FOD PREVENTION GUIDELINE

NATIONAL AEROSPACE FOD PREVENTION, INC
1-800-FOD-1121

MISSION STATEMENT

National Aerospace FOD Prevention, Inc. (NAFPI), is a nonprofit, educational organization developed to standardize terms and methods for the prevention of foreign object damage to aircraft and aerospace vehicles. The objective is to make the aerospace industry aware of the need to eliminate foreign object debris and provide information about current proven practices and technological advancements that prevent FOD. Additionally, Board members work with all interested companies, associations, and government agencies to help prevent FOD. NAFPI also co-hosts an annual conference for the community to meet and share lessons learned, ideas, etc., toward the common goal of ground and flight safety

FOREWORD

The purpose of this document is to establish a guideline for the military and commercial industry to prevent foreign object damage (FOD) to aerospace products being designed, developed, manufactured, assembled, operated, repaired, modified, refurbished and maintained. Most FOD can be attributed to poor housekeeping, facilities deterioration, improper maintenance or careless assembly and inadequate operational practices. An effective FOD prevention program identifies potential problems, corrects negative factors, provides awareness, effective employee training, and uses industry "lessons learned" for continued improvement. The objective of the FOD Prevention Guideline is to promote ground and flight safety and the preservation of private and national assets. This process is intended to be used as a baseline for FOD prevention. Users are encouraged to apply the contents of this guideline to suit their particular product, company and or government agency.

INTRODUCTION

The Board of Directors was established in 1985 to oversee the activities of the National Aerospace FOD Prevention Conference and represents members from aerospace companies, suppliers, associations, and government agencies. This guideline is developed by the Board and designed to provide assistance and share awareness with the aerospace industry. Valuable "lessons learned" are communicated so the industry can become more effective in their individual FOD prevention programs. It is anticipated that as the aerospace community accepts and implements these recommendations, quality and product integrity will improve thereby reducing avoidable costs. The Board recognizes each program must be individually based on applicable philosophies, contract requirements and policies. As in any process, employee involvement is the key to a successful program. This guide- line will be helpful toward the goal of permanent and continuous improvement in promotion of ground and flight safety.

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I. GENERAL

A. SCOPE

This guideline establishes general workmanship practices and standard terms for the prevention of Foreign Object Damage (FOD) to aerospace products. Aerospace products include aircraft missiles, launch vehicles, drones, satellites, engines, operating systems, manufactured parts, associated ground support equipment, related components, etc.

B. DEFINITIONS

Foreign Object Debris (FOD): A substance, debris or article alien to a vehicle or system which would potentially cause damage.

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

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 or electrical terminals, circuitry, connectors, components, etc.
- Tools, hardware, or debris left in the vicinity, or in a migratory path or a vehicle's control system or engine inlets
- Debris lying on runways, ramps and taxiways
- Propwash exhaust blasts
- Inclement weather
- Ice and salt
- Birds and other animals
- Electro-Static Discharge (ESD)
- Construction debris

FOD Critical Area: Any area where flight hardware is in place and exposure to foreign objects would potentially cause a system or product failure due to deterioration, malfunction or damage.

Critical FO: Foreign objects in areas from which migration is possible, e.g., through tooling holes, bend relief cutouts, drain holes, intakes, etc., which are probable to cause system or component malfunction or deterioration should the product be put into use.

Foreign Object Elimination (FOE): A program or process used to assure a FOD-free product/system.

Tote Tray: A device for storing/carrying/transporting tools or equipment in a secure manner to prevent inadvertent dropping: 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.

Clean As You Go:
- 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 prior to inspection.
- Clean at the end of each shift.
- If you drop something or hear something drop - pick it up!

Consumables: Supplies provided to workers that are expendable. Examples are:
- Issued apparel Safety glasses
- Glue, paint, sealant Rags
- Sandpaper, brushes, applicators
- Stock items such as rivets, washers, fasteners and other hardware.

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

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

C. REFERENCES

1. MIL-STD-980 (deleted 11/95)
2. AF121-101,ACC121-101
3. OPNAV 4790.2
4. ISO-9000/9001
5. NAS 412

II. IMPLEMENTATION CONTROL METHODS

Establish and maintain an effective FOD prevention program that is planned and implemented using the "continuous improvement" approach.

Basic Elements:

1. FOD Prevention Training
2. Early design consideration for FOD prevention, resistance to damage, foreign object entrapment, etc.
3. Assembly sequencing and maintenance/manufacturing techniques that include proper care and use of assembly/maintenance equipment and parts protective devices.
4. Handling of material
5. Housekeeping
6. Control of tools and personal items
7. Control of hardware/consumables
8. Measuring techniques for analysis, trending, and feedback
9. Incident investigation/reporting, "lessons learned"
10. Control of hazardous material
11. Access controls
12. Awareness/Employee Feedback

Preventive Practices:

1. Follow procedures
2. Practice good housekeeping, "Clean-As-You-Go."
3. Account for all tools, hardware and equipment at specific intervals.
4. Use x-ray, borescope, and other state-of-the-art equipment to inspect inaccessible areas.
5. Provide worker awareness to FOD causes.
6. Establish designated storage areas for ladders, hoses, tool boxes and other work aids.
7. Industry feedback through benchmarking proven practices.

A. MEASURING PERFORMANCE

The operational target in any FOD Prevention Program should always be "zero" to enable visibility to problem areas and trends, provide management and workers with inspection results, incident/mishap reports, and feedback of progress. Methods providing this information are:

1. Visibility Charts - statistical graphics derived from audit or incident data. Usually provided on an isochronic schedule, i.e., weekly or monthly.
2. Trend Analysis - Where have you been? Where are you going?
3. Report Card - a checklist of areas routinely inspected that shows specific problem areas.
4. Performance Review - a review of worker conformance to standards or expectations.
5. Customer comments, concerns, or complaints.

Workers need specific information about what is wrong before they can be expected to improve processes. Let them know when they're doing well or when they're not. Feedback is vital to process improvement.

B. TRAINING

The primary objectives of a FOD prevention training program is to increase employee awareness to the causes and effects of FOD, promote active involvement through specific techniques, and stress good work habits through work disciplines.

A FOD prevention training Program for employees associated with design, development, manufacturing, assembly, test, operations, repair, modification, refurbishment, and maintenance is required as part of initial job orientation and on a continuing basis.

Training subjects include:
1. Proper storage, shipping and handling of material, components, and equipment.
2. Techniques to control debris
3. Housekeeping
4. Cleaning and inspection of components and assemblies
5. Accountability/control of tools and hardware
6. Control of personal items, equipment and consumables
7. Care and protection of end items
8. Quality workmanship ("Clean-As-You-Go," Inspection)
9. Flight line, taxiway and ramp control methods
10. How to report FOD incidents or potential incidents.

C. MATERIAL HANDLING AND PARTS PROTECTION

A well established plan for material handling and parts protection can eliminate many potential FOD hazards. First, identify the specifics such as sensitive parts, assemblies, surfaces, areas, etc. Then, sequence events for packaging, handling, shipping and storage, and finally, evaluate cleanliness and care requirements.

Control Techniques:

1. All employees should be trained to assure compliance with packaging, handling, shipping, and storage requirements.

2. Materials and accessories used in the packaging, handling, shipping and storage which have intimate contact with the part or assembly should be clean and free of contamination.

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

4. Protective and packaging materials should be chosen based on their ability to adequately resist penetration by tearing, parting or piercing from forces either external or internal during normal handling operations.

5. Specific instructions for packaging/unpackaging/handling.

6. Protective devices (edge protectors, caps, plugs, covers, filters, rub strips) should be cleaned and secured to prevent accidental damage. Once installed, unauthorized removal of the protective devices is prohibited and should be controlled through assembly or maintenance paperwork.

Consideration should be given to the visibility/detection of material used for Protection so that the material in itself doesn't become FOD. Consideration should include:

1. Color of packaging or protective devices so they don't appear to be a part of what they are protecting.
2. Streamers for removal for critical items

Material Characteristics

1. Materials should be compatible with the environmental and physical stresses expected to be encountered during product service.
2. Static sensitive devices should be properly protected to avoid damage. Materials that are used to protect electro-explosive devices and sensitive electronic components should be kept clean, covered, and stored away from ordinary nonstatic safe materials.

Condition

Visually inspect all packaging, handling, shipping and storage containers for the following:

1. Nicks, dents, holes, abrasions, scratches, bums, etc., which may be detrimental to the function and integrity of the part or assembly.
2. Grease, preservatives, corrosion products, weld slag, shop and other dirt, and other materials foreign to the item.

D. HOUSEKEEPING

Maintenance, manufacturing and operational areas must remain clean. Employees should be informed that housekeeping is a part of their job and they will be graded on their performance, Incorporate "Clean-As-You-Go" as a required work ethic to prevent debris from migrating into flight hardware.

1. Ensure that all production, maintenance and test areas meet "good housekeeping" standards that enhance foreign object elimination. This includes sweeping and vacuuming production areas as well as a regular schedule for sweeping ramp areas.

2. Assure that taxiways, runways, and flight decks are free of foreign objects that may cause damage.

3. Ensure that grounds and surfaces on which aerospace vehicles and ground support equipment are operated and maintained are free of objects that could cause damage due to ingestion of foreign object or jet blast effects.

4. Establish and maintain safe taxi distances between aircraft to minimize the danger of debris being moved by the jet blast exhaust or rotor wash.

5. Ensure prior to the occupation of newly constructed aircraft facilities that all construction debris (including overhead welding slag) is removed as a foreign object elimination measure.

6. In the refurbishment or maintenance of existing airfield facilities or construction of new facilities, assure that all construction debris is removed at the end of each task and the end of each shift. This requirement should be entered into contractual agreements.

E. TOOL ACCOUNTABILITY

The primary objective of a positive tool accountability program is to eliminate accidents/incidents and loss of life or equipment due to tool FOD.

There are numerous methods to facilitate accountability: use of shadow boards, shadowboxing, bar coding, special canvas layouts with tool pockets, tool counters, chit system tool tags, or consolidated tool kits.

Unique control methods should be implemented for special tools used in checkout, test and operational environments.

Tools/equipment should be tethered or suitably restrained to the user in areas around structural workstands or any other locations where a dropped article could result in damage to flight hardware, injury to personnel, or where difficulty in retrieval would result if the tool were dropped.

All loose tools should be contained in a tote tray, soft tool bag or other suitable spill-proof container and not placed in a manner that would cause damage to flight hardware or injury to personnel.

F. HARDWARE ACCOUNTABILITY

The primary objective of hardware accountability is to assure control.
There are many methods that can be established for control of hardware (nuts, bolts, screws, cotter pins, rivets, clecoes, etc.):

1. Kit hardware by task
2. FOD containers should be placed in key locations within the work area and entry and exit points.
3. "Clean-As-You-Go"
4. Removal/installation paperwork to track loose parts
5. Furnish and specify tote trays.
6. Covered spring-loaded containers

G. LOST ITEMS

Any time an item is lost during an assembly, manufacturing, or maintenance task, cease activity in the affected area and initiate a search for the item. Continue this search until the item is found or adequate assurances are made that the item is not in the aerospace vehicle or assembly. Searching for such items may require depaneling or nondestructive inspections, including borescope and/or x-ray. If an item cannot be located after a search has been completed, annotate applicable forms with a description of the item and search procedure followed.

H. HAZARDOUS MATERIAL

Management of hazardous waste materials is important in the prevention of FOD. Disposition of hazardous waste materials is dependent upon the commodity discarded. Consult federal, state and local Hazardous Material Procedures for disposal specifics.

I. PHYSICAL ENTRY INTO FOD CRITICAL AREAS

When physical entry is required into flight hardware, such as crew compartments, engine intake, exhaust, fuel tank areas, etc., personnel should remove all loose objects, badges, jewelry, etc., from clothing. Pocketless coveralls should be worn to preclude foreign objects dropping from pockets onto a FOD critical area.

J. FOCAL POINT

The designated Foreign Object Damage Prevention Focal Point(s) should develop and implement plans and programs to prevent hardware damage during associated design, manufacturing, assembly, test, acceptance, packaging, handling, storage, transporting, maintenance, flight line, and launch operations. The focal point(s) should be appointed by the chief operating official and have sufficient authority and organizational freedom to identify and implement FOD preventive measures whenever and wherever required. The focal point(s) duties should include:

1. Review and assess the FOD prevention program and make necessary revisions.

2. Conduct scheduled audits of work areas to assess effectiveness of the FOD prevention program.

3. Assure implementation of corrective actions for FOD prevention throughout the organization.

4. Require investigations and studies by other organizations necessary to define preventive measures which should result in elimination of potential FOD hazards.

5. Assure that FOD incidents are thoroughly investigated and that incident reports are completed as applicable.

6. Assure that causes of FOD incidents are thoroughly analyzed to define essential corrective measures.

7. Notify affected organizations and personnel of unique FOD prevention requirements.

8. Develop techniques and assign responsibilities for publication of special FOD prevention instructions.

9. Review results of the FOD incident investigations and evaluate adequacy of corrective actions.

10. Evaluate the amount and kind of foreign objects found and how they were found.

11. Review and approve FOD prevention training curricula designate training personnel, and assure that personnel receive required training.

12. Assure that written procedures provide for adequate records at testing to the current status and adequacy of the FOD prevention program.

III. DESIGN CONSIDERATIONS

Begin the reduction of damage potential and elimination of FOD hazards with the design process. Assure design includes, but is not limited to:

1. Identify and eliminate foreign object entrapment areas.

2. Identify and seal areas through which foreign objects can migrate.

3. Use screens over exposed openings when appropriate: e.g., intakes, exhausts, etc.

4. Install special access panels, ports, etc., for inspection and clean-out of foreign objects that could potentially cause damage.

5. Use blind fasteners in critical areas, such as fuel cells, that are not prone to leaving debris during installation.

6. Use fasteners with self-retaining features to secure high usage access panels.

7. Locate service points, ground points, and built-in test equipment in areas which are least FOD sensitive.

8. Use compatible metals and seals to prevent accelerated deterioration and subsequent failure of seal materials.

9. Use conformal coatings as a positive seal against entry of minute foreign object including dust and water vapor.

10. Design aircraft inlets to minimize traps where water can collect and freeze. Wets should be easily plugged and completely sealed against water when plugged.

12. Provide screening or other means of foreign object blockage for water drainage holes forward of the engine inlet path.

13. Procedures should include provisions for FOD incident feedback and appropriate corrective action.

IV. ASSEMBLY OPERATIONS

Plan and sequence maintenance/manufacturing tasks to preclude foreign object damage and entrapment of debris or contamination. Documents should contain necessary processes and procedures for controlling and removal of contamination and debris during fabrication and assembly operations. As applicable, the following should be included in work instructions:

1. Upon completion of 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.

2. Adequately protect hardware and equipment from splatter accumulation during brazing, soldering, welding and like operations.

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

4. 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 installed.

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

6. Inspect for and remove extraneous material as part of the assembly step, conduct a foreign object inspection and remove debris.

7. Inspect production tooling jigs, fixtures, handling equipment, etc.) to assure it is clean, undamaged and free of foreign material prior to installation and build-up of components or assemblies. Exercise this same care for workstands, ladders, special test equipment, etc., which must be placed on, in, or around production hardware to accomplish specific tasks.

8. Protect products by using FOD barriers, foam pads, covers, etc. For instance, cover composites on the wings and place pads between a tool and the aircraft/assembly. Always protect sensitive areas and potential FOD entrapments (engine, open fuel line, harnesses, etc.)

V. TEST CELL ENVIRONMENT

When products are in a test cell environment, FOD prevention procedures should include, but are not limited to, the following:

1. Assure that adequate preventive maintenance is performed on the test facility.

2. Inspect the test cell and facility equipment for deterioration or damage and assure that deficiencies which present a FOD hazard are corrected prior to test cell operations.

3. Inspect the area before introduction of the test article to the test environment to be sure that it is clean, tools are secured, fixtures, dollies and special test equipment are properly prepared and secured, and that required protective devices (engine inlet screens, covers for engine components and instruments, etc.) are on hand, clean and undamaged.

4. Visually inspect the test article before it is placed in the test cell, removal of loose objects and installation of the necessary protective devices.

5. Ensure test cell equipment, tools and accessories are maintained and used in a manner to protect test articles from damage or contamination through tool abuse or in-use failure(chipping, cracking, peeling, fraying, etc.)

6. Prior to start, visually inspect engine intake/exhaust areas for potential FOD and rotate the engine through sufficient revolutions to ascertain if there is unusual noise or binding condition instrumentation lines, hoses and wires should be taped or clamped to eliminate vibratory failure. Use of lockwire or cotter pins for this purpose should be prohibited.

7. Upon completion of each test article run and prior to removal from the test cell, inspect test article for presence of FOD and install protective covers.

VI. FIELD OPERATIONS

Field operations may primarily involve scheduled modifications, inspections, care and maintenance of ramps, structures, runways, and taxiways. A comprehensive, scheduled maintenance system using sweepers, magnets on vehicles and frequent inspections will provide some confidence, but additionally, special considerations may include:

1. Tarmac repair methods/materials and frequency of inspections.

2. Vehicular traffic patterns and controls; i.e., all vehicles should be driven on paved surfaces when possible. If a vehicle must be driven on an unpaved surface, the operator should check the vehicle tires for foreign objects immediately after returning to the pavement.

3. Support equipment cleanliness - items used in and around aircraft must be FOD free and should be inspected prior to movement.

4. Sweeper effectiveness - just because a sweeper is used, does not mean it is effective. Periodically check sweeper routes and speed to assure cleanliness. Also, sweeper brushes made with metal bristles or spines should not be used.

5. Attendants, flight line workers and contractors should be briefed and continually reminded of expectations related to foreign object damage and control.

6. A flight line traffic plan depicting routes to be used by all approved vehicles requiring access to buildings on or around the flight line should be developed and posted.

7. Routine inspection of areas used by contractors, tenants, and concessionaires for staging equipment, load/off-load, operations, etc.

8. Establish FOD control procedures for all personnel, vehicles, equipment and special events having access to the airport operations area.

9. Include FOD prevention considerations in the design, contracting award, and construction management for all airfield projects.

VII. REPORTING/INVESTIGATION

All incidents of actual or potential FOD should be reported and investigated. When a FOD incident occurs, operations should immediately cease and an investigation initiated to determine the cause. Cause and corrective action should be attained in a timely manner to preclude similar occurrences from happening in the future - "lessons learned." Cause may be determined by visual observation, forensic analysis, or by location of the object.

A FOD incident report format should include the following:

- Date
- Part name (nomenclature)
- Type and/or model
- Part serial number
- Part location
- When discovered
- Who discovered
- How discovered
- Narrative description of FOD - when analyzed - who analyzed - how analyzed
- Root Cause
- Corrective action
- Reported by

If FOD incident is discovered after flight operations:

- Ground/flight maneuvers performed
- Taxi route
- Airports involved
- Aircrew contact phone number
- Time/sequence of events
- Weather/environment
- Abnormal operations

These reports should be directed to the FOD Focal Point who should perform tracking and trending analysis. The focal point should also assure all affected personnel are aware of all potential (near mishap) /actual FOD reports to facilitate feedback ("lessons learned").

VII. REPORTING/INVESTIGATION (cont)

When an incident occurs, check contractual requirements and notify the appropriate representative as applicable.

Where a foreign object exists but cannot be eliminated, found or effectively sealed, identify, document and record all significant search activity in the appropriate aircraft paperwork.

A “near mishap” is one where FOD incidents would have occurred had the event remained undetected. Documenting near mishap incidents and sharing them with workers is another important part of feedback, awareness and “lessons learned.”

To ensure you have the current revision and if you have any other questions regarding this guideline, contact any member of the National Aerospace FOD Prevention, Inc., Board of Directors or dial: 1-800-FOD-1121

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