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Foreign Object Elimination
Elements of Basic Awareness

Study Guide

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FOE (Foreign Object Elimination) Elements of Basic Awareness
Study Guide

1. Scope

The ASTM NCATT FOE Elements of Basic Awareness Study Guide addresses the fundamental activities and functions for professionals engaged in Foreign Object Elimination (FOE) program activities.

This study guide is designed to be used by technicians and students preparing for the ASTM NCATT FOE certification examination. Each FOE knowledge "Standard" is addressed at the required level of understanding for success on the certification examination. The examination contains one or more questions from each of the standards areas. Use of this study guide, coupled with a serious review of the references and study materials that are provided, will help individuals prepare for the ASTM NCATT FOE certification examination.

2. Referenced Documents

A. ASTM Standards:

i. F3060 Terminology for Aircraft:

B. Federal Aviation Administration (FAA)

i. FAA Advisory Circulars 150/5370-2E and 150/5380-5B (www.faa.gov)

ii. Guidelines for The Prevention and Elimination of Foreign Object Damage/Debris (FOD) in the Aviation Maintenance Environment Through Improved Human Performance, by David C. Kraus, Galaxy Scientific Corporation and Jean Watson, FAA Flight Standards Service, Aircraft Maintenance Division (www.hf.faa.gov)

C. Others:

i. National Aerospace Standard (NAS) 412 – Foreign Object Damage (FOD) Prevention Guidance Document Standard Practice

ii. Foreign Object Damage (FOD) Prevention Inc. Guidelines (https://fodprevention.com/)

iii. The FOD control Cooperation (www.fodcontrol.com), (www.fodnews.com)

3. Significance and Use

A. This study guide was created solely for use by individuals preparing for ASTM NCATT Foreign Object Elimination (FOE) certification. While not intended for use in developing Foreign Object Elimination or FOD Prevention and Control programs, the information contained in this guide, coupled with ASTM F3617-22 Standard Guide for Foreign Object Elimination (FOE) Elements of Basic Awareness and Personnel Certification, provides relevant information which may assist with program development or strengthening existing programs.

4. Basic Terms & Definitions

A. Consumables / MSP (Miscellaneous Small Parts) and PLS (Production Line Stock)— Supplies provided to workers that are expendable. Examples are:

i. Issued apparel

ii. Safety glasses

iii. Glue, paint, sealant

iv. Rags

v. Sandpaper, brushes, applicators

vi. Stock items (e.g. rivets, washers, fasteners and other hardware)

vii. Perishable Tools (e.g. drills, reamers, apex tips)

B. Foreign Object (FO) – An alien substance or article (examples include, but are not limited to tools, consumables, hardware, product protective devices, personal items, product process debris, operations debris, environmental debris)) that could potentially enter and/or migrate into or on a product or system, potentially causing damage if not removed and controlled.

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

D. Foreign Object Debris (FOd) – Any foreign object that has entered and/or migrated into/on a product or system and could potentially cause FOD if not removed or controlled.

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

F. Foreign Object Occurrence (FOO) – The condition where a foreign object has been discovered and has entered and/or migrated into/on the product or system. Foreign object

occurrence should be recorded but typically does not trigger an investigation until there is a reoccurrence, or the occurrence has the potential to become a FOD incident.

G. FOD Barriers – Devices such as edge protectors, caps, plugs, and protective covers used for hoses, cables, ducts, electronic components, and other hardware exposed to potential damage.

H. FOD Prevention Committee – Assists the FOD Prevention Program Leader with implementation and administration of the FOD Prevention Program. Committee representatives should be selected from cross-functional activities within the organization, i.e. production, manufacturing engineering, quality, management, design engineering, etc.

I. FOD Prevention Area Designation – Process ensuring the appropriate level of control is assigned to each applicable area in a FOD Prevention Program. Designation is based on several factors for the area being categorized, including, but not limited to, the criticality of the area's product, process and equipment, and specific customer requirements.

J. FOD Prevention Designated Areas – Areas with products or systems in which the application of housekeeping cleaning processes and regular inspections will help prevent migration and ensure that Foreign Objects are not passed on or impact testing or development.

K. FOD Prevention Area Focal – Person assigned to provide guidance, support, FOD prevention initiatives, and ensure coverage with sufficient authority, time, budget, and organizational freedom to identify and implement FOD prevention measures.

L. FOD Prevention Program Leader – Person with the responsibility and authority for establishment, implementation, and maintenance of the FOD Prevention Program.

M. FOD Walk/Sweep – Physical inspection and removal of FOs in an assigned area or a zone.

N. Housekeeping – A process for maintaining a clean and orderly work area with necessary tools, materials, and equipment in their places of orderly arrangement.

O. Shadow Box or Shadow Board – Tool storage system with specifically marked locations (e.g. foam cutouts) for each tool so that a missing tool is readily noticeable.

5. FOD Prevention Program Responsibilities – Responsibility for ensuring a robust FOD prevention program resides with any and all persons who work on or around aerospace products. The FOD Prevention Program can only be successful if *all persons who work in and around operational areas take responsibility for it*. For a successful program, it is important to become familiar with the following principal elements of effective FOD Prevention Programs:

A. FOD Prevention Program Leader – this is a person designated by leadership who has the responsibility and authority for establishing, implementing and maintaining the

organization's FOD prevention program. Responsibilities include, but may not be limited to:

i. Developing the organization's overarching FOD prevention program.

ii. Approving FOD Prevention Area designation/risk mitigation level.

iii. Developing and implementing Lost Tool/Lost Item processes.

iv. Reviewing and assessing FOD prevention program procedures and making necessary revisions.

v. Ensuring appropriate data collection systems and metrics are in place to enable analysis and corrective actions.

vi. Ensuring assessments to gauge effectiveness of the FOD prevention program are actually performed.

vii. Providing oversight to ensure preventive, investigative, analysis, root cause and corrective action processes not only exist but are adequate to mitigate further occurrences.

viii. Developing, implementing and maintaining FOD prevention curricula commensurate with FOD risk assessment results. Training curricula may include additional courses with enhanced FO detection "hands-on" exercises.

ix. Ensuring provisions exist to assure anyone entering a designated FOD Prevention Area has received FOD prevention training or is escorted by trained personnel. This includes personnel not typically assigned to the designated area, i.e. customers, visitors, contractors, and infrastructure maintenance personnel.

B. FOD Prevention Committee – Representatives for these committees should be selected from cross-functional activities within an organization, i.e. production, manufacturing engineering, quality, management, design engineering, etc. Responsibilities include, but are not limited to:

i. Promoting a culture of FOD prevention within all areas of the organization.

ii. Reviewing and assessing the FOD prevention program and procedures to identify opportunities for improvement and recommend necessary revisions.

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

iv. Reviewing results of FOd/FOD incident investigations and root cause/corrective actions.

C. FOD Prevention Area Focal – Responsible for oversight and promotion of a FOD prevention culture in the work environment. Assigned to provide guidance, support FOD initiatives, and ensure coverage with sufficient authority, time, budget and organizational freedom to identify and implement FOD prevention measures. Typically site, program, product or function personnel. Responsibilities may include, but are not limited to:

i. Working with all functions and areas to implement and validate the effectiveness of the established FOD prevention program with their area independently or as directed by the FOD Prevention Program Leader.

ii. Acting as a member of the company FOD Prevention Committee (if established).

iii. Acting as a point of contact for training and program implementation.

iv. Recommending FOD Prevention Area designation categorization.

6. Consumables, Hardware and Personal Items Accountability and Control – it is important to establish defined practices for accountability, control, storage, use/consumption and disposal of consumables, hardware and personal items to mitigate risk of the these items being left within aerospace vehicles.

A. Consumables include supplies, materials and miscellaneous items required for production that are generally thrown away after use.

i. This includes, but is not limited to, glue, paint, sealant, rags, sandpaper, brushes, applicators, paper towels, ear plugs, gloves, respirator cartridges, acid brushes, cotton swabs, abrasives, tape, safety wire, sanding discs, and knife blades.

B. Hardware includes commonly used small parts found in aerospace production and/or operations.

i. This includes, but is not limited to, standard fasteners, nuts, rivets, washers, screws, bolts, spacers, cotter keys, wire terminals, wire splices or other common usage items.

C. Personal items are those items owned by individuals or distributed by the organization for personal use.

i. These include, but are not limited to, badges, stamps, keys, cell phones, wallets, personal protective equipment, food, drink, tobacco products, tool chits, pens, pencils, jewelry, ear buds, watches, and coins.

D. Kitted Hardware describes the exact amount of hardware assigned to perform a task (no spare parts).

i. Kitting ensures there is no spare hardware and what is provided is all that is available to use. If hardware becomes lost it is readily noticeable and can be reported immediately.

ii. Kitted hardware includes nuts, bolts, plastic ties, safety wire, cue tips, rags, screws, or any item used to complete a task.

E. Hardware Removal, Control and Replacement – Most companies have established procedures for removing, controlling and replacing hardware. This is sometimes overlooked and can be a major contributor to introducing Foreign Objects into the work area.

i. Procedures may differ from company to company but will have a means of replacing hardware, for example an avionics box, and accounting for the nuts, bolts, or screws when hardware is being replaced or removed from the product, vehicle or assembly.

ii. The procedure assists in controlling hardware that was removed from the product, vehicle or assembly and ensures hardware is controlled and accounted for properly.

F. Hardware Storage – it is critical to have hardware in use on the manufacturing floor contained in a manner that does not promote migration to the final product. As hardware storage moves closer to FOD sensitive areas, greater preventive and control features should be implemented.

G. Containers & Tote Trays – A Tote Tray is a covered device for storing, carrying, or transporting hardware in a secure manner to prevent inadvertent dropping.

i. Containers with spring loaded lids are used to prevent accidental spilling of hardware into hard to retrieve critical areas when working over a product, vehicle, or assembly.

H. Controls and accountability for consumables, hardware, and personal items include, but are not limited to:

i. For consumables, maintaining organization and cleanliness for storage within production areas, use of appropriate containers, properly identifying container contents, (including hazardous material control), periodically removing and properly disposing of consumed/used items when the potential for spillage or migration exists.

ii. Containerizing all used hardware in properly labeled containers during disassembly/rework if intended for re-use and properly disposing of if not.

iii. For personal items, methods which account for and control them, up to and including restricting or prohibiting taking them into work areas if not inventoried as tools.

iv. For all consumables, hardware and personal items, reporting any lost articles immediately and initiating documentation to prevent product/vehicle release to next operation until a thorough search is concluded.

v. Ensuring proper containment and return of excess issued items not used during operations.

vi. Identifying point-of-use storage areas with minimum and maximum quantities.

vii. Employing spill proof/spring loaded tote trays and containers for storage, transportation, distribution and during use.

viii. Use of item control methods, i.e. kitting, daily consumption quantities, shadowing, identifying exact quantities to be brought into production, and utilizing logging processes for items not traceable to an issuing source.

ix. Taking only the minimum amounts of items required to complete individual tasks.

x. Immediate processing of used items or at specified intervals, i.e. disposal, return to source, storage, etc.

xi. Properly controlling personal/administrative items, i.e. pens/caps, dry erase markers, staples, push pins, paper clips, binder clips, notebooks, pads, drawings, loose/uncontained paper, etc.

7. **Housekeeping and Clean-As-You-Go –** It is essential for any Foreign Object Elimination program that cleanliness standards be established to prevent Foreign Object migration into operational areas. These may include:

A. Clean As You Go Process: The purpose is to establish product cleaning processes to prevent foreign object debris (FOd) from migrating out of sight or into inaccessible areas. Clean As You Go is an ongoing process that removes work debris as it accumulates, therefore keeping the work area clean while performing a task in FOD sensitive areas. Everyone should ensure the work area is clean:

i. Prior to starting an operation.

ii. During operations as the task progresses and work debris accumulates.

iii. During work stoppages when the operation cannot continue.

iv. When work is complete and prior to inspection.

v. At shift change/end.

B. Housekeeping – The purpose of housekeeping practices is to prevent foreign object (FO) migration in operational areas. Operational areas include, but are not limited to, manufacturing, maintenance, testing, development, shipping/receiving, or storage areas.

C. FOD Cans and Containers – It is everyone's responsibility to use FOD cans and containers for any trash or foreign material generated or discovered in FOD designated areas. These collection devices are strategically placed to capture any trash or debris with potential to migrate into aerospace products.

D. FOD Bags – Work residue (i.e. scrap wire cuttings, string ties) generated during the shift may be temporarily stored in FOD Bags or other designated FOD containers until they can be properly discarded.

E. Personal Pack – All personal belongings, i.e. coins, pocket contents, jewelry (chains/necklaces/ear rings/rings, watches), sun glasses, badges, or any items with the potential to become a Foreign Object should be placed in Personal Packs.

F. 5S – Sort, Straighten, Shine, Standardize, and Sustain describes a concept for housekeeping and organization of the workplace.

iii. Some companies in the industry use 6S, which includes Safety.

iv. In order to launch a 5 or 6S event all employees in the area participate to organize the area using the 5S process.

v. Organization methods include taping off areas and color coding and organizing tool cabinets. A map of the area is created displaying each assigned locations.

G. Permanent Tooling – FOD prevention considerations should be included in tooling and equipment design or the procurement approval process. Tooling and equipment should be designed to prevent product damage and eliminate Foreign Object (FO) or Foreign Object debris (FOd) entrapment areas. Considerations should include, but are not limited to:

i. Tooling construction materials reviews, i.e. use of painted coatings vs, stainless steel, one-piece construction, etc.

ii. Methods to capture FO/FOd at the source during design, refurbishment, or purchase of machinery and tooling, i.e. incorporating vacuum systems, barriers, etc.

iii. Enclosing ball bearings and other rotating machinery to capture balls/rollers and other components/parts to ensure containment if a failure occurs.

H. Production Support Equipment – A review of portable tooling and equipment, i.e. lifts, ground support equipment fixtures, jigs, etc., to ensure surface protection devices are installed to prevent damage to aerospace vehicles or subassemblies.

8. Lost Tools/Items – Control of all tools, hardware, consumables, or any other items taken into FOD-sensitive operational areas is critical. This includes timely reporting of anything discovered lost or otherwise unaccounted for.

A. Reporting Missing, Lost and Found Items

i. An integral part of a successful Foreign Object Elimination (FOE) program is to

communicate there are NO repercussions for reporting a lost or missing tool or item even if the technician is at fault. There is typically a documented process of steps that are to be followed and these are intended to ensure employees report lost tools or items before they cause damage. Although established as a positive self-reporting method, repeat offenders could potentially face disciplinary action.

ii. Anytime an item is lost during a task, activity in the affected area must be ceased and a search for the item initiated. The search must continue until the item is either found or adequate assurance is made that the item is not contained in the product. Searches may require de-paneling or nondestructive inspections, such as flashlight and mirror, borescope and/or x-ray. If an item cannot be located after a search has been completed, the applicable forms must be annotated with a description of the item and the search procedure that was followed.

iii. Reporting procedures should include notification to the responsible parties, documentation of the search process, and summarizing results before closeout of the area.

iv. Products should not be released for next assembly operations until this search process is concluded and the lost tool or item reconciled.

9. Material Handling – FOD prevention controls for material handling, packaging and storage operations to prevent the introduction of FO/FOd into aerospace products. The following should be a feature in all material packaging, handling, shipping and storage processes:

A. Control techniques for material handling include, but are not limited to:

i. Ensuring materials and accessories used in the packaging, handling, shipping and storage that have intimate contact with the part or assembly are clean and free of contamination.

ii. Ensuring parts and assemblies are packaged in a manner that precludes the chance of one item making contact with another during normal handling operations.

iii. Choosing protective and packaging materials based on their ability to adequately resist penetration by tearing, parting or piercing from forces either external or internal during normal handling operations.

iv. Following specific instructions for packaging/unpackaging/handling when provided.

v. Ensuring protective devices (edge protectors, caps, plugs, covers, filters, rub strips) are clean and secured to prevent accidental damage. Once installed, removal of the protective devices should be controlled through assembly or maintenance paperwork.

vi. Consideration given to the visibility/detection of material used for protection so that the material itself doesn't become FOD.

B. Material characteristics for handling, packaging and storage operations should be compatible with the environmental and physical stresses expected to be encountered during product service.

   i. Static sensitive devices should be properly protected to avoid damage. Materials that are used to protect electro-explosive devices and sensitive electronic components should be kept clean, covered, and stored away from ordinary non-static safe materials.

C. Container condition:

   i. All packaging, handling, shipping and storage containers should be visually inspected for the following:

      1. Nicks, dents, holes, abrasions, scratches, bums, etc., which may be detrimental to the function and integrity of the part or assembly.

      2. Grease, preservatives, corrosion products, weld slag, shop and other dirt, and other materials foreign to the item.

D. Packaging Methods, Materials and Processes

   i. Packaging materials and containers can be a source of Foreign Object debris (FOd) and could result in damage to FOD sensitive products.

   ii. Certain materials cannot be used with FOD sensitive articles and there may also be design considerations for packaging methods. It is important that proper packaging and containers are used.

   iii. Caution must be taken when opening and closing containers. Nailing, strapping or installing screws can cause damage to hardware or generate additional internal FOD in the container.

   iv. Container storage procedures must be followed to prevent damage. Improper storage procedures can be a cause of Foreign Object Damage.

   v. Transporting FOD sensitive products can cause damage if transportation procedures are not implemented and followed. This consideration includes ensuring transportation vehicles are free of loose debris while transporting FOD sensitive products.

10. Parts Protection

A. FOD Prevention Devices – These are measures employed to protect hardware that may be exposed to potential damage.

   i. FOD Barriers

1. Protective devices, such as edge protectors, caps, plugs, and protective covers, that are used to seal-off and provide protection for hoses, cables and ducts.

2. These barriers can also cause FOD if not controlled or accounted for properly.

3. When FOD barriers are used, flags should be placed strategically on the exterior of the article to remind personnel to remove them.

4. Failure to remove FOD barriers has been, and continues to be, a cause of serious incidents and accidents.

ii. Electrostatic Discharge (ESD)

1. ESD can be considered a source of Foreign Object Damage.

2. If a FOD sensitive product, vehicle or assembly is also EDS Sensitive, proper handling should be utilized as to prevent ESD from causing damage.

11. Physical Entry and Personnel Control

A. General Entry – When physical entry is required into flight hardware (e.g., crew compartment, engine intake, exhaust, fuel tank areas, etc.) personnel should remove all loose objects, badges, jewelry, etc., from clothing.

i. Pocketless or closed zippered pocket coveralls should be worn to preclude foreign objects dropping from pockets.

B. FOD Prevention Designated Areas are areas where flight hardware is located and exposure to foreign objects could potentially cause a system or product failure.

i. Most manufacturing companies identify FOD designated areas based on a risk assessment of the potential for FOs to migrate into the final product.

ii. Requirements for entry into and working within these areas increase as the product progresses to completion.

iii. FOD designated areas, whether found in manufacturing operations, repair station or general repair facilities, are selected and defined by the company in accordance with their particular operational requirements.

C. Types of FOD Prevention Designated Areas - An area physically roped off by stanchions, placards, banners, and signs to identify the area as a FOD Designated Prevention Area.

i. These areas have heightened policies and procedures that must be followed by all persons entering and leaving the area.

ii. Policies and procedures can include tool accountability, Clean As You Go, Dress

Code and Housekeeping methods.

iii. Only authorized personnel should be allowed unescorted access to FOD Prevention Designated Areas.

iv. Types of FOD Prevention Designated Areas include:

1. FOD Awareness Area

2. FOD Critical Area

3. FOD Control Area

v. Entry into these areas is limited in accordance with the organization's established FOD/FOE Program Procedures. The procedures may include training and/or certification(s) coupled with the appropriate authorization.

12. Reporting & Investigating

A. All FOD must be reported. Established procedures for formally reporting FOD incidents must be followed as they may vary from company to company based on contractual requirements. All FOD incident reports should be forward to the FOD Prevention Area Focal (see definitions) for investigation, cause and corrective action.

B. When a FOD incident occurs, operations should immediately cease and an investigation initiated to determine the cause. Cause may be determined by visual observation, forensic analysis or by location of the object.

C. Cause and corrective action should be attained in a timely manner. Results should then be communicated throughout the operations community as "lessons learned."

D. A closed-loop system should also be in place for follow-up to assure the corrective actions taken to preclude similar occurrences in the future were effective.

13. Tool Accountability and Control

A. Tool Control – The purpose of a formalized tool control process is to assure that each tool that is brought into the operational environment is removed and accounted for.

i. Tool control systems must cover all tools, including:

1. Hand Tools

2. Power Tools

3. Test Kits

4. Contract Tools

5. Production Aids

ii. Effective tool accountability and control systems are easy to follow and difficult to circumvent. The responsibility for tool control rests with anyone who brings a tool into the work area.

B. Shadow Box or Shadow Board, when used properly, can be inventoried in 60 seconds or less. Shadow boxing is a popular system often used in conjunction with other methods.

C. Tethers, consisting of a lanyard made of wire, rope, cable, etc. are secured to the user, a work stand, or other suitable location at one end (as appropriate) and to a tool or piece of equipment at the other end. Tethers are useful to preclude dropping tools or items onto products when working overhead.

i. Tethers should be minimum length to preclude damage from a tethered tool "free swing."

ii. Tethering prevents dropping tools or equipment onto or into aerospace products.

iii. The tether itself can become FOD if it (including tether related hardware) is not regularly inspected for damage and wear.

D. Chit Systems are tool control methods utilizing assigned identification tags displaying a control number that are issued to users.

i. The tag (chit) can be put in place of a tool when the tool is in use. If another technician or area supervisor is inventorying the tool box the missing tool is accounted for.

ii. Chits can also designate a tool is out for repair or calibration.

iii. A Chit System only works if every technician understands the one-for-one policy of placing assigned tags in place of the tool when it is in use.

iv. In addition, tool boxes must be shadow boxed with specifically marked locations for each tool in order for this method of tool accountability to be effective.

v. Chits can become FOD themselves and it is the responsibility of every technician to control their chits in any FOD sensitive areas.

E. Tool Inventory Sheets/Logs – Written Tool Inventory Sheets or Logs are a listing of tools and materials that would be checked in and out when entering or departing a FOD sensitive area.

F. Tool Pouches/Tool Pockets/Tool Bags – These are tool control devices that contain an identified (inventoried) set of tools.

i. Tool Pouches, tool pockets and tool bags are each subject to logging in and out of work areas.

G. Tool Identification – Every tool that is assigned to a specific location/tool box and taken into work areas must be clearly marked for accountability. The following methods are commonly used to mark tools:

i. Tool tags – permanently attached to the tool.

ii. Radio Frequency Identification (RFID) sensors for location tracking

iii. Bar codes for ease of inventory

iv. Laser etching/engraving for ease of inventory

v. Color coding for specific uses

H. For specific tasks, a tool kit with all tools inside for the task is known as a Consolidated Tool Kit or CTK. CTKs are inventoried by the tool crib or area supervision. CTKs contain shadow boxes (foam cutouts) for easy inventory.

I. It is important to assure tool condition before use, i.e. that they are clean, undamaged and free of Foreign Objects, in order to prevent them from introducing FOD into products or flight elements. All tools slated for use in operational areas should always be visually inspected for the following conditions:

i. Visually inspect for broken or worn areas that can become FOD.

ii. Visually inspect for damage.

iii. Ensure tools are clean and ready for use.

iv. Visually inspect for flaking – flaking creates Foreign Object debris (FOd) and can become a serious problem if undetected.

v. Tools found to have any of these conditions should be removed from service and repaired or replaced to prevent the damaged tool from becoming FOD.

J. The term Sponge Count describes a formal procedure utilizing a written record of all items entering and leaving a work area.

i. The medical industry coined this term and uses this procedure to ensure that all surgical materials that are taken into a surgical procedure are properly accounted for at the end of the procedure.

ii. This prevents Foreign Objects (a sponge, surgical tool, etc.) from accidentally

being introduced or left inside a patient.

iii. Applying the “sponge count” methodology in aerospace industry settings ensures that foreign objects (Critical FO) are not left inside aerospace products, assemblies or vehicles.

K. Technology offers the ability to create systems that can be used for accounting for inventory and issuing tools on the production floor. Electronic Tool Accountability Systems have vastly improved tool control and tracking.

i. Through these electronic systems, tools can be tracked to a user by a unique identifier such as a badge.

ii. Many electronic tool accountability systems utilize sensors and/or bar codes to identify each individual tool (see “Tool Identification” in this section).