

FED. SUPPLY CLASS

FOREIGN OBJECT DAMAGE / FOREIGN OBJECT DEBRIS (FOD) PREVENTION STANDARD PRACTICE



AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.
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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	Scope	5
1.2	Purpose	5
2.	REFERENCED DOCUMENTS.....	5
3.	DEFINITIONS.....	6
4.	PROGRAM ADMINISTRATION.....	8
4.1	Executive Commitment	8
4.2	FOD Prevention Program Leader	9
4.3	FOD Prevention Committee	9
4.4	FOD Prevention Area Focal Point (Focal).....	10
4.5	Managers/Supervisors	10
4.6	Quality Department	10
4.7	Measuring Performance	11
4.8	Identification and reporting.....	11
4.9	FOD Prevention Training and Awareness.....	12
4.10	Internal/External Supply Chain Management.....	13
4.11	Industry Benchmarking.....	14
5.	AREA DESIGNATION	14
5.1	FOD Areas	14
5.2	Levels and Risk	14
5.3	Teaming	14
5.4	Designation of FOD Areas	14
5.5	Designation.....	15
6.	MANUFACTURING DEBRIS/FOD MIGRATION	16
6.1	FO/FOD Migration Risk	16
6.2	Preventing Migration	16
6.3	Cleaning of the Product	16
6.4	Detection	17
7.	CLEAN-AS-YOU-GO AND HOUSEKEEPING	17
7.1	Clean-As-You-Go	17
7.2	Housekeeping	17
8.	MANAGEMENT OF CONSUMABLES, EXPENDABLES, AND HARDWARE	18
8.1	Purpose	18
8.2	Basic FO/FOD Mitigation Controls/Techniques	18
8.3	Intermediate FO/FOD Mitigation Controls/Techniques.....	19
8.4	Advanced FO/FOD Mitigation	19

REVISION

1



NAS412

SHEET 2

Document Sharing Hub

9.	TOOL MANAGEMENT	20
9.1	Purpose	20
9.2	Basic Tool Management	20
9.3	Intermediate Tool Management	20
9.4	Advanced Tool Management	21
10.	MATERIAL HANDLING AND PACKAGING	22
10.1	Purpose	22
10.2	General Guideline	22
10.3	Assessing Risk.....	22
10.4	Protection Devices.....	22
10.5	Food and Beverages.....	22
10.6	Basic Material Handling Controls.....	22
10.7	Intermediate Material Handling Controls	24
10.8	Advanced Material Handling Controls.....	24
11.	PRODUCT AND PROCESS DESIGN CONSIDERATIONS.....	24
11.1	The Importance of Design	24
11.2	Product Design Considerations	24
11.3	Process Design Considerations.	25
11.4	Tooling and Equipment Design Considerations.	26
12.	TEST CELL ENVIRONMENT	26
12.1	Purpose	26
12.2	Procedures.....	26
13.	AERODROMES.....	27
13.1	The Aerodrome Environment	27
13.2	Aerodrome Foreign Object Sources.....	27
13.3	Typical Aerodrome FO	27
13.4	Aerodrome Foreign Object Locations	28
13.5	Aerodrome FOD Prevention Processes	29
13.6	Aircraft Servicing.....	30
13.7	Aircraft Maintenance.....	30
13.8	Airfield Maintenance Operations	30
13.9	Aerodrome Foreign Object Detection	30
13.10	Metrics and Statistical techniques	30
13.11	Aerodrome foreign object Removal Methods	30
14.	BIRD/WILDLIFE AIRCRAFT STRIKE HAZARD (BASH)	31
14.1	Purpose	31
14.2	Conduct wildlife hazard assessment.....	31
14.3	Basic BASH Management	31
14.4	Intermediate BASH Management.....	32
14.5	Advanced BASH Management (High Tech Strategies)	32
14.6	Strike Reporting	33

REVISION

1



NAS412

SHEET 3

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APPENDIX A – EXAMPLE FOD AREA DESIGNATION MAPPING	34
APPENDIX B – FOD AREA DESIGNATION PROCEDURE MAPPING TOOL	36
APPENDIX C – EXAMPLES OF FOD AREA DESIGNATION PROCEDURE MAPPING TOOL.....	38

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REVISION
1



NAS412

SHEET 4

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1. INTRODUCTION

This National Aerospace Standard (NAS) has been written with one overriding goal in mind, "To provide the reader with clear and precise, practical information on Foreign Objects (FO) and Foreign Object Debris (FOD) detection and elimination to help create a climate of Foreign Object Damage prevention."

NAS412 is a performance-based standard. The end state, safe FOD free aerospace vehicles, is the important thing. The "How's" in this standard should be viewed as guidance, benchmark solutions, and recommendations, and not as requirements. The only requirement is to seek a FOD prevention culture to the maximum extent possible. NAS412 provides guidance on every key aspect of a proven successful FOD Prevention Program. Some of the guidance in this Standard will not be applicable to all programs. What is applicable to a particular program depends on the risks to that program and how those risks are evaluated. A FOD prevention culture will follow the creation and implementation of an effective FOD prevention program. And, while written for aerospace, the information has application in many fields, like the shipbuilding, automotive, and food industries.

If you are a novice to FOD prevention, this standard will provide the guidance you will need to help create a successful program. If you are an experienced FOD prevention professional this standard will provide you with information on advanced FOD prevention methods.

1.1 Scope

This standard establishes general practices and standard terms for the prevention of Foreign Object Damage (FOD) to aerospace products and operating environments. Aerospace products include aircraft, missiles, launch vehicles, unmanned aerospace systems, satellites, engines, manufactured parts associated with aerospace products, etc. Operating environments include fabrication, manufacturing, assembly, test, hangars, ramp, airport operations, launch, flight, etc.

1.2 Purpose

This standard provides guidance for the prevention of Foreign Object Damage to aerospace products being designed, developed, manufactured, assembled, operated, repaired, modified, refurbished and maintained. This standard is designed to reduce the risk from Foreign Objects /Foreign Object Debris to products or systems through the elimination of foreign objects.

The objective of this standard is to promote aerospace safety and the preservation of private and national assets.

An effective FOD Prevention Program identifies potential problems, mitigates risks, promotes awareness, provides effective employee training, and uses industry best practices and lessons learned for continued improvement. Users are encouraged to apply the contents of this standard to suit their particular product or program.

2. REFERENCED DOCUMENTS

IAQG Supply Chain Management Handbook website <http://www.sae.org/iaqg/handbook/scmhtermsfuse.htm>

IAQG Supply Chain Management Tool: See FOD Robustness Tool and Assessment Forms, available through IAQG, IAQG Supply Chain Management Handbook

AS 9100, Quality Management Systems - Requirements for Aviation, Space and Defense Organizations (Series)

FAA Guidance Manual, *Wildlife Hazard Management at Airports*

The Combined Instruction Contractor's Flight and Ground Operations

DCMA INST 8210.1(Series), AFI 10-220, AR 95-20, NAVAIRINST 3710.1(Series)

FAA Advisory Circular 150/5200-30, Airport Winter Safety and Operations

FAA Advisory Circular 150/5220-24, Airport Foreign Object Debris (FOD) Detection Equipment

FAA Advisory Circular 150/5210-24, Airport Foreign Object Debris (FOD) Management

REVISION

1



NAS412
SHEET 5

Document Sharing Hub

3. DEFINITIONS

Definitions as they apply to this standard.

- 3.1 5S Methodology/Lean Manufacturing. A workplace organization method that describes how to organize work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.
- 3.2 Aerodrome. A defined area on land or water (including any buildings, installations, and equipment) intended to be used wholly or in part for the arrival, departure, and surface movement of aircraft.
- 3.3 Best Practice. A process or technique that achieves the standard or requirement and is extremely effective.
- 3.4 Consumables. Supplies provided to workers (for example, hardware, glue, paint, sealant, rags, sandpaper, brushes, applicators), and/or items that are expected to be consumed or destroyed during the course of work performed. Material Consumables are items that are generally thrown away after each use (for example, paper towels, ear plugs, gloves, respirator cartridges, acid brushes, cotton swabs, abrasives, tape, safety wire, sanding discs, sealant, and knife blades).
- 3.5 Control. To reduce or prevent the unintentional spread of, to verify, or regulate.
- 3.6 Expendables. Commodities or items used during the manufacturing process that after extended usage or reconditioning become non-functional. (for example, Plastic knives, apex tips, insertion/removal tools, clevos, clamps, rivet sets, drill bits, reamers; end mills, counter sinks, counter bores, and some safety supplies).
- 3.7 Foreign Object (FO). A substance or article alien to a product or system that could potentially cause Foreign Object Damage (FOD) if not removed or controlled and allowed to migrate onto the product, system, or introduced into an operational environment.
- 3.8 Foreign Object Damage (FOD). Any damage attributed to foreign object debris that may be expressed in physical or economic terms, which may or may not degrade the product's required safety and/or performance characteristics.
- 3.9 Foreign Object Debris (FOD). The condition where a foreign object has invaded a product or system. Examples include (but are not limited to):
 - 3.9.1 Manufacturing by-products and materials.
 - 3.9.2 Solder balls, screws, nuts, washers, insert tangs, component lead ends, wire and sleeve clippings, pieces of electronic components, flux, excess solder, tin whiskers.
 - 3.9.3 Dust/dirt from bench tops, equipment, and facility infrastructure.
 - 3.9.4 Finger oils or lotions, fibers from clothing, hair.
 - 3.9.5 Consumables, expendables, hardware, personal items, shop and production aids.
 - 3.9.6 Pests, wildlife, and their by-products.
- 3.10 FOD Incident. The discovery of a foreign object that has caused or has the potential to cause damage, impairment, or restriction to the operation or service life of a product, major assembly, component, or system.
- 3.11 Foreign Object Occurrence. The condition where a foreign object has been discovered but has not invaded a product or system but has the potential to become FOD. A foreign object occurrence is recorded but does not typically trigger an investigation until there is reoccurrence.

REVISION

1



NAS412

SHEET 6

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- 3.12 FOD Prevention Program Leader. The individual responsible for the development and implementation of the FOD Prevention Program.
- 3.13 FOD Prevention Area Focal. Site, Program, Product, or Function personnel assigned to provide guidance, support FOD initiatives, and ensure coverage with sufficient authority, time, budget and organizational freedom to identify and implement FOD prevention measures.
- 3.14 FOD Prevention Committee. A group of cross functional representatives within an organization established to assist the FOD Program Leader and promote FOD Prevention.
- 3.15 FOD Critical Area(s). Product area(s) with product(s) or system(s) that require isolation from exposure to foreign objects due to the potential for migration, entrapment, ingestion, damage, or failure to critical aspects, operation, or development of the product or product systems.
- 3.16 FOD Control Area(s). Product area(s) with product(s) or system(s) that must have limited exposure to foreign objects due to the potential for migration, entrapment, or damage to non-critical aspects, operation, or development of the product or product systems.
- 3.17 FOD Awareness Area(s). Product area(s) with product(s) or system(s) in which the application of housekeeping cleaning processes and inspections will help prevent migration and ensure that no foreign objects will be passed on or impact testing or development.
- 3.18 General Housekeeping Area(s). Production, non-production, test, or development area(s) in which application of housekeeping will ensure that foreign objects will not migrate to additional areas, contaminate the product, or affect testing or development.
- 3.19 Hardware. Parts and/or part stock (for example, nuts, rivets, washers, screws, bolts, spacers, cotter keys, wire terminals, wire splices).
- 3.20 Housekeeping. A process for sweeping, vacuuming, applying 5S Methodology/Lean Manufacturing, and cleanliness to ensure all work areas are kept clean, orderly, and free of potential foreign objects.
- 3.21 Items. Hardware, consumables, expendables, shop and production aids, and personal items.
- 3.22 Manager. An individual in charge of a certain group of tasks or people. A manager is responsible for making significant decisions on what the unit does, its purpose, functions and role, and for making commitments and decisions that require the expenditure of significant unit resources.
- 3.23 Personal Items. Property owned by or distributed to employees for personal use (for example keys, wallets, cell phones, eye glasses, safety glasses, personal protective equipment, tool chits, stamps, food, drink, etc.).
- 3.24 Production Aids. Tooling, tooling details, tooling fixtures, and tooling assemblies, non-flight hardware used to assist operations.
- 3.25 Production Support Equipment. Ladders, lifts, air hoses, lights, power cords, mats, steps, fans, trash receptacles, FOD bags, vacuums, mobile placards or stands, etc.
- 3.26 Shop Aids. A non-designed, non-certified item used to assist operations.
- 3.27 Should. This document is a guide to the implementation of FOD program. However, to implement activities or controls to achieve the appropriate level of risk protection some activities and controls need to happen as defined by the company. These important activities and controls will indicate a "should" expectation.
- 3.28 Supervisor. Individual in the first-line management who monitors and regulates employees in their performance of assigned or delegated tasks.

REVISION

1



NAS412
SHEET 7

Document Sharing Hub

- 3.29 Test Cell/Stand. A facility/stand used to characterize and test engines or other components.
- 3.30 Test Kit. A combination of instruments or equipment needed for servicing or testing of a product or system.
- 3.31 Tether. A lanyard (for example, wire, rope, cable) of sufficient strength attached to the tool/equipment and to the user or fixed secure object. The tether should be of a length to eliminate damage from tool free swing. NOTE. A tether device, if not regularly examined may itself be a foreign object. Fraying of the tether material and the hardware (rings, snaps, etc.) can all become FOD.
- 3.32 Tool Container. A storage medium (for example, tool box, cabinet, tool kit, shadowbox, shadow board).
- 3.33 Tools. A device used in the performance of a maintenance, manufacturing, or assembly/disassembly task, or operation.
- 3.34 Trained. Instructed in the necessary knowledge and skills to perform assigned duties and responsibilities.
- 4. PROGRAM ADMINISTRATION**
- The FOD Prevention Program must have key administrative elements as part of an overall systems approach to ensure effectiveness. The subsections that follow are key elements of the FOD Prevention Program. Each of the following should be included in program administration.
- 4.1 Executive Commitment
- The success of an effective FOD Prevention program is heavily dependent on the level of commitment exhibited by the company's executive leadership. At a minimum, company/business unit executive management should fulfill the following responsibilities:
- 4.1.1 Set expectations for the FOD Prevention Program and lead by example.
- 4.1.2 Identify a FOD Prevention Program Leader that has sufficient authority, resources, and organizational freedom to implement FOD prevention measures and guide policy.
- 4.1.3 Ensure all affected personnel receive FOD prevention education and training.
- 4.1.4 Ensure a culture of FOD prevention is every employee's responsibility through employee engagement. The key to a successful FOD Prevention Program is the early involvement of all employees.
- 4.1.5 Executive Leadership can foster employee engagement by ensuring the following:
- 4.1.5.1 Be visible in the production areas and participate in the routine assessment process.
- 4.1.5.2 Encourage employees to recommend FOD prevention improvements.
- 4.1.5.3 Listen to employee concerns, and take appropriate action.
- 4.1.5.4 Attend production meetings at the line or cell level to promote the FOD prevention message.
- 4.1.5.5 Provide an environment where employees are encouraged to report foreign object occurrences and/or FOD incidents without fear of reprisal.
- 4.1.5.6 Promote a culture where employees feel empowered to implement and improve FOD prevention processes within the parameters of company policy.

REVISION

1



NAS412
SHEET 8

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4.1.5.7 Provide vital feedback for process improvement. Workers need specific information about what is wrong before they can be expected to improve processes. Let workers know when they are doing well or when they are not.

4.1.5.8 Establish/implement a reward/recognition system to acknowledge positive contributions to FOD prevention.

4.2 FOD Prevention Program Leader

The FOD Prevention Program Leader has the following responsibilities including, but not limited to:

4.2.1 Develop the organization's overarching FOD Prevention Program.

4.2.2 Establish FOD Area Designation requirements (see Section 3.14 through 3.17 and Section 5 Area Designation).

4.2.3 Approve FOD area designation risk mitigation level.

4.2.4 Develop and implementation of the Lost Tool/Item process.

4.2.5 Review and assess the FOD Prevention Program procedures and make necessary revisions.

4.2.6 Ensure assessments are performed to gauge effectiveness of the FOD Prevention program.

4.2.7 Provide oversight to ensure preventive, investigative, analysis, root cause and corrective action processes exist for FOD prevention and ensure corrective actions are adequate to mitigate further occurrences.

4.2.8 Ensure appropriate data collection system is in place and metrics are produced to enable analysis and corrective actions.

4.2.9 Develop, implement, and maintain FOD prevention training curricula.

4.2.10 Serve as the company/business unit subject matter expert for all FOD Prevention issues.

4.3 FOD Prevention Committee

Where appropriate, an organization may consider the establishment of a FOD Prevention Committee to assist the FOD Prevention Leader in the implementation and administration of the FOD Prevention Program. Where appropriate, the committee representatives should be selected from cross functional activities within the organization (for example Production, Manufacturing Engineering, Quality, Management, Design Engineering, etc.). Responsibilities of the FOD Prevention committee should include:

4.3.1 Promotion of a culture of FOD prevention within all areas of the organization.

4.3.2 Review and assessment of the FOD Prevention Program, identify opportunities for improvement and recommend necessary revisions.

4.3.3 Assisting in the development of unique FOD prevention techniques and assign responsibilities for publication of special FOD prevention instructions.

4.3.4 Reviewing results of FOD investigations and root cause/corrective actions.

4.3.5 Reviewing the quantity, types, and location of FO/FOD found and how they were found.

4.3.6 Providing input for FOD Prevention training curricula.

4.3.7 Assisting Program Leader with the periodic reviews of the FOD Prevention Program procedures and recommend necessary revisions.

REVISION

1



NAS412

SHEET 9

Document Sharing Hub

4.4 FOD Prevention Area Focal Point (Focal)

FOD prevention area focals may be identified and assigned to specific work areas/functions or work cells. FOD prevention area focals' responsibilities include but are not limited to:

- 4.4.1 Working with all functions and areas to validate the effectiveness of the established FOD prevention program, independently or as directed by the FOD Prevention Program Leader.
- 4.4.2 Acting as a member of the company FOD Prevention Committee (if established).
- 4.4.3 Acting as a point of contact for training and program implementation.
- 4.4.4 Recommending FOD area designation categorization.

4.5 Managers/Supervisors

Managers/Supervisors are essential to the success of a FOD Prevention Program. Managers/Supervisor duties include but not limited to:

- 4.5.1 Ensuring the FOD Prevention Program policies are followed.
- 4.5.2 Verifying all area FOD prevention and Tool Control procedures are followed as applicable.
- 4.5.3 Verifying all area FO/FOD and Tool Report & Investigation requirements are followed as applicable.
- 4.5.4 Assisting in investigations and root cause corrective action of FOD incidents.
- 4.5.5 Implementing corrective action to prevent future occurrences for FOD incidents.
- 4.5.6 Verifying all visitors in designated FOD areas adhere to FOD prevention requirements.
- 4.5.7 Communicating area FOD prevention needs to proper manager or FOD Leader.
- 4.5.8 Assuring FOD prevention training is current and does not lapse.
- 4.5.9 Reviewing and assessing metrics for process compliance and improvement (see Sections 4.7.3 and 4.7.4).

4.6 Quality Department

The Quality organization and quality management system are essential to the success of a FOD Prevention Program. Quality Department responsibilities include but not limited to:

- 4.6.1 Initiating and tracking FOD non-conformances within the Quality system. Use of non-conformance records provides a source of data for the FOD Prevention Program Leader to assess, analyze and track FOD Prevention Program data trends.
- 4.6.2 Actively engaging with the FOD Prevention Program Leader to relay and support resolution of FO/FOD related issues.
- 4.6.3 Auditing the FOD Prevention Program for compliance.
- 4.6.4 Ensuring Quality personnel understand the requirements and are trained in the methods and techniques of FOD detection.

REVISION

1



NAS412

SHEET 10

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4.7 Measuring Performance

FOD Prevention Program performance measures should be developed, tracked, and maintained to ensure program effectiveness and visibility to all appropriate levels of the organization.

4.7.1 Measurement methods may include:

- 4.7.1.1 problem areas/trends,
- 4.7.1.2 inspection/audit results,
- 4.7.1.3 occurrences/incident reports,
- 4.7.1.4 area assessment results,
- 4.7.1.5 customer feedback,
- 4.7.1.6 lost or found items and tool reports,
- 4.7.1.7 Supplier FOD prevention data, and
- 4.7.1.8 FO/FOD (types and locations).

4.7.2 Reporting methods may include charts/graphs reflecting both current and past:

- 4.7.2.1 trend analysis to reflect areas of opportunity and illustrate gaps,
- 4.7.2.2 customer comments, concerns, and complaints,
- 4.7.2.3 FO/FOD escapes,
- 4.7.2.4 assessment findings to provide performance and process improvement opportunities,
- 4.7.2.5 repeat/systemic issues, and
- 4.7.2.6 report cards (checklist of areas routinely assessed that show specific improvements or problem areas).

4.7.3 FOD metric data should be prominently posted/displayed, distributed to appropriate levels of management, and reported to middle and executive management as part of their Quality Management System metrics review cycle.

4.7.4 Analysis of the metrics should be used to adjust FOD prevention strategies. Corrective actions should be implemented in a timely manner to preclude similar occurrences.

4.8 Identification and reporting

All FO/FOD incidents/occurrences should be identified and documented.

4.8.1 The following may require additional investigation for root cause through visual observation, forensic analysis, or by location of the object as well as actions taken to prevent recurrence:

- 4.8.1.1 Lost items,
- 4.8.1.2 Undocumented tools/items found,

REVISION

1



NAS412

SHEET 11

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4.8.1.3 Foreign Object Damage (actual damage to a product or operating system caused by a foreign object),

4.8.1.4 FO/FOD that escapes containment, and

4.8.1.5 System contamination.

4.8.2 Report lost tools/items. Also see Section 9 Tool Management for Lost Tool / Item procedures.

4.8.3 FO/FOD reports should include the following elements as applicable: date, part name (nomenclature), part number and/or model, part serial number, part location, type of FO/FOD, when discovered, reported by, how discovered, narrative description of occurrence, root cause, and corrective actions taken (if any).

4.8.4 If FO/FOD is discovered after flight operations, the FOD incident report should additionally include these elements: ground or flight maneuvers performed, taxi route, airports involved, aircrew contact information, time and sequence of events, weather/environment, and flight profile (for example high-G maneuvers, low level flight, etc.).

4.8.5 Aerodrome incidents or Bird/Wildlife Aircraft Strike Hazard (BASH) incidents may require additional FAA reporting. FOD Prevention Program Leaders should work closely, as applicable, with the leaders of these groups to ensure that timely and accurate investigation/reporting is conducted. Additional guidance on aerodromes and BASH are in sections 12 and 13 respectively, of this Standard.

4.8.6 FO/FOD reports should be directed to the appropriate designated responsible area or agency to perform tracking, trending and analysis. All affected personnel should be made aware of reports to facilitate lessons learned.

4.9 FOD Prevention Training and Awareness

The primary objectives of a FOD prevention training program are to increase employee awareness, promote active involvement in the FOD Prevention Program, promote appropriate work habits and prevent FOD.

4.9.1 The FOD prevention training program as defined by the organization, should be provided as part of initial job orientation, periodic refresher training, or whenever a major change in the FOD Prevention Program occurs resulting in procedure revision/updates that impact the FOD Prevention program requirements.

4.9.2 FOD Prevention Training Plan. Organizations should develop, as part of their training plan, a FOD Prevention and Tool Control training section to ensure that personnel are trained to perform their tasks. Training subjects could include:

4.9.2.1 Housekeeping,

4.9.2.2 Clean-As-You-Go,

4.9.2.3 Control of hardware,

4.9.2.4 Requirements of designated areas,

4.9.2.5 General Tool Control Rules, for example, use of tool containers,

4.9.2.6 Tool inventory process,

4.9.2.7 Tool checkout procedures,

4.9.2.8 Tool Accountability/Control (as applicable to company operations),

4.9.2.9 Control of items and equipment,

4.9.2.10 Cleaning and inspection of components and assemblies,

REVISION

1



NAS412
SHEET 12

Document Sharing Hub

- 4.9.2.11 Techniques to control debris,
- 4.9.2.12 Proper storage, shipping and handling of material, components, and equipment,
- 4.9.2.13 Flight line, taxiway and ramp control methods (If applicable),
- 4.9.2.14 Lost items/tool procedures,
- 4.9.2.15 FO/FOD incidents / occurrence or potential incidents, and
- 4.9.2.16 FO/FOD reporting.

4.9.3 Awareness. FOD prevention awareness should be continually visible to all employees through any combination of the following methods:

- 4.9.3.1 Review of assessment findings at routine line production meetings.
- 4.9.3.2 Posters that reflect the importance of FOD prevention and the connection between the employee and the end product or user.
- 4.9.3.3 Centrally located "FOD Prevention Boards" that highlight metrics/ improvements.
- 4.9.3.4 A method of issuing "FO/FOD Alerts" when a potential problem is discovered or an incident has occurred that details what happened, root cause and corrective/preventive actions.
- 4.9.3.5 FOD prevention focused activities such as awareness weeks, displays, benchmarking events and attendance at industry conferences.
- 4.9.3.6 An internal website/page with the focus on FOD prevention.

4.9.4 FOD Awareness for Visitors. The requirements for FOD prevention need to be communicated to visitors, vendors, external audit agencies, and contractors. Supporting media should also be made available through any combination of the following methods:

- 4.9.4.1 Pre-visit communications via letter/email,
- 4.9.4.2 Distribution of a "Visitors guide" upon arrival to the site,
- 4.9.4.3 Documented requirements at an opening meeting briefing,
- 4.9.4.4 Awareness video,
- 4.9.4.5 For escorted tours, verbal instruction upon arrival at location.

4.10 Internal/External Supply Chain Management

An effective supply chain management process should include the following objectives:

- 4.10.1 Ensure the supply chain meets FOD goals by imposing a FOD quality assurance provision (QAP) on each purchase order.
- 4.10.2 Collect, track and report all FO/FOD findings attributed to suppliers.
- 4.10.3 Monitor root cause and corrective actions submitted by suppliers and forward to the FOD Prevention Program Leader for concurrence.

REVISION

1



NAS412
SHEET 13

Document Sharing Hub

4.10.4 Upon request from the supplier, provide assistance (in coordination with the company FOD Prevention Leader) in the development of a basic FOD Prevention Program through the detection, cause and effects of FO/FOD to parts, devices and/or products (deliverables).

4.10.5 With support of the FOD Prevention Program Leader, perform initial and periodic audits of suppliers. Provide feedback of audits or reviews to supplier for the purpose of process improvement.

4.11 Industry Benchmarking

Review best practices and lessons learned through industry feedback, workshops, seminars, conferences, benchmarking, etc.

5. AREA DESIGNATION

5.1 FOD Areas

The area designation process allows the appropriate level of control to be assigned to each applicable area in the FOD Prevention Program, based on several factors for the area being categorized, including, but not limited to the criticality of the area's hardware, processes and equipment, and specific customer requirements.

5.2 Levels and Risk

Requirements for FOD prevention and tool management should be progressively more stringent based on the risk level defined. Based on this categorization, varying levels of cleaning, inventory management, work processes and incidence reporting, etc., are required for risk mitigation.

5.3 Teaming

Area designations should be a collaborative effort and based on the risk mitigation level of the area and customer input. Collaborative team members may include:

5.3.1 Team members from the area,

5.3.2 Area Supervisors,

5.3.3 Manufacturing or Process Engineers for the area under consideration, and

5.3.4 FOD Prevention Program Leader/FOD Prevention Area Focals.

5.4 Designation of FOD Areas

FOD prevention requirements within a designated area should be based on the criticality and potential risk of FOD migration. Due to the wide variation of industries, it would be impractical to have a "one-size-fits-all" approach to area designation. To determine the risk mitigation level (for example no, low, medium, high, etc.) and appropriate requirements for each level, the following should be considered:

5.4.1 Location/type of area. For example: flight line, maintenance, overhaul, assembly, and systems installation facilities, crew compartments, fuel cells, engine compartments (intakes/exhausts), flight controls, missile integration/assembly areas, test cells/labs, electronic assembly areas with open hardware, engineering labs, and clean rooms.

5.4.2 Activities/processes being performed. For example: drilling, riveting, inter-stage assembly of components or major units, electronic assembly such as soldering, component installation, wire-bonding, tank cleaning, engine assembly or inspection, and product design.

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1



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