accounted for at the end of each shift and put away.

f.   Items shall be cleaned prior to entry into the area to reduce dust or dirt buildup.

g.   Packaging that minimizes the production of FOs shall be used.

h.   Unused or spent consumables shall be returned to storage or dispositioned after use.

3.3.6 FOD Control Areas

3.3.6.1   For FOD Control Areas, the following control techniques shall be implemented:

a.   FOD Control signs shall be posted.

b.   "Clean-As-You-Go" shall be performed to prevent debris from migrating into FOD-sensitive areas and hardware.

c.   Smoking, food, and drink shall be in authorized areas only.

d.   Walk-downs shall be performed at a periodicity determined by the branch head.

e.   A tool checklist shall be used to ensure tool accountability.

f.   Employees shall only take items needed to accomplish a specific task into the work area.

g.   Unused or spent consumables shall be returned to storage or dispositioned immediately after use.

h.   Items shall be cleaned prior to entry into area to reduce dust or dirt buildup.

i.   Packaging that does not produce FOs shall be used.

j.   Eyewear, ear protection, loose jewelry, badges, and other personal items shall be secured.

3.3.7 FOD Critical Areas

3.3.7.1   For FOD Critical Areas, the following control techniques shall be implemented:

a.   FOD Critical signs shall be posted.

b.   "Clean-As-You-Go" shall be incorporated to prevent debris from migrating into FOD-sensitive areas and hardware. This includes sweeping and vacuuming fabrication areas, wind tunnel, test cells and rigs, and model build-up areas.

c.   No smoking, food, or drink shall be allowed in the area.

d.   Walk-downs shall be performed at a periodicity determined by the branch head.

e.   Employees shall not bring personal items (e.g., jewelry, keys, and wallets) into the work area.

f.   Employees shall not use phones or pagers in FOD Critical Areas unless there is a safety or communication requirement authorized by the branch head.

g.   Employees shall tether tools and equipment where a dropped article could result in damage or where it would be difficult to retrieve a dropped item.

h.   Employees shall contain tools not in use in a tote tray, soft tool bag, or other suitable spill-proof container, and shall not place tools in a manner that would cause damage.

i.   Employees shall only take items needed to accomplish a specific task into the work area.

j.   Unused or spent consumables shall be returned to storage or dispositioned immediately after use. These items shall be stored separately from point of use and carried in sealable containers.

k.   Hardware (e.g., nuts, bolts, screws, cotter pins, rivets) shall be kitted (i.e., packaged) by task.

l.   Items shall be cleaned prior to entry into area to reduce dust or dirt buildup.

m.   Packaging that does not produce FOs shall be used.

n.   Eyewear and ear protection shall be secured.

o.   Tools shall be accounted for after exiting the FOD Critical Area by ensuring that they are returned to their proper location through the use of methods such as shadow boards, shadowboxing, bar coding, or special canvas layouts with tool pockets.

3.4   FO/FOD INCIDENT REPORTING

3.4.1 For purposes of this LPR, a FO/FOD incident is defined as an instance where a FO is found in a FOD-sensitive area or FOD is found to a facility, aircraft, or quality-sensitive or flight project hardware.

3.4.2   Reporting a FO/FOD Incident for Facilities, Wind Tunnels, and Aircraft

a.   If damage occurs, the event is a mishap. The employee who has found the damage shall report the incident by dialing 4-SAFE (4-7233) from any Center telephone or (757) 864-7233 from a cell phone.

b.   The employee who discovers the debris and/or damage shall notify his/her immediate supervisor, fill out an LF 360, and submit the completed form to the supervisor.

c.   The supervisor shall notify the following persons:

(1)   FOD Representative,

(2)   FOD Program Manager,

(3)   SMAO Facility System Safety Engineer (for facility/wind tunnel incidents),

(4)   FSH, and

(5)   If flight hardware is involved, the appropriate Project Manager.

d.   The supervisor, with appropriate personnel, shall determine a Corrective Action Plan to prevent future occurrences.

e.   After the Corrective Action Plan has been specified on the LF 360, the supervisor shall notify the following persons:

(1)   FOD Representative,

(2)   FOD Program Manager,

(3)   SMAO Facility System Safety Engineer, and

(4)   FSH.

f.   Upon implementation of actions identified in the Corrective Action Plan, the supervisor and FSH shall close the LF 360 by signing the form and report the status of the Corrective Action Plan as directed on the LF 360.

g.   Corrective Action Plans shall be completed in a timely manner commensurate with the effort required.

h.   The supervisor shall maintain the LF 360 in an appropriate filing system.

i.   The supervisor shall also submit a "Safety Concern" online by completing an LF 164, located at https://safety.larc.nasa.gov/index.cfm?ContentID=4.

3.4.3   Additional Guidelines for Wind Tunnels

3.4.3.1   A domestic item is defined as an actual part of the tunnel structure that could potentially cause damage (e.g., piece of wind tunnel ceiling broken off due to facility deterioration, backing screen wire grid deterioration, panel arc sector).

3.4.3.2   Reporting a Domestic Item Found or Damage Caused by Domestic Items

a.   When a domestic item is found, but no damage has occurred, an LF 360 is not required. However, the LaRC Safety Manager shall be contacted and a "Safety Concern" shall be submitted online by completing an LF 164, "Report of LaRC

Safety/Health Concern/Close Call" through the Safety and Mission Assurance Office's (SMAO) website at https://safety.larc.nasa.gov/index.cfm?ContentID=4.

b.   When damage is caused by a domestic item, an LF 360 is not required. However, this event is considered a mishap and shall be reported by dialing 4-SAFE (4-7233) from any Center telephone or (757) 864-7233 from a cell phone. A "Safety Concern" shall also be submitted online by completing an LF 164, located at https://safety.larc.nasa.gov/index.cfm?ContentID=4.

3.4.3.3   Reporting a FO or FOD Incident Involving Flight Projects Hardware (Non-Aircraft)

a.   If damage occurs, the event is a mishap. The employee who has found the damage shall report the incident by dialing 4-SAFE (4-7233) from any Center telephone or (757) 864-7233 from a cell phone.

b.   The employee who discovers the debris and/or damage shall notify his/her immediate supervisor, the Project Manager, and generate a nonconformance report per the project's product assurance plan requirements.

c.   The Project Manager shall notify the following persons:

(1)   FOD Representative for the area where the incident occurred,

(2)   FOD Program Manager,

(3)   SMAO Chief Safety Officer,

(4)   FSH, and

(5)   Project Chief Engineer or equivalent.

d.   The Project Manager, with appropriate personnel, shall determine the path forward as documented in the corresponding nonconformance report via the project's Material Review Board process.

e.   If there is a facility aspect involved in the FO/FOD incident that requires facility changes or improvements, including processes, procedures, and/or training of personnel, the responsible supervisor, with appropriate personnel, shall follow steps 3.4.2.c through 3.4.2.i.

3.5   LOST ITEMS

3.5.1 Any time an item is lost in a FOD Control Area or FOD Critical Area, all activity shall be ceased and:

a.   A search for the item shall be initiated.

b.   A thorough search shall be continued until the item is found or adequate assurances are made that the item is not in the area.

   Note: Searching for critical foreign objects or other items may require parts removal or nondestructive inspections.

c.   If an item cannot be located after an appropriate search has been conducted, facility/project management, with concurrence from SMAO, may allow activities to resume.

d.   Project-specific or site-specific rationale and/or operational constraints shall be developed and documented for any lost items.

CHAPTER 4: DESIGN CONSIDERATIONS, ASSEMBLY OPERATIONS, AND MATERIAL HANDLING

4.1   DESIGN CONSIDERATIONS

4.1.1 The reduction of damage potential and elimination of FOD hazards shall begin with the design process.

4.1.2 Design considerations may include:

a.   Identifying and eliminating FO entrapment areas;

b.   Identifying and sealing areas through which FOs can migrate;

c.   Using screens over exposed openings when appropriate (e.g., intakes, exhausts);

d.   Installing special access panels and ports for inspection and clean-out of FOs that could potentially cause damage;

e.   Using blind fasteners in critical areas that are not prone to leaving debris during installation;

f.   Using fasteners with self-retaining features to secure high usage access panels;

g.   Locating service points, ground points, and built-in test equipment in areas, which are least FOD-sensitive;

h.   Using compatible metals and seals to prevent accelerated deterioration and subsequent failure of seal materials; and

i.   Using conformal coatings as a positive seal against entry of minute FO, including dust and water vapor.

4.2   ASSEMBLY OPERATIONS

4.2.1 Engineering and fabrication personnel shall plan and sequence maintenance and manufacturing tasks to preclude FOD and entrapment of debris or contamination.

4.2.2 Documents shall contain necessary processes and procedures for controlling and removing contamination and debris during fabrication and assembly operations.

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

a.   Upon completion of final machining operation, clean or flush the machined component to ensure that it is free of debris. Protect exposed openings to prevent FO entry.

b.   Adequately protect hardware and equipment from splatter accumulation during brazing, soldering, welding, bonding, and similar operations.

c.   Inspect components and equipment for damage prior to installation and repair as necessary. Always ensure part integrity before installation.

d.   Verify required protective devices (e.g., dust covers, temporary seals, cushioning) are present and properly installed. Items with protective devices missing are to be inspected for FO and FOD, cleaned (if necessary), and installed with protective devices.

e.   After fluid and pneumatic system lines and tubing are cut and deburred, ensure thorough cleaning and cap ends of lines.

f.   Inspect for and remove extraneous material as part of the assembly step, conduct a FO inspection, and remove debris.

g.   Inspect production tooling (e.g., jigs, fixtures, handling equipment, or other production tools) to ensure it is clean, undamaged, and free of foreign material prior to installation and build-up of components or assemblies. The same level of care shall be exercised for scaffolding, work stands, ladders, special test equipment, or like equipment placed on, in, or around critical hardware to accomplish specific tasks.

h.   Protect products by using FO barriers, foam pads, covers, or other protective measures. Always protect sensitive areas and potential FO entrapment areas.

i.   Provide for proper instruction, performance of, and inspections necessary to remove any caps or seals used for FO and FOD prevention that must be removed during assembly or build-up of a system.

4.3   MATERIAL HANDLING, PARTS PROTECTION, PACKAGING, AND SHIPPING

4.3.1   Preparing for and moving products from one area to another shall include processes necessary to protect all products from FO and FOD.

4.3.2   In order to eliminate FO hazards, controlled conditions shall be established for material handling, including consumables and parts protection, using the following process:

a.   Identify quality-sensitive parts, assemblies, surfaces, areas, and other items to be protected from FO and FOD.

b.   Evaluate cleanliness and care requirements.

c.   Sequence events for packaging, handling, shipping, and storage.

4.3.3   All protective devices (e.g., edge protectors, caps, plugs, covers, filters, rub strips), other materials, and/or accessories shall be clean and free of contamination if used in the packaging, handling, shipping, and storage of parts or assemblies.

4.3.4   Parts and assemblies shall be packaged in a manner that shall include provisions to prevent damage resulting from making contact with another object during normal handling and shipping operations.

4.3.5   Protective and packaging materials shall be selected by the assigned project engineer and based on the materials' abilities to adequately resist penetration by tearing, parting, or piercing from forces either external or internal during normal handling operations.

4.3.5.1   Packaging that does not produce FOs shall be used.

4.3.5.2   FO barriers shall be installed during movement and storage.

4.3.6   Once installed, unauthorized removal of the protective devices shall be prohibited and shall be controlled through assembly or maintenance paperwork.

4.3.7 When packaging material, personnel shall:

a.   Consider the visibility and removal of material used for protection so that the material itself does not become a FO.

b.   Use appropriately colored packaging or protective devices so they do not appear to be a part of what they are protecting.

c.   Include streamers for removal of critical items and "remove before flight" items.

4.3.8 Materials shall be compatible with the environmental and physical stresses expected during product service.

4.3.9 To ensure compliance, MAB Quality Assurance, facility, or aircraft personnel shall visually inspect all packaging, handling, shipping, and storage containers for the following:

a.   Nicks, dents, holes, abrasions, scratches, burns, or other defects, which may be detrimental to the function and integrity of the part or assembly.

b.   Grease, preservatives, corrosion products, weld slag, dirt, and other materials foreign to the item.

APPENDIX A: DEFINITIONS

Clean-As-You-Go. Defined by National Aerospace FOD Prevention, Inc. (NAFPI) as follows: "Clean the immediate area when work cannot continue. Clean the immediate area when debris has the potential to migrate to an out of sight or inaccessible area and give the appearance of poor workmanship. Clean the area prior to leaving it unattended, when work cannot continue, after work is completed, or at the end of shift, whichever comes first. If you see something, drop something, see or hear something drop, pick it up."

Consumables. Consumables are supplies provided to workers that are considered expendable (e.g., personal protective equipment, sealants, solvents, paint, brushes, applicators, sandpaper, rags, wipes, rivets, washers, fasteners, and other hardware).

Corrective Action Plan. Steps to be taken to prevent the root cause(s) of a FO and/or FOD incident from occurring again. The Corrective Action Plan is not the set of directions necessary to remove the FO and restore the hardware.

Critical Foreign Object. FO debris that has a significant probability of causing system or component malfunction or deterioration if the item containing the FO debris is put into use.

Domestic Item. An item that is an actual part of the tunnel structure that could potentially cause damage (e.g., piece of wind tunnel ceiling broken off due to facility deterioration, backing screen wire grid deterioration, panel arc sector).

Flight Project Hardware. All LaRC projects that produce, launch, and/or operate flight hardware and/or software. The scope or coverage includes all exploration projects, atmospheric science instruments, satellites and missions, International Space Station payloads and experiments, and planetary science payloads missions, risk reduction flights; flight experiments or technology demonstrations; flights of opportunity that are sub-orbital; involve sounding rockets; un-crewed aerospace vehicles; drop models; and major Unmanned Aerial Vehicle (UAV) operations as determined by management.

Foreign Object (FO). A substance, debris, or article alien to a hardware or system, which could potentially cause damage.

Foreign Object Damage (FOD). Any damage attributed to a FO that can be expressed in physical or economic terms, which may or may not degrade the product's safety and/or performance characteristics.

FOD Awareness Area. Any location designated as a low-risk area where quality-sensitive products or hardware are in place and exposure to FOs would potentially cause a system or product malfunction or failure. Organizational culture is focused on safety, reliability, and functionality by protecting all personnel, products, and services from FO debris and damage.

FOD Control Area. Any location identified as a medium-risk area where quality-sensitive products or hardware are in place and exposure to FOs would potentially cause system or product damage, malfunction or failure. Stringent accountability measures shall be applied to control the risk of FOD in the area.

FOD Critical Area. Any location identified as a high-risk area where quality-sensitive products or hardware are in place and exposure to FOs would potentially cause system or product damage, malfunction, or failure. Strict accountability measures shall be applied to control the risk of FOD in the area.

FOD-Sensitive Area. Any location designated as either a FOD Awareness Area, a FOD Control Area, or a FOD Critical Area.

FOD-Sensitive Work. Work that is being conducted in a FOD-sensitive area.

FO and FOD Incident. An instance where a FO is found in a FOD-sensitive area or FOD is found to a facility, aircraft, or quality-sensitive or flight project hardware.

Housekeeping. Basic element of controlling a safe and effective work environment. Proper cleaning and organizing techniques are followed to ensure the prevention and elimination of FOs. Maintenance, manufacturing, testing, and all other operational areas shall remain clean and organized with the ultimate goal to prevent debris from migrating into critical and complex hardware and facilities. The "Clean-As-You-Go" work ethic is one of the most effective provisions for production, service, and preservation of products.

Mishap. An unplanned event resulting in at least one of the following:

a.   Occupational injury or occupational illness to non-NASA personnel caused by NASA operations.

b.   Occupational injury or occupational illness to NASA personnel caused by NASA operations.

c.   Destruction of or damage to NASA property, public or private property, including foreign property, caused by NASA operations or NASA-funded research and development projects.

d.   NASA mission failure before the scheduled completion of the planned primary mission.

Non-FOD-Sensitive. An area where the risk associated with a FO is negligible and no FOD control measures are needed.

Shadowbox. A toolbox with specific, marked locations for each tool so that a missing tool will be readily noticeable.

Tether. A lanyard of sufficient strength (e.g., wire, rope, cable) attached to the tool/equipment and to the user or fixed secure object. The tether should be of minimum length to preclude damage from tethered tool "free swing."

Tote Tray. A device for storing, carrying, and transporting tools or equipment in a secure manner to prevent inadvertent dropping (e.g., a tool holder, an apron with pocket rings to which tools can be secured). Tote trays with lids should have the lid secured to the tote tray body.

APPENDIX B: ACRONYMS

FO   Foreign Object

FOD   Foreign Object Damage

FSH   Facility Safety Head

LaRC   Langley Research Center

LF   Langley Form

LPR   Langley Procedural Requirements

MAB   Mission Assurance Branch

NCR   Nonconformance Reporting

SMAO   Safety and Mission Assurance Office

APPENDIX C: REFERENCES

C.1   NPD 8700.1, NASA Policy for Safety and Mission Success.

C.2   NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects.

C.3   NPR 8715.3, NASA General Safety Program Requirements.

C.4   LAPD 1440.7, Langley Research Center (LaRC) Records Management.

C.5   LPR 1710.12, Potentially Hazardous Materials - Hazard Communication Standard.