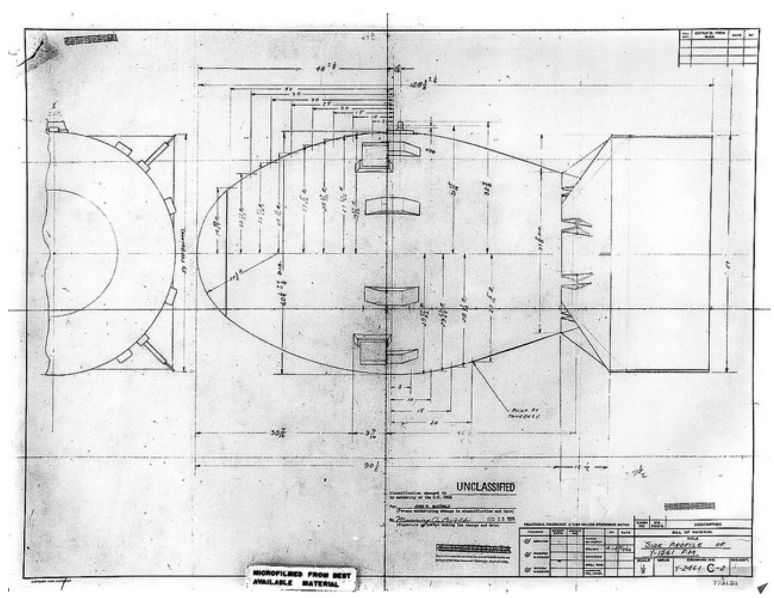
CDC 2W251A

Nuclear Weapons Journeyman

Volume 2. Safety Program, Forms and Records, Technical Orders, Theory and Operation of Nuclear Weapons



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Author: MSgt Joshua D. Brown
363d Training Squadron
Nuclear Weapons Technical Training School (AETC)
363 TRS/TRR
520 Missile Road (Stop 244)
Sheppard Air Force Base, Texas 76311-2261
DSN: 736-2105
E-mail address: 363TRSCDCWriters@us.af.mil

Instructional Systems Specialist: Sherie A. Davis

Editor: Sherie A. Davis

Air Force Career Development Academy (AFCDA)
Air University (AETC)
Maxwell AFB-Gunter Annex, Alabama

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THIS SECOND VOLUME of CDC 2W251A discusses safety, forms, technical orders, and nuclear theory. It provides you with the necessary background information to perform your duties as a nuclear weapons technician. This volume also presents safety areas that apply most frequently to the 2W251 AFSC and points out how we can eliminate or lessen hazards. Unit 1 covers safety and health programs. Unit 2 covers technical orders, forms, records, and reports. Finally, unit 3 covers the nuclear weapons operations and history.

A glossary is included for your use.

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NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. Safety and Health Programs

AS YOU PROGRESS through the career field ladder, you will assume various duties that require your absolute attention. Safety is a high priority no matter what job you are assigned. Our career field can range from having you work behind a desk to you handling a weapons system or any support equipment (SE). Any inattention to detail may jeopardize your life or the lives of your wingmen. It is required that you perform at your maximum level of competency, and at the same time, expect the same performance from your fellow technicians. This unit will not make you a safety expert, but it is a good starting point; the rest will be up to you. You have a duty to ensure that safety is paramount in the office environment, in the maintenance bay, and on the flight line.

1–1. Air Force Occupational Safety and Health Standards and Mishap Prevention

Air Force (AF) leadership is committed to providing a safe and healthy environment for AF personnel and for those affected by AF operations. In essence, the AF is mandated to implement a comprehensive safety program that identifies and controls hazards, to include preventing mishaps. This section consolidates the Air Force Occupational Safety and Health (AFOSH) and mishap prevention programs into one integrated framework for safety management.

201. Air Force Occupational Safety and Health standards

The purpose of the AFOSH program is to protect our vital resources and the Airmen who perform the missions and prevent occupational deaths, injuries, or illnesses. Enforcing the Occupational Safety and Health Administration (OSHA) standards ensures these resources are protected. To begin this lesson, let’s cover the objective of the AFOSH program.

Program objective

The AFOSH program promotes a safe and healthy working environment and implements AF safety, fire prevention, and health standards into our mission. The program is divided into two major parts—safety and health.

1. Safety is about creating a safe work environment. This is accomplished by inspecting equipment, identifying hazardous conditions, and placing controls in processes. Lastly, we investigate all mishaps in the event of an accident or incident.

2. Health is about eliminating or controlling unhealthy conditions and emphasizing health considerations in the work environment.

Commanders throughout the AF must ensure all workplaces meet federal safety and health requirements. In addition, it mandates the AF establish a specialized publication system for issuing, updating, and indexing AFOSH standards in conjunction with the mishap prevention program.

Ground safety guidance

The AF publishes industrial and general ground safety guidance as Air Force instructions (AFI), which implement OSHA standards called AFOSH. AFOSH covers hazards that exist in various situations and are not specifically written towards our nuclear weapons career field. The AFOSH standards will be applied in addition to other safety programs, such as the nuclear surety program.

Commanders are responsible for the safety of their facilities and personnel, to include the correction of all hazards and deficiencies in the workplace. To aid in this responsibility, the AF published Air Force Manual (AFMAN) 91–203, *Air Force Occupational Safety, Fire, and Health Standards*, to provide a uniform program to help commanders manage their safety and health programs. This instruction is a consolidation of all 91-series AFOSH standards relating to general operations from multiple sources into a single document for the protection of workers and to ensure compliance with federal law.

Program responsibilities

As mentioned before, the commander is responsible for the safety of their buildings and the personnel who work inside or around them. To assist commanders in a viable safety program, supervisors will be responsible for each of the following:

- Ensure safe working conditions and provide necessary protective equipment to their personnel.
- Ensure necessary guards and protective equipment are provided, used, and maintained.
- Plan the workload and assign employees only to jobs they are qualified to perform.
- Ensure employees understand the work to be done, the hazards that may be encountered, and the proper procedures for doing the work safely.
- Take immediate action to correct any violation of safety rules observed or reported.
- Ensure workers exposed or potentially exposed to hazardous chemicals or materials are trained on the hazards of those chemicals and materials.
- Conduct a job safety analysis (JSA) of job tasks as required to ensure a safe work environment. Accomplish a JSA when a new piece of equipment is installed, equipment is relocated, or new procedures are implemented in critical or hazardous operations.

All workers (military and civilian) are responsible for the following:

- Comply with AFOSH standards.
- Promptly report unsafe working conditions including any safety, fire, and health hazards and deficiencies to the supervisor.
- Promptly report injuries and illnesses to the supervisor whether on or off duty.
- Comply with protective equipment requirements, to include its use, inspection, and care.
- Give due considerations to personal safety and the safety of fellow workers while performing assigned tasks.

No technical data, instruction, or operating instruction (OI) can address every hazard or potential hazard that may arise from a specific task or combination of tasks. Where situations exist that are not covered by existing directives, use a risk management (RM) process to assess risk associated with those situations and determine adequate safeguards or procedures to manage the risk. Refer to AFI

90–802, *Risk Management*, and Air Force Pamphlet (AFPAM) 90–803, *Risk Management (RM) Guidelines and Tools*, for more information on using the RM process.

Hazard communication program

Hazardous chemicals are found in virtually every AF operation. AFI 90–821, *Hazard Communication (HAZCOM) Program*, is intended to minimize the amount of incidents involving chemically induced occupational illnesses and injuries in the workplace. This is accomplished by establishing guidance for training employees on the health and physical hazards associated with hazardous chemicals, and the proper preventive measures to be taken when using or handling chemicals in work areas. Hazard communication (HAZCOM) is a performance-based program with separate training requirements. Its successful implementation can only be measured by evaluating worker awareness of work area hazards.

All employees who work in an environment where any hazardous chemical is known to be present will be provided information about the hazardous chemicals to which they are exposed. We provide this information and training through a HAZCOM program, which includes information pertaining to safety data sheets (SDS), labels, and other forms of warning.

Responsibilities of key personnel

Squadron commanders (SQ/CC) maintain an effective HAZCOM program within the work areas under their control. In addition, SQ/CCs will approve a written work area specific training program prior to implementation in the work area. This training program will identify the location of the SDS and training materials to support the HAZCOM program.

Work area supervisors are responsible for HAZCOM in their work areas, but may designate an alternate to assist in the daily program execution. In addition, the work area supervisor, or their alternate, will be responsible for the following:

- Develop and implement a written work-area-specific HAZCOM program accessible via hard copy or electronically to all assigned personnel.
- Review supervisor HAZCOM training initially and as needed to maintain competency.
- Develop a work-area-specific training plan using the United States Air Force School of Aerospace Medicine (USAFSAM) template and route it through all required offices prior to implementation to ensure it is technically accurate.
- Ensure all assigned personnel are trained in the HAZCOM program.
- Ensure personnel receive additional training any time a different type of hazardous material is introduced into their work area.
- Document all HAZCOM training on AF Form 55, Employee Safety and Health Record, in another electronic form, or in the Air Force Enterprise Environmental, Safety, and Occupation Health Management Information System (AF EESOH-MIS).
- Maintain or have access to all hazardous materials used in the work area. Maintain access to the SDS for these materials. At least annually, reconcile the SDS on file along with the hazardous chemical inventory.

The work area supervisor is responsible for ensuring that you and every worker that handles hazardous material are properly trained on the chemical hazards within your work area or shop. At a minimum, your training will consist of the following:

- Identification of operations or processes in the work area or shop where hazardous chemicals are present or used. Identification of the complete list of hazardous material used in association with work area or shop processes.
- Identification of relevant hazard categories associated with each chemical used (e.g., flammability, carcinogenicity, etc.) or the individual chemical hazards including, but not

limited to, those with specific regulatory requirements (e.g., asbestos, benzene, beryllium, cadmium, formaldehyde, and lead).

- Location and contents of the work area or shop-specific written HAZCOM program.
- Proper labeling of hazardous materials.
- How to access and read an SDS.
- Control the requirements workers must use to minimize or eliminate exposure to hazardous chemicals specific to a task (e.g., certain gloves to use with certain chemicals). Supervisors shall refer to the installation bioenvironmental survey reports for specific control requirements.
- Emergency procedures, such as recognition of a spill or accidental chemical release (e.g., visual, odor, or alarm), escape procedures, locations of emergency eye wash stations, showers, and monitoring capabilities.
- Chemical hazards associated with non-routine tasks (e.g., solvent tank change-out every three months).

Safety data sheet

The SDS is designed to provide workers and emergency personnel with the proper procedures for handling or working with chemicals. The SDS includes information, such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill/leak procedures. An SDS may vary in appearance and length. The Air Force Institute for Operational Health (AFIOH) is the focal point for entering the manufacturer's SDS into the Defense Logistics Agency's (DLA) database. This ensures completeness, legibility, and standardization of all SDSs making information easier to find regardless of the chemical supplier.

An SDS is formatted into 16 sections in accordance with (IAW) the Code of Federal Regulations (CFR) 1910.1200. The following table provides you the 16 sections and a description of each.

SDS SECTIONS	DESCRIPTIONS
1. Chemical identification.	Contains the chemical name and the manufacturer's information (i.e., name, address, and phone number)
2. Hazard(s) identification.	Lists any hazardous ingredients within the chemical that are dangerous.
3. Composition/information on ingredients.	Lists hazardous ingredients and may include other information, such as effects of exposures (acute or chronic) and OSHA's permissible exposure limits.
4. First-aid measures.	Provides instructions on what to do if exposure occurs and may include instructions for medical professionals (e.g., emergency procedures during inhalation, ingestion, and eye and skin contact).
5. Fire-fighting measures.	Explains the likelihood of substance to catch fire and other circumstances: - Chemicals that ignite at or above 100 degrees Fahrenheit (°F) are classified as combustible. - Chemicals that ignite below 100 °F are classified as flammable. Additionally, it will list the proper types of fire extinguishers to safely extinguish a fire, special fire-fighting procedures, and any unusual associated fire and explosion hazards.
6. Accidental release measures.	Provides methods to contain a spill or leak and clean-up procedures and safety precautions.
7. Handling and storage.	Provides information on safe handling and storage practices, such as keeping this chemical away from sparks, heat, and flames or storing in a cool, dry place.
8. Exposure controls/personal protection.	Lists personal protective clothing and equipment necessary to prevent exposure to the chemical.
9. Physical and chemical properties.	Contains the physical and chemical properties that help identify the type and degree of hazard. May include chemical appearance and odor.

SDS SECTIONS	DESCRIPTIONS
10. Stability and reactivity.	Describes the conditions that could cause the chemical to have a potentially hazardous reaction.
11. Toxicological information.	Explains how the chemical was tested for health hazards and the test results.
12. Ecological information.	Describes the effects of the chemical if released into the environment and the chemical's environmental fate.
13. Disposal considerations.	Provides proper procedures for disposal.
14. Transport information.	Contains the shipping information.
15. Regulatory information.	Provides information on regulations affecting the chemical.
16. Other information.	Other useful information such as information on SDS revisions.

The SDS on file must match the manufacturer and part number/trade name of the chemical on hand. In addition, the SDS preparation date must be consistent with the date/lot of any chemical on hand. If a new SDS is received, but chemicals of previous lot numbers are still on hand, we must also retain the SDS for those chemicals with previous lot numbers.

202. Mishap prevention program

The AF uses safety offices, which are normally located at the wing level, to implement the mishap prevention program. This also pertains to base tenant units who must also support the mishap prevention program and adapt it to their needs. It is the responsibility of all commanders, functional managers, supervisors, and workers to fully understand and comply with the established safety standards under the mishap prevention program. In addition, everyone assigned to an AF unit must be alert to identify workplace hazards early and try to eliminate them as soon as possible. In this lesson, we define and discuss mishaps, mishap prevention, safety enforcement, how to apply safety information, and reporting procedures.

Mishaps

A "mishap" is an unplanned or unsought event or series of events that results in death, injury, occupational illness, or damage to or loss of equipment or property. A mishap can result in damage or injury that meets Class A, B, C, D, and/or Class E mishap reporting criteria. The five mishap classes are defined in AFI 91–204, *Safety Investigations and Reports*. Mishaps normally have several causes that act together to produce damage to property or personnel injury. In most cases, you can avoid or control mishaps by paying attention to detail and planning.

Human error is a key factor in mishaps and the creation of risk. One of the key sources of human error is the lack of knowledge of hazards and risk control procedures. Human-error mishaps can also be attributed, but are *not* limited, to the specific areas of background, motivation, training, characteristics, personality, awareness, complacency, and supervision of an individual. The following are four examples of mishap causes and possible results:

1. The supervisor failed to analyze the job site for potential hazards. As a result, the supervisor overlooked a high-voltage power line in the work area. The heavy machine operator struck the power line, which damaged the equipment and put his life in danger.
2. While transferring weapons to a storage structure, the team chief failed to guide the vehicle operator. As a result, the vehicle operator struck a weapon's nose on a storage igloo door.
3. A scheduled nondestructive inspection was not performed on a 10-ton hoist hook, which allowed a damaged hook to go undetected. This allowed lifting operations to continue and the hook to fracture causing a weapon to fall from the hoist.
4. A team chief did not make sure the trailer form (Air Force Technical Order [AFTO] Form 244, Industrial/Support Equipment Record) was checked before the transfer task. As a result, the red "X" condition of "hydraulic cylinder check valve inoperative" was missed and equipment was permanently damaged.

In these cases, they could have avoided all of these mishaps if they had only paid closer attention to detail. The AF categorizes mishaps based upon the materiel involved (e.g., space systems, weapons, aircraft, motor vehicles, person, etc.), the state of the involved materiel (e.g., launch, orbit, existence of intent for flight, on or off duty, etc.), and when the mishap occurs. The following list provides a few mishap categories used in the AF:

- Nuclear.
- Guided missile.
- Explosive and chemical agents.
- Motor vehicle.
- Ground and industrial.

Most of us usually recognize bad situations, but at times, we may decide to take a chance under the current conditions rather than taking the time to safeguard ourselves or resources against a possible mishap.

The direct results of a mishap can include unusable equipment, delay in a mission, mission failure, injury, or death. All of this means money—direct or indirect costs. The direct cost of a mishap can be determined by the sum of the original cost and replacement cost of an item. The indirect cost of a mishap includes the cost for man-hours lost by injured personnel; cost of the investigation and local agency participation; expenses for hospitalization; and the loss of an invaluable asset—you. As a rule of thumb, the indirect cost of a mishap is about four times that of the direct cost. That is one dollar's worth of direct damage costs versus another four dollars indirectly.

Mishap prevention

It is often difficult to determine the proper way to prevent or eliminate a particular hazard, but there are three areas you can consider that will help you in your decision making—planning and engineering, procedural actions, and personnel actions. These three areas, along with the application of safety information, can eliminate many accidents. Mishap prevention depends on you identifying, reporting, and correcting hazards promptly and efficiently.

The awareness of mishap prevention also helps you to avoid injuries to yourself and damage to equipment. This preventive measure is done by following the established procedures and directives, asking for help when you need it, and making sure you use the right personal protective equipment (PPE). When you receive proper training, appropriate work procedures, and supervisory control before doing a job, you can control potential physical fires and health hazards. It is everyone's responsibility to recognize the sources of hazards and apply appropriate safety practices to minimize their effect.

The routine tasks of handling and maintaining nuclear weapons call for a variety of safety precautions in our specialized field. Each weapon system has their own specific requirements and hazardous conditions during maintenance, handling, transportation and storage. Generally, weapons are heavy and awkward to handle, but inherently safe in design. They require stricter tool discipline and a variety of hazardous materials during their maintenance. Explosives safety along with nuclear safety and surety considerations are always present. This is where as a maintenance technician or supervisor, your extensive knowledge of requirements will keep the environment safe on a day-to-day basis. Let's now review the three areas that are very important in the prevention or elimination of a hazard.

Planning and engineering

Use the RM processes during the planning, design, and execution phases of planning and engineering to identify and eliminate hazards as early as possible. This is where hazards will have the least cost and operational impact on the program. You also continually review plans, specifications, and drawings to identify and eliminate hazards until the equipment or workplace is operating with acceptable risk levels. Designing safe equipment or environments can often eliminate situations that can cause accidents. Such designing may necessitate mechanical modifications to eliminate existing unsafe conditions. It may also require special devices to correct specific unsafe conditions and to prevent unsafe acts. Machine guards, fail-safe hoist brakes, electrical interlock switches on test sets, forklift overhead cage guards, and handrails are varied examples of safety engineering at work. Although most of your equipment and buildings meet basic specifications, it may be necessary for you to recommend safety changes or to add locally approved safety devices.

Procedural actions

Develop procedures or restrictions to minimize risk if planning or engineering actions cannot be used to eliminate hazards. If necessary, impose restrictions such as operational limits, frequent inspections, and protective equipment, or stop the operation until corrective action is taken.

Personnel actions

Education and training are the supervisor's best tools for eliminating accident causes. People usually work safely and effectively when they are properly trained and motivated. A technician who does not understand the dangers of a maintenance operation has no reason to take precautions. If that technician understands how ignoring safety precautions may cause a person to lose an arm, for instance, you can be sure the technician will take precautions. You can promote safety education by assigning reading, lectures, movies, and demonstrations. You can also reinforce safety information by emphasizing it during practical work.

Safety enforcement

Safety enforcement is paramount regardless of the situation, and everyone is charged with ensuring a safe environment. Supervisors and commanders must enforce safety requirements at all times. Following safe practices can be difficult if non-compliance is allowed to perpetuate. This can occur on a wider scale during times of heavy workloads and narrow time lines, emergency war plans, or even exercises. A normally safe worker can become careless. Always be vigilant, use safe practices, and follow technical guidance.

Applying safety information

We cannot overemphasize the importance of placing proper technical instructions and detailed guidance in the hands of the "user" at the handling and maintenance level. AF-wide standardized procedures are preferable, but often they do not cover variations in local circumstances or operating conditions. United States Air Force (USAF)-approved publications strictly govern the application of safety information to movement or maintenance of a nuclear weapon.

Checklists are shortened forms of directives you can use to accomplish a task. However, in a case where they do not cover local variations, you may end up using OIs or other locally approved directives. Keep in mind that before you can use *any* checklist or OI, in order to prevent mishaps, you must have a good working knowledge of the information in the governing manuals. A checklist used for weapons maintenance is detailed enough to include inspection and safety checks. Those used for weapons movement include such items as safety chains or cables and wheel chocks. A pre-task briefing checklist should include such items as fire extinguishers, explosive signs, vehicle operator qualifications, guards, movement speeds, quantity-distance (Q-D) requirements, and enough people for two-person-concept needs.

Hazard reports

A "hazard" is a condition, procedure, or practice that creates a potential for producing death, injury, illness, fire, property damage, equipment damage, or environmental damage. Reportable hazards include, but are not limited to, unsafe procedures, practices, or conditions in the following areas:

- Maintenance facilities.
- Training and education programs.
- Nuclear and nonnuclear munitions storage facilities.

- Handling operations and equipment.
- Health hazards to AF workers.
- Work environment.
- Vehicle traffic or road conditions.
- Fire hazards.

Anyone assigned, attached, or under contract to the AF may report a hazard. Submit a hazard report on any event or condition that affects flight, ground, weapons, or space safety. The purpose of submitting a hazard report is to protect others from the hazard and to eliminate the hazard.

You should submit a hazard report unless personnel can take corrective action under AFI 91–202, *The US Air Force Mishap Prevention Program,* or any of the following AF publications:

- AFI 11–215, *Flight Manuals Program*.
- AFI 51–1101, *The Air Force Procurement Fraud Remedies Program.*
- AFI 91–204.
- TO 00–5–1, *AF Technical Order System*.
- TO 00–35D–54, *USAF Deficiency Reporting, Investigation, and Resolution*.

It is vital to detect and promptly correct hazards at the lowest level possible. Report any hazard to your supervisor or local safety agency so that action can be taken to correct the situation. If a hazard can be eliminated on the spot, no further action is necessary. If it cannot be eliminated on the spot, submit an AF Form 457, USAF Hazard Report.

Blank copies of an AF Form 457 should be posted on your ground safety bulletin board. If they are not posted, ask your supervisor for the form. Filling out the AF Form 457 is self-explanatory. You may submit a hazard report anonymously, but complete the report to the fullest extent possible. If you leave the name and organization block empty, the reviewing agency will not be able to get additional information that may be necessary to investigate the hazard.

There are some instances where you may feel that by submitting a report you would be stepping on someone's toes, or you may feel that by putting your name and organization on a report, you could be subjected to repercussions. If at any time you receive reprisal for reporting a hazard, notify your chain of command immediately. The important thing is to identify a hazard by submitting a report, with or without your name. Do *not* let a hazard go unreported! A key element in hazard reporting is regardless of whether a reported hazard is valid or not, someone must make a prompt response to the originator. The response to the originator must *not* minimize the importance of the effort taken to report the hazard.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. Air Force Occupational Safety and Health standards

1. What is the purpose of the AFOSH program?

2. What are the two major parts and primary concerns of the AFOSH program?

3. Which publication provides a uniform program to help commanders manage their safety and health programs?

4. Specify who is responsible for the following duties by placing an "S" for supervisor or "W" for worker preceding each duty statement.

   ___ (1) Provide necessary protective equipment.

   ___ (2) Plan the workload.

   ___ (3) Promptly report unsafe working conditions.

   ___ (4) Promptly report injuries and illnesses.

   ___ (5) Conduct JSA.

5. What is the intention of the HAZCOM Program?

6. What form is used to document all HAZCOM training?

7. What does the supervisor refer to for specific control requirements as part of HAZCOM training?

202. Mishap prevention program

1. What is the definition of a mishap?

2. What specific causes can be attributed to mishaps from human error?

3. How can you determine the direct cost of a mishap?

4. Name three areas that can be considered to prevent or eliminate hazards.

5. What are a supervisor's best tools for eliminating the causes of accidents?

6. What must you have before you use a checklist in an operation?

7. What action do you take if a hazard is corrected on the spot?

1–2. Hazardous Materials and 91b Waste

Modern life would be impossible without the use of flammable materials and chemicals. Plastics, drugs, and fibers are just a few things that are manufactured using chemicals. We must treat chemicals and hazardous materials with respect because many can cause injury or illness if we do not handle them properly. Lastly, with what we know now about chemicals and other waste products, we ultimately have the responsibility to protect the environment and ourselves.

203. Hazardous material handling and disposal

International, federal, and state regulatory requirements dictate how to manage hazardous waste. Your base develops procedures for storing, handling, accumulating, and disposing of hazardous waste through supplements and locally developed instructions to ensure you meet all regulatory requirements. Since waste management requirements are constantly changing, and procedures vary from base and state, we only give generalized information in this lesson starting with personnel responsibilities.

Personnel responsibilities

Personnel working with or handling flammable and combustible liquids may be exposed to spills, hazardous vapors, accidental mixture of flammables and combustibles, or industrial hazards associated with handling of containers and products. It is the supervisor's responsibility to make sure of the following:

- Anyone working with or handling flammables or combustibles have accomplished the appropriate training associated with the tasks and hazards related to the task.
- Individuals involved in dispensing of flammable or combustible liquids receive instruction on hazards of static electricity.
- Workers handling and storing flammable or combustible liquids receive training in fire prevention and protection as it relates to their duties.
- Appropriate spill and containment control materials are readily available at storage or dispensing areas.
- PPE is available and appropriately worn when handling flammable or combustible liquids.

Personal protection

Certain chemical products cannot be used safely in any amount without some personal PPE. As the user, you must be familiar with (or refer to) the manufacturer's SDS, OSHA regulations, and local chemical safety regulations (as implemented by AF policies). It is ultimately your responsibility to be familiar with these regulatory guides. The Department of Energy (DOE) designates in its technical order (TO) the minimum protective equipment needed to safely use a product on a one-time application (defined as the user completing the procedures once during an 8-hour period) in a well-ventilated area. This minimum protective equipment is required during the use of these products and the type of equipment is specified in the TO by a warning statement. The warning statement will precede the procedure before using the product. The following is an example of a warning statement in a DOE manual.

WARNING: Aluminum coating compound contains hazardous chemicals, one of which is known to cause cancer in humans. The minimum required PPE is impervious gloves and either splash-proof chemical safety goggles or a full-face shield.

The using (your) organization must determine what, if any, additional protection is needed. However, the organization must meet all regulatory standards.

It is your responsibility as the user to know what type of protective equipment is required (by either the TO, local policies, or the SDS) and how to use the equipment whenever you handle hazardous materials.

Personal safety precautions

There are certain do's and don'ts that must become everyday routines when you use hazardous expendable materials. The following table provides you some examples of personal safety precautions.

	Precautions
DO	Wash your hands with soap and warm water after using hazardous expendable materials, even if you wore gloves. Use hazardous expendable materials in limited quantities that are appropriate for the task at hand (e.g., ounce versus gallon). Handle hazardous expendable materials only when necessary and keep handling time as short as possible. Health hazards are increased by extended exposure. Know where the SDSs are located and what information they contain *before* you use hazardous materials. Make sure that containers for hazardous expendable materials are clearly labeled with the identification of the material and the appropriate hazard warning(s). Keep container lids tightly closed between operations and while in storage. Use only approved containers for the storage of hazardous expendable materials. As a minimum, use flammable hazardous expendable materials only in a well-ventilated, flame-free, and spark-free area.
DON'T	Remove or deface labels on incoming containers of hazardous expendable materials. Eat, smoke, or drink in areas in which hazardous expendable materials are handled. Dispose of hazardous expendable materials by dumping them in storm drains, dirt, or other non-approved areas. Use hazardous expendable materials when other nontoxic procedures or methods are available.

Storage cabinets

All flammable/combustible material shall be listed and approved for the specific chemicals being stored. No more than 120 gallons of chemicals may be stored in a single storage cabinet. In addition, there can be no more than three such cabinets located in a single fire area except in an industrial area. In order to add additional storage cabinets in the same fire area of an individual area, the extra storage cabinets must be separated by at least 100 feet from the other three cabinets. This type of situation needs to be coordinated with fire emergency services and approved to ensure its adherence to safety. Some additional safety requirements are as follows:

- Storage cabinets will be labeled with conspicuous lettering "Flammable – Keep Fire Away."
- Grounding or bonding of flammable/combustible liquid storage cabinets are not required if the cabinet meets national fire codes and OSHA requirements.
- At least one portable fire extinguisher with a rating of at least 40B:C shall be located within 30 feet of the storage cabinet.
- Open flames or smoking areas shall not be permitted within 50 feet of flammable or combustible liquid storage areas.
- The storage cabinets are *not* required to be vented for fire protection purposes. However, if the cabinets are vented, then the cabinet inlet shall be vented outdoors. Otherwise, the vent opening will be sealed with bungs that were supplied with the cabinet.

Hazardous waste disposal

Handle hazardous waste with special care because of its potential for environmental damage and potential harm to you. Note that none of the following five disposal methods we are about to discuss are completely satisfactory for all materials. Let's begin our discussion with the chemical-physical treatment disposal method.

Chemical-physical treatment

The chemical or physical modification of a waste substance to reduce or eliminate its toxic or hazardous nature is the most common disposal method. Detoxification methods are diverse and highly dependent on the waste material.

Biodegradation

Certain types of bacteria are effective in the rapid breakdown of oil in the environment. On land, you can inject the spill area with commercial bacteria preparations, add nutrients, and then let the mixture decompose. Plowing speeds this process and will limit contamination runoff. This process is most effective in warm weather.

Incineration

It's unlikely that special incinerators could be justified by an AF facility strictly for hazardous waste disposal, but many types of hazardous wastes may be destroyed that way. There are commercial firms available that are approved to provide this method of disposal.

Land disposal

You can also dispose of hazardous waste securely by placing it in secure landfills, underground cavities, caves, mines, or by pumping liquid wastes into deep geological rock beds. On occasion, special deep wells are used for disposal of toxic industrial wastes that cannot be treated otherwise. Land disposal of hazardous wastes is not permitted on military installations, but disposal in off-base facilities that meet federal and state regulations is appropriate by contract.

Off-site contract disposal

Off-site contract disposal is the most frequently used method for hazardous waste disposal. Disposal through a specialized contractor is an attractive alternative, especially for contingency planning for wastes that may never actually be produced. However, it is essential to make sure that any waste materials disposed of are handled and transported according to governmental regulations and in a manner consistent with the goal of environmental and personnel protection.

The commander is responsible for the hazardous waste program from "cradle to grave" and liable even though waste is transported or disposed of by civilian contract. Contracts for hazardous waste transportation, treatment, and disposal must incorporate provisions for certifying compliance with applicable regulations, verification of the certificate by the state, and inspection by civil or bioenvironmental engineers.

204. 91b Waste and Resource Conservation and Recovery Act

Three basic types of tightly regulated materials can be generated during nuclear weapons maintenance activities, which are the Resource Conservation and Recovery Act (RCRA) hazardous waste, 91b Waste, or potentially mixed waste. It is always a best practice to keep these waste streams as small as possible to decrease accumulation and overall disposal costs. This means you should use the smallest applicators and rags to effectively perform the operation in order to reduce the total amount of waste generated during the operation. Let's start this lesson by discussing 91b Waste.

91b Waste

91b Waste is generated when a system component is inherently contaminated and/or becomes contaminated solely by a radioactive source within the contiguous volume where a tritium reservoir resides without the introduction of a hazardous material. These wastes include items such as the compression pads, expired weapon desiccants, ungreased O-rings, paper tissue, or cotton tipped applicators used to wipe internal components without the use of solvents. The following list describes where waste is located in the Mark (MK) 12A and 21 systems:

- For the MK 12A systems, 91b Waste is located inside of the associated aft section and inside surfaces of the H1223A/B aft bulkhead cover/ring.

- For the MK 21 systems, 91b Waste is located in the enclosure formed by the inside of the warhead electrical system (WES) cap and aft end of the arming and fuzing assembly (AFA) and inside the WES cap.

Technicians are required to package 91b Waste in plastic bags consistent with the operation being performed and store the bags in drums. The packages and associated drums must be labeled with "Potentially 91b Waste." Continental United States (CONUS) locations will coordinate pickup and disposal with the local bioenvironmental office. The outside Continental United States (OCONUS) location will coordinate disposal with their major command (MAJCOM).

Resource Conservation and Recovery Act

The RCRA regulated hazardous waste includes materials that are available for use in the routine conduct of maintenance activities to include solvent soaked rags or wipes. RCRA hazardous waste, however, does not include materials that become contaminated by a radioactive source or demonstrate a radioactive property. RCRA wastes include items such as unusable or spent solvents, lubricants, and paints.

Potentially mixed waste

Potentially mixed waste is generated when a 91b Waste is combined with a RCRA hazardous waste. An example of mixed waste is when greased O-rings or a paper tissue (or cotton tipped applicator) becomes contaminated with spent hazardous material solvent once used to wipe internal components and surfaces of radioactive sources.

Technicians are required to package mixed waste in plastic bags consistent with the operation being performed and store it in drums. The packages and associated drums must be labeled with "Mixed Waste Potentially 91b." CONUS locations will coordinate pickup and disposal with the local bioenvironmental office and the OCONUS location will coordinate with their MAJCOM.

Low level radioactive waste

The low-level radioactive waste (LLRW) programs are driven by environmental regulatory compliance and are not a personnel safety issue because radiation levels are extremely low. Waste generated during cleaning of tools used during maintenance is *not* a 91b Waste issue. It is not necessary to wear protective or safety equipment while working around gas transfer systems of a weapon within the parameters outlined in the applicable TOs, unless otherwise directed (e.g., cleaning with solvents).

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

203. Hazardous material handling and disposal

1. What hazards could workers be exposed to when dispensing flammable and combustible liquids?

2. What should the user be familiar with (or refer to) in order to safely use certain chemical products?

3. How does DOE designate the minimum protective equipment needed to safely use hazardous materials?

4. Where in the TO does it address the minimum protective equipment required prior to using chemical products?

5. Who is required to know the type of protective equipment and how it is used while handling hazardous expendable materials?

6. After using a hazardous material, what do you do?

7. What is the handling time for hazardous expendable materials? Why?

8. What are the labeling requirements for containers of hazardous expendable material?

9. What are the minimum precautions for using flammable hazardous expendable materials?

10. What is the storage capacity of a single storage cabinet containing chemicals?

11. List the disposal methods for hazardous waste.

12. Explain how the military can use land disposal.

13. What is the most frequently used method of disposal of hazardous waste?

204. 91b Waste and Resource Conservation and Recovery Act

1. What are the three types of waste that can be generated during a maintenance operation?

2. Where is the 91b Waste located for a MK 12A system?

3. What are the RCRA regulated hazardous waste?

4. How must potentially mixed waste be labeled on packages and associated drums?

5. What is the LLRW program driven by?

1–3. Explosives Safety

You must know the degree of sensitivity of any explosive before you try to do anything with it. All explosives are sensitive and must be handled according to their relative sensitivity. The more sensitive the explosive, the smaller the quantity you should handle at any one time. Remember that sensitivity involves initiation by a form of energy, such as friction, compression, or shock, resulting from mechanical, thermal, chemical, or electrical sources.

205. Basic explosive safety

To be familiar with all handling and safety precautions of a particular weapon system, you must be proficient on that system. This detailed knowledge is better left to the training you will receive on the weapon system(s) maintained at your unit. This lesson covers only common information found in our line of work.

Handling precautions

Since you may handle, transport, or store explosives other than assembled nuclear weapons, you should be aware of specific precautions. These 12 rules help prevent unintended explosions by reducing the chance of fire, severe concussion or impact, and an impulse from an initiating agent.

1. Only trained personnel under the supervision of an individual who understands the hazards and risks involved in the operation are to handle explosives.
2. Handle detonators, initiators, squibs, and other such electrically or mechanically initiation devices in protective containers during storage, transportation, and inspection. Use containers designed to prevent item-to-item contact. Mark containers to identify the contents.
3. Do *not* use bale hooks for handling explosives.
4. Do *not* use nails to secure covers or make repairs on explosive containers unless there is no hazard to the explosive item or danger of penetrating protective coverings.
5. Do *not* drop, tumble, drag, roll, or “walk” munitions. You may push or pull containers designed with skids for positioning.
6. Do *not* roll un-palletized conventional high-explosive (HE) bombs or other explosives unless authorized by the TO. Additionally, ensure lugs or other projections have been removed or if they are protected by dunnage rails.
7. Do *not* use conveyors, chutes, hand trucks, or forklifts in atmospheres and locations where they will create hazards.
8. Interlock and support sections of roller conveyors used to move explosives. Do not use boxes containing explosives or munitions to support conveyors.
9. Always store explosive items in original containers and in a dry, well-ventilated area.
10. Do *not* move explosives rapidly across any non-conductive surface.
11. Restraining devices will be used with vehicles and handling equipment IAW applicable TOs.
12. Do *not* smoke in, on, or within 50 feet of any motor vehicle, trailer, or material-handling equipment that is loaded with explosive items.

You *must* acquaint yourself *thoroughly* with the contents of pertinent safety instructions, manuals, and local instructions before you start any operation. AFMAN 91–201, *Explosives Safety Standards,* is the AF guidance on explosives safety.

Explosives operations

Storage, maintenance, and weapons movement are just a few examples of operations involving explosives. You must scrutinize each operation involving explosives to reduce the number of people and the quantity of explosives that could be exposed to an incident. Though you may not always be able to post a sign to show personnel and explosive limits, you and everyone else need to keep asking, "Are all these people needed?" and, "Are we concentrating too many explosives in one place?"

Personnel limits

Personnel limits during explosive operations are designed to expose the minimum number of personnel to the minimum amount of explosives or chemical agents for the minimum amount of time consistent with safe and efficient operations. This safety precaution is the "cardinal principle" of explosive safety. Supervisors are responsible for enforcing and posting personnel limits at each explosive operating location. Posting personnel limits are not required at aircraft parking locations, even if they are used for uploading or downloading explosives. Posting personnel limits are also not required at storage locations or licensed explosives storage locations. However, everywhere else, posted limits will distinguish between supervisors, workers, casuals, and visitors as explained in the following list:

- Supervisors are those personnel who perform supervisory duties during an explosive operation (e.g., bay chief and team chief).
- Workers are those personnel who perform the various duties needed to accomplish the explosive operation (e.g., team members).
- Casuals are persons not normally part of an explosive operation but have duties that require their presence (e.g., quality assurance [QA], medical, safety, or inspectors).
- Visitors are non-essential personnel with limited access and are not part of an explosive operation; therefore, you must *stop* the explosive operations when visitors are present.

Each location will differ in personnel roles during explosive operations; therefore, each location must develop locally written instructions called OIs to address additional specific requirements for that location.

Explosives limits

Determining an explosive limit requires a careful analysis of all facets of the operation. You must consider the size of the item you are working with, the chemical and physical characteristics of the materials, the time available, the facilities available, and the work to be done. Stricter limits are necessary for the more sensitive or hazardous materials. Explosives limits are based on the minimum quantity of explosives needed for the operation. Explosive limits must also be consistent with the Q-D separation criteria.

Except for storage buildings, do not set explosives limits based on the maximum quantity of explosives permitted by Q-D separation. You can express limits in units of weight, number of weapons, or any other basis that fits the operation. You must conspicuously post the maximum amount of explosives permitted in each room or building in each space. The number of nuclear weapons in an igloo also can be limited by physical size or by plutonium and criticality considerations. In a maintenance building, the quantity of weapons usually is limited to the job to be done and the room available for work. The supervisor *must* have plans that include how to provide the best safety for each operation.

General safety

Safety in handling and storing nuclear weapons is *critical* because the results of an accidental nuclear detonation would be disastrous. Although modern nuclear weapons have many built-in safety features to prevent an accidental detonation, there is always the chance of the unexpected happening. You need to be aware of the hazards involving nuclear weapons.

Nuclear weapons have two hazards you must consider: *explosives* and *radioactive material*. You can minimize the threat of these hazards by handling nuclear weapons properly. The amount and “type” of explosive in a weapon directly affects any decision on transportation and storage to include fire-fighting decisions.

The two types of explosives in nuclear weapons are high explosive (HE) and insensitive high explosive (IHE). Obviously, when detonated, both types produce an HE. The difference between the two is the IHE is far less sensitive to shock and is less likely to burn (and possibly detonate) if exposed to fire. Because of these differences, we developed limitations and procedures.

Storage limitations

The number of HE weapons you may store or move in a group is based on the total plutonium weight in the group of weapons. There are no limitations for IHE weapons as long as *only* IHE weapons are within the group. When HE and IHE weapons are within the same group, the limitation is determined as if all weapons are HE.

When a group uses the HE rule, the total plutonium weight limitation is based on *storage category* and *storage location*. The storage categories are open storage, earth-covered or underground structure, and compartmented structure. The storage locations are either closed in or remote.

Criticality limitations

Criticality limitations have been established for certain types of nuclear weapons. The purpose of the limitations is to avoid excessive nuclear interaction between nuclear materials of adjacent weapons. When you arrange these weapons close together, maintain specified minimum distances to prevent this interaction. The physical dimensions of some weapons provide this spacing; for others, the storage or shipping container provides the spacing.

Intergroup separation distance

Any two groups of plutonium-bearing weapons exceeding established limits of combined plutonium weight must be separated by the appropriate aboveground intermagazine separation distance. The distances vary depending on whether the structure is barricaded or unbarricaded. This requirement is based on the largest total explosive weight in any single group involved. If only IHE weapons are involved, there is no separation requirement. If one group of weapons is IHE and the other is HE, then this rule applies as if both groups are HE.

Hazard classification system

When handling and storing explosives, you must consider both Q-D and storage compatibility. Q-D refers to the amount (quantity) of explosive material and the distances allowed between them and other facilities, roads, runways, buildings, and so forth, for given degrees of protection. In other words, Q-D is the relationship between quantities of explosives, distances, and degrees of protection. Q-D separations ensure there is an acceptable level of risk between explosives locations, called a potential explosion site (PES), and surrounding facilities, called exposed sites (ES). The approved package of all this information is called an Explosive Site Plan.

The Department of Defense (DOD) hazard classification system is based on the system recommended for international use by the United Nations Organization. It has nine classes of dangerous goods. The DOD hazard classification system is applied in the development, manufacture, testing, maintenance, storage, handling, transportation, and the loading and unloading of vehicles and aircraft of ammunition and explosives. The classes and divisions identify hazards. They determine the levels of protection for people and property from the effects of fires and explosives on and off military installations. As a nuclear weapons journeyman, the hazard classification you need to be interested in is Class 1—Explosives.

Hazard classes and divisions

We group munitions with like explosive characteristics together in a division, and we use these divisions to determine Q-D criteria for storing munitions. Hazard Class 1 is divided into six divisions based on the nature of the hazard and its potential for injury or damage. The AF actively uses four of the divisions (1.1 through 1.4). The four divisions are used in assigning explosives to four fire symbol classes (fig. 1–1) for fire-fighting purposes.

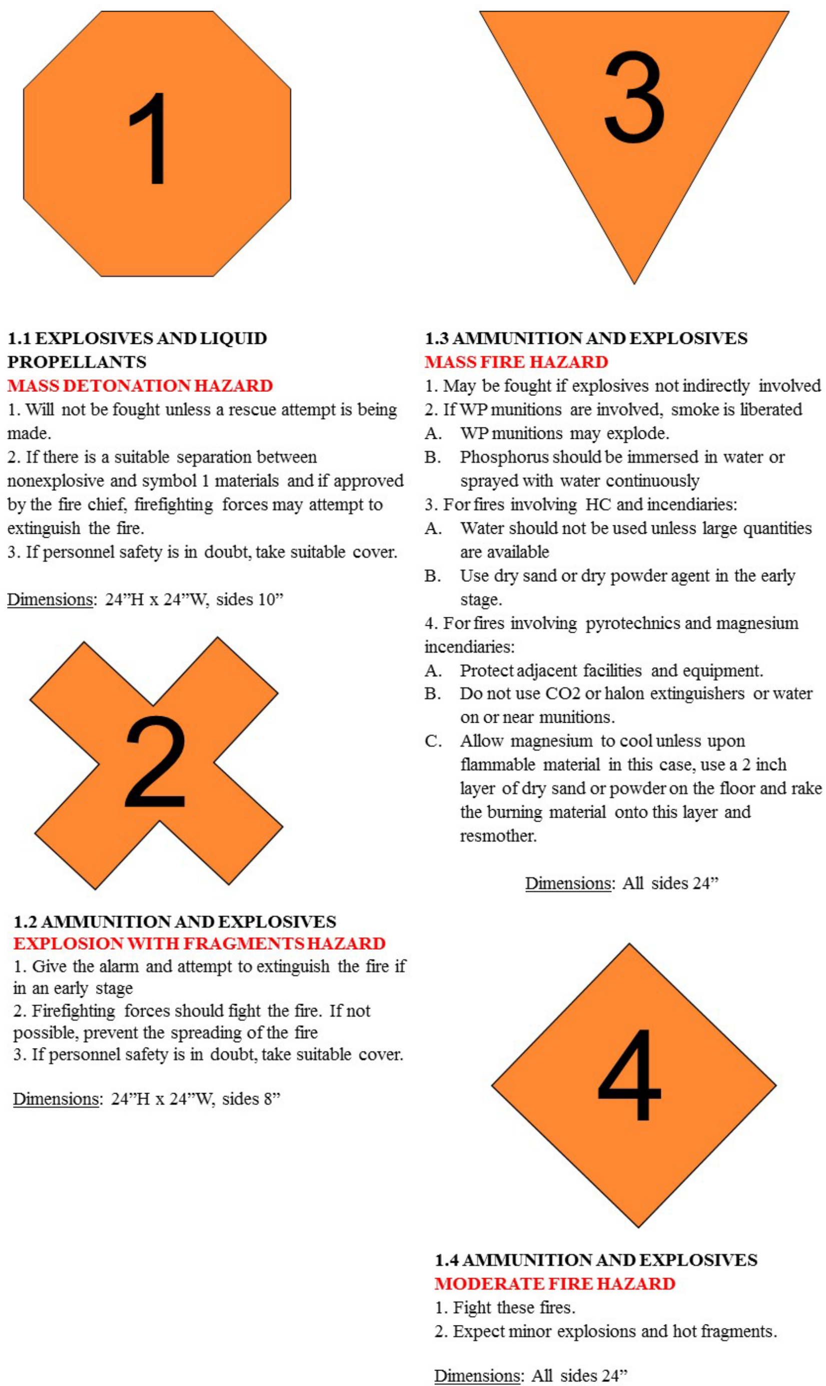


Figure 1–1. Fire symbol signs.

Insensitive high explosive

An IHE has exceptions to some specific rules that normally apply to HE. It is an explosive substance that, although mass detonating, is so insensitive to initiation by fire, severe concussion, or impact, the probability of detonation is slim. IHE weapons are not categorized as a separate class and division. They depend on other explosives with which they are stored for their class and division. For example, nuclear weapons containing an IHE are considered as class and division 1.4 when stored with other IHE weapons. When you store munitions with compatible items of other classes and divisions, the most restrictive class and division present applies to the combination.

AFMAN 91–201 lists the Q-D criteria for each division of explosives. TO 11N–20–7, *Nuclear Safety Criteria*, provides limiting factors for nuclear weapons; when more restrictive, they override the Q-D criteria listed in AFMAN 91–201. It is very unlikely that you will ever have to worry about Q-D based on explosive weights. In most cases, your main concern when working with nuclear weapons will be the amount of plutonium present and the criticality spacing. For general guidance and adjustments required in Q-D determination, refer to AFMAN 91–201. Always remember that separation distances are not absolute safe distances, but are *relative* protective or safe distances.

Storage compatibility

The compatibility of explosives is determined through extensive testing of different types of munitions. These tests show that certain types of explosives behave alike under all circumstances. These circumstances vary from intentional fires and detonations to attempts to extinguish these fires. The tests account for the difficulty encountered, the length of time the fire burned, and the degree and number of detonations. We place explosives that react the same way through test after test into compatibility groups.

206. Electrostatic-sensitive devices and electroexplosive devices

Most nuclear weapons have electrostatic-sensitive devices (ESSD). They are very sensitive to static electricity. When you expose these devices to electrostatic discharge, you may affect your safety and/or weapon function. These devices may be either electroexplosive devices (EED) or nonexplosive devices. Failure to equalize body potential with that of the weapon or component as directed in the appropriate weapons manual may activate or damage the ESSD. If operations are being carried out under ESSD warnings, or cautions are interrupted and actions are taken that may build up static electricity, you must equalize your body potential with that of the weapon or component as directed in the appropriate weapons manual before resuming operations. In this lesson, we begin by discussing the different device types.

Device types

Within the system circuitry, there are several types of ESSDs or EEDs that are electrically initiated. An electrical device called a squib activates all EEDs. In most cases, you will not handle these items directly because they are contained within the system. Although when you are working with most missile systems, you must physically handle them; in either case, you will be testing them. Improper handling or testing of EEDs can have devastating consequences; you *must* adhere to the prescribed safety precautions and *not* deviate from any TO procedures.

There are several different types of ESSDs or EEDs used in nuclear weapon systems. How they work depends on the function they perform. For example there are explosive switches that, when initiated, close a circuit. Igniters and pyrogenic (heat-generating) units initiate various types of rocket motors.

There are also gas generators that produce pressure to mechanically operate coupling systems or to activate a parachute deployment. These are only a few of the types of ESSDs or EEDs used in nuclear weapon systems. Now let’s discuss the hazards of an ESSD or EED.

Hazards

Dealing with ESSDs or EEDs is more hazardous than dealing with mass detonating explosives. The increased danger comes from their design features, which are needed to start the explosive train. The following are a few situations that can inadvertently activate an ESSD or EED:

- Electrical current.
- Temperature.
- Shock.

NOTE: Electrical current is one of the main hazards when working with ESSDs or EEDs.

Electrical current

A very small amount of electrical energy is needed to activate an ESSD, which makes it susceptible to unintentional activation. Stray electromagnetic energy, either direct or induced, can activate an ESSD or EED and be present in many ways in a squib circuit.

When electrical charges build up on the surface of a material, it creates static electricity. This electrical charge can build up on objects, such as weapon skins, plastics, and clothes (especially silk, wool, and synthetics). The word *static* means “at rest,” and that’s exactly what static electricity is—electricity at rest. When an object gains or loses a large amount of electrons, it develops a static charge. You can produce static electricity by walking across the floor, running a vacuum cleaner, handling a plastic bag for enclosing components with desiccant, or unwrapping a component that is enclosed with plastic. As two differently charged bodies come close to one another, the attraction becomes stronger. When they are physically close enough, they will balance out, resulting in a spark. That is why it is important for you to follow all technical data when you handle ESSDs or EEDs.

Another potential form of electrical current is through radio frequency (RF) energy. A squib lead can act as a radio antenna making EEDs susceptible to inadvertent ignition by exposure to RF energy from ground and airborne transmitters. Other sources of electrical current are batteries, energized testing equipment, and lightning strikes.

Temperature

Generally, colder temperature equates to an increase in a buildup of electrostatic potential. A decrease in humidity will also lead to increase in electrostatic potential.

Shock

Do not throw, carelessly drop, or roughly handle items that contain explosive material. If you drop an explosive component, packaged or unpackaged, consider it unserviceable, and report this through normal service channels.

Safety precautions and procedures

In most cases, using common sense with ESSDs works well; although, you must follow some specific precautions and procedures that are not dictated by common sense. As a nuclear weapons journeyman, you know the importance of placing shorting plugs (shielding caps) on gas generators and on the connector of the reservoir and valve. Have you actually realized that you have electrical contact with other ESSDs or EEDs in the system? It is important to heed the cautions and warnings in the TOs; they are for you and your coworkers’ safety. You can minimize the effects of static electricity discharges by adhering to the following five rules:

1. Use a shorting plug or cap to provide a short between the pin and case in the circuitry.
2. Do not rub or polish squib parts as this deposits a static charge on insulated metal surfaces.
3. Whenever possible, avoid wearing outer garments made of materials that have static-generating characteristics (e.g., 100 percent polyester, nylon, rayon, and wool). Even though most raincoats are 100 percent nylon, they still can generate high static. Techniques will be emphasized for controlling any discharge prior to exposure to ESSDs or EEDs.

4. Immediately before installing an ESSD or EED into a circuit, perform a stray current check.
5. Most importantly, immediately before handling, connecting, or disconnecting ESSDs, you must equalize your body's static potential to the weapon or component. This means you touch the bare metal of the weapon or component. Under no circumstances do you equalize your static potential by touching a grounding bar or any other grounding source unless directed to do so by the TO. Dissipating body static to ground does not equalize an individual to the potential of the weapon unless the weapon is grounded also.

CAUTION: DO NOT connect any weapon to ground unless directed by the TO.

Handling and storage

Do not store or handle ESSDs or EEDs without proper shielding. Some EEDs use shorting caps and others use shielding plugs. Do not remove the shunt or shorting device except for continuity testing or immediately before connecting the component into the circuit. Store EEDs below the maximum ambient temperature prescribed by the specific TO.

207. Fire prevention and protection

Fire is one of the greatest single hazards in munitions facilities and storage areas. Some explosives ignite at temperatures substantially lower than temperatures needed to ignite wood, paper, or fabrics. Therefore, make every effort to prevent explosives from exposure to excessive temperatures.

Explosives are least hazardous when they are stored properly and when proper work habits are used. Much of proper storage has to do with the elimination or reduction of heat. You can eliminate heat sources or reduce their effect by following standard rules and installing fire prevention devices. We discuss eight rules and devices within this lesson, starting with authorized smoking areas.

Authorized smoking areas

Only smoke in designated areas within an explosive area. Each authorized smoking area will display a certification of approval by the fire chief. In addition, a "no smoking" sign will be posted at each entrance to an explosive storage area to include a notice that flame-producing devices are prohibited in areas where exposed explosives or concentrated flammable vapors are present.

Vehicles and handling equipment

Most nuclear weapon maintenance and storage areas use forklifts and tow vehicles for moving weapons and equipment from one place to another. Do not park vehicles other than those in the actual process of being loaded or unloaded any closer than 25 feet from any explosives storage area or facility. All privately owned vehicle (POV) parking areas must be located *outside* an explosives area.

Proper vegetation control

The primary purpose of vegetation control is to limit the probability of combustible vegetation catching fire and to slow the spread of vegetation fires. Use the following guidelines to determine proper vegetation control:

- Except for firebreaks, limit grounds maintenance in or near explosive storage areas or operating locations necessary to prevent erosion.
- Balance the level of vegetation control with operation factors, such as cost to control, security, erosion prevention, and passive defense (camouflage).
- Wherever feasible, use varieties of vegetation that are resistant to burning.
- When you use animals for vegetation control, use measures to prevent excessive erosion of barricaded surfaces or the earth cover of igloo magazines.
- Where vegetation growth is ineffective in preventing erosion, use a layer of about 2 inches of pressure-applied (gunite) concrete or asphalt mixture.

Firebreaks criteria

Where environmental and security factors allow, maintain 50-foot firebreaks around each potential explosive site (PES). Maintain 5-foot firebreaks around igloo ventilators.

Fire-fighting course of action

Determine general and specific courses of action before a fire occurs. A fast reaction to the beginning of a fire may prevent its propagation throughout the facility or operation. As a minimum, take these actions if a fire starts in your maintenance bay or storage structure. Follow the acronym SPEED:

S—Sound the alarm.

P—Phone the fire department.

E—Evacuate nonessential people.

E—Extinguish the fire if possible.

D—Direct fire-fighting people.

Because we rarely think clearly during a fire, it is important that you know these procedures. Within the explosive storage area, conduct fire drills at intervals not to exceed six months. Keep in mind that each explosives class requires a fire-fighting plan to meet its own peculiar situation. The factors that determine your fire-fighting procedures are the type of weapons involved, the type of sprinkler or fire hose system installed (if installed), and the distance from the fire department.

Fire classification identification

Fires are grouped into four general classes depending on what it takes to extinguish them. A maintenance bay usually has two or more types of extinguishers. If a fire starts, immediately determine its class so that you use the most effective extinguisher on it. Some fire extinguisher agents are ineffective on some classes of fires. Some tend to spread the fire, and if used on an electrical fire, the agent may act as a conductor and permit your electrocution. Now we will discuss the four classes of fires and fire-fighting hazards.

Class A

You can extinguish Class A fires with water or solutions containing water effectively and safely. Class A fires are fires involving ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. The cooling or quenching effect of water is primarily what puts out the fire. Fires in this class are deep seeded in that they can penetrate to quite a depth in the burning material.

Class B

Fires occurring in flammable and combustible liquids and gases, such as gasoline, oil, lacquers, solvents, grease, paints, thinners, or similar substances are Class B fires. The agents required for extinguishing this type of fire are those that dilute or eliminate the air supply, thereby creating a smothering effect.

Class C

Class C fires are those that occur in electrical equipment (computers, power generators, and test equipment). Use extinguishing agents that are nonconductors of electricity. They smother the fire like extinguishing agents used to extinguish Class B fires. A nonconducting extinguishing agent, such as dry chemical or carbon dioxide (CO_2) controls these fires. If you can unplug the test set or otherwise disconnect the electrical power leading to a Class C fire, the fire becomes a Class A or a Class B depending on what is burning. A hazard in fighting a Class C fire is that you can electrocute yourself by using the wrong type of extinguisher. For example, water used on Class A fires, and foam used on Class B fires are both excellent conductors of electricity and can cause an electrocution.

Class D

Class D fires occur in combustible metals, such as magnesium, potassium, powdered aluminum, zinc, sodium, and titanium. These materials are particularly hazardous in their powdered form. Proper airborne concentration of metal dusts can cause powerful explosions if exposed to a suitable ignition source. The extremely high temperatures of some burning metals make water and other common extinguishing agents ineffective. Use dry-powdered extinguishers on Class D fires.

Fire extinguisher requirement criteria

The types and quantities of fire extinguishers for a particular building or area are determined by the base fire department and on the type of fire you will be fighting. An example of this would be using a Class C fire extinguisher on a type C fire. The typical maintenance bay is in a closed, windowless building that constantly contains explosives, flammable liquids, and electrical test equipment. It contains more extinguishers for its cubic capacity than a normal dwelling because all classes of fire are possible due to its contents.

At least two 2A:10B:C-rated fire extinguishers must be available for immediate use when explosives are being handled. They need not be located permanently at the operation site, but they must be in an accessible location and properly maintained. Two 2A:10B:C-rated extinguishers must also be provided on each explosives-laden vehicle used for transport. The prompt use of portable fire extinguishers can avoid serious fires. They are needed primarily for fires involving combustibles such as wood, paper, rubbish, or grass, and lastly, only on such fires that have just begun.

Portable fire extinguishers are classified (fig. 1–2) according to their intended use on the four classes of fire (A, B, C, and D). Besides the letter classification, Class A and Class B extinguishers get a numerical rating. Extinguishers for use on Class C fires get only the letter rating because Class C fires are essentially Class A or Class B fires involving energized electrical equipment. The Class C designation just confirms that the extinguishing agent is nonconductive. Class D extinguishers, likewise, do not have a numerical rating. The effectiveness of the extinguisher on Class D metals is detailed on the faceplate of the extinguisher. Multiple letters or numeral-letter ratings are used on extinguishers that are effective on more than one class of fire.

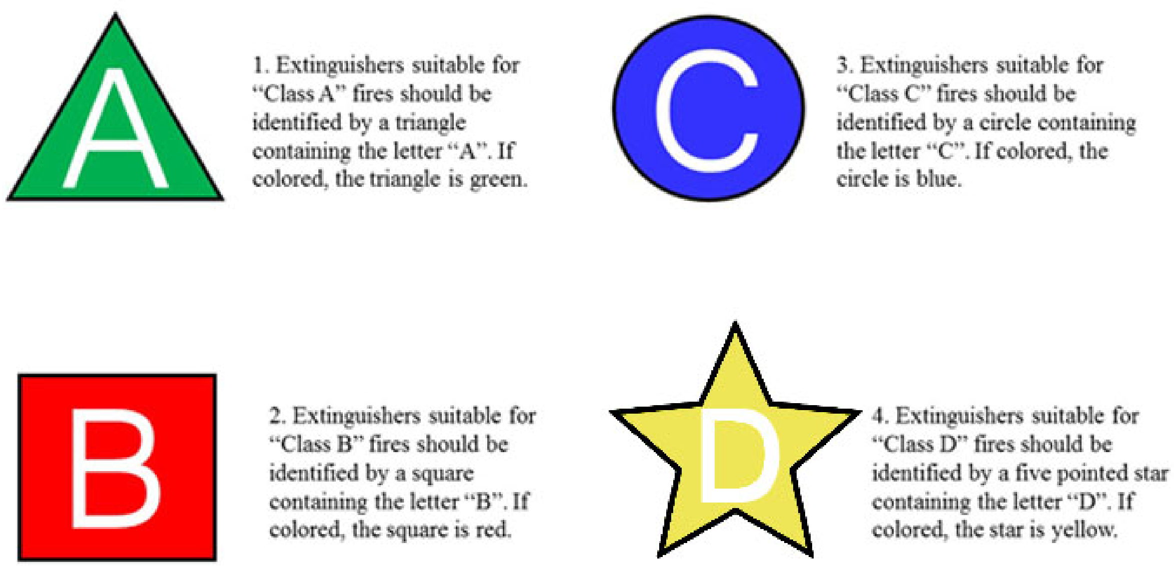


Figure 1–2. Fire extinguisher classification.

We can review the multipurpose extinguisher rated 2A:10-B:C for a better understanding. The ratings are described using numbers preceding the class letter, such as 2A:10-B:C. The number preceding the A multiplied by 1.25 gives the equivalent extinguishing capability in gallons of water. The number preceding the B indicates the size of fire in square feet that an ordinary user should be able to extinguish. An extinguisher will never have a rating of just C. For a *1A* rating, the extinguisher is good for 1¼ gallons (5 liters) of water or water equivalence. A *2A* rating means the extinguisher is good for Type *A* fires with a 2½ gallon (10 liters) water or water equivalence. Therefore, a dry chemical extinguisher rated 2A equals a 2½-gallon water extinguisher. The *10B:C* indicates it should extinguish fires with approximately 10 square feet equivalency. It is also safe to use on fires involving energized electrical equipment.

General fire-fighting policy

Your safety while fighting a fire involving nuclear weapons depends on the accuracy of the information given to the fire-fighting forces. TO 11N–20–11, *General Firefighting Guidance*, has a listing of nuclear weapons and components in various configurations with a line number assigned to each. Therefore, you can inform fire-fighting personnel of precisely what nuclear material is in your area simply by referring to the line numbers in TO 11N–20–11. The policy on fighting fires involving nuclear weapons and components is to fight fires as long as there is a reasonable expectation of any of the following:

- Preventing loss of life or serious injury.
- Preventing scatter of nuclear contamination.
- Salvaging burning aircraft, vehicles, structures, or nuclear contents.
- Preventing property or material damage affecting mission accomplishment.

The ultimate decision to begin fire-fighting efforts, to withdraw from, or continue fighting a nuclear weapon fire rests with the fire chief or senior on-scene fire department official. That person must immediately notify the on-scene commander of the decision to withdraw. The fire chief or senior on-scene fire department official bases that decision on the following compelling factors:

- Status of accident victims (e.g., whether surviving people are trapped).
- Location of the accident (populated area or remote area).
- Number, type, condition, and so forth of the weapon and components involved.
- Current military operational situation.

208. Static grounding and lightning protection

When working with nuclear weapons, you must know about grounding and lightning protection. An electrical storm is considered “in the vicinity” if an official weather report locates lightning flashes within 5 nautical miles (nm). In this case, stop all explosives operations that are outdoors or in any indoor locations that do not have a lightning protection system (LPS). In this lesson, we discuss the pertinent grounding systems and LPS requirements.

Grounding systems

We must inspect grounding systems if they are installed in a facility. The five basic types are lightning grounds, static grounds, equipment grounds, electrical system grounds, and signal reference grounds; however, we will discuss only three of the systems that you are more likely to experience in your work center.

Lightning grounds

Lightning is very dangerous and is a serious concern for all nuclear weapon operations. This is why we install LPSs on various facilities. A *lightning watch* will be in effect 30 minutes prior to thunderstorms observed within a 5 nm radius of the predetermined location. This warning can help your team initiate controlled termination procedures for all explosives operations at outdoor locations equipped with an LPS, to include locations (outdoor and indoor) not equipped with an LPS, facilities containing exposed explosives, explosive dust, or lastly explosive vapor. When nuclear weapons are involved, there will also be observations for lightning within 10 nms. If lightning is within a 5 nm radius, it is considered a *lightning warning.*

Depending on your operating location, you may be required to cease all operations and evacuate all personnel. The purpose of lightning grounds is to dissipate lightning strikes into the earth safely. They are part of an LPS that usually includes air terminals (lightning rods), down conductors, arresters, and other connectors or fittings required for a complete system. The sole purpose of an LPS is to protect a building, its occupants, and its contents from the thermal, mechanical, and electrical effects of lightning. An LPS must be installed on all facilities used for manufacturing, processing, handling or storing explosives, ammunition, explosive ingredients, flammable gases or liquids, and other hazardous materials, except as specifically exempted by AFMAN 91–201. Lightning protective systems must comply with the requirements listed in the National Fire Protection Association (NFPA) 780, *Standard for the Installation of Lightning Protection Systems*. AFI 32–1065, *Grounding Systems,* lists the responsibilities for installation and maintenance of LPSs.

Static grounds

A static ground is a connection between a piece of equipment and earth to dissipate static electricity charges before they reach a sparking potential. Typically, static grounding involves connecting large metal objects such as fuel tanks or aircraft to earth through a ground rod. Static grounds are not part of an electrical power system, but if an equipment-grounding conductor is adequate for power circuits, it is also adequate for static grounding. When making a grounding connection, you should attach the ground wire, cable, or strap to the item requiring grounding first, then connect the other end of the ground wire, cable, or strap to the approved facility grounding system. This ensures that if a spark occurs, it will occur at the connection to the facility grounding system instead of at the item. Just remember you are trying to keep the spark as far away from the item as possible. The phrase “spark away” may help remind you when connecting or disconnecting a static ground.

Equipment grounds

Equipment grounding involves interconnecting and connecting to earth all non-current-carrying metal parts of an electrical wiring system and equipment connected to the system. Grounding is already provided when equipment has a three-conductor power cord fitted with a three-prong polarized plug plugged into the building power supply that incorporates a grounding conductor. The purpose of grounding equipment is to ensure personnel safety by reducing any charge in an equipment item to near-zero volts with respect to ground. Equipment grounds must be capable of carrying the maximum ground fault current possible without causing a fire or explosive hazard, until the circuit protective device clears the fault.

Lightning protection system requirements

Normally, base civil engineers (BCE) maintain lightning and grounding systems. They ensure the user understands their maintenance responsibilities, and provide proper training for users to inspect and maintain these systems. In certain overseas locations, the host nation maintains the LPS systems. If LPSs are installed, make sure BCE interconnects all grounds including static grounds.

LPSs for explosives areas require a visual inspection every 12 months and a continuity and resistance check every 24 months. BCE must check static-bus-bar continuity to ground every 24 months with a reading of 1 ohm or less. Normally, the BCE performs these inspections, but it depends on the location. You, as the user, are responsible for making a visual inspection of static wires and grounds before use each day for hazardous explosives areas and quarterly for nonhazardous explosives areas. You are also responsible for making a continuity check from equipment to static ground bar every three months for a hazardous explosives area.

The BCE must provide copies of the completed inspection and test to the user. Keep records for explosives facilities for at least six inspection cycles. If host nation civil engineers maintain your munitions facilities, you must get a copy of all completed paperwork for your records.

209. Hazards of Electromagnetic Radiation to Ordnance

Electromagnetic radiation (EMR) is all around us and comes from a wide variety of sources. These sources could be the sun, radars, microwaves, radios, and even rotating electric motors, to name a few. When ordnance and their electrically initiated devices (EID) are exposed to EMR, it could be harmless or cause irreparable damage. Therefore, the Hazards of Electromagnetic Radiation to Ordnance (HERO) Program was developed to ensure the safety of ordnance and personnel by creating standards, along with identifying and labeling the electromagnetic environment (EME). Let’s start the lesson by discussing EMR principles.

Electromagnetic radiation principles

An electron or atomic particle that is accelerated by an electric field causing it to move in a wave pattern causes EMR. This movement is an oscillating electric and magnetic field at right angles from each other in a bundle of light energy called a photon. This oscillation causes electromagnetic waves to have certain properties such as a frequency, wavelength, and energy. The properties of certain waves determine the interaction with the matter around it. Figure 1–3 describes a simple electromagnetic wave structure. EMR consists of these waves that radiate from emitters such as an antenna.

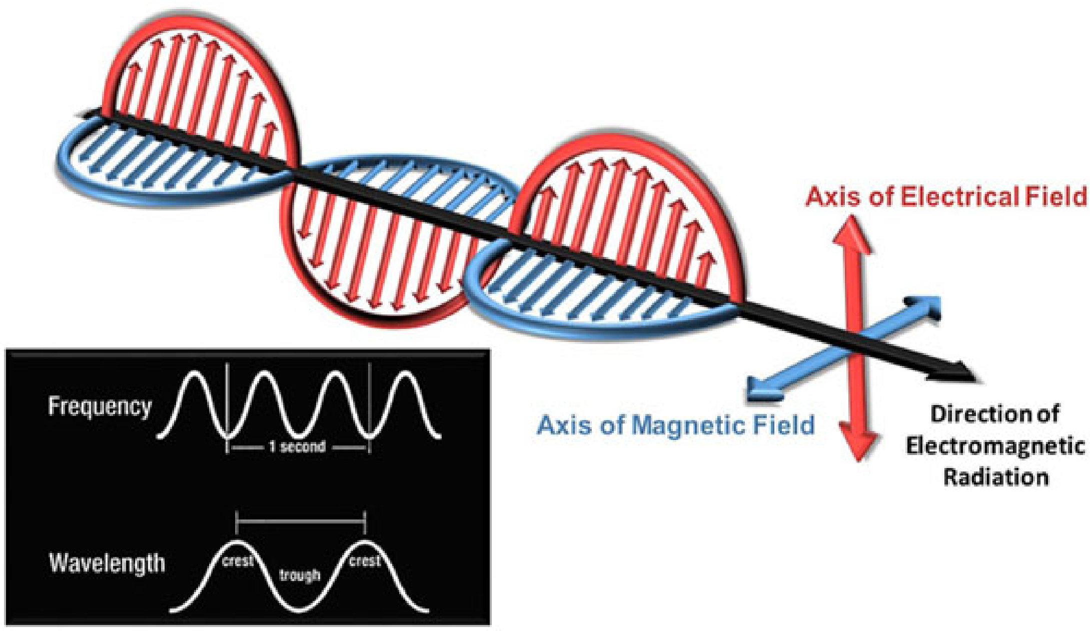


Figure 1–3. Electromagnetic wave.

So what sources are out there? Examples of the frequencies and wavelengths of many different emitters are shown in figure 1–4. The largest concerns are emitters, which are broadcasting intentionally, such as radio antennae (fixed and mobile), ground-based and aircraft radars, and modern mobile emitters (MME). EMR can be absorbed, pass through, or reflect depending on the matter it is interacting. Depending on the frequency and the energy associated, an EMR can induce a current in ordnance wiring, such as the circuits of a firing set or across sensitive electronic components. Induction can cause heat damage to wiring, solder, and circuit cards, or it can cause a device to initiate. This is due to the power of some EMR and the generated magnetic field. It is important to know the EME where ordnance will be maintained, stored, handled, and transported. This is where the HERO Program comes in, which we cover in the next part of this lesson.

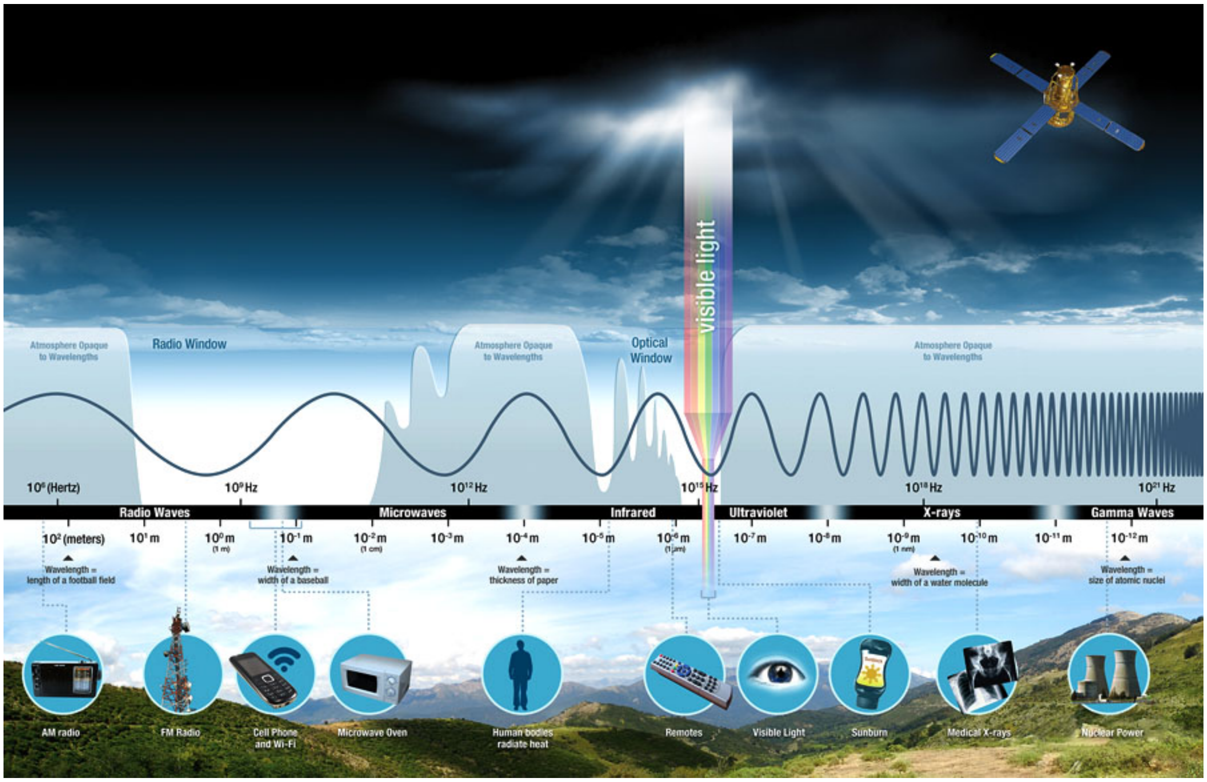


Figure 1–4. EMR sources.

Hazards of Electromagnetic Radiation to Ordnance Program

HERO is an extremely important part of weapon safety and overall nuclear surety. The HERO Program encompasses the establishment and implementation of explosives reliability and safety standards, as well as criteria, instructions, regulations, and electromagnetic emission control procedures of EMR emitters throughout the AF. AFI 91–208, *Hazards of Electromagnetic Radiation to Ordnance (HERO) Certification and Management,* governs the HERO Program. Across the globe, the HERO Program encompasses all AF ordnance to include nuclear weapons. Every ordnance and nuclear weapon must be analyzed under the scrutiny of MIL–STD–464, *Electromagnetic Environmental Effects Requirements for Systems,* to be certified under one of the three following classifications:

1. HERO SAFE—Any ordnance item that is sufficiently shielded or otherwise so protected that all EIDs contained by the item are immune to adverse effects (safety and reliability) when the item is employed in the RF environment delineated in MIL–STD–464. The general HERO requirements defined in the hazards from EMR manuals must still be observed.
2. HERO SUSCEPTIBLE—Any ordnance item containing EIDs proven by test or analysis to be adversely affected by EMR to the point that the safety and/or reliability of the system is in jeopardy when the system is employed in the EME delineated in MIL–STD–464.
3. HERO UNSAFE—Any ordnance item containing EIDs not certified as HERO SAFE or HERO SUSCEPTIBLE as a result of a HERO analysis or test. Additionally, any ordnance item containing EIDs (including those previously certified as HERO SAFE or HERO SUSCEPTIBLE) that consists of any of the following five factors:
   - Has its internal wiring exposed.
   - When tests are being conducted on that item resulting in additional electrical connections to the item.

- When EIDs having exposed wire leads are present and handled or loaded in any but the tested condition.
- When the item is being assembled or disassembled.
- When such ordnance items are damaged, causing exposure of internal wiring or components or destroying engineered HERO protective devices.

The primary objective of the HERO Program is to have all AF ordnance certified as HERO SAFE. During design, ordnance goes through the certification process to ensure their compatibility with their proposed EMR environment. This ensures the ordnance is safe, operates properly, and performs as intended. Our nuclear weapons were built long before the HERO Program. To ensure those weapons are HERO SAFE, they have either recently undergone the certification or are currently in the process. As of the publication of this course, the W80 and B61 modifications 3,4,7,10,11 are all HERO Safe, unless undergoing maintenance, then they are considered HERO UNSAFE. The safest EMR configuration of a nuclear weapon is in “all up round,” which is completely assembled and all connector caps installed. This gives the weapon the most protection from EMR by shielding it from damage.

Electromagnetic environment

Now that you understand the types of HERO certifications, you need to know how we identify the local EME. Every emitter across the installation is surveyed to understand the types of signals being emitted and how they are going to affect our operations. The results of this survey are calculated for each type of emitter using AFI 91–208 and the calculator provided by the Air Force Safety Center (AFSEC)/Weapon Safety Division (SEW). These calculations are plotted on a map to identify the hazardous zones for ordnance. This kind of mapping is used for traditional fixed location emitters (TFE), which consist mainly of stationary antenna on towers or roofs and mobile emitters (ME), such as relocatable radar trailers or vehicles. All of the information from the survey is filed into a HERO survey package, which is maintained by the weapons safety manager (WSM) and reviewed annually. The WSM must be notified of all new or modifications to existing emitters and movement of a ME so they can make the proper assessment for operations.

Another type of EMR hazard you need to be familiar with is an MME. They emit at much lower powers and have the capability of moving with respect to the location of the EIDs. They include items like cellular telephones, barcode readers, wireless laptops, tablets, and network access points. These MMEs can be brought much closer, but require a safe separation distance (SSD) of at least 10 feet from HERO SAFE nuclear weapons. If operations require an MME to be brought closer than 10 feet to ordnance, then the MME must be approved by AFSEC/SEW to do so. A listing of the currently approved MMEs is available from AFSEC/SEW.

So why is all this scrutiny needed? Imagine if a weapon was exposed to high-energy EMR during internal weapons maintenance. The weapon may have had an EID damaged, which cannot be readily seen or inspected. Now the entire weapon may no longer work as intended. This is called “dudding” since this could dud the weapon or make it not produce a nuclear yield. You would never know if the dudding had occurred because you were unable to see the damage caused by the high-energy EMR. The problem may only present itself during its use, and surely, that is not the time to have a weapon malfunction.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

205. Basic explosive safety

1. How must detonators, initiators, squibs, and other such electrically or mechanically initiation devices be handled?

2. Where must you store explosives?

3. What should you use with vehicles and handling equipment in regards to transporting explosives?

4. What is the cardinal principle of explosive safety?

5. When are personnel limits not required to be posted?

6. What should happen during an explosive operation when visitors are present?

7. What are explosive limits based on?

8. What are the two hazards involved with nuclear weapons?

9. What is the storage limitation for IHE?

10. What is the purpose of criticality limitations?

11. What is required if two groups of plutonium-bearing weapons exceed the limitations of combined plutonium weight?

12. What is the hazard of class/division 1.1 explosives?

13. How is a class/division assigned to IHE weapons?

14. What manual and TO do you use to find Q-D criteria for explosives and nuclear weapons?

206. Electrostatic-sensitive devices and electroexplosive devices

1. What must you do if operations being carried out under an ESSD warning or caution are interrupted?

2. What are all EEDs activated by?

3. What situations can cause inadvertent activation of an ESSD or EED?

4. What is static electricity?

5. What are some examples of personnel producing static electricity?

6. What should personnel avoid wearing to minimize the effects of static electricity discharges?

207. Fire prevention and protection

1. What are the requirements for smoking areas within an explosives area?

2. What operational factors are considered to balance the level of vegetation?

3. What is the requirement for firebreaks around igloo ventilators?

4. What actions do you take if a fire starts in your maintenance bay?

5. Define a Class A fire.

6. What are examples of Class B fires?

7. What is the hazard associated with extinguishing a Class C fire?

8. How many fire extinguishers are required for areas where explosives are handled?

9. Explain what the 2A:10-B:C rating on a fire extinguisher means.

10. What is the policy for fighting fires involving nuclear weapons?

11. What factors influence fighting a fire?

208. Static grounding and lightning protection

1. What is the purpose of an LPS?

2. What facilities require lightning protection?

3. What is a static ground?

4. How is grounding provided for equipment?

5. How often do LPSs in an explosives area require a continuity and resistance check? Who makes the check?

209. Hazards of Electromagnetic Radiation to Ordnance

1. What causes EMR?

2. What are the three types of HERO certification?

3. What is the safest EMR configuration for a nuclear weapon?

4. Who maintains the HERO survey package and how often is it reviewed?

5. What is the required SSD for MME not approved by AFSEC/SEW?

1–4. Radiation Safety and Associated Hazards

When thinking about nuclear weapons most people immediately think of radiation. Being in the proximity of nuclear weapons and their components, which emit radiation, is likely a part of your daily duties. Knowing more about radiation and how it affects you will give you a better understanding and respect for it. Radiation is all around us, but you cannot hear, see, taste, or feel its presence. This is why you need to become familiar with how to handle yourself around sources of radiation.

210. Basic radiation safety

Here we will cover what radiation is, the types of radiation, its effects on the human body, materials encountered/handled, and your exposure potential. The knowledge gained here is an extremely important part of your awareness of radiation and for work around nuclear weapons. You must take care to minimize unnecessary radiation exposures. We will begin by defining radiation.

Radiation defined

Radiation is all around us and we are subjected to its effects every day. Things like granite, fertilizer, smoke detectors, even bananas and Brazil nuts are radioactive. Radioactive simply means the atomic structure of something is unstable and in a state of decay. While atoms are losing mass and trying to become more stable, radiation is being emitted. Furthermore, radiation is the emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles that cause ionization through a medium or space. Background radiation is simply the radiation that is present in the environment without the introduction of additional sources. There are different types of radiation and ways to protect yourself from it.

Types of radiation

Radiation is either ionizing or non-ionizing. Non-ionizing radiation is unable to strip electrons from atoms, but is able to excite atoms and heat them up. Some examples of non-ionizing radiation are microwaves, infrared, and light along the visible spectrum. Ionizing radiation, on the other hand, produces enough energy to strip electrons from atoms; this can be directly or indirectly. These radiation types are alpha, beta, and gamma, which are directly ionizing, while neutron radiation is indirectly ionizing (fig. 1–5).

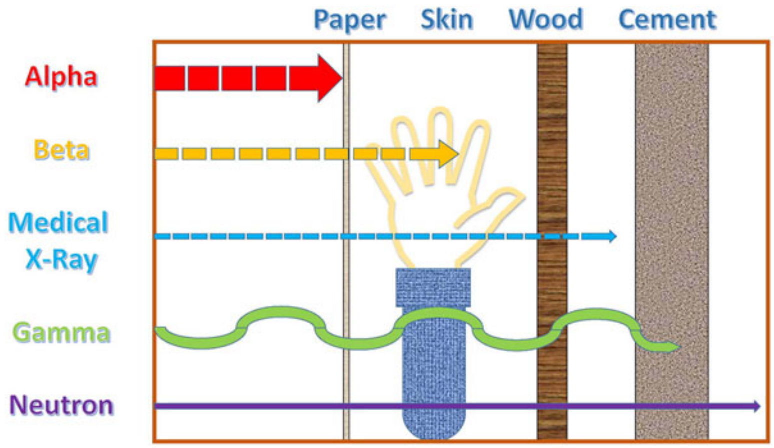


Figure 1–5. Types of ionizing radiation.

Alpha radiation

This type of radiation is a heavy particle, which is actually a helium-4 isotope, and consists of two protons and two neutrons. It interacts strongly with matter due to its atomic structure. However, due to its mass, it can only travel a few centimeters in air and has a limited ability to penetrate other materials. This type of radiation can hardly penetrate the dead outer layer of our skin and can be stopped by a piece of paper.

Beta radiation

This type of radiation is an emission of either an electron or positron from an atom. It has a smaller mass than alpha particles, therefore it can travel a few meters in air and can penetrate skin a few centimeters. Items similar to thin sheets of aluminum or wood can stop this type of radiation.

Gamma radiation

This type of radiation does not consist of a particle and is a photon of energy from an atom. It has no mass; therefore, it can travel a great distance in air and penetrate most materials. Lead plates or other dense materials can stop this type of radiation.

Neutron radiation

This type of radiation consists of a free neutron, which does not have a charge. This means these neutrons could indirectly cause ionization. These neutrons can travel thousands of meters in air and penetrate through most material. Hydrogen-rich material, such as water, can stop this type of radiation.

Radiation effects on the human body

The human body is an amazing organism made up of trillions of cells working together. That working relationship can easily be disturbed when exposed to ionizing radiation. When human cells are exposed to ionizing radiation, it could have several disruptive effects. Some cells lose their ability to reproduce or function, their genetic code can alter leading to the potential of cancer, simply have no effect due to the exposure of radiation, or cause the cell to die entirely. These occurrences are due to the stripping of electrons from the atomic cell structure changing the properties of the cell. Acute exposure to ionizing radiation can easily cause death due to the body's inability to recover quickly enough from the destruction of fragile cells throughout the body.

Materials encountered and exposure potential

Many different radioactive materials make up nuclear weapons. Types, locations, and amounts are classified, but we will discuss a few materials later that are more hazardous than others are. Depending on the weapon system being maintained, you may be exposed to different materials at different levels. A fully assembled nuclear weapon provides a great deal of shielding of its internal radioactive materials and components due to the weapon's case construction. This, however, does not completely eliminate your exposure. You must disassemble nuclear weapons to replace and repair items throughout their lifecycle, and your exposure to radiation is greater during this maintenance because of less shielding.

Exposure during accidents and incidents

While weapon accidents and incidents are extremely rare, you need to be aware of your potential for the increased exposure. In extreme situations, a weapon could be exposed to a fire or to its own HE detonation. During the fire or detonation, particles from the radioactive materials inside could become airborne if the material ejects from the weapon or aerosols from the fire. This could increase the probability of inhalation of the material or absorption through wounds.

ALARA description/definition

AFI 48–148, *Ionizing Radiation Protection*, defines "as low as reasonably achievable" (ALARA) as making every reasonable effort to maintain exposures to radiation as far below applicable dose limits as is practical. Exposure must be consistent with the purpose for which the activity is undertaken, considering the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations. Implementation of AFI 91–108, *Air Force Nuclear Weapons Intrinsic Radiation and 91(B) Radioactive Material Safety Program*, and the ALARA concept must not compromise weapons' safety, security, reliability, or operational mission considerations.

Primary methods of achieving ALARA

The primary methods of achieving ALARA are to comply with the following:

- Minimize the time individuals spend near weapon systems.
- Increase personnel distance from weapon systems.
- Use shielding.
- Take a combination of these actions.

The ALARA concept's intent is not to eliminate all exposure to radiation but to reduce unnecessary exposure. Personnel have the greatest control over minimizing time spent near the weapon systems. An example of reducing exposure would be to stand away from the weapon or component when it is no longer necessary. This could be when preparing paperwork, discussing issues related to the operation, or taking a quick break. The policy of ALARA is to keep your exposure for your day-to-day operations as low as possible.

Annual exposure limits

The roentgen equivalent man or "rem" is the measurement of ionizing radiation exposure to the human body. The higher the rem count equals the more damage occurring to living cells in the body. The current annual maximum exposure limit for an occupationally exposed worker is 5 rem, which equates to 5,000 millirems (mrem). This level of 5 rem is for your exposure during weapons maintenance and handling alone. This does not take into account for the rest of your normal day-to-day exposure to the natural environments, medical procedures, or otherwise. You, as a nuclear weapons maintainer, can expect to be exposed to a level between .016 rem to .128 rem per year on the average. This example given is a four-year average from 2012–2015. Your average exposure as an American is 620 mrem according to the National Council on Radiation Protection and Measurements (NCRP). Figure 1–6 will give you a perspective on where this average comes from.

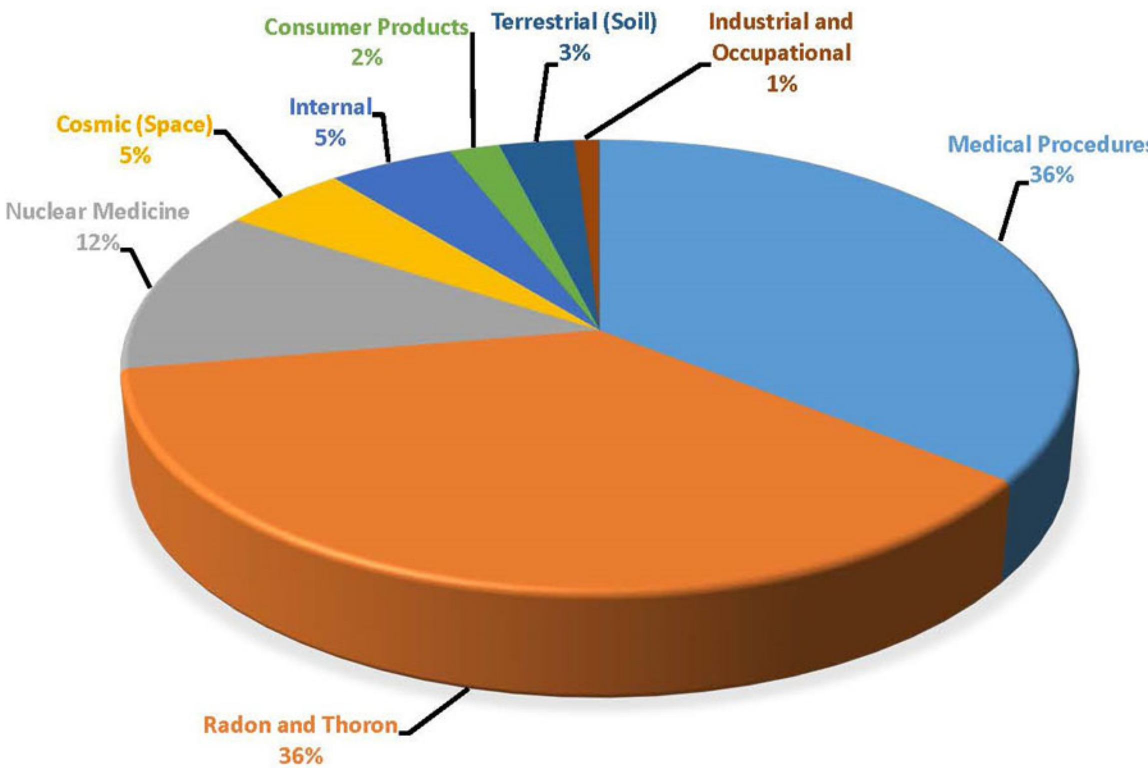


Figure 1–6. Radiation exposure levels.

Intrinsic radiation description/definition

The term "INRAD" is an acronym for intrinsic radiation that is inherent to nuclear weapons and refers to the ionizing radiation emitted through the weapon surface or directly from exposed components of nuclear weapons. The radiation is "intrinsic" to the design of the weapon and consists primarily of alpha, beta, gamma, and neutron radiation emitted from fissionable material. AFI 91–108 provides the necessary guidance for personnel. It is important to remember that small doses of radiation have some chance of causing cancer. This is true of exposure to natural radiation (e.g., sunlight and granite) and those that are man-made (e.g. smoking and radiology procedures). As even very small doses of radiation may have some risk, you should not allow yourself to receive a dose without a reason. At all times, keep ALARA in your mind when working around radiation.

Reducing intrinsic radiation exposure

The INRAD safety program implements the ALARA concept by keeping exposure of persons to ionizing radiation ALARA consistent with operational requirements as well as to make sure individuals are not receiving the maximum permissible dose (MPD). This concept requires reducing or eliminating INRAD hazards at the engineering design stage of a weapon system (that is, before it becomes operational). When exposure cannot be reduced to acceptable levels through engineering design, personal protective procedures and administrative controls (such as time restrictions) are used to keep exposures below the MPD.

As a nuclear weapons technician exposed to INRAD, you are aware of the potential radiation hazards in the workplace and how to protect yourself from those hazards. Female personnel are educated about the risks of ionizing radiation to an unborn child during a pregnancy and monitoring requirements for those who continue to perform duties involving exposure to INRAD while pregnant. The publications you use for on-the-job and upgrade training have only appropriate radiation safety instructions.

There are several things working in favor of reducing personnel exposure to INRAD. Trial programs conducted at AF depots have shown that under normal conditions, personnel will not receive an annual dose more than 500 mrems. There is also an ongoing program to measure the INRAD of all weapons in the stockpile. This information is located in Table 3–1 of TO 11N–20–7. It allows supervisors to calculate the amount of exposure technicians will receive for each type of operation performed.

The primary key to further reduction to INRAD exposure is to apply the principles of time and distance. INRAD exposure is directly related to the time spent near the weapons. Time is of particular value in reducing exposure, since this is the factor over which personnel have the most control. Careful review of work practices and procedures can identify actions that reduce exposure by reducing the time spent near the weapons. Some examples of time control to reduce exposure are as follows:

- Plan the work to be done, including specific work assignments, prior to the start of the operation.
- Gather necessary tools, tech data, and materials needed for the work.
- Avoid any unnecessary work near the weapons.
- Where practical, consolidate work requirements to minimize the total time required in the nuclear weapons maintenance areas.

The ALARA principles and weapon monitoring procedures are means ensuring a safe work environment for AF personnel. Make sure only essential personnel are allowed in weapons handling and storage areas, and their time exposed is minimized.

Dosimeters

You use a dosimeter to track personnel exposure to radiation and at what levels. The specific type used in the field is called a thermoluminescent dosimeter or “TLD” and is an integral part in monitoring the safety of personnel exposure to INRAD. These devices resemble small badges, which are personally assigned to each worker. A TLD can be used to measure electrons (gamma) or neutrons. A TLD is also comprised of a solid crystal structure consisting of lithium fluoride (LiF) or calcium fluoride (CaF) housed by a plastic outer container that clips onto the wearers’ attire. When it is exposed to ionizing radiation, the crystal catches electrons by locking them in its structures. When the TLD is collected on a quarterly basis, it is processed by heating the crystal. This frees the electrons, and in doing so produces light, which is measured to indicate the quantity of radiation the TLD was exposed to. When an exposure level is recorded, it will reside within a permanent record for each person. Always ensure you are wearing TLDs properly to ensure they are able to capture and record your exposure. This record can be requested at any time through the organizational radiation safety officer (RSO).

211. Radiation hazards

In your day-to-day work, you should not be exposed to any significant amounts of radiation; however, when components must be replaced, loaded, or inspected you will be exposed to possible radiation hazards. The two main elements of greatest concern with radiation exposure are tritium and plutonium. Within this lesson, we will discuss those radioactive materials and when danger or exposure is greatest, beginning with tritium.

Tritium exposure

There are many radioactive materials associated with nuclear weapons; but in workers’ minds, the most misunderstood is tritium. Tritium is a radioactive isotope of hydrogen and is extremely rare in the natural world. It is produced in nuclear reactors by the neutron activation of litium-6. The gas is used in nuclear weapon boosting during the initial fission reaction by increasing the neutrons and improving the fission process. The capability of each weapon system relies on a fresh source of tritium for proper weapon operation. Since tritium decays over time, this source must be replaced in a limited-life component exchange (LLCE). During the removal of these components, policy requires technicians to utilize tritium detection equipment. This is to ensure the tritium has not somehow escaped its component. Outside the body, tritium is not a severe biological hazard. Tritium can enter the body in three ways—inhalation, ingestion, and absorption.

Inhalation of gaseous tritium is the least hazardous, due to much of the gaseous tritium being released upon exhaling. It is normal for a small amount of tritium to diffuse through weapons components. Although detectable concentrations can be measured very close to certain components, studies have shown normal dilution reduces these concentrations to background levels by the time they reach a worker's breathing zone.

Absorption and ingestion normally occur after making contact with a surface contaminated by tritium or tritium water vapor (HTO). The hazardous nature of tritium is due to its ability to combine with other materials. Because tritium combines so easily with other materials, it can contaminate surface areas easily by *plating* and *hydriding*. Plating takes place when a thin film of tritium forms on the surface of a metal. Hydriding occurs when tritium chemically combines with a metal. Either way, an absorption hazard exists. When inhaled or in contact with the skin, up to 100 percent of the HTO may be absorbed into the body and be incorporated into body fluids. Once in the body, it can irradiate living tissue. This makes HTO much more hazardous to health than tritium gas. The human body normally eliminates and renews 50 percent of its water in about 14 days. If you become exposed to a significant intake of tritium, doctors may increase the amount of fluid you drink to flush out your system. This can significantly reduce the radiation dose.

Plutonium exposure

Hazards associated with plutonium are directly related to the radioactive properties and principles of the element. Though interactions with this element may be rare, its hazards warrant explicit detail. Plutonium is a heavy metal element with an atomic number of 94, which is produced artificially in breeder-type reactors. In freshly milled form, plutonium is a heavy metal with a shiny appearance like stainless steel. When it is exposed to the atmosphere for any amount of time, plutonium metal oxidizes to a dark brown or black appearance.

There are many different isotopes of plutonium. When bombarding uranium (U) 238 to produce plutonium (Pu), you get Pu^{239}, Pu^{240}, Pu^{241}, and Pu^{242}. Pu^{239} is the desired fissile material and is considered weapons grade. The other isotopes are considered contaminates.

Plutonium is mainly an alpha-emitter and does not cause too much of a concern as an external hazard. However, the greatest hazard for plutonium is as an internal hazard caused by ingestion or inhalation of plutonium particles. These particles will damage delicate internal organs and find their way into bone structure. Your direct exposure to plutonium would only be during accident or incident scenarios. This is due to the plutonium being heavily encased by other elements of the weapon or components surrounding it.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

210. Basic radiation safety

1. What are the two types of radiation and what is the difference between them?

2. What are the four types of ionizing radiation?

3. What does the acronym ALARA stand for?

4. What are the primary methods to achieve the ALARA concept?

5. What are the radiation limits for occupationally exposed workers?

6. What does INRAD refer to, and what is INRAD?

7. When engineering design cannot reduce radiation exposure to acceptable levels, what other methods are used?

8. List four ways to reduce the time spent near weapons.

9. What is a TLD and what is it used for?

211. Radiation hazards

1. In what three ways can tritium enter the body?

2. What makes tritium hazardous?

3. Explain the difference between plating and hydriding.

4. Why is HTO more hazardous than gaseous tritium?

5. What is the radiation danger from plutonium?

Answers to Self-Test Questions

201

1. To protect our vital resources, the Airmen who perform the mission, and prevent occupational deaths, injuries, or illnesses.
2. (1) Safety—providing a safe work environment by making sure work areas and equipment are inspected, mishaps are investigated, and hazardous conditions are abated (removed or decreased).
   (2) Health—eliminating or controlling unhealthy conditions and emphasizing health considerations in the work environment.
3. AFMAN 91–203.
4. (1) S.
   (2) S.
   (3) W.
   (4) W.
   (5) S.
5. To minimize the amount of incidents involving chemically induced occupational illnesses and injuries in the workplace.
6. AF Form 55.
7. Installation bioenvironmental survey reports.

202

1. An unplanned or unsought event or series of events that results in death, injury, or occupational illness, or in damage to or loss of equipment or property.
2. Background, motivation, training, characteristics, personality, awareness, complacency, and supervision of an individual.
3. By the sum of the original cost and replacement cost of an item.
4. (1) Planning and engineering.
   (2) Procedural actions.
   (3) Personnel actions.
5. Education and training.
6. Good working knowledge of the information in the governing manuals.
7. None—no further action is necessary.

203

1. Spills, hazardous vapors, accidental mixture of flammables and combustibles, or industrial hazards associated with handling of containers and products.
2. Manufacturer’s SDS, OSHA regulations, and local chemical safety regulation (as implemented by AF policies).
3. Based on a one-time application (defined as the user completing the procedures once during an 8-hour period), in a well-ventilated area, and following the procedures outlined in the manual.
4. In a warning statement that precedes the procedure before using the chemical product.
5. The user.
6. Wash your hands with soap and warm water, even if you wore gloves.
7. Handle only when it’s necessary, and keep handling time as short as possible. Health hazards are increased by extended exposure.
8. Containers must be clearly labeled with the identification of the material and the appropriate hazard warning(s). Only approved containers can be used and keep container lids tightly closed.
9. Use only in a well ventilated, flame-free, and spark-free area.
10. No more than 120 gallons of chemicals may be stored in a single storage cabinet.
11. (1) Chemical-physical treatments.

(2) Biodegradation.
(3) Incineration.
(4) Land disposal.
(5) Ocean disposal.
(6) Off-site contract disposal.

12. By contract in off-base facilities that meet federal and state regulations.
13. Off-site contract disposal.

204

1. RCRA materials waste, 91b Waste, and potentially mixed waste.
2. Located inside of the associated aft section and inside surfaces of the H1223A/B aft bulkhead cover/ring.
3. RCRA wastes include items such as unusable or spent solvents, lubricants, and paints.
4. Mixed waste potentially 91b.
5. Environmental regulatory compliance.

205

1. Use containers designed to prevent item-to-item contact.
2. In the original containers and in a dry, well-ventilated area.
3. Restraining devices.
4. Expose the minimum number of personnel to the minimum amount of explosives or chemical agents for the minimum amount of time consistent with safe and efficient operations.
5. Aircraft parking locations, even if it’s used for uploading or downloading explosives or at storage locations or licensed explosives storage locations.
6. Stop the explosive operations.
7. Minimum quantity of explosives needed for the operation.
8. Explosive and radioactive material.
9. There are no limitations as long as IHE weapons are the only weapons within the group.
10. To avoid excessive nuclear interaction between nuclear materials of adjacent weapons.
11. Separated by the appropriate above ground intermagazine separation distance, based on the largest, total explosive weight in any single group involved.
12. Explosives and liquid propellants—mass-detonation hazard.
13. IHE weapons depend on the other explosives that they are stored with to give them a class/division.
14. AFMAN 91–201 and TO 11N–20–7.

206

1. Equalize your body potential with that of the weapon or component, as directed in the appropriate weapons manual, before resuming the operation.
2. Squib.
3. Electrical current, temperature, and shock.
4. When electrical charges build up on the surface of a material.
5. By walking across the floor, running a vacuum cleaner, handling a plastic bag for enclosing components with desiccant, or unwrapping a component that is enclosed in a plastic bag.
6. Outer garments made of materials that have static-generating characteristics (e.g. 100 percent polyester, nylon, rayon, wool, etc.).

207

1. Display a certification of approval by the fire chief. In addition, post a “no smoking” sign at each entrance to an explosive storage area to include a notice that flame-producing devices are prohibited.
2. Control cost, security, erosion prevention, and passive defense (camouflage).
3. Maintain 5 feet.

4. You SPEED: S—Sound the alarm; P—Phone the fire department; E—Evacuate nonessential people; E—Extinguish the fire if possible; D—Direct fire-fighting people.
5. Fires involving ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. They can be extinguished effectively and safely by water or solutions containing water.
6. Gasoline, oil, lacquers, solvents, grease, paints, thinners, or similar substances.
7. You can electrocute yourself by using the wrong type of extinguisher.
8. At least two 2A:10-B:C rated fire extinguishers.
9. The 2A is equivalent to a 2½-gallon water extinguisher. The 10-B:C indicates it should extinguish approximately 10 square feet and safe to use on fires involving energized electrical equipment.
10. Fight fires as long as there is a reasonable expectation of doing any of the following: preventing loss of life or serious injury; preventing scatter of nuclear contamination; salvaging burning aircraft, vehicle, structure, or nuclear contents; or preventing property or materiel damage affecting mission accomplishment.
11. The status of accident victims; location of the accident; number, type, condition, and so forth of the weapon and components involved; and current military operational situation.

208

1. The sole purpose of an LPS is to protect a building, its occupants, and its contents from the thermal, mechanical and electrical effects of lightning.
2. Facilities used for manufacturing, processing, handling or storing explosives, ammunition, explosive ingredients, flammable gases or liquids, and other hazardous materials, except as specifically exempted by AFMAN 91–201.
3. A connection between a piece of equipment and earth to drain off static electricity charges before they reach a sparking potential.
4. When the equipment has a three-conductor power cord fitted with a three-prong polarized plug that is plugged into the building power supply that incorporates a grounding conductor.
5. Every 24 months. BCE.

209

1. EMR is caused by an electron or atomic particle that is accelerated by an electric field causing it to move in a wave pattern.
2. HERO Safe, HERO Susceptible, HERO Unsafe.
3. An “all up round,” which is completely assembled and all connector caps installed.
4. The WSM; reviewed annually.
5. At least 10 feet from HERO SAFE nuclear weapons. If an MME requires to be brought closer than 10 feet to ordnance then the MME must be approved by AFSEC/SEW to do so.

210

1. Non-ionizing radiation is unable to strip electrons from atoms, but is able to excite atoms and heat them up. Ionizing radiation produces enough energy to strip electrons from atoms directly or indirectly.
2. Alpha, beta, gamma, and neutron.
3. ALARA.
4. Minimize the time individuals spend in the vicinity of weapon systems, increase people distance from weapon systems, use shielding, and take a combination of these actions.
5. For occupationally exposed workers—5,000 mrems (5 rems).
6. It is an acronym for intrinsic radiation that is inherent to nuclear weapons and refers to the radiation emitted through the weapon surface or directly from exposed components of nuclear weapons.
7. Personal protective procedures and administrative controls such as time restrictions.
8. (1) Plan the work to be done prior to the start of the operation.
   (2) Gather necessary tools, tech data, and materials needed for the work.
   (3) Avoid any unnecessary work near the weapons.
   (4) Consolidate work requirements to minimize the total time required in the nuclear weapons maintenance areas.

9. TLDs and they are an integral part in the monitoring the safety of personnel exposed to INRAD.

211

1. (1) Inhalation.
   (2) Ingestion.
   (3) Absorption.
2. Its ability to combine with other materials.
3. Plating is when a thin film of tritium forms on the surface of a metal. Hydriding occurs when tritium chemically combines with a metal.
4. When inhaled or in contact with the skin, up to 100 percent of the HTO may be absorbed into the body and be incorporated into body fluids. Once in the body, it can irradiate living tissue.
5. Since plutonium is primarily an alpha emitter, we are concerned with it as an internal hazard. The ingestion or inhalation of plutonium particles will damage delicate internal organs and find their way into bone structure.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

1. (201) In which instance will a supervisor perform a job safety analysis (JSA)?
   a. Prior to operating a replacement equipment of the same make and model.
   b. When new hazardous waste disposal procedures are implemented.
   c. When equipment does not have manufacturer’s instructions.
   d. When equipment does not have a technical order (TO).

2. (201) It is the supervisor’s responsibility to reconcile *all* safety data sheets (SDS) on file and the chemical inventory *at least*
   a. annually.
   b. semi-annually.
   c. quarterly.
   d. monthly.

3. (201) Chemicals that ignite at or above 100 degrees Fahrenheit (°F) are classified as
   a. combustible.
   b. flammable.
   c. explosive.
   d. sensitive.

4. (202) The indirect cost of a mishap is about how many times that of direct cost?
   a. 1.
   b. 2.
   c. 3.
   d. 4.

5. (202) Special devices such as machine guards, fail-safe hoist brakes, electric interlock switches on test sets, forklift overhead cage guards, and handrails are *all* examples of
   a. supervisor safety.
   b. safety engineering.
   c. safety enforcement.
   d. applying safety information.

6. (202) Which person or agency associated with the Air Force (AF) may submit a hazard report affecting flight, ground, weapon, or space safety?
   a. Immediate supervisor only.
   b. Quality assurance (QA) only.
   c. Anyone assigned.
   d. Safety office only.

7. (203) The use of personal protective equipment (PPE) is *required* when using hazardous materials because
   a. it is directed by the base hazardous waste manager.
   b. it is directed by the Environmental Protection Agency.
   c. certain chemical products can be used safely without protective equipment.
   d. certain chemical products cannot be used safely without protective equipment.

8. (203) Who is *ultimately* responsible for knowledge of the safety data sheets (SDS) and Occupational Safety and Health Agency (OSHA) regulations?
   a. User.
   b. Supervisor.
   c. Unit commander.
   d. Unit safety officer.

9. (203) A Department of Energy (DOE) manual identifies the requirement, the type, and *minimum* protective equipment you should use when handling hazardous material by
   a. using the information contained in the safety data sheet.
   b. placing a note or statement prior to the procedures for using the product.
   c. providing a warning statement prior to the procedures for using the product.
   d. relying on the experience and training of performing weapons tasks every day.

10. (203) What should you do *before* you use hazardous expendable materials?
    a. Provide adequate ventilation for explosive atmospheres.
    b. Remove detection labels on incoming hazardous expendable containers.
    c. Ensure there are open flames or spark-producing devices in the work area.
    d. Know where the safety data sheets (SDS) are located and what information they contain.

11. (203) What is the *most* frequently used hazardous waste disposal method?
    a. Land.
    b. Ocean.
    c. Incineration.
    d. Off-site contract.

12. (203) Who has the *overall* responsibility for the hazardous waste program from cradle to grave?
    a. User.
    b. Commander.
    c. Superintendent.
    d. Hazardous materials monitor.

13. (204) Compression pads, ungreased O-rings, and desiccant are examples of which type of *waste* generated when a system component becomes contaminated?
    a. Resource Conservation and Recovery Act (RCRA) materials.
    b. Low level radioactive waste.
    c. Potentially mixed waste.
    d. 91b Waste.

14. (205) Where is the *best* location to safely store explosives?
    a. Cool, damp area.
    b. Airtight building.
    c. High-humidity location.
    d. Dry, well-ventilated area.

15. (205) Explosives limits for an operation are based on the
    a. maximum quantity of explosives needed.
    b. minimum quantity of explosives needed.
    c. number of operating personnel.
    d. largest expected workload.

16. (205) In the Department of Defense (DOD) hazard classification system, Class 1 explosives are further divided based on the
    a. physical size of the explosive.
    b. explosive content of the weapon.
    c. hazard and its potential for injury or damage.
    d. shelf life and chemical makeup of the explosive.

17. (205) Which class and division do you assign an insensitive high explosive (IHE) weapon when stored with other IHE weapons?
    a. 1.1.
    b. 1.2.
    c. 1.3.
    d. 1.4.

18. (205) When insensitive high explosive (IHE) weapons are stored with other high explosive (HE) weapons, the class and division that takes priority
    a. contains a nuclear weapon/warhead.
    b. has the larger amount of explosive.
    c. has the most restrictive criteria.
    d. has a conventional weapon.

19. (206) Which feature is *not* a hazard when dealing with electrostatic-sensitive devices (ESSD) or electroexplosive devices (EED)?
    a. Size.
    b. Shock.
    c. Temperature.
    d. Electrical current.

20. (206) Static electricity is produced by
    a. the buildup of an electrical charge on an object.
    b. grounding yourself to a bus bar.
    c. the attachment of a ground cable.
    d. plugging in an electrical tester.

21. (206) When do you remove the shunt or shorting device from an electroexplosive device?
    a. When desiccating the weapon.
    b. Immediately before grounding the weapon.
    c. Immediately before connecting or for continuity testing.
    d. When polishing squib parts and surfaces to reduce static electricity.

22. (207) Vehicles, with the exception of those in the process of loading or unloading, *must* be parked no closer than how many feet from an explosives storage area or facility?
    a. 10.
    b. 25.
    c. 50.
    d. 100.

23. (207) Which type of information found inside Technical Order (TO) 11N–20–11 do you give fire-fighting personnel to inform them of the type of nuclear material in your area?
    a. Explosive quantity per weapon.
    b. Class/division grouping.
    c. Separation distance.
    d. Line numbers.

24. (207) The *ultimate* decision to begin, withdraw, or continue fire-fighting efforts involving nuclear weapons rests with the
    a. fire chief or senior on-scene fire department official.
    b. officer charged with custody of the weapons.
    c. unit or squadron commander.
    d. on-scene commander.

25. (208) A lightning warning is given when lightning is within how many nautical miles (nm) of the operational location?
    a. 1.
    b. 5.
    c. 10.
    d. 20.

26. (208) A visual inspection is performed on a lightning protection system (LPS) in an explosives area every
    a. 3 months.
    b. 6 months.
    c. 12 months.
    d. 24 months.

27. (208) The base civil engineer (BCE) maintains lightning protection system (LPS) records for *at least*
    a. six inspection cycles.
    b. six months.
    c. three inspection cycles.
    d. three months.

28. (209) How often is the Hazards of Electromagnetic Radiation to Ordnance (HERO) survey package reviewed?
    a. Monthly.
    b. Annually.
    c. Semi-annually.
    d. Only when a change occurs.

29. (209) The safe separation distance (SSD) for modern mobile emitters (MME) around nuclear weapons is *at least* how many feet?
    a. 5.
    b. 10.
    c. 50.
    d. 100.

30. (210) Which type of radiation is *not* a type of ionizing radiation?
    a. Alpha.
    b. Gamma.
    c. Neutron.
    d. Infrared.

31. (210) What is the intent of the As Low As Reasonably Achievable (ALARA) concept?
    a. Eliminate all exposure to radiation.
    b. Reduce unnecessary radiation exposure.
    c. Eliminate inherent intrinsic radiation (INRAD) exposure.
    d. Reduce INRAD hazards regardless of mission considerations.

32. (210) What is the *maximum* permissible dose of radiation measured in roentgen equivalent mans (rem) acceptable annually for occupationally exposed workers?
    a. 5.
    b. 10.
    c. 15.
    d. 20.

33. (210) Which option is *not* a characteristic of intrinsic radiation?
    a. Ionizing radiation emitted from radioactive material.
    b. Can be alpha, beta, gamma, and neutron radiation.
    c. It is inherent of nuclear weapons.
    d. It is perfectly harmless.

34. (211) The radioactive material tritium is hazardous due to its ability to
    a. change its structure chemically.
    b. combine with other materials.
    c. explode by static electricity.
    d. settle in low-lying areas.

35. (211) The radioactive material plating is a contamination that occurs when
    a. tritium chemically combines with a metal.
    b. the surface of radioactive metals oxidize and flake.
    c. uranium is exposed to the atmosphere and oxidizes.
    d. a thin film of tritium forms on the surface of a metal.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Technical Orders, Forms, Records, and Reports

THE AF CAN DO VERY LITTLE without the use of publications. Your maintenance shop will need extensive files of TOs, forms, records, and reports to be used to effectively help you do your job and to establish a history for the next person. Without accurate records, you could possibly use an unserviceable item, which could cause an accident; or you could use something that's not properly modified, thereby making it incompatible with the overall weapon system. Reports give the upper echelon an accurate picture of a unit's war capability. We also use them to generate logistic support for your unit and to identify deficiencies in materials developed and bought for the AF. Without paperwork, our mission capability could be impaired or could result in complete failure.

In this unit, we discuss basic TO functions within the system. We will cover the 11N-series, which are the TOs you will use the most. We will provide you information on ways to use a TO and how the TO improvement system works. We will also discuss historical records and reports for equipment items and weapons. You will be introduced to deficiency, mishap/safety, and unsatisfactory reports (UR) and you will learn how to submit them.

2–1. Technical Order Application and Improvement

Every task you do will be done "by the book." The book, in this case, is the technical order also known as a "tech order" or TO. TOs are exactly as their name states—"orders." They are published under the authority of the Secretary of the Air Force, and we must comply with them. TOs must be available in your work area and readily accessible for you to review and consult. To use a TO, you must first find it. Do not hesitate to ask other technicians or your team chief for help to locate the right TO or to identify the right equipment items or part numbers. Somewhere along the way, someone helped them, and later on in your career, you will help others. Along with locating and using TOs, you need to know how to recommend changes and improvements to TOs. Occasionally you may find something in a TO that just does not read or seem right. The TO improvement system gives you a chance to clarify instructions or to correct obvious technical errors. In the following lessons, we discuss TO use and the improvement system.

212. Using technical orders to perform tasks

One of the most difficult problems a team chief has while he or she performs nuclear weapons maintenance is getting team members to wait for each verbal command before they perform a procedural step. For instance, you, as a highly trained technician, will probably know the operation extremely well and know every step. This may incline you to try and complete a step without any direction from the team chief. You might think you know the procedures from memory, but the odds are you may incorrectly perform a weapon operation without your team chief's verbal commands. If you don't follow proper procedures, you can forget a step, miss a safety check, inspect out of sequence, or miss a recent change in the TO that is critical to the weapon system. But most of all, you might damage the weapon system or seriously injure or even kill a fellow team member.

Technical orders principles

Some basic principles to follow when using TOs and technical manuals are as follows:

- Know which TOs are available.
- Know how to locate information.
- Have the TOs on hand.
- Know how to apply the information.

These principles are obvious and overlapping. As simple as they are, not applying them in whole or in part is a basic cause of poor maintenance. Let’s take each principle and discuss some practical applications starting with knowing which TOs are available.

Technical orders availability

There are many TOs available to technicians. The primary ones used in most day-to-day operations are the 11N-series TOs. Each TO serves its own individual purpose and contains information that may be needed in conjunction with another TO. This can occur when you start combining operations that cross between the DOD- and DOE-owned systems or equipment. Knowing the TOs and what they contain is of the utmost importance when completing any maintenance operation. Just about everything we do has a direct reference to a TO or another publication.

Your unit maintains a library with all the TOs that prescribe maintenance for each item of equipment you have on hand, whether it’s a hard copy product or an electronic version. This includes multimeters, test and handling (T&H) equipment, common test equipment, radiac (radioactivity, detection, indication, and computation) sets, air compressors, forklifts, and vehicles—any item you use. Some items, like vehicles, may not require maintenance TOs if, for example, a group other than your organization provides the maintenance on the equipment. Each item of equipment has its own TO or is included with another item. In some cases, there may be other technical manuals that you will need, such as manufacturer’s instructions for equipment not yet having a TO.

Technical orders indexes

It is unlikely that you can follow procedures or obey instructions when you do not know where to find them. In some cases, you may not know the TOs you need (by number) or what information is available in manuals other than those in the 11N series. Under such circumstances, you can do only part of your job.

Use TO indexes to locate information by using the following procedure. If you know the type of equipment, you can locate the applicable TO index by using either the alphabetical index or the numerical index of indexes, 0–1–01, *Numerical Index*. Using the numerical index is often slow because it requires checking each listing if you are not familiar with the series.

As an example, suppose you want to locate the TOs on torque wrenches. A torque wrench is a standard hand wrench unless it is designed to perform a specific job. Use TO 00–5–18, *AF Technical Order Numbering System,* since this TO describes the procedures and techniques used to assign TO numbers to technical data used to operate, install, maintain, inspect, perform procedural functions on, and modify AF weapons systems and equipment. Find “Wrenches (Standard Tool)” in TO 00–5–18 and you’ll notice it’s located in the 32B14 series. This means the TO index you need is 0–1–32, *Numerical Index for Standard and Special Tools*. Looking in the TO numbering section of TO 00–5–18, locate category 32—“Standard and Special Tools.” Here you find hand wrenches listed in 32B14–3. Going on to index 0–1–32, you find torque wrenches listed in 32B14–3–1, –2, and –4. At this point, you can identify the particular TO that matches your wrench. If not, try looking at a copy of each listed TO and find the one you require. This procedure is straightforward; however, you may find that you may need practice locating a particular TO you need to accomplish your job. Do not get frustrated; the process will become easier the more you do it.

In trying to locate copies of these TOs, you may find that they are not in your organization. If they are not, check the base TO library. Once you identify a TO as the one you need, requisition it through your local technical order distribution office (TODO).

When you have located the correct TO, you must know how to find the information in the TO. Once again, the TOs you will use the most are the 11N series. A good working knowledge of the different sections in an 11N-series TO is a great aid in locating desired information and procedures.

Typical –1 technical order

The weapon maintenance procedures in the –1 book are divided into a number of sections relating to different types of maintenance actions required and general information. A typical –1 has these sections as outlined in the next table.

Section	Title
Section 1	Introduction
Section 2	Special Equipment
Section 3	Inspection and Test
Section 4	Preparation For Strike
Section 5	Preparation for Storage and Shipment
Section 6	Maintenance
Section 7	Emergency Procedures
Addendum A	Permissive Action Link (PAL) Procedures
Addendum B	Command-Disable Procedures
Addendum C	Continuity

Different weapons' TOs may have added sections or slightly different section titles. Knowledge of this format is an aid in locating information quickly in the TO.

Applying maintenance instructions

Methods of applying maintenance instructions are largely determined by the type of information involved (procedural or general). Follow procedural instructions according to the step-by-step format in which they are written. General instructions, such as ones found in safety manuals, have rules you must also always follow.

Procedural

Follow procedural instructions by complying with the instructions in the manual or by using a checklist. To use a checklist, you must have a full understanding of the main TO before using the abbreviated version. Job complexity and your skill influence the way you follow instructions. A proficient technician can read the abbreviated instructions and then do all the steps of the task. In more complicated situations, you may find it necessary for one person to read the instructions and another to perform that task—the supervisor decides if you should use this method.

General

General instructions require a different technique. These instructions, for example, are the type that require a forklift operator to shut off the engine and lower the tines before getting off the forklift. Other examples include wearing PPE when using solvents, weight-testing hoists periodically, checking speed limits when moving weapons, and using nonsparking equipment. Each of these instructions requires both supervisors and workers to have prior knowledge of the requirements and to make provisions for them before starting routine maintenance. Checklists include reminders of important items that should be available (e.g., the type and number of fire extinguishers). Following general instructions can become a hazardous habit of the maintenance crew because the prime interest is to inspect the weapon. Do not let this happen.

Demand-response technique

While performing any certifiable operation, the team chief is in charge and requires feedback from his or her team members. This feedback is called verbal demand and response. This ensures that the team members, along with the team chief, understand the step to be performed and when it is completed. The team chief will read the step to be performed, along with all notes, cautions, and warnings to technicians performing the work. The performing technicians will acknowledge understanding, perform the step, and then verbally verify completion to the team chief reading the step. The team chief reading the step will then check off the step in the TO and repeat this until the maintenance operation or handling task is complete. The following bullets provide an example of this:

- Team chief reads, “Ensure ejector rack hooks are fully engaged.”
- Team members will acknowledge the step by stating, “Noted!” and then perform the step.
- Once the step is complete, the team members will state, “Engaged.”
- The team chief will verify the step is complete, check off the step in the TO, and then read the next step.

If technicians are using TOs and checking off steps as they perform them (such as the cleaning person on LLCE operations), a team chief must ensure all steps are completed prior to weapon/component reassembly.

NOTE: The demand-response technique or checking off steps is not required in both operations and maintenance and methods and procedures TOs (e.g., 11N–35–51, *General Instructions Applicable to Nuclear Weapons;* 1–1A–8, *Application and Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment*; and 00–25–234, *General Shop Practice Requirements for the Repair, Maintenance, and Test of Electrical Equipment*).

Any time you are unsure of the steps the team chief reads, ask for an explanation or clarification. *Never perform a task unless you know exactly what is required.* During your initial training and the first few operations, read the TO word for word; then, as your system knowledge and experience increases, you can summarize or condense steps and notations. However, you must do this in such a manner that you can understand exactly what is expected.

Authorization and referencing

TO 11N–35–51 is “the book” you use for general nuclear weapons maintenance. You should become as familiar with this manual as much as you can. The –1 and –1A constantly refer you to this manual for general maintenance instructions. When you are referred to TO 11N–35–51 for a maintenance action, you will find that the referencing manual quotes the title of the procedure exactly as it is worded in the table of contents of TO 11N–35–51. With one exception, you can use these procedures *only* when referred to them by the governing manual. The one exception is section 2. This section always applies to DOE war reserve materiel, with or without specific reference from other manuals. Procedures from 11N–35–51 apply to DOD specially designed (service) materiel only when specified in the referencing manuals.

Nuclear weapons publications frequently make use of certain notational directives; you should know what they mean. Three of the most common directives are the following:

1. Record—This word is used when you must make a permanent entry.
2. Make a Note of—This phrase is used when you must make a temporary record.
3. Note—This word is used when only a mental reference is required.

Marking in manuals

All TOs that require a step-by-step procedure should have their pages in page protectors. You can mark on the plastic surface of these page protectors to add check marks by each step. Adding a check mark will ensure once you complete a step, it is marked off. You can also “road map” your operation by adding notes or tabs to the page protectors to help direct you along the way. You can do this if the notes clarify procedures without altering the procedures or their intent. Setting up your operation this way can improve your efficiency and help you keep on track.

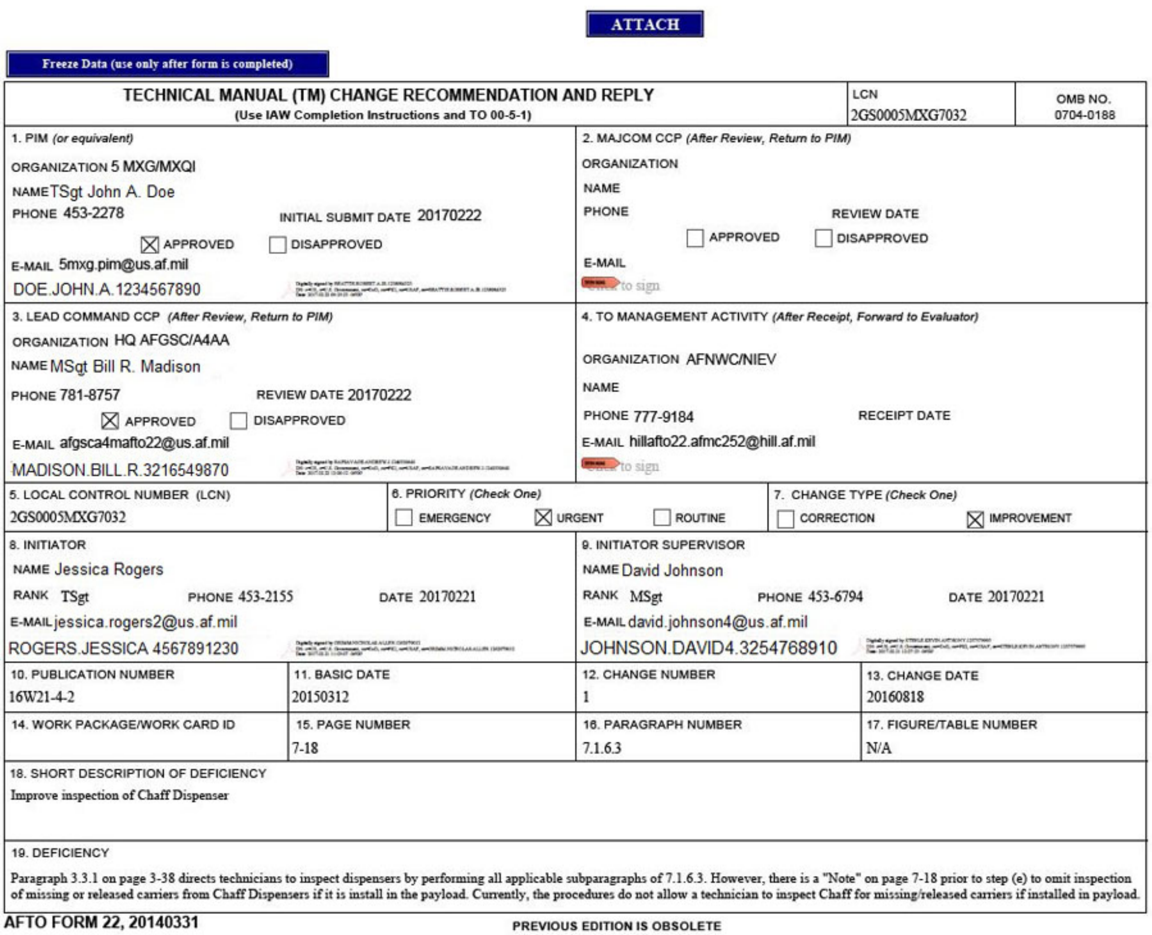
213. Technical order improvement system

Sometimes in your daily use of TOs, you find errors in the written material or in illustrations. Some are obvious typographical errors, while others are incorrect instructions. The former is minor, but the latter can be harmful. The TO improvement reporting system provides a way of correcting errors by using an Air Force Technical Order (AFTO) Form 22, Technical Manual (TM) Change Recommendation and Reply.

Technical order improvement report

You may find it difficult to decide if a TO deficiency is the type you should report. You submit recommendations for TO improvements to correct errors or to correct omissions of a technical nature. When you submit a recommended change, submit it against a single discrepancy and attach all necessary supporting documents. Identify the TO (publication number, basic date, change number, and change date) and the item within the TO (paragraph, figure, table, or task identifier) requiring improvement or correction. Also recommend a corrective action, a change type, and a priority.

The recommended change type is either an “improvement” or “correction.” An “improvement” will result in an addition or significant change to a process or procedure, which allows a function to perform better, safer, faster, or cheaper. A “correction” merely fixes a minor error or omission in the TO. You should base the recommended priority on the likelihood that adverse consequences will occur and also include, the degree of adverse impact if the change is not implemented within a given timeline. Figure 2–1 shows a sample TO improvement report.


ATTACH

Freeze Data (use only after form is completed)

TECHNICAL MANUAL (TM) CHANGE RECOMMENDATION AND REPLY
(Use IAW Completion Instructions and TO 00-5-1)

LCN 2GS0005MXG7032

OMB NO. 0704-0188

1. PIM (or equivalent)
ORGANIZATION 5 MXG/MXQI
NAME TSgt John A. Doe
PHONE 453-2278
INITIAL SUBMIT DATE 20170222
☒ APPROVED ☐ DISAPPROVED
E-MAIL 5mxg.pim@us.af.mil
DOE.JOHN.A.1234567890

2. MAJCOM CCP (After Review, Return to PIM)
ORGANIZATION
NAME
PHONE
REVIEW DATE
☐ APPROVED ☐ DISAPPROVED
E-MAIL
to sign

3. LEAD COMMAND CCP (After Review, Return to PIM)
ORGANIZATION HQ AFGSC/A4AA
NAME MSgt Bill R. Madison
PHONE 781-8757
REVIEW DATE 20170222
☒ APPROVED ☐ DISAPPROVED
E-MAIL afgsca4mafto22@us.af.mil
MADISON.BILL.R.3216549870

4. TO MANAGEMENT ACTIVITY (After Receipt, Forward to Evaluator)
ORGANIZATION AFNWC/NIEV
NAME
PHONE 777-9184
RECEIPT DATE
E-MAIL hillafto22.afmc252@hill.af.mil
to sign

5. LOCAL CONTROL NUMBER (LCN)
2GS0005MXG7032

6. PRIORITY (Check One)
☐ EMERGENCY ☒ URGENT ☐ ROUTINE

7. CHANGE TYPE (Check One)
☐ CORRECTION ☒ IMPROVEMENT

8. INITIATOR
NAME Jessica Rogers
RANK TSgt PHONE 453-2155 DATE 20170221
E-MAIL jessica.rogers2@us.af.mil
ROGERS.JESSICA 4567891230

9. INITIATOR SUPERVISOR
NAME David Johnson
RANK MSgt PHONE 453-6794 DATE 20170221
E-MAIL david.johnson4@us.af.mil
JOHNSON.DAVID4.3254768910

10. PUBLICATION NUMBER	11. BASIC DATE	12. CHANGE NUMBER	13. CHANGE DATE
16W21-4-2	20150312	1	20160818
14. WORK PACKAGE/WORK CARD ID	**15. PAGE NUMBER**	**16. PARAGRAPH NUMBER**	**17. FIGURE/TABLE NUMBER**
	7-18	7.1.6.3	N/A

18. SHORT DESCRIPTION OF DEFICIENCY
Improve inspection of Chaff Dispenser

19. DEFICIENCY
Paragraph 3.3.1 on page 3-38 directs technicians to inspect dispensers by performing all applicable subparagraphs of 7.1.6.3. However, there is a "Note" on page 7-18 prior to step (e) to omit inspection of missing or released carriers from Chaff Dispensers if it is install in the payload. Currently, the procedures do not allow a technician to inspect Chaff for missing/released carriers if installed in payload.

AFTO FORM 22, 20140331 PREVIOUS EDITION IS OBSOLETE

Figure 2–1. Sample, AFTO Form 22.

Technical order recommendation priorities

The title of each priority shows the seriousness of the needed improvement. The recommendation priority determines the transmission method, routing and the timeline for implementing, downgrading or disapproving the recommended change. Start and submit emergency reports immediately. Refer to TO 00–5–1, *AF Technical Order System*, for specific instructions on who to address and how to make entries on the AFTO Form 22. The three priorities associated with TO improvements are emergency, urgent, and routine.

Emergency recommendations

These describe TO deficiencies that affect safety and unit mission. If not corrected, the deficiencies *would* be fatal or cause serious injury to personnel, cause extensive damage or destruction of equipment or property, or create an atmosphere for the inability to achieve or maintain operational posture (MISSION ESSENTIAL), to include field-level work stoppage. In addition, an emergency priority includes discrepancies that directly affects the handling, maintenance, operations, transportation, training, and testing or storage of nuclear weapons.

The activity that corrects the deficiency must act within 48 hours (72 hours for work stoppage) after it receives one of these reports. The correcting activity issues an interim time compliance technical order (TCTO), rapid action change (RAC) or an interim supplement. The correcting activity must also include any disapproval or downgrade of the recommendation.

Transmit emergency recommendation reports as a “high” precedence electronic mail (e-mail). The subject of the messages will be “EMERGENCY AFTO FORM 22.” A read receipt will be used on all e-mails.

Urgent recommendations

These reports require action on a TO deficiency that *could* cause personnel injury or damage to equipment or property, reduce operational efficiency, threaten the safety or success of the mission, or could result in over $25,000 or 1,000 man-hours in annual savings to the AF. You submit TCTO deficiencies and replacements for hazardous materials as urgent reports. The correcting activity issues a corrective TO change, revision, or supplement within 40 calendar days after receiving an urgent report. No reply is made to the report unless it is disapproved, downgraded, or an action cannot be completed within 40 days.

Routine recommendations

These reports are for TO deficiencies that do not fall into emergency or urgent categories. You submit a routine report for TO improvements to simplify work, clarify procedures, or report a condition that, through continued use, may have a negative effect on the operating life of equipment. The activity that corrects a deficiency replies to routine reports within 45 days, stating the action taken or the reason for disapproval. Normally, routine recommendations are published and distributed in a TO within 365 days after receipt of the AFTO Form 22.

Air Force Technical Order Form 22/preparation and submission

A technician of any grade or rank can submit an improvement report. The AFTO Form 22 report comes close to being a personal report from the worker to those who can correct the deficiency. To provide control of DRs and to prevent their indiscriminate use, the initiator’s supervisor and the product improvement manager or equivalent must sign the report. Since each MAJCOM has different requirements for routing and preparation, be sure to follow your particular MAJCOM’s directions. QA often acts as the product improvement manager. The supervisor ensures the report is accurate and approves its submission. QA reviews and validates the report and then forwards it on to the next level.

Detailed instructions for preparing and submitting an AFTO Form 22 are in TO 00–5–1. Read the entire section and follow the instructions when you prepare a report, particularly your first report. After that, preparing a report is a simple matter. Approved AFTO Forms 22 can also be submitted

IAW AFI 38–402, *Airmen Powered by Innovation and Suggestion Program*, to potentially be eligible to receive monetary awards.

If you complete an AFTO Form 22 that contains classified data, mark it with the proper classification and appropriate downgrading and declassification instructions. If you make an unclassified report on a classified manual, identify it as unclassified on all AFTO Forms 22. Use the statement: “This is an unclassified AFTO Form 22 on a classified manual.” If you find a security violation involving a TO, you should report it accordingly.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

212. Using technical orders to perform tasks

1. What are the primary TOs available to nuclear technicians?

2. What TO describes the procedures and techniques used to assign TO numbers to technical data?

3. In a typical –1 TO, where would you find emergency procedures?

4. When can a technician use a checklist?

5. When do technicians use a verbal demand-response technique?

6. When is a verbal demand-response technique not required?

7. With the exception of section 2, when may you use the maintenance procedures covered in TO 11N–35–51?

8. When a TO tells you to “record” something, what should you do?

213. Technical order improvement system

1. What is the purpose of the TO improvement reporting system?

2. When you submit a TO change, what is the difference between an “improvement” or a “correction” recommended change type?

3. By what method must you submit an emergency report?

4. What could be the results of not submitting an urgent report on a TO deficiency?

5. Why do you submit a routine report?

6. When are routine recommendations normally published and distributed in a TO?

7. Why must the initiator’s supervisor and QA person sign the AFTO Form 22?

8. How do you mark the AFTO Form 22 if you make an unclassified report on a classified manual?

2–2. Nuclear Weapons Records and Forms

Mission accomplishment is directly related to the status (or serviceability) of weapon systems and SE. It would be impossible for anyone to maintain an accurate picture of a unit’s ability to meet its mission without the aid of a necessary evil—paperwork! You create all paperwork for one major purpose—to inform. In order to keep people informed at all levels, we have records and reports. Some of these reports indirectly end up updating the Joint Chiefs of Staff and even the president. The Defense Integration and Management of Nuclear Data Services (DIAMONDS) is an auditable system and replaces many past paper processes or accountable documents.

In this section, we cover the documents you often use to support your mission. We cover equipment and weapon historical records as well as reports submitted to various agencies to keep them informed of such things as weapon status and serial number association. You can find step-by-step instructions for using DIAMONDS in TO 11N–3150–8–1, *USAF DIAMONDS Policy and Procedures*.

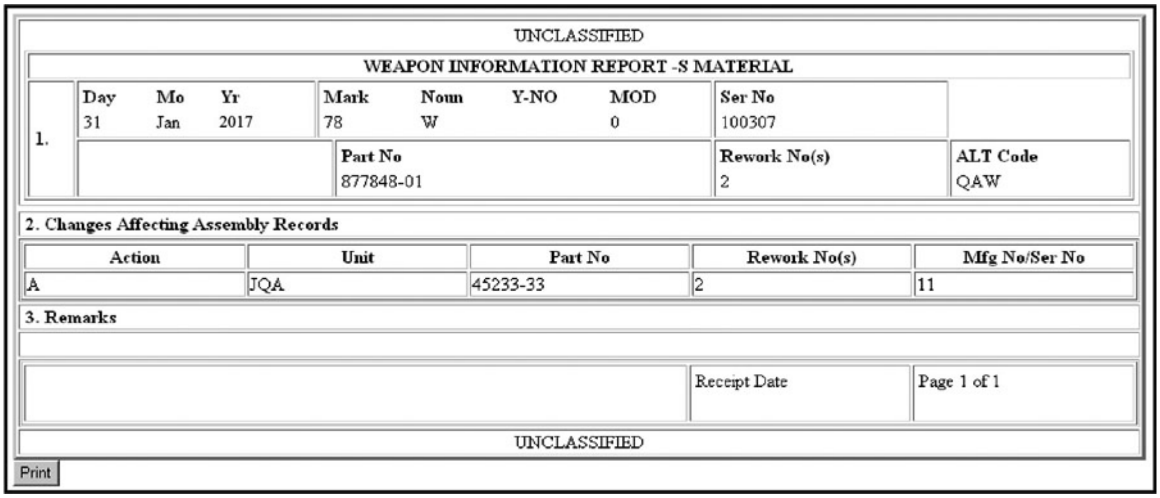
214. Weapon records and forms

The forms and reports you complete on the weapon systems at your base provide historical data for numerous agencies throughout the AF and the DOE. You use the data to maintain accountability of components and weapons, perform quality studies, and even provide the history of a weapon from the production agency until its retirement. In this lesson, we will discuss the following records and forms: weapon information report (WIR), maintenance activity report (MAR), electronic inspection record card (eIRC) or inspection record card (IRC), and storage location and planning report (SLPR).

Weapon information report

The WIR (fig. 2–2) is more like a record than a report. It provides Sandia National Laboratories (SNL)/DOE with a record of assembly information on specified S (Sandia) material. You will need this information to maintain records of component association to support stockpile quality studies. Actions that require a WIR are changes in association with any S material or any serial/manufacturing numbered weapon components associated with S material. TO 11N–35–50, *Instructions for Completion of Nuclear Weapon Information Reports*, gives instructions for filling out WIRs. It also lists some items that do not require reporting. Unless you are directed to do so by a specific weapon publication, you *do not* report the following items:

- Limited-life components (LLC).
- Strike enable plugs, pullout cables, lift lugs, stabilizer bands, spin-rocket port covers, and fins of a weapon that may have several alternates. For weapon assembly, these items may be associated with the weapon or disassociated from it and stored in bags, base spares, or other locations.
- The same serial/manufacturing numbered component that you added and removed or removed and added.
- Alteration (ALT) 900-series removed or replaced components.


UNCLASSIFIED

WEAPON INFORMATION REPORT -S MATERIAL

1.	Day 31	Mo Jan	Yr 2017	Mark 78	Noun W	Y-NO	MOD 0	Ser No 100307
				Part No 877848-01			Rework No(s) 2	ALT Code QAW

2. Changes Affecting Assembly Records

Action	Unit	Part No	Rework No(s)	Mfg No/Ser No
A	JQA	45233-33	2	11

3. Remarks

Receipt Date | Page 1 of 1

UNCLASSIFIED

Print

Figure 2–2. Sample, WIR.

DIAMONDS is the primary means for reporting WIRs. If information is not available or applicable for a particular area, leave it blank. Never disassemble an item merely to get a number.

Using DIAMONDS to create a weapon information report

The WIR consists of three parts (1) header, (2) components, and (3) remarks. From the main menu, screen select “Maint Ops” and then “WIR.” Select the “Create/Modify” tab and then in the “WIR Header” field, select “New.” A pop-up will appear and you must select the correct weapon designator, part number, and serial number and then select save. Then, in the “WIR Components” field, select “New.” This will allow you to use a radio button to add a new component by adding unit, part number, rework number, manufacture number or serial number, and then select save. You can add more if required. Lastly under the “WIR remarks” field, select new and add any remarks to the WIR by typing in the space provided. After all of the information is in the WIR, it can be printed by following the prompts. The WIR will be transferred upon checking in the laptop.

Maintenance activity reports

When you perform weapons maintenance, more often than not, a MAR is required. This is because you must report certain operations and transactions that affect a major assembly or component. Your shop must submit a MAR to the Nuclear Accountability and Reporting Section (NARS) each day a reportable change occurs. TO 11N–100–3150, *Joint Reporting Structure; Nuclear Weapons Reports*, lists the items that you must report. Some examples of reportable changes are the following:

- Weapon or LLC receipt, shipment, addition, or deletion.
- Weapon code, ALT code, color code (operational "Y" or nonoperational "R"), or charge code changes.
- Weapon association, loss, or destruction.
- LLC removal and installation.
- Weapon LLC exchange.

As the user, you assemble each maintenance transaction into a MAR in DIAMONDS. From the "Maint Ops" drop-down menu in DIAMONDS, you can access all of the current MARs. Once your MARs have been completed, they must be verified and submitted to NARS by a user with the proper supervisory privileges in DIAMONDS. This is usually a bay chief or higher. When they arrive in the processing chain for NARS, they will be reviewed once again for accuracy and either approved or rejected/returned to maintenance for correction. There are so many different MARs and ways to produce them via DIAMONDS; you need to thoroughly review 11N–3150–8–1 for exact procedures governing each one.

When LLCs are removed and installed, you must report the serial number of associated and unassociated LLCs. Accuracy is extremely important when completing the MAR. When you receive shipments of weapons and certain other items, you must perform a verification/receipt inspection and submit a MAR. A MAR is also required for custody transfers that happen during operational movements between your shop and a launch facility or strike/strategic aircraft, for example.

Electronic inspection record cards

AF organizations responsible for assembly, storage, inspection, maintenance, monitoring, handling, or shipment of DOE nuclear weapons materiel will use DIAMONDS for processing and handling eIRCs. The eIRC provides a record of specific historical actions performed on each individual weapon. DIAMONDS does not support eIRCs for non-war reserve shapes so you will have to maintain paper IRCs, the Sandia Form 5700, Inspection Record Card, for non-war reserve shapes according to TO 11N–35–7, *Inspection Records*.

General information

You should consider eIRC entries as part of the operation you perform. The operation is not considered complete until you have made all the entries. Two sections make up the eIRC—Heading and Operation. The heading contains all of the identifying information for the weapon. The operation section contains the inspection or operation that was performed along with the date completed and signatures of the technician and the verifier.

To make entries on weapon records, you must refer to TO 11N–35–7 and 11N–3150–8–1, which gives complete guidance concerning eIRCs and the entries that are required. Because eIRC is a historical record and accuracy of the information is extremely important, use DIAMONDS to select the standardized eIRC entry for the operation performed. If selections do not fully describe the operation you performed, use the eIRC Amplification area to describe the operation or defect accurately. DIAMONDS supports editing the entries you make until the eIRC is submitted. Each entry requires two individuals, a technician and verifier, to complete it. DIAMONDS uses each individual's specific log-in to create a unique electronic signature. Once both individuals have completed the entry, the verifier can select "Submit IRC Now" or "Close." When selecting the option to submit it, or when NARS completes an end of day on DIAMONDS, it will cause the eIRC to become historical. Before correcting historical entries that are obviously in error, believed to be in error, made by other DOD organizations, or typographical, you must submit a UR. Selecting "Close" will place it in an "IRC Awaiting Action" section until it is submitted. If an entry is corrected, it will be "lined-out" and requires a new entry. The entry will state the date of the lined-out entry, the purpose for the line out, and the authority such as the UR number. The new entry will require two signatures, and the person creating the entry will have their name in the “MONITOR” column of the lined-out entry.

Heading section
DIAMONDS automatically corrects or updates the entries in the heading blocks at the top of the form, as necessary, to reflect changes, although you will still be required to enter specific drop/rework number information.

Operation section
In this section, you will find entries covering historically significant inspections and operational events specified in assembly, test, storage, maintenance, and modernization manuals. A few examples of these entries include (but are not limited to) verification inspections, receipt inspections, modifications, alterations, LLC exchanges, PAL code changes or status changes, delayed repair actions, and configuration changes.

Shipping
DOD units shipping weapons to DOE facilities will print out the eIRC and attach it according to the specific weapon’s technical data. DOE facilities may use DIAMONDS to create specific entries or have the Defense Threat Reduction Agency (DTRA) do the transcription into DIAMONDS when shipping weapons to DOD units. DOD to DOD shipping transactions using DIAMONDS capabilities are *not* required to print out a paper eIRC. The losing and gaining units will use DIAMONDS to send and receive all applicable eIRC data.

Storage location planning report
The SLPR is a report maintained in DIAMONDS that is continuously updated as weapons, unassociated components, and joint test assemblies (JTA) are relocated throughout the area. The SLPR will show serial numbers, storage location/area, and service status/color code. The munitions accountable systems officer (MASO) provides munitions control an updated copy at the end of every duty day on which changes occur unless they have a DIAMONDS terminal.

215. Equipment forms
To meet mission requirements, equipment must be serviceable, safe to operate, and be in the proper configuration. Managers must know the status of their equipment—whether it’s in service, in need of repair, or if it requires inspection. There must be some method of recording deficiencies discovered and work performed.

This lesson covers the historical equipment records that meet these needs. We use TO 00–20–1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures*, to complete Air Force Technical Order (AFTO) Forms 95, Significant Historical Data, and AFTO Forms 244, Industrial/Support Equipment Record. This lesson provides you detailed instructions for completing equipment forms beginning with the AFTO Form 95.

Air Force Technical Order Form 95
Historical records may reside in the maintenance information system (MIS); however, an AFTO Form 95 (fig. 2–3) will be used if they are not. This form provides a method of maintaining a permanent history of significant maintenance actions for SE, training equipment, and other components designated by higher authority (e.g., MAJCOM or the maintenance group commander [MXG/CC]).

Start an AFTO Form 95 on any equipment upon the issuance of the first TCTO, the occurrence of the first significant maintenance condition, or an incident requiring a data entry. An AFTO Form 95 contains blocks for this information, which include type of equipment, name of manufacturer, serial number of the equipment, date of acceptance by the AF, and remarks about the equipment. Column A is for the date, column B is remarks (for recording inspection and maintenance actions), and column C is the organization making the entry. The remarks you make on an AFTO Form 95 should provide a life profile of a piece of equipment. As a minimum, ensure these remarks include any conditions that could have a bearing on future maintenance of the equipment. When making entries, use as many lines as necessary. An AFTO Form 95 is inspected annually for accuracy and format. If you are the individual performing the review, you will make an entry in the AFTO Form 95 stating that the review has been performed.

SIGNIFICANT HISTORICAL DATA			PAGE 1 OF PAGES 1
1. MISSION DESIGN SERIES/TYPE, MODEL AND SERIES/PART NUMBER MUNITIONS HANDLING TRAILER	2. MANUFACTURER MOBILITY SYSTEMS INC.	3. SERIAL NUMBER 174087DD80661	4. ACCEPTANCE DATE 20130116

DATE A	REMARKS B	ORGANIZATION C
	Acceptance inspection accomplished. No defects.	123 MUNS/ABC AFB, TX
20130215		
	Brake fluid changed from DOT 3 to silicone.	123 MUNS/ABC AFB, TX
20130310		
	180 Day P.E. C/W	123 MUNS/ABC AFB, TX
20130908		
	Annual Review accomplished IAW T.O. 00-20-4.	123 MUNS/ABC AFB, TX
20140310		
	A one-time inspection was performed I.A.W. MSG# R052035Z APR 05 to ensure brake fluid was the correct MIL SPEC.	123 MUNS/ABC AFB, TX
20150504		
	Annual Review C/W	123 MUNS/ABC AFB, TX
20160504		
	Annual Review C/W	123 MUNS/ABC AFB, TX
20170417		

AFTO FORM 95, 20130411 PREVIOUS EDITION IS OBSOLETE.

Figure 2–3. Sample, AFTO Form 95.

Air Force Technical Order Form 244

Your job as a nuclear weapons journeyman requires you to perform and record maintenance, inspection, and historical data for SE and training equipment. Such records document delayed discrepancies and corrective actions, service, periodic and special inspections, and inspection status. Maintain a separate AFTO Form 244 for each piece of powered and non-powered aerospace ground equipment (AGE) having specific inspection requirements in TOs or inspection work cards. Figures 2–4 and 2–5 show the front/back and the inside portion of an AFTO Form 244.

Standard entries

As you can see in the figures, the form has five parts. In most respects, the “parts” and their respective entries are self-explanatory. Remember, when you use an AFTO Form 244 on the job, some of these entries may vary slightly. Always refer to the TO when completing the form. Except for “symbol” entries, make all your entries on the form using a black pencil or ballpoint pen. Enter all dates on the form using an eight-digit number in the order of year, month, and day (YYYYMMDD); for example, 20171208 for 8 December 2017. However, if your MAJCOM so elects, you can use a different date format.

III. SCHEDULED INSPECTION

INSPECTION REQUIREMENT	INTERVAL	DATE DUE	DATE COMPL	DATE DUE	DATE COMPL
Lubrication	180 Day	20171024	20171024	20180422	
P.E.	360 Day	20171120	20171118	20181113	
P.E.	720 Day	20191002			

IV. SUPERVISORY REVIEW

EMPLOY NO	DATE	EMPLOY NO	DATE	EMPLOY NO	DATE
00880	20171009				

AFTO FORM 244, 20170421 PREVIOUS EDITIONS ARE OBSOLETE

INDUSTRIAL/SUPPORT EQUIPMENT RECORD

I. ITEM IDENTIFICATION

1. NOMENCLATURE/MODEL: MUNITIONS HANDLING TRAILER MHU-141M		2. REGISTRATION/SERIAL NO.: 174087DD80661
3. ID NO.: GWA 37	4. FIELD NO. (If applicable): 37	5. WORK UNIT CODE: ADZ00
6. ORGN WC ASSIGNED: 123 MUNS	7. PERIOD COVER: 20171018 TO	8.

II. NON-SCHEDULED INSPECTION

TIME	INSP INIT	TIME	INSP INIT	TIME	INSP INIT	TIME	INSP INIT	TIME	INSP INIT	TIME	INSP INIT
DATE		DATE		DATE		DATE		DATE		DATE	
1430	JAD										
20171024											
0715	ACW										
20171105											
1105	LLC										
20171118											
1318	DWS										
20171210											

Page 1 of 2

Figure 2–4. Sample, AFTO Form 244 (front/back).

V. MAINTENANCE/DELAYED DISCREPANCY

9. T.O. 35D3-2-27-1 | 10. NSN | 11. 1740-01-031-5868 | 12.

DATE DISCOVERED	DISCOVERED BY / SUP DOC NO.	SYMBOL	DISCREPANCY	JOB CON/ W.O. NO.	CORRECTIVE ACTION	DATE CORRECTED	CORRECTED BY / INSPECTED BY
20171105	J. Doe 12345 / A1231A73091234	M	AWP- Brake shoe release spring broken	173094001	Spring replaced	20171110	D. Johnson 56789 / B. Madison 07931
20171210	J. Doe 12345	J	Parking brake binding		Linkage adjusted and lubricated	20171215	D. Johnson 56789
20180425	J. Doe 12345	D	Lubrication overdue		Lubrication C/W	20180427	J. Doe 12345

AFTO FORM 244, 20170421 Page 2 of 2

Figure 2–5. Sample, AFTO Form 244 (inside).

Name entries (minimum signature) are required in three locations on the form: DISCOVERED BY, CORRECTED BY, and INSPECTED BY blocks. Make name entries using the first-name initial, last name, and employee number. Of the three name entry locations on the form, the following list describes two situations you'll frequently put your signature.

1. If you make the initial entry in part V for a discrepancy, sign the DISCOVERED BY block.
2. If you complete the repair action for a discrepancy entry, sign the CORRECTED BY block.

To alert users and maintenance technicians about the status of an item of equipment, use a symbol to enter discrepancies in part V. Enter the symbols in red to make them stand out clearly. To show the seriousness of the discrepancies, use one of the following three symbols:

1. The red X represents the most serious condition and means the equipment is unsafe or unserviceable.
2. The red dash (–) represents the next most serious condition and means the condition of the equipment is unknown. This can be due to an overdue or incomplete inspection.
3. The red diagonal (/) represents the least serious condition and means the equipment has a condition that is not sufficiently urgent or dangerous to discontinue its use.

NOTE: You can find detailed use of these symbols in TO 00–20–1.

Erroneous symbols

You *never* erase erroneous symbols once they are entered. If you accidentally make an erroneous entry, correct the mistake by entering this statement in the CORRECTIVE ACTION block: "Symbol entered in error, item reentered below" or "Symbol entered in error, no discrepancy exists." If the error is *not* a red X, enter your minimum signature in the "CORRECTED BY" block and initial over the symbol. When required, reenter the discrepancy and correct symbol in the next open "DISCREPANCY" block on the form. If the error is a red X, the individual discovering the incorrect entry will enter the applicable statement identified above, but an individual authorized to clear these symbols must fill out the INSPECTED BY block. Make a new entry in the next open DISCREPANCY line, this time using the correct symbol.

Clearing symbols

When you correct a discrepancy, enter the corrective action and date and fill out the CORRECTED BY block. If someone inspects your work (an authorized inspector must inspect all red X conditions), the inspector also fills out the INSPECTED BY block. To clear a red dash (–) or diagonal (/), write over the symbol with your last-name initial. If the symbol is a red X, only an authorized inspector writes his or her last-name initial over the symbol.

Specific entries

The material just covered applies throughout the AFTO Form 244. The next area of discussion is the application of "individual parts" of the form, which is described in the next table.

Individual Parts	Descriptions
Part I	Use this part of the form for item identification. Enter the applicable information in each block. If a block is not used, leave it blank or enter N/A (not applicable). The period covered (block 7) is from the date the form is initiated to the date the form is closed out, or the equipment is turned in to supply or salvage.
Part II	Use this part of the form to document required service inspections and when required by the MXG/CC, prior-to-use inspections. If you are the individual doing the inspection at its completion, enter the time in 24-hour military time, date in the YYYYMMDD format, and your employee number (first, middle, and last initial if no employee number) in the appropriate blocks.
Part III	Use this part of the form to document inspection requirements and compliance status. Enter the type of inspection due and its respective inspection interval. Then enter the next inspection due date in the next open DATE DUE block. As you complete an inspection, enter the inspection

Individual Parts	Descriptions
	completion date. Don't forget to enter the next inspection due date.
Part IV	Supervisors and QA people use this part of the form to document inspection of the AFTO Form 244. The MXG/CC decides the frequency of these inspections. Do not use this part to document a completed maintenance action. The individual inspecting the form enters his or her employee number (or first-name initial, last name, and grade) and the date of the inspection.
Part V	As the heading indicates, document all required maintenance actions, overdue inspections, and discrepancies in this part. Enter only one defect in each block for each job control number; however, you may use as many blocks as necessary to describe a single discrepancy. If you have to order a part for repair, you enter the base supply document number in the block marked SUP DOC NO. If several parts are required, enter any document numbers at the end of the discrepancy statement.

Form close out

The form will be closed out and a new form initiated when additional recording space is required. You must transcribe everything in blocks 1 through 6 of the old form to the new form and then enter the current date in block 7 prior to the "TO." You must transcribe all inspections and discrepancies in part III and V, respectively, to the new form. When you transcribe the discovered by block in part V print the name and employee number of the individual who originally discovered the discrepancy.

On the old form, you enter the current date in block 7 following the "TO." You also must enter "CF" which stands for "carried forward" followed by your first and last name initials in the "DATE COMPL" block of part III. In part V enter "CF" and your minimum signature in the corrective action block for each open discrepancy carried forward.

Department of Defense Form 1570 series, condition status tags

These tags and labels are in various colors to show equipment and materiel condition or status at a glance. Attach the tags to the equipment by string, wire, or gummed backing. TO 00–20–3, *Maintenance Processing of Reparable Property and the Repair Cycle Asset Control System*, contains two tables that explain condition tags. One table lists condition tags, their purpose, and the condition codes. The second table lists require entries for each tag and label. Here, we only familiarize you with five condition status tags.

DD Forms 1574 and 1574–1 (yellow)

Use the Department of Defense (DD) Form 1574, Serviceable Tag–Materiel, (fig. 2–6), and DD Form 1574–1, Serviceable Label–Materiel, to show the identity and serviceable condition of property received, stored, and issued by the AF. The yellow color readily identifies these forms.

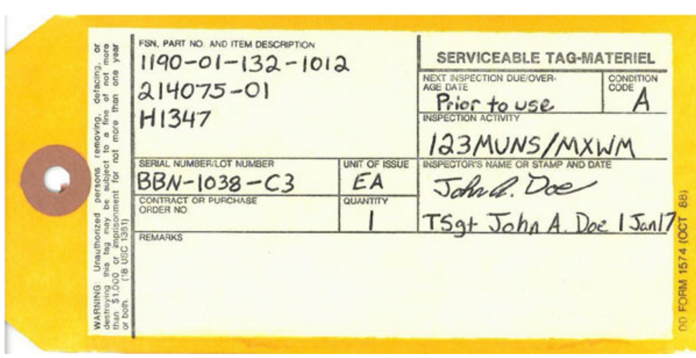


Figure 2–6. Sample, DD Form 1574.

DD Forms 1575 (brown) and 1575–1 (buff)

Use the DD Form 1575, Suspended Tag–Materiel, and DD Form 1575–1, Suspended Label–Materiel, to identify materiel in stock that has been suspended for issue, items returned to supply that are suspended for issue, and items on record that have been turned over to a maintenance facility or a contractor.

DD Forms 1576 and 1576–1 (blue)

Use the DD Form 1576, Test/Modification Tag–Materiel (fig. 2–7), and DD Form 1576–1, Test/Modification Label–Materiel, to identify materiel that requires modification or testing.

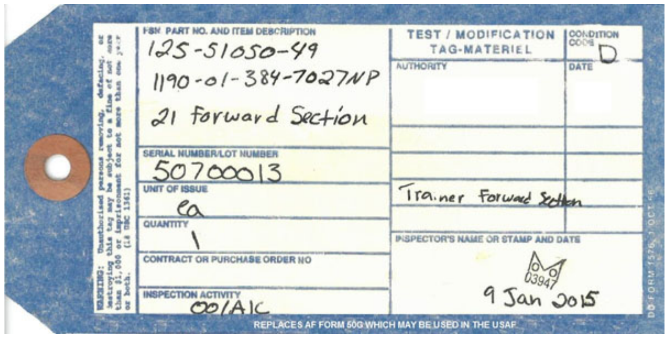

FSN PART NO. AND ITEM DESCRIPTION
125-51050-49
1190-01-384-7027NP
21 Forward Section
SERIAL NUMBER/LOT NUMBER
50700013
UNIT OF ISSUE
ea
QUANTITY
1
CONTRACT OR PURCHASE ORDER NO
INSPECTION ACTIVITY
00/AIC
TEST / MODIFICATION TAG-MATERIEL
CONDITION CODE
D
AUTHORITY
DATE
Trainer Forward Section
INSPECTOR'S NAME OR STAMP AND DATE
03947
9 Jan 2015
REPLACES AF FORM 50G WHICH MAY BE USED IN THE USAF

Figure 2–7. Sample, DD Form 1576.

DD Forms 1577 and 1577–1 (red)

Use DD Form 1577, Unserviceable (Condemned) Tag–Materiel (fig. 2–8), and DD Form 1577–1, Unserviceable (Condemned) Label–Materiel, to show that the item is unserviceable and too costly to repair or that a TCTO directs condemnation. The red color of the forms is a quick means of recognizing condemned parts.

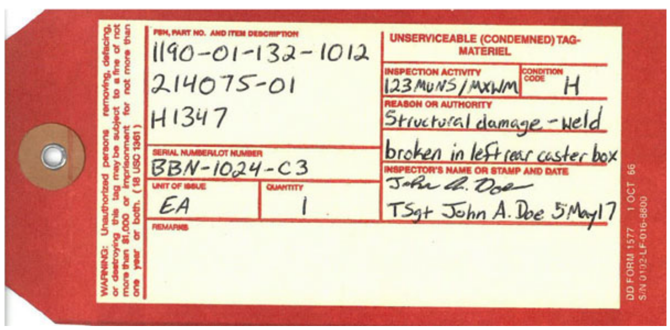

WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)
FSN, PART NO. AND ITEM DESCRIPTION
1190-01-132-1012
214075-01
H1347
SERIAL NUMBER/LOT NUMBER
BBN-1024-C3
UNIT OF ISSUE
EA
QUANTITY
1
REMARKS
UNSERVICEABLE (CONDEMNED) TAG-MATERIEL
INSPECTION ACTIVITY
123 MUNS/MXWM
CONDITION CODE
H
REASON OR AUTHORITY
Structural damage - Weld broken in left rear caster box
INSPECTOR'S NAME OR STAMP AND DATE
John A. Doe
TSgt John A. Doe 5 May 17
DD FORM 1577 1 OCT 66

Figure 2–8. Sample, DD Form 1577.

DD Forms 1577–2 and 1577–3 (green)

The green-colored DD Form 1577–2, Unserviceable (Reparable) Tag–Materiel (fig. 2–9), and DD Form 1577–3, Unserviceable (Reparable) Label–Materiel, indicates that an item or part is reparable. Notice that these forms have both a tag and a gummed label to attach to outer packages for shipment, as required.

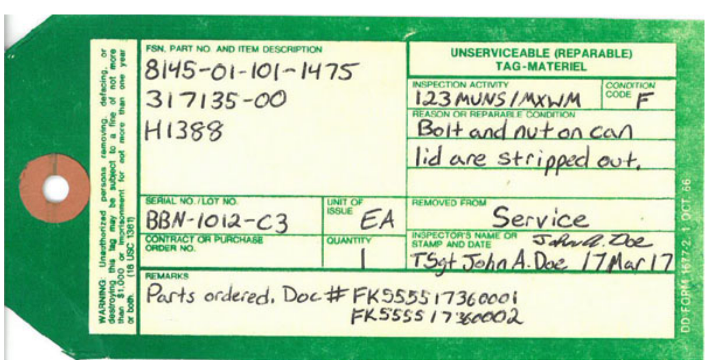

WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)
FSN, PART NO. AND ITEM DESCRIPTION
8145-01-101-1475
317135-00
H1388
SERIAL NO./LOT NO.
BBN-1012-C3
UNIT OF ISSUE
EA
CONTRACT OR PURCHASE ORDER NO.
QUANTITY
1
REMARKS
Parts ordered. Doc # FK55551736000l
FK55551736002
UNSERVICEABLE (REPARABLE) TAG-MATERIEL
INSPECTION ACTIVITY
123 MUNS/MXWM
CONDITION CODE
F
REASON OR REPARABLE CONDITION
Bolt and nut on can lid are stripped out.
REMOVED FROM
Service
INSPECTOR'S NAME OR STAMP AND DATE
John A. Doe
TSgt John A. Doe 17 Mar 17
DD FORM 1577-2 1 OCT 66

Figure 2–9. Sample, DD Form 1577–2.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

214. Weapon records and forms

1. What does a WIR provide to SNL/DOE? Why is it needed?

2. What actions would require a WIR?

3. When would you (if ever) use a WIR to report a LLC exchange or same serial-numbered component you added and removed?

4. When do you submit a MAR?

5. List four examples of MAR-reportable changes.

6. What TO will give you instructions on how to complete a MAR?

7. What TO do you use for specific guidance concerning eIRC entries?

8. How do the technician and verifier sign for eIRC entries?

9. When does an eIRC entry become historical?

10. What needs to be accomplished prior to correcting a historical eIRC entry?

11. What information is provided in the Operations Section on an eIRC?

12. What is the purpose of the SLPR?

215. Equipment forms

1. What is the purpose of an AFTO Form 95?

2. What do you annotate, as a minimum, in the remarks section of an AFTO Form 95?

3. What information do you record on an AFTO Form 244?

4. How do you make date entries on an AFTO Form 244?

5. How do you make name entries on an AFTO Form 244?

6. What is the purpose of red symbols?

7. List the red symbols from the most serious condition to the least serious condition.

8. Who can clear a red X condition?

9. What inspections are documented in part II of an AFTO Form 244?

10. How do you document inspection requirements in part III of an AFTO Form 244?

11. What inspection do you document in part IV of an AFTO Form 244?

12. If several document numbers are necessary for a maintenance action, where do you record it on an AFTO Form 244?

13. Why are different colors used on condition tags and labels?

14. Match the explanations and uses in column A with the form numbers in column B. Use each item in column B only once.

Column A	*Column B*
____ (1) A green-colored tag that indicates an item is reparable.	a. DD Form 1577–2.
____ (2) A red tag indicating condemned parts.	b. DD Form 1576.
____ (3) A yellow tag indicating a serviceable item.	c. DD Form 1577.
____ (4) A manila tag for items turned over to a maintenance facility.	d. DD Form 1574.
____ (5) A blue tag for test or modification.	e. DD Form 1575.

2–3. Deficiency, Mishap/Safety, and Unsatisfactory Reports

The AF is a big business. Its physical assets are in the trillions of dollars, ranging from the everyday common paper stapler to the B2 bomber. We procure most of the assets of the AF from private industry; and it's not uncommon for some of these items to have defects. If defective items are not identified and corrected, it could be costly to the AF and ultimately to the American taxpayer. In some cases, uncorrected deficiencies can have devastating consequences, such as failure of a mission or loss of life. You will use procedures from TO 11N–5–1, *Unsatisfactory Reports,* to report deficiencies on DOE-designed nuclear weapons or related components. You use procedures in AFMAN 91–221, *Weapons Safety Investigations and Reports,* to report a safety related accident, incident, or deficiency. In addition, use TO 00–35D–54 to report deficiencies on DOD-designed items. In certain instances, it may be necessary to submit multiple reports on one deficiency. In this section, we discuss the reporting of deficiency, mishap/safety, and URs.

216. Deficiency reporting using Technical Order 00–35D–54

Users must report deficiencies associated with nuclear weapons, nuclear weapon-related items, associated equipment, software, or TOs and/or publications. Deficiency reporting (DR) provides historical collection of deficiency data to share knowledge to authorized activities responsible for design, development, safety, purchasing, production, supply, maintenance, contract administration, and other functions as needed.

Deficiency reporting purpose

TO 00–35D–54 covers identifying, reporting, and resolving deficiencies. DR promotes the ability to identify and correct deficiencies before they impact mission capability. This system ensures that users route deficiency information to the activity responsible for the development, procurement, or other management functions so action can be taken to correct and prevent maintenance, materiel, design, and quality deficiencies. This reporting is done for AF-owned and -managed military or weapon systems along with their sub and support systems. Keep in mind that you also work with a lot of DOE-owned and -managed items that include some T&H gear that will be reported through the UR process discussed later. Currently, the AF utilizes an internet based system called the Joint Deficiency Report System (JDRS) in order to electronically process deficiency reports (DR).

Deficiency types designations

There are several types of USAF report designations covered in 00–35D–54. The following list provides four examples of deficiency types, followed by a description of each type:

1. Product quality.
2. Acceptance inspection.
3. Engineering Investigation.
4. Test and evaluation.

Product quality deficiency report

These are DRs (on hardware or software) resulting from an initial failure, defect, or nonconforming condition discovered on a new, newly repaired, or an overhauled product, typically when that product is placed in service. Product quality deficiency reports (PQDR) also include failures that result after the item was placed in service that are suspected as latent defects or quality escapes. These failures result from poor workmanship, nonconformance to applicable specifications, drawings, standards, processes, or other technical requirements.

Acceptance inspection deficiency report

Acceptance inspection deficiency reports (AIDR) identifies discrepancies discovered during acceptance inspections performed on aircraft, engines, engine modules and major assemblies, support systems, and equipment. Reportable discrepancies are those that are attributable to non-conformance to applicable specifications during manufacture, repair, modification, or maintenance associated with the general work requirements and contract specifications of the work performed.

Engineering investigation deficiency report

This report type is used to report an unacceptable condition or request failure analysis for conditions, such as systems compatibility issues, mishap analysis, component/item failures, anomalous behavior, or to provide recommendations for improvements to existing capabilities (enhancement) and software/application failures.

Test and evaluation deficiency report

These are reports of deficiency identified during test and evaluation (T&E). These include, but are not limited to, those deficiencies that are the result of incompatibility or failures as measured against required capabilities, applicable specifications, or procedures. It also identifies test equipment and recommendations for enhancements to improve operational safety, suitability, and effectiveness.

Deficiency report submission

The starting point for any DR is you, the originator. You must use this program effectively to keep your unit fully mission capable. There are two categories of DRs—Category (CAT) I and CAT II. Anytime you discover one of the above deficiencies, you must submit a DR. QA, the safety NCO, or the product improvement section will assist you in filling out this report. The severity of the deficiency dictates the category of the report. Once you have discovered a defect on a piece of equipment, classify the report. Submit a CAT I or II DR along with the proper priority for any one of the reasons shown in the chart below from TO 00–35D–54.

NOTE: Annotate the DR CAT (I or II) and the corresponding priority. Submit a CAT I DR and assign the corresponding priority when a condition falls under the listed CAT I impact.

NOTE: When the condition does not meet the safety or mission impact criteria of a CAT I report, submit a CAT II DR with the corresponding priority when the condition falls under the listed CAT II impact.

CAT I	Priority	Impact
	Emergency	If uncorrected, may cause death, severe injury, or severe occupational illness. If no workaround is known; or, if uncorrected, may cause major loss or damage to equipment or a system, and no workaround is known; or prevents the accomplishment of an essential capability or critically restricts operational safety, suitability, and effectiveness (OSS&E), to include required interaction with other mission-critical platforms or systems; and no acceptable workaround is known.
	Urgent	Adversely affects an essential capability or negatively impacts OSS&E and no acceptable workarounds are known or adversely affects technical, cost, or schedule risks to the project or to life cycle support of the system, or results in a production line stoppage and no acceptable workaround is known.

CAT II	Priority	Impact
	Emergency	Adversely affects an essential capability or negatively impacts OSS&E and adequate performance is achieved through significant compensation or acceptable workaround and or adversely affects technical, cost, or schedule risks to the project or to the life cycle support of the system, but an acceptable workaround is known.
	Routine	Does not affect an essential capability but may result in user/operator inconvenience or annoyance. Adequate performance is achieved through minimal compensation. Results in inconvenience or annoyance for development or maintenance personnel, but does not prevent the accomplishment of the task. Adequate performance is achieved through minimal compensation. Any other effect, (i.e., enhancements) having little or no impact to OSS&E under current requirements.

NOTES:

1. Careful consideration should be given in assigning the category and corresponding priority recommendation to accurately define the deficiency's impact.

2. Prior to test, the test team and program office shall ensure understanding and consensus of priority definitions. If required, definitions may be further defined to support the individual test program and defined in the local operating procedures.

3. T&E deficiency category and priority will be determined by the test director. Subsequent changes may occur only with consensus of the primary Materiel Improvement Project Review Board (MIPRB) members (program office, lead operating command, and applicable test director). See AFI 99–103, *Capabilities-Based Test and Evaluation,* for additional T&E information.

4. Originators/originating points should consider and document factors such as cost, schedule, and performance risks; availability of spares; difficulty of operation or maintenance, repair, or replacement; system redundancy; associated trends; secondary failures or damages; and environmental impacts among other possible factors.

5. Workarounds refer to approved/authorized alternate procedures, which could include, but are not limited to manual processes, order of task accomplishment, more restrictive or intensive procedures, and the use of back-up or redundant systems or processes.

Originator responsibilities

Once you identify the deficiency, you must prepare and submit a report in JDRS to the local originating point, which is normally QA. You must accomplish this within 24 hours for a CAT I DR and within three workdays for a CAT II DR. When you find a reportable deficiency on an item and an exhibit is required, set the item aside and attach a DD Form 1575 (fig. 2–10), and a DD Form 2332, Product Quality Deficiency Report Exhibit (fig. 2–11). Check the national stock number (NSN) of the deficient item against the master nuclear certification list (MNCL). If the item is listed, the PQDR may be reportable under AFMAN 91–221 as potential Dull Sword.

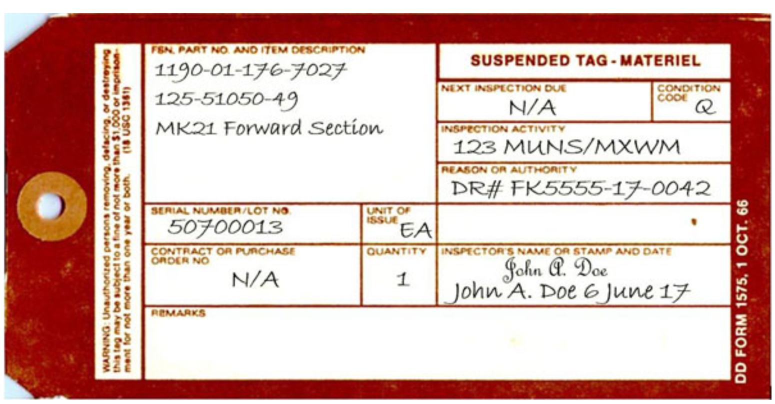
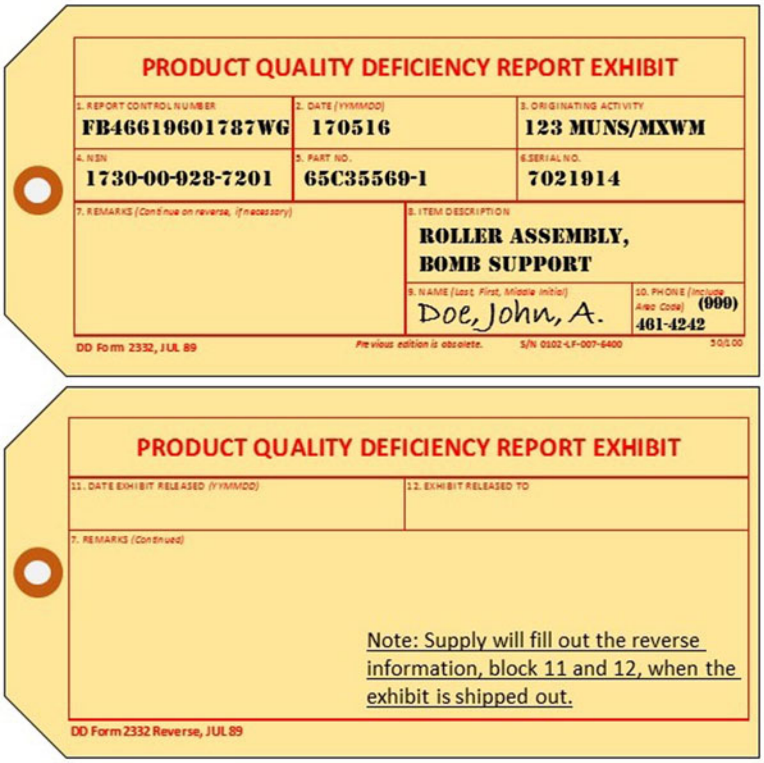


Figure 2–10. Sample, DD Form 1575.



PRODUCT QUALITY DEFICIENCY REPORT EXHIBIT

1. REPORT CONTROL NUMBER	2. DATE (YYMMDD)	3. ORIGINATING ACTIVITY
FB46619601787WG	170516	123 MUNS/MXWM
4. NSN	5. PART NO.	6. SERIAL NO.
1730-00-928-7201	65C35569-1	7021914

7. REMARKS (Continue on reverse, if necessary)

8. ITEM DESCRIPTION: ROLLER ASSEMBLY, BOMB SUPPORT

9. NAME (Last, First, Middle Initial): Doe, John, A.

10. PHONE (Include Area Code): (999) 461-4242

DD Form 2332, JUL 89 — Previous edition is obsolete. — S/N 0102-LF-007-6400

PRODUCT QUALITY DEFICIENCY REPORT EXHIBIT

11. DATE EXHIBIT RELEASED (YYMMDD)	12. EXHIBIT RELEASED TO

7. REMARKS (Continued)

Note: Supply will fill out the reverse information, block 11 and 12, when the exhibit is shipped out.

DD Form 2332 Reverse, JUL 89

Figure 2–11. Sample, DD Form 2332.

217. Unsatisfactory reports

The vast majority of reports you will submit will be UR. TO 11N–5–1 provides policy and procedures for processing URs that relate to DOE-designed items that are owned and managed by the DOE. This includes the nuclear weapons themselves. They are very similar to DRs and they may be required to be submitted together depending on the deficiency. Two main types of URs that you need to be familiar with are action and information reports.

Unsatisfactory report types

An action UR requires review and action on the part of the receiver of the UR. This means the unit will be awaiting further instruction or direction from the results of the UR. Depending on the urgency of the UR the following are two ways to submit an action UR:

1. Routine—A UR relating to conditions that do not meet the criteria for priority reporting.
2. Priority—A UR relating to conditions affecting safety or security and having a negative operational impact, posing a potential work stoppage, or being hazardous to the environment. These require you to provide a justification statement.

An information UR serves as an informative report of collected data and does not require a response from the addressees. These types of URs do not have an urgency assigned.

Unsatisfactory report reportable conditions

Report deficiencies via a UR on DOE-designed nuclear weapons or related components, DOE-designed equipment/software, and Joint Nuclear Weapons Publication System (JNWPS) TO discrepancies/deficiencies, or when DOD-designed items require evaluation based upon their interface with DOE-designed items.

You need to report the following conditions with an *action* UR:

- A DOE-designed item fails to function or perform as designed.

- Procedural changes that affect repair, replacement, packaging, and shipping criteria not available in JNWPS publications. Personnel exposure to hazardous conditions and clarification, correction, revision, or updating.
- DOE-designed items deteriorated due to climatic conditions.
- Defective DOE-designed items, nuclear weapons, and JTAs; nuclear weapons components; T&H equipment; disablement and PAL equipment; PAL controllers and use control software; and special-design tools and equipment.
- Any nuclear weapon trainer discrepancy that is the result of vendor quality control or a manufacturing defect.

You need to report the following conditions with an *information* UR so that DOE can monitor trends:

- Any recurring problem or unusual circumstances even though procedures are available to correct the condition.
- Any time similarly reported discrepancies may substantiate a possible need to redesign or modify another item, component, or procedure.
- Any discrepancy or deficiency with nuclear weapon trainers.
- You do not have to report defects that are the result of fair wear and tear and for which replacement items or repair procedures are available.

Reporting unsatisfactory reports

URs are submitted through DIAMONDS. Be as specific as possible when describing the defect and provide as much detail as possible. The photos that accompany the UR must also be very clear and specific and ultimately highlight the defect in question very well. This is all because Air Force Global Strike Command/Nuclear Control Point (AFGSC/NCP), DOE, and DTRA have to read and evaluate the information with only what you provide them. Field activities are to submit URs and photographs within three duty days of discovery of the defect. The normal routing for a UR is first to AFGSC/NCP for evaluation then, if required, it will be routed to DTRA. Once at DTRA, they will assign a DTRA UR number and route it to SNL for their DOE evaluation. Some MAJCOMs may have additional guidance and instructions. The unit holds UR exhibits until the final disposition is received.

218. Assistance request types

When assistance is required and the problem does not fit into the UR, weapons safety, or DR categories, use procedures in TO 00–25–107, *Maintenance Assistance,* for resolution. There are two types of assistance requests: engineering technical assistance request (ETAR) and MAR.

Engineering technical assistance request

An ETAR is used for engineering support for advice, assistance, disposition, and training pertaining to installation, operation, and maintenance of equipment using authorized procedures. It also provides authorization for one-time repairs or time definite repairs beyond what is spelled out in existing TOs. In addition, ETARs may provide units with a one-time authority to use a specific part with defects or deviations beyond the TO limits or the engineers may authorize limited use of a non-listed substitute to prevent work stoppages.

Maintenance assistance request

A maintenance assistance request (MAR) is assistance provided by the Air Force Materiel Command (AFMC) to resolve problems with maintenance procedures or production that are beyond the capability of the maintaining unit. MARs may take the form of emergency maintenance support, technical assistance, or a combination of both.

Format for assistance requests

If your unit creates an assistance request, furnish a detailed description of the discrepancy and the maintenance requirement. Next, list the type, model, and serial number of the equipment involved. Include the NSN and nomenclature, special tools or equipment, number of personnel required, applicable security, two-person policy, and Personnel Reliability Program (PRP) requirements. For further guidance and formatting, follow the procedures in TO 00–25–107 when submitting a request.

Procedures for requesting assistance

All requests for assistance in regards to nuclear support will be sent directly to the Air Force Nuclear Weapons Center (AFNWC). The system program manager (SPM), or equipment specialist (ES) in the AFNWC will receive assistance requests by a Web-based system used by the SPM (if available), by e-mail, or by telephone (use of telephone is for emergencies) with an information copy sent to the operating command. Once the SPM receives the assistance request, they will route the request to the engineers. The engineers will then review the request from the field and determine if the published TO procedures are insufficient, or deviations from procedures are requested. Depending on the results of the review the following actions will be performed:

- If yes, the engineer will provide disposition to the requesting unit. Although TO 00–5–107 allows a maximum of 120 days to repair non-nuclear equipment, AFI 21–204, *Nuclear Weapons Maintenance*, requires units to return non-operational tools, test, and handling equipment to operational status as soon as possible, not to exceed 30 duty days.
- If no, then the assistance request will turn into a MAR.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

216. Deficiency reporting using Technical Order 00–35D–54

1. What is the purpose of the DR program?

2. Match the definitions and explanations in column A with the deficiency types in column B. Items in column B will be used once, more than once, or not at all.

Column A	*Column B*
____ (1) A deficiency caused by poor workmanship or nonconformance to technical specifications.	a. Test and evaluation.
____ (2) Discrepancies discovered during acceptance inspections performed on aircraft, engines, engine modules and major assemblies, support systems, and equipment.	b. Acceptance inspection deficiency.
____ (3) An unacceptable condition such as a component and/or item failure, or recommendation for an enhancement that impacts the operational safety, suitability, and/or effectiveness of a system, subsystem or component.	c. Engineering deficiency.
____ (4) Deficiencies that are the result of incompatibility or failures as measured against required capabilities, applicable specifications, or procedures.	d. Product quality deficiency.

3. What dictates the category of report you must submit?

4. Match the conditions in column A with the appropriate report category listed in column B. Items in column B will be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Does not affect an essential capability.	a. Category I.
____ (2) May cause death or system loss.	b. Category II.
____ (3) May cause major loss or damage to equipment.	
____ (4) May result in user and/or operator inconvenience.	
____ (5) May cause severe injury.	
____ (6) Schedule risks to the project or to the life cycle support of the system, but an acceptable workaround is known.	

5. From the time you discover a defect, how soon must you submit a draft to the screening point for a CAT I DR?

217. Unsatisfactory reports

1. What are the two main types of URs?

2. When would an action UR be sent as a priority?

3. Do nuclear weapons and components reportable defects require action or informational URs?

4. Do trainers require URs for defects that are from normal wear and tear?

218. Assistance request types

1. What are the two types of assistance requests?

2. What is the ETAR used for?

3. What can the MAR take the form of?

4. What do you need to furnish in the message when submitting an assistance request?

Answers to Self-Test Questions

212

1. 11N series TOs.
2. TO 00–5–18.
3. Section 7.
4. Only when the technician has a full understanding of the main TO before using the abbreviated version.
5. While performing any certifiable operation, the team chief is in charge and requires feedback from their team members.
6. Operations and maintenance and methods and procedures TOs.
7. Only when you are referred to it by the governing manual.
8. You must make a permanent entry.

213

1. Provides a way of correcting TO errors by using an AFTO Form 22.
2. An "improvement" will result in an addition or significant change to a process or procedure which allows a function to be performed better, safer, faster, or cheaper. A "correction" merely fixes a minor error or omission in the TO.
3. Transmitted as a "high" precedence e-mail.
4. It could cause personnel injury, cause damage to equipment or property, reduce operational efficiency, threaten the safety or success of the mission, or result in over $25,000 or 1,000 man-hours in annual savings to the AF.
5. For TO improvements to simplify work, to clarify procedures, or to report a condition that, through continued use, may have a negative effect on the operating life of equipment.
6. Within 365 days after receipt of the report.
7. To provide control of DRs and to prevent their indiscriminate use. The supervisor ensures the report is accurate; QA reviews and validates the report.
8. "This is an unclassified AFTO Form 22 on a classified manual."

214

1. It provides a record of assembly information on specified S (Sandia) material to maintain records of component association to support stockpile quality studies.
2. Changes in association of any S material or of any serial/manufacturing-numbered weapon components associated with S material.
3. When directed by the specific weapon publication.
4. Each day a reportable change occurs.
5. (1) Weapon or component receipt, shipment, addition, or deletion.
   (2) Weapon code, alteration code, color code (Y or R), or charge code changes.
   (3) Weapon association, loss, or destruction.
   (4) Component removal and installation.
6. TO 11N–3150–8–1.
7. TO 11N–35–7 and 11N–3150–8–1.
8. DIAMONDS utilizes each individual's specific log-in to create a unique electronic signature.
9. Submitting it or NARS completing an end of day on DIAMONDS causes it to become historical.
10. Before correcting historical entries that are obviously in error, believed to be in error, made by other DOD organizations, or typographical you must submit a UR.
11. Entries covering historically significant inspections and operational events specified in assembly, test, storage, maintenance, and modernization manuals.
12. A report maintained in DIAMONDS that is continuously updated as weapons, unassociated components, and JTA are relocated throughout the area. The SLPR will show serial numbers, storage location/area, and service status/color code.

215

1. It provides a method of maintaining a permanent history of significant maintenance actions for support and training equipment and other components designated by higher authority (e.g., MAJCOM or the MXG/CC).
2. Any condition that could have a bearing on future maintenance of the equipment.
3. Maintenance, inspection, and historical data for SE and training equipment. It documents delayed discrepancies and corrective actions, service, periodic and special inspections, and inspection status.
4. Using an eight-digit number in the order of year, month, and day, unless your MAJCOM authorizes the use of a different format.
5. Using first-name initial, last name, and employee number.
6. To alert users and maintenance technicians as to the status of an item of equipment.
7. Red X, red dash, and the red diagonal.
8. Only an authorized inspector.
9. Servicing and prior-to-use inspections.
10. Enter the type of inspection and its interval. Then enter the next inspection due date in the next open DATE DUE block. After inspection completion, enter the inspection completion date and the next inspection due date.
11. Inspection of the AFTO Form 244.
12. In part V at the end of the discrepancy statement.
13. To indicate equipment and materiel condition or status at a glance.
14. (1) a.
    (2) c.
    (3) d.
    (4) e.
    (5) b.

216

1. To promote the ability to identify and correct deficiencies before they impact mission capability.
2. (1) d.
   (2) b.
   (3) c.
   (4) a.
3. The severity of the deficiency.
4. (1) b.
   (2) a.
   (3) a.
   (4) b.
   (5) a.
   (6) b.
5. Within 24 hours.

217

1. (1) Action.
   (2) Information.
2. A UR relating to conditions affecting safety or security, having a negative operational impact, posing a potential work stoppage, or being hazardous to the environment.
3. Action.
4. No.

218

1. ETAR and MAR.

2. Engineering support for advice, assistance, disposition, and training pertaining to installation, operation and maintenance of equipment using authorized procedures.
3. Emergency maintenance support, technical assistance, or a combination of both.
4. A Web-based system used by the SPM (if available), or by e-mail, or telephone (use of telephone is for emergencies) with an information copy sent to the operating command.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

36. (212) When would you *not* have a maintenance technical order (TO) in your file for an equipment item you have on hand?
    a. Equipment is seldom used.
    b. TO is available at the base TO library.
    c. Similar equipment items require only a general TO.
    d. An item other than what your organization provides maintenance.

37. (212) When the team chief reads a step from the technical order (TO), you acknowledge understanding, perform the task, and verbally verify the work performed. This process is called
    a. verbal stewardship.
    b. loud and proud principle.
    c. inspection ready protocol.
    d. verbal demand and response.

38. (212) When the –1 and –1A technical orders (TO) refer you to TO 11N–35–51 for a maintenance action, the referencing manual quotes the title of the procedure
    a. as referenced in the subject index at the back of the TO.
    b. exactly as it is worded in the table of contents.
    c. and lists the chapter title and paragraph number.
    d. and gives the paragraph number.

39. (212) The procedures in technical order (TO) 11N–35–51, section 2, apply to Department of Defense (DOD) specially designed (service) material at which appropriate time?
    a. Only when specified in the referencing manuals.
    b. Only when authorized by the maintenance supervisor.
    c. At all times, when specified in TO 11N–35–51, section 1.
    d. At all times, with or without specific reference from other manuals.

40. (212) When the term "note" is used in a nuclear weapons publication, you are required to
    a. only make a mental reference.
    b. only make a permanent entry if preceded by a warning or caution.
    c. always make a permanent entry.
    d. make a temporary record.

41. (213) To provide control of technical order (TO) deficiency reports (DR) and to prevent their indiscriminate use, who must sign the report?
    a. Quality assurance (QA) personnel only.
    b. Initiator's supervisor only.
    c. Initiator's supervisor and the product improvement manager.
    d. Initiator's supervisor and the squadron commander.

42. (214) What *must* you accomplish prior to correcting a historical electronic inspection record card (IRC) entry?
    a. Deficiency report (DR).
    b. Unsatisfactory report (UR).
    c. Maintenance activity report (MAR).
    d. Nothing. Line it out and make a new entry.

43. (214) What are the two sections of an electronic inspection record card (IRC)?
    a. Operation and heading.
    b. Weapon and operation.
    c. Information and maintenance.
    d. Weapon description and actions.

44. (215) What are the *minimum* remarks recorded on an AFTO Form 95, Significant Historical Data?
    a. Any condition that could have a bearing on future maintenance of the equipment.
    b. Any classified information concerning war reserve (WR) weapons.
    c. Only equipment deficiencies reportable by unsatisfactory reports.
    d. Only classified conditions encountered during maintenance.

45. (215) Which red symbol represents the *least* serious condition on an Air Force Technical Order (AFTO) Form 244, Industrial/Support Equipment Record?
    a. X.
    b. –.
    c. /.
    d. ?.

46. (215) On an Air Force Technical Order (AFTO) Form 244, Industrial/Support Equipment Record, an authorized inspector *must* inspect and clear *all* red
    a. symbols.
    b. X conditions.
    c. dash conditions.
    d. diagonal conditions.

47. (215) What do the *red* Department of Defense (DD) Forms 1577 and 1577–1 indicate when used on parts or component items?
    a. Repairable.
    b. Serviceable.
    c. On suspense for issue.
    d. Unserviceable and condemned.

48. (216) Which technical order (TO) covers deficiency reporting (DR)?
    a. 00–20–14.
    b. 11N–35–51.
    c. 00–35D–54.
    d. 11N–35–51A.

49. (216) Which type of deficiency is caused by an error in workmanship?
    a. Product quality.
    b. Accident.
    c. Materiel.
    d. Software.

50. (216) From the time you discover a defect, how soon *must* you submit a draft to the originating point for a Category (CAT) II deficiency report (DR)?
    a. 24 hours.
    b. 3 workdays.
    c. 10 calendar days.
    d. 15 calendar days.

51. (217) What are the two types of unsatisfactory reports (UR)?
    a. Urgent and normal.
    b. Priority and routine.
    c. Action and information.
    d. Critical and controlled.

52. (217) Report deficiencies on nuclear weapons or related components via a/an
    a. product quality deficiency report (PQDR).
    b. maintenance activity report (MAR).
    c. weapon information report (WIR).
    d. unsatisfactory report (UR).

53. (217) How do you report *minor* manufacturing defects discovered on training weapons?
    a. Unsatisfactory report (UR).
    b. Maintenance activity report (MAR).
    c. Product quality deficiency report (PQDR).
    d. Engineering technical assistance request (ETAR).

54. (217) Which agency tracks and forwards unsatisfactory reports (UR) to the Defense Threat Reduction Agency (DTRA)?
    a. Air Force Safety Center (AFSEC).
    b. Major commands (MAJCOM).
    c. Air Force Nuclear Weapons Center (AFNWC).
    d. Air Force Global Strike Command/Nuclear Control Point (AFGSC/NCP).

55. (218) The *maximum* allowable time given to return non-operational handling equipment back to operational status is
    a. 30 duty days.
    b. 30 calendar days.
    c. 120 duty days.
    d. 120 calendar days.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Nuclear Weapons Operation

THIS UNIT COVERS aspects of physics that pertain to the structure of the atom, the nature of its components, and the predictable behavior of the subatomic components. It also covers, very briefly, the means that scientists have developed, or are now developing, for releasing the energy available inside the nucleus of the atom. Within the limits allowed by security restrictions, the following lessons trace the use of nuclear energy in weapons. Material contained here is from unclassified military, nonmilitary, and other unclassified sources. Keep in mind the purpose of this text is to present theory and not to represent actual materials or methods in the use of these weapons.

3–1. Theory and Operation

A nuclear weapon can produce a large amount of energy from a small amount of active material. This large yield-to-weight ratio is its principal advantage over conventional weapons, which obtain energy by chemical means. Although specific details of weapon designs are classified, we present certain general ideas here. In this section, we introduce you to atomic theory and the fission and fusion processes used to achieve a nuclear explosion.

219. Theory and interactions

What is required to produce a nuclear explosion? When a chain reaction becomes self-sustaining because fissionable material reaches a supercritical mass, a nuclear explosion occurs. Although the process is highly technical, we can express it in readily understandable terms. The basic principle behind the whole process is the atomic theory; let us start the lesson by discussing the atomic structure.

Atomic structure

To understand a nuclear reaction, you need to know something about atomic (nuclear) theory. To study the atom, you first must know about the structural nature of matter itself. Some Greeks, the atomists, such as Epicurus and Democritus, thought all matter consisted of elemental and indivisible units called *atoms*. We eventually found out the atomic structure consists of particles called protons, neutrons, and electrons. Electrons are negatively charged particles orbiting the outer reaches of the atom. Protons are positively charged, and neutrons not having a charge are particles that make up the nucleus of the atom in the center. In 1913, Neils Bohr and Ernest Rutherford created a model of an atom that looks much like a miniature solar system. This model, still used today, visually represents the quantities of components in any given atom more easily. However, the advancement of quantum mechanics and mathematical equations aimed to predict atomic orbitals updated this atomic model. It now looks more like a cloud with certain orbitals. This is due to the exact positions of any of the electrons at any given time being unknown. The electron cloud model developed in 1926 by Erwin Schrödinger and Werner Heisenberg is now more widely accepted in the scientific community as a more realistic representation. You can see the Schrödinger and Bohr models in figure 3–1. Throughout the rest of this volume, we will use Bohr's model to represent items more easily.

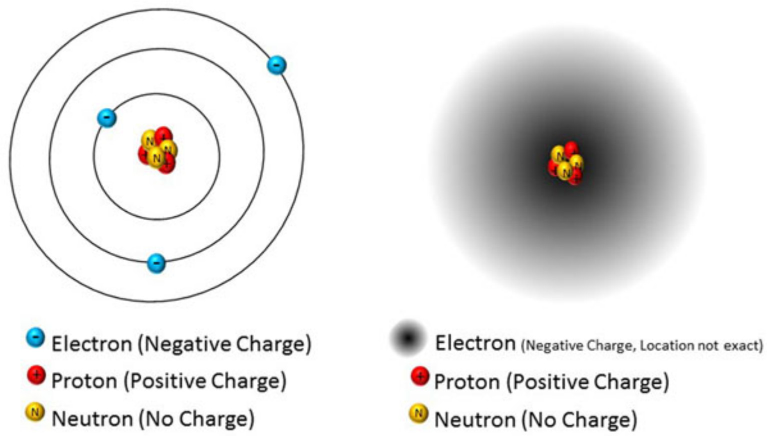


Figure 3–1. Atomic models, Bohr's (left) and Schrödinger's (right).

Eventually, people discovered the basic substances of which all matter is composed—the *natural elements.* One or more of the 92 kinds of natural elements make up all naturally occurring matter or substances. Among the elements are the *gases*—hydrogen, oxygen, and nitrogen; the *solid nonmetals*—carbon, sulfur, and phosphorus; and *various metals*, such as iron, copper, and zinc. Several have been produced artificially as a *synthetic element*; for instance, plutonium. Counting all known elements there are currently 118.

If we kept dividing a particle of a substance into smaller and smaller parts, we would have a molecule of the substance—the smallest particle that still retains the properties of the substance. Figure 3–2 is a drawing of the water molecule, which has three atoms: two of hydrogen and one of oxygen. We can divide the molecule into these atoms. Atoms are the smallest parts of any *element* that can exist while retaining the characteristics of the element. The hydrogen atom is the lightest of all atoms, while the atoms of uranium are the heaviest of those found in nature. Heavier atoms, such as those of plutonium are made artificially from uranium.

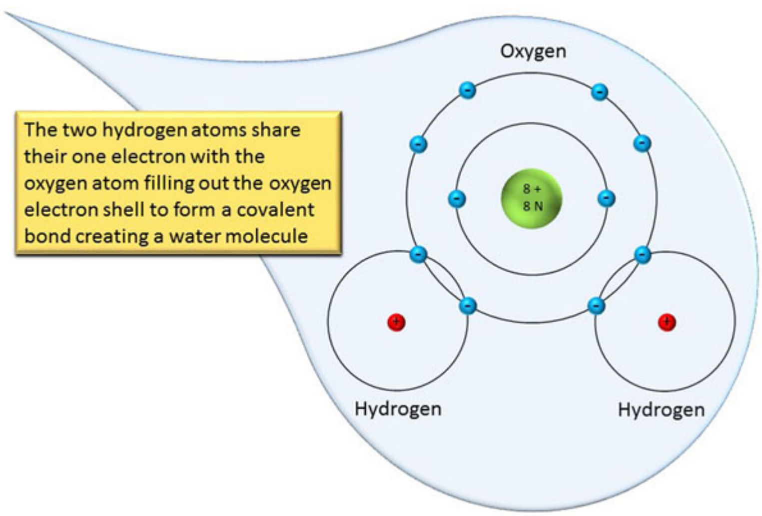


Figure 3–2. Molecule of water.

Nucleus and electrons

As shown in figure 3–3, we separate the atom further into its component parts—electrons, protons, and neutrons. This shows the positively charged protons, the neutral neutrons in the nucleus (center) of the atom, and the negatively charged electrons in a constant orbit or shells around this nucleus.

Since the proton is positively charged and the electron is negatively charged, we assume the atoms of which matter is composed are electrically neutral; that is, they contain no measurable charge. Atoms normally contain exactly as many electrons moving in shells around the nucleus as there are protons in the nucleus. Neutrons, having no charge, do not affect the chemical nature of the atom.

The number of protons in the nucleus determines the element to which an atom belongs. For example, hydrogen has one proton and one orbital electron. Helium has two protons and two electrons. The proton count increases for each heavier atom up to the last natural element, uranium, which has 92 protons and 92 electrons.

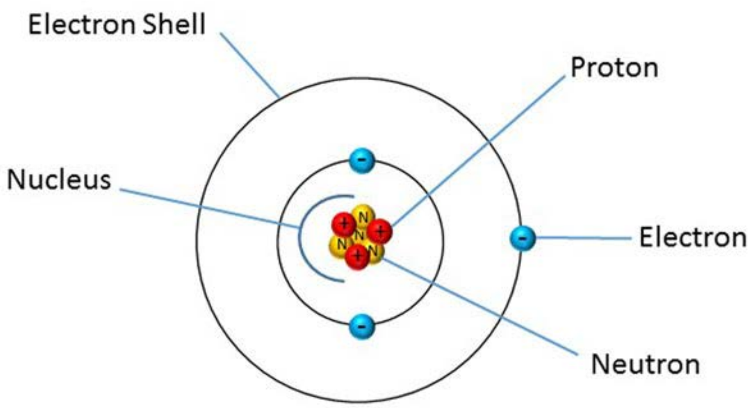


Figure 3–3. Lithium atom.

Electron shells

Electrons are not distributed at random about the nucleus; they exist in arrangements that follow definite laws and certain orbitals. Figure 3–3 shows an atom of lithium with three protons, four neutrons, and three electrons. Two of these electrons are in the shell next to the nucleus. No more than two electrons may be present in this shell.

No matter which atom is under consideration if a nucleus has more than two protons, electrons in excess of two lie in shells outside the first one. Since the electron is so far from the nucleus, an atom can lose an outer electron under certain conditions. These free or stray electrons, having a negative charge, usually seek an atom with a vacant space in its outer shell. When an atom gains or loses an electron, the gain or loss changes the electrical balance of the atom. We then say the atom is *ionized.* When an atom loses an electron, it becomes a positive ion. When it gains an electron, it becomes a negative ion. The product of an ionizing event is usually an ion pair of equal and opposite charge.

Atomic number

The essential difference between atoms of different elements lies in the number of protons in the nucleus, which uniquely identifies each element. We call this the *atomic number* of the element. Hydrogen atoms, for example, contain only one proton; helium atoms have two protons; uranium atoms have 92 protons; and plutonium atoms have 94 protons. Although all the nuclei of a given element contain the same number of protons, they may have a different number of neutrons. We call elements with identical atomic numbers that differ in their masses isotopes of that particular element.

Isotopes

We define isotopes as atoms of the same element, but different atomic mass numbers. Hydrogen has three isotopes (fig. 3–4), and the most abundant isotope, *protium*, has one proton and no neutron. Another isotope of hydrogen, *deuterium*, has one proton and one neutron. The third isotope, *tritium*, has one proton and two neutrons.

It is a basic law of nature that the conversion of any system in which weaker forces interact into one hold the constituents (components) together or the forces are stronger and must be accompanied by the release of energy and a corresponding decrease in mass. Two kinds of nuclear interactions that can produce this large amount of energy are fission and fusion.

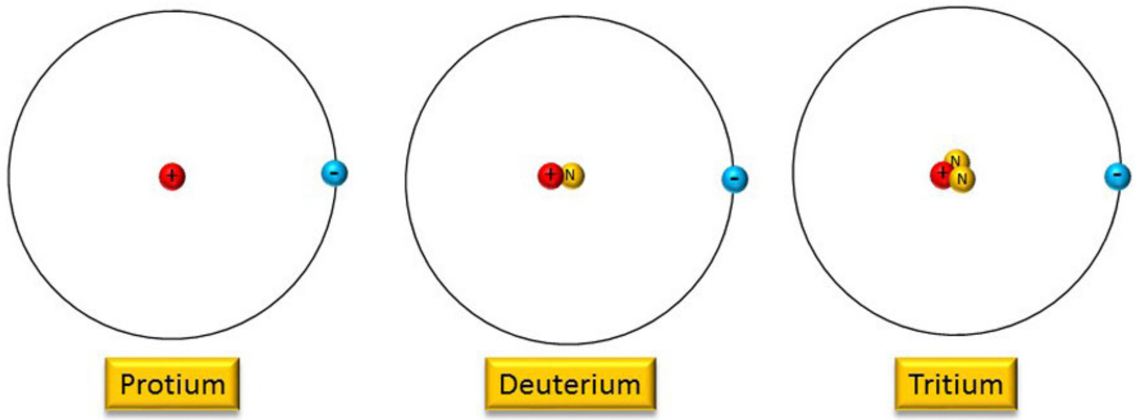


Figure 3–4. Isotopes of hydrogen.

Fission

The fission process takes place with some of the heaviest (high atomic number) nuclei, while the fusion process involves some of the lightest (low atomic number) nuclei. The materials used to produce nuclear explosions by fission are isotopes of the elements uranium and plutonium. Uranium as found in nature mainly consists of two isotopes: uranium 235 (U^{235}) and uranium 238 (U^{238}). The U^{235} isotope is the least abundant and is far more fissionable than the U^{238} isotope. As we previously stated, plutonium does not occur naturally. The fissionable isotope Pu^{239} is made artificially by bombarding U^{235} or U^{238} with neutrons.

Fission takes place when a neutron enters the nucleus of a fissionable atom. It causes the nucleus to split into two smaller parts and releases a large amount of energy. The complete fission of one pound of uranium or plutonium releases as much energy as the explosion of about 8,000 tons of trinitrotoluene (TNT).

Fission weapons

You must remember that the nuclear material in a nuclear weapon is always in a subcritical condition until you take certain sequential steps. This ensures there can be *no* spontaneous nuclear detonation. In fact, it is the requirement that supercriticality must first be attained that makes the nuclear weapon inherently safe to maintain and handle.

For a nuclear weapon to operate most efficiently, a supercritical mass of fissionable material must be achieved. If only criticality was achieved, the energy release would be small and no explosion would result. If the neutron multiplication factor were only slightly above one, there would be the chance of a very small explosion or the material could melt. Then the mass probably would go subcritical with no substantial energy release. To achieve a nuclear explosion, minimize the loss of neutrons. In this light, it is important to reduce the neutrons that escape from the material undergoing fission.

One method that reduces neutron loss is reflection. By surrounding the fissionable material with a suitable neutron "reflector," you reduce the loss of neutrons by escape and decrease the mass required for criticality. Elements of high density that make good reflectors for neutrons of high energy also provide inertia, which delays the expansion of the exploding material. For a nuclear explosion to take place, a sufficient amount of uranium (or plutonium) must exceed the critical mass in an extremely short time. The critical mass depends, among other things, on the shape of the material, the composition, and the presence of impurities that can remove neutrons in nonfission reactions.

Gun-type method

One method of bringing the fissionable material to supercriticality quickly is the gun-type method used in the first atomic weapon (fig. 3–5). This weapon works on the increase in mass principle, in which a projectile of active material is fired by a charge of conventional explosives into a target of active material, thus increasing the mass of the material to the state of supercriticality. Surrounding the fissioning material with a tamper holds the chain reaction together until supercriticality occurs.

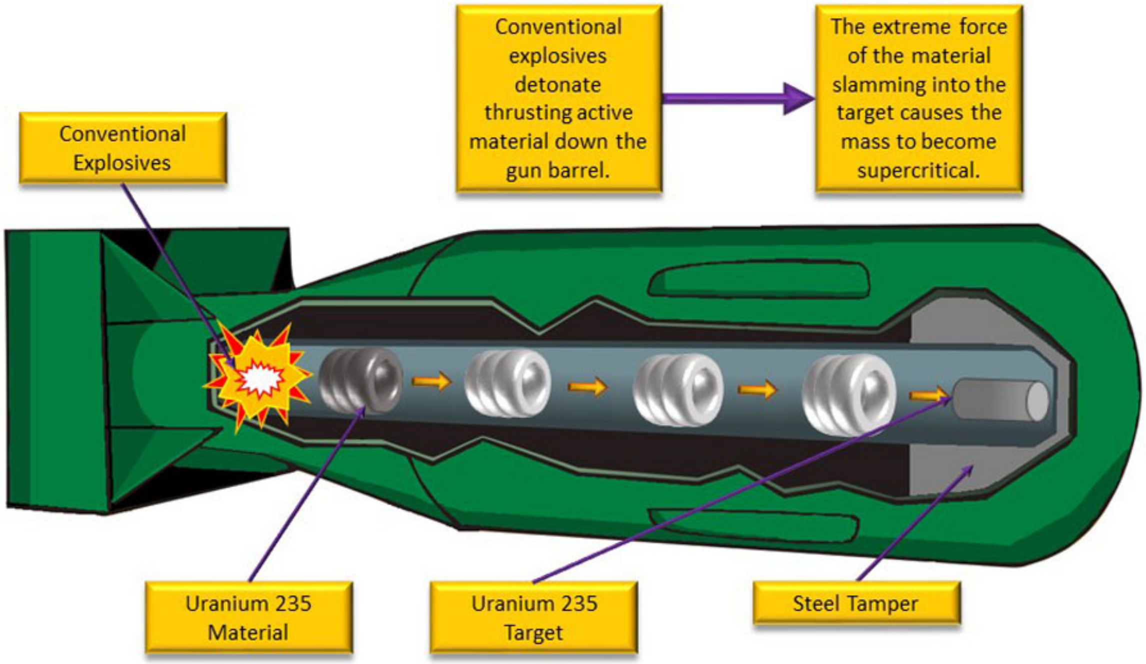


Figure 3–5. Gun-type method.

Implosion method

Another method by which subcritical masses reach a supercritical state is through implosion. Supercriticality is achieved by squeezing the subcritical mass into a smaller volume by means of tremendous pressure. This increases the density and the criticality of the fissionable material. In other words, you are increasing the mass by reducing the surface area. The pressure applied to squeeze the active material is developed by detonating high explosives in such a way that the pressure moves inward. This inward movement of pressure describes *implosion*.

It is important to note, for a full-scale explosion to take place, the implosion wave must move inward from all directions. To ensure this, you must embed explosive devices called *detonators* in the high explosive, and all detonators must fire at the same time. When detonating the high explosive, a shock wave moves inward against the active material, striking it with equal force at all points and reducing the volume of active material (fig. 3–6). Because of this compression, the material increases in density, and the multiplying fission chain reaction that occurs leads to a nuclear explosion. If one detonator fails or malfunctions, a significant nuclear yield is highly improbable.

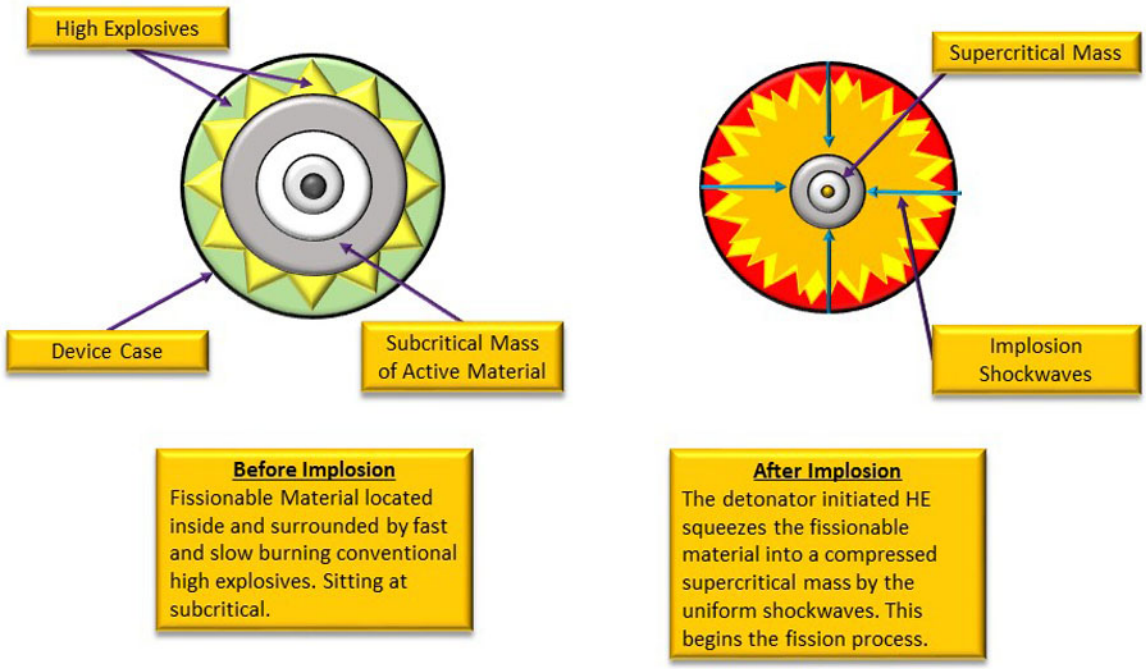


Figure 3–6. Implosion method.

Neutron sources

A neutron source, such as uranium or plutonium, is assembled in the weapon. Even in subcritical masses, these radioactive substances undergo a small amount of spontaneous fission that results in the release of free neutrons.

The designers of nuclear weapons wish to be absolutely certain an abundance of neutrons are available for use when the mass becomes supercritical. Therefore, a source of neutrons is required to be available at the exact time required. A device called an initiator or neutron source tube in or near the fissionable material (fig. 3–7) is used to ensure this need is met. These sometimes contain two substances. One could be a reliable alpha emitter, such as polonium or radium; the other could be a light element, such as beryllium. When the light material is bombarded with an alpha particle, neutrons are emitted. The capsule is carefully designed to prevent any premature neutron development. The activation of this source occurs when the mechanical impulse that forms the supercritical mass shatters the initiator and makes emitted neutrons available to start the multiplying chain reaction.

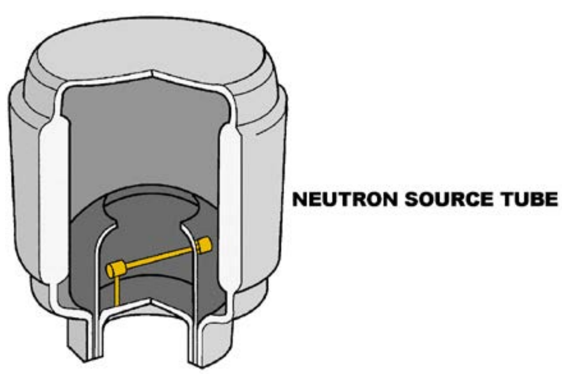


Figure 3–7. Neutron source tube.

Fission boosted weapons

The efficiency is improved significantly in many fission weapon designs by introducing fusion fuel, deuterium, tritium, or a mixture of both, directly into the fission primary (pit). Upon initiation of the fission reaction, the tritium gas provides vast quantities of free neutrons (fig. 3–8). These neutrons greatly increase the efficiency of the fission reaction. Although fusion does occur, it may add only slightly to the total yield of the weapon; we call this addition of fusion fuel "boosting." Boosted single-stage weapons are considered fission rather than thermonuclear weapons.

In discussing a nuclear weapon, remember the nuclear material is always in a subcritical state until certain conditions and steps are taken. The subcritical state ensures there can be no spontaneous nuclear detonation. We must emphasize the importance of the subcritical mass. This inherent feature makes its operation unique.

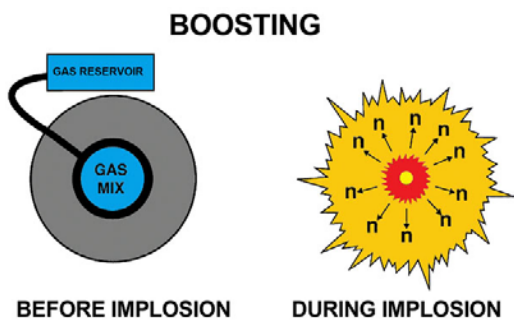


Figure 3–8. Gas boosting.

Fusion

As the development of nuclear weapons continued, an increase in yield was required. It is found impractical to increase the yield of atomic (fission) weapons beyond about 500 kilotons (kt). To increase weapon yields beyond this apparent maximum requires a new concept in weapon design, thus, the thermonuclear weapon using the fusion principle was born. This is the opposite of the fission principle used in single-stage atomic weapons. As we stated earlier, fusion is the combining of light nuclei to form heavier nuclei with a subsequent release of energy.

Normally fusion reactions occur from isotopes of hydrogen. Several different fusion reactions have been observed among the nuclei of the three hydrogen isotopes, involving either two similar or two different isotopic nuclei. The nuclei must have high energies to make these reactions occur. The high energy is needed to overcome the repulsive forces between the positively charged nuclei. One way in which this energy can be supplied is by means of a charged-particle accelerator, such as a cyclotron. Another possibility is to raise the temperature to a very high level—several million degrees.

Besides the sun, the only place to find such temperatures is in the fission reaction of the nuclear weapon. For this reason, we refer to fusion weapons as thermonuclear weapons. For a given mass of material, the quantity of energy liberated depends on the isotope (or isotopes) involved in the nuclear fusion reaction. As an example, the fusion of all the nuclei present in one pound of the hydrogen isotope deuterium would release roughly the same amount of energy as the explosion of 26,000 tons of TNT.

Fusion weapons

For fusion to take place, fission must first produce the necessary temperatures that will cause the fusion reaction to occur. The following are the reactions required for a typical thermonuclear weapon to work correctly:

1. Fission—The HE detonates, compressing the active material of the primary. This process causes fission, which gives off heat and pressure.

2. Fusion—The fusion fuel (the secondary), raised to tremendously high temperatures and density by the fission of the primary stage, undergoes a reaction that results in a release of high-energy neutrons.
3. Fission—High-energy neutrons from the fusion reaction cause additional fission reactions.

For fusion to occur there must be fusionable fuel that "feeds the fire." Fusionable fuels are held in thermonuclear weapons normally in the two following ways:

1. In the form of metallic salts (such as isotopes of lithium) (fig. 3–9), which release deuterium and tritium gas upon bombardment by neutrons and exposure to intense heat. Incorporate fusion material in these weapons directly in the design of the fission device, separated, but next to the fission device.
2. The other way fusionable fuels are placed in the weapon is the use of gas reservoirs. They are normally outside the containment vessel. Since this gas is radioactive, it suffers decay and must be replaced on a regular basis.

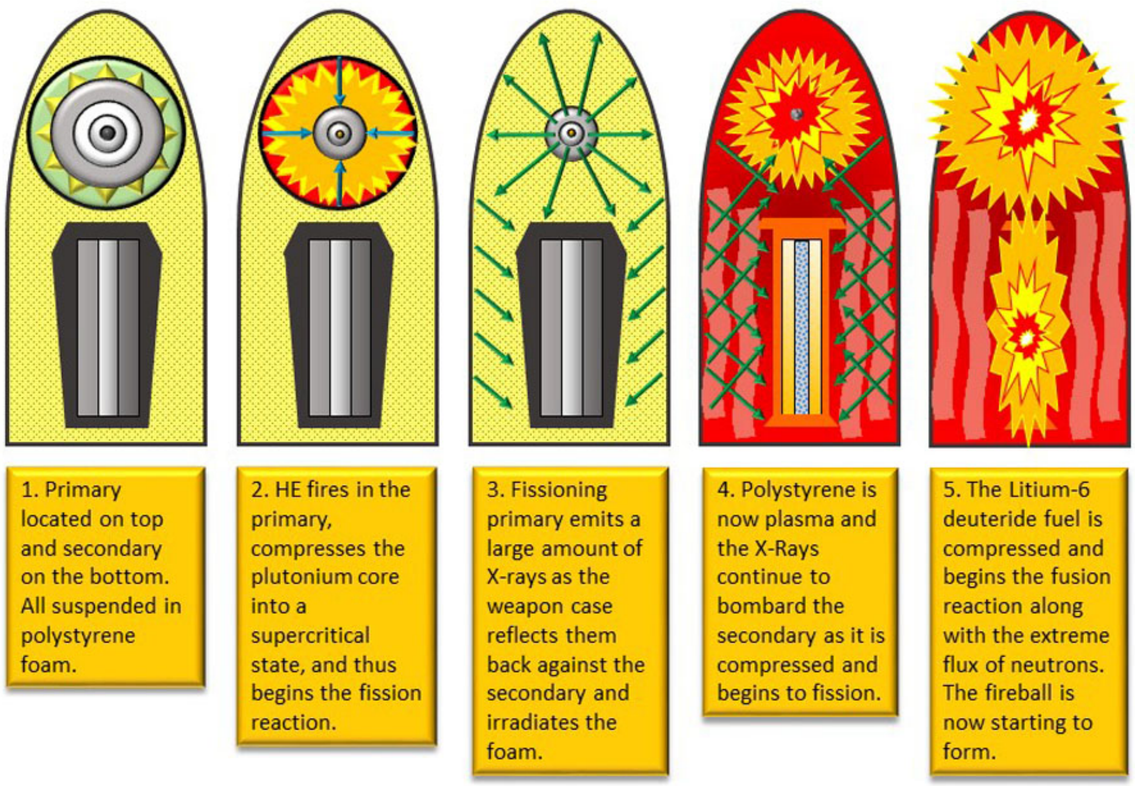


Figure 3–9. Implosion type thermonuclear device.

220. Effects of nuclear detonations

In a conventional explosion, the energy released arises from chemical reactions involving a rearrangement of the atoms. In a nuclear explosion, the energy is produced because of the formation of different atomic nuclei by the redistribution of the protons and neutrons within the interacting nuclei. The forces between the protons and neutrons within atomic nuclei are tremendously greater than those between the atoms. What we sometimes referred to as atomic energy is actually nuclear energy, since it results from particular nuclear reactions. It is for that same reason we call atomic weapons nuclear weapons. Let us start this lesson by comparing the similarities and differences between nuclear and conventional weapons.

Nuclear and conventional weapons

Nuclear weapons are similar to conventional weapons in that their destructive action is due mainly to blast or shock. On the other hand, there are several differences between nuclear weapons and high explosive weapons. First, nuclear explosions can be many (thousands or millions) times more powerful than the largest high explosive detonations. Secondly, the light and thermal energy from a nuclear explosion can cause skin burns and start fires at far more considerable distances. Thirdly, highly penetrating and harmful invisible rays accompany the nuclear explosion. Finally, the substances remaining after a nuclear explosion are radioactive and produce fallout. For a comparison, to date the massive ordnance air blast (MOAB), which is the AF's largest conventional weapon, produces an explosion equivalent to roughly 11 tons of TNT, whereas the lower yields in our current stockpile range in the thousands of tons of TNT.

Distribution of energy in nuclear explosions

The distribution of energy between thermal radiation and air shock is relative to the explosive energy yield, the burst altitude, and to some extent, the weapon design. As an approximate rule, the distribution of energy released from a nuclear weapon is as follows:

- 50 percent blast and shock.
- 35 percent thermal radiation.
- 10 percent residual nuclear radiation.
- 5 percent initial radiation.

The effects produced by any nuclear explosion, as well as the effects of shock and blast and of thermal and nuclear radiations, depend largely upon whether the weapon detonates as a high-altitude burst or airburst, or a surface or subsurface burst.

Within less than a millionth of a second (millisecond) after detonation, the fission of uranium (or plutonium), or the fusion of the isotopes of hydrogen in a nuclear weapon, leads to a liberation of a large amount of energy in a very small period of time. As a result, the temperature of the fission products, bomb casing, and other weapon parts rises extremely high. The maximum temperature attained by a fission weapon is several tens of millions of degrees. Because of the great heat produced by the nuclear explosion, all the materials convert to a gaseous form. Since the gases at the instant of explosion are restricted to the region occupied by the weapon, it produces tremendous pressures. These pressures are probably over a million times the atmospheric pressure in the order of many millions of pounds per square inch. The extremely hot weapon residue radiates large amounts of energy, mainly as invisible X-rays, which are absorbed within a few feet in the surrounding atmosphere. This leads to the formation of extremely hot and highly luminous roughly spherical mass of air and gaseous weapon residue, called the fireball.

Thermal radiation

The observed phenomena associated with a nuclear explosion and the effects on people and materials are largely determined by the thermal radiation and its interaction with the surroundings. Thermal radiations belong in the broad category of what we call EMR. These are a kind of wave motion resulting from oscillating electric charges and their associated magnetic fields. Ordinary visible light is the most familiar kind of EMR, and all such radiations travel through the air (or, more exactly, a vacuum) at the same velocity, namely, the velocity of light, at 186,000 miles per second. EMR ranges from the very short wavelength (or very high frequency) gamma rays and X rays, through the invisible ultraviolet to the visible region, and then to the infrared, radar, and radio waves of relatively long wavelength (and low frequency).

Thermal radiation travels at the speed of light, so that the time elapsing between its emission from the fireball and its arrival at the target, a few miles away, is quite insignificant. Much like the sun, the fireball radiates ultraviolet (short wavelength), as well as visible and infrared (long wavelength) rays.

Due to certain phenomena associated with the expanding fireball, the surface of the earth will feel two pulses of thermal energy.

For a one-megaton weapon, the *first pulse* lasts for about a tenth of a second. The temperatures are very high, and much of the thermal radiation is in the ultraviolet region. This pulse is a hazard mainly to the eyes, especially to the individuals who happen to be looking in the direction of the explosion.

The *second pulse* phase is quite different. This pulse may last for several seconds (10 seconds for a one-megaton explosion) and carries approximately 99 percent of the total thermal energy. These temperatures (approximately 3,270 °F to 7,200 °F) are lower than what is experienced in the first pulse, and most of the rays reaching the earth are visible and infrared (invisible) light. This thermal radiation is the main cause of skin burns suffered by exposed individuals up to 12 miles or more from ground zero and the cause of eye damage at even greater distances.

When thermal radiation falls upon any material or object, part of the radiation may be reflected, part will be absorbed, and the remainder, if any, will pass through and ultimately fall upon other materials. It is the radiation absorbed by a particular material that produces heat and determines the damage suffered by that material. Highly reflecting and transparent substances do not absorb much of the thermal radiation. A thin material will often transmit a large proportion of the radiation falling upon it and, thus, will escape serious damage. Black fabric will absorb a much larger proportion of the thermal radiation than white fabric, and the light colored material will not char as readily as a dark piece of the same material.

The important physical effects of the high temperatures resulting from the absorption of thermal radiation are burning of the skin, scorching, charring, and possible ignition of combustible materials such as wood, fabrics, and paper. Thin or porous materials, such as lightweight fabrics, newspaper, dried grass, and dried or rotted wood will ignite when exposed to sufficient thermal radiation.

Blast and shock

The expansion of intensely hot gases at extremely high pressures in the rapidly expanding fireball produces a blast wave. The destructive force of this blast wave is expressed in terms of overpressure (i.e., pressure in excess of normal atmospheric pressure, with normal atmospheric pressure being 14.7 pounds per square inch at sea level), and will be the greatest cause of material destruction. A few milliseconds after detonation, the blast wave develops and moves outward from the fireball. The front of the blast wave (shock front) travels rapidly away from the fireball in all directions, behaving like a moving wall of highly compressed air.

When the blast wave strikes the surface of the earth, it reflects back, similar to a sound wave producing an echo. This reflective blast wave, like the original wave, also causes damage. As the shock front moves outward from ground zero, the reflected wave expands along with it. At a distance from ground zero, the shock front and the reflective wave merge or fuse. (The distance will depend on height of burst [HOB] and energy yield of the weapon.) This reinforced wave is termed the “Mach effect” or “Mach stem.”

For a one-megaton weapon, detonated at an altitude of 6,500 feet, the direct and reflective wave fronts merge approximately 4.5 seconds after the explosion at a radius of 1.3 miles from ground zero. The overpressure at this point is about 20 pounds per square inch. This means the total air pressure is more than double the normal atmospheric pressure (14.7 + 20). With this overpressure, all the aboveground structures except specially reinforced buildings will be destroyed. The height of the Mach front is small at first, but as the blast wave continues to move outward, the Mach front height increases steadily, and at the same time, the overpressure decreases because of loss of energy and the ever-increasing area of the advancing front.

Strong winds are associated with the passage of the shock/Mach front that blows almost horizontally outward from ground zero. This wind is like a concentrated, short-lived hurricane. Below in the next table are some of the maximum winds associated with the peak overpressure.

Peak overpressure (pounds per square inch)	Maximum wind velocity (miles per hour)
200	2,078
150	1,777
100	1,415
72	1,168
50	934
30	669
20	502
10	294
5	163
2	70

Though it no longer glows, the fireball is still very hot. It rises swiftly, like a hot-gas balloon, sucking air inward and upward behind it. The suction phase of the burst creates strong winds, opposite in direction to the Mach wind. Near ground zero, these winds pull upward a large amount of surface dirt and light debris. This windborne material forms the stem or center column of the mushroom cloud that is characteristic of a nuclear airburst.

Nuclear radiation

In a nuclear explosion, there is an emission of various radiations consisting of gamma rays, neutrons, and alpha and beta particles. Most of the gamma rays accompanying the actual fission process gets absorbed by the weapon materials and is converted into other forms of energy. Thus, only a small proportion (about one percent) of this gamma radiation succeeds in penetrating any distance from the exploding weapon. Similarly, many neutrons produced in the fission and fusion reactions are captured by the weapons residue or by the air. Nevertheless, sufficient numbers of high-energy neutrons escape from the explosion and represent a significant hazard at considerable distances away. Accompanying a nuclear explosion is the initial and residual nuclear radiation.

Initial nuclear radiation

The definition of *initial nuclear radiation* is "radiation emitted from both the fireball and the radioactive cloud within (approximately) the first minute after an explosion." Initial nuclear radiation emitted by the fireball and cloud column consist mainly of neutron and gamma rays.

An initial nuclear radiation emits alpha and beta particles, but these particles have such short ranges and little penetrating power that they will not reach more than a few yards from the radioactive cloud. Because of this, we consider initial nuclear radiation as consisting only of gamma rays and neutrons. Both of these nuclear radiations can travel considerable distances through the air and can produce harmful effects in living organisms. It is the highly injurious nature of these nuclear radiations, combined with their long range, which makes them such a significant aspect of nuclear explosions.

Residual radiation

Residual radiation is radiation emitted after approximately one minute from the instant of a nuclear explosion. This radiation originates mainly from the bomb residues; that is, from the fission products and to a lesser extent, from the uranium and/or plutonium, which have escaped fission. Additionally, the residues will usually contain radioactive isotopes because of "neutron capture" by other weapon materials. Still another source of residual nuclear radiation is the activity induced by neutrons captured in various elements present in the explosion environment. The primary hazard of residual radiation results from the creation of fallout particles (which incorporate the radioactive weapon residues) and the induced activity in the soil, water, and other materials near the explosion.

Fallout

The extent and nature of the fallout can range between wide extremes. The following combinations of factors influence the effects of fallout:

- Yield and design of weapon.
- Height of the explosion.
- Type of surface beneath the point of burst.
- Meteorological conditions.

As the height of the burst of a nuclear weapon occurs nearer and nearer to the surface of the earth, larger and larger proportions of rock, soil, water, and other materials vaporize and are sucked up into the fireball as it rises. This includes the radioactive fission products, uranium (or plutonium) that has escaped fission, the weapon casing, and other materials. As the fireball increases in size and cools, the vapors condense to form a cloud containing solid particles of the weapon debris, as well as many small drops of water derived from the air sucked into the rising fireball. When sufficient cooling has occurred, the fission products become incorporated with earth particles because of the condensation of the vaporized products onto fuzed particles of earth, and so forth. As the violent disturbance subsides, these contaminated particles fall gradually back to earth, which is referred to as *fallout*.

Fallout is a gradual phenomenon extending over a period of time. There can be a considerable amount of fallout many hours after the surface detonation of a nuclear weapon, and it can occur many miles away. Fallout that occurs within 24 hours after a nuclear detonation is referred to as *early* and sometimes called *local* or *close-in* fallout. Additionally, there is a phenomenon called *delayed* or *worldwide* fallout, which are small particles that descend very slowly over large areas of the earth's surface and may continue for years after a nuclear explosion.

Types of bursts

For the many variations and intermediate situations that arise, there are five types of bursts used. There is also no specific boundary line to distinguish between one burst and another, but we generally characterize them as high-altitude, air, surface, underground, and underwater. The following factors influence the physical effect of a nuclear weapon detonation:

- Yield of the weapon.
- Type of burst (air, surface, or subsurface).
- Type of surface or terrain over which the weapon is detonated.
- Weather conditions.

High-altitude burst

A high-altitude burst is one in which the explosion takes place at an altitude of more than 100,000 feet. We may use high-altitude airbursts in special situations to reduce the intensity of neutron-induced gamma activity near ground zero. A high-altitude burst also provides greater coverage of soft ground targets, such as parked aircraft and frame buildings.

Airburst

An airburst is one in which the weapon is exploded in the air at an altitude below 100,000 feet, but high enough that the fireball does not touch the surface of the earth. A low airburst gets the most effective coverage and does the greatest damage to most of the ground targets. For example, in the explosion of a 1-megaton weapon, the fireball may grow until it is nearly 5,800 feet across at maximum brilliance. This means the explosion must occur at least 2,900 feet above the earth's surface in order to be called an airburst. Either airburst option provides a 99 percent assurance that fallout having a military significance will *not* occur. Two effects of the airburst are *blackout* and *electromagnetic pulse* (EMP).

Blackout

Blackout is the blocking of radio and radar transmissions. It is the development of an ionized area in the atmosphere by a nuclear detonation. Blackout is important because it seriously degrades the ability to communicate by radio; additionally it affects the proper function of radar. A specific limit of interference caused by ionization of the atmosphere depends on the yield and HOB. The effects on radio and radar transmissions differ according to the frequency band and method of propagation (ionosphere bounce or line of sight).

Electromagnetic pulse

An EMP is generated by gamma rays and X-rays released by a nuclear chain reaction interacting with air molecules that cause the freeing of electrons from these molecules. These electrons accelerate by the magnetic field of the earth, and because of their acceleration, they radiate a pulse of electromagnetic waves (the EMP). Figure 3–10 shows the area the EMP covers for a 1-megaton weapon at different HOBs.

The EMP strikes the ground over a wide area and induces large currents in such wires as communications power lines, and radio antennas. This leads to power failures, prevention of many communication transmissions, and causes the breakdown of essential electrical equipment. These currents are large enough to burn out electronic equipment and may trip circuit breakers in power networks. For example, a typical radio transmitter may handle 100 watts, while an EMP may carry one million watts. EMP and blackout occur at all heights of burst, but are more significant for high airburst. Although a high HOB generates an EMP current smaller than that of a surface burst, the pulse extends for larger distances.

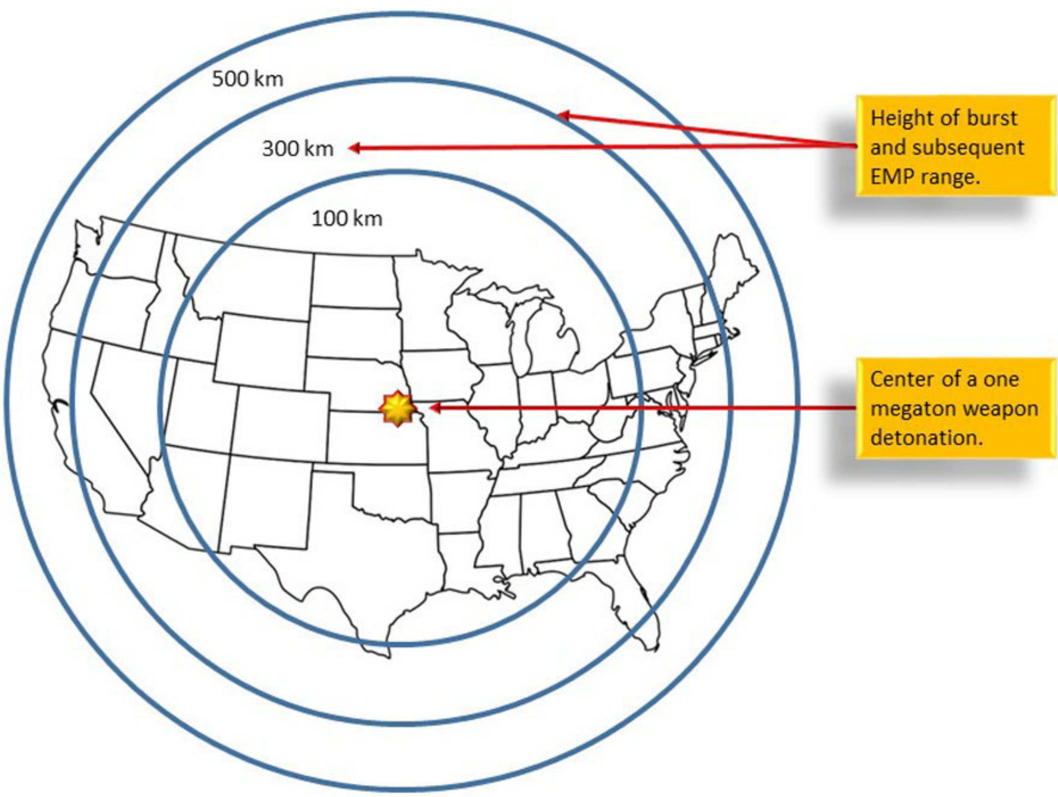


Figure 3–10. EMP.

Surface burst

Surface bursts cause fallout and cratering. This type of burst may be used against hard targets located near the surface of the earth. A surface burst is one in which the fireball, in its rapid, initial growth, touches the surface of the earth. Because of the intense heat, a considerable amount of rock, soil, and other material in the area vaporizes and becomes part of the fireball. This produces the fallout.

The blast wave and wind remove the vaporized material, which causes a crater to form. The size of the crater varies with the character of the soil, as well as the energy of the explosion. For a 1-megaton weapon, there would be no appreciable crater unless detonation occurred at an altitude of 450 feet or less. For example, one percent of the energy of a 1-megaton weapon expends in this manner and adds approximately 4,000 tons of vaporized soil material to the contents of the fireball. If a weapon of the same magnitude explodes near the surface of water, about 20,000 tons of water converts into vapor.

Underground burst

In an underground burst, the center of the fireball is beneath the earth’s surface. If the detonation occurs at a shallow depth, you can see the fireball as it breaks through the earth’s surface before clouds of dirt and dust obscure it. This type of burst damages underground targets and structures, which causes cratering. From tests made in Nevada, scientists estimate that if a 1-megaton weapon dropped from the air penetrated the ground of sandy soil to a depth of 50 feet before exploding, the crater would be about 300 feet deep and nearly 1,400 feet across. Additionally, the action would hurl approximately 10 million tons of earth and rock upward from the earth’s surface.

Underwater burst

The definition of an underwater burst is the same as that of an underground burst, only the environment changes. An underwater detonation forms a fireball, but it is smaller than one from an airburst. The water in the area is illuminated, but because of the distortion caused by waves on the surface, it appears as if seen through a ground-glass screen. When the fireball breaks through the water’s surface, the cooling effect is very rapid and the fireball is no longer visible.

In a shallow underwater test at Bikini Atoll, testers detonated a 20 kt nuclear weapon well below the surface of the lagoon, which was about 200 feet deep. The hollow column of water extended about 6,000 feet high and had a maximum diameter of about 2,000 feet. The walls of the column were about 300 feet thick. The burst raised about a million tons of water in the column.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

219. Theory and interactions

1. What items make up an atom’s structure?

2. When an atom loses or gains an electron, what do we consider it to be?

3. What subatomic component determines the identity of an atom?

4. How do you define an isotope?

5. List the materials used to produce nuclear explosions by fission.

6. What is the equivalent energy release of a complete fission of one pound of uranium or plutonium?

7. If only criticality of the active material is achieved, what would happen to the weapon?

8. What is the purpose of a neutron reflector?

9. Explain the gun-type method.

10. Explain the implosion method.

11. What do designers of nuclear weapons want to be certain of when it comes to neutron sources?

12. What is the equivalent energy release of fusion of all the nuclei present in one pound of hydrogen deuterium?

13. List the two ways that fusionable fuels are held in thermonuclear weapons.

220. Effects of nuclear detonations

1. What is the approximate distribution of energy released from a nuclear weapon?

2. What is the difference between the first and second pulse of thermal radiation from a nuclear weapon detonation?

3. What causes the typical mushroom cloud during a nuclear airburst?

4. What types of radiation are emitted during the initial radiation phase of a nuclear blast?

5. List the five basic types of nuclear bursts.

6. List four factors that influence the physical effects of a nuclear explosion.

7. Explain the difference between a high-altitude burst and an airburst.

8. Define the term "EMP."

9. What is the purpose of a surface burst?

3–2. Nuclear Weapon Components and Safety Features

A nuclear weapon needs to be as safe as possible to maintain, store, and handle. We also do not want a weapon producing a nuclear yield during an accident or incident. The only time we want a nuclear yield is when we are going to employ it during a conflict. Therefore, components of nuclear weapons are engineered precisely to produce a nuclear yield exactly when we want them. We will discuss components used in nuclear weapon operation and weapon safety design in this section.

221. Weapon components

In the early 1950s, scientists began to think in terms of thermonuclear weapons. Sometime in 1952, development of the thermonuclear weapon began. These early models had yields in the megaton range. The first sizes were a diameter of 5 feet, with a length of 9 to 20 feet, and weighed from 10 to 20 tons. As scientists developed thermonuclear weapons for stockpile purposes, research proved that smaller and lighter weapons were possible. Improvements were so extensive that the weapons of today bear little resemblance to the first weapons. Presently, the circuit of a nuclear weapon has power supplies and switches for arming and firing detonators, but the arrangement and operating principles of these devices may vary from weapon to weapon. In this lesson, we list components in weapon circuitry with a brief explanation of their functions.

Environmental sensing devices

An environmental sensing device (ESD) is a safety device in the arming circuitry of a weapon. It prevents an inadvertent function of the circuit until after the weapon been launched, released, or experience an environmental change peculiar to its delivery method. Differential pressure switches and integrating accelerometers are often used for this purpose.

Accelerometer switch

This is an ESD (fig. 3–11), which must sense several "Gs" (or gravitational force) of acceleration or deceleration to operate. This change would be sensed for a period of time before functioning like the firing of engines during a launch. This could ultimately close or open the switch, or step it to the next event required.

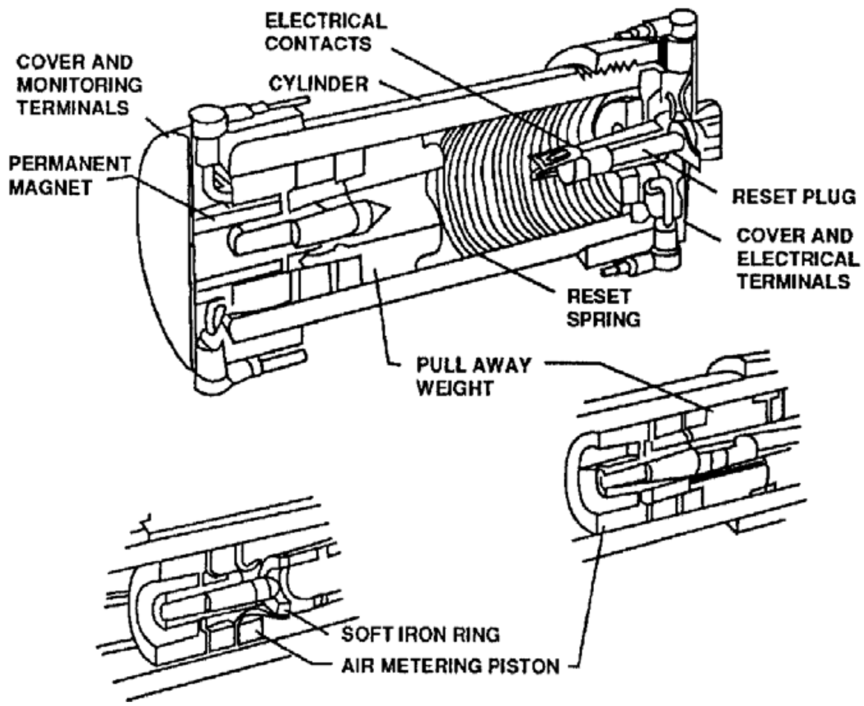


Figure 3–11. Accelerometer switch.

Barometric pressure switch

This switch works as a ground-handling safing device by preventing arming and firing until certain environmental conditions are reached (fig. 3–12). In a weapon drop, the switch operates by sensing a change in atmospheric pressure. Two types of barometric switches normally are used. Both have two chambers separated by a diaphragm and open to the atmosphere; one has electrical contacts on both sides of the diaphragm and the other has electrical contacts only on one side. By sealing off one chamber at release of the weapon, changes in atmospheric pressure cause the diaphragm to distort towards the sealed chamber. When the weapon reaches the desired altitude, the contacts close and the circuit is completed for either fuzing or firing.

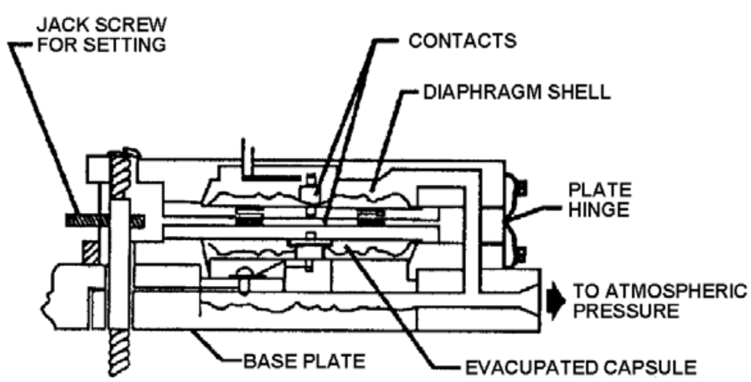


Figure 3–12. Barometric pressure switch.

Velocity pressure switch

This switch operates much as the barometric switch operates. When the weapon is moving through the air, the airflow over external protrusions (sometimes referred to as “fences”) creates a high pressure at a front port and a low pressure at a back port. The pressure difference, routed by manifolds, deflects a diaphragm towards a fixed contact. The diaphragm deflects sufficiently to close the contacts when a certain speed creates the desired pressure difference.

Bleeder circuit

A bleeder circuit provided for the X-unit capacitor bank has an effective resistance of about one megaohm. If the firing system fails to operate or the batteries somehow charge, the bleeder circuit reduces the voltage to a safe level within one hour or less. This act as a safety feature in the event the weapon becomes engulfed in fire.

Capacitor bank

The capacitor bank has dielectric capacitors connected in parallel. The capacitor bank stores energy until receipt of the firing signal by the firing set.

Contact crystals (piezoelectric ceramic devices)

Use these crystals mainly to deliver a firing signal to the weapon when the weapon impacts the ground. If desired, contact crystals can be a primary way to detonate the weapon or a backup method if the primary method fails. Contact crystals work on the piezoelectric effect. They generate a voltage across their surface when subjected to stress.

Command disablement system

The command disablement system (CDS) is a system internal to a bomb or warhead, but have external control devices, such as the preflight control panel (fig. 3–13). Operation of the CDS requires a classified three-digit code. When activated, the CDS destroys a weapon's ability to achieve a significant nuclear yield. The CDS is a nonviolent way to make a weapon inoperative.

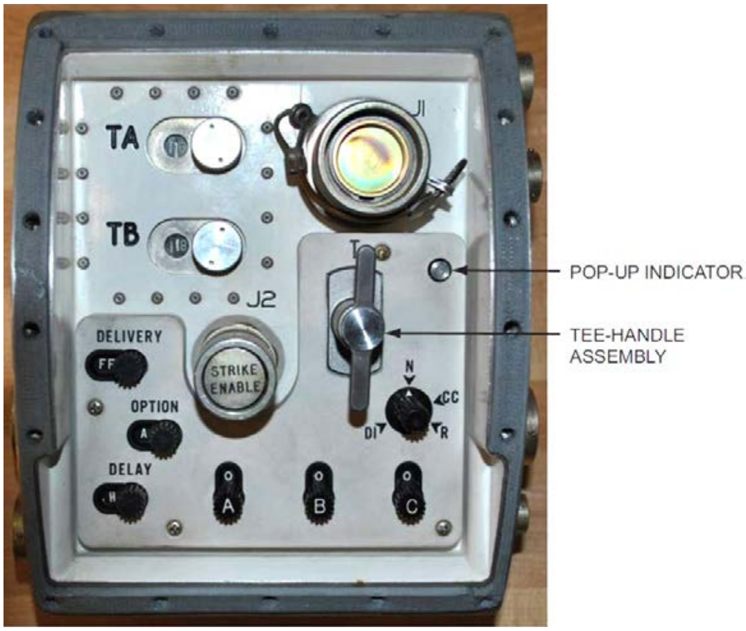


Figure 3–13. Preflight control panel.

Electrical safing switches

Electrical safing switches are available in most weapons to safe the weapon electrically by interrupting the circuit from the power supply to the capacitor bank. In an emergency, you may turn these switches manually from the armed (ready) position to the safe position (without electrical power applied to the weapon). Move this switch to the armed position electrically only when power is applied to the weapon. In addition, aircraft are equipped with an aircraft monitor and control (AMAC) device for the pilot to know the switch condition during flight.

Firing set

Upon receipt of a fuzing signal, the firing set controls the start of the final HE sequence in a nuclear weapon.

Fuzing set (arming)

The fuzing set is the part of a weapon that starts the signal that triggers the firing system.

Insensitive high explosives

IHEs require a shock of more than usual strength to cause detonation. IHE reduces the possibility of accidental HE detonation and minimizes the likelihood of nuclear material scattering in an accidental situation. This relative insensitivity contributes to weapon safety.

Neutron generator

The neutron generator provides a flux of neutrons during maximum compression of the active material. This results in a higher yield from a more complete fission.

Permissive action link

The PAL is a device included in or attached to a nuclear weapon system to preclude arming or launching until a prescribed discrete code or combination is inserted. A PAL may include equipment and cabling external to the weapon or weapon system to activate components within the weapon or weapon system. This also adds additional protection for unauthorized use.

Parachute retardation system

The retardation system usually has a pilot chute and a main chute. Timers or environmental switches control the deployment of parachutes. Parachutes slow the descent of a weapon to allow time for the release aircraft to escape or to “cushion” the weapon for a lay-down option.

Power supplies

Electrical power must be available for weapon components to work. Two of the most widely used power sources are the low-voltage thermal batteries (LVTB) and the high-voltage thermal batteries (HVTB). Besides supplying power for components, use LVTBs widely for activation of the HVTB for capacitor charging. In place of the normal liquid acid used in most batteries, thermal batteries use a solid electrolyte.

Melt the electrolyte for power to develop in the batteries. Do this by firing electrical squibs. They are equipped with a continuity loop to check their status electrically. Thermal fuses (that melt before the battery electrolyte—in case the weapon is involved in a fire) are in the battery line. These fuses open the battery line and keep power from going to any other component. The LVTB normally delivers 28 volts, direct current (VDC) while the HVTB normally delivers 2,500 VDC. Weapons not equipped with HVTB normally use a rotary chopper converter to develop high voltage. The rotary chopper converter takes the 28 VDC from the LVTB, puts it out as pulsating direct current (DC) and feeds it to a step-up transformer. The step-up transformer then puts the voltage out as 2,500 VDC and feeds it to the capacitor bank.

Pullout plug/cables

Pullout plugs are nothing more than electrical connectors. Connect the bomb electrically to the aircraft by a cable connected to the pullout switches through a connector. Power from the aircraft “sits” on a set of isolated contacts in the pullout plug until the bomb falls away from the aircraft. When this occurs, the cable pulls the plug upward letting the isolated contacts meet each other. This passes a power pulse from the aircraft to the bomb to operate other weapon components. The power is short in duration, as the cable will break away from the bomb.

Radar
This is a way to fuze or fire a weapon. It operates by measuring the time elapsed between the sending and receiving of a radio wave that, in turn, gives the distance to the target.

Spark gap tube
The spark gap tube is pulse-triggered and has two main electrodes and two trigger probes. The function of the spark gap tube is to transfer stored electrical energy from the capacitor bank to the detonators, through the load plate and at the same time, to furnish the neutron generator a triggering voltage.

Timers
Timers affect the arming or firing of a weapon. They may be used to delay activation of other components until a previously determined time has elapsed. One type of timer is electrically driven, while other types may be spring driven or pyrotechnic (the burning of an explosive). Figure 3–14 shows a sequential timer.

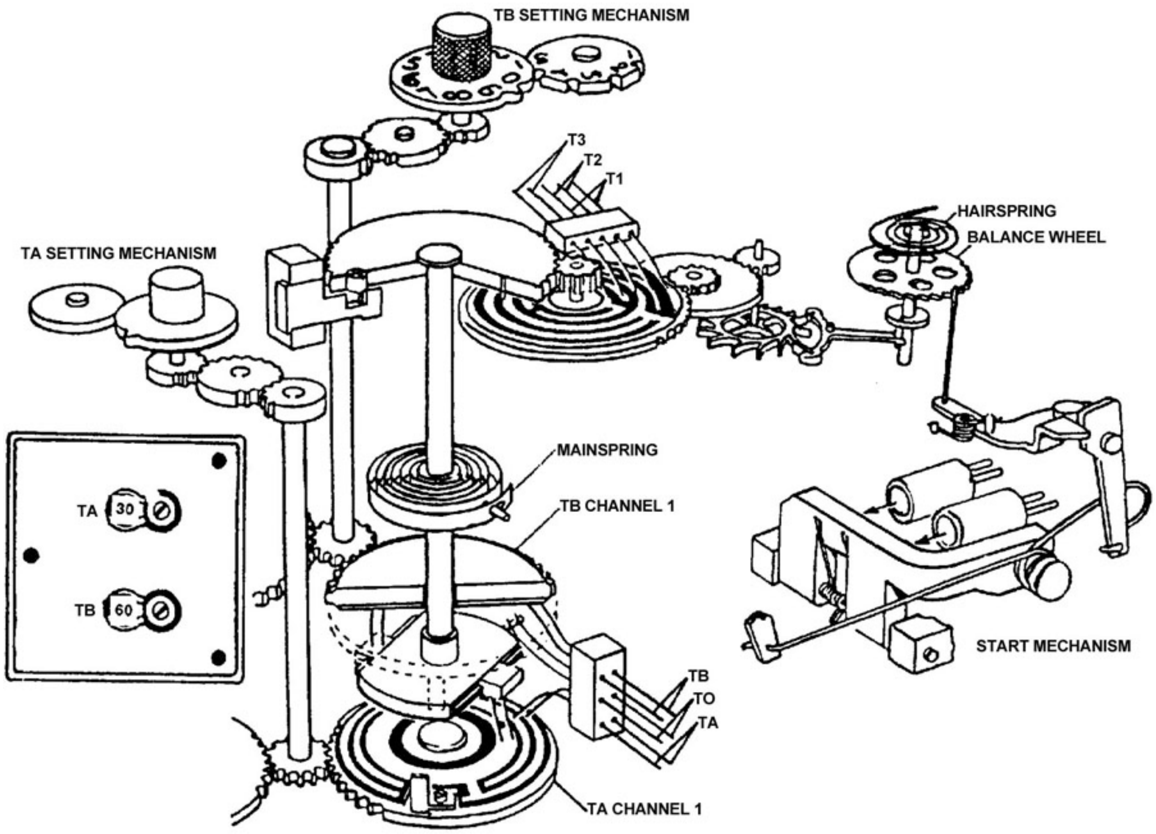


Figure 3–14. Sequential timer.

X-unit
The X-unit has a capacitor bank, a distribution system, and a spark gap tube. The X-unit stores and transfers sufficient electrical energy to fire the detonators simultaneously. The stored energy is released to the detonators and neutron generators through the spark gap tube upon receipt of a firing signal from the fuzing system.

222. Weapon safety design and operations
The components in the last lesson are tied together to form a complete weapon circuit. A nuclear weapon (i.e., implosion type, gun type, or thermonuclear type) in its ultimate configuration, upon

completion of the prescribed arming, fuzing, and firing sequence, can produce the intended nuclear reaction and release of energy. Nuclear weapons have internal safety devices to protect against inadvertent operation and detonation. Here you learn about safety design features and critical functions of nuclear weapon systems and the typical operating sequence described in a theoretical nuclear weapon—not a specific weapon in the stockpile today.

Nuclear weapon safety design philosophy

The DOE designs nuclear weapon safety devices to withstand credible abnormal environments. Safety devices last longer than the weapon's critical arming components or until the weapon is physically incapable of providing a nuclear detonation. The design of AF nuclear weapon systems must consider the DOE nuclear weapon design concepts.

Exclusion region

This region contains the firing set and weapon detonator system. It also has the necessary packaging and safety devices to exclude electrical energy for other than intended use from the firing set and weapon detonator system.

Strong links

Strong links are safety devices that provide the signal path to the firing set for the arming and firing signals. Strong links as well provide energy isolation in an abnormal environment and operate in the normal mode only when used. Prearm devices and environmental or trajectory sensing devices are examples of strong links.

Weak links

A weak link is a selected functional unit, such as a capacitor or transformer, vital to operating the firing set and weapon detonator system. The unit is not likely to be duplicated or bypassed. Weak links respond predictably to certain levels and types of abnormal environments by becoming irreversibly inoperative. This renders the system inoperable at levels less than those, at which the strong links fail to keep electrical isolation. Because weak links and strong links are placed together, they experience essentially the same environment at the same time.

Nuclear weapon system safety design philosophy

AF designs implement critical function control to provide adequate protection against premature detonation of a nuclear weapon in both normal and credible abnormal environments. Energy control concept and information control concept also supports this safety feature.

Critical function control concept

The criteria for adequately controlling some critical functions depend on the specific nuclear safety design concept of the weapon system. Older nuclear weapons and weapon systems use the energy control (or removal) concept. However, many currently deployed systems and those in development use the information control concept or a combination of both concepts.

Energy control concept

Limiting the entry of energy into the weapon system controls the critical functions. The devices that execute critical functions need high-energy signals to operate. Other functions need signals with very low energy and occur as infrequently as possible. Reliability requires that the weapon system respond when the specified high-energy command signals are present at the weapon interface. Therefore, safety levels of weapon systems using this design concept depend on the safety controls that blocks application of high-energy signals to the weapon interface, until the controls are removed properly.

Information control concept

Command critical functions by uniquely encoded information or data words. Safety levels depend on the uniqueness of the command or data word and are evaluated based on the assumptions of worst-case power levels, such as a lightning strike.

Weapon safety critical functions

This term describes functions, circuits, or activities that directly control the authorization, prearming, arming, launching or releasing of a nuclear weapon, or the targeting of a ground-launched nuclear weapon system.

Authorization

Authorization to use a weapon is a critical function. Nuclear weapon systems have one or more devices to control the authorization to use the weapon. These devices prevent prearming or arming (or both) of a bomb or warhead in aircraft-carried weapons. They also prevent the launch of a ground-launched missile, until the command and control system provides authorization to use the weapon.

An example of a ground launch missile control is the enable device in the Minuteman weapon system and PAL in nuclear bombs. The authorization device operates on the information-control concept. A secure method provides the information through command and control channels. It has built-in positive design features to prevent inadvertent operation of the data entry control. The positive features protect against inadvertent operation of the authorization device and an attack on, or bypass of, the device.

Prearming

The prearm command signals the weapon that the weapon system operators want it to produce a nuclear detonation. Once commanded to the prearm state and presented with proper arming stimuli, the weapon arms. The weapon system design keeps the prearming function separate and independent from the authorization function. Weapon design features preclude prearming in the absence of the prearm command signal and prevent bypass of any prearming device. Weapons designed on the information control concept use uniquely coded prearm command signals. The information needed to generate the unique signal must be physically unavailable to the unique signal generator until its use is required. Weapons designed on the energy control concept physically and electrically isolate the prearm command signal from all other circuits.

Launching

The operation of a rocket motor propulsion system (control of launch) is controlled through two independent functions: the ignition system arm or safe command and the ignition command. Without the arm command, the propulsion system ignition does not occur even if the ignition command is sent. Design features preclude accidental or deliberate unauthorized transmission of the arm and ignition commands.

Releasing

The operation of the release system for aircraft-carried weapons is controlled through two independent functions: the release systems unlock command and the release command. Without the unlock command, separation of the weapon from the combat delivery aircraft will not occur even if the release command is sent. Design features preclude accidental transmission of unlock and release commands. It also prevents any failure from allowing bypass of the lock device, which would permit the release of the weapon when the device is locked.

Arming

If the weapon is prearmed, arming will be the design response of the weapon to sense that the environment is within the limits defined for operational use (after launch or release). Design features measure the environment so that environments other than “intended use” are discriminated against. If a missile has a self-contained guidance, a good guidance signal measures the proper operational environment. The armed condition allows the selected fuze signal (such as radar, contact, or timer) to detonate the warhead. Design features preclude arming unless the proper operational environment is sensed, prevent erroneous transmission of the good guidance signal, and lastly, preclude bypass of the arming system that would permit nuclear detonation of the warhead without arming.

Targeting

Targeting is a critical function for ground-launched missiles. It includes preparation, weapon system processing, and transmission of targeting data to missile guidance and the arming and fuzing systems. Targeting data consists of the flight control and fuzing constants needed to deliver and detonate the weapons within the designated target area.

Operating sequence of a weapon

The following description and figure 3–15 show the typical relationship between components already discussed and its theoretical use in a weapon. Before loading the weapon on an aircraft, the weapon is prepared for strike in the required configuration. Those configurations are the setting of the fuze, the yield, and TA (time A) and TB (time B) timers taken from the operational orders received by your base. You can find the cables, wire ropes, and fin configuration in the appropriate –1 series TO.

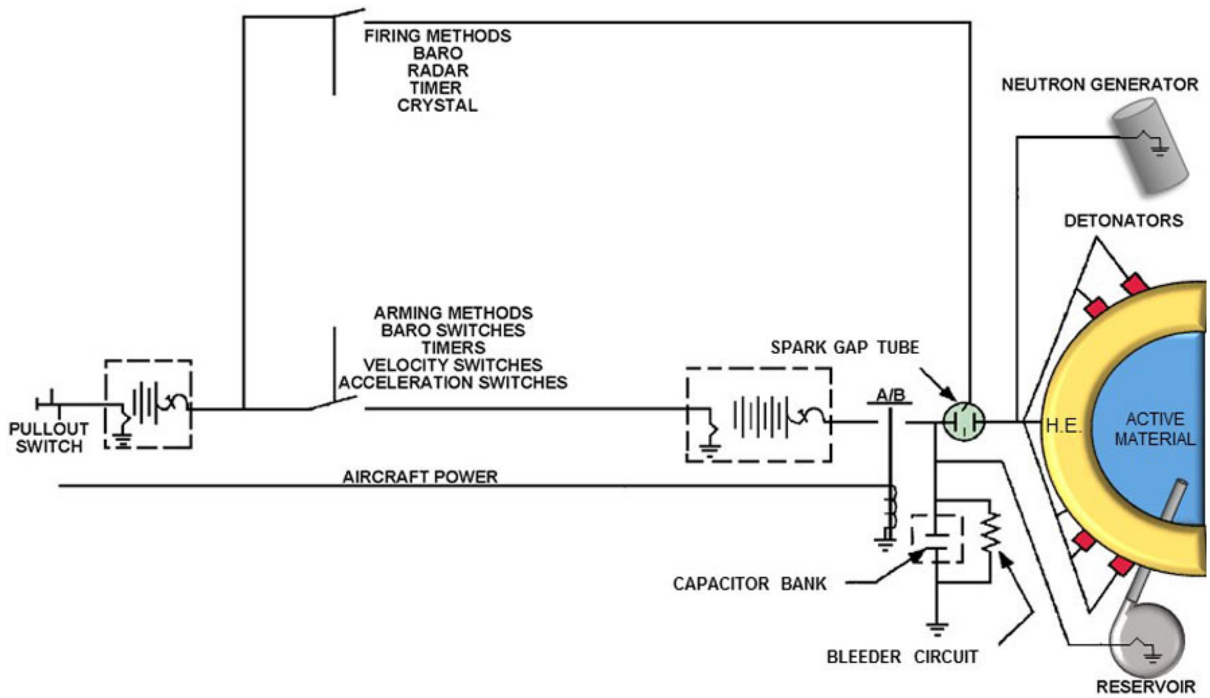


Figure 3–15. Theoretical nuclear system.

Before release from the aircraft, aircraft power rotates the arm-safe switch (electrical safing switch) to the arm position. The pilot can choose the type of burst (if orders have changed) by using an AMAC box. At release, the pullout switches/cables transfer the aircraft power to activate the squib in the LVTB. The devices that arm the bomb are now started. Wire ropes attached to the pulse plug generator are extracted, which starts timers and thermal batteries for the deployment of the parachute. Parachute deployment time is set on the preflight control panel depending on which type of strike is required.

When the LVTB comes up to power, 28 VDC is supplied to the open contacts of the arming and firing lines. Upon operation of one or more of the selected arming methods, the power from the LVTB is transferred to ignite the squib of the HVTB. When discharging the high voltage from the HVTB, it charges the capacitor bank and fires the guillotine valve in the reservoir and valve assembly, thus providing the boost required for the weapon.

Upon operation of one of the firing methods, radar, timers, environmental switches, or contact crystals, power is supplied from the LVTB to the probe in the spark gap tube. The tube ionizes and passes voltage from the capacitor bank to the detonators, which, in turn, initiate the explosives in the weapon. The voltage from the capacitor bank also triggers the time delay circuit in the neutron generators. At the right moment (maximum compression of the primary), the neutron generators supplies a flux of neutrons to the compressed active material. This creates a greater fission of the active material, followed by a nuclear detonation. In case the primary method of detonation fails, contact crystals, if present, provides the fire signal upon contact with the ground.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

221. Weapon components

1. Define ESD.
2. What is the function of a barometric pressure switch?
3. What is the purpose of contact crystals?
4. Explain how the CDS operates.
5. What is the purpose of a PAL device?
6. Explain how power is developed in thermal batteries.
7. What is the function of the rotary chopper converter?
8. Explain how timers are used.

222. Weapon safety design and operations

1. What is contained in an exclusion region of a nuclear weapon?
2. List two examples of strong links.

3. Explain the operation of a weak link.

4. On what type of safety controls do weapon systems using the energy control design concept depend?

5. Explain how authorization devices are used.

6. What does the prearm command signal to the weapon?

7. Explain how prearming is prevented in weapons designed on the information control concept and the energy control concept.

8. What functions control the release of aircraft-carried weapons?

9. How do weapon system design features prevent arming?

10. What does targeting data provide?

3–3. Our Heritage

To understand who we are, we have to understand where we came from. As you read about our nuclear history, just keep in mind the historical accomplishments that shaped our current operations could not have happened without the right people doing the right job.

223. Nuclear history

History plays a vital role in shaping our present day operations as a nuclear force. Much of our rules, regulations, directives, policies, and TOs were either non-existent or contained less information than they do today. In fact, we have been chipping, molding, and paving the way to galvanize our nuclear enterprise. Along the way, we have created various new policies, surety guidelines, and operational procedures to match. So let's start this lesson from the beginning of our distinguished career field.

The beginning

The history of the atom began as early as the late 1700s. Over the years, scientists have been building upon one discovery after another until December 1938 when two German chemists conducted the first nuclear fission experiment.

In January 1939, scientists led by Enrico Fermi at Columbia University in New York performed the first nuclear fission experiment on American soil. This was not only to replicate an earlier discovery, but also to determine the amount of energy released from a nuclear fission. The experiment validated that uranium was capable of being split into parts when hit by neutrons, causing each uranium atom to eject additional neutrons. This ultimately released a tremendous amount of energy. If this energy could be harnessed, it could serve as a basis for generating electricity (e.g., nuclear reactors) or could serve as a military tool of destruction (e.g., nuclear bomb).

In August 1939, a band of Hungarian scientists wrote a letter, signed by Albert Einstein, to President Franklin D. Roosevelt concerning the potential use of nuclear fission to create “extremely powerful bombs of a new type.” It also indicated that German scientists were diligently working on the same project evidenced by the fact Germany had stopped the uranium export from Czechoslovakia. President Roosevelt appointed a committee known as the “Uranium Committee” to determine if the federal government should be involved in the uranium research. Ultimately, the committee concluded in favor of using the fission energy of uranium for military use.

So it began, the United States was directly involved in the research and development of nuclear fission. By 1940, President Franklin D. Roosevelt created the National Defense Research Committee to continue the uranium research. The Uranium Committee originally led the research, but later reorganized as one of its sub-committees later. In September 1942, the Manhattan Engineering District (MED), also known as the “Manhattan Project” was established under the command of Major General Leslie R. Groves Jr. to resume development of the nuclear bomb and to perform all related functions. After three short years of research and development, a collection of scientists and military officers were led to the southwest corner of the United States, where in the middle of the New Mexican desert, a demonstration was set to change history forever.

The rain of ruin

Trinity Test Site is located in an isolated area 35 miles east of Socorro, New Mexico, and within the boundaries of the White Sands Missile Range. On 16 July 1945 at 0530 hours, the sky over the New Mexican desert illuminated with an intense light brighter than the sun, followed by a thunderous sound never heard before. As noted by a general officer at the test site, “The whole country was lit up by a searing light with the intensity many times that of the midday Sun.” The world’s first man-made nuclear explosion occurred on this day, and the United States was the first to achieve this success. After this successful test at the Trinity Test Site, President Harry S. Truman authorized the use of nuclear bombs against the Empire of Japan.

On the early morning of 6 August 1945, a single B–29 Superfortress bomber named Enola Gay, commanded by Colonel Paul W. Tibbets, Jr., took off from Tinian Island. The aircraft headed to its military target Hiroshima, Japan. At exactly 0816 hours, the Enola Gay dropped the nuclear bomb nicknamed “Little Boy” over the city of Hiroshima, Japan. Little Boy detonated 1,900 feet above ground zero with a yield equivalent to 12,500 tons of TNT. Though the causality figures are not exact, approximately 135,000 people died from this single bomb. Approximations are given because many were vaporized or completely consumed by the fires that spread rapidly throughout the city soon after. There were also several thousand deaths due to gamma radiation exposure and nuclear fallout from the explosion. The bomb destroyed 90 percent of the city. Japan’s military officials could not believe the United States had perfected a nuclear bomb until 16 hours later when President Truman announced to the world:

> “A short time ago, an American airplane dropped one bomb on Hiroshima and destroyed its usefulness to the enemy. That bomb had more power than 20,000 tons of TNT. The Japanese began the war from the air at Pearl Harbor. The dropping of Little Boy repaid Japan many folds with the end of the repayment still not over. With this bomb, we have now added a new and revolutionary increase in destruction to supplement the growing power of our armed forces. In their present form, these bombs are now in production and bombs that are even more powerful are in development. It is an atomic bomb; it is a harnessing of the basic power of the universe. The force which the sun draws its power has been loosed against those who brought war to the

Far East…We are now prepared to destroy more rapidly and completely every productive enterprise the Japanese have in any city. We shall destroy their docks, their factories, and their communications. Let there be no mistake; we shall completely destroy Japan's power to make war…If they do not now accept our terms, they may expect a rain of ruin from the air the like of which has never been seen on this earth..."

– Harry S. Truman.

On the early morning of 9 August 1945, just three days after Little Boy detonated over Hiroshima, another B–29 Superfortress was outfitted with another nuclear bomb. This time, Major Charles W. Sweeny led an attack on the city of Kokura, the second city chosen to fall under nuclear attack. Major Sweeny, aboard Bock's Car, departed the Island of Tinian and headed for the city of Kokura, Japan. As Bock's Car approached their target, heavy clouds of haze and smoke covered the city of Kokura and hindered the crew's ability to see the city. After three unsuccessful passes and still no visibility of Kokura, Bock's Car quickly broke away from the primary target and headed towards their secondary target, Nagasaki. At their first opportunity of a clear sky, Bock's Car dropped the nuclear bomb nicknamed "Fat Man" at exactly 1058 hours. Fat Man detonated 1,800 feet above ground zero with a yield equivalent to 22,000 tons of TNT. Approximately 64,000 people died in the same manner as before. Even though the yield equivalent was larger than that used in the Hiroshima bomb, damage and causalities were much lower than Hiroshima due to the irregular topography and hilly terrain of Nagasaki.

The succession of two nuclear explosions on Hiroshima and Nagasaki ultimately resulted in Japan's surrender. World War II finally ended when the Japanese foreign affairs minister Mamoru Shigemitsu signed the surrender documents on the USS Missouri on 2 September 1945. Realizing the implications and devastating aftereffects of a nuclear blast, President Truman directed Congress to set up a system to continue development of this power, not only as an instrument of war, but as an advocate for peace.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

223. Nuclear history

1. Why did scientists at Columbia University perform a nuclear fission experiment?

2. Why did a band of Hungarian scientists write a letter to President Franklin D. Roosevelt?

3. For what purpose did President Franklin D. Roosevelt create the Uranium Committee?

4. Where did the world's first man-made nuclear explosion occur and when?

5. What was the name of the B–29 Superfortress that carried and dropped the first nuclear bomb on Japan? Which city?

6. Who led the second nuclear attack, and what was the primary target?

7. Why were there less causalities and damage in Nagasaki even though Fat Man had a higher yield than Little Boy?

Answers to Self-Test Questions

219

1. Protons, neutrons, and electrons.
2. Ionized.
3. The number of protons in the nucleus.
4. Atoms of the same element but different atomic mass numbers.
5. Isotopes of the elements uranium and plutonium.
6. 8,000 tons of TNT.
7. The energy release would be small and no explosion would result.
8. To reduce the loss of neutrons due to escape and decrease the mass required for criticality.
9. This weapon works on the increase in mass principle, in which a projectile of active material is fired by a charge of conventional explosives at a target of active material.
10. Subcritical masses reach a supercritical state through implosion. Supercriticality is achieved by squeezing the subcritical mass into a smaller volume by means of tremendous pressure.
11. An abundance of neutrons will be available for use when the mass becomes supercritical.
12. 26,000 tons of TNT.
13. (1) In the form of metallic salts.
    (2) By the use of gas reservoirs.

220

1. 50 percent blast and shock, 35 percent thermal radiation, 10 percent residual nuclear radiation, 5 percent initial radiation.
2. The first pulse lasts for about a tenth of a second, temperatures are very high, and much of the thermal radiation is in the ultraviolet region. The second pulse phase lasts for several seconds, temperatures are lower than in the first pulse, and most of the rays reaching the earth are visible and infrared (invisible) light.
3. The fireball sucks air inward and upward behind it. The suction phase of the burst creates strong winds, opposite in direction to the Mach wind. Near ground zero, these winds pull upward a large amount of surface dirt and light debris. This windborne material forms the stem or center column of the mushroom cloud that is characteristic of a nuclear airburst.
4. Initial nuclear radiation emitted by the fireball and cloud column consist mainly of neutron and gamma rays.
5. (1) High-altitude.
   (2) Air.
   (3) Surface.
   (4) Underground.
   (5) Underwater.
6. (1) Yield of the weapon.
   (2) Type of burst (air, surface or subsurface).

(3) Type of surface or terrain.

(4) Weather conditions.

7. High-altitude burst is in excess of 100,000 feet and an airburst is below 100,000 feet but high enough that the fireball does not touch the surface of the earth.
8. An EMP is generated by gamma rays and X-rays released by the nuclear chain reaction that interacts with air molecules causing the freeing of electrons. When an EMP strikes the ground, it induces large currents in wires such as communications and power lines and radio antennas. This will lead to power failures, prevention of many types communication transmissions, and cause the breakdown of essential electrical equipment.
9. A surface burst is used to cause fallout and cratering. It may also be used against hard targets located near the surface of the earth.

221

1. A safety device placed in the arming circuitry of a weapon. It prevents inadvertent function of the circuit until after the weapon, having been launched or released, experiences an environmental change peculiar to its delivery method.
2. Acts as a ground-handling safing device by preventing arming and firing until certain environmental conditions are reached.
3. Used mainly to deliver a firing signal to the weapon when the weapon impacts the ground. If desired, contact crystals can be a primary way to detonate the weapon or a backup method if the primary method fails.
4. It requires the use of a classified three-digit code. When activated, it destroys a weapon’s ability to achieve a significant nuclear yield.
5. To preclude arming and launching until insertion of a prescribed discrete code or combination.
6. By melting the electrolyte. This is done by firing electrical squibs.
7. Takes the 28 VDC voltage from the LVBT, puts it out as “pulsing DC”, and feeds it to a step-up transformer.
8. Timers are designed to affect arming or firing of a weapon and may be used to delay activation of other components until a previously determined time has elapsed.

222

1. The firing set and weapon detonator system. It also has the necessary packaging and safety devices to exclude electrical energy.
2. (1) Prearm devices.

   (2) Environmental or trajectory sensing devices.
3. Weak links respond predictably to certain levels and types of abnormal environments by becoming irreversibly inoperative. This renders the system inoperable at levels less than those at which the strong links fail to keep electrical isolation.
4. Controls that block application of high-energy signals to the weapon interface until the controls are properly removed.
5. Used to prevent prearming or arming (or both) of a bomb or warhead in aircraft-carried weapons and the launch of a ground-launched missile until authorization to prepare to use the weapon is received through the command and control system.
6. That the weapon system operators want it to work as designed and produce a nuclear detonation.
7. Weapons designed on the information control concept use uniquely coded prearm command signals. The information needed to generate the unique signal must be physically unavailable to the unique signal generator until its use is required. Weapons designed on the energy control concept physically and electrically isolate the prearm command signal from all other circuits.
8. The release system unlock command and the release command.
9. The proper operational environment must be sensed; prevents erroneous transmission of the good guidance signal; and design precludes bypass of the arming system that would permit nuclear detonation of the warhead without arming.

10. The flight control and fuzing constants needed to deliver and detonate the weapons within the designated target area.

223

1. To replicate the discovery and to determine the amount of energy released from a nuclear fission.
2. To address the potential use of nuclear fission to create extremely powerful bombs of a new type. The letter indicated that German scientists were working on the same project due to the fact Germany had stopped the uranium export from Czechoslovakia.
3. To determine if the federal government should be involved in the uranium research.
4. Trinity Test Site on 16 July 1945 at 0530 hours.
5. Enola Gay; Hiroshima, Japan.
6. Major Charles W. Sweeney; original primary target was the city of Kukora Japan.
7. Due to the irregular topography and hilly terrain of Nagasaki.

Complete the unit review exercises.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

56. (219) What is the *smallest* part of any element that can exist while retaining the characteristics of the element?
    a. Molecule.
    b. Nucleus.
    c. Shell.
    d. Atom.

57. (219) What type of *charge* does an electron hold?
    a. Negative.
    b. Positive.
    c. Neutral.
    d. Inert.

58. (219) When an atom *gains* an electron, what type of *ion* does it become?
    a. Neutralized.
    b. Polarized.
    c. Negative.
    d. Positive.

59. (219) Which part of a fissionable atom does a neutron enter in order for fission to take place?
    a. Proton.
    b. Nucleus.
    c. Neutron.
    d. Electron.

60. (219) What *must* happen to fissionable material for a nuclear weapon to operate *most* efficiently?
    a. The subcritical mass must be achieved.
    b. The supercritical mass must be achieved.
    c. The mass must be compressed for a specific period of time.
    d. The mass must be compressed while injecting electrons for a specific period of time.

61. (219) How is supercriticality achieved through the implosion method?
    a. Decreasing the mass of the active material by reducing the surface area.
    b. Increasing the mass of the active material by increasing the surface area.
    c. Expanding the subcritical mass into a larger volume by means of tremendous pressure.
    d. Squeezing the subcritical mass into a smaller volume by means of tremendous pressure.

62. (219) In fission weapons, what do you call a capsule placed near fissionable material to *ensure* an abundance of neutrons?
    a. Gas reservoir.
    b. Accelerator.
    c. Initiator.
    d. Booster.

63. (220) The *destructive* effects of a nuclear weapon detonation is *mainly* due to
    a. fire.
    b. dust.
    c. blast.
    d. radiation.

64. (220) Which type of radiation is the *main* cause of skin burns up to 12 miles away from a one-megaton explosion?
   a. Alpha.
   b. Beta.
   c. Neutron.
   d. Thermal.

65. (220) Which type of burst *may* be used in special situations to *reduce* the intensity of neutron-induced gamma activity near ground zero?
   a. Air.
   b. Surface.
   c. High-altitude.
   d. Underground.

66. (220) Which type of burst gives the *most* effective coverage and does the *greatest* damage to a *majority* of ground targets?
   a. Air.
   b. Surface.
   c. High-altitude.
   d. Underground.

67. (220) The blackout effect of an airburst *seriously* degrades the ability to
   a. work in the area due to the extensive fallout.
   b. stay conscious due to the extensive radiation.
   c. function at night due to the brilliance of the flash.
   d. communicate by radio and affects the function of radar.

68. (220) What are the effects of an electromagnetic pulse (EMP)?
   a. High levels of static electricity and structural failure of equipment.
   b. Power surges and the polarization of essential electrical equipment.
   c. Power failures, prevention of communications, and the breakdown of electrical equipment.
   d. High levels of static electricity, magnetizing of steel materials, and structural failure of equipment.

69. (221) Which type of device is commonly called a differential pressure switch and integrating accelerometer?
   a. Electroexplosive sensing.
   b. Environmental sensing.
   c. Barometric pressure.
   d. Velocity pressure.

70. (221) An acceleration switch is an environmental sensing device (ESD), which *must* sense
   a. atmospheric changes to actuate mercury switches.
   b. several Gs (or gravitational force) of acceleration or deceleration to operate.
   c. barometric pressures during acceleration for a specific period of time.
   d. temperature changes in the atmosphere to actuate mercury explosive switches.

71. (221) Which *switch* functions as a ground-handling safing device, by preventing arming and firing until certain environmental conditions are reached?
   a. Differential.
   b. Inertial safing.
   c. Electrical safing.
   d. Barometric pressure.

72. (221) Which weapon component acts as a *safety* feature if the weapon becomes engulfed in fire?
    a. Single pulse generator.
    b. Capacitor bank.
    c. Bleeder circuit.
    d. Fuzing set.

73. (221) The initiation of the *final* high explosive (HE) sequence is controlled by the
    a. firing set.
    b. fuzing set.
    c. neutron generator.
    d. single pulse generator.

74. (222) What is *not* a Department of Energy (DOE) nuclear weapon design concept?
    a. Exclusion region.
    b. Energy control.
    c. Strong links.
    d. Weak links.

75. (222) Which *critical* function does the permissive action link (PAL) device control?
    a. Releasing.
    b. Targeting.
    c. Prearming.
    d. Authorization.

76. (222) Which characteristic describes weapons designed on the information control concept?
    a. Use uniquely coded prearm command signals.
    b. Perform prearming in the absence of the prearm command signal.
    c. Isolate the prearm signal from other circuits physically and electrically.
    d. Combine the prearming and authorization functions to bypass other circuits.

77. (223) The significance of scientists at Columbia University replicating the nuclear fission experiment is it became the *first-ever* nuclear
    a. fusion experiment.
    b. fusion experiment on American soil.
    c. fission experiment.
    d. fission experiment on American soil.

78. (223) Who commanded the Manhattan Engineering District (MED) to resume development of the nuclear bomb and *all* of its related functions?
    a. Major General Leslie R. Groves Jr.
    b. President Franklin D. Roosevelt.
    c. Colonel Paul W. Tibbets Jr.
    d. Dr. Albert Einstein.

79. (223) What was the name of the nuclear bomb dropped on Hiroshima, Japan?
    a. Trinity.
    b. Fat Man.
    c. Little Boy.
    d. Enola Gay.

80. (223) Which Japanese city was *initially* chosen for the second nuclear attack mission, but had to be redirected due to heavy clouds and smoke?
    a. Hiroshima.
    b. Hong Kong.
    c. Nagasaki.
    d. Kokura.

Glossary of Abbreviations and Acronyms

°F	degrees Fahrenheit
AF	Air Force
AF EESOH-MIS	Air Force Enterprise Environmental, Safety, and Occupation Health Management Information System
AFA	arming and fuzing assembly
AFGSC/NCP	Air Force Global Strike Command/Nuclear Control Point
AFI	Air Force instruction
AFIOH	Air Force Institute for Operational Health
AFMAN	Air Force manual
AFMC	Air Force Materiel Command
AFNWC	Air Force Nuclear Weapons Center
AFOSH	Air Force Occupational Safety and Health
AFPAM	Air Force pamphlet
AFSEC	Air Force Safety Center
AFTO	Air Force technical order
AGE	aerospace ground equipment
AIDR	acceptance inspection deficiency report
ALARA	as low as reasonably achievable
ALT	alteration
AMAC	aircraft monitor and control
BCE	base civil engineer
CaF	calcium fluoride
CAT	category
CDS	command disablement system
CF	carried forward
CFR	Code of Federal Regulations
CO_2	carbon dioxide
CONUS	continental United States
DC	direct current
DD	Department of Defense
DIAMONDS	Defense Integration and Management of Nuclear Data Services
DLA	Defense Logistics Agency
DOD	Department of Defense

DOE	Department of Energy
DR	deficiency report/deficiency reporting
DTRA	Defense Threat Reduction Agency
EED	electroexplosive device
EID	electrically initiated device
eIRC	electronic inspection record card
e-mail	electronic mail
EME	electromagnetic environment
EMP	electromagnetic pulse
EMR	electromagnetic radiation
ES	exposed site; equipment specialist
ESD	environmental sensing device
ESSD	electrostatic-sensitive device
ETAR	engineering technical assistance request
G	gravitational force
HAZCOM	hazard communication
HE	high explosive
HERO	Hazards of Electromagnetic Radiation to Ordnance
HOB	height of burst
HTO	tritium water vapor
HVTB	high-voltage thermal battery
IAW	in accordance with
IHE	insensitive high explosive
INRAD	intrinsic radiation
IRC	inspection record card
JDRS	Joint Deficiency Report System
JNWPS	Joint Nuclear Weapons Publication System
JSA	job safety analysis
JTA	joint test assembly
kt	kiloton
LiF	lithium fluoride
LLC	limited-life component
LLCE	limited-life component exchange
LLRW	low-level radioactive waste
LPS	lightning protection system

LVTB	low-voltage thermal battery
MAJCOM	major command
MAR	maintenance activity report; maintenance assistance request
MASO	munitions accountable systems officer
ME	mobile emitter
MED	Manhattan Engineering District
millisecond	one millionth of a second
MIPBR	Materiel Improvement Project Review Board
MIS	maintenance information system
MK	mark
MME	modern mobile emitter
MNCL	master nuclear certification list
MOAB	massive ordnance air blast
MPD	maximum permissible dose
mrem	millirem
MXG/CC	maintenance group commander
N/A	not applicable
NARS	Nuclear Accountability and Reporting Section
NCRP	National Council on Radiation Protection and Measurements
NFPA	National Fire Protection Association
nm	nautical mile
NSN	national stock number
OCONUS	outside Continental United States
OI	operating instruction
OSHA	Occupational Safety and Health Administration
OSS&E	operational safety, suitability, and effectiveness
PAL	permissive action link
PES	potential explosion site
pit	fission primary
POV	privately owned vehicle
PPE	personal protective equipment
PQDR	product quality deficiency report
PRP	Personnel Reliability Program
Pu	plutonium
QA	quality assurance

Q-D	quantity-distance
RAC	rapid action change
radiac	radioactivity, detection, indication, and computation
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RF	radio frequency
RM	risk management
RSO	radiation safety officer
S	Sandia
SDS	safety data sheet
SE	support equipment
SEW	weapon safety division
SLPR	storage location and planning report
SNL	Sandia National Laboratories
SPEED	sound the alarm, phone the fire department, evacuate nonessential people, extinguish the fire (if possible), direct fire-fighting people
SPM	system program manager
SQ/CC	squadron commander
SSD	safe separation distance
T&E	test and evaluation
T&H	test and handling
TA	time A
TB	time B
TCTO	time compliance technical order
TFE	traditional fixed location emitter
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TO	technical order
TODO	technical order distribution office
U	uranium
U^{235}	uranium 235
U^{238}	uranium 238
UR	unsatisfactory report
USAF	United States Air Force
USAFSAM	United States Air Force School of Aerospace Medicine

VDC	volts, direct current
WES	warhead electrical system
WIR	weapon information report
WSM	weapons safety manager

Student Notes

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