U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Airport Foreign Object Debris (FOD) Management	**Date:** 9/30/2010 **Initiated by:** AAS-100	**AC No:** 150/5210-24 **Change:**

1. PURPOSE. This advisory circular (AC) provides guidance for developing and managing an airport foreign object debris (FOD) program. In addition, this AC provides specifications for the equipment used in FOD removal operations.

2. SCOPE. The program described herein is composed of four main areas: prevention; detection; removal; and evaluation. Each of the four areas (corresponding to a dedicated chapter in this AC) contains strategies and practices that can help reduce FOD at airports.

The guidance in this AC is particularly applicable to airport owners and operators, air carrier station managers, and general aviation operators. Individuals in these positions may then be able to communicate to apron crews, maintenance technicians, and aircraft servicing personnel the safety hazards posed by FOD.

The FOD management guidelines presented in this AC are advisory and can be implemented at the discretion of the airport operator in accordance with the airport operator's approved Airport Certification Manual.

3. CANCELLATION. AC 150/5380-5B, Debris Hazards at Civil Airports, dated 7/5/96, is canceled.

4. APPLICATION. The Federal Aviation Administration (FAA) recommends the guidance and specifications in this Advisory Circular for developing and managing an airport FOD management program. In general, use of this AC is not mandatory. However, use of this AC is mandatory for the acquisition of FOD removal equipment through the Airport Improvement Program (AIP) or the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, Policies, Standards, and Specifications, and PFC Assurance No.9, Standards and Specifications.

5. COMMENTS OR SUGGESTIONS for improvements to this AC should be sent to:

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CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1. DEFINITIONS.

a. Air Operations Area (AOA). All airport areas where aircraft can operate, either under their own power or while in tow. The AOA includes runways, taxiways, apron areas, and all unpaved surfaces within the airport's perimeter fence.

b. Airport Apron (or Ramp). A surface in the AOA where aircraft park and are serviced (refueled, loaded with cargo, and/or boarded by passengers).

c. Clean-as-you-go. The practice of cleaning one's surroundings before, during, and after a shift, especially when working with items that may become FOD.

d. Foreign Object Debris (FOD). Any object, live or not, located in an inappropriate location in the airport environment that has the capacity to injure airport or air carrier personnel and damage aircraft. **NOTE:** *The FAA is cooperating with international aviation organizations in an effort to develop a standard, international definition of FOD. If, and when, such a definition is developed and adopted by the International Civil Aviation Organization (ICAO), that definition will take precedence over the one provided in this AC.*

e. Foreign Object Debris (FOD) Damage. Any damage attributed to a foreign object that can be expressed in physical or economic terms which may or may not downgrade the product's safety or performance characteristics. **NOTE:** *For the purposes of this AC, and to reduce confusion and ensure consistency in language and terminology, "FOD" will only refer to the phrase "foreign object debris."*

f. Hazard. A condition, object or activity with the potential for causing damage, loss, or injury.

g. Manufacturer. The distributor, lessor, or supplier of automated FOD detection equipment. This includes any operator of a FOD removal program that incorporates FOD detection equipment and removal equipment.

1.2. ACRONYMS AND TERMS.

ACM	Airport Certification Manual
AOA	Air Operations Area
FAA	Federal Aviation Administration
FOD	Foreign Object Debris
GSE	Ground Support Equipment
ICAO	International Civil Aviation Organization

NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
USAF	United States Air Force

1.3. APPLICABLE DOCUMENTS.

The following documents form part of this specification and are applicable to the extent specified.

a. DOT Standards / FAA Orders, Specifications, Drawings, and Advisory Circulars (ACs).

AC 150/5200-5	Wildlife Attractants On or Near Airports
AC 150/5210-5	Painting, Marking, and Lighting of Vehicles Used on an Airport
AC 150/5200-18	Airport Safety Self-Inspection
AC 150/5200-30	Airport Winter Safety and Operations
AC 150/5220-24	Airport Foreign Object Debris (FOD) Detection Equipment
AC 150/5300-13	Airport Design
AC 150/5370-2	Operational Safety on Airports During Construction
AC 150/5380-6	Guidelines and Procedures for Maintenance of Airport Pavements
NHTSA FMVSS 103	Windshield Defrosting and Defogging Systems

b. Industry Publications.

Chaplin, G.	Make it FOD Free: The Ultimate FOD Prevention Program Manual
NAFPI	Foreign Object Debris (FOD) Prevention Guidelines
NAS 412	Foreign Object Damage/Foreign Object Debris (FOD) Prevention
San Antonio International Airport	FOD Prevention Program Manual
SAE 1247	Aircraft Ground Support Equipment — General Requirements
SAE J1503	Performance Test for Air-Conditioned, Heated, and Ventilated Off-Road Self-Propelled Work Machines

c. Sources.

(1) FAA ACs may be obtained from the FAA website at: http://www.faa.gov/regulations_policies/advisory_circulars/

(2) FAA Orders, Specifications, and Drawings may be obtained from: Federal Aviation Administration, ATO-W CM-NAS Documentation, Control Center, 800 Independence Avenue, SW, Washington, DC 20591. Telephone: (202) 548-5256, FAX: (202) 548-5501 and website: http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/atc_facilities/cm/cm_documentation/

(3) NHTSA Standards may be obtained from: NHTSA HQ, 1200 New Jersey Avenue, SE, West Building Washington, DC 20590. Website: www.nhtsa.dot.gov

(4) Industry publications may be obtained from:

(a) National Aerospace FOD Prevention, Inc., Telephone: (800) 363-1121 and website: www.nafpi.com

(b) The FOD Control Corporation, 8987 East Tanque Verde Road, Building 309 - Mail Stop #360, Tucson, Arizona USA, 85749-9399 and website: www.makeitfodfree.com

(c) National Aerospace Standards (NAS), from the Aerospace Industries Association of America, Inc., 15 Inverness Way East, Inglewood, CO 80112 and website: global.ihs.com/?RID=AIA

(d) San Antonio International Airport, 9800 Airport Blvd., San Antonio, TX 78216, Telephone: (210) 207-3475 and website: www.sanantonio.gov

(e) Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001

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CHAPTER 2. INTRODUCTION

2.1. GENERAL.

The presence of FOD on an airport's air operations area (AOA) poses a significant threat to the safety of air travel. FOD has the potential to damage aircraft during critical phases of flight, which can lead to catastrophic loss of life and airframe, and at the very least increased maintenance and operating costs. FOD hazards can be reduced, however, through the implementation of a FOD management program and the effective use of FOD detection and removal equipment.

2.2. FOD FUNDAMENTALS.

a. FOD Hazards. FOD can severely injure airport or air carrier personnel or damage equipment. Types of potential damage include: cutting aircraft tires; being ingested into engines; or becoming lodged in mechanisms affecting flight operations. Personnel injuries or even death can occur when jet blast propels FOD through the airport environment at high velocities.

b. Sources of FOD.

(1) FOD comes from many sources, which complicates efforts to maintain safe airfield operations. FOD can be generated from personnel, airport infrastructure (pavements, lights, and signs), the environment (wildlife, snow, ice) and the equipment operating on the airfield (aircraft, airport operations vehicles, maintenance equipment, fueling trucks, other aircraft servicing equipment, and construction equipment).

(2) FOD can collect both on and below ground support equipment stored or staged on the airport apron, particularly in apron areas. Jet blast can then blow FOD onto personnel or an aircraft. Jet blasts can also create runway FOD when an aircraft transitions from a relatively large-width runway onto a smaller-width taxiway. Outboard engines blow any loose dirt and materials from the shoulder and infield areas onto the runway. Also, the outboard engines of four-engine aircraft can move debris from the runway edge and shoulder areas, where it tends to accumulate, back toward the center of the runway or taxiway.

(3) Helicopters that maneuver over freshly mowed or loose-dirt infield areas can also move FOD onto runways, taxiways, and ramps. In addition, the rotor wash from a helicopter can propel lightweight ground support equipment (GSE) or materials staged nearby.

(4) FOD is often more common when airports begin construction activities. FOD may also be more prevalent in winter conditions, as aging pavement infrastructure may be influenced by weathering (freeze and thaw cycles) and begin to crack or break apart.

(5) Advisory Circular 150/5200-30, Airport Winter Safety and Operations, contains specific guidance on using and removing sand to minimize its chances of becoming FOD in winter weather conditions.

(6) Weather can also be the cause of FOD due to movement. For example, wind can blow dry debris, such as sand or plastic bags, from relatively non-critical areas onto the flight area. Rain water and drainage can stream mud, pebbles and other small items along the path of least resistance. Awareness of weather-related sources of FOD movement helps civil engineers to design barriers and other structures properly.

c. FOD Taxonomy. The exact nature of FOD is also varied. FOD can be composed of any material and can be of any color and size. In a one year airport study (Information Paper on French Study on Automatic FOD Detection Systems – Workshop EUROCONTROL, 9-10 June 2008), over 60% of the collected, known FOD items were made of metal, followed by 18% of the items being made of rubber. Dark-colored items made up nearly 50% of the FOD collected. Typical FOD includes the following:

- aircraft and engine fasteners (nuts, bolts, washers, safety wire, etc.);
- aircraft parts (fuel caps, landing gear fragments, oil sticks, metal sheets, trapdoors, and tire fragments);
- mechanics' tools;
- catering supplies;
- flight line items (nails, personnel badges, pens, pencils, luggage tags, soda cans, etc.);
- apron items (paper and plastic debris from catering and freight pallets, luggage parts, and debris from ramp equipment);
- runway and taxiway materials (concrete and asphalt chunks, rubber joint materials, and paint chips);
- construction debris (pieces of wood, stones, fasteners and miscellaneous metal objects);
- plastic and/or polyethylene materials;
- natural materials (plant fragments, wildlife and volcanic ash); and
- contaminants from winter conditions (snow, ice).

FOD removal operations are not meant to occur when a given area is contaminated with snow or ice. In such winter conditions, the procedures listed in AC 150/5200-30, Airport Winter Safety and Operations, are used to clear the AOA surfaces.

2.3 AN AIRPORT FOD MANAGEMENT PROGRAM

a. Airport Regulatory Requirements.

(1) The need for an airport to manage FOD is based on the requirements outlined in 14 CFR Part 139, Certification of Airports. The presence of FOD in the airport environment is discussed in §139.305.(a).(4), Paved Areas, which states: “Except as provided in paragraph (b) of this section, mud, dirt, sand, loose aggregate, debris, foreign objects, rubber deposits, and other contaminants must be removed promptly and as completely as practicable.” In addition, daily inspections performed at certificated airports (which form the primary means of FOD detection and removal at some airports) are required under §139.327, Self-Inspection Program. Inspections are a key component in airport operations, and an effective self-inspection program enables an airport operator to identify and eliminate unsafe conditions.

(2) Other FAA guidance documents, such as AC 150/5200-18, Airport Safety Self-Inspection, contain detailed information on the Part 139 inspection process, stating that "The inspector should continuously check for, and remove any FOD in movement areas, aircraft parking areas and loading ramps" (reference paragraph 11.g). It should be noted that while Part 139 requirements are mandatory for a holder of a Part 139 Airport Operating Certificate, the regulation contains many safety practices the FAA recommends for use at all airports.

(3) International standards and practices also discuss the issue of FOD in airports. ICAO Annex 14, Aerodrome Design and Operations, Chapter 10.2.1 states, "The surfaces of all movement areas including pavements (runways, taxiways and aprons) and adjacent areas shall be inspected and their conditions monitored regularly as part of an aerodrome preventive and corrective maintenance programme with the objective of avoiding and eliminating any loose objects/debris that might cause damage to aircraft or impair the operation of aircraft systems."

b. Program Areas.

(1) A successful FOD management programs typically contain four main areas, each containing significant elements, as outlined below and in Figure 2-1:

- Prevention
  - Awareness (existence of the FOD program and management support)
  - Training and education (implementation of the FOD program)
  - Maintenance
- Detection
  - Operations (manual inspections and use of detection equipment)
  - Equipment
- Removal
  - Equipment
  - Operations
- Evaluation
  - Data collection and analysis
  - Continuous improvement (trending, feedback, incident investigation)

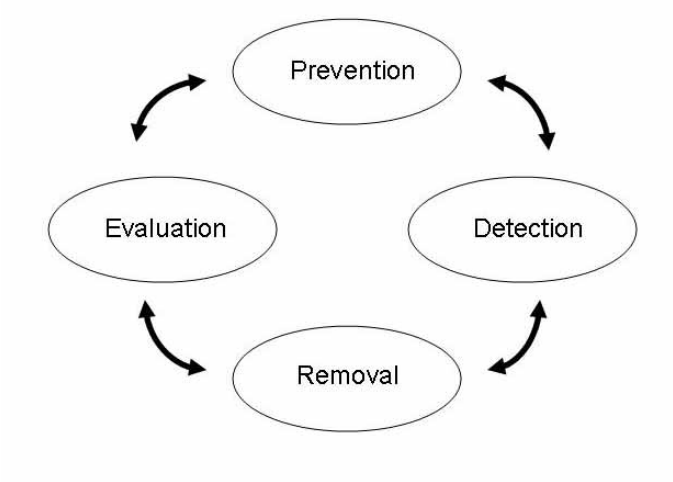

Figure 2-1. Relationship between the four main areas in a FOD program

(2) Practical guidance for FOD managers. FOD managers are encouraged to build upon the guidance provided in this AC when implementing or improving their own programs.

CHAPTER 3. FOD PREVENTION

3.1. AWARENESS.

a. Program Existence and Status.

(1) A first step in implementing a successful FOD management program is making sure that applicable personnel are aware of the program's existence. An airport's FOD management system should be visible in all aspects of the airport operation. Improvements in FOD safety will occur most efficiently if all airport personnel are actively encouraged to identify potential FOD hazards, act to remove observed FOD, and propose solutions to mitigate those hazards. Some examples of organizational communication are:

(a) FOD seminars;

(b) FOD letters, notices and bulletins;

(c) FOD lessons-learned;

(d) FOD bulletin boards, safety reporting drop boxes, and electronic reporting through web sites or email; and

(e) A method to exchange safety-related information with other airport operators through regional offices or professional organizations.

(f) Airport FOD program promotional materials, such as t-shirts, stickers, FOD disposal cans, and smaller give-away items.

(g) FOD discussion at employee staff meetings.

b. FOD Policy and Management Support.

(1) An effective FOD program must also have the full support of management. Management's commitment to FOD prevention should be formally expressed in a statement of the organization's FOD policy. The statement will serve to formally establish the FOD management program. Posting this policy statement in conspicuous locations will help reinforce the organization's commitment to FOD prevention and help remind employees of their FOD management duties. Some key elements of an airport's FOD policy are:

(a) An outline of the methods and processes that the organization will use to achieve desired safety outcomes.

(b) The organization's policy concerning responsibility and accountability.

(2) The FOD Program Manager.

(a) Airport operators should designate an accountable staff member to manage the airport's FOD programs and issues. This designated individual can be a dedicated FOD manager or can have other duties (e.g., operations manger, safety manager, etc.).

(b) The responsibilities of the FOD Manager should be clearly defined along the identified lines of communication within the organization. Additionally, the FOD manager should be allowed to report to the highest levels of management (e.g. airport president, chief executive officer (CEO), etc.) to assure appropriate consideration of all reports, recommendations, and issues.

(c) The FOD manager should regularly communicate the status of the FOD program to airport staff and ensure that lessons learned from hazardous occurrence investigations and case history or experiences, both internally and from other organizations, are distributed widely. An open line of communication should always be available between the FOD Manager and the airport/air carrier staff.

(d) An expanded discussion of the suggested duties and responsibilities of a FOD manager are provided in Appendix A.

(3) The FOD Committee.

(a) A number of airports of varying sizes and complexities have found it helpful to establish a FOD committee. Note: The level of authority or power of the FOD committee will be different for each airport, as it is set by the airport's executive management.

(b) The composition of the committee is under the airport's discretion, but typical committee members include those stakeholders with a direct relationship to FOD (such as those in a position to produce or remove FOD), including: tenant representatives, air carriers, airport operations and public safety staff, and contractor representatives, etc. The FOD manager would typically chair the committee.

(c) One of the most important functions of the FOD committee is to serve as a resource for the FOD manager. In addition, the determination of potentially hazardous FOD situations can be performed by the FOD committee, as well as performing an evaluation of collected FOD data.

c. Safety Culture. An effective FOD management program requires more than the implementation of rules and procedures to be followed. It requires the support of management to establish the attitude, decisions, and methods of operation at the policy-making level that demonstrate the organizations priority to safety. In effective safety cultures, there are clear reporting lines, clearly defined duties and well understood procedures. Personnel fully understand their responsibilities and know what to report, to whom and when. Though it is an intangible aspect of a safety program, proper personal attitudes and corporate commitment enable or facilitate the elimination of unsafe acts and conditions that are the precursors to accidents and incidents.

3.2. TRAINING AND EDUCATION.

a. Audience. Each individual with access to the AOA should understand their role in the prevention of FOD. These personnel include: airport operations; construction; aircraft maintenance and permanent/seasonal servicing staff (e.g. catering, fuel, cabin cleaning, baggage and cargo handling, waste disposal, etc.), and any other contractors. A formal orientation/indoctrination program familiarizing new employees with safety, security, communications, and vehicle operations should include FOD management training. This training can supplement the general FOD awareness incorporated into the driver training curriculum (or training for apron walking privileges) already in place at many airports.

b. Features. The FOD manager provides current information and continual training relating to FOD issues relevant to the specific operation of the airport. The provision of appropriate training to all staff, regardless of their level in the organization, is an indication of management's commitment to an effective FOD management program. FOD training and education programs typically contain the following features:

(1) A documented process to identify training requirements;

(2) A validation process that measures the effectiveness of training;

(3) Recurrent training and education (to help maintain awareness);

(4) Human (and organizational) factors.

c. Training Objectives. The primary objectives of the FOD training program will be to increase employee awareness of the causes and effects of FOD damage and to promote active employee participation in eliminating FOD during performance of daily work routines. The FOD manager should emphasize FOD management through employee motivational programs as well as by conducting training courses to emphasize FOD prevention through efficient design, product discipline, maintenance, and flight line activities. The following subject matter should be included, as applicable, in the FOD manager's FOD prevention program:

(1) Overview of the FOD management program in place at the airport;

(2) Safety of personnel and air carrier passengers;

(3) Causes and principal contributing factors of FOD;

(4) The consequences of ignoring FOD, and/or, the incentives of preventing FOD;

(5) Practicing clean-as-you-go work habits, and the general cleanliness and inspection standards of work areas (including the apron and AOA);

(6) Proper care, use, and stowage of material and component or equipment items used around aircraft while in maintenance or on airport surfaces;

(7) Control of debris in the performance of work assignments (e.g. loose items associated with luggage, ramp equipment, and construction materials);

(8) Control over personal items and equipment;

(9) Proper control/accountability and care of tools and hardware;

(10) Requirements and procedures for regular inspection and cleaning of aircraft and apron areas;

(11) How to report FOD incidents or potential incidents;

(12) Continual vigilance for potential sources of hazardous foreign objects;

(13) FOD Detection procedures, including the proper use of detection technologies (if applicable); and

(14) FOD Removal procedures.

d. Training Documentation. Training requirements and activities should be documented for each area of activity within the organization. To the extent possible, a training file should be developed for each employee, including management, to assist in identifying and tracking employee training, training requirements, and verifying that the personnel have received the planned training. Any training program should be adapted to fit the needs and complexity of the airport in question. At certificated airports, this is already being done for training required by 14 CFR Part 139, Certification of Airports.

3.3. MAINTENANCE PROGRAMS.

a. An airport's FOD prevention program should be tailored to mitigate the particular actions and activities that generate FOD. A few examples of these activities include:

(1) Aircraft Servicing. Air carriers and airport tenants generate much of the FOD found in the airport apron, service roads, baggage makeup areas, and areas near flight kitchens. Agreements between air carriers and their support organizations should specify which of the parties are responsible for cleaning various areas. In addition, the airport can help these organizations to establish procedures to inspect GSE for signs of wear and tear that can lead to FOD hazards. Procedures to inspect the baggage loading and unloading areas every time an aircraft is serviced can also be helpful, as luggage items (such as baggage wheels, zippers, and accessories) are common FOD items found in the airport apron.

(2) Aircraft Maintenance. Account for and dispose of nuts, bolts, washers, safety wire, etc. Account for hand tools used in repair jobs. Aids in the control of these items include checklists, shadow boards, and cut out tool tray liners. All items should be contained in a spill proof tote bag, tray or toolbox.

(3) Air Cargo. In an air cargo area, there is a high potential for blowing debris such as cargo strapping and plastic. Establish procedures to contain such debris, possibly by installing

(and monitoring) fencing where appropriate. Of course, FOD trapped by such fences should be removed regularly.

(4) Construction.

(a) Both airside and landside construction activities, as well as scheduled maintenance, should be communicated to airports users as early as possible. Specific FOD prevention procedures should be established and employed for each construction project. These procedures should be based on the proximity of construction activities to operational areas but in general should stress containment and regular cleanup of construction debris. Airport preconstruction planning should include a means for controlling and containing FOD generated by the construction. This is especially true in high-wind environments where debris is more likely to become airborne. For additional guidance on airport actions during construction activities, please reference AC 150/5370-2, Operational Safety on Airports During Construction.

(b) The designated routes of construction vehicles on the AOA should be examined, so as to avoid or minimize crossings of critical areas of aircraft operations. If high-risk crossings cannot be avoided, subsequent provisions such as an increased frequency of FOD inspections could be implemented. Airport operators should ensure that these provisions are incorporated into their FAA-approved Safety During Construction Plan.

(c) Contractors must fully understand the requirements and penalties incorporated in their contracts regarding the control and removal of FOD. To help ensure this occurs, airport operators may consider drafting standard "FOD Control and Clean-up" related language for all construction projects taking place within the AOA. The standard and project-specific FOD provisions could then be included into the contract documents for AOA construction projects. These items may include:

- Requiring contractors to cover all loads;
- Requiring contractor to secure any lose items that could easily be blown;
- Specifying whether any mechanical FOD removal devices will be required;
- Specifying how monitoring for FOD hazards will be done; and
- Requirements for inspecting tires prior to traversing areas where aircraft are located.

(5) Airfield Maintenance Operations.

(a) Mowing and other maintenance operations routinely disturb the vegetation and soil in areas adjacent to areas traveled by aircraft. Establish procedures to remove debris such as the use of an assigned airfield sweeper or personnel on foot using shovels to repair vegetation and soil.

(b) Airfield lighting, pavement, and marking maintenance operations generate concrete/asphalt debris as well as increase the potential for dropped repair parts, tools, and other items stored on the maintenance vehicles. Corrective procedures should include the use of airfield sweepers and inspection of the work site after the procedures are completed.

(6) Pavements. Asphalt and concrete pavements may be the most common source of FOD on an airport. Therefore, effective pavement maintenance practices are critical to the mitigation of FOD. The FAA has developed extensive resources for pavement maintenance. For further information on this topic, please refer to AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements, or visit http://www.faa.gov.

CHAPTER 4. FOD DETECTION

4.1. GENERAL.

a. While proper FOD awareness is fundamental for any successful FOD program, the act of detecting FOD is one of the critical FOD operations that occur at an airport. This process involves not only the identification of potential FOD causes and locations, but also the timely detection of any FOD on airport surfaces. Whether detection occurs manually, through regular inspections, as a result of pilot reports, or through the use of advanced detection technologies, the outcome is equally important.

b. Runway Closures.

(1) A highly sensitive question involved in the use of continuously operating FOD detection technologies arises once an object is detected. If the location or characteristics of the FOD present no immediate safety hazard the object should be removed as soon as the operational schedule permits. If the location or characteristics of the FOD present an immediate safety hazard, provisions in the FOD management program should clearly indicate that a hazard exists and allow for an airport supervisor to take action and temporarily cease operations and, in the case of aircraft or airport equipment source of the FOD, notify the equipment operator. This is an appropriate issue, for example, for an airport's FOD committee to study and provide further guidance to airport management and operations staff.

(2) On March 17, 2009, the FAA issued CertAlert 09-06, Closing active runway for FOD checks increases safe operations. In this advisory notice, the FAA stated that although not all types of FOD will necessitate an immediate runway closure, quick and decisive action should be taken, in all cases, to assess the threat posed by reported FOD. The FAA recommends that airports work closely with their Airport Traffic Control facilities in establishing procedures for handling such matters. For those interested, local FAA Airport District or Regional Offices can provide sample Letters of Agreement that address these types of situations and that have been successfully implemented at high activity air carrier airports.

4.2. FOD RISK ASSESSMENT.

A FOD risk assessment enables an airport to determine where unsafe FOD conditions exist. However, since the risk assessment process is an integral part of an airport's Safety Management System (SMS) program, and the FAA does not require airports to have an SMS program, the risk assessment process will not be discussed at this time. If, or when, airports are required to have an SMS program in the future, this AC will be updated to reflect the appropriate risk assessment procedures.

4.3. FOD DETECTION OPERATIONS

a. Inspection Areas. While detailed inspection guidance is provided in AC 150/5200-18, Airport Safety Self-Inspection, additional information can be helpful for airport personnel conducting FOD inspections. The following areas and operations are typically prone to having FOD:

(1) Movement Areas (runways and taxiways).

(a) The portion of the runway used by aircraft to take off is where departing aircraft are most susceptible to FOD damage.

(b) Deteriorating or neglected pavement can exhibit spalling or cracks. For example, pieces of concrete can break loose from pavements or FOD can develop from fatigue corner cracks and airfield markings. FOD associated with building materials, debris falling from construction vehicles or blown from the airport apron onto aircraft maneuvering areas. Broken pieces of pavement can collect at the edge of the airport apron and be carried onto the aircraft maneuvering area by the tires of vehicular GSE.

(c) Service roads that cross taxiways should be monitored closely to prevent the vehicles using these roads from moving FOD onto the taxiways (especially in the case of construction operations, as addressed in the airport's Safety During Construction Plan).

(d) Shoulders. Unpaved areas adjacent to pavement should be stabilized to prevent FOD. (AC 150/5300-13, Airport Design, provides further guidance in the construction of stabilized shoulders.)

(e) Pavement Joints. Special attention should be paid to the cleaning of cracks and pavement joints as tests have shown that these are the main sources of foreign objects which are ingested.

(f) Turf Areas. Turf grass and ditches collect and hold large amounts of light debris such as paper, cardboard, plastic, and various containers that trash often originate in terminal aprons, cargo ramps, and hangar ramps. This trash can blow back into areas traveled by aircraft unless collected in a timely manner.

(g) Fence-lines. Fences can collect trash on windy days. This FOD should be collected before the wind increases or shifts direction and the trash blows back on to areas traveled by aircraft.

(2) Airport Apron. Anywhere on the aircraft apron where ground vehicles operate.

(3) Aircraft Servicing Operations.

(a) Refueling, catering, cabin cleaning, and baggage and cargo handling can produce broken materials.

(b) Baggage pieces, including bag tags and wheels, can break off luggage and either fall onto the apron or collect in the door sill. Items collected in the door sill can damage the door or prevent it from properly closing. They can also be knocked out of the sills and onto the apron at the next station.

(c) Other areas where FOD is likely to collect include the ground at both ends of the conveyor, and the area between the baggage cart and the conveyor belt.

(4) Air Cargo Operations.

(a) High potential for blowing debris such as plastic cargo wrappers.

(b) Fencing used to contain debris should be cleaned regularly.

(5) Construction Operations.

(a) The proximity of construction activities to operational areas presents a risk of debris.

(b) Regular and thorough cleaning of the construction site, including the construction haul routes, is expected. These provisions are typically outlined in local rules and pre-existing agreements, such as the construction safety plan. Particular attention should be paid to construction vehicle routes that cross or are adjacent to active pavements.

(6) Aircraft Maintenance Activities.

(a) These activities, which may be performed on the apron, require a variety of small objects, such as rivets, safety wire, and bolts that become FOD when they are inadvertently left behind.

(b) All tools should be accounted for as a matter of practice. Aids in the control of these items include checklists, shadow boards, and cut out tool tray liners. For more information on an effective tool control program, please see NAS 412, Tool Accountability.

(7) Other activities. All vehicles should be driven on clean, paved surfaces when possible. If a vehicle must be driven on unpaved surfaces, the operator should check the vehicle tires for foreign objects immediately after returning to the pavement.

b. Methods and Techniques.

(1) The FAA and ICAO require a daily, daylight inspection of aircraft operating areas. Operational areas must be inspected at least once each day, with additional inspections being made in construction areas and immediately after any aircraft or ground vehicle accident or incident or any spill of material which may cause slippery conditions. In addition to performing these inspections at the beginning of the day or shift, personnel in the AOA should practice a clean-as-you-go technique of looking for FOD during their normal shifts in the course of their regular duties. Inspections occurring at night, taking place after the runway is closed or before the runway is opened, also occur frequently. During night time inspections, personnel and vehicles should be equipped with additional lights/lighting systems to better detect FOD.

(2) Detection Technologies.

(a) Recent technological developments have greatly expanded the capabilities of FOD detection through automation. Advanced technologies are now available for improved FOD detection, including capabilities for continuous detection on runways and other aircraft movement areas and mobile detection devices to supplement the capabilities of airport personnel.

If an airport chooses to implement these new FOD detection technologies, they should ensure that the personnel monitoring these systems either have the authority (or the ability to quickly contact those in authority) to take appropriate and timely action if FOD is detected. Please see AC 150/5220-24, Airport FOD Detection Equipment, for more detailed information on the performance capabilities of advanced FOD detection technologies.

(b) FOD Detection Notification. The airport operator and air carriers have considerable flexibility in terms of how to implement continuous detection systems at the airport. The user interface may be located in the airport's operation or maintenance center, or it may be located in the airport traffic control (ATC) tower. Regardless of the configuration, an airport will determine the most efficient way to notify airport/air carrier personnel to remove the detected FOD, as well as the ATC staff to divert aircraft if a significant risk is presented.

(c) Wildlife. There are currently no uniform standards or procedures for the detection of wildlife on an airport. However, anecdotal evidence suggest that dead wildlife are more appropriately handled as a component of a FOD management program, while live wildlife are a component of a wildlife hazard management program. An overlap of these two programs therefore occurs whenever wildlife are struck by aircraft and/or their remains serve as an attractant to other wildlife. In addition, elements of certain wildlife programs can create FOD, e.g. the introduction of cracker shell casings. Certificated airports (under 14 CFR Part 139) and airports that have a Wildlife Hazard Assessment Plan may therefore need to review their plan as it relates to the airport's FOD program.

(3) Manual Detection.

(a) When conducting an inspection on a runway, inspection techniques will be determined by runway availability and type of operation. Ongoing construction requires more frequent inspections. It may even be necessary to assign dedicated personnel to continually inspect for FOD during major construction activities. As part of the FOD management program, the FOD manager may find it appropriate to reach out to air carriers and flight crews to leverage the airport's current FOD management efforts. For example, flight crews could be asked to report to ATC and station operations any FOD they observe on runways and taxiways. Air carrier and aircraft handling agents may also be asked to designate individuals to inspect apron areas prior to aircraft movement to and from the gate.

(b) A runway inspection will involve passage along the length of the runway to observe and remove FOD. The most effective method involves two or more passages to reduce the width of the inspection zone. When there is time to do only one pass on the runway, inspection personnel, whenever practical, should drive in the opposite direction that aircraft are landing on the runway with high intensity flashing beacon and headlights on at all times. This practice will enable self-inspection personnel to see approaching aircraft and improve visibility of the vehicle to pilots. Inspection personnel should also drive the stub taxiways between the runway and parallel taxiway because these areas are commonly overlooked.

(c) Encouraging the participation of airport tenants in inspections will reinforce the concept that FOD prevention is a team effort and demonstrate the airport operator's commitment to a debris-free environment. As such, air carrier personnel, when feasible, should join the

airport staff in daily movement area inspections. This practice helps increase familiarity with local airfield conditions, and promotes effective communication between the airport and air carriers. The placement of convenient and conspicuous FOD containers (as described in Paragraph 5.2 of this AC) is a helpful reminder of the need to be vigilant in preventing the occurrence of FOD.

(i) An effective and clever operation currently in place at airports is the promotion of all-hands "FOD walks." These walks are typically conducted as part of an airport's FOD management campaign. Walks involve the coordination and invitation of airport and air carrier staff (e.g. ground handling agents, air carriers, Aircraft Rescue and Fire Fighting (ARFF) and apron personnel), external partners, and other community volunteers to participate in manually collecting airport FOD. These events can be promoted with offering food and water to participants, and various prizes (i.e. airport clothing) to those who collect the most FOD. Of note, during this type of event, identifying the location and origin of FOD (for data analysis and evaluation) is not always possible.

(d) For further guidance on the performance of airport inspections, please see AC 150/5200-18, Airport Safety Self-Inspection.

4.4. FOD DETECTION EQUIPMENT.

The standards and specifications found in AC 150/5220 24, Airport Foreign Object Debris (FOD) Detection Equipment, represent the FAA guidance for the evaluation and procurement of FOD detection systems.

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CHAPTER 5. FOD REMOVAL

5.1. BACKGROUND.

Once FOD is detected, the next major operation of a FOD management program will occur: removing FOD from the airport environment. The most effective resource for FOD removal is the use of FOD removal equipment, especially in areas where FOD can be expected, such as near areas of construction. For removal of an isolated FOD object detected on a runway, manual removal will be the most efficient. Although specialized equipment is available and highly suited to some airport operations, FOD removal methodologies and technologies are available for all airports.

5.2. EQUIPMENT CHARACTERISTICS.

This AC does not limit the equipment that airports may use for FOD removal. Currently available removal equipment can be categorized into two types: mechanical and non-mechanical. Additionally, the category of storage systems (FOD containers) is also of fundamental importance.

a. Mechanical Systems. These technologies use powered devices in mechanical systems that remove or retrieve FOD items and contain retrieved FOD for proper disposition. Equipment in this category varies in size, and is found in sizes from small push units to large area systems that are truck mounted. Types of mechanical removal systems include:

(1) Power Sweepers, including tow-behind bristle trailers. The sweeper removes debris from cracks and pavement joints, and is typically used in all areas of the AOA including areas where GSE are staged. **NOTE:** *For all brush systems, operators are cautioned that bristles can detach from brooms and produce a FOD source. Brushes made with metal bristles or spines are not recommended to be used for FOD removal purposes. Plastic or combination plastic/metal bristles may be appropriate, but the user should consult the equipment manufacturer for specific recommendations. Regardless of the equipment used, a thorough check of the pavement should be conducted at the conclusion of the sweeping procedure.*

(2) Vacuum Systems. These systems perform FOD removal functions similar to the power sweepers described above, but use air flow as the primary means of object retrieval. The systems may also perform in conjunction with mechanical brooms or other recirculating air units.

(3) Jet Air Blowers. These systems move FOD and other debris by directing a stream of high velocity air towards the pavement surface. When used in the airport environment, it is recommended that these systems incorporate a debris collection mechanism so that FOD will not simply be relocated to another area in the AOA.

b. Non-Mechanical Systems.

(1) Friction Mat Sweepers. A rectangular assembly towed behind a vehicle that employs a series of bristle brushes and friction to sweep FOD into sets of capture scoops, which are covered by a retaining mesh to hold collected debris.

(2) Magnetic Bars (attached to vehicles). These bars can be suspended beneath tugs and trucks to pick up metallic material. However, the bars should be cleaned regularly to prevent them from dropping the collected debris. Vehicles operation in the AOA should be inspected periodically to ensure that they have no loose items that can fall off. Common magnetic materials include ceramic, rare earth, and alnico metals. Conversely, magnetic bars are not able to pick up the following types of common FOD materials: titanium and aluminum alloys, some stainless steels, and plastics.

(3) Rumble strips (also "FOD Shakers"). Long devices, which are 10 to 15 ft (3 to 4.60 m) long, that are positioned on the pavement to dislodge FOD from vehicles that drive over them. While these devices may have been used in the past, they are no longer a widely accepted FOD removal system. Their effectiveness at removing debris from tires or vehicle undercarriages is negligible, and the equipment can generate its own FOD if not cleaned out regularly. The current best practice for removing FOD from tires is to stop a vehicle at a designated checkpoint, perform a visual inspection, and then use a hand tool to manually remove detected debris.

c. Storage Systems (FOD Containers).

(1) Designated FOD containers should be conspicuously placed at all gates for the collection of debris. The containers should be well marked, properly secured, and emptied frequently to prevent them from overflowing and becoming a source of FOD themselves. In addition, airport personnel can wear waist pouches to collect debris.

(2) "Closed-type" containers are preferable, given the opportunity for wind to dislodge the container contents. Consequently, "open-type" containers are not advised. Airport operators should ensure that FOD containers do not blow over during periods of high winds. This can be accomplished by using heavy trash cans or securing the containers to the ground with a tether or a weight. FOD containers should also have placards stating that hazardous materials may not be deposited in them.

(3) Locations. Suggested locations include: near all entry points to the AOA, in hangars, in aircraft tie-down and aircraft maintenance areas, and at each aircraft gate or baggage area. Central or well-known storage locations increase the likelihood that collected debris will be deposited by personnel.

(4) Other means for containing FOD include: wind barriers and netting to restrict movement of airborne FOD; fencing to prevent animals from entering the airfield; and well-maintained paved surfaces. If damaged pavement cannot be repaired immediately, airport operators should make arrangements for aircraft to take an alternate route.

(5) Evaluating the debris collected in containers and pouches can reveal its sources and indicate where personnel and equipment should be deployed for more effective control. Chapter six of this AC will provide more information on this practice.

5.3. PERFORMANCE.

a. Operational Standards. Unless otherwise specified, the following standards apply only to "mechanical" FOD removal systems.

(1) Operational Speeds. The minimum speeds that FOD removal equipment should operate and collect 90% of FOD (based on the "test/validation objects described in paragraph 5.3.b) is 15 mph (25 km/h). Maximum speeds are limited by airport operations regulations. (Mechanical and non-mechanical systems)

(2) Collection Path.

(a) The minimum path for a removal system used during airport operations is 60 in (150 cm) wide.

(b) Systems that are used on the airport apron or designed to be mounted on existing airport operations vehicles must have a minimum path 40 in (100 cm) wide.

(c) Magnets must be at least 36 in (90 cm) long and 4 in (10 cm) wide. (Mechanical and non-mechanical systems)

(3) Retention / Hopper Capacity.

(a) The minimum usable capacity of a power sweeper used during airport operations is 40 cu ft (1 cu m).

(b) For systems mounted on airport operations vehicles, the volume of the truck bed will represent the retention capacity.

b. Testing / Validation.

(1) All FOD removal equipment must be able to demonstrate the ability to collect 90 percent of the items listed in paragraph below, when they are placed in a 10 ft x 10 ft (3 m x 3 m) square on the pavement surface, on one pass of the equipment at a minimum speed of 15 mph (25 km/h). Where specific dimensions and weights are not provided, the purchaser will determine the object properties most characteristic of those found on their airport.

(2) Test / Validation Objects.

- A metal cylinder measuring 1.2 in (3.1 cm) high and 1.5 in (3.8 cm) in diameter (both ferrous (i.e., magnetic) or non-ferrous metals are acceptable),
- A sphere, measuring 1.7 in (4.3 cm) in diameter (i.e., a standard size golf ball),
- A "chunk" of asphalt or concrete,
- Any portion of a runway light fixture (in-pavement or edge light),
- A wrench (up to 8 in. (20 cm) in length),
- A socket (at least 2 in. (5 cm) in length),
- A piece of rubber from an aircraft tire,

- A distorted metal strip (up to 8 in. (20 cm) in length),
- Fuel cap (aircraft or automotive),
- Lug nut,
- Hydraulic line (from aircraft or GSE, up to 8 in. (20 cm) in length), and
- Aircraft fasteners and safety wire.

(3) Further testing requirements are contained in Appendix B, Section B.3, of this document.

c. Additional Standards. Additional FOD removal system standards are located in Appendix C.

5.4. REMOVAL OPERATIONS.

a. Individuals responsible for FOD removal operations should have direct responsibility for the safety of those operations and should be given the resources to implement the necessary controls.

b. The majority of FOD removal operations are performed in conjunction with the detection operations described in paragraph 4.2 of this AC. While the exact actions are specific to each airport, the following two examples of FOD removal operations from a high activity air carrier airport in the U.S. represent the successful implementation of FOD removal equipment:

(1) Assigning an airfield sweeper(s) to work with maintenance crews and/or respond as required to reports of FOD.

(2) Deploying a maintenance employee on a small all-terrain vehicle with a litter stick and garbage bags to pick up trash in grassy areas and fence-lines. This operation is intended to pick up debris before it returns to the pavement areas. In one year, over 2,898 bags of trash were collected using this method.

c. The equipment described in this chapter may be used singularly or in combination. In either case, FOD managers are cautioned that personnel using particular FOD removal equipment may become complacent and completely rely on the equipment to remove all pieces of FOD in their area of operation. Personnel must be constantly aware of the performance of their equipment, and should regularly check to make sure visually detected FOD is in fact collected by their equipment during FOD removal operations.

CHAPTER 6. FOD EVALUATION

6.1. DATA COLLECTION AND ANALYSIS.

a. A critical part of any FOD management system is the information available for problem assessment and management program design. Although anecdotal information on FOD collected at airports is available, no comprehensive assessment of FOD types and sources is possible unless a comprehensive data collection and analysis scheme is in place.

b. Documentation. The FOD manager will ultimately determine the documentation guidelines in a FOD management program. Certain small items, such as plastic wrappers or baggage tags, may simply warrant efficient collection and disposal. A consistent trend of small items, such as those coming from a particular entity or operation, or particularly large or hazardous FOD, may require detailed documentation for effective analysis and prevention efforts. It is recommended that airport personnel collect the following information, to the extent practicable, whenever FOD is collected:

(1) How the FOD object was detected

(2) Date and time of FOD detection and retrieval

(3) Description of FOD retrieved (category, size, color), and/or image (if available)

(4) Location of FOD object (coordinates and reference to the AOA location)

(5) Possible source

(6) Name of personnel detecting / investigating FOD item

(7) Airport operations and weather data during the FOD detection event

c. Reporting.

(1) Depending on the volume or significance of collected FOD, the FOD manager may decide that it is necessary to designate and train certain personnel to collect, tag, store, and report on the collected FOD for future data analysis efforts. An additional communication procedure may also need to be established, so that the person who first collects the FOD will notify the person responsible for reporting the FOD. In any case, a well-defined reporting procedure is an important aspect of any FOD management program.

(2) The FOD management program should include a visible FOD reporting system supported by management. The reporting system should permit feedback from personnel regarding FOD hazards and other safety-related concerns. The FOD management system should use this information to identify and address operational or administrative deficiencies.

(3) Depending on the potential hazard of FOD collected, a reoccurrence of FOD from the same source, and the personnel available at an airport, the FOD management program may

contain provisions to notify the FOD source of a FOD occurrence. Operational experience from at least one airport has shown that notifying the source of FOD helped to correct the underlying safety deficiencies that caused multiple FOD events.

d. Investigation. It is recommended that major FOD incidents (as determined or classified by the airport operator) are investigated by the FOD manager or other appropriate airport personnel. An investigation should try to determine the source of FOD and damage caused. When the investigation is completed and necessary corrective action has been implemented in accordance with the FOD management plan, final disposition of the incident should be entered into the airport's FOD reporting system.

e. Database. It is important that the organization maintain a record of the measures taken to fulfill the objectives of the FOD management system. These records may be required in the event of a formal investigation of an accident or serious incident, and can also be used to identify any trends, repeats, unusual conditions, etc., in order for corrective action to be initiated. Records can also provide quantitative data for future risk assessments, support the assessment of system operational history and assure operational capabilities. The disposition of reported information will be based on the airport's FOD management program specifications and support §139.327 certification. All records should be maintained in sufficient detail for a period of at least 2 years to ensure traceability of all significant safety-related decisions. The FAA is currently developing the framework for a national FOD database. Airport's collecting high-quality FOD data (showing at least the type, location, and source), are encouraged to submit their data to FAA once the national database is in operation.

6.2. CONTINUOUS PROGRAM IMPROVEMENT.

a. Safety performance monitoring validates the FOD management program, confirming the organization's safety objectives. Through regular review and evaluation, management can pursue continuous improvements in FOD management and may revise safety objectives, policies, procedures, and training programs to ensure that the FOD management program remains effective and relevant to the organization's operation.

b. The FOD Manager, in assessing the effectiveness of the FOD management program, should work with the persons that have direct responsibility for analyzing hazards, identifying control measures derived from that analysis, and ensuring those measures are effective.

c. Program Evaluation. These evaluations provide a means for systematically assessing how well the organization is meeting its FOD management objectives. The evaluation provides a review of existing conditions and results in recommendations for enhanced debris control. Management may choose to have an external organization evaluate the system (e.g., by a consultant or another airport operator), or choose to perform the evaluation using airport/air carrier staff. In addition to supporting the airport operator's existing responsibilities for self-inspection and correction of discrepancies under 14 CFR Part 139, an effective airport FOD management program evaluation should:

(1) Systematically review the effectiveness of existing FOD-management procedures used by airport and air carrier personnel, including all available feedback from daily self-inspections, assessments, reports, and other safety audits:

(2) Verify that the airport is meeting identified performance indicators and targets;

(3) Solicit input through a FOD system;

(4) Communicate findings to staff and implement agreed-upon corrective procedures, mitigation strategies, and enhanced training programs; and

(5) Promote safety in the overall operation of the airport by improving coordination between airport staff, air carrier personnel, and airport tenants.

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APPENDIX A: SUGGESTED DUTIES AND RESPONSIBILITIES OF THE FOD MANAGER

The information presented in this section represents only one of many potential approaches to designating the duties and responsibilities of a FOD Manager. Airports should select/modify any items that would be most appropriate for their situation when developing their FOD program.

A.1. GENERAL. Where appropriate, the airport operator should designate a FOD Manager(s) that will develop and implement plans and programs to prevent, detect, and remove FOD on an airport. The FOD Program Manager may be a dedicated position, but will more likely than not be an additional role assigned to someone currently serving in the airport operations staff. The FOD Manager(s) should be appointed by an Airport executive, or executive of the commercial business operating at the airport, and should have sufficient authority and organizational freedom to identify and implement FOD preventive measures whenever and wherever required.

A.2. THE FOD MANAGER should:

a. Review and assess the airport's FOD management program and make necessary revisions.

b. Conduct scheduled and unscheduled evaluations/inspections of work areas to assess the effectiveness of the FOD management program.

c. Assure implementation of corrective actions for FOD prevention.

d. Assure that FOD incidents are thoroughly investigated and that incident reports are accomplished as specified in paragraph 6.1 of this AC.

e. Assure that causes of FOD incidents are thoroughly analyzed to identify corrective measures.

f. Notify affected contractor/tenant organizations and personnel of unique FOD prevention requirements.

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

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

i. Evaluate the amount and kind of foreign objects found and how they were found (e.g. during daily inspections, by pilots, airport operations staff, etc.).

j. Review and approve FOD prevention training curricula, designate training personnel, and assure that airport/contractor/tenant personnel receive required training.

k. Assure that written procedures provide for adequate records attesting to the current status and adequacy of the FOD management program.

l. Manage any additional program activities, including the scheduling of the FOD committee meetings, as required.

APPENDIX B: FOD REMOVAL EQUIPMENT: ADDITIONAL STANDARDS

B.1 DESIGN STANDARDS.

a. General.

(1) Total Life. FOD removal systems must be designed to perform their intended function for their "total life" period, when maintained according to the manufacturer's instructions. The "total life" for which the equipment is designed, assuming it is used and maintained in accordance with the manufacturer's recommendations, must be a minimum of:

(a) 20 years, or 200,000 miles (322,000 km), for mechanical systems, excluding consumable parts (e.g. bristles, brooms, and other portions of the collection mechanism)

(b) 10 years, or 10,000 miles (16,000 km), for friction mat sweeper equipment and towing hardware. The consumable portions of the system (e.g. friction mat), must be capable of operating for at least 2,000 miles (3,000 km) before replacement is needed.

(c) 30 years for all other non-mechanical systems.

(2) Environmental. FOD removal equipment, including all associated outdoor mounted equipment, must be designed to withstand the following climatic conditions and operate without damage or failure:

(a) Weather

(i) Ambient temperature range: 32 degrees F (0 degrees C) to 123 degrees F (52 degrees C) ambient outdoor air temperature (may be modified by the purchaser if the device is to be used in extreme climates)

(ii) Relative Humidity: 5% to 90% (may be modified by the purchaser if the device is to be used in extreme climates)

(iii) General Environment: Dust and airborne hydrocarbons resulting from jet fuel fumes.

(b) Components must be protected from mechanical, electrical, and corrosion damage causing impairment of operation due to rain, snow, ice, sand, grit, and deicing fluids.

(c) All electric motors, controls, and electrical wiring / equipment placed outdoors must be weatherproof in order to protect the equipment and connections from the elements.

(d) All non-moving structural components and materials must be individually and collectively designed and selected to serve the total life requirement under such conditions. Moving or working components, such as tires, motors, brakes, etc. are exempt from this provision.

b. Safety.

The device must meet the requirements of SAE ARP1247, paragraph 3.8.

(1) Personnel Safety. The device must meet the requirements of SAE ARP1247, paragraph 3.9, except as provided below.

(a) If highway transportability, defined as the capability (of a self-propelled device) to be licensed for operation on public highways, is not specified by the purchaser, the provisions of SAE ARP1247, paragraph 3.9.1 do not apply.

(b) If the device is not self-propelled, the provisions of SAE ARP1247, paragraphs 3.9.2 through 3.9.4 do not apply.

(c) Noise and Vibration. The device must meet the requirements of FAA HF-STD-001, paragraph 13.5 (Noise) and MIL-STD-1472F, paragraph 5.8.4 (Vibration). The unit must be designed and constructed to prevent parts from working loose in service. It must be built to withstand the stresses, jars, vibrations, and other conditions incident to shipping, storage, installation, and service. Suitable and durable vibration isolators must be used between the engine and structural mounts and to include all other structural mountings to protect the operator, instruments, components, hydraulics, and structure from vibration transmission.

(2) Equipment Safety. The device must meet the requirements of SAE ARP1247, paragraph 3.10. For any device not completely manually operated, a 5 lb (2 kg) BC-rated fire extinguisher must be mounted on the device at a location easily accessible to the operator.

(3) Emergency Operations. The device must meet the requirements of 49 CFR §38.23(b)(3)) and SAE ARP1247, paragraph 3.9.11. Where there is a conflict with the two documents, the DOT regulations take precedence.

(a) Power or Equipment Failure. The device must meet the requirements of 49 CFR §38.23(b)(4)).

(4) Storage / Security. All requirements needed to properly store and secure the device must be supplied by the manufacturer.

c. Engines and Related Equipment.

(1) General. The vehicle must have a commercially-produced engine that is certified to comply with the Environmental Protection Agency (EPA) and state laws for off-highway emission requirements at the time of manufacture. The engine and transmission must operate efficiently and without detrimental effect to any drive train components when lubricated with standard, commercially available lubricants in keeping with the recommendations of the engine and transmission manufacturers.

(2) Acceleration. The fully loaded vehicle will accelerate from 0 to 50 miles per hour (mph) on a level paved road within 30 seconds.

(3) Altitude. Where justified, the vehicle will be designed for operation at 2,000 feet above sea level.

(4) Indicators. Engines used to drive systems, other than the vehicle propulsion system, must be equipped with a tachometer (green-lined within the correct operating RPM range and red-lined above this range) or automatically governed to prevent over-revving.

(5) Engine Cooling System. Liquid coolant systems must be rated for the maximum engine loads under the environmental conditions specified by the airport, or at the conditions of maximum intermittent output approved by the engine manufacturer, whichever criterion results in the largest heat transfer capacity. A label will be installed near the engine coolant reservoir reading "Engine Coolant Fill."

(6) Fuel System.

(a) Gasoline powered engines must meet all performance requirements without requiring premium grades of fuel. Diesel powered engines must be certified for aviation turbine fuel. LPG engines must be certified for (Natural Gas Producers Association) HD-5 motor fuel.

(b) Alternative fuels, such as bio-diesel, clean diesel, gaseous fuels (natural gas and liquid petroleum gas), alcohols (methanol and ethanol), Jet A, and reformulated gasoline may also be used. Equipment modifications to allow the use of such fuels must conform to manufacturer specifications.

(c) Fuel filters. Primary and secondary fuel filters will be provided. Fuel filter elements will be easily replaceable by a mechanic without loss of engine prime.

(d) Fuel tank. The fuel tank will have a fill opening readily accessible to personnel standing on the ground and designed to prevent fuel splash while refueling. Each tank will be located and mounted so as to provide maximum protection from damage, exhaust heat, and ground fires. If more than one tank is furnished, means will be provided to assure equalized fuel level in both tanks. An overturn fuel valve will be provided for each tank to prevent spillage in the event of a rollover. Each fuel tank must be prominently labeled with the type of fuel used in the engine.

(7) Exhaust System. The exhaust system will be constructed of high grade rust resistant materials and protected from damage resulting from FOD impact. Exhaust system outlet(s) will be directed upward or to the rear, away from personnel accessing equipment compartments and the engine air intake, and will not be directed toward the ground. Engine exhaust systems must be provided with flame and spark arrestors.

d. Chassis and Vehicle Components

(1) Transmission. A fully automatic transmission will be provided.

(2) Driveline. If the driveline is equipped with a differential locking control, a warning/caution label will be placed in view of the driver indicating the proper differential locking/un-locking procedures. The operator's manual will also include a similar warning/caution. All moving parts requiring routine lubrication must have a means of providing for such lubrication. There must be no pressure lubrication fittings where their normal use would damage grease seals or other parts.

(3) Axle Capacity. Each axle will have a rated capacity, as established by the axle manufacturer.

(4) Tires and Wheels. Tires and wheels will be certified by the manufacturer for not less than 25 miles of continuous operation at 60 mph at the normal operational inflation pressure. A spare tire and wheel assembly will be provided; however, the spare tire and wheel assembly are not required to be mounted on the vehicle. Tires will be new. Retreads, recaps, or re-grooved tires are not permitted.

(5) Towing Connections. The vehicle will be equipped with towing connections allowing for the vehicle to be towed fore and aft.

(6) Brake System.

(a) The vehicle will be equipped with a braking system in accordance with Federal Motor Vehicle Safety Standard (FMVSS) standards. Vehicles with a Gross Vehicle Weight Ratio (GVWR) above 26,000 lbs will be equipped with air brakes. All components of the braking system will be installed in such a manner as to provide protection from objects liable to strike and cause damage to the brake system components. No part of the braking system will extend below the bottom of wheel rims, to ensure, in case of a flat tire, that the weight of the vehicle will be supported by the rim and the flat tire and not be imposed on any component of the braking system.

(b) Braking systems for vehicles with a maximum speed of less than 20 mph (32 km/h) must meet the requirements of Title 49 CFR Part 393, §393.41 and 393.52. The maximum stopping distance in feet must be equal to the design speed in mph.

(7) Steering. The vehicle will be equipped with power steering. The fully loaded vehicle will have a wall to wall turning diameter of less than three times the overall length of the vehicle in both directions.

e. Cab. The vehicle will have a fully enclosed door cab of materials which are corrosion resistant, such as aluminum, stainless steel, or glass reinforced polyester construction. Steps and handrails will be provided for all doors. The lowermost step(s) will be no more than 20 inches above level ground when the vehicle is fully loaded. A tilt steering column will be provided.

(1) Windshield and Windows. The windshield and windows will be of tinted safety glass. Each door window will be capable of being opened far enough to facilitate emergency occupant escape in the event of a vehicle accident.

(2) Instruments and Controls. All instruments and controls will be illuminated and designed to prevent or produce windshield glare. Gauges will be provided for oil pressure, coolant temperature, and automatic transmission temperature. All device instruments and controls must be located within convenient reach of the seated driver.

(3) HVAC System. If an HVAC system is specified by the purchaser, enclosed lift systems must meet the requirements of SAE J1503 and FMVSS No. 103. In sections where the two documents may conflict, FMVSS No. 103 takes precedence.

(4) Seats. The driver seat will be adjustable fore and aft. Each seat will be provided with a Type 2 seat belt assembly (i.e., 3-point retractable restraint) in accordance with Code of Federal Regulations (CFR) 49 CFR Part 571, §571.209.

(5) Windshield wipers and washer. The vehicle will be equipped with electrically powered windshield wiper(s). The wiper arm(s) and blade(s) will be of sufficient length to clear the windshield area described by Society of Automotive Engineers (SAE) J198, Windshield Wiper Systems - Trucks, Buses, and Multipurpose Vehicles. Individual wiper controls will include a minimum of two speed settings and an intermittent setting. The wiper blades will automatically return to a park position, out of the line of vision. The vehicle will be equipped with a powered windshield washer system, including an electric fluid pump, a minimum one gallon fluid container, washer nozzles mounted to the wiper arms (wet arms), and a momentary switch.

(6) Warning Signs. Signs that state "Occupants must be seated and wearing a seat belt when apparatus is in motion" will be provided in locations that are visible from each seated position.

f. Electrical / Lighting.

(1) General.

(a) Lighting must in all cases meet the requirements of AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport, using the standards for airfield service vehicles.

(b) Unless otherwise specified, electrical systems incorporating a storage battery must have a nominal rating of 12 or 24V DC.

(c) If highway transportability is specified, or otherwise specified by the purchaser, the vehicle lighting must comply with the appropriate provisions of the Uniform Vehicle Code and Federal Motor Vehicle Safety Standards (i.e. FMVSS Title 23, Chapter 2, Standard No. 108 "Lamps, Reflective Devices, and Associated Equipment"). The following lighting equipment must also be provided:

(i) Two sealed-beam headlamps with high and low beams and a beam indicator.

(ii) Two red combination tail and stop lamps, visible from the rear of the vehicle.

(iii) Directional turn signals.

(iv) Dual backup lights controlled by the transmission shift lever.

(d) When possible, headlights must be located on the vehicle so that they are 22 in (559 mm) below the operator's eye level.

(2) Battery Powered Devices.

(a) Batteries must be designed to have a minimum life of 3 years when maintained according to the manufacturer's instructions. For design purposes, a frequency of use of 1000 cycles per year must be assumed.

(b) A self-contained battery charger with automatic voltage control must be provided. The charging process will require the operator to connect a readily-accessible plug to a standard 110 or 220-volt receptacle, as specified by the purchaser.

(c) The battery system must incorporate a battery condition gauge. If a low voltage condition could result in higher amperage flow and motor burnout, then the status-monitoring device must provide a time warning to the operator.

(3) Electromagnetic Interference. The equipment must meet the current issues of radio suppression specification MIL-STD-461, Class 3D, Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility. It must be capable of operating through the entire amplitude modulated aircraft radio frequency range of 75 MHz – 136 MHz.

g. Hydraulic and Pneumatic. The following requirements apply to hydraulic systems other than the chassis brake system.

(1) Raising and lowering of the system hopper must be accomplished by one person and through two or more hydraulic cylinders, powered by an electric or engine driven pump.

(2) Hydraulic fluid must be as recommended by the manufacturers of the hydraulic system components.

(3) The materials used for each hydraulic line must be consistent with its application. Fixed lines must be made of high quality steel or stainless steel. Flexible lines must be used only where necessary.

h. IDENTIFICATION AND MARKING.

(1) The device must meet the requirements of SAE ARP1247, paragraph 3.13.9 and AC 150/5220-5, Painting, Marking, and Lighting of Vehicles Used on an Airport, using the standards for airfield service vehicles. The shifting diagram placard specified in SAE ARP1247, paragraph 3.13.9.6 may be provided in a medium other than metal if designated to last for the total life of the equipment. In the event that identification and marking guidance differs between SAE ARP1247 and AC 150/5210-5, AC 150/5210-5 takes precedence.

(2) Painting and Marking. The device must meet the requirements of SAE ARP1247, paragraph 3.13.11.

(a) The system must be primed in accordance with accepted industry standards for heavy-duty industrial equipment intended for outdoor use.

(b) The system must be furnished as specified by the purchaser, in accordance with AC 150/5210-5, using the standards for airfield service vehicles.

i. Optional Equipment.

(1) The following options are not allowed unless specific justification is provided:

(a) Turbocharged engine;

(b) Auxiliary hand hose, and hand hose hydraulic assist;

(c) Gutter-broom attachments**.**

(2) Vehicle undercarriage coatings are not allowed.

B.2 CONSTRUCTION STANDARDS.

a. General Requirements.

(1) All equipment and material must be new, undamaged, and of the best grade.

(2) Where items exceed one in number, the manufacturer must provide products from the same component manufacturer with identical construction, model numbers, and appearance.

(3) Insofar as possible, products must be the standard and proven design of the manufacturer.

(4) The manufacturer must install electrical connections for power, controls, and devices in accordance with NEMA and NEC recommendations and requirements. Transmitting equipment must be installed and adjusted in accordance with manufacturer's published instructions and the requirements specified herein.

b. Workmanship. The device must meet the requirements of SAE ARP1247, paragraph 3.13.7.

c. Materials. The device must meet the requirements of SAE ARP1247, paragraph 3.13.2.

(1) Moisture and Fungus Resistance. The device must meet the requirements of SAE ARP1247, paragraph 3.13.4.

(2) Corrosion of Metal Parts. The device must meet the requirements of SAE ARP1247, paragraph 3.13.5.

d. Parts.

(1) Standard and Commercial Parts. The device must meet the requirements of SAE ARP1247, paragraph 3.13.3.

(2) Interchangeability and Replaceability. The device must meet the requirements of SAE ARP1247, paragraph 3.13.6.

(3) Spare / Replacement of Parts. The manufacturer must develop and provide to the purchaser a parts list, including associated replacement/repair costs.

(4) Substitutions. The purchaser must approve any material or equipment designated as an "or equal" product, but these items must be clearly distinguished and noted in the technical manuals as substitutions.

e. Codes, Standards, Regulations, and References. The manufacturer must recognize and comply with all codes and standards applicable to the design and construction of this type of equipment which are generally accepted and used as good practice in the industry.

B.3 DELIVERY AND ACCEPTANCE STANDARDS.

a. For self-propelled, mechanical FOD removal equipment, the manufacturer must provide trained personnel at the time of delivery to place the device into operation.

b. Transportability. If highway transportability is specified by the purchaser, the device must meet the requirements of SAE ARP1247, paragraph 3.7.

c. Quality Assurance. The manufacturer must test all of the equipment installed under this specification and demonstrate its proper operation to the purchaser. The manufacturer must furnish all required labor, testing, instruments and devices required for the conduct of such tests.

(1) The manufacturer must install all electrical, instrumentation, and mechanical works to the satisfaction of the purchaser, with inspecting authorities having jurisdiction.

(2) The manufacturer must notify the purchaser in writing of any instances in the specifications that are in conflict with applicable codes. The manufacturer must perform all work in accordance with applicable laws, rules, or regulations.

(3) Deviations from the specifications required for conformance with the applicable codes and/or laws must be corrected immediately, but not until such deviations have been brought to the attention of the purchaser.

(4) For applicable codes and/or laws that govern the minimum design requirements; where this AC calls for materials, vents, ductwork, sizes, design details, etc., in excess of the code requirements, the AC takes precedence.

d. Inspection. Inspections must meet the provisions of SAE ARP1247, paragraph 4.3.

e. Testing. After the equipment has been inspected, adjusted, and placed in correct operating condition, the equipment must be field tested in accordance with the purchasers testing procedures and requirements. The field tests must demonstrate that the equipment functions are in compliance with the specifications over the entire range of operation. The manufacturer must report any unusual conditions and correct deficiencies of any of the units.

(1) Preliminary Qualification Tests. Preliminary qualification tests may be specified by the purchaser.

(2) Formal Qualification Tests. Formal qualification tests may be specified by the purchaser.

(3) Specification Conformance Tests. The manufacturer must perform any tests referred to in SAE ARP1247, paragraph 4.6, if specified by the purchaser. The purchaser may elect to accept documentation of previously run tests.

(4) Reliability Test and Analysis. A reliability test and analysis may be specified by the purchaser.

f. Data and Analyses. If requested by the purchaser, the requirements of SAE ARP1247, paragraph 4.4, must be met by the manufacturer.

g. Manuals and Publications. The following operation and maintenance manuals must accompany the delivered equipment. The quantity of items is specified by the purchaser. No special format is required.

(1) Operator's handbook.

(2) Illustrated parts breakdown and list.

(3) Preventive maintenance schedule.

B.4 POST-DELIVERY STANDARDS.

a. Training. For self-propelled, mechanical FOD removal equipment, the manufacturer must provide trained personnel at the time of delivery to adequately train airport/air carrier staff in the operation and maintenance of the equipment.

(1) Training must include written operating instructions that depict the step by step operational use of the device. Written instructions must include, or be supplemented by, materials which can be used to train subsequent new operators.

(2) Training topics must include trouble shooting and problem solving, in the form of theory and hands-on training, for personnel designated by the purchaser.

(3) A minimum of 4 hours of training for every airport/air carrier personnel and technician on the purchaser's maintenance staff must be provided by the manufacturer. Training selected personnel as part of a "Train the Trainer" program will also satisfy this requirement.

(4) Training time per day must not exceed 8-hour shifts, unless otherwise specified by the purchaser.

(5) Upon the completion of training, the manufacturer must issue each participant a certificate of completion.

b. Maintenance / Reliability. The equipment and its accessories must be designed and constructed with reliability of operation as a primary consideration. The minimum reliability design requirement is that the equipment be designed to operate between periodic preventive maintenance activities of 4 months. The above interval does not apply in cases where the component manufacturer recommends more frequent maintenance intervals.

(1) Preventive. The manufacturer must develop and provide to the purchaser written documentation on recommended preventive maintenance actions. For the purpose of this specification, normal servicing of fuel, oil, tire pressure, battery, and water are not considered preventive maintenance.

(2) Cleaning. The manufacturer must develop and provide to the purchaser written documentation on recommended cleaning procedures, including solvent types and tools.

(3) Inspection. The manufacturer must develop and provide to the purchaser written documentation on regularly scheduled maintenance inspection procedures. A focus on sensitive equipment and schedule timelines must be included in the documentation.

(4) Spare / Replacement of Parts. The manufacturer must develop and provide to the purchaser a parts list, including associated replacement/repair costs.

(5) Tools and Test Equipment. The device must meet the requirements of SAE ARP1247, paragraph 3.12.4.