IPC-WP-116A 2021 - October Guidance for the Development and Implementation of a Foreign Object Debris (FOD) Control Plan

A White Paper Report Developed by IPC



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IPC-WP-116A

Guidance for the Development and Implementation of a Foreign Object Debris (FOD) Control Plan

Developed by the Wire Harness Design Task Group (7-31k) of the Product Assurance Committee (7-30) of IPC

Supersedes:

IPC-WP-116 -December 2015 Users of this publication are encouraged to participate in the development of future revisions.

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Acknowledgment

Members of the Wire Harness Design Task Group worked to develop this document. We thank them for their dedication and service to this effort. Any document involving a complex technology draws material from a vast number of sources across many continents. While the principal members of the Wire Harness Design Task Group (7-31k) of the Product Assurance Committee (7-30) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Guidance for the Development and Implementation of a Foreign Object Debris (FOD) Control Plan

TECHNICAL BACKGROUND

Most Foreign Object Damage/Foreign Object Debris (FOD) issues can be attributed to poor housekeeping, facilities deterioration, improper maintenance, careless assembly, or inadequate operational practices. An effective FOD Prevention Program (Control Plan) identifies potential problems, corrects negative factors, promotes awareness, provides for effective employee training, and uses "lessons learned" for continual improvement. The objective of any FOD Prevention Program should always be zero FOD, to provide visibility to problem areas and trends, provide management and workers with inspection results, incident/mishap reports, and feedback of progress.

1 GENERAL REQUIREMENTS

1.1 Scope This document introduces design concepts, attributes, and recommendations for the control and mitigation of performance and reliability risks associated with the introduction of Foreign Object Debris (FOD) in electrical and electronic (E/E) assemblies, including optical and metallic cable and wiring harness assemblies, and elements thereof.

1.2 Purpose The intent of this document is to provide guidance and a template for the development and implementation of a Foreign Object Debris (FOD) Control Plan.

For purposes of this document:

- The Designer is the design agent for the User.
- The User is the individual, organization, company, contractually designated authority, or agency responsible for the procurement or design of electrical / electronic / electromechanical (EEE) hardware, and having the authority to define the class of equipment and any variation or restrictions to the requirements of this document (e.g., the originator/custodian of the contract detailing these requirements). The User is the Design Authority.
- The Supplier is the individual, organization or company that provides the Manufacturer (assembler) components (electrical, electronic, electromechanical, mechanical, printed boards, etc.) and/or materials (solder, flux, cleaning agents, etc.).



Figure 1-1 Foreign Object Debris (FOD) Logo

• The Manufacturer is considered the entity that provides a service or product to the User.

1.3 Applicability This document is targeted for control of Foreign Object Debris (FOD) in areas where both critical and complex work is performed, and to operations involved with designing, developing, manufacturing, assembling, testing, operating, repairing, modifying, refurbishing, and maintaining Class 3 (or higher) hardware to the User specified cleanliness level.

- a. The design concepts, guidelines, and procedures presented in this document are for guidance ONLY, and **are not** requirements. As such, the use of the words **''must**," **''should**" and **''shall**" (and derivations thereof) have no special meaning in this document, and they **do not** indicate a binding criterion.
- b. This document **is not** binding, unless separately and specifically included by the applicable contract, approved drawing(s), or purchase order.

1.4 Commercial Off-The-Shelf (COTS) This document **does not** apply to Commercial-Off-The-Shelf (COTS) or catalog items (e.g., components, assemblies, subassemblies and/or hardware). Designers considering the use of COTS hardware for applications described above **are** responsible for identifying and managing risks associated with hardware built without a control plan to control and/or reduce the introduction of Foreign Object Debris (FOD) in electrical and electronic (E/E) assemblies, including optical and metallic cable and wiring harness assemblies, and elements thereof.

1.5 Existing or Previously Approved Designs The implementation of a Foreign Object Debris (FOD) Control Plan **should not** constitute the sole cause for the redesign of previously approved designs. When drawings for existing or previously approved designs undergo revision, they **should** be reviewed and changes made that allow for compliance with the requirements of this document.

1.6 Measurement Units and Tolerances All dimensions and tolerances, as well as other forms of measurement in this standard are expressed in SI (System International) units, with Imperial English equivalent dimensions provided in [brackets], except as noted.

- a. Linear dimensions and tolerances use centimeters (cm) [inches (in)] as the main form of dimensional expression; millimeters (mm) [inches (in)] or micrometers (μm) [microinches (μin)] are used when the required precision makes the use of centimeters (cm) too cumbersome.
- b. Temperature values are expressed in degrees Celsius (°C) [Fahrenheit (°F)].
- c. Mass is expressed in grams (g) [ounces (oz)].
- d. Wire, wire harness, and cable diameters are expressed in the non-dimensional unit (d), where a numerical dimension, such as 2d, is solely dependent on a physical attribute of the hardware (e.g., wire gauge, harness diameter, etc.).
- e. Time values are expressed in hours, minutes and seconds (hh:mm:ss).
- f. Absolute Dimensions. For the purposes of determining conformance to this specification, all specified dimensions and/or tolerances in this standard are "absolute limits" as defined in ASTM E29 [5.1]. Actual measurement of specific dimensions and determination of percentages is not required, except for referee purposes, or as specified otherwise by engineering documentation.

Note: This Standard uses other SI prefixes (ASTM SI10, Section 3.2), as applicable, to eliminate leading zeroes (for example, 0.0012 mm becomes 1.2 μm) or as alternative to powers-of-ten (3.6 x 103 mm becomes 3.6 m).

1.7 Terms and Definitions For purposes of this document, the acronyms, abbreviations, and terms used in addition to those listed in IPC-T-50 are listed in Section 4.

2 APPLICABLE DOCUMENTS

The following documents are applicable to the extent specified herein. Unless otherwise specified, the issue/revision identified herein, or the issue/revision in effect on the date of invitation for bid, or request for proposal, will be applicable.

2.1 Industrial Standards

ASTM E29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

2.2 Reference Documents Unless otherwise specified, these documents fall in order of precedence behind the contract, approved drawings, and any standards imposed on the program. The requirements and recommendations in these documents are not binding, are not to be construed as implied requirements to be imposed on the program, and are not to be used if they conflict with any contractual or program-specific requirements.

EV-067 (JSC) Foreign Object Debris (FOD) Control Plan for the Avionic Systems Division

IPC-TA-724-1 Clean Rooms for Printed Circuit Boards

JPR 5335.05 JSC Foreign Object (FOD) Damage Prevention Program

MSFC-STD-3598 MSFC Technical Standard, Standard for Foreign Object Damage/Foreign Object Debris (FOD) Prevention

SAE AS9146 Foreign Object Damage (FOD) Prevention Program - Requirements for Aviation, Space, and Defense Organizations

Note: The following section(s) of this document form a tailorable template for implementation of a Foreign Object Debris (FOD) Prevention Program (FOD Control Plan). The review of all **''shall**'' statements and/or requirements listed in this and subsequent sections for applicability during development of the control plan is advised. Italicized text is for informational purposes.

3 FOREIGN OBJECT DEBRIS (FOD) PREVENTION PROGRAM

A Foreign Object Debris (FOD) Prevention Program (FOD Control Plan) **shall** be established for the design, development, manufacturing, assembly, repair, processing, testing, maintenance, operation, and check out of the equipment to prevent immediate and latent damage and to ensure compliance to the User specified cleanliness level.

3.1 FOD Focal Point Each Supplier that manufactures, fabricates, assembles, tests, or handles hardware **shall** designate an individual as the "FOD Focal Point" who **will** be responsible for developing and maintaining the FOD Control Plan.

The FOD Focal Point shall:

- a. Develop, update, and maintain a written FOD Control Plan in accordance with the recommendations of this document.
- b. Designate FOD Awareness Areas Areas where FOD prevention, monitoring and additional training greatly reduces the likelihood and repercussions of FOD entrapment, migration and impact damage.
- c. Perform a periodic FOD risk review for areas designated as FOD Awareness Areas.
- d. Verify that appropriate signs (conforming to Figure 1-1), barriers and other visual cues necessary to alert personnel they are entering a FOD Awareness or Control Area.
- e. Verify that established FOD protocols are being followed when FOD-sensitive hardware is present.
- f. Ensure that adequate precautions are in place and followed to protect FOD-sensitive items from damage during logistical activities (e.g., handling, storage, shipping, etc.).
- g. Determine areas within a FOD Awareness Area, if any, which may be acceptable for facilities custodial personnel to clean.
- h. Specify necessary FOD prevention tools (FOD containers, FOD organizer belt pouches, tethers, stanchions, etc.) for use in FOD Awareness and Control Areas.
- i. Ensure that FOD incidents, the results of FOD walk downs, and FOD audits are documented in an official repository.
- j. Investigate FOD incidents and recommend corrective action.
- k. Ensure signs, barriers stanchions, floor tape, FOD posters, other FOD control visual cues are removed when a FOD Awareness or Control Area is terminated.

3.2 Housekeeping – "Clean As You Go" Employees **shall** be informed that housekeeping is a part of their job and that compliance with FOD housekeeping protocols will be a part of their performance evaluation.

- a. Employee training and daily operations **shall** incorporate "clean-as-you-go" as a required work ethic to prevent the build-up and migration of debris.
- b. Floors, aisles, support structures, access platforms, and other facility surfaces **shall** be cleaned on a routine schedule to maintain good housekeeping standards that enhance FOD elimination.
- c. Sweeping, dusting, vacuuming, and other facility cleaning methods **shall** remove debris in a manner that precludes migration or distribution onto hardware or onto work surfaces that could provide a migration path to hardware.

Note: Cleaning methods that continuously remove debris rather than relocate it, such as HEPA-filtered vacuum cleaners, externally exhausted vacuum systems, and damp wiping, are preferred.

- d. In the refurbishment or maintenance of existing facilities or construction of new facilities, all construction debris **shall** be removed at the end of each task or at the end of each shift.
- e. Areas requiring cleaning and the extent of cleaning **shall** be reviewed with all involved parties (e.g., custodial contractor, facilities representative, and facility operators responsible for cleaning hardware) and agreed upon for FOD Awareness or Control.

3.3 Control of Personal Items, Tools, Hardware and Consumables Personal items **shall** be controlled (prohibited or secured) in accordance with the appropriate protocol for the specific FOD Awareness or Control Area.

- a. A protocol specific to each FOD Awareness and/or Control Area for controlling tools, small parts, and shop consumables (e.g., stock fasteners, wipers, gloves, etc.) to prevent these items from becoming FOD **shall** be documented.
- b. The appropriate protocol for each specific FOD Awareness Area shall be posted and visible prior to entry.
- c. Nonessential tools and materials shall not be permitted in the FOD Awareness Area.

Notes:

- (1) Personal items are defined as any item not identified as required for the manufacturing, fabrication, assembly, test, or quality assurance operation performed within the FOD Awareness or Control Area. Personal items include clothing items, badges and badge holders, eyeglasses, watches, personal medical devices, keys, jewelry, office supplies, cell phones, wallets, coins, etc.
- (2) The objective of a tool and small parts control program is to eliminate damage from dropped items or entrapment of FOD related to lost tools, small parts, or consumables (e.g., solder wick, wire clippings, etc.) that are inadvertently left behind or migrate into hardware.

3.4 Control of Hazardous Material Control of chemicals and process fluids, including cleaning solvents and water, is necessary to prevent accidental spillage and contamination of hardware.

- a. Only chemicals specified on approved work instructions shall be permitted within a FOD Awareness Area.
- b. Fluids **shall** be contained in pre-moistened wipes or in small, unbreakable, spill-proof dispenser bottles commensurate with specific need to minimize the spill hazard.
- c. Dispenser bottles containing fluids shall not be placed directly on hardware.
- d. Overhead and inspection lighting containing light bulbs/tubes containing mercury **shall not** be serviced or replaced unless capture bags or other collection media are used to prevent accidental dropping of the bulbs onto hardware or work surfaces.

Note: Light sources (e.g., bulbs, fluorescent tubes, etc.) containing mercury present a potentially serious FOD hazard to hardware and/or health concern to personnel should they fall and break. Use of light sources containing mercury should be avoided when possible.

3.5 FOD Awareness and Prevention Training

- a. FOD Awareness Training shall:
 - (1) be made available to all personnel 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.
 - (2) include an introduction to the causes and effects of FOD on hardware, FOD prevention approaches, familiarization with FOD control logos, signs, area agreements, and general work rules.
- b. FOD Prevention Training shall:
 - (1) be made available to employees associated with development, manufacturing, fabrication, assembly, test, operations, repair, modification, refurbishment, maintenance, and transportation.
 - (2) be required as part of initial job orientation and on a continuing basis.
- c. FOD Prevention Training shall include the following (at a minimum):
 - (1) Awareness of FOD entrapment hazards and susceptibility of hardware to impact damage and to leaks and spills.
 - (2) Personnel who are assigned to work in FOD Awareness Areas or who occasionally require entry into FOD Awareness Areas.
 - (3) Personnel who are assigned to work in FOD Awareness Areas or who create written lifting and handling instructions for FOD Sensitive hardware.
 - (4) Personnel assigned to serve as FOD Monitors for FOD Awareness Areas.
 - (5) Proper storage, shipping and handling of material, components, and equipment.
 - (6) Techniques to control debris.
- 3.6 Measurement and Performance FOD Control Plans shall address measurement and performance:
- a. The objective of any FOD Prevention Program **shall** always be zero FOD, to provide visibility to problem areas and trends, and provide management and workers with inspection results, incident/mishap reports, and feedback of progress.
- b. The use of following measurement and performance improvement indicators is recommended:
 - (1) Visibility Charts Statistical graphics derived from audit or incident data. Usually provided on a periodic schedule (e.g., weekly, 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.
- c. Report Card A checklist of areas routinely inspected that shows specific problem areas.
- d. Performance Review A review of worker conformance to standards or expectations.
- e. Customer comments, concerns, or complaints.

3.7 FOD Incident Investigation Reporting, and Corrective Action When FOD results in damage or suspected damage, the FOD Focal Point **shall** lead an investigation into the incident and identify corrective action and recurrence control as part of the overall FOD trending and measurement assessment.

- a. When FOD is suspected or known to have caused damage to hardware or test article hardware, the event **shall** trigger a Discrepancy Report (DR)/Material Review Record (MRR) or the appropriate nonconformance documentation for User-supplied product.
- b. The User shall be notified of the known or suspected damage as required per the contract.

Note: While a DR/MRR is initiated to flag, instigate, and disposition damage to a hardware item, the purpose of the FOD investigation is to flag and determine corrective action for the FOD item found on or near hardware to prevent recurrence.

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

- a. FOD signage in accordance with Figure 1-1 **shall** be posted at entrances and within FOD Awareness Areas to serve as a visual cue and reminder that one is entering or within a FOD Awareness Area.
- b. Metrics specific to the FOD Awareness Area **shall** be posted in a prominent location within or near the entrance to all FOD Awareness Areas. These metrics **shall** be discussed in employee team meetings where all team members are encouraged to provide suggestions for improvement.

Note: The FOD logo shown in Figure 1-1 is a nationally recognized logo used for FOD control in the United States.

4 ACRONYMS AND TERMS

For purposes of this document, the following additional acronyms and terms are listed in addition to those listed in IPC-T-50.

4.1 Clean-As-You-Go The process of cleaning the immediate work area to eliminate the accumulation or migration of Foreign Object Debris that may potentially become entrapped within the product, degrade product performance or reliability, or cause damage.

4.2 Cleanliness Level An established maximum allowable amount of contamination in a given area or volume, or on a component / part.

4.3 Commercial Off-The-Shelf (COTS) Items (modules, assemblies, etc.) offered without modification and available from a vendor catalog or stock for sale, lease, or license in substantial quantities in the commercial/consumer marketplace.

4.4 Complex Work Complex work involves either: (a) the design, manufacture, fabrication, assembly, testing, integration, maintenance, or repair of machinery, equipment, subsystems, systems, or platforms, or (b) the manufacture/fabrication of parts or assemblies which have quality characteristics not wholly visible in the end item and for which conformance can only be established progressively through precise measurements, tests, and controls applied.

4.5 Contaminant Any unwanted matter, which could be detrimental to the required operation, reliability, or performance of a part, component, subsystem, or system.

4.6 Critical Work Critical work is any hardware task that, if performed incorrectly or in violation of prescribed requirements, could result in loss of performance or reliability in a product where (a) continued high performance or performance-on-demand is critical, (b) equipment downtime cannot be tolerated, (c) the end-use environment may be uncommonly harsh, (d) serious injury to the User may result, and/or (e) the equipment must function when required (e.g., life support or other critical system, etc.).

4.7 Discrepancy Report (DR) A formal report documenting a confirmed non-conformance to requirements. See also Material Review Record (MRR).

4.8 FOD Awareness Areas Areas where FOD prevention, monitoring and additional training greatly reduces the likelihood and repercussions of FOD entrapment, migration, and/or damage.

4.9 FOD Control Area Any clearly marked and access-controlled area where introduction of foreign object debris could potentially cause the deterioration of process control or repeatability, reduction in workmanship/quality, or product problem/failure due to deterioration, malfunction, or damage.

4.10 FOD Focal Point An individual/function designated as responsible for the development and implementation of the Foreign Object Debris (FOD) Control Plan.

4.11 Foreign Object Debris A substance, debris, or article alien to a system that would potentially cause damage.

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

4.13 Material Review Record A formal report documenting a confirmed non-conformance to requirements and the final disposition/ resolution.

4.14 Personal Items Items owned by individuals, or distributed by the organization, for personal use (e.g., badge, stamps, keys, cell phones, wallets, personal protective equipment, food, drink, tobacco products, etc.).





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Company Annual Revenue							
Annual Revenue		1 Year Membership	2 Ye	2 Year Membership (10% discount)		3 Year Membership (15% discount)	
<\$1M		\$550		\$495 per year		\$468 per year	
\$1M - <\$5M		\$850		\$765 per year		\$722 per year	
\$5M - <\$25M		\$1,450		\$1,305 per year		\$1,233 per year	
\$25M - <\$50M		\$1,700		\$1,530 per year		\$1,445 per year	
\$50M - <\$100M		\$2,050		\$1,845 per year		\$1,743 per year	
\$100M - <\$250M		\$2,400		\$2,160 per year		\$2,040 per year	
\$250M - <\$500M		\$3,000		\$2,700 per year		\$2,550 per year	
\$500M - <\$1B		\$3,500		\$3,150 per year		\$2,975 per year	
\$1B - <\$2.5B		\$4,000		\$3,600 per year		\$3,400 per year	
\$2.5B+		\$4,600		\$4,140 per year		\$3,910 per year	
Education Institution		\$1,700		\$1,530 per year		\$1,445 per year	
Government Agency		\$2,400		\$2,160 per year		\$2,040 per year	

Standards Subscription Customer							
Annual Revenue	1 Year Membership		2 '	2 Year Membership (10% discount)		3 Year Membership (15% discount)	
<\$1M		\$2,000.00		\$1,800 per year		\$1,700 per year	
\$1M - <\$5M		\$2,500.00		\$2,250 per year		\$2,150 per year	
\$5M - <\$25M		\$3,000.00		\$2,700 per year		\$2,550 per year	
\$25M - <\$50M		\$3,500.00		\$3,150 per year		\$2,975 per year	
\$50M - <\$100M		\$4,000.00		\$3,600 per year		\$3,400 per year	
\$100M - <\$250M		\$5,000.00		\$4,500 per year		\$4,250 per year	
\$250M - <\$500M		\$6,000.00		\$5,400 per year		\$5,100 per year	
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\$1B - <\$2.5B		\$10,000.00		\$9,000 per year		\$8,500 per year	
\$2.5B+		\$15,000.00		\$13,500 per year		\$12,750 per year	
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Standard Improvement Form

IPC-WP-116A

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s). If you can provide input, please complete this form and return to: IPC 3000 Lakeside Drive, Suite 105N Bannockburn, IL 60015-1249 Fax: 847 615.7105 E-mail: answers@ipc.org www.ipc.org/standards-comment

1. I recommend changes to the following:

____ Requirement, paragraph number _____

____ Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

____ Unclear ____ Too Rigid ____ In Error

___ Other __

2. Recommendations for correction:

3. Other suggestions for document improvement:

Submitted by:	
Name	Telephone
Company	E-mail
Address	
City/State/Zip	Date



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ISBN #978-1-63816-055-7