U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

Subject: Airport Foreign Object Debris/Damage (FOD) Detection Equipment	**Date:** DRAFT **Initiated by:** AAS-100	**AC No:** 150/5220-xx **Change:**

1. PURPOSE. This advisory circular (AC) provides information that airports can use to procure and operate foreign object debris/damage (FOD) detection equipment.

2. SCOPE. This AC contains performance specifications for systems and equipment that detect foreign objects on airports. Four types of detection systems are discussed, including: stationary radar; stationary electro-optic; hybrid radar and electro-optic; and mobile radar.

This AC is based on research conducted by the Federal Aviation Administration's (FAA's) Airport Technology Research and Development Program and Center of Excellence in Airport Technology (CEAT) to examine the performance of several new FOD detection technologies.

3. APPLICATION:

a. The Federal Aviation Administration (FAA) recommends the guidance and specifications in this Advisory Circular for implementing and conducting a FOD management program. In general, use of this AC is not mandatory. However, use of this AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, "Policies, Standards, and Specifications," and PFC Assurance No.9, "Standards and Specifications."

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

Manager, Airport Engineering Division (AAS-100)
ATTN: FOD MANAGEMENT
Federal Aviation Administration
800 Independence Avenue SW
Washington DC 20591

5. COPIES OF THIS AC. The public may obtain electronic copies of this AC by visiting the FAA home page and navigating to The Office of Airport Safety and Standards, Advisory Circular database (www.faa.gov). A printed copy of this AC and other ACs can be ordered from:

U.S. Department of Transportation
Subsequent Distribution Office
Ardmore East Business Center
3341 Q 75th Avenue
Landover MD 20785

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Director of Airport Safety and Standards

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CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1. DEFINITIONS.

a. Aircraft Operations Area (AOA). All airport areas where aircraft can operate, either under their own power or while in tow. The AOA includes runways, taxiways, and apron areas.

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

c. Airport Ramp. See Airport Apron.

d. Alarm. The outcome of sensor use where a foreign object is detected and requires a response to remove the object.

e. Alert. The outcome of sensor use where a foreign object is detected and personnel are notified of the object's presence.

f. Calibration Target. An object with shape, color, or other properties that provide a known detection response from a sensor.

g. Continuous Inspection. Uninterrupted surveillance by a sensor of a surface within a specific scan area.

h. Continuous Surveillance Inspection. Continuous surveillance inspection consists of general observation of activities for compliance with regulations, procedures, etc., as well as abnormalities with physical facilities that are readily apparent. This is performed any time inspection personnel are on the air operations area. Continuous surveillance of airport physical facilities and activities should cover at least the areas described in AC 150/5200-18.

i. Dry. A surface on the AOA that has no sign of moisture (for the purposes of this AC only).

j. Electro-Optical Sensor. A sensor that uses visual light wavelength (in the visible band, and in some cases the near-infra-red band) to passively detect and characterize objects.

k. FOD Management Program. A formal, documented, disciplined program designed to prevent, detect, and remove FOD from an airport.

l. Foreign Object Debris/Damage (FOD). The presence of, or damage related to, a foreign object.

m. Foreign Object. Any object located in an inappropriate location in the airport environment that has the capacity to injure airport or airline personnel and damage aircraft.

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

o. Hybrid Sensor. A sensor containing both an electro-optic sensor and a radar sensor.

p. Image Processing. Analysis of electro-optical sensor data using digital processing to achieve enhanced images. Adaptive processing enhances images under variable lighting conditions.

q. Quality Assurance Plan (QAP). A part of a quality assurance program that contains detailed requirements and standards to define the performance of technology and assure that minimum standards of performance are met through quantitative measurement

r. Radar Reflectivity. Response of radar transmissions to a sphere in free space; the reflectivity of a 4.75” metallic sphere is approximately – 20 dBm^2 and is used as a reference for radar sensors. For calibration testing purposes, a cylinder measuring 1.2 in (3 cm) high and 1.5 in (3.70 cm) in diameter is the most commonly used reference object. For any other object shape, the radar reflectivity depends on the radar frequency used and on object material and shape (for example, for the same size and shape, metal objects are more reflective than other materials).

s. Radar Sensor. A sensor based on radio detection and ranging, which actively transmits and receives radio signals at a given frequency to detect and provide the location of objects relative to the sensor.

t. Risk. The chance of loss or injury measured in terms of severity and probability.

u. Two-Year Storm. A statistical event (containing rainfall, wind speed, and/or surge properties) of given intensity and duration having a fifty percent (50%) chance of occurring in any one year. This does not imply that it will occur only every two (2) years, or having occurred, will not happen again for another two (2) years.

v. Wet. A surface on the AOA that displays signs of moisture (for the purposes of this AC only).

1.2. ACRONYMS AND TERMS.

ACM	Airport Certification Manual
FAA	Federal Aviation Administration
FOD	Foreign Object Debris or Foreign Object Damage
ICAO	International Civil Aviation Organization
QAP	Quality Assurance Plan
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. FAA Orders, Specifications, Drawings, and Advisory Circulars (ACs):

AC 150/5200-5	*Wildlife Attractants On or Near Airports*
AC 150/5200-18	*Airport Safety Self-Inspection*
AC 150/5200-30	*Airport Winter Safety and Operations*
AC 150/5300-13	*Airport Design*

AC 150/5340-30	*Design and Installation Details for Airport Visual Aids*
AC 150/5345-46	*Specification for Runway and Taxiway Light Fixture*s

b. Military Publications:

MIL-STD-980	*Foreign Object Damage (FOD) Prevention in Aerospace Products*

c. National Oceanographic and Atmospheric Administration (NOAA), National Climatic Data Center.

CLIM 20	*Climatology of the United States No. 20*

d. Sources:

(1) FAA ACs may be obtained from: U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave., Landover, MD 20785. Telephone: (301) 322-4961, FAX: (301) 386-5394, website: www.faa.gov .

(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) 548-5502, FAX: (202) 548-5501, website: www.faa.gov/cm/dcc

(3) NOAA, Satellite and Information Service, National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville NC 28801-5001, Telephone: (828) 271-4800, FAX: (828) 271-4876, website: http://www.ncdc.noaa.gov/oa/mpp/

(4) Military standards and specifications may be obtained from: DAPS/DODSSP, Building 4, Section D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Telephone: (215) 697-2179, FAX: (215) 697-1460, website: dodssp.daps.dla.mil

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CHAPTER 2. INTRODUCTION

2.1. GENERAL.

The presence of FOD on airport runways, taxiways, aprons and ramps 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 the airframe, or increased maintenance and operating costs. Costs to the industry are now estimated to be in excess of $1-2 billion per year for direct costs and as much as $12 billion when indirect costs are considered. FOD hazards can be reduced, however, by the establishment of an effective FOD management program.

2.2. FOD FUNDAMENTALS.

a. FOD Damage. FOD causes damage through direct contact with airplanes, such as by: cutting airplane tires; being ingested into engines; become lodged in mechanisms affecting flight operations; or as a result of being thrown by jet blast and damaging airplanes or injuring people.

b. Sources of FOD. The fact that FOD can come from many sources increases the complexity of maintaining safe aircraft movement areas. 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).

c. Types of FOD. The exact nature of FOD is also varied. FOD can be composed of any material 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 items were metal followed by rubber (18%), black items made up nearly 50% of the FOD collected, and common FOD could be 1 in by 1 in (1 in (2.50 cm) x 1 in (2.50 cm)) or smaller. Typical foreign objects include 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, 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 and wildlife); and
- contaminants from winter conditions (snow, ice).

CHAPTER 3. FOD DETECTION EQUIPMENT

3.1. BACKGROUND.

a. As of the writing of this AC, the primary "sensor" used to detect FOD on airport surfaces has been the eyes of airport personnel and users. Recent technological developments have greatly expanded the capabilities of FOD detection and management. 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 per paragraph 4.3.a of this AC.

b. The advanced technologies use different methods and sensors to perform the mission of detecting FOD. Commercially available technologies employ radar and optical sensors with performance capabilities to detect small FOD items rapidly, providing operations staff with alerts or alarms to achieve high levels of removal performance. A summary of the sensor categories and operational modes available from current technologies is shown in Table 1.

Table 1. FOD Detection Sensors.

Sensor	Characteristics	Capability	Function in FOD Management Program
Human Eye	Fundamental baseline for FOD management. Human observation provides detection and human judgment provides the hazard assessment capability to assure safety.	Supports periodic inspection based on access opportunity.*	Human agent is an essential element of all FOD management programs, but effectiveness may be limited by training and circumstance. At present, no substitute exists for human judgment in the assessment of safety hazards.
Radar	Uses radio transmissions to detect and locate FOD on runways and AOA surfaces. Systems are available for fixed location and mobile inspection in support of FOD management on the runway and other airport surfaces.	Fixed location systems support continuous inspection; mobile systems supplement and improve human capabilities for visual inspection.*	Continuous radar systems provide an alarm based on FOD detection in scanning zone. Supplementary technology added to continuous radar sensors can provide video information for giving the opportunity for identification and assessment of the FOD hazard. Mobile systems support airport personnel by detecting FOD items beyond normal visual range and alerting personnel to FOD presence for action on all airport surfaces.
Electro-Optical	Uses video technology and image processing to detect and locate FOD on runways and AOA surfaces. Systems utilize fixed location sensors with the area scanned dependent on sensor location.	Fixed location systems support continuous inspection.	Electro-Optical systems provide alerts to FOD presence. Process video information provides the opportunity for identification and assessment of FOD hazard before an alarm requiring a response is made. Electro-Optical systems can also provide video records of events

Sensor	Characteristics	Capability	Function in FOD Management Program
Hybrid Sensor	Uses a combination of radar and optical sensors to detect and locate FOD on surfaces.	Available systems support continuous inspection.	Systems provide hybrid sensor response to FOD presence supporting alert or alarm functions in FOD management programs.

* As described in AC 150/5200-18 *Airport Safety Self-Inspection,* Section 11g – Continuous Surveillance Inspection/FOD and Section 13.e.(5) - Special Condition Inspection/Construction Area/FOD.

c. System Characteristics and Operation.

(1) Characteristics. Major advances in FOD detection technologies provide FOD management programs with a wide range of price and performance opportunities to tune the FOD management program to specific airport circumstances and requirements. FOD detection systems use different sensors in different configurations. There are two general designs:

(a) One design features continuous FOD detection systems that operate from a fixed location, scanning the airport surface and providing alarms or alerts to FOD presence. These designs employ radar, optical, or hybrid radar/optical sensors.

Table 2. Fixed-Location Sensor: System Concept.

Centralized	Distributed
Will typically have few sensors. Each sensor scans a large portion of the AOA.	Will typically have many sensors. Each sensor scans a small portion of the AOA.

(b) The second design features a mobile detection system, using a short-range radar sensor mounted a vehicle, to enhance the capabilities of airport personnel in FOD detection during normal inspection activities. The available mobile design uses a radar sensor, although alternatives include a combined laser and radar system.

(2) Operation. FOD detection systems that are available as of the writing of this AC include:

(a) Stationary Radar. The continuous radar system sensor operates in the 90-100 gHz range that is optimized to scan the entire runway surface with two or three sensors, depending on runway length. The system will detect a -20 dBm^2 target at ranges of up to 0.60 mile (1 km). Sensors are located 165 ft (50.0 m) or more to the side of the runway. Supplemental video is available, which is slaved to radar detection to assist in FOD object identification and location in all light levels including zero ambient light.

(b) Stationary Electro-Optic. The continuous optical system uses an optical sensor, lens, scanning hardware and adaptive image processing software. The system can detect a 0.80 in (2 cm) object target at ranges of up to 985 ft (300 m) using only ambient lighting. Sensors are located up to 820 ft (250 m) from the runway center line. Multiple sensors are employed along the runway with the sensor number defined by hardware characteristics and management program requirements.

(c) Stationary Hybrid. A continuous hybrid sensor system uses an electro-optical sensor and a 70-80 GHz radar in a scanner unit that is designed to be collocated with the runway edge lights. The system can detect a 0.80 in (2 cm) target with scan time suitable for between-movement inspection.

Depending on FOD management program requirements, coverage may be provided with a sensor on every edge light or every other edge light.

(d) Mobile Radar. The mobile radar sensor operates in the 78-81 Ghz range and continuously scans the surface in front of a moving vehicle. The radar progressively scans an area 600 ft by 600 ft (183 m by 183 m) to detect FOD items with a reflectivity of -20 dBm^2 or greater. The mobile system can operate at speeds of up to 30 mph (50 km/h) supplementing visual inspections with radar technology.

d. System Selection. An airport operator will select an appropriate FOD detection technology based on a number of factors specific to the airport in question. Considerations such as the number and type of aircraft operating, the number and size of runways and taxiways, and the ability of personnel to recover FOD from runway surfaces, are all factors in the sensor selection process.

e. System Performance.

(1) All systems advance FOD detection capabilities using technology, but all technologies are limited by natural laws and price/performance considerations. Physics governs both radar and electro-optical sensor performance where FOD detection is dependent on the contrast with background atmospheric conditions.

(a) For radar systems, the contrast will be reflectivity of an object to radio transmissions in relation to background reflectivity or clutter. Lighting is not an issue, although radar performance is degraded under certain atmospheric conditions such as rainfall.

(b) For electro-optical systems, the contrast will be established by color and general optical reflectivity of an object in relation to background surface and reflectivity under given lighting conditions. Optical sensors must operate during daylight and darkness and may be challenged by the variable lighting conditions of dawn or dusk, requiring image processing for full effectiveness.

(c) For hybrid systems, the contrast will be established by the ability of the system to integrate, and evaluate the performance of, the radar sensor and electro-optical sensor.

(2) The range between the sensor and the FOD item will influence system performance. Generally, longer range sensors will require fewer sensors in the complex airport environment. Shorter range sensors will require more sensors to provide adequate surface coverage.

(3) Sensors can be optimized to meet detection performance criteria. In general, an increase in detection precision will also increase false or nuisance detections, making any sensor selection a compromise based on needs and requirements and programmatic integration of alerts or alarms. Sensors generally operate most effectively under clear and dry conditions. Heavy rainfall or snow will degrade sensor effectiveness for a time. A critical performance issue is the recovery of detection ability following a weather event.

3.2. PERFORMANCE SPECIFICATIONS.

a. Functions. FOD detection equipment must perform the following functions:

(1) Provide surveillance in the AOA based on the airport FOD management program.

(2) Detect and locate single and multiple FOD items on the AOA.

(3) Provide an alert or alarm to the user when FOD has been detected.

(4) Operate in conjunction with, and not interfere with, airport and aircraft communication, navigation, and surveillance systems.

(5) Provide a data record of detected FOD, allowing for equipment calibration and maintenance, and for analysis of the FOD event.

b. Detection Performance

(1) The performance of FOD detection technologies is based on systems design as implemented at an airport. This systems design will consider basic performance objectives set as a part of the FOD management program. Important considerations will be:

(a) detection timing and response requirements that will affect scan duration,

(b) the number of sensors and sensor location;

(c) surfaces to be inspected; and

(d) operational requirements defined by the airport size, topography, configuration, and weather.

(2) System Calibration – FOD detection systems should detect single calibration targets placed in the sensor coverage area. The number of calibration targets and calibration target placement should meet quality assurance plan (QAP) requirements established as part of the FOD management program. Sensors should be commissioned based on performance using calibration targets. Calibration targets should also be used in regular QAP testing after commissioning.

(a) For a stationary radar system located more than 200 ft (60 m) from the runway center line, the radar sensor should detect a calibration object with a radar reflectivity of -20 dBm^2 on the runway surface at a range of 1640 ft (500 m) from the sensor.

(b) For stationary electro-optic systems located more than 200 ft (60 m) from the runway center line, the sensor should detect a 1.60 in (4 cm) calibration object of any color or reflectivity on the runway surface at a distance of up to 985 ft (300 m).

(c) For stationary hybrid sensor (optical and radar) systems located within 200 ft (60 m) of the runway center line, the system should detect a 1 in (2.50 cm) diameter and 1 in (2.50 cm) high cylinder of any color on the runway surface at a distance of up to 150 ft (46 m) from the sensor.

(d) For a mobile radar system, the sensor should detect a calibration object with a radar reflectivity of -20 dBm^2 in a rectangle defined on the runway surface consistent with the runway width and at a distance in front of the radar of 400 ft (122 m) at a speed of up to 20 mph (30 km/h).

(e) **Calibration Objects.** An object from each of the following FOD categories will comprise the group of objects used in detection equipment and FOD removal equipment calibration and testing (maximum dimensions will vary and are defined in the respective sensor and removal equipment sections of this AC):

- Runway material – asphalt or concrete
- Expansion joint material
- Infrastructure part (e.g. piece of runway light fixture)
- Mechanics tool
- Rubber – typical of a tire burst
- Distorted metal strip
- Fuel cap
- Lug nut
- Aircraft part
- Construction material

(3) Single FOD Objects – Stationary FOD detection systems should have the capability of detecting single FOD objects on AOA surfaces with a primary application to runways and other applications to taxiways and ramps. Mobile FOD detection systems should have the capability of detecting single FOD objects on all AOA surfaces. Technology suppliers should demonstrate the capability of the FOD detection system to detect 90% of the objects placed in commissioning testing for the objects listed in subparagraph (e) "Calibration Objects" above.

(a) For a stationary radar system located more than 150 ft (46 m) from the runway center line, the radar sensor should detect a calibration object with a radar reflectivity of -20 dBm^2 on the runway surface at a range of 1640 ft (500 m) from the sensor.

(b) For stationary electro-optic systems located more than 150 ft (46 m) from the runway center line the sensor should detect a 1.60 in (4 cm) calibration object comparable to the calibration target of any color or reflectivity on the runway surface at a distance of up to 985 ft (300 m).

(c) For stationary hybrid sensor (electro-optical and radar) systems located within 150 ft (46 m) of the runway center line the system should detect a 1.0 in (2.5 cm) diameter object comparable to the calibration target of any color or reflectivity on the runway surface at a distance of up to 150 ft (46 m) from the sensor.

(d) For a mobile radar system, the sensor should detect a calibration object with a radar reflectivity of -20 dBm2 in a rectangle defined on the runway surface consistent with the runway width at a distance in front of the radar of 400 ft (122 m) at a speed of 20 mph (30 km/h).

(4) Multiple FOD Objects – FOD detection systems should have the capacity to identify the presence of multiple FOD items present at one time. FOD detection systems must be able to discriminate 2 or more FOD objects placed on a runway or airport surface. Object size or reflectivity should be based on sensor type. Objects should be placed 16 ft (5 m) or less apart in a 100 ft by 100 ft (30 m by 30 m) rectangle.

(5) Location Accuracy – FOD detection systems must demonstrate the capability to provide and retain a digital record of accurate location information within 16 ft (5 m) of the actual FOD object location.

(6) Inspection Frequency

(a) Continuous Detection Systems – These systems must provide continuous operation from fixed sensors to allow for the continuous inspection of runway surfaces during flight operations. The duration of flight operations is dependent on the airport and specified by the user.

(b) Mobile Detection Systems – These systems provide a mobile operations capability to enhance mandated airport safety self-inspections (per AC 150/5200-18) and are, therefore, needed only as frequently as specified by the user.

(7) Time to Detection – FOD detection systems must have the capability to provide rapid detection within 4 minutes of a FOD occurrence in the area being scanned. Sensors and systems can be designed to operate continuously and provide alerts or alarms between aircraft movements or to operate continuously with detection updates as defined by the FOD management program.

(a) For continuously operating FOD detection systems that are designed to provide between-movement alerts, the system must provide inspection of runway surfaces between aircraft movements.

(b) For other continuously operating FOD detection systems, the system must provide inspection updates as specified in the FOD management program requirements.

(8) Performance in Weather. FOD detection systems must demonstrate the detection performance under both clear and inclement weather conditions. Under clear weather conditions, the pavement of the AOA is expected to be dry, while under inclement weather conditions the pavement will be wet with rain, snow, or mixed precipitation.

(a) Detect calibration targets under rainfall or snow conditions (e.g. having a specific intensity, duration, and frequency) for a two-year category of storm in the local region. More stringent requirements may be specified by the user.

(b) FOD detection systems must have site-specific performance specifications that include:

(i) performance during clear weather conditions;

(ii) performance during inclement weather conditions; and

(iii) provide the user with the amount of time required for the system to recover after a rain or snow storm, that is, to return the performance capabilities of clear weather conditions after adverse weather conditions subside. In this case, the end of adverse weather conditions will be defined when precipitation of rain or snow operations end.

(c) Lighting conditions. All systems must demonstrate detection performance during daylight, nighttime, and dawn/dusk operations.

(9) Alerts and Alarms. FOD detection systems must provide alerts to the operator of the presence of FOD in scanned areas and alarms to trigger a rapid response to remove FOD hazards.

(a) For non-visual sensors, provide alarm to operational personnel in a procedure that will facilitate rapid assessment and removal of FOD hazard.

(b) For visual sensors, provide alert of FOD presence and facilitate identification of hazard potential and decision for FOD management.

(c) Nuisance or False alerts or alarms should be minimized and not exceed 5 nuisance alarms/day as averaged over any 90 day period.

c. System Output.

(1) Detection Data. All FOD detection systems must provide a data record on FOD detected that contains the following minimum information:

(a) Alert / Alarm time and date

(b) Description of FOD detected or retrieved (e.g. size, name, type, serial number, etc.)

(c) Location of FOD object

(d) Time and date of disposition of alert / alarm

(e) Time and date of FOD retrieval

(f) Additionally, the following information is helpful, but not required:

(i) Name of personnel detecting / investigating FOD item

(ii) An image of the FOD object retrieved (if available)

(iii) Airport operations data (during FOD detection event)

(iv) Weather data (during FOD detection event)

(v) Flight schedules (during FOD detection event)

(vi) Chain of custody information

(2) Data Presentation. FOD detection data can be provided in a coordinate scheme, on maps of the airport, in an operator's console, or broadcast to mobile units for response. The selection of information options will be based on the FOD management program, consistent with airport systems operations.

(3) Data Management. Data collected in the FOD detection process should be permanently and digitally recorded, not subject to post-processing modification.

3.3. OTHER STANDARDS

a. Design Standards.

(1) Total Life. FOD detection equipment must be designed to perform its intended function for its "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) 10 years for continuous detection systems, or

(b) 10 years, based on a frequency of use of 365 cycles per year, for mobile systems.

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

(a) Weather

(i) Ambient temperature range: -25 degrees F (-32 degrees C) to +123 degrees F (+52 degrees C) ambient outdoor air temperature.

(ii) Relative Humidity: 5% to 90%.

(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.

(e) The temperature ranges specified may be modified by the purchaser if the device is to be used in extreme climates.

(3) Power Supply. In the event of a power failure, the system must have the capability to automatically power-up and operate in the condition and settings that were available just prior to the power failure.

b. Construction Standards

(1) General Requirements.

(a) All equipment and material must be new, undamaged, and of the best grade; decisions concerning quality, fitness of materials, or workmanship must be determined by the purchaser.

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

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

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

(2) Workmanship. The manufacturer must install all equipment, materials, specialties, etc., in accordance with the best engineering practice and standards for this type of work.

(3) Materials.

(a) Equipment exposed to the weather must be weatherproof type.

(b) All external components must be constructed and finished in a manner to inhibit corrosion based on the purchaser's specific environment.

(c) All machined surfaces must be coated with a suitable rust preventative.

(4) Parts.

(a) Standard and Commercial Parts. Insofar as practicable, commercially available standard parts complying with commercial and/or military standards must be used throughout.

(b) Interchangeability and Replaceability.

(i) All parts having the same manufacturer's part number must be directly and completely interchangeable with each other with respect to installation and performance.

(ii) All components and assemblies incorporated in the equipment must be designed and manufactured to dimensional tolerances which permit future interchangeability and facilitate the replacement of parts.

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

(d) 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.

(5) 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.

c. Installation and Acceptance Standards.

(1) Installation.

(a) Obstructions and other standards. FOD detection systems must conform to applicable airport obstruction criteria, marking and lighting, and equipment design and installation standards.

(i) For systems located near the Runway within the Runway Safety Area:

(A) Frangibility. Sensors must be mounted on a frangible coupling (reference AC 150/ 5345-46D)

(B) Height. The height of the sensors must be between 14 in (0.36 m) and 30 in (0.76 m), depending on the height of existing edge lights for the runway. (reference AC 150/5340-30D)

(C) Connector. The sensor must be connected through a connector that will disconnect upon sensor impact. (reference AC 150/ 5345-46D)

(D) Wind. The sensors must withstand a wind loading of 300 mph (483 km/h). (reference AC 150/5345-46D)

(b) Prior to installation, the manufacturer must obtain all site construction, environmental, and coordination requirements for installation of the detection system at the airport.

(c) Unless otherwise specified by the purchaser, installers of mechanical and electrical work must participate in any pre-installation meetings at the project site to review conditions of other related project work.

(d) The manufacturer must provide trained personnel at the time of delivery to place the device into operation.

(e) The mobile system must be installed on existing vehicle infrastructure, tested and ready for use within 5 days after delivery.

(2) 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.

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

(b) 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.

(c) 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.

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

(3) Inspection. The manufacturer will establish a formalized final inspection regimen to ensure each system is adjusted as designed, all systems are operating properly, and the finish in complete and undamaged. The user may choose to participate in the final inspection of designated systems.

(4) Testing. After the equipment has been installed and the various units have been inspected, adjusted/calibrated, and placed in correct operating condition, the equipment must be field tested in accordance with the purchaser's 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.

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

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

(5) 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.

(a) Operator's handbook.

(b) Illustrated parts breakdown and list.

(c) Preventive maintenance schedule.

d. Equipment Training and Maintenance Standards.

(1) Training.

(a) The manufacturer must provide trained personnel at the time of delivery to adequately train airport/airline staff in the operation and maintenance of the detection equipment.

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

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

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

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

(2) Maintenance.

(a) Preventive. The manufacturer must develop and provide to the purchaser written documentation on recommended preventive maintenance actions.

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

(c) 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.

(d) Recalibration. The manufacturer must develop and provide to the purchaser a recalibration plan and recalibration procedures. Recalibration should assure FOD management program performance specifications are maintained for the life of the sensor.